COAL IN EASTERN IDAHO.

By George R. Mansfield.

INTRODUCTION.

The general coal shortage in the winter of 1916–17 was particularly acute in eastern Idaho, notwithstanding the relative proximity of this area to the coal fields of western Wyoming. The mines of the Horseshoe district, on the west side of the Teton Basin, afforded some relief but were unable to supply the demands of the region.

In the summer of 1917, in response to urgent requests by residents of eastern Idaho, the United States Geological Survey undertook the investigation of certain reported coal fields in that part of the State to determine if there were any lands that could be classified and appraised as coal land and thus made available for local mining, so that the threatened shortage for the ensuing winter might be averted.

The writer, who was detailed to make the examination, spent about two months in the summer of 1917 with camp outfit and two helpers visiting the reported localities and mapping the geology of portions of the country.

SCOPE OF INVESTIGATION.

The territory examined falls in general within four districts—(1) the Willow Creek-Caribou district, southwest of Snake River, including prospects on Willow Creek, on Grays Lake Outlet, and in the Fall Creek basin; (2) the Pine Creek district, northeast of Snake River, including the land between the head of Pine Creek on the northwest and Palisade Creek on the southeast and also Burns Canyon; (3) Teton Basin, Teton County, including the valleys of Horseshoe, Mahogany, Patterson, and Trail creeks; (4) the Continental Divide district, Fremont County, in T. 14 N., Rs. 38 and 40 E.

In addition to these districts, two prospects were reported to the writer while he was in the field—one at Heise, in the SE. ¼ sec. 25, T. 4 N., R. 40 E., and the other at Barney's ranch, 4 miles up Canyon Creek from the former Canyon Creek post office. At Heise conditions proved to be similar to those seen at the Willow Creek localities, but the prospect at Barney's ranch, which was stated by the writer's informant to be probably on an occurrence of obsidian, was not visited.

In this report only such geologic data are presented as have a direct bearing on the occurrence and usability of the coal.

MAPS.

The general map (Pl. XIV) shows the location of the region examined and the distribution of the general geologic and other features. This map also shows the location of the principal prospects and exposures examined where detailed work was not done. Plate XV and figure 13 show, respectively, on a larger scale the Pine Creek and Teton Basin region and the area in T. 14 N., Rs. 38 and 39 E., near the Continental Divide.

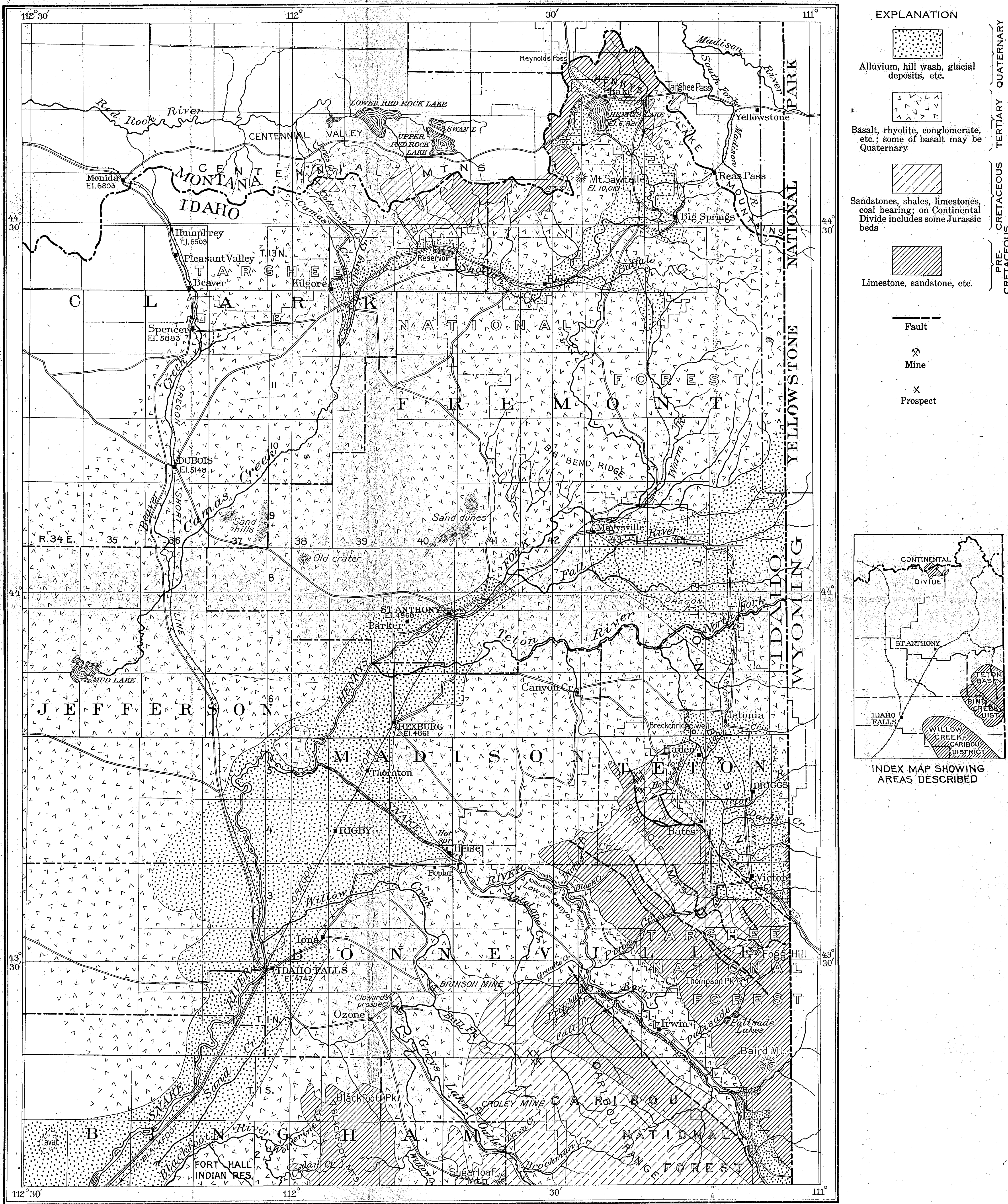
SUMMARY OF RESULTS.

The results of the examination are disappointing. In the Willow Creek-Caribou and Pine Creek districts coaly shale, with some impure coal, is present in beds ranging in thickness from a few inches to 7 feet or more. As a rule the coaly portions of these beds are not persistent but wedge in and out. Lumps of usable coal may be obtained here and there, but commercial development seems to be impracticable. The rock formation in which these coal beds occur is not the one in which the active mines of western Wyoming are located.

The only part of the Teton Basin that is producing coal at the present time is the Horseshoe district. Though conditions in this district are such that large-scale development is probably impracticable, work now in progress will doubtless make possible a somewhat greater yield than that of previous seasons. There is little chance that workable coal beds will be discovered elsewhere in the basin.

On the Continental Divide in T. 14 N., R. 38 E., a 32-inch bed of good coal was found, but the area in which it crops out is not large and its remoteness from lines of transportation and a suitable market make its early exploitation doubtful.

In the districts examined two substances occur that are commonly mistaken for coal, namely, phosphate rock and obsidian, a black volcanic glass. The phosphate rock in these districts when distilled yields a small quantity of petroleum, is unusually black, and has a gloss that makes its appearance very deceptive, as in the Patterson Creek, Burns Canyon, and Palisade Creek localities, where this rock has hitherto been regarded as coal.



Base from General Land Office Map with corrections from U. S. Geol. Survey Map of Idaho and other sources.

5 0 5 10 15 20 25 Miles

GEOLOGIC MAP OF PART OF EASTERN IDAHO

1920

During the examination of the Teton Basin several reported occurrences of oil were investigated, but these do not indicate the presence of oil in paying quantities.

ACKNOWLEDGMENTS.

The writer is indebted to the United States Forest Service and particularly to officers of the Caribou, Palisade, and Targhee national forests for maps and the free use of their field facilities. A. R. Schultz,[1] D. D. Condit, and E. H. Finch, of the Geological Survey, have kindly permitted the use of manuscript maps and reports relating to portions of the region visited. The published work of earlier geological surveys has been drawn upon in the preparation of both the general map and the text and will be specifically acknowledged on later pages. Mr. J. A. Cloward, whose ranch is on Willow Creek, in sec. 6, T. 1 N., R. 40 E., furnished valuable information. Mr. L. Hillman, of Driggs, Idaho, manager of the Teton Valley Coal Co., was kind enough to show personally the workings of the Brown Bear and Boise mines. Mr. L. Perry, of Bates, Idaho, took the writer to see several prospects on Mahogany Creek and in the vicinity of Tetonia. Information from other sources will, so far as practicable, be acknowledged below.

SURFACE FEATURES OF THE COUNTRY.

The region here described lies in the southeastern part of Idaho, in Fremont, Jefferson, Madison, Teton, Bonneville, and Bingham counties, and includes the east end of the Snake River plains, with their mountainous borders, which have been so vividly and admirably described by Russell.[2]

The Blackfoot, Caribou, Snake River, and Big Hole ranges, which form the rugged mountain border in the southeastern part of the district, are composed of folded and broken sedimentary rocks that represent many geologic periods and vary considerably in resistance to weathering and erosion. These rocks have been subjected to more than one cycle of uplift and erosion, so that broad valleys or basins have been excavated along the strike of the relatively weaker rocks, such as certain sandstones, shales, and clays, while harder rocks, such as massive limestones, sandstones, or quartzites, have formed prominent peaks and ridges 7,000 to 9,000 feet or more in general elevation and cut by narrower transverse canyons or gulches. The broader valleys, 1,000 to 3,000 feet lower and occupied in part by lava, together with the adjacent transverse valleys and gulches,

[1] Mr. Schultz's report has since been published as U. S. Geol. Survey Bull. 680, 1918.

[2] Russell, I. C., Geology and water resources of the Snake River plains of Idaho: U. S. Geol. Survey Bull. 199, 1902.

have been deepened and sharpened by the erosion of later epochs to dimensions varying with the locality and the character of the rock. The most impressive of these renewed canyons is that of Snake River.

The east side of Teton Basin is formed by the lava-covered western foot slopes of the Teton Range, which a few miles to the east of this district culminates in beautiful alpine peaks that serve as landmarks for a wide region and are known as the Tetons. The Grand Teton, 13,747 feet above sea level, is the highest. The lavas of Teton Basin are continuous northward with those that lap around the north end of the Teton Range and merge with the volcanic plateau of the Yellowstone, which forms the northeastern border of the district.

On the north in the region described in this report the Snake River plains are bordered by lavas that rise gently to the Continental Divide. The lavas in all probability once completely covered this portion of the region, but they have been considerably dissected, so that here and there relatively recent conglomerates and older sedimentary rocks are exposed. Lava cliffs and hard sedimentary rocks now form the high and rugged mountains along the divide as viewed from the south. Where weaker sedimentary rocks have been exposed by erosion the divide is lower. According to Forest Service maps some of the higher peaks attain elevations greater than 10,000 feet.

The Snake River plains in this region are underlain by basalt, covered in some places to a considerable extent by soil that has largely been deposited by the wind, alluvium and stream gravel, and drifting sand or dunes. Elsewhere the somber basalt forms the surface in large or small exposures, locally rough with low broken ridges, and elsewhere with low, relatively smooth, dark surfaces marked by polygonal cracks. Over considerable areas the thin, grass-covered soil, with intervening dark ledges, resembles in the fall the surface of a yellowish sea with black waves. Bold cliffs of black basalt with columnar aspect border the principal stream valleys and in places, as in the lower canyon of Snake River, form high canyon walls. The old broken cone and crater of Sand Mountain, near St. Anthony, with the adjacent group of sand dunes, are conspicuous topographic features. Elsewhere volcanic cones with craters rise above the surface of the plain. Some of them consist of basaltic débris, but others, notably Big and East buttes, northwest of Blackfoot, are composed of rhyolite and stand as volcanic islands in the basaltic sea.

The drainage of the region south of the Continental Divide is all gathered by Snake River and delivered through Columbia River to the Pacific Ocean. North of the Continental Divide are the headwaters of the Missouri. The mountains have many springs and permanent streams which on the Idaho side supply the two forks of Snake River and their larger tributaries, such as Blackfoot River, Willow Creek, and Teton River.

In the vicinity of the mountains these streams are rather closely spaced and water for camping or other purposes is available at numerous places along the roads. In the bench lands underlain by lava, however, the permanent streams are much farther apart and water may be had at comparatively few places. On the road from Tetonia to St. Anthony, a distance of about 30 miles, Canyon Creek is practically the only watering place between the two crossings of Teton River, some 24 miles apart. Ranchers who occupy dry farms on these benches must sink wells through the lava perhaps 200 feet or more until a suitable supply of water is reached, or haul it for long distances. The water wagon and water barrel are familiar sights throughout the dry-farm district.

The low alluvial lands adjoining Snake River and the lower courses of its tributaries are supplied with water by means of irrigating ditches, some of which are themselves large-sized creeks. Northwest of Snake River the Continental Divide is also well supplied with permanent streams, but most of the surface drainage sinks through the porous and shattered lava so that comparatively little reaches the river directly, though much is doubtless supplied by springs. On the direct road from St. Anthony to Kilgore, a distance of approximately 30 miles, no water is seen after leaving the ditch a mile north of Parker until Camas Creek, at the lower end of Camas Meadows, is reached, some 25 miles beyond.

INDUSTRIES.

The alluvium along Snake River and some of the larger creeks at elevations of 4,500 to 5,000 feet furnishes considerable areas that are suitable for irrigated fields, which produce a variety of valuable crops. Locally these lands are subject to local frosts or are too wet for cultivation but yield abundant crops of hay and support large numbers of cattle. All the larger soil areas, whether irrigable or not, are being rapidly taken up for cultivation, and forlorn homesteads are even perched here and there among the lava ledges where only a few square rods or acres of cultivable soil is available. Owing to the scarcity of water, much of the lava country must remain waste until through a system of wells or otherwise water is furnished for stock and for domestic use.

The mountains are heavily timbered with aspen, red fir, and other conifers, which yield local supplies of fuel and building material. Several sawmills supply the demand for rough lumber, but dressed lumber is largely shipped in by rail. The mountains also, through the grazing regulations of the United States Forest Service, are made available for the summer pasturage of large numbers of sheep and cattle.

Coal is mined in the Horseshoe district of Teton Basin. The coal beds and their development are described on pages 137–145.

St. Anthony and Idaho Falls, the two principal cities in the district, owe their location to the presence of falls where Snake River has cut through the alluvium and plunges over basaltic ledges, and Blackfoot, just to the southwest, is located favorably at the confluence of Snake and Blackfoot rivers. All three cities are railway junction points and distributing centers for the increasingly important agricultural products of the region.

Many details regarding the settlements, industries, scenery, and general geology of the district are given in the guidebook of the Overland Route published by the Geological Survey.[3]

GEOLOGY.

SEDIMENTARY ROCKS.

The sedimentary rocks of the region have a wide range both in character and in geologic age. All the great geologic periods from early Carboniferous to the present are represented. In southeastern Idaho these rocks have been subdivided into many formations, which are rather fully described in some of the published accounts of that region.[4] They are summarized in the accompanying table, which is given for reference. Some of the formations that occur in the southern part of southeastern Idaho were not recognized here, and others were not differentiated. An additional column has therefore been placed in the table to show the units mapped.

The Phosphoria formation deserves brief description because it has been prospected and mined for coal at several places in the region here described. The formation occurs in many bands distributed through the mountain ranges. (See Pl. XV.) The phosphatic shale

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[3] Lee, W. T., Stone, R. W., Gale, H. S., and others, Guidebook of the western United States, Part B, The Overland Route: U. S. Geol. Survey Bull. 612, pp. 130–147, 1915.

[4] Gale, H. S., and Richards, R. W., Preliminary report on the phosphate deposits in southeastern Idaho and adjacent parts of Wyoming and Utah: U. S. Geol. Survey Bull. 430, pp. 457–535, 1910.

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Richards, R. W., and Mansfield, G. R., Geology of the phosphate deposits northeast of Georgetown, Idaho: U. S. Geol. Survey Bull. 577, 1914.

Mansfield, G. R., and Roundy, P. V., Revision of the Beckwith and Bear River formations of southeastern Idaho: U. S. Geol. Survey Prof. Paper 98, pp. 75–84, 1916.

Mansfield, G. R., Geography, geology, and mineral resources of the Fort Hall Indian Reservation, Idaho: U. S. Geol. Survey Bull. 713 (in press).

Carboniferous and later formations in eastern Idaho.

System.	Series.	Formation.	Character.	Southern part. Thickness (feet).	Northern part. Thickness (feet).	Northern part. Remarks.
Quaternary.			Recent soils, alluvium, hill wash, travertine, glacial deposits, some basalt.			
Unconformity						
Tertiary.	Pliocene (probably).	Salt Lake formation.	Conglomerate, sandstone, marl and tuff, rhyolite, and basalt.	2,500+	600+	Chiefly conglomerate, probably also rhyolite and basalt. Age undetermined.
	Eocene.	Wasatch formation.				
Unconformity						
Cretaceous.	Upper Cretaceous.	Absent.			10,800	Light-colored sandstone and clay aggregating 5,800± feet, with coal beds and some calcareous beds tentatively correlated with the Frontier and Aspen formations of southwestern Wyoming.
						Dark-colored sandstone and shale with some calcareous beds, aggregating 5,000 feet; typical Bear River (basal Upper Cretaceous) fossils.
	Lower Cretaceous (?).	Wayan formation.	Sandstone, shale, carbonaceous shale, limestone, and some conglomerate.	11,800		
Unconformity						
Cretaceous (?).		Gannett group. Tygee sandstone		100	1,300+	Not differentiated; conglomerate much reduced in topographic prominence and thickness.
		Gannett group. Draney limestone		200		
		Gannett group. Bechler conglomerate		1,775		
		Gannett group. Peterson limestone		205		
		Gannett group. Ephraim conglomerate		1,025		
				3,305		
Jurassic.		Stump sandstone.	Greenish-gray sandstone, with massive calcareous bed at base.	200-600	1,500	Formations recognized but not differentiated.
		Preuss sandstone.	Red sandstone and shale.	1,300		
		Unconformity				
		Twin Creek limestone.	Whitish shaly limestone, some massive beds.	3,500+		
		Nugget sandstone.	Red and light-colored sandstone.	1,500	800	
Triassic (?).		Wood shale.	Red shale, locally gypsiferous.	250	1,400	Not definitely recognized.
		Deadman limestone.	White, greenish, grayish, or purplish limestone, somewhat cherty, nonfossiliferous.	150±		
		Higham grit.	White, locally pinkish or yellowish gritty or conglomeratic sandstone.	500±		
		Unconformity				
Triassic.	Lower Triassic.	Timothy sandstone.	Sugary yellowish to grayish sandstone.	30-800		
		Unconformity				
		Thaynes group. Portneuf limestone.	Limestone with red sandstone and shale.	1,500±		
		Thaynes group. Fort Hall formation.	Siliceous and cherty limestones and calcareous sandstones.	800±		Recognized but not differentiated.
		Thaynes group. Ross Fork limestone.	Limestone with calcareous shale.	1,350±		
		Woodside shale.	Olive-drab calcareous shale.	1,000-2,000		Not definitely recognized.
Carboniferous.	Permian.	Phosphoria formation.	Rex chert member at top, one or more massive strata of cherty limestone or chert, prominent as a ledge maker, grading in part to a purplish cherty or flinty shale.	240-550	350	Locally the phosphatic shale of the Phosphoria formation yields a little petroleum when distilled, is black and shiny, and is mistaken for coal. Rex chert member well developed but without limestone; quartzite in upper part.
			Rock phosphate, phosphatic shale, sandstone, and minor limestone bands.	75-180		
		Unconformity in places				
	Pennsylvanian.	Wells formation.	Massive white calcareous sandstone, weathering with projecting fossil fragments, generally with bluish chert bands and in some localities with black chert in rounded nodules in the lower portion. White sandstone and quartzite, calcareous sandstone, and light-colored limestone, with variable amounts of interbedded quartzite. Light-colored cherty limestone with interbedded sandstone.	2,400	4,400+	Not differentiated.
	Mississippian.	Brazer limestone.	Bluish-gray thick-bedded limestones with spherical nodules of black chert; gray sandy limestone streaked with calcite and specked with siderite; locally marked with fossil corals, crinoid stems, and brachiopods.	1,130+		
		Madison limestone.	Thick massive blue to gray limestone, generally making high mountainous country where brought to the surface in mass; thinner bedded than overlying limestone.	1,000+		

member is distinctly nodular or even conglomeratic at the base, and there is a bed of hard phosphate a foot or more thick that is somewhat siliceous and furnishes large float fragments with the characteristic bluish-white bloom. The main phosphate beds lie above this bed and are dark colored, locally coaly black, and yield upon distillation a little petroleum. The characteristic oolitic texture, however, may be clearly distinguished, the tiny rounded grains or oolites being readily visible to the naked eye. The disturbance that the shale has undergone in assuming its usual inclined position has made it shiny and smooth in some places so that it might readily be mistaken for coal. The thickness of the phosphatic shale, where exposed in Palisade Creek, is estimated at more than 100 feet.

The coal of the region occurs in formations known or supposed to be of Cretaceous age. Some of it is hardly more than carbonaceous or lignitic shale. Several of these formations were recognized but are not differentiated on the map. The lowest corresponds with the Gannett group (Cretaceous ?) and Wayan formation (Cretaceous) of southeastern Idaho. There is a distinctive dark conglomerate about 25 feet thick at the base, composed chiefly of chert pebbles. Above this are variegated beds with some limestones, succeeded by yellowish and dark-grayish sandstones with interbedded carbonaceous shale, the whole aggregating about 1,300 feet in thickness.

The second formation consists of dark-grayish sandstone and shale, with carbonaceous shale and some calcareous beds aggregating perhaps 5,000 feet in thickness. Typical Bear River fossils have been found in it at a number of places, but there is uncertainty about the position of the upper and lower limits of the formation.

Above the beds assigned to the Bear River is gray clay of undetermined thickness which may correspond with the Aspen formation of southwestern Wyoming. Above this are generally light-gray sandstone and clay, with some coal beds, which together with the underlying clay apparently aggregate more than 5,800 feet in thickness if there is no duplication. There is a suggestion, however, as shown in figure 12 (*A*), that the coal beds in the Horseshoe district may be folded into a syncline. If they are, the thickness is only 3,600 feet.

Fossil invertebrates and leaves have been found in these beds. The invertebrates were collected from calcareous beds at the Brown Bear mine. T. W. Stanton states that they probably belong to the fauna of the Colorado group and may have come from the Frontier formation. An earlier determination of perhaps more scanty material from the same locality gave the age as that of the younger Mesaverde formation (of the Montana group) of the Rock Springs district, or the Adaville formation of southwestern Wyoming.[5]

[5] Woodruff, E. G., The Horseshoe Creek district of the Teton Basin coal field, Fremont County, Idaho: U. S. Geol. Survey Bull. 541, p. 382, 1914.

The evidence of the fossil leaves collected in the Horseshoe field and on the Continental Divide in T. 14 N., R. 38 E., as determined by F. H. Knowlton, is equally inconclusive. The field relations and lithology favor Frontier rather than Mesaverde age, and the beds are tentatively so referred. This provisional assignment is in accord with the views of A. R. Schultz,[6] who is familiar with the formations at Rock Springs and Adaville, Wyo., and in the Horseshoe district of Idaho.

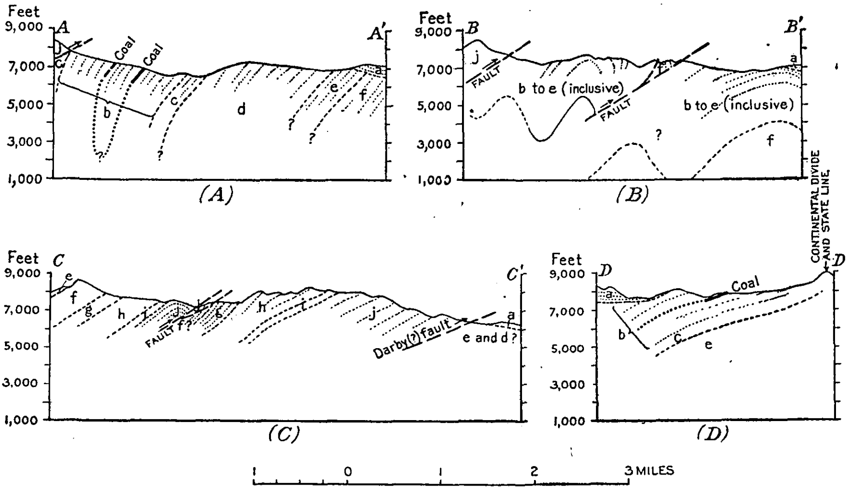


FIGURE 12. Geologic structure sections of parts of the Horseshoe, Teton Basin, and Continental Divide districts, Idaho. *A*, Section across the Horseshoe district in the vicinity of the Brown Bear and Boise mines; *B*, section in the region of the Horseshoe Creek-Mahogany Creek divide; *C*, section along the divide between Mahogany Creek and Patterson and Henderson creeks; *D*, section across Cottonwood Creek, Continental Divide district, in the vicinity of the Scott & Bucy mine. *a*, Lava and conglomerate; *b*, Frontier (?); *c*, Aspen (?); *d*, Bear River; *e*, Wayan formation (?) and Gannett group; *f*, Stump sandstone, Preuss sandstone, and Twin Creek limestone; *g*, Nugget sandstone to Thaynes group; *h*, Thaynes group and Woodside formation; *i*, Phosphoria foramtion; *j*, Wells, Brazier, and Madison (?) formations.

The occurrence of clay in the supposed Frontier formation gives rise to frequent landslides.

The other formations of the region are sufficiently described for the purposes of this report in the preceding table.

GENERAL STRUCTURE.

Three broad structural areas may be distinguished in the general region—(1) the mountains of the southeastern part; (2) the Snake River plains, occupying the great central portion; and (3) the Continental Divide, on the north. The first and third areas are composed largely of sedimentary rocks that have been deformed to a greater or less extent by folding and faulting. This is particularly

[6] Personal communication.

true of the southeastern area, where the structural features represent the northwestward continuation of great folds or faults, some of which extend many miles to the southeast. The dominant faults of the region appear to be northeastward overthrusts. The names applied to faults on the maps indicate their supposed relation to well-known faults farther southeast. The folds are generally open and upright, but a certain tendency to overturning may be noted. The inferred details of structure in the sedimentary areas are shown on the accompanying maps and geologic structure sections.

Little attention was paid in the present examination to the structure of the Snake River plains. Locally near the margins, as in the Willow Creek district, sedimentary rocks exposed through the removal of the lavas by erosion indicate the continuation of the folded and faulted sedimentary rocks beneath the lavas. The lavas that underlie the plains have been built up by a succession of practically horizontal flows, between which at certain places there were intervals of time sufficient for the deposition of alluvial or lake deposits or for the formation of soils. Along the canyon walls of Snake River and in wells at various places the composite nature of the lava series is revealed. A well sunk in the lava several miles east of Teton passed through a number of layers of soil between beds of basalt and rhyolite. One bed of soil was encountered at a depth of 400 feet.[7]

COAL BEDS.

GENERAL OCCURRENCE AND CHARACTER.

Coal occurs at a few places in eastern Idaho in two or perhaps three of the Cretaceous formations. It is definitely known to be associated with the Bear River formation and with less certainty is believed to occur also in the Wayan formation. In neither of these formations is it of commercial value. Better coal is found in a higher formation, thought to be the Frontier, though the paleontologic evidence of its age is not entirely conclusive. The distribution of the Cretaceous strata is shown in Plate XIV and the inferred position of the workable coal beds is indicated in Plate XV and figure 13.

The coal of the Wayan (?) and Bear River formations is hardly more than carbonaceous shale in which the carbon is locally abundant enough to burn. The moisture and ash are high and the heating value is low, as shown by the analysis of a sample from Pine Creek Pass, No. 29280 in the table on page 152. (See also section 1, fig. 14.) The coals of the Willow Creek-Caribou and Pine Creek districts are of this class.

[7] Lee, W. T., Stone, R. W., Gale, H. S., and others, op. cit., p. 139.

The coal of the Frontier(?) formation in this region, however, is of bituminous rank, fairly pure, and of relatively high heating value. The areas of known commercial coal are not sufficiently large and the beds are not thick enough to be worked on any great scale. Even if the mines were fully developed they would probably not supply the local demand, at present prices. They are grouped in two districts—the Horseshoe district, in Tps. 4 and 5 N., Rs. 43 and 44 E., and the

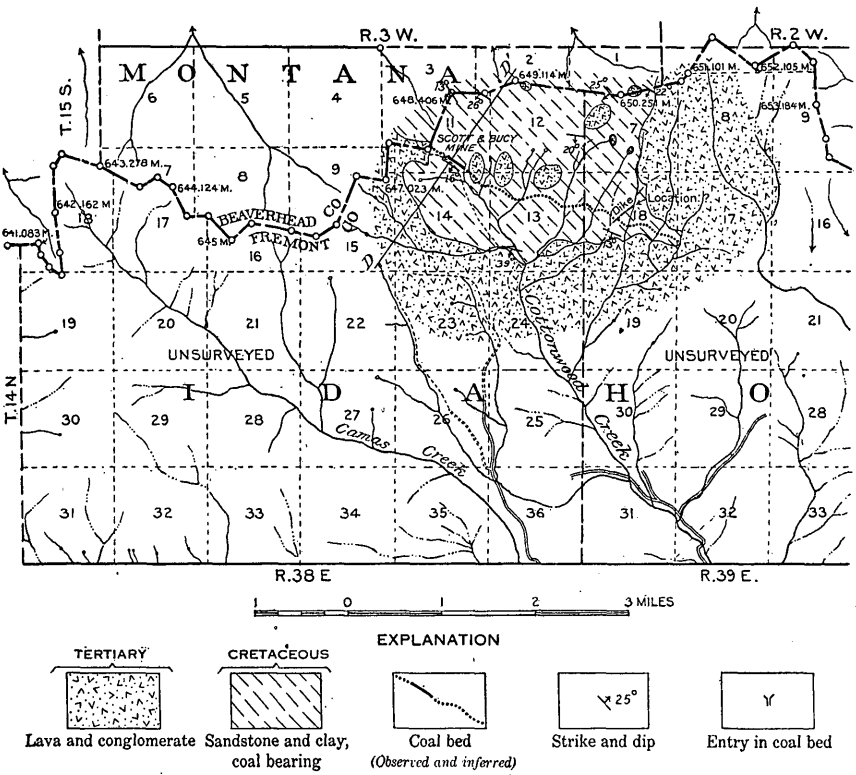


FIGURE 13.—Geologic map of part of the Continental Divide district, on Cottonwood Creek, in unsurveyed T. 14 N., Rs. 38 and 39 E., Idaho.

Cottonwood Creek district, in T. 14 N., Rs. 38 and 39 E., on the Continental Divide. The Horseshoe district has been productive for several years, but the other district is not yet developed.

WILLOW CREEK-CARIBOU DISTRICT.

Cloward entry.—In the SE. ¼ sec. 6, T. 1 N., R. 40 E., on the hill slope a few rods back of the house of J. A. Cloward, is an entry that was opened in the winter of 1916. It is about 100 feet long and trends about N. 50° E., curving slightly toward the south. The "coal" consists of the more carbonaceous portions of earthy and carbonaceous shaly lenses that wedge in and out and have a white powdery substance in the partings. Nine layers were counted at one place, ranging in thickness from about one-sixteenth of an inch to 18 inches. It is doubtful, however, if enough fuel of this character can be obtained for local needs without involving prohibitive expense.

Brinson mine.—The Brinson mine, in the NE. ¼ SE. ¼ sec. 34, T. 2 N., R. 40 E., is probably the property described by Schultz[8] as the Miller mine. A man named Miller is reported to have been associated with Mr. Brinson. According to Schultz, work was begun at the Miller mine in 1900 by the Canyon Coal Mining Co., which constructed a shaft, tunnel, road, and buildings, and installed machinery, the whole at a cost reported at $6,000. In 1910 Mr. Miller, one of the members of the former company, filed application to purchase and was permitted to make payment for 160 acres of coal land at $10 an acre. Work was continued. A shaft 40 feet deep was sunk and an engine and hoisting machinery were installed at an additional cost of about $2,500. The developments just described tally well with those seen at the Brinson mine, which is the only mine known to such residents of the vicinity as the writer was able to consult.

The tunnel is about 115 feet long and trends N. 76° E. at the entrance. About 61 feet from the portal is a shaft in nearly vertical carbonaceous and gypsiferous shale 7 feet 6 inches thick, the so-called coal bed. Two other coaly layers 6 inches and 11 inches thick, respectively, were noted. As in Cloward's prospect, the shale is probably carbonaceous enough in places to burn, and such material is reported to be excellent for blacksmithing. At the time of the writer's visit the shaft was largely filled with water and the exposed parts of the shale were intensely sheared and weathered. The shaft is reported to end in gravel like stream gravel. A fault by which conglomerate beds were brought against the shale might give rise to such a report and is not improbable. No coal of promising appearance was seen. Several other prospects occur in the vicinity.

The road, which is cut in the steep and rocky canyon wall at a uniform grade for nearly a mile, is now out of repair, and it is evident that no recent work has been done at the mine. No reports are available regarding the amount of coal extracted from this mine, but from the character of the so-called vein it is clearly negligible and the prospects of successful development are slight.

Croley mine.—The carbonaceous shale of the Wayan (?) formation along Grays Lake Outlet has been prospected here and there for coal. Perhaps the most extensive development is the so-called Croley mine, in the SE. ¼ SW. ¼ sec. 27, T. 1 S., R. 41 E. The workings

[8] Schultz, A. R., A geological reconnaissance for phosphate and coal in southeastern Idaho and western Wyoming: U. S. Geol. Survey Bull. 680, p. 74, 1918.

consist of two caved tunnels and several prospects. The bed can not now be seen, but according to one report it is 8 inches thick, and according to another 18 inches thick. It was stated that material was obtained that would burn, but it crumbled and would not form lumps. Fragments of dark shale and of carbonaceous matter, somewhat lignitic in character, were seen on the dumps.

Another prospect, known to some as Croley's mine, is reported farther down the valley in the northeast face of Pine Mountain, opposite a small island in Grays Lake Outlet and on the south side. This prospect was not found in the time available for search. It may perhaps be the one indicated as the Croley mine by Schultz and Richards on their map and shown as a coal tunnel in the SE. ¼ SE. ¼ sec. 24, on the plat of T. 1 S., R. 40 E. The structural relations of the region suggest that it lies on the strike of the beds already described. Unless unsuspected faults intervene it is clearly in the same formation.

Fall Creek basin and Heise.—The coal prospects of the Fall Creek and Heise districts are in carbonaceous shale that contains lignitic material and is of either Wayan or Bear River age.

PINE CREEK DISTRICT.

Pine Creek Pass.—The old prospect at Pine Creek Pass, approximately in the SW. ¼ NW. ¼ sec. 24, T. 3 N., R. 44 E.[9] (unsurveyed), was reopened in September, 1917, by John Nocker and an associate, of Kemmerer, Wyo. At the time of the writer's examination the slope excavated on the dip of the coal bed had been cleared to a depth of about 15 feet from the surface. A tiny fault was noted. The following section was measured at a depth of 12 feet:

Section of coal bed at Pine Creek Pass prospect.

	Ft.	in.
Limestone, dark; Bear River fossils		8+
Clay, sandy and rusty		6±
Coal, mashed, slickensided	1	10
Clay, dark, sheared.		

The coal bed strikes N. 55° W. and dips 55° SW. About 2 feet higher along the dip the thickness of the bed is 2 feet. The coal apparently contains much clay, for when moist it becomes plastic. A sample from the place measured was analyzed with the results indictated in the table on page 152 (analysis 29280). The section is graphically shown in figure 14. The content of moisture and ash is high, and the heating value (7,376 British thermal units for the air-dried sample) is below the minimum allowed (8,000 British thermal

[9] Schultz, A. R., A geologic reconnaissance for phosphate and coal in southeastern Idaho and western Wyoming: U. S. Geol. Survey Bull. 680, p. 74, 1918.

units) for workable coal according to present rules of the United States Geological Survey for coal-land classification.[10]

Kunz drift.—About a mile east of Pine Creek Pass, on the north side of the road, is a caved drift in Bear River carbonaceous shale. The writer is indebted to Mr. Joseph Kunz, of Victor, Idaho, for the following data regarding it. This drift was driven about four years ago by Samuel and Joseph Kunz and their associates. The " coal " occurs in a 6-foot bed, channeled with boulders and gravel, lying above a black clay and below a limestone which is sugary just above the coal but hard farther above.

The writer's examination showed a black shale with carbonaceous lenses. Several lenses, ranging in thickness from 2 to 8 inches, were noted, and above them lay a black fossiliferous limestone. The rocks at this prospect appear to be near the axial region of a subordinate

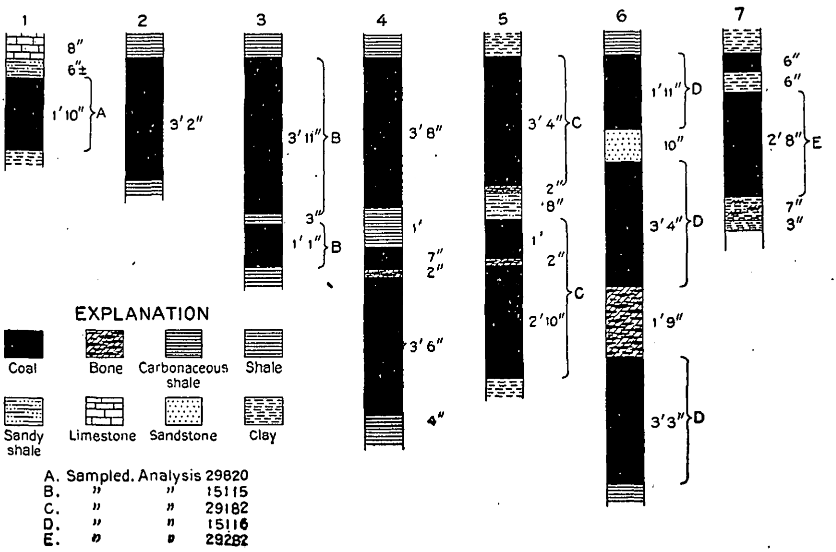


FIGURE 14.—Coal sections in the Pine Creek and Teton Basin districts and at Cottonwood Creek in the Continental Divide district, Idaho. 1, Pine Creek Pass; 2, Boise mine; 3, Brown Bear mine; 4, Woodruff's locality 10; 5, Bellcut mine; 6, Horseshoe mine; 7, Scott & Bucy mine.

fold and to strike N. 84° E. and dip 19° N. The stratigraphic relations suggest that this is the same bed as the one exposed at Pine Creek Pass. The greater thickness of coal noted by Mr. Kunz may be in part due to the location of the bed in the fold or to irregularity of the bed.

Other prospects.—About 1,000 feet west of the Kunz prospect, and on the south side of the road, is another caved drift opened by the

[10] Smith, G. O., and others, The classification of the public lands: U. S. Geol. Survey Bull. 537, p. 96, 1913.

same prospectors. The caving is so complete that only fine dark shale fragments are to be seen. In a neighboring canyon south of the Pine Creek road other coal prospects are reported. A cabin and one or two openings so badly caved as to be scarcely recognizable were all that were found.

RAINY CREEK.

Southeast of Pine Creek the rocks of the Cretaceous basin continue across Rainy Creek. About 100 yards southwest of the point where the trail from Pine Creek to Fogg Hill crosses Rainy Creek there is a group of coal prospects. Two of the prospects occur on the same bed at different heights, and the third is a tunnel about 100 feet west. The bed at Rainy Creek has been locally reported as 10 feet thick, but this appears to be an error. The bed in which the first two prospects are made is a dark shale with a carbonaceous stratum about 7 feet thick. The footwall at the entrance of the lower prospect, a caved drift, is a gray sandstone which strikes N. 64° W. and dips 66° E., and the hanging wall is a black shale. No coal was exposed, but some fine carbonaceous matter lay distributed through the dump. No fossils were seen. The upper opening was also caved. According to A. E. Harris, of Rexburg, Idaho, who is familiar with much of this region, the prospector who dug the main drift struck a fault and stopped. He then started a tunnel, the third prospect above mentioned, and after digging a short distance ran into his previous working and stopped again. The tunnel is now caved.

East of the coal prospects and over the hill between the forks of the creek the Fogg Hill trail descends a long point on which a fossiliferous ledge of brownish-gray limestone occurs. Fossils were collected from this ledge, among which species of *Ostrea* and *Modiola* were identified by T. W. Stanton, who states that they may have come from the Bear River formation, though he thinks it more probable that they came from the Frontier formation. The stratigraphic relations appear to favor the Bear River rather than the Frontier formation, but it is possible that a small local syncline of the Frontier is present.

PALISADE CREEK.

Reports from several sources of a fine natural exposure of coal in Palisade Canyon led to the extension of the reconnaissance to that exposure. No difficulty was experienced in reaching it, and there is no doubt of the identity of the locality visited with that of the reports. About a mile below the forks of the creek a black, coaly-looking rock extends along the south side for perhaps 100 feet and rises abruptly from the water for 40 or 50 feet. The beds are vertical and strike N. 55° W., and their smutty and shiny surfaces are certainly suggestive of coal. A closer examination, however, reveals the oolitic texture of phosphate rock, which, with interbedded shale and black, fetid limestones, makes up the exposure. The phosphate rock is part of the Phosphoria formation, which here lies along the west side of a fault between Carboniferous formations and Jurassic limestone. The line of the fault is marked by small canyons that extend northwest and southeast from the main creek. This is probably the same fault that separates the Cretaceous and Carboniferous rocks in Pine Creek. Palisade Canyon was not traversed above the Fogg Hill trail, but there seems little reason to suppose that Cretaceous rocks or coal beds occur there.

BURNS CANYON.

The General Land Office plat for T. 4 N., R. 43 E., shows indications of coal in sec. 2 and near the southwest corner of sec. 19. The locality in sec. 2 is in Carboniferous rocks and was not visited. The locality in sec. 19 is in Coal Mine Canyon, a tributary of Burns Canyon, and is reported to have produced "coal that would burn." This mine was visited. It lies near the head of the canyon, in the phosphatic shale of the Phosphoria formation, like the fine natural exposure in Palisade Creek. Masses of phosphate rock, black, smutty, glossy from rock shearing, and superficially resembling coal, lie scattered on the dump, but the characteristic oolitic texture of the phosphate is readily seen, and on some pieces the bluish-white bloom may be detected.

TETON BASIN.

HORSESHOE DISTRICT.

The coal deposits of the Horseshoe district have been described by Woodruff,[11] who gives details of the mines and prospects, including analyses and sections, some of which are reproduced in the table on page 152 and in figure 14. The Horseshoe district, which is the only producing coal field in eastern Idaho, lies on the west side of Teton Basin and includes portions of Tps. 4 and 5 N., Rs. 43 and 44 E. (See Pl. XV.) The district as a whole may be considered as including all the Cretaceous rocks with their intervening formations north of the line of Mahogany Creek, an area of nearly 20 square miles. The part that carries coal beds that can be profitably mined, however, is much smaller and probably does not exceed 3 or 4 square miles. The distribution of the formations of the district is shown on the map, and the general structure of the coal-bearing portion as here interpreted is shown in the geologic structure section, figure 12 (*A*).

[11] Woodruff, E. G., The Horseshoe Creek district of the Teton Basin coal field, Fremont County, Idaho: U. S. Geol. Survey Bull. 541, pp. 370–388, 1914.

STRUCTURAL FEATURES.

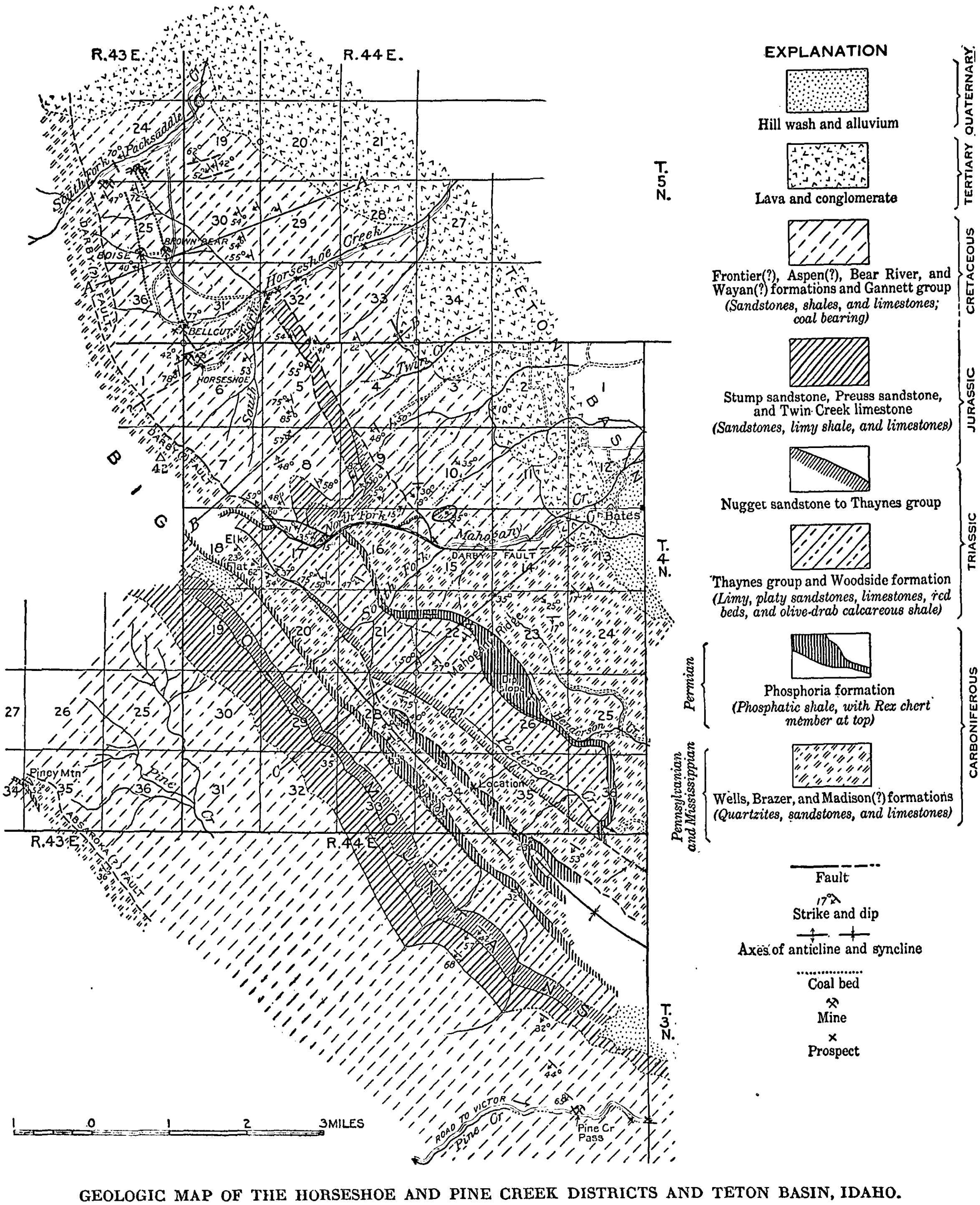
The fault along the west side of the Cretaceous area is here considered a thrust rather than a normal fault, as shown by Woodruff. In the line of the section given in figure 12 (*A*) it would be difficult and perhaps even impossible to discriminate between normal and thrust faults by inspection. Great overthrusts are, however, more characteristic of southeastern Idaho and western Wyoming than great normal faults. Notable overthrusting has also taken place in this region, as is well illustrated by the little Carboniferous outlier on the Cretaceous rocks of secs. 10 and 15, T. 4 N., R. 44 E. According to Schultz [12] the parallel normal fault farther west shown by Woodruff is not evident in a traverse along the line of structure section *A–A′* but may represent a subordinate strike fault more clearly shown at its junction with the main thrust. Such a fault would be difficult to detect in beds similar on both sides.

The rocks east of the coal-bearing beds as mapped by Woodruff are not Paleozoic, as he suggests, but belong to lower portions of the Cretaceous, as shown by the characteristic Bear River fauna from sec. 19, T. 5 N., R. 44 E. Similarly the supposed Paleozoic ledges in sec. 32, T. 5 N., R. 44 E., are Jurassic or Cretaceous. The fault in the eastern part of the district as mapped by Woodruff may be present, but as the strata west of it are not Paleozoic his argument for it [13] has little weight. Several minor cross faults occur in the Cretaceous, as noted by Woodruff, but no strike faults were recognized in the rocks of that age north of Horseshoe Creek. Such faults might be present and easily escape detection because of the lithologic similarity of the beds.

The structure south of the general line of Horseshoe Creek differs considerably from that to the north. The Jurassic ledges that form the backbone of the ridge east of the south fork of the creek terminate abruptly south of the main creek. The productive coal beds also have not been traced much south of the Horseshoe mine in the northeast corner of T. 4 N., R. 44 E. This may be due to the extensive mantle of débris composed of older rocks, but there are numerous gullies in which such beds might be exposed. Because of these differences a normal fault with downthrow to the north is tentatively drawn south of the Horseshoe mine and of the main creek, although other considerations, which can not be entered upon here, indicate that such a fault may not be required.

The generally troughlike structure east of the great thrust fault, and clearly shown at the south end of the district, has an important economic bearing, for it leads to the suggestion that the two coal beds mapped by Woodruff may in reality be the same bed caught in a

[12] Schultz, A. R., personal communication.
[13] Woodruff, E. G., op. cit., p. 383.



GEOLOGIC MAP OF THE HORSESHOE AND PINE CREEK DISTRICTS AND TETON BASIN, IDAHO.

rather closely folded syncline of which the two beds would represent the opposite limbs, as indicated with a query in structure section *A–A′*. Such a structure would naturally limit the depth to which the coal could be worked, even if no other limiting factors were involved. Certain differences in the coal beds at the Boise, Brown Bear, Bellcut, and Horseshoe mines seem at first sight to oppose the synclinal suggestion, but they may not be so serious as to disprove it. For example, the section at the Bellcut mine (probably Woodruff's locality 10) shows 7 feet 4 inches of coal with a parting of sandy clay 10 inches thick near the middle. A similar sandy clay bed occurs in the coal bed 10 feet 3 inches thick at the Horseshoe mine but nearer the top. It is thought by Woodruff and by L. Hillman, manager of the mine at the time of the writer's visit, that the bed at these two localities is the same. The bed at the Brown Bear mine ranges from 4 feet 5 inches to 5 feet 3 inches in thickness, and the bed at the Boise mine is only 3 feet 2 inches thick. These beds do not show the sandy clay bed. The Brown Bear bed contains a thin layer of shale and the Boise bed is clear coal. Available analyses of the coals from Brown Bear, Bellcut, and Horseshoe mines show considerable similarity in the quality of the coal. Clay and shale beds are generally lenticular, though at many places attenuated, and may be expected to thicken, thin, or disappear even if the strata suffer no deformation.

If the coal beds are parts of a closely folded syncline they would be likely to vary in thickness with their location in the fold. Parts of the bed nearer the axial region or bottom of the trough would be thicker than parts of the bed on the limbs or sides. The thickness of the portions on the limbs would vary with the amount and character of the shearing stresses developed during the deformation of the rocks. These stresses would also cause the thinning or disappearance of clay or shale beds on the limbs of the fold and their thickening in the axial region. The same stresses would also develop throughout the coal lines of cleavage or parting which would cause it to break easily or crumble when extracted. The crumbling of the coal is one of the disadvantageous features in mining in this field.

In a northward-pitching syncline the axial portion with thicker beds would be exposed at the south end. The Horseshoe mine with the thickest beds of the district is so located. Farther north the axial region would be deeper and the exposed portions would lie along the limbs where the beds are thinner. If the axial plane of the syncline were tilted or bent, as suggested in the structure section, the exposed portions of the limbs would not be symmetrically located with reference to the axial plane and might be expected to differ somewhat in character and thickness. These reasons seem sufficient to account for the differences noted in the coal bed at the different mines. The hypothesis of synclinal structure of the coal bed appears to be supported by such facts as are available, but owing to the heavy cover of débris and the thick growth of vegetation in the region where the bed should be exposed, confirmation of this hypothesis must await more extended exposure of the strata by mining operations.

At the westernmost opening of the Horseshoe mine the slope follows the dip of the sandstone, about 33° NW. About 100 yards west of this slope is a broad ledge of massive sandstone, whose attitude is obscure but which seems to strike N. 55° E. and dip about 10° NW. These exposures appear to be near the axis of the supposed syncline, and give suggestions of its pitch. On the assumption of the steeper dip, which seems justified by the somewhat steeper dip given by Woodruff for a locality near by, the bottom of the synclinal coal bed at the Brown Bear and Boise mines should lie about 4,800 feet below the surface, as indicated in figure 12 (*A*). On the assumption of the 10° dip, it should lie about 1,200 feet below the surface. The dip of the bed at the Bellcut mine, 70°, suggests that the dip steepens down the limbs of the fold, as shown in the structure section.

The structure of the southeastern part of the Horseshoe district is apparently anticlinal, with the axis near the western edge of the lava and largely concealed by it. The rock between the Jurassic beds and the lava along the line of the structure section *B–B′*, in figure 12, is Cretaceous sandstone, rather poorly exposed but apparently dipping southwest. The southeast face of the prominent lava-capped hill in the southeast corner of sec. 33 gives an excellent exposure of the sandstone with a northeasterly dip of 21°. The stratigraphic position of the sandstone is not known, but it is assumed to be possibly of Bear River age. No fossils were found in it.

CHARACTER OF THE COAL.

Woodruff states that the coal is bituminous and rather free from impurities but is noncoking according to the agate-mortar test. A large part of the coal breaks down to fine fragments. It is thus not adapted to long-distance transportation.

OWNERSHIP.

The properties recently consolidated under the name Teton Valley Coal Co. were transferred in December, 1917, to mineral operators from Seattle and Spokane.[13]

[13] Bell, R. N., Nineteenth annual report of the mining industry of Idaho, for the year 1917, p. 101.

COAL BEDS.

According to Bell[14] 20 beds ranging in thickness from 6 inches to 10 feet have been identified by surface work throughout a linear extent of 2 miles, and three of these beds have been rather extensively developed. The number of beds present can only be conjectured until much underground work has been done and a detailed knowledge of the structure obtained. The beds can not well be traced at the surface because of the thick cover of rock débris and vegetation. There may be as many as 20 beds or even more, but practically all of those prospected, except the beds on which the four mines described below are located, have given little or no promise of commercial value. Probably some of the openings now regarded as exposures of distinct beds may prove to be on the same bed. There seems little doubt that the Horseshoe and Bellcut mines are so located. On page 139 reasons are given for thinking that the Brown Bear and Boise mines may be on the same bed as the Horseshoe and Bellcut mines.

MINES.

Brown Bear mine.—The coal bed at the Brown Bear mine varies somewhat in thickness and character, as shown by the following sections measured by Woodruff, who also recognized and mapped several faults in the coal bed:

Sections of coal bed in Brown Bear mine.

North end of mine.	Ft.	in.	South end of mine.	Ft.	in.
Shale.[15]			Shale.		
Coal[15]	3	11	Coal	2	10
Shale		3	Coal, crushed	1	7
Coal[15]	1	1	Shale.		

The general plan of the Brown Bear mine comprises a horizontal crosscut tunnel 325 feet long with drifts and stopes north and south along the coal bed. The south drift, which is about 800 feet long, has caved. The north drift is 1,700 feet long. Further extension in that direction is unprofitable both because of the cost of handling the material by present methods and because of the deterioration of the coal by the northward thickening of a parting.

In August, 1917, work was undertaken to extend an inclined air shaft, then 80 feet deep on the dip of the coal bed, 44°, to a depth of 200 feet below the surface. This shaft was to be used for hoisting the coal from stopes at the new level. A hoist, track, and car of about 1-ton capacity were to be installed. According to Bell[16] the

[14] Bell, R. N., op. cit., p. 103.

[15] See anaylsis No. 15115 (p. 152), and also section 3, fig. 14.

[16] Bell, R. N., op. cit., pp. 101–104.

shaft was sunk to a depth of 250 feet by the former owners and extended to 400 feet by the present owners, who plan to extend it to the 500-foot level. The owners also plan a crosscut tunnel 5,000 feet long, which will afford natural ventilation, drainage, and means of handling the coal by gravity. It is claimed that 4,000,000 tons of coal is available above the 500-foot level, but no statement is made regarding the basis of the estimate. A spur track to the mine from the Oregon Short Line Railroad and equipment to handle 500 tons a day are among the plans for future development.

Water is rather abundant in the mine and will require pumping until the crosscut tunnel is completed. Before the deepening of the shaft it was removed by gravity along the tunnel.

Horseshoe mine.—The coal bed at the Horseshoe mine is thicker than at any other recorded locality in the district, and the heating value of the coal is relatively high. The following section was measured by Woodruff:

Section of coal bed in the Horseshoe mine.

	Ft.	in.
Shale.[17]		
Coal	1	11
Sandstone		10
Coal,[17] crushed	3	4
Coal, bony	1	9
Coal,[17] crushed	3	3
Shale.		

This mine, which consists of a single entry 500 feet long, is badly caved but can still be entered for a distance of about 200 feet. An attempt was made in the winter of 1916 to reopen the mine, and a small amount of coal was extracted. The attempt was abandoned on account of the unsatisfactory condition of the old workings.

Bellcut mine.—The Bellcut is a new mine opened in the fall of 1916 in what is probably Woodruff's locality 10. The workings consist of an open cut perhaps 100 feet long leading to a crosscut tunnel 30 feet long to the coal bed. Drifts extend north and south 170 and 315 feet, respectively, each timbered to the end. The north drift is very wet. The coal at the face is crushed fine, forming mud that has slumped forward at least 10 feet into the drift. The miners are said to have struck a fault here. The south drift is fairly dry. The coal at the face is hard and breaks unevenly without any special tendency to follow bedding planes. The dip of the bed is 70° W. The following section was measured at the south face:

[17] See analysis 15116 (p. 152), and section 6, fig. 14.

Section of coal bed at Bellcut mine.

	Ft.	in.
Clay, slickensided.		
Coal, hard	3	4
Bone		2
Clay, sandy, gray		8
Coal,[18] including 2-inch bone irregularly distributed about 1 foot from top	4	0
Clay, slickensided	8	2

At the portal the coal-bearing formation is exposed for about 45 feet along the open cut, showing buff-colored sandstone and clay with dark shale, much weathered and somewhat carbonaceous.

About 100 feet up the gully above the Bellcut mine a 20-inch bed of poor coal, much weathered, is exposed in the north bank. About 200 yards above the mine in the same gully is a bed 22 inches thick, said by Mr. Hillman to be good coal for blacksmithing. The bed strikes N. 33° W. and dips 69° W. It was too thoroughly weathered for sampling. Streaks of iron-stained clay were seen in it but no parting or bone. The hanging and foot walls are both clay.

Boise mine.—The coal bed at the Boise mine is 38 inches thick, without bone or parting, and lies between beds of shale. (See section 2, fig. 14.) Unfortunately it has caved so that further production is delayed or perhaps even prevented.

PRICES AND PRODUCTION.

The coal from the Bellcut mine was sold in the winter of 1916 as run of mine coal at $1.50 a ton at the mine. The lump coal from the Brown Bear mine brought $4.50 a ton at the mine during the same season. The fine coal on the dumps at the Brown Bear was selling in the summer of 1917 for $1 a ton at the mine.

The production has always been small, a few tons a day. The total production in 14 years, including the output of the Horseshoe mine, amounted, according to Mr. Hillman (August, 1917), to 24,000 tons.

CONCLUSIONS.

The area in which coal beds of commercial grade occur is not as large as was formerly supposed and probably does not exceed 3 or 4 square miles. The shattered condition of much of the coal, due to rock movements, is unfavorable for handling and transportation. For this reason only a relatively small proportion of the output is likely to command a favorable price, and much of it must continue to be sold locally as run of mine or fine coal at low prices. The steep dip of the coal bed makes mining difficult and expensive and induces caving, such as has already blocked workings that might otherwise

[18] See analysis 29182 (p. 152) and section 5 (compare with section 4), fig. 14.

be productive. The variable and faulted character of the coal limits the extent to which a given mine can be worked. The disposal of water in the mines will increase the cost of production in those workings that lie beneath the level of the tunnel. If the projected improvements are completed and sufficiently favorable prices can be obtained for the product to offset the installation, operation, and amortization charges, there is probably enough coal in the ground to keep the mine running for a number of years. The future activity of the mines will depend in large measure on how well the operators are able to compete with Utah or Wyoming coals of equal or better grade (see table, p. 152) shipped in by rail.

An account of the Horseshoe district by G. W. Evans,[19] published since the completion of the present paper, gives a description in which the geologic features are based on Woodruff's report. Although an estimate of 11,000,000 tons is given by Evans, he is careful to add the following qualifying statement, which should not be overlooked: "No one is justified in assuming that this amount of coal has been proved in this district. * * * The actual tonnage can be determined only by actual gangway and slope development." The following analyses are given:

Analyses of coals from Horseshoe district.

Bell Gulch bed.

[See p. 94 of report cited for section.

	Air dried.	As received.	Moisture free.	Moisture and ash free.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	2.7	8.4	....	....
Volatile matter	41.3	38.9	42.5	45.2
Fixed carbon	50.4	47.4	51.7	54.8
Ash	5.6	5.3	5.8	....
Air-dry loss 6.2 per cent.				

Brown Bear bed.

[See p. 94 of report cited for section.]

Moisture	2.7	7.0	....	....
Volatile matter	42.5	40.6	43.7	45.0
Fixed carbon	50.8	48.6	52.2	54.5
Ash	4.0	3.8	4.1	....
Air-dry loss 4.6 per cent.				

Boise bed.

Moisture	3.6	9.1	....	....
Volatile matter	42.1	39.7	43.7	45.1
Fixed carbon	51.4	48.5	53.3	54.9
Ash	2.9	2.7	3.0	....
Air-dry loss 6.1 per cent.				

[19] Varley, Thomas, and others, A preliminary report on the mining districts of Idaho: Bur. Mines Bull. 166, pp. 90–103, 1919.

MAHOGANY CREEK.

Several coal prospects in the Cretaceous rocks on the north side of Mahogany Canyon, in the NW. ¼ sec. 15, T. 4 N., R. 44 E., were opened in carbonaceous shale of probably either Bear River or Wayan age. They give little promise of workable coal. A reported "coal" prospect in the south fork, which was not visited, is with little doubt in the phosphatic shale belt of the Phosphoria formation, which crosses the creek in the NE. ¼ sec. 21.

PATTERSON CREEK.

One of the two reported "coal" prospects in the basin of Patterson Creek was visited. This is approximately on the township line, in the SW. ¼ sec. 35, and proved to contain phosphate rock but not any coal. The other prospect is about a mile farther northwest, in the same belt of phosphatic shale.

SOUTH END OF TETON BASIN.

The road to Jackson ascends the valley of Trail Creek. Beyond the rhyolite the first ledges encountered are light-gray limestones that may be Cretaceous (Wayan). The road follows the strike of the beds rather closely but gradually cuts across Jurassic and lower beds. To the west lie Carboniferous rocks. Thus a fault of considerable magnitude passes up the valley of Trail Creek, cutting out the Cretaceous coal-bearing rocks.

NORTH END OF TETON BASIN.

The north end of Teton Basin is closed by rhyolite that forms prominent ledges in the vicinity of Tetonia. Associated with the rhyolite are beds of volcanic ash, including fragments of grayish-white pumice and black volcanic glass (obsidian). The glass has been mistaken by some persons for anthracite or coal.

On the Breckenridge ranch at Haden, in the NE. ¼ SE. ¼ sec. 35, T. 6 N., R. 44 E., a well was sunk 15 years or more ago for oil. It has been commonly reported that 10 feet of coal was struck in this well at a depth of 600 feet. Upon visiting the locality the well was found in good condition with parts of the old broken derrick still standing. The writer is indebted to Mr. Preston K. Breckenridge, son of the former owner, for the following details regarding it.

The well was drilled under the direction of a man named McDonald from Florence, Colo. It had been intended to sink 3,000 feet but drilling stopped at about 700 to 760 feet. On the last day of drilling, when the men went to dinner, Mr. McDonald and one other man remained a few minutes at the well. The others after their return from dinner resumed drilling and at once struck coal. After 10 feet of coal had been penetrated drilling stopped. Mr. McDonald then went to Denver to obtain further funds and additional machinery, but while there sickened and died. Some three or four years later Mr. Spencer Clawson, of Salt Lake City, had the well cleaned out and expended about $1,000 in sampling and casing it. Special devices were employed in exploring the well for coal, but none was found. Both the elder Mr. Breckenridge and Mr. Clawson have since died. Mr. Preston Breckenridge states that his father had always felt that the well had been "fixed" before the reported coal was found. The well is cased to bedrock, 240 feet, and is 10 inches in diameter at the top and tapers to 8 inches at the bottom. No record of the character of the rock penetrated is available. Water stands in the well at a depth of 40 or 50 feet, as estimated by dropping a pebble. The well has been kept locked until recently but is now open.

BROADER STRUCTURAL FEATURES.

St. John,[20] Blackwelder,[21] and Schultz [22] have observed and figured the gently westward-dipping Paleozoic strata that pass beneath the lava along the west flank of the Teton Range on the east side of the basin. Schultz has made out anticlinal structure along the west side. Thus the structure of the basin appears with little doubt to be synclinal, as figured by Schultz. It was the opinion of Schultz that the syncline was deep enough to include coal-bearing Cretaceous beds and that commercial coal might be found by drilling at favorable points in the basin. The reported occurrence of coal in the Breckenridge well at Haden seemed to support this view.

PROBABILITY OF COAL.

One of the principal objects of the present examination was to procure data to test, if possible, the validity of the hypothesis just mentioned. As the basin is completely covered with Quaternary deposits to a depth of 240 feet at one locality, at least, and possibly to greater depths elsewhere, and is fringed with lava, inferences regarding the probability of the occurrence of coal beneath the cover must necessarily be drawn from the exposures and structure of the rocks surrounding the basin.

The Paleozoic exposures to the east have a structure so simple that they suggest equally simple structure for the concealed portions of

[20] St. John, Orestes, U. S. Geol. and Geog. Survey Terr. Eleventh Ann. Rept., pp. 411-424, pl. 34, 1879.

[21] Blackwelder, Eliot, A reconnaissance of the phosphate deposits in western Wyoming: U. S. Geol. Survey Bull. 470, pp. 463-464, 1911.

[22] Schultz, A. R., A geologic reconnaissance for phosphate and coal in southeastern Idaho and western Wyoming: U. S. Geol. Survey Bull. 680, p. 69, 1918.

the basin. The west side of the basin, however, exhibits many complications of structure, including pitching folds and branching thrust faults of considerable magnitude. It seems probable, too, that along the west side of the Horseshoe district close folds occur in the Cretaceous beds. Doubtless the more intensive effects of the thrusting may die out eastward, but it seems that a simple synclinal structure for the basin can not safely be assumed.

Again, the Cretaceous formations below the commercially important beds have a thickness of possibly more than 9,000 feet, so that there is no assurance that the syncline is deep enough to have carried the coal beds beneath the level of erosion, where they could have been preserved. If, as seems likely, the basin is a large complex syncline containing smaller folds, one or more synclines might be present and deep enough to hold coal measures, but the positions of these synclines could be determined only by systematic drilling, and the possibility of faults would add much uncertainty to the problem. The record of the Breckenridge well is inconclusive, because it now affords no information regarding the character of the bedrock.

If one were disposed to spend the necessary money to test the synclinal hypothesis the place to drill would be on the eastern slopes of the foothills east of the Horseshoe district or somewhat farther north and in the region between those slopes and Teton River. A few wells sunk on a northeast-southwest line to depths of 200 to 500 feet would probably suffice to indicate the geologic formation upon which the lava rests. If this should prove to be the Frontier formation, coal beds that could be profitably mined might be expected. Because of the gentler dips in the broad syncline the coal if present would probably be relatively free from the objectionable crumbling that characterizes the coal in the Horseshoe district and would thus be better adapted for transportation and marketing.

CONTINENTAL DIVIDE.

Two districts were visited on the Continental Divide, one at the headwaters of Cottonwood Creek in T. 14 N., Rs. 38 and 39 E. (unsurveyed), and the other at the head of Sheridan Creek, chiefly in T. 14 N., R. 40 E. (unsurveyed). Coal was found in the Cottonwood district but not in the Sheridan district.

COTTONWOOD CREEK.

GENERAL FEATURES.

The rocks of the Cottonwood district are chiefly Cretaceous sandstone, shale, and clay. The stratigraphic position is not definitely known, but they are presumed to be of Frontier or later age. They have been exposed by the partial erosion of the overlying Tertiary conglomerate and lava. One coal bed of probable commercial importance is exposed, and there are several others each a few inches in thickness. Numerous landslides with fresh scars afford exposures of the rocks here and there, but débris accumulations of similar origin and patches of Tertiary conglomerate conceal much of the bedrock of the region. The Cretaceous rocks and some of the larger areas of Tertiary formations are shown in figure 13.

The strata have a general northwesterly to westerly strike and a dip of 13°–39° SW. At the Scott & Bucy entry the strike is N. 69° W. and the dip is 16° SW. Toward the northeastern and southwestern parts of the district the dip steepens. These structural features are shown in structure section *D–D′*, figure 12, for which, as well as for figure 13, sheet 4 of the United States Forest Service map of the Targhee National Forest was used as a base.

The outcrop of the coal can be traced for only about a quarter of a mile, and a traverse through the country to the east failed to strike the continuation of the bed in that direction. The accumulation of débris above noted and the vegetation might readily conceal it. There is no apparent reason, however, why the coal should not continue eastward. In fact, it is desirable that the approximate area presumed to be underlain by it outside the Tertiary cover should be shown on the map. Accordingly, on the basis of the available readings of strike and dip and the topography, the inferred position of the line where the bed should crop out is indicated on the map by a dotted line. The region southwest of this line may be tentatively regarded as underlain by the coal bed at depths varying in the manner suggested by the structure section. The exact position of the bed at any particular locality will have to be determined by drilling.

A dike of dark amygdaloidal lava occurs in the SE. ¼ NW. ¼ sec. 18, T. 14 N., R. 39 E. (unsurveyed; location estimated from topography). It is accompanied on the west by a breccia 5 or 6 feet thick composed of sandstone and clay cut by stringers of lava and containing pieces of lava. The sandstone to the south strikes N. 55° W. and dips 23° S. A small pocket of black, coaly shale occurs in the breccia. Thin pieces of sandstone float containing carbonaceous flakes were found on the south side of the dike. Beneath the sandstone is a light gray clay. The dotted line representing the theoretical position of the projected coal bed crosses the line of the dike. The coal was not found here, but the pocket of coaly shale suggests its proximity.

Northwestward the coal bed probably continues an unknown distance into Montana. Two traverses were made north of the divide, but the bed was not found. The region is thickly timbered and obstructed by landslide débris and bogs, and one might readily pass within a few feet of an exposure or prospect without being aware of its presence. A large slide was found about three-quarters of a mile northwest of the Scott & Bucy entry, in which occur fragments of coal and a massive bed of fossiliferous light-gray sandstone. The fossils here are different from those at the entry, and the horizon is therefore probably not the same but perhaps stratigraphically lower. The coal bed, though not exposed, is probably much thinner than at the entry. The northward continuation of the Cretaceous formation and other geologic data in Montana, as shown on the general map (Pl. XIV), are taken from a map by Condit and Finch.[23]

DEVELOPMENT.

The Scott & Bucy entry is driven in rock down the dip of the coal bed and is untimbered. It trends N. 47° E. and is 110 feet long. The roof of the entry is of slabby sandstone, in places somewhat broken and dangerous. Some falls of rock have already obstructed the passage. At the time of the writer's visit no work had apparently been done within two or three years. The location notice is dated July 24, 1912, and the locators are C. W. Scott, of Dillon, and M. W. Bucy, of Monida, Mont.

CHARACTER OF COAL.

The coal bed is exposed along the walls of the entry its entire length and shows little change in character or thickness. About 50 feet from the portal a small normal strike fault lowers the bed 2 feet on the west. The coal at the face of the entry is relatively fresh and fairly hard. It did not appear to break more easily in one direction than in another. The following section was measured at the face of the entry, where the strike of the coal is N. 60° W. and the dip 16° W.:

Section of coal bed at Scott & Bucy mine in the SW. ¼ SE. ¼ sec. 11, T. 14 N., R. 38 E. (unsurveyed) Boise meridian, Idaho.

	Ft.	in.
Clay, gray; grades upward into sandstone		6
Coal, sheared and slickensided; pinches out eastward		6
Clay, gray		6
Coal,[24] hard, dense	2	8
Clay, black, partly bone		7
Clay, gray		3
	5	0

The following analysis of coal, presumably from the same opening, is contributed by Mr. Scott in correspondence with the Survey:

[23] Condit, D. D., and Finch, E. H., personal communication.
[24] See analysis 29281 (p. 152) and section 7, fig. 14.

Analysis of coal from Scott & Bucy claim.

[Analyst not stated.]

Moisture	3.70
Volatile matter	27.09
Fixed carbon	59.29
Sulphur	.01
Ash	9.91
Heating value (British thermal units)	13,050

This analysis appears to indicate coal of a considerably higher grade than that from which sample 29281 (p. 152) came, and was doubtless made from a picked sample of coal. Sample 29281 was taken from a channel across the entire face of the bed in the general manner prescribed by the Bureau of Mines.[25] Differences in methods of sampling or of analysis might account in part for the discrepancy between the two analyses. The difference may also be due to the proximity of the Scott & Bucy sample to a dike. The face of the entry where channeled for sampling, although seemingly fresh, had been exposed to the air for two years or more, and the coal bed had doubtless suffered changes by weathering. No tests of the coking qualities of the coal are available.

According to analysis 29281 the coal would be considered as of subbituminous rank or low rank bituminous. Its heating value (10,062 British thermal units for the air-dried sample) is less than that of the coals of the Horseshoe district or of the Wyoming coals cited for comparison in the table on page 152. To judge from the condition of the exposure along the walls of the entry it would not slack readily on exposure to weathering and would probably stand hauling and transportation.

ACCESSIBILITY.

Although in an air line the mine lies within 15 miles of Beaver or Humphrey, on the Butte branch of the Oregon Short Line Railroad, the actual haul to the railroad would be much longer. By way of Kilgore the distance from the coal bed to Spencer, the nearest railroad point south of the divide, is approximately 27 miles. On the north side of the divide the distance to Monida, by way of Jones Creek and Centennial Valley, is approximately the same. Further exploitation of the field north of the divide might disclose more favorable points of access nearer Centennial Valley, but even then the distance from the present railroad would exceed 15 miles.

A well-traveled and well-graded wagon road leads up East Camas Creek to a point within about 2½ miles of the coal entry. On the north side of the divide a road, now somewhat out of repair, has

[25] Holmes, J. A., The sampling of coal in the mine: Bur. Mines Tech. Paper 1, 1911.

been constructed up Jones Creek to the divide. The grade for the last mile is very steep.

OUTLOOK.

The country both north and south of the divide is so sparsely settled that there is doubt if it could soon afford a sufficient market to warrant the development of mines in this field. The thickness of the bed, the quality of the coal, and the size of the field would not in themselves justify the construction of spur tracks to the mine, but should other causes cooperate in bringing a railroad sufficiently near profitable mines might be developed

ANALYSES.

The accompanying analyses were made at the Pittsburgh laboratory of the Bureau of Mines. Four forms of analysis are given for each sample. A represents the material as received at the laboratory, essentially as it is found in the mine. B represents the coal after drying to a constant weight at a temperature of 30° to 35° C. This form of analysis is best adapted to general comparisons. C represents the coal after all moisture has been removed. D represents the coal after both moisture and ash have been eliminated. C and D are theoretical forms derived from A and B by recalculation.

The samples analyzed have all been collected in accordance with the regulations of the Bureau of Mines, which require, in brief, that the face to be sampled must be cleared of weathered coal, powder stains, and other impurities and channeled across the bed to obtain the sample. Materials from large partings and lumps of impurities are rejected. The sample is collected on a sampling cloth, broken up to pass through a ½-inch mesh sieve, thoroughly mixed and quartered, and the alternate quarters rejected. Mixing and quartering are repeated until the sample is reduced to about 4 pounds. This residue is then placed in a can, which is sealed and forwarded to the laboratory.

Analyses of two Wyoming coals are included in the table for comparison.

Analyses of coal samples from eastern Idaho and adjacent regions.

[Made at the Pittsburgh laboratory of the Bureau of Mines; A. C. Fieldner, chemist in charge.]

Locality.	Laboratory No.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heating value.	
				Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Brown Bear mine, Horseshoe district, SE. ¼ sec. 25, T. 5 N., R. 43 E.	15115	8.3	A	11.5	37.2	47.0	4.30	0.54	5.94	68.09	1.40	19.73	6,720	12,090
			B	3.4	40.6	51.3	4.69	.59	5.47	74.25	1.53	13.47	7,325	13,190
			C	....	42.0	53.1	4.86	.61	5.27	76.89	1.58	10.79	7,590	13,660
			D	....	44.2	55.8	....	.64	5.54	80.82	1.66	11.34	7,975	14,360
Bellcut mine (probably Woodruff's locality 10), SW. ¼ sec. 31, T. 5 N., R. 44 E.	29182	4.8	A	7.7	39.6	48.2	4.53	.54	5.94	70.82	1.37	16.80	6,985	12,580
			B	3.1	41.6	50.6	4.76	.57	5.68	74.35	1.44	13.20	7,335	13,200
			C	....	42.9	52.2	4.91	.58	5.51	76.71	1.48	10.81	7,565	13,620
			D	....	45.1	54.9	....	.61	5.79	80.67	1.56	11.37	7,955	14,320
Horseshoe mine, NW. ¼ sec. 6, T. 4 N., R. 44 E.	15116	4.3	A	7.7	39.7	50.4	2.2	.38	....	....	....	....	7,155	12,880
			B	3.6	41.5	52.6	2.3	.40	....	....	....	....	7,475	13,460
			C	....	43.0	54.6	2.4	.41	....	....	....	....	7,755	13,960
			D	....	44.1	55.9	....	.42	....	....	....	....	7,945	14,300
Prospect at Pine Creek Pass, sec. 24, T. 3 N., R. 44 E. (unsurveyed).	29280	14.3	A	20.3	20.1	29.0	30.6	1.12	....	....	....	....	3,515	6,320
			B	7.1	23.4	33.8	35.7	1.31	....	....	....	....	4,100	7,380
			C	....	25.2	36.4	38.4	1.41	....	....	....	....	4,410	7,940
			D	....	41.0	59.0	....	2.29	....	....	....	....	7,160	12,890
Scott & Bucy entry, SW. ¼ SE. ¼ sec. 11, T. 14 N., R. 38 E. (unsurveyed).	29281	7.9	A	18.4	31.1	40.1	10.4	.71	....	....	....	....	5,150	9,270
			B	11.4	33.7	43.5	11.4	.77	....	....	....	....	5,590	10,060
			C	....	38.1	49.1	12.8	.87	....	....	....	....	6,310	11,350
			D	....	43.7	56.3	....	1.00	....	....	....	....	7,235	13,020
Union Pacific mine No. 1, Rock Springs, Wyo.	5358	2.3	A	8.5	35.6	50.4	5.48	.78	5.36	66.15	1.19	21.04	6,575	11,830
			B	6.4	36.4	51.6	5.61	.80	5.22	67.71	1.22	19.44	6,730	12,110
			C	....	38.9	55.1	5.99	.85	4.82	72.32	1.30	14.72	7,185	12,940
			D	....	41.4	58.6	....	.90	5.13	76.93	1.38	15.66	7,645	13,760
Diamondville No. 1 mine, Kemmerer, Wyo.	2284	1.3	A	5.1	40.5	49.8	4.61	.49	5.63	72.95	1.18	15.14	7,200	12,960
			B	3.9	41.0	50.4	4.67	.50	5.56	73.91	1.20	14.16	7,295	13,[illegible]0
			C	....	42.7	52.4	4.86	.52	5.33	76.89	1.24	11.16	7,590	13,660
			D	....	44.9	55.1	....	.54	5.61	80.82	1.31	11.72	7,980	14,360

OCCURRENCE OF OIL.

Reported indications of oil were investigated on Mahogany Creek, on the west side of Teton Basin, and in Darby Canyon, on the east side. On Mahogany Creek swamp slime with iridescent iron films was mistaken for oil, and in Darby Canyon the gently undulating and faintly westward-dipping Carboniferous limestone near the old sawmill was thought to have a favorable structure for the accumulation of oil. It was also reported that oil scum was common on the creek at certain seasons of the year. The stream at the time of the examination was exceptionally free from scum of any kind, although a collapsed bridge near the sawmill afforded excellent opportunities for the gathering of oil. The Carboniferous rocks alluded to are part of the thick Paleozoic strata that form the west flank of the Teton Range. With the exception of the phosphatic shale of the Phosphoria formation, which yields small amounts of petroleum on destructive distillation,[26] the Paleozoic rocks are not known to bear significant amounts of oil in this portion of the Rocky Mountains. Many of them, however, when struck with a hammer or freshly broken, give a fetid odor like that of crude petroleum. The dip and exposure of the strata are such as to afford ready opportunity for the escape of such hydrocarbons as may have been present in these rocks.

The coal bed and some of the shale beds at the Brown Bear mine yield small quantities of petroleum upon destructive distillation.[27]

The anticline along the west side of the basin east of the Horseshoe district, as noted by Schultz,[28] furnishes the most promising structure in the region for the accumulation of oil. The axial portion and eastern limb of this fold are largely concealed by lava, and to the west faults occur in parts of the district. The gathering area for oil apparently is not large. The presence of oil could be determined only by drilling, which should not be undertaken without full realization of the cost and the great chance of failure.

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[26] Condit, D. D., Oil shale in western Montana, southeastern Idaho, and adjacent parts of Wyoming and Utah: U. S. Geol. Survey Bull. 711, p. 31, 1919. Schultz, A. R., op. cit., pp. 80, 81.

[27] Condit, D. D., op. cit., pp. 32, 33.

[28] Schultz, A. R., op. cit., p. 79.