GEOLOGY OF THE UPPER STILLWATER BASIN, STILLWATER AND CARBON COUNTIES, MONTANA, WITH SPECIAL REFERENCE TO COAL AND OIL.

By W. R. CALVERT.

INTRODUCTION.

In 1907 a coal field on the west side of the Bighorn Basin, Wyo., was examined by the United States Geological Survey, and the investigation was extended northward to include the coal-producing area in the vicinity of Red Lodge, Mont. Mapping was discontinued at Rock Creek, however, and no definite information was obtained relative to the westward extent of the coal field beyond that stream. Coal had been reported at Nye, on Stillwater River, and it was considered possible that this coal bed and some one of those developed at Red Lodge were identical. In 1908 the writer extended the investigation of the previous year westward from Red Lodge with the idea of ascertaining whether the coal beds at Red Lodge and at Nye are of the same geologic age and whether they are continuous in the intervening area.

Time has not been available from 1908 until now to prepare for publication the data obtained in the field examination. In consequence the notes on the coal development here given are incomplete, as they refer to conditions during and prior to 1908. The chief object of this paper is to discuss the geologic conditions in the field and the relation of the coal at Nye and Red Lodge.

In common with other investigations of Rocky Mountain coal fields made by the United States Geological Survey in recent years, the examination was made primarily for the purpose of classifying the land with respect to coal. In the field, therefore, land lines were followed wherever it was feasible, and locations were checked from time to time by established land corners. The topography was sketched by plane-table methods, an aneroid barometer being used for vertical control.

In the field the writer was assisted by F. H. Kay and E. F. Schramm and in the office by Mr. Kay in the compilation of data obtained.

SURFACE FEATURES.

The area to which this report relates lies adjacent to and north of the Beartooth Mountains and extends westward from Rock Creek to Stillwater River. It contains about 300 square miles. (See Pl. XX.)

The surface of the field is considerably diversified, including broad terraces and areas of rolling or much dissected country. On the south it is bordered by the rugged Beartooth Mountains. Glaciation has done much to modify land forms in the vicinity of the mountains, as nearly every stream valley and interstream divide is filled or covered with glacial débris. Aside from the mountainous tract the roughest topography is seen in the western part of the field, where the interstream areas rise to an altitude of 6,000 feet, or 1,000 feet above the valleys. The lowest place is in the extreme northeast corner of the field, where the altitude is about 4,600 feet above sea level. From this locality the surface rises toward the south and culminates in the high peaks of the Beartooth Mountains, whose glacier-crowned summits reach a maximum altitude of over 12,000 feet, the highest in the State. Mapping was not extended southward beyond the base of the mountains, where the altitude is uniformly about 6,000 feet.

The field as a whole is well drained by perennial streams flowing from the mountains. The largest of these are Rock, East and West Red Lodge, East and West Rosebud, and Fishtail creeks and Stillwater River, all direct or indirect tributaries of the Yellowstone.

Red Lodge is the largest town in the area, having a population of about 4,860. Other post offices are Luther, on West Red Lodge Creek; Dean, on a branch of Fishtail Creek; and Nye, near the junction of West Stillwater River with the main stream. Red Lodge is connected with the transcontinental line of the Northern Pacific Railway by a branch from Laurel, about 16 miles west of Billings. Transportation from other parts of the field is effected by wagon to points on the Northern Pacific.

GEOLOGY.

STRATIGRAPHY.

The rocks of the area comprise a great thickness of strata ranging from coal measures of lower Montana (Upper Cretaceous) age to beds more than 8,000 feet up in the Fort Union formation of the Eocene. Older sedimentary formations and crystalline rocks are exposed in the Beartooth Mountains, along whose north base there is a profound fault that brings Paleozoic rocks into contact with Tertiary formations south of Red Lodge and with successively older strata to the west. The geology of this area is shown on Plate XXI.

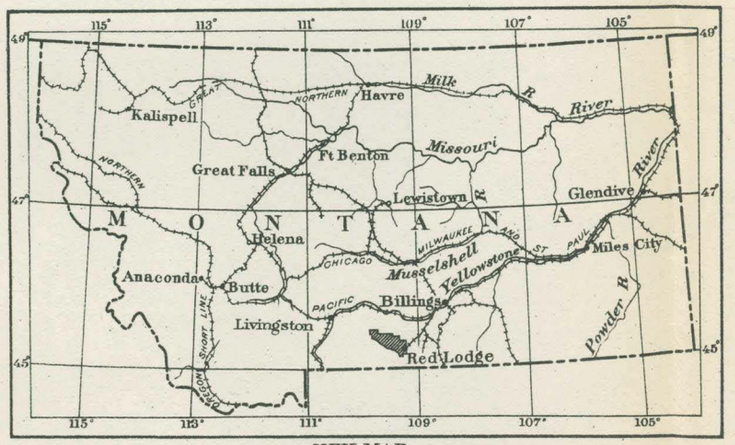
R.15 E. R.16 E. R.17 E. R.18 E. R.19 E. R.20 E.

T.4 S. T.5 S. T.6 S. T.7 S. T.8 S.

BEARTOOTH MOUNTAINS

TOPOGRAPHIC MAP OF THE UPPER STILLWATER BASIN

STILLWATER AND CARBON COUNTIES MONTANA



KEY MAP

Shaded portion of key map shows location of Upper Stillwater Basin

0 1 2 3 4 5 6 Miles

Dean P.O. Roscoe P.O. Luther P.O. Linley RED LODGE

CRETACEOUS SYSTEM.

EAGLE SANDSTONE AND LIVINGSTON FORMATION (UPPER CRETACEOUS).

The oldest rocks in the area consist of a white sandstone about 300 feet thick, the upper part of which is massive and grades downward into a sandy shale. The entire thickness of this sandstone occurs only in the western part of the field, but the upper portion is exposed locally as far east as sec. 4, T. 6 S., R. 18 E. A carbonaceous zone, locally coal bearing, occurs at the top of the sandstone. This white sandstone is overlain by a mass of greenish or brownish sandstone and sandy tuffaceous shale about 3,200 feet thick in the central part of the area. On examination these overlying beds appear to be highly andesitic in character and therefore to have been derived from volcanic rocks. These andesitic strata are exposed over a considerable area in the western part of the field. On West Rosebud Creek poorly assorted volcanic agglomerate, also of andesitic material, appears as a thin wedge in the midst of the tuffaceous beds, and this agglomerate thickens westward until in the vicinity of Stillwater River it is about 2,000 feet thick. In spite of this notable thickening and the fact that the base of the agglomerate is uniformly about 625 feet above the base of the andesitic beds, the stratigraphic distance between the agglomerate and the overlying Tertiary beds (Fort Union formation) remains fairly constant. A section of the andesitic beds measured in T. 5 S., R. 18 E., where the agglomerate is absent, is as follows:

Section in T. 5 S., R. 18 E.

	Feet.
Sandstone, brownish, platy, and sandy shale (thickness estimated).	1,500
Sandstone, platy, brownish gray, with layers of chocolate-colored concretions as much as 1 foot in diameter	99
Partly concealed; lower 100 feet is yellowish-brown platy sandstone and yellowish sandy shale	287
Sandstone, very irregular in lithology and bedding, coarse grained to pebbly	55
Sandstone, brown, and sandy shale	120
Partly concealed; where exposed consists of brown sandy shale and thin brown sandstone	880
Sandstone, gray or brown, with intercalated yellowish shale; texture and bedding variable, chiefly fine grained and tuffaceous, with plant fragments	214
Shale and thin platy sandstone, brownish gray, compact and fine grained	11
Sandstone, thin bedded, coarse grained	39
Shale, gray and yellow, with thin sandstone and lignitic bands	28
	3,233

On Stillwater River the section of the andesitic beds differs from that given above and comprises about 625 feet of shale and sandstone, 2,000 feet of agglomerate, and 2,500 feet of shale and thin sandstone,

all highly andesitic. All of this section is not exposed in the area mapped but is shown on each side of Stillwater Valley farther northeast.

Considerable interest attaches to the age of the basal coal-bearing sandstone and the overlying andesitic beds. Fossil leaves are present in both formations, although they are confined chiefly to rocks closely associated with the coal bed of the massive sandstone and to the andesitic beds underlying the agglomerate. These leaves are similar to those found in the vicinity of Livingston, about 35 miles northwest of Nye, and the rocks containing them are therefore to be correlated with similar plant-bearing beds at Livingston. In that locality the rock section consists of a mass of shale about 3,600 feet thick, which has been considered by previous writers to be the representative of the Colorado shale, Pierre shale, and Fox Hills sandstone. Overlying this mass of shale at Livingston is a coal-bearing sandy formation about 800 feet thick that contains fossil leaves similar to those found in the coal measures near Nye. Next higher stratigraphically is a mass of andesitic rocks about 5,000 feet thick, near the base of which occur leaves of the identical species found in the andesitic beds east of Stillwater River. In earlier reports the coal measures at Livingston were considered to be of Laramie age and the andesitic rocks above, termed the Livingston formation, were supposed to have been deposited after a period of orogenic movement following the Laramie. According to this interpretation the coal-bearing sandstone at Nye should be considered Laramie and the overlying andesitic rocks to be of Livingston age. Regional study by R. W. Stone and the writer, however, leads to the conclusion that the stratigraphy at Livingston has been misinterpreted. Colorado fossils have been found at the top of the mass of shale that constitutes the lowest formation in the section as described, and it therefore appears that the coal-bearing sandstone at Livingston is of lower Montana age rather than Laramie, as has been previously supposed. Furthermore, no unconformity was was found between the coal measures and the overlying Livingston formation, and there is evidence of continuous deposition from Colorado time into Fort Union time. The present interpretation is that the coal measures near Livingston are of lower Montana age, and that the Livingston formation itself is the time equivalent of the Claggett, Judith River, Bearpaw, and possibly even younger formations as developed elsewhere in the State, and is therefore of Upper Cretaceous and Eocene age.

In this report, therefore, the coal measures in the vicinity of Nye are assigned to the Eagle sandstone, the lowest formation of the Montana group. As the overlying rocks up to the Fort Union can not be separated on the basis of either lithology or paleontology the term Livingston formation will be applied to them, although it is to be under-

GEOLOGIC MAP OF THE UPPER STILLWATER BASIN STILLWATER AND CARBON COUNTIES MONTANA

BY W.R. CALVERT

LEGEND

QUATERNARY
- Glacial drift (Including terminal, lateral, and ground moraines, and outwash)
- Terrace gravel

TERTIARY
- Linley conglomerate
- Fort Union formation (May include Lance formation in lower portion)

IGNEOUS
- Intrusive andesite

CRETACEOUS
- Livingston formation (agglomerate member)
- Livingston formation (leaf-bearing beds)
- Eagle sandstone (coal bearing)

- Outcrop of coal bed
- Coal mine
- Coal prospect
- Strike and dip
- Govt. land corner found

R.15 E. R.16 E. R.17 E. R.18 E. R.19 E. R.20 E.

T.4 S. T.5 S. T.6 S. T.7 S. T.8 S.

Nye P.O. Dean P.O. Roscoe P.O. Luther P.O. Linley RED LODGE

STILLWATER RIVER Canyon Creek Magpie Creek Midnight Canyon Rock Creek Meadow Creek Fishtail Creek Fiddler Creek Rosebud Creek Antelope Creek Butcher Creek West Rosebud Creek Ingersoll Creek Morris Creek East Rosebud Creek Red Lodge Creek Willow Creek Thiel Creek Bergum Creek Hoggam Creek Rock Creek

STILLWATER CO. CARBON CO.

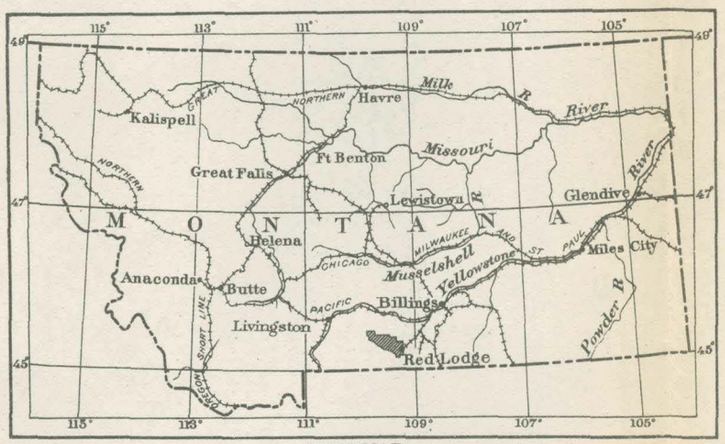
BEARTOOTH FAULT

BEARTOOTH MOUNTAINS

COAL ZONE

NORTHERN PACIFIC R.R. RED LODGE BRANCH

0 1 2 3 4 5 6 Miles



KEY MAP

Shaded portion of key map shows location of Upper Stillwater Basin

stood that by the use of this name no attempt is made to convey an idea of distinct geologic time. It is not appropriate to discuss in this report all the details on which are based the present interpretation of the stratigraphic questions involved, and the reader interested in the subject is referred to a paper in which the problem is treated at greater length.[1] In any event, however, it has been ascertained beyond question that the coal measures at Nye are not in the same geologic formation as those at Red Lodge, but are nearly 9,000 feet lower.

TERTIARY SYSTEM.

FORT UNION FORMATION (EOCENE).

The rocks in the eastern part of the field, aside from surficial material and those of an area of about 5 square miles south of Linley, represent fresh-water deposits of Fort Union age, which are predominantly sandy. Woodruff[2] has separated the Fort Union formation of this region into three members, the division being based on the presence or absence of valuable coal beds. The lowest member consists of variable yellowish sandstone and shale 5,700 feet thick, in which no coal of any consequence occurs. Above is a member 825 feet thick, which is lithologically similar in appearance to the underlying member, but which contains several beds of coal. The upper member, about 2,000 feet thick, is also of essentially the same character as the lower, and likewise differs from the middle member in that it contains no valuable coal beds. Although it is likely that the lower part of the section should be referred to the Lance formation ("Ceratops beds"), fossils belonging to that formation were not found, and as there is no distinct change in lithology in the mass of rocks described, the entire sequence is tentatively designated Fort Union.

LINLEY CONGLOMERATE (POST-EOCENE).

In addition to the Eagle sandstone, the Livingston and Fort Union formations, as previously described, other rocks are represented in the area. Between Linley and the Beartooth Mountains is an area of about 5 square miles in which a conglomeratic sandstone lies with marked unconformity on tilted and eroded Fort Union rocks. The conglomerate is bedded throughout and is composed mainly of grains and well-rounded pebbles, 6 inches or less in diameter, of greenish porphyry, with smaller amounts of limestone and pink granite, all presumably originating in the Beartooth Mountains. The strata appear to dip at a moderate angle to the northeast, but this dip is considered to be the original attitude of deposition rather than the result of subsequent structural disturbance. It is difficult

[1] Stone, R. W., and Calvert, W. R., The stratigraphic relations of the Livingston formation of Montana: Econ. Geology, vol. 5, Nos. 6, 7, and 8, 1910.

[2] Woodruff, E. G., The Red Lodge coal field, Mont.: U. S. Geol. Survey Bull. 341, pp. 92–107, 1907.

to determine the thickness of this conglomerate, but it attains an approximate maximum of 300 feet. Toward the north it thins to a mere film. Although erosion has now separated the conglomerate from the Beartooth Mountains, its southern border no doubt formerly extended to that uplift. Because of the development of this conglomerate in the vicinity of Linley, it is here designated the Linley conglomerate.

No fossils were found in the conglomerate, and its age is therefore uncertain. Its superposition on highly tilted Fort Union rocks indicates that it is considerably younger than the Fort Union and also more recent than the major structural disturbances of the region. That it is not of glacial age or origin is indicated by the evenly bedded and solidified character of the rocks, by the entire absence of striæ, and by the superposition of undoubted glacial drift along the eastern margin of the conglomerate. The date of the deposition of the Linley conglomerate is rather to be correlated with the period when erosion had laid bare the crystalline core of the Beartooth Mountains and when streams emerging from the uplift had much greater gradient and carrying capacity than at present. The conglomerate was laid down as a fan or delta deposit by Red Lodge Creek at the locality where its gradient was suddenly lowered on emergence from the mountainous area. Criteria to determine the date of this condition are not available, and the Linley conglomerate is therefore merely referred to the post-Eocene.

QUATERNARY SYSTEM.

Glacial drift covers a considerable part of the area and effectually conceals all older sediments wherever it occurs. This drift is made up of lateral and terminal moraines, outwash, and other forms of glacial débris. On the recession of the glacier that once occupied Stillwater Valley a lake was formed, and along its borders were strewn bowlders, probably left by floating ice; the lake floor was also covered by débris, which now conceals the underlying rock. Terrace gravel occupies the surface in much of the eastern part of the field.

IGNEOUS ROCKS.

Two areas of intrusive andesite were noted in the vicinity of Dean post office—one in secs. 13 and 14, T. 5 S., R. 16 E., and the other in secs. 15, 16, and 17, T. 5 S., R. 17 E. These rocks were not examined in detail, but as they cut the lower part of the Livingston formation they must have been intruded at a later date than the deposition of that material, and they were probably intruded before the movement which resulted in the formation of the Dean anticline.

STRUCTURE.

The structure in the eastern part of the field is relatively simple. At Red Lodge the strata associated with the coal beds dip at an angle of 18° toward the Beartooth Mountains, but the angle decreases as the mountains are approached. The beds are finally terminated by a fault of great throw which extends northwestward along the base of the mountains entirely across the field. Near Red Lodge Paleozoic limestone standing vertical occurs just south of the fault line, but farther west younger rocks up to and including the Jurassic appear, indicating that the throw of the fault lessens in that direction.

North of Red Lodge the strike of the beds remains fairly constant in direction, although interrupted by minor flexures. The dip gradually decreases, however, and at the northern border of the area it is less than 5°. Because of this decrease in dip the entire thickness of the Fort Union is not exposed in the area surveyed, and the total of 8,500 feet assigned to the formation was measured northeast of Red Lodge.

Minor faults and folds are numerous in the district west of Rock Creek and northwest of Red Lodge. These local structural features were generally not mapped, however, as the lack of persistent well-defined key beds rendered it practically impossible to work out the structure in detail. West of R. 19 E. the structure is dominated by an anticline which trends N. 70° W. to the western border of the field. East of Nye this anticline is cut by a fault. The fault can not be followed for any considerable distance, as on the east it extends into andesitic rocks where the structure is largely concealed by lack of well-defined bedding and on the west it passes under a mantle of alluvium and glacial material. The amount of vertical displacement can not be determined with certainty, but in the cliff near the south side of T. 4 S., R. 16 E., it must be nearly 600 feet. Southeast of this locality the structure seems best explained by two faults.

COAL IN THE RED LODGE DISTRICT.

FORT UNION FORMATION.

The coals at Red Lodge had been studied prior to the examination by the writer in 1908, and only one main point, that relating to the westward extent of the Red Lodge field, remained to be decided. For details regarding the coals, therefore, the reader is referred to the previous publication on this field.[1] The repetition of certain points relative to the coal, however, seems desirable. The workable

[1] Woodruff, E. G., The Red Lodge coal field, Mont.: U. S. Geol. Survey Bull. 341, pp. 92-107, 1907.

beds have a vertical range of about 800 feet and are underlain by about 5,700 feet of practically barren strata. Above them is a similar mass of sandstone and sandy shale about 2,000 feet thick which is also unproductive of coal. Measurement of the coal shows a total of 71 feet in beds more than 3 feet thick. The workable beds are known locally as Nos. 1, 1½, 2, 3, 4, 4½, 5, and 6. The coals are high-grade subbituminous coals, and compare favorably in heat value with the bituminous coals of the Mississippi Valley but do not stock so well.

The Fort Union coal beds west of Red Lodge are exposed in outcrop on both sides of Rock Creek, where they dip 18° S. and strike N. 78° W., but immediately west of the town exposures are lacking and there is nothing to indicate whether or not the structure continues regularly. Near the west quarter corner of sec. 28, T. 7 S., R. 20 E., however, a coal bed has been prospected, and though the opening was badly caved certain information was obtainable. It was noted that the strike and dip of the bed were identical with those on Rock Creek, and by sighting back along the strike it seemed probable that the bed is No. 1½, an assumption which is strengthened by the apparent thickness and character of the bed at the prospect, which is comparable to No. 1½ as developed at Red Lodge.

West of the prospect in sec. 28 exposures are not good, but the structure seems to be regular. If so, the upper coal bed meets the Beartooth fault near the east side of the township to the west, and the lower beds continue only a short distance farther. It seems likely, therefore, that the producing district at Red Lodge will be practically confined to Tps. 7 and 8 S., R. 20 E., for although the Fort Union formation constitutes the surface over a large area northwest of Red Lodge the highest strata exposed are below the productive zone.

LIVINGSTON FORMATION.

On West Rosebud Creek a carbonaceous zone near the base of the andesitic beds overlying the Eagle sandstone has been prospected at several localities, but in only one place has coal actually been removed. This is in sec. 23, T. 5 S., R. 17 E., where T. E. Philip drove an entry 250 feet long. The coal occurs here in four irregular benches with partings of bone and shale. The lower bench reaches a maximum thickness of 17 inches, and the bench above ranges from 1 inch to 13 inches. The next higher bench is termed the "rotten vein" and is worthless; the top bench is the most variable of all. This coal is not valuable, as the waste is excessive and the coal bed extremely variable and faulted. Where opened at other localities

the zone comprises only carbonaceous shale with thin partings of coal. Carbonaceous zones occur also near the top of the Livingston formation, but no coal bed was found more than 8 inches thick.

EAGLE SANDSTONE.

Coal is mined near Nye, in what is known as the Upper Stillwater Basin, from a single bed that is near the top of the massive white sandstone believed to be the Eagle. Above this are the brownish clay shale and thin tuffaceous sandstone constituting the lower part of the Livingston formation. The coal bed is exposed in outcrop in the cliff east of Stillwater River, gradually approaching the level of the valley floor, which it crosses in sec. 28, T. 4 S., R. 16 E., and it continues in a direction slightly north of west to the vicinity of the south quarter corner of sec. 19. From this locality it apparently swings to the south along the southeast base of Sheep Mountain, where it turns to the east and probably passes beneath alluvium and glacial drift. It is not known with certainty whether the bed appears elsewhere within the area, as the structure in this vicinity is complex and largely concealed by glacial débris.

Three mines have been opened on this coal bed and operated to supply a small local demand. The easternmost of these is the Albertson mine, in the SE. ¼ NW. ¼ sec. 28, T. 4 S., R. 16 E. At this locality the coal bed is split by bone or sandstone partings into several benches, as shown in the following section, measured at a point in the mine 250 feet from the entrance:

Section of coal bed in the Albertson mine.

	Ft.	in.
Sandstone.		
Coal		10
Sandstone		1
Coal		11
Bone		1
Coal		8
Bone		4
Sandstone		4½
Coal		7½
Bone and sandstone	2	10
Coal	1	
Sandstone.		
Total coal	4	½

Sample No. 6314 (see p. 210 for analysis) was cut at this place and includes the upper three benches of coal. At the time of the examination the entry of the Albertson mine was about 250 feet long on a very slight dip. No water or gas has been encountered in the workings.

On the northwest side of Stillwater River, in the NE. ¼ NW. ¼ sec. 29, is the Loffer mine. Here the bed is opened by a slope 400 feet

long on a dip of 11°. The coal occurs in three benches, as shown by the following section, measured at the end of the slope:

Section of coal bed in Loffer mine.

	Ft.	in.
Sandstone.		
Coal		5
Sandstone		2
Coal		11
Bone		9
Sandstone		3
Coal	3	3
Sandstone.		
Total coal	4	7

Sample No. 6320 (see p. 210) was obtained by making a cut across the three benches of coal at the place where the section given above was measured. Although under considerable cover, the coal is badly weathered near the outcrop and is not marketable for at least 125 feet from the mouth of the entry.

About three-quarters of a mile west of the Loffer mine is the Lehner opening. The entry was filled with water at the time of visit, so that an examination could not be made, but it was reported that the coal occurs in three benches, which are shown in the following section, given by a local resident:

Reported section of coal bed at Lehner mine.

	Feet.
Sandstone.	
Coal	1
Bone parting.	
Coal	1
Shale	2
Coal	3
Sandstone.	
Total coal	5

Aside from these three mines no development worthy of mention has been made in the vicinity of Nye. The coal bed has been prospected southeast of the Albertson mine, in the southern part of sec. 33, and shown to be of poor quality and insufficient thickness. On the opposite side of the valley, southwest of the Lehner mine, nothing is known of the coal bed. Its probable outcrop is indicated on the map (Pl. XXI) but it was not seen, and therefore the area of readily available coal in the vicinity of Nye is probably of small extent. Dips near the outcrop are comparatively slight as a rule, yet a short distance away from the outcrop the coal bed is carried by increasing dips to considerable depths. Coal is mined from a thin bed in sec. 8, T. 5 S., R. 16 E., from rocks which in lithology might belong either to the coal measures or to the overlying

andesitic beds. Fossil plants do not serve to differentiate these formations sharply, so that there is doubt as to the stratigraphic position of the coal. It is probable, however, that the bed is above the coal bed exposed north and east of Nye. On the west side of Stillwater River, outside of the area mapped, a bed of coal has been opened that is probably the same as that near Nye. It is, however, of poor quality and is not considered further in this report.

CHARACTER OF THE COAL.

The coal of the Nye district is fairly dense and rather dull in luster, though it contains brighter bands ranging from a mere film to some a quarter of an inch thick. Brown resin occurs in a few minute lenses. So far as known the coal is noncoking.

Samples were taken from the Albertson (No. 6314) and Loffer (No. 6320) mines, and their analyses, made in the United States Geological Survey laboratory at Pittsburgh, are given below.

Analyses of coal samples from the Nye coal field, Mont.

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

Laboratory No.	Location.				Thickness.		Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
	Quarter.	Section.	T. S.	R. E.	Coal bed.	Part sampled.			Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
					Ft. in.	*Ft. in.*													
6314	NW...	28	4	16	7 9	3 1½	2.2	A	7.0	30.1	44.2	18.7	0.49	.....	.....	.....	.....	5,625	10,130
								B	4.9	30.8	45.2	19.1	.50	.....	.....	.....	.....	5,755	10,360
								C	.....	32.4	47.5	20.1	.53	.....	.....	.....	.....	6,050	10,890
								D	.....	40.5	59.5	.....	.66	.....	.....	.....	.....	7,575	13,640
6320	NE...	29	4	16	5 9	4 7	2.4	A	6.7	32.4	44.5	16.41	.53	5.04	61.47	1.10	15.45	5,935	10,680
								B	4.4	33.2	45.6	16.81	.54	4.89	62.98	1.13	13.65	6,080	10,940
								C	.....	34.7	47.7	17.60	.57	4.60	65.92	1.18	10.13	6,365	11,450
								D	.....	42.1	57.9	.....	.69	5.58	80.00	1.43	12.30	7,720	13,900
3590	SE....	30	7	20	11 5	6 0	4.7	A	11.7	36.1	40.2	11.98	1.05	5.26	55.46	1.20	25.05	5,435	9,790
								B	7.3	37.9	42.2	12.57	1.10	4.97	58.20	1.26	21.90	5,705	10,270
								C	.....	40.9	45.5	13.57	1.19	4.48	62.80	1.36	16.60	6,155	11,080
								D	.....	47.3	52.7	.....	1.38	5.19	72.66	1.57	19.20	7,125	12,820
5823	.....	6	8	21	3 11	3 9	3.3	A	9.8	34.7	47.2	8.27	2.17	5.20	60.20	1.42	22.74	6,045	10,880
								B	6.7	35.9	48.8	8.55	2.24	5.00	62.25	1.47	20.49	6,250	11,250
								C	.....	38.5	52.3	9.17	2.41	4.56	66.74	1.57	15.55	6,705	12,070
								D	.....	42.4	57.6	.....	2.65	5.02	73.48	1.73	17.12	7,380	13,280
5495	SW...	17	6	23	7 8	3 6	8.8	A	14.8	26.9	44.9	13.35	.33	5.61	57.05	.91	22.75	5,575	10.040
								B	6.6	29.6	49.2	14.64	.36	5.08	62.55	1.00	16.37	6,115	11,010
								C	.....	31.6	52.7	15.67	.39	4.65	66.98	1.07	11.24	6,545	11,790
								D	.....	37.5	62.5	.....	.46	5.51	79.42	1.27	13.34	7,765	13,970
5508	NE...	13	5	22	7 5	4 1	3.7	A	9.7	27.7	46.2	16.42	.63	5.09	56.19	1.01	20.66	5,685	10,240
								B	6.3	28.7	47.9	17.05	.65	4.86	58.35	1.05	18.04	5,905	10,630
								C	.....	30.6	51.2	18.20	.70	4.44	62.27	1.12	13.27	6,300	11,340
								D	.....	37.5	62.5	.....	.86	5.43	76.13	1.37	16.21	7,705	13,870

In the table the analyses are given in four forms, marked A, B, C, and D. Analysis A represents the composition of the sample as it comes from the mine. This form is not well suited for comparisons, for the amount of moisture in the sample as it comes from the mine is largely a matter of accident and consequently analyses of the same coal expressed in this form may vary widely. Analysis B represents the sample after it has been dried at a temperature a little above the normal until its weight becomes constant. This form of analysis is best adapted to general comparisons. Analysis C represents the theoretical condition of the coal after all the moisture has been eliminated. Analysis D represents the coal after all moisture and ash have been theoretically removed. This is supposed to represent the true coal substance, free from the most important impurities. Forms C and D are obtained from the others by recalculation. They should not be used for commercial representation, for they represent theoretical conditions that never exist.

In the analytical work chemists generally recognize that it is not possible to determine the proximate constituents of coal or lignite with the same degree of accuracy as the ultimate constituents. Therefore the air-drying loss, moisture, volatile matter, fixed carbon, and ash are given to one decimal place only; whereas the ash (in an ultimate analysis), sulphur, hydrogen, carbon, nitrogen, and oxygen are given to two decimal places. It is also understood that calorific determinations to individual units are not reliable; therefore in the column headed "Calories" the heat values are given to the nearest five units, and in the column headed "British thermal units" they are given to the nearest tens, a British thermal unit being about one-half the value of a calorie.

In order to make direct comparisons with other coals of this general region analyses of some of the best-known coals have been inserted in the table. No. 3590 represents a sample from bed No. 1 in the mine of the Northwestern Improvement Co. at Red Lodge. No. 5823 represents a sample from bed No. 4 in the mine of the Bear Creek Coal Co. at Bear Creek. Both of these beds are in the Fort Union formation and hence are much younger geologically than the Nye bed in this field. Nos. 5495 and 5508 represent coal from the Bridger bed, in the eastern part of Carbon County, which occupies about the same stratigraphic position as the Nye bed. No. 5495 is the analysis of a sample from the mine of the Bridger Coal Improvement Co. and No. 5508 of a sample from Gebo No. 2 mine of the Bituminous Coal Co.

By comparison of the analyses it will be seen that the composition of the Nye coal is more nearly like that of the Bridger coal than it is like that of the coal at Red Lodge and Bear Creek. The moisture of the Nye coal is nearly the same as that of the Bridger coal and

considerably less than that of the Fort Union coals at Red Lodge and Bear Creek. The amount of volatile matter is also nearly the same in the Nye and Bridger coals and less than in those of Bear Creek and Red Lodge. Ash, on the other hand, is greater in the Nye and Bridger coals than it is in the Red Lodge and Bear Creek coals. The real value of the coal itself, aside from any impurities such as moisture and ash that it may contain, is well shown by a comparison of the heating values in the analyses of form D:

Heating values of some Montana coals.

Coal.	Laboratory No.	British thermal units.
Nye	6314	13,640
Nye	6320	13,900
Bridger	5495	13,970
Bridger	5508	13,870
Red Lodge	3590	12,820
Bear Creek	5823	13,280

From this table it is evident that the substance of the Nye and Bridger coals is superior in heating value to that of the Red Lodge and Bear Creek coals, but the higher ash content would tend to neutralize this advantage and make the two coals as they reach the market of about the same value.

These coals are doubtless near the dividing line between bituminous and subbituminous. Those of Red Lodge and Bear Creek, owing to their tendency to slack when exposed to the atmosphere, are generally regarded as subbituminous, whereas the Bridger coal, which shows little or no tendency to slack, is regarded as bituminous. It is said that the coal at Nye will stock as well as that at Red Lodge, if not better, and if this claim is in accord with the facts it appears that the Nye coal may be classified as bituminous rather than subbituminous like the Red Lodge and Bear Creek coals. This assignment of the Nye coal to the bituminous class is still further strengthened by the similarity of its composition to that of the Bridger coal as shown by the analyses.

FUTURE DEVELOPMENT.

In the Red Lodge district development is certain to be steady and continued, as a great amount of coal is known to be available and transportation facilities are entirely adequate. The coal in the Upper Stillwater Basin, however, is less fortunately situated, and the present demand is purely local. The future of this area, therefore, is dependent on future transportation facilities. Surveys have been made from Columbus, on Yellowstone River, to the headwaters of the Stillwater, the object being to build a line to Cooke City to aid in the development of the metalliferous district in that vicinity. If

this line is ever built it will afford an outlet for the coal near Nye, and as this coal compares favorably with that of competing fields, a considerable amount would no doubt find its way to market. The tonnage of available coal, however, is not comparable to that of the Red Lodge field, where there are at least eight workable beds and where the area underlain by coal within 2,000 feet of the surface is considerably greater than at Nye.

OIL PROSPECTS.

At two localities in the area mapped there have been attempts to obtain oil by drilling. One of these is in the northeastern part of sec. 4, T. 6 S., R. 18 E., and the other is in the SE. ¼ sec. 32 of the same township. At the former place several holes were put down to different depths, the deepest being 1,500 feet. After passing through surface wash and the lower sandy portion of the Eagle sandstone the drilling was in dark shale and thin sandstone, presumably of Colorado age. All the holes were dry, although indications of oil were reported. The drilling was done on the axis of an anticline, but nevertheless the absence of oil in the rock section has not been conclusively shown, first because the holes were of insufficient depth, and second because they were put down on the pitching end of the anticline. The absence of water in the drill holes, however, suggests that the beds penetrated are not charged with oil higher in the anticlinal arch and that if oil is present at any horizon through which the drill passed it has accumulated at that horizon lower down on the flanks of the anticline. All prospecting at this locality had ceased at the time of examination in 1908.

At the locality in sec. 32 there is more justification for oil prospecting, and considerable money had been expended prior to 1904, when large operations ceased, owing, it is said, to disagreement among the stockholders. One hole had been drilled to a depth of 1,100 feet and several others to about 600 feet. Indications of oil were reported in each, and it was asserted that in one hole small amounts of oil were obtained. At three points near by small pools of asphalt occur, and in 1908 these pools were being augmented by asphalt oozing from the ground.

Geologic relations in this vicinity are much obscured by thick growths of quaking aspen, but enough was observed to ascertain that the drilling was done in Fort Union rocks dipping toward the Beartooth fault at an angle of 22°. The exact location of the fault here is somewhat doubtful, owing to the covering of talus, but it is probable that the holes are about a quarter of a mile from the fault line. Because of the relation of the drill holes to the fault the original stratigraphic horizon of the oil is in doubt, and whether or not it is indigenous to the Fort Union beds with which it is at present asso-

ciated is uncertain. It seems probable, however, that the original source of the hydrocarbons was at a lower stratigraphic horizon, and that the Beartooth fault has afforded opportunities for migration upward to the pervious strata of the Fort Union. Evaporation at the surface then dissipated the volatile portion, and the residuum remains as asphalt. The fact that this bituminous residue is present at the surface suggests that oil in large quantity is not likely to be found in the strata from which the asphalt oozes. Moreover, whatever oil is present would be more likely to be encountered by drilling nearer to the Beartooth fault, but the possible oil-bearing strata would naturally be at a greater depth than is reached in the holes drilled prior to 1908.