

THE NORTHWARD EXTENSION OF THE SHERIDAN COAL FIELD, BIG HORN AND ROSEBUD COUNTIES, MONTANA

By ARTHUR A. BAKER

INTRODUCTION

SCOPE OF REPORT

This report presents the results of a geologic examination of an area of about 700 square miles in southeastern Montana, including parts of Rosebud and Big Horn Counties. The examination was undertaken primarily to obtain the information necessary for classifying the public lands and for the proper administration of the laws relating to these lands. Data on the several coal beds were collected in detail, and observations were made on the geologic structure, stratigraphy, and physiographic development.

The report is divided into two parts; the first part presents the geologic features that pertain to the whole area, and the second part is devoted to those features that pertain to the several townships.

LOCATION AND RELATIONS OF THE FIELD

The Sheridan coal field is part of a large region underlain by coal-bearing rocks, which includes northeastern Wyoming, northwestern South Dakota, western North Dakota, and eastern Montana and occupies part of a wide basin between the Black Hills and the Big Horn Mountains. Taff¹ chose arbitrary boundaries for the Sheridan field, except on the west, where the limit of the coal-bearing rocks marks the limit of the field. For convenience the Wyoming-Montana State line was chosen as the northern boundary, but as the same coal beds that crop out in the Sheridan field can be traced north of the State line it is inappropriate to call the area north of that line a separate field, and therefore the area described in this report is called the northward extension of the Sheridan coal field.

The portion of the coal field here described is limited in part by geographic boundaries and in part by boundaries chosen for convenience, and not by the extent of coal-bearing rocks. The boun-

¹ Taff, J. A., The Sheridan coal field, Wyo.: U. S. Geol. Survey Bull. 341, pp. 123-150, 1909.

daries are the Wyoming-Montana State line on the south, the Crow Indian Reservation on the west, the Northern Cheyenne Indian Reservation on the north, and an irregular boundary line on the east following the Tongue River, Hanging Woman Creek, the north and east lines of T. 8 S., R. 43 E., and the east line of Tps. 9 and 10 S., R. 43 E., south to the State line. As the land in the Indian

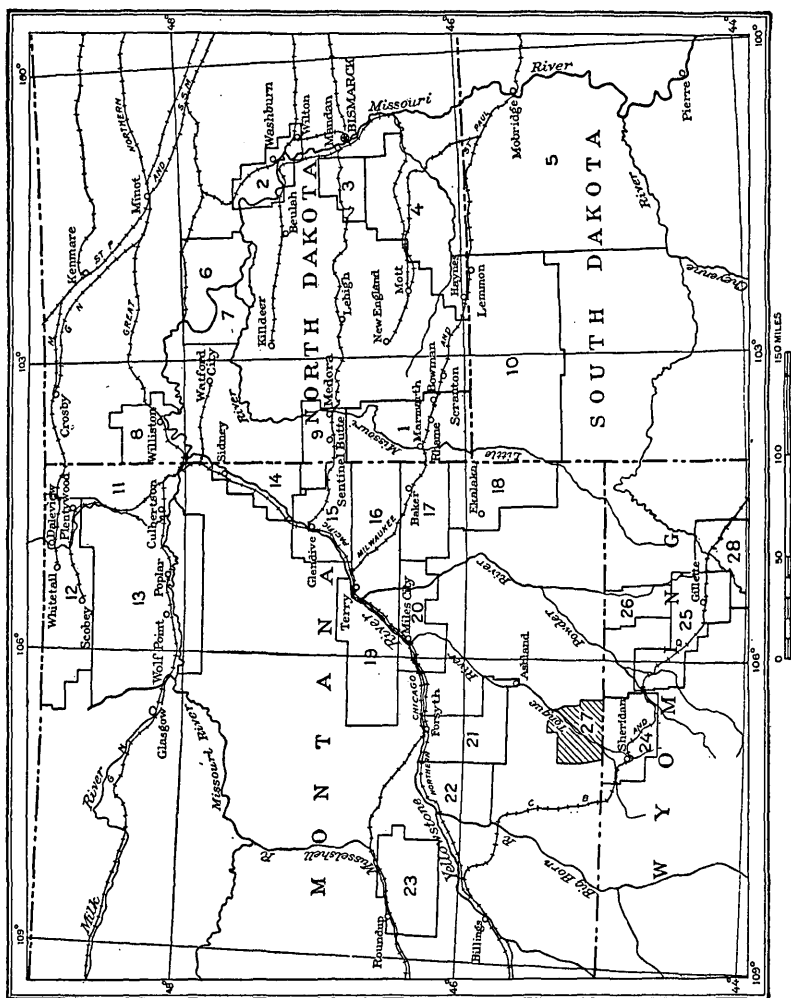


FIGURE 2.—Index map showing location of the Sheridan coal field and its relation to other coal fields in eastern Montana and adjacent States. (See p. 17)

reservations is not open to entry, their boundaries were taken as the boundaries of the area examined. The eastern limit was chosen arbitrarily, corresponding to the limit of the area mapped. The area of the part of the field examined is about 700 square miles.

Figure 2 shows the location of the area covered in this report and of other coal-bearing areas that have been mapped and described in publications of the United States Geological Survey. The names

of the fields designated by numbers on the map and references to the Geological Survey publications in which they have been described are as follows:

Coal fields whose locations are shown in Figure 2

No.	Field	Bulletin	No.	Field	Bulletin
1	Marmarth.....	775.	15	Glendive.....	471-D.
2	Washburn.....	381-A.	16	Terry.....	471-D.
3	New Salem.....	726-A.	17	Baker.....	471-D.
4	Cannonball River.....	541-G.	18	Ekalaka.....	751-F.
5	Standing Rock and Cheyenne River.....	575.	19	Little Sheep Mountain.....	531-F.
6	Fort Berthold.....	381-A and 471-C.	20	Miles City.....	341-A.
7	do.....	726-D.	21	Forsyth.....	812-A.
8	Williston.....	531-E.	22	Tullock Creek.....	749.
9	Sentinel Butte.....	341-A.	23	Bull Mountain.....	647.
10	Northwestern South Dakota.....	627.	24	Sheridan.....	341-B.
11	Culbertson.....	471-D.	25	Powder River.....	381-B.
12	Scobey.....	751-E.	26	Little Powder River.....	471-A.
13	Fort Peck.....	381-A.	27	Northward extension of Sheridan coal field.....	806-B.
14	Sidney.....	471-D.	28	Gillette.....	796-A.

PREVIOUS INVESTIGATIONS

Although the earliest settlers knew of the existence of thick coal beds in the country adjacent to Tongue River and Taff² had described the adjacent Sheridan coal field, no detailed description of the geology of any part of the area described in this report was available until 1924, when the results of Bass's investigations of the geology and coal beds along the Tongue River Valley were published.³ Darton's general discussion of the geology of the central Great Plains⁴ covered this area, but he touched only the broad geologic features. Reports by Thom and Hall⁵ and by Renick⁶ describe the principal geologic features in this and adjoining areas but are devoted particularly to a study of the wells and springs and the quality and quantity of ground water and give suggestions for developing the ground-water supplies.

PRESENT INVESTIGATION

Field work and acknowledgments.—New impetus was given to the study of the vast coal reserves in this region in 1923, when active construction work was begun on the North & South Railway, which

² Taff, J. A., The Sheridan coal field, Wyo.: U. S. Geol. Survey Bull. 341, pp. 123-150, 1909.

³ Bass, N. W., Coal in Tongue River Valley, Mont.: Interior Dept. Press Notice 16748, 1924.

⁴ Darton, N. H., Geology and underground waters of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, 1905.

⁵ Thom, W. T., jr., and Hall, G. M., Geology and ground-water resources of Big Horn County, Mont.: U. S. Geol. Survey Water-Supply Paper (in preparation).

⁶ Renick, B. C., Geology and ground-water resources of central and southern Rosebud County, Mont.: U. S. Geol. Survey Water-Supply Paper 600 (in press).

was to operate between Sheridan, Wyo., and Miles City, Mont. The route of the railroad followed the valley of Tongue River across the area, and it was expected that the operation of this railroad would lead to commercial development of the coal. N. W. Bass, of the Geological Survey, made a study of the possible stripping areas along the route of the railroad, and the information which he obtained in the area here described is incorporated in this report. During the summer of 1924 the part of the area west of Tongue River was mapped by the writer, assisted by J. B. Stone, P. D. Torrey, C. M. Clark, and H. M. Burnside, and in 1925 the part of the area east of Tongue River was mapped by the writer, assisted by C. E. Erdmann, J. C. Beam, A. J. Bauernschmidt, J. M. Dunning, H. H. Chen, and H. M. Burnside.

The method of mapping employed was a combination of triangulation and traversing with plane table and telescopic alidade. Engineers, while surveying for the proposed railroad, carried levels along the right of way from a Government bench mark at Sheridan, Wyo., so it was possible to start the present mapping from a railroad bench mark whose altitude was accurately known. By projecting the triangulation net the altitude was determined at several points in the field, and the land surveys of the General Land Office gave adequate horizontal control.

The writer wishes to acknowledge the assistance received during the field work and the preparation of this report from W. T. Thom, jr., under whose direction the surveys were made, and C. E. Dobbin, who organized the party in 1924. To those who assisted in gathering information and whose industry and cooperation so largely made this report possible, the writer offers grateful acknowledgment. He also wishes to express his appreciation of the courtesy and helpful spirit manifested by the ranchers and merchants of the region, whose cooperation expedited the field work materially.

Land surveys.—Over most of the area the General Land Office surveys have been made since 1912 and are of the high quality customarily found in the more recent surveys. Parts of several townships, including the agricultural lands along Rosebud Creek, Tongue River, and Hanging Woman Creek, and three complete townships, T. 8 S., Rs. 40 and 41 E., and T. 9 S., R. 40 E., were surveyed prior to 1890. Few of the original corner markers placed in these surveys could be found, and it is uncertain whether some of those found are at the original locations. On the maps (pls. 28 and 29, in pocket) the land lines for T. 8 S., Rs. 40 and 41 E., and T. 9 S., R. 40 E., are dotted, as the small number of corners located do not afford adequate control.

GEOGRAPHY

Land features.—The northward extension of the Sheridan coal field lies near the western margin of the Great Plains Province and exhibits a surface relief greater than is common in the province. The old upland surface that once extended over the region has been trenched by deep valleys bordered in many places by precipitous slopes, and the remnants of this surface now preserved are relatively small. The maximum surface relief within the area is about 1,500 feet; the highest points on the Tongue River-Rosebud Creek divide rise to altitudes of about 4,600 feet, compared with 3,100 feet in the Tongue River Valley near Cook Creek and 3,500 feet in the same valley near the Wyoming State line. In the southwestern part of T. 7 S., R. 39 E., the divide has an altitude of 4,500 feet. Thence southward the old erosion surface (pl. 6) slopes to the south, and near the State line its altitude is about 4,000 feet. Only one or two peaks rise as much as 200 feet above the general sloping surface, and consequently the maximum relief in the southern part of the area is 800 feet and the relief between Tongue River and the main part of the upland is not more than 600 feet.

The valley bottom of Tongue River is half a mile or more in width and is in most places bordered by cliffs and steep slopes from 100 to 500 feet high, commonly divided into a series of steps or benches, which were formed in part by Tongue River during pauses in its downcutting and are in part due to the resistance to erosion of rocks clinkered by burning of the coal beds.

The bottom of the valley of Rosebud Creek has an altitude of 3,700 feet at the south line of the Cheyenne Indian Reservation. The valley is narrow, and the tributaries are short and steep. West of the Tongue River-Rosebud Creek divide the tributaries to Rosebud Creek are about 4 miles long, whereas east of the divide the tributaries to Tongue River are 12 miles or more in length and have developed narrow valleys some 400 feet deep which are comparable in size to that occupied by Rosebud Creek.

Most of the area east of Tongue River that is described in this report lies between the river and Hanging Woman Creek, a large tributary. The flat valley floor of Hanging Woman Creek is about half a mile wide, and along the lower part of its course the west side of the valley rises steeply about 400 feet and is dissected by many short gulches. The valley sides become less abrupt toward the south, and in T. 9 S., R. 43 E., the sides of the valley rise in long, gentle slopes.

At the southern border of the area Tongue River and Hanging Woman Creek are about 18 miles apart and the divide is about halfway between them. The streams converge toward the north, and the tributary gulches become shorter and are cut more deeply into

the valley sides. The rocks forming the divide have been clinkered from the burning of coal beds and are resistant to erosion, so that the tributary gulches cut headward slowly. The highest part of the divide is at an altitude of about 4,200 feet, in the southwestern part of T. 8 S., R. 42 E. From this point southward to the State line the altitude of the divide falls less than 100 feet, and northward the altitude decreases slowly to a point about 3 miles from the forks, where the surface slopes more steeply. The highest point east of Tongue River in this area is the crest of the Badger Mountains at the State line, south of T. 9 S., R. 41 E. The highest of these hills has an altitude of 4,600 feet. The total relief east of Tongue River is about 1,500 feet, although between the divide and the river the relief is about 1,100 feet.

Drainage and water supply.—This part of the Great Plains has a semiarid climate and little snow or rain. Most of the low-water flow of the streams is derived from springs. During the summer the few rains come in sudden, heavy downpours, often accompanied by hail, and at these times, as the scanty vegetation does not much impede the run-off, all streams are subject to destructive floods.

Tongue River is the dominating geographic feature of the area. It is a large stream, which heads in the Big Horn Mountains in Wyoming, flows northeastward, and empties into Yellowstone River near Miles City, Mont. About 650 square miles of the 700 square miles described in this report lies in the drainage basin of Tongue River. For most of its length this river has an average gradient of 8 feet to the mile and meanders through alluvial flats. During the summer, except after the rainstorms, it is shallow and may be forded at many places. In the spring and after heavy rains the river is deep and treacherous and often overflows the wide alluvial flats that border it. The current, which is swift and strong at such times, may change the channel of the river and do much damage to bridges, fords, dams, and other improvements along its course.

The alluvial flats bordering the river are productive when irrigated, and many small dams and irrigation projects developed and maintained by individual ranches divert the river water to them. A Government gaging station at Carneyville, Wyo., just south of the State line, measured the discharge of Tongue River for 1915, 1916, and 1917. For these three years the maximum discharge was 2,600 second-feet in June, 1917, and the minimum was 42 second-feet in April, 1915. As water in Tongue River is augmented north of the Carneyville gaging station by the flow of perennial tributaries fed by large springs, these figures are too small to be applied to the part of the river in Montana.

Many tributaries flow into Tongue River. The largest one is Hanging Woman Creek, which flows north in the eastern part of

the area here described and joins Tongue River at Birney. It contains flowing water in part of its course throughout the year. None of the tributaries of Hanging Woman Creek are perennial streams, but many of them are fed by springs and contain flowing water in parts of their courses. Of the other tributaries of Tongue River, Squirrel and Youngs Creeks are the only perennial streams, and only a small part of the course of Youngs Creek lies in this area. Squirrel Creek gives an abundant supply of water that is suitable for the use of stock, but, although nonalkaline, is of doubtful purity for domestic use. Most of the other tributaries are fed by one or more springs and have running water in portions of their courses. Canyon, Fourmile, Leaf Rock, Badger, and Deer Creeks are the more conspicuous of this class. Canyon Creek is a flowing stream through most of its course and is fed by several large springs. Only in the last mile of its course does the flow of water disappear beneath the gravel. The springs in Canyon Creek have water relatively free from mineral salts and yield an excellent supply for domestic or camp use, and the flowing water makes this valley an excellent range for stock. The water in most of the spring-fed streams is too alkaline for domestic use. In some large areas it is impossible to obtain palatable surface water. On the ranch of Adam Anderson, near the mouth of Spring Creek, are two springs that give a bountiful supply of cold water suitable for domestic use, and the flow from the springs is sufficient to irrigate many acres of meadow land.

Rosebud Creek drains a small tract in the northwestern part of the area. It heads in the Wolf Mountains and flows eastward through the Crow Indian Reservation and to the middle of T. 7 S., R. 39 E., where it turns and flows north to join Yellowstone River near Rosebud. About 50 square miles in the northwest corner of this area is included in the drainage basin of Rosebud Creek. No figures are available to show the flow of this creek, but it is small in this area. The average gradient of Rosebud Creek from the Crow Indian Reservation line to the point where it leaves the area, at the north line of T. 6 S., R. 39 E., is about 19 feet to the mile, or more than twice the gradient of Tongue River.

The tributaries of Rosebud Creek are short and of steep gradient and usually carry little water. The largest one is Indian Creek, which flows east from the Crow Indian Reservation and enters Rosebud Creek in sec. 32, T. 6 S., R. 39 E. Its flow is large, and the water is reported to be excellent for drinking. Dry Creek flows westward and empties into Rosebud Creek near the mouth of Indian Creek. Several springs supply water to Dry Creek, and it contains running water in the lower part of its course. A boxed-in spring about a mile from the mouth of Dry Creek furnishes good water for domestic use.

The water for domestic use, for stock, and for gardens in this area is obtained chiefly from springs or wells. Most of the springs issue at the outcrop of coal beds or at the base of clinker masses. A few of the wells are driven or bored, but most of them are either dug or drilled. The dug wells are generally several feet in diameter and less than 50 feet deep. They are usually put down along the valleys, where water is obtained from the gravel, but many wells have been dug to provide storage where small springs issue. Most of the drilled wells are $2\frac{1}{2}$ inches in diameter at the bottom and are 100 to 500 feet deep. Water in these wells usually rises to a level far above the water-bearing stratum, and in a well at the Three Circle ranch, in the SE. $\frac{1}{4}$ sec. 1, T. 6 S., R. 42 E., the water overflows.

Timber.—The area is not heavily forested but contains a few thick stands of timber. The soil formed by the disintegration of the rocks above a point about halfway between the Smith and the Roland coal beds does not favor the growth of timber, and the uplands in the southern half of the area are devoid of trees. In the northern half and in the part of the southern half where the soil favors their growth there are local moderately dense stands of pine and cedar. (See pl. 7, A.) At several places in the area sawmills have produced a small amount of lumber for local use, and some timber has been cut for log houses, corrals, and fence posts. Along the streams, especially those fed by springs, are scattered cottonwood trees, and around many of the ranch houses other varieties of poplar have been planted.

Settlement.—The population of the northward extension of the Sheridan coal field is not great, and there are no large towns in the area. The financial center and the source of most supplies is Sheridan, Wyo., a thriving town of about 10,000 population, on the Chicago, Burlington & Quincy Railroad. Decker, in sec. 22, T. 9 S., R. 40 E., has a post office and general store, and Kirby, in sec. 17, T. 6 S., R. 39 E., has a post office and two general stores. The population of Kirby is perhaps 25 or 30. Birney, in sec. 6, T. 6 S., R. 43 E., on the east side of the Tongue River, has a post office and two general stores which serve as a source of supplies for a large area. The population of Birney is about 30. Supplies for the stores at Kirby, Birney, and Decker are freighted from Sheridan.

Stock raising and dry farming are the chief enterprises and meet fair success. Cattle raising suffered severely from the unusually rigorous winter of 1919-20 and at present is less important than it has been.

Routes of travel.—The nearest railroad is the Chicago, Burlington & Quincy Railroad, which passes through Sheridan, Wyo., 16 miles south of the State line, and then turns northward to follow the valley of Little Big Horn River about 16 miles west of this area. However,

as it is necessary to cross the high divide to reach a station in the valley of Little Big Horn River, the railroad is not as accessible on the west as it is on the south. The Northern Pacific Railway and the Chicago, Milwaukee & St. Paul Railway follow the valley of Yellowstone River about 50 miles north of the area and pass through the important towns of Forsyth and Miles City.

The proposed line of the North & South Railway follows Prairie Dog Creek and Tongue River between Sheridan, Wyo., and Miles City, Mont. (See pls. 28 and 29.) Construction work on this line stopped late in 1923, and no further work was done in 1924-25. The completion of this railroad would make most of the area east of the Rosebud Creek-Tongue River divide readily accessible, and the large coal beds could then be reached for mining on a commercial scale.

Many roads cross the area. A graded and well-traveled road from Sheridan, Wyo., to Decker, Mont., follows each side of Tongue River from the State line to Decker. From Decker a graded road extends northeast to Otter and another road extends north to Kirby and Forsyth. In the middle of sec. 1, T. 8 S., R. 39 E., a graded road branches from the Decker-Kirby road and after crossing Leaf Rock and Post Creeks follows the divide between Post and Fourmile Creeks to the Tongue River Valley. The divide is high and sharp, and the road is commonly known as the "Skyline Road." From the mouth of Fourmile Creek the road follows the Tongue River Valley to Birney and Ashland. The road that follows the valley of Youngs Creek in the southwest corner of the area is one of the main routes between Sheridan and the Crow Indian Reservation. Unimproved roads follow nearly all the larger valleys, and the country is thus easily traversed parallel to the drainage lines, but travel across the drainage lines by automobile is possible in only a few places, and travel on horseback is slow and arduous.

GEOLOGY

STRATIGRAPHY

GENERAL FEATURES

The Sheridan coal field is part of a large area in which the surface rocks are nearly horizontal Tertiary formations, and it lies near the southwest margin of a great exposure of coal-bearing rocks which is terminated on the southwest and west by the uplift of the Big Horn Mountains. The area here described is so far from the mountains that the rocks have not been sharply folded by the uplift and the exposed rocks belong to the coal-bearing Tongue River member of the Fort Union formation and the overlying Wasatch formation. The

Tongue River member is underlain in turn by the Lebo shale member of the Fort Union formation and the Tullock and Hell Creek members of the Lance formation, of Tertiary (?) age, which do not, however, crop out within the limits of the area here described.

In his work in Wyoming in the Dayton quadrangle, which adjoins the area here described on the southwest, Darton⁷ grouped together the whole of the Lance and Fort Union formations and part of the Wasatch in a thick series which is called the "DeSmet formation." Taff⁸ subsequently divided the "DeSmet" into a lower member and an upper member, the latter consisting of the Tongue River, Intermediate, and Ulm coal groups. According to the classification more recently proposed by Thom and Dobbin,⁹ the lower part of Taff's lower member corresponds to the Lance formation, the upper part to the Lebo shale member of the Fort Union, and the Tongue River coal group to the Tongue River member of the Fort Union, and the Intermediate and Ulm coal groups belong to the Wasatch formation. As originally defined the Lebo member consists predominantly of somber-colored shale and sandstone, and the Tongue River member of yellow coal-bearing rocks. In passing northward from Sheridan, however, the lithologic change from somber-colored to yellow beds takes place at progressively lower horizons, so that the Tongue River member as mapped near Ashland, Mont., includes from 800 to 1,000 feet of beds corresponding to beds that lie below the Carney coal and hence are included in the Lebo of the Sheridan field.

EOCENE ROCKS

FORT UNION FORMATION

TONGUE RIVER MEMBER

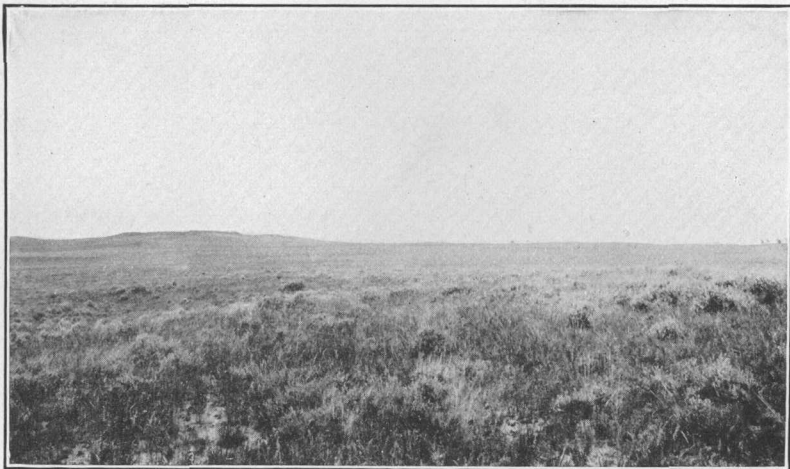
The Tongue River member of the Fort Union formation includes most of the sedimentary rocks that crop out in this area. It corresponds closely to the Tongue River coal group as defined by Taff¹⁰ from exposures along Tongue River just south of the Wyoming line. Taff included in this coal group about 800 feet of coal-bearing rocks extending from the base of the Carney coal bed to the top of the Roland coal bed. In the Sheridan field the base of the member (so selected) corresponds to the plane of lithologic change from somber-colored beds, predominantly shale, below to the lighter-colored buff sandstone and interbedded gray shale above. North of Ashland, in the Tongue River Valley, Mont., the base of the Tongue River member

⁷ Darton, N. H., U. S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (No. 141), 1905.

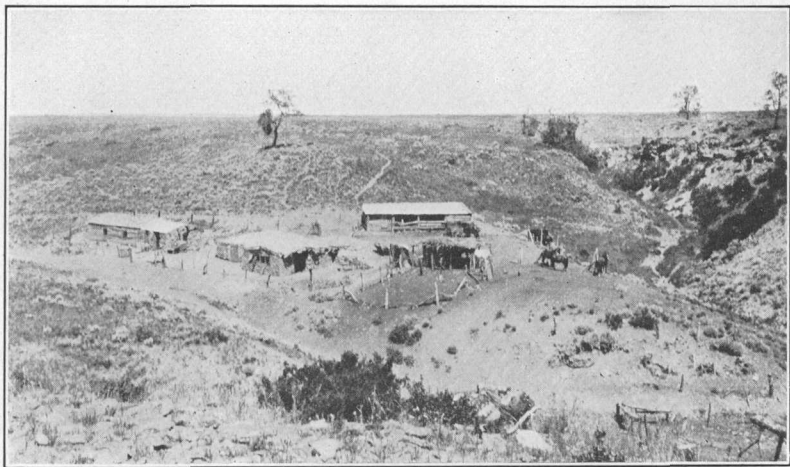
⁸ Taff, J. A., op. cit., pp. 127-130.

⁹ Thom, W. T., jr., and Dobbin, C. E., Stratigraphy of Cretaceous-Eocene transition beds in eastern Montana and the Dakotas: Geol. Soc. America Bull., vol. 35, p. 488, 1924.

¹⁰ Taff, J. A., op. cit., pp. 129-130.

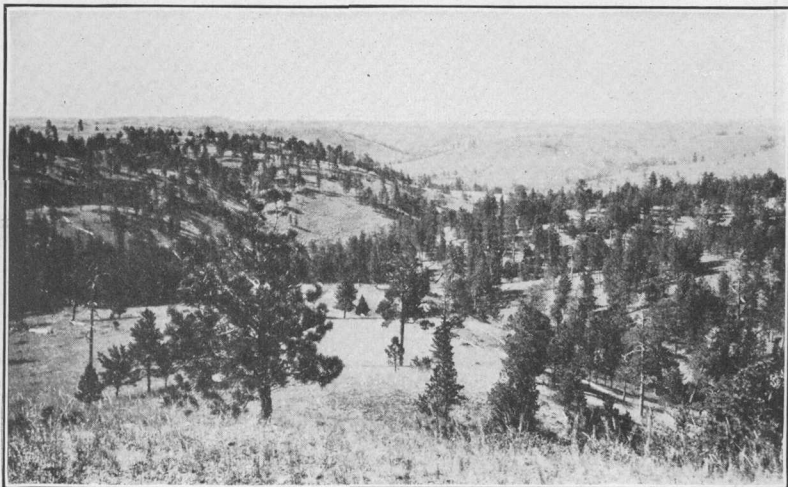


A. VIEW SHOWING THE SMALL RELIEF ON THE OLD EROSION SURFACE, PART OF WHICH FORMS THE DIVIDE BETWEEN SQUIRREL AND SPRING CREEKS IN T. 8 S., R. 39 E., MONTANA

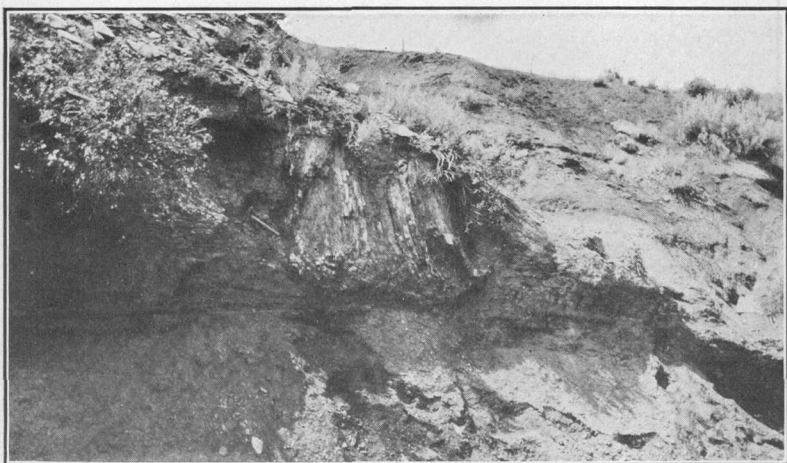


B. VIEW OF THE BROAD FEATURELESS DIVIDE BETWEEN PEARSON CREEK AND THE SOUTH FORK OF SPRING CREEK, FROM A POINT IN SEC. 34, T. 8 S., R. 39 E., MONTANA

Looking north across the head of Pearson Creek. The cabins are typical of a nonirrigated farm in this area

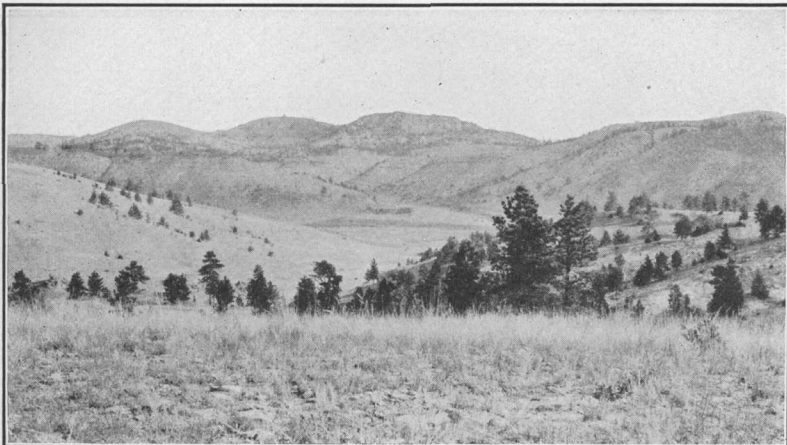


A. VIEW SOUTH ACROSS CANYON CREEK IN SEC. 34, T. 6 S., R. 40 E., MONTANA
Showing the topography of the clinker-capped divide between Canyon and Fourmile Creeks



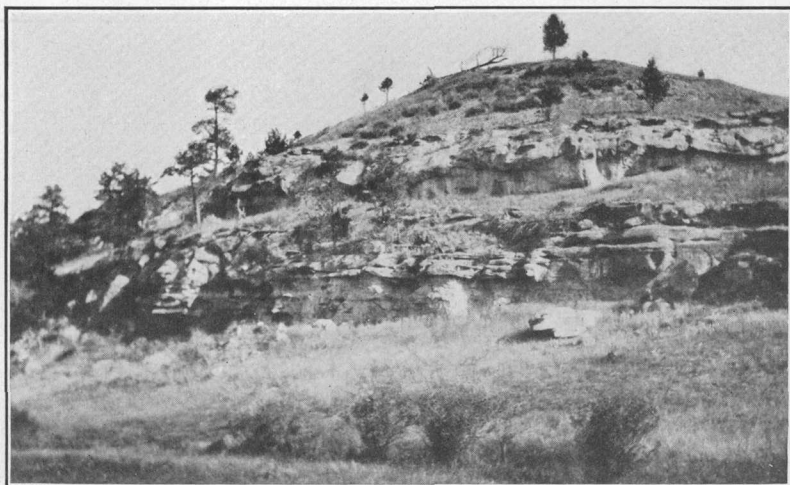
B. SILICIFIED STUMP STANDING UPRIGHT IN THE ROLAND COAL BED IN
THE SW. $\frac{1}{4}$ SEC. 35, T. 8 S., R. 39 E., MONTANA

The stump is 6 feet in diameter at its smaller end



A. VIEW NORTH ACROSS FOURMILE CREEK FROM A POINT IN SEC. 21, T. 7 S.,
R. 41 E., MONTANA

Showing the characteristic topography of an area in which the coal beds have been burned.
The clinker of the Anderson bed caps the highest hills, and that of the Canyon bed forms the
broad bench intermediate between the Anderson bed clinker and the valley bottom



B. TYPICAL EXPOSURE OF THE LIGHT-COLORED SANDSTONE THAT CHARAC-
TERISTICALLY UNDERLIES THE SMITH COAL BED IN THE VALLEY OF
ROSEBUD CREEK, SEC. 22, T. 7 S., R. 39 E., MONTANA

has been placed at the top of the Lebo shale member of the Fort Union formation. This shale is not exposed in the area here described but crops out in the Tongue River Valley near Brandenburg, in T. 1 S., R. 44 E. The classification accepted by the Geological Survey places the top of the member at the top of the Roland coal bed. There is, however, no great lithologic difference between the Tongue River and Wasatch rocks as developed in the area here described.

Continental deposits, such as those of the Tongue River member, vary so much in lithology that the series of beds shown in one columnar section would scarcely be recognizable as the same beds in a section measured a short distance away. In these deposits correlation on the basis of lithology is uncertain. At some localities there is a preponderance of shale and at others of sandstone, but for the formation as a whole there are about equal portions of sandstone and shale. The sandstone of the member is yellow and the shale a somber gray, but the lighter-colored sandstone gives a distinctly yellow to buff tone to the Tongue River member wherever it is exposed. The sandstone commonly occurs in thick beds, which make prominent ledges. (See pl. 8, *B*.) The thick beds of sandstone are not persistent and should be used with caution for correlation of exposures.

The following measured sections show the general character and proportions of the beds composing the Tongue River member.

Section at mouth of McGhee Gulch, in secs. 31 and 32, T. 6 S., R. 43 E.

	Ft.	in.
Clinker of Dietz No. 1 and Anderson coal beds.		
Shale, light gray to white-----	11	
Sandstone, fine grained, hard, gray-----	12	
Sandstone, with interbedded buff shaly sandstone and gray shale-----	27	6
Shale, steel-gray-----	5	6
Sandstone, friable, buff-----	5	
Shale, steel-gray-----	2	
Sandstone, fine grained, hard, gray; weathers yellow---	10	6
Sandstone, buff, shaly-----	35	
Shale, steel-gray-----	20	
Sandstone, fine grained, hard, arkosic-----	2	
Shale, steel-gray-----	12	
Sandstone, gray, friable, coarse grained, arkosic-----	3	
Shale, sandy, gray to buff, changing upward into buff sandstone-----	11	
Clinker from burning of Canyon bed-----	33	
Shale, dark gray-----	10	
Sandstone; limy yellow concretions-----	2	
Shale, dark gray-----	6	
Sandstone, friable, buff-----	8	
Sandstone, fine grained, hard, gray; weathers yellow----	2	

	Ft.	in.
Sandstone, friable, buff-----	17	6
Shale, steel-gray, with streaks of coal-----	18	
Sandstone, fine grained, hard, gray; weathers yellow---	3	
Shale, gray; changes upward into buff shaly sandstone---	31	
Sandstone, buff, friable, thin bedded, with 2 feet of hard gray, yellow-weathering sandstone at top-----	24	
Shale, black to brown, carbonaceous-----	5	
Sandstone, shaly, gray to buff-----	30	
Shale, light gray-----	8	
Sandstone, yellow, shaly, with thin dark-yellow iron- rich bands-----	6	6
Shale, sandy, light gray-----	7	
Shale, brown, carbonaceous-----	3	
Coal-----	2	10
Sandstone, friable, buff to gray-----	5	6
Sandstone, fine grained, hard, gray-----	7	
Shale, light gray-----	5	6
Sandstone, fine grained, hard, gray-----	8	
Shale, light gray, with carbonaceous streaks-----	9	
Sandstone, friable, buff, changing into gray shale above---	13	
Sandstone, medium grained, gray, ledge forming-----	3	
Sandstone, friable, buff-----	22	
Coal-----	4	5
Shale, gray, with carbonaceous bands-----	5	6
Sandstone, gray, shaly-----	3	6
Shale, gray-----	11	
Sandstone, fine grained, gray, hard, irregularly bedded---	1	6
Shale, steel gray-----	4	
Sandstone, buff, fine grained, hard-----	1	6
Shale, dark gray-----	4	
Sandy yellow concretion-----	2	
Shale, steel gray-----	12	
Sandstone, buff, shaly-----	10	
Shale, fissile, steel gray-----	6	
Sandstone, fine grained, gray-----	3	
Shale, gray to brown, with thin coal near base-----	17	6
Sandstone, friable, buff, shaly, with several thin bands of harder sandstone-----	33	
Concealed to level of Hanging Woman Creek-----	10	
	575	3

Section in the SW. ¼ sec. 4, T. 9 S., R. 41 E.

	Ft.	in.
Clinker from burning of Roland coal-----	12	
Shale, dark gray, carbonaceous-----	5	6
Sandstone, friable, buff, medium grained-----	10	6
Shale, steel gray-----	6	
Sandstone, hard, gray, arkosic-----	3	
Shale, light gray-----	5	
Sandstone, fine grained, shaly, yellow-----	4	
Shale, light gray-----	3	6
Sandstone, buff, medium grained, friable-----	14	

	Ft.	in.
Shale, gray, sandy at top-----	11	
Coal -----	2	
Shale, sandy, yellow-----	3	
Shale, gray-----	4	
Sandstone, friable, fine grained, arkosic-----	15	
Shale, gray-----	3	
Sandstone, friable, gray-----	2	
Shale, gray, with thin coal at top; contains gypsum-----	6	
Sandstone, fine grained, hard, white-----	6	
Sandstone, soft, friable, gray to white-----	4	6
Shale, light gray; thin coal at top-----	10	
Sandstone, medium grained, arkosic, friable, gray to white-----	14	
Shale, brown, carbonaceous, with thin coal at top-----	5	
Sandstone, friable, arkosic, gray-----	4	
Shale, light gray; contains gypsum-----	5	
Sandstone, medium grained, friable, arkosic-----	6	
Shale, brown to black, carbonaceous-----	8	6
Sandstone, friable gray-----	6	
Shale, dark gray, carbonaceous-----	5	
Sandstone, friable, medium grained, arkosic, gray-----	10	
Shale, light gray, with some iron-rich concretions-----	12	
Sandstone.		
Clinker from burning of Smith bed-----	20	
Sandstone, soft, gray, arkosic, cross-bedded; weathers into badlands; typically found below Smith in south- ern part of area-----	+100	
	325	6

As the base of the Tongue River member is not exposed in the area mapped, a complete section was not measured. Farther down Tongue River, Bass measured a section from the Lebo shale to the clinker regarded as that of the Anderson coal bed, which caps Garfield Peak. This interval is 1,480 feet. As the Roland bed is about 300 feet above the Anderson coal bed, the total interval from the top of the Lebo shale to the Roland bed is estimated at 1,780 feet. A composite of the intervals measured between the several coal beds at many points within this area shows that the distance between the Knoblock and Roland coal beds is about 1,230 feet. If the interval of 396 feet between the top of the Lebo shale and the base of the Knoblock coal bed as measured farther north is added, the total local thickness of the Tongue River member is 1,626 feet. In the Sheridan field Taff¹¹ measured about 800 feet of beds between the base of the Carney coal and the top of the Roland coal. It is not possible to correlate definitely the Carney bed of the Sheridan field with any coal bed of this area, but the Wall bed and the Carney are approximately at the same horizon. It is thus apparent that the

¹¹ Taff, J. A., op. cit., p. 129.

lower 800 feet of the thick coal-bearing series of light-colored sandstone and shale mapped as the Tongue River member in Montana merges southwestward into somber-colored beds which are practically barren of coal along Tongue River in Wyoming.

WASATCH FORMATION

The contact of the Fort Union and Wasatch formations has been traced northward from Wyoming by Thom and Dobbin,¹² who now regard the top of the Roland coal bed as marking the Wasatch-Fort Union contact. Within the area here described there is, however, locally no marked difference between the beds below and above the Roland coal bed, although variegated beds such as are characteristic of the Wasatch are reported to overlie the Roland bed near Pumpkin Buttes, Wyo.¹³

The rocks belonging to the Wasatch formation cap the high ridges in the southern part of the area and exhibit the following section:

Section in southwestern part of T. 9 S., R. 41 E.

	Ft.	in.
Sandstone, coarse grained, cross-bedded, arkosic.....	28	
Sandstone, cross-bedded, with some interbedded shale; contains mud balls, silicified wood, and thin coal lenses...	15	
Shale, gray.....	6	
Sandstone, fine grained, thick bedded, yellow; contains fossil leaves.....	8	
Shale, gray, with scattered yellow limy concretion.....	52	
Coal, Badger bed.....	6	
Sandstone, gray, thin bedded.....	2	
Shale, light gray.....	10	
Sandstone, thin bedded, buff to yellow.....	2	6
Shale, gray.....	6	
Sandstone, gray, fine grained, thin bedded.....	5	
Shale, gray, with several thin beds of sandstone.....	18	
Coal.....	2	
Shale, gray.....	3	
Sandstone, friable, gray.....	4	
Sandstone, cross-bedded, medium grained, grading into limy yellow concretion.....	5	
Sandstone, yellow; many fossil fragments in soil.....	5	
Shale, light gray, with carbonaceous band at top.....	5	
Sandstone, arkosic.....	5	6
Sandstone, yellow, fine grained, hard.....	1	
Shale, light gray.....	3	
Sandstone, thin bedded, friable, medium grained, arkosic....	3	6
Shale, light gray.....	7	
Shale, dark gray, carbonaceous at top.....	4	

¹² Thom, W. T., jr., and Dobbin, C. E., op. cit., pp. 495-496.

¹³ Dobbin, C. E., personal communication.

	Ft.	in.
Concretions, yellow, sandy limestone	3	
Shale, light gray, with some carbonaceous bands.....	22	
Concretions, yellow, sandy limestone.....	3	
Shale, light gray, with thin yellow sandstone beds.....	8	
Shale, black to brown, carbonaceous.....	37	
Sandstone, soft gray.....	11	
Shale, gray, carbonaceous.....	4	
Sandstone, soft, gray.....	10	
Sandstone, yellow, limy; weathers like concretions and has hackly fracture.....	18	
Shale, brown fissile.....	7	
Shale, gray, sandy.....	10	
Shale, dark brown.....	11	
Sandstone, soft, light gray, thin bedded.....	5	
Shale, light gray.....	5	
Sandstone, yellow, fine grained, platy.....	6	6
Shale, dark gray, with abundant gypsum.....	10	
Sandstone, soft gray.....	3	6
Shale, gray.....	13	
Sandstone, friable, gray.....	3	6
Shale, gray.....	7	
Shale, carbonaceous, with thin beds of coal.....	3	6
Concealed.....	5	
Shale, light gray.....	4	6
Sandstone, fine grained, hard; weathers yellowish brown and platy.....	25	
Shale, carbonaceous in part; contains fresh-water fossils..	15	
Clinker, Roland bed.....	15	
	472	

Some 300 to 500 feet of younger beds belonging to the Wasatch are exposed in the Badger Mountains near the State line, in the southern part of T. 9 S., R. 41 E., but no detailed section of them was measured.

QUATERNARY ROCKS

TERRACE GRAVEL AND ALLUVIUM

Superficial deposits of terrace gravel and alluvium are found along the valleys of Tongue River and most of the larger tributaries. Apparently these deposits were formed at times when conditions were not favorable for downcutting by Tongue River, and the river spread laterally. The gravel then deposited on the widened river bed remained to cap the terraces that were left when the cutting power of the river was renewed. Such gravel-covered terraces are found along Tongue River at several levels, but no attempt was made to map them. The alluvial fill in the bottoms of the larger valleys is neither thick nor of wide extent.

STRUCTURE

The area here described lies in the northern part of the Powder River Basin, a great structural depression between the Big Horn Mountain uplift on the west and the Black Hills uplift on the east, and displays a maximum structural relief of about 1,100 feet. The area is north of the deeper part of this basin, and most of it is west of the axis, the dips being therefore chiefly toward the southeast,

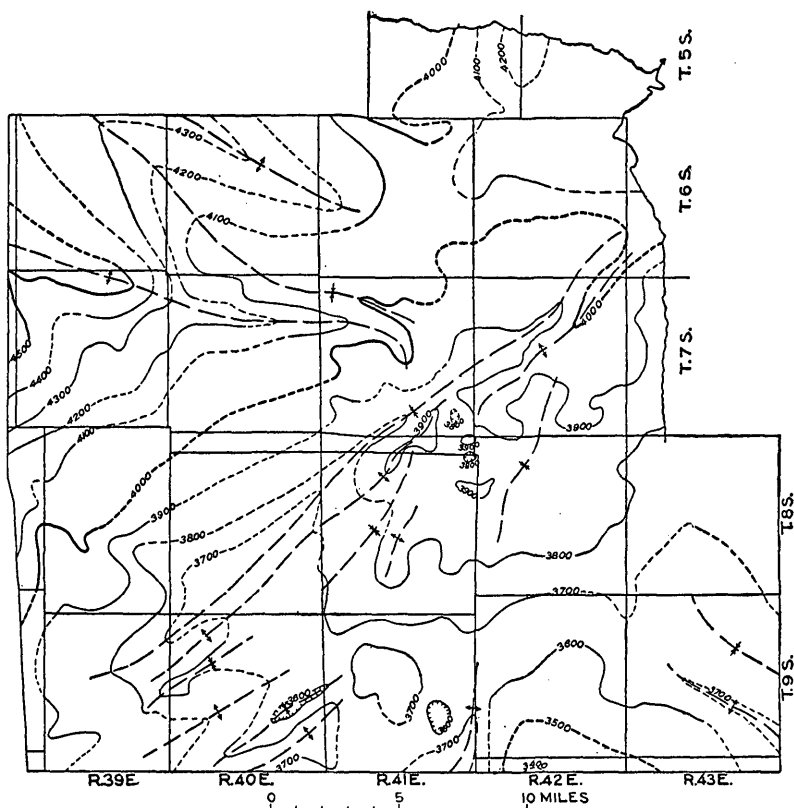


FIGURE 3.—Structure sketch map showing attitude of strata in the northward extension of the Sheridan coal field, Mont., by means of contours drawn on the base of the Smith coal bed

though veering toward the south and finally toward the southwest in the southeast corner of the area. For the most part the strata within this area have a slight slope to the south and southeast, which is locally modified by several minor anticlinal noses and folds. Figure 3 is a structure-contour map showing the location and trend of these minor structural features. The contour lines connect points of equal altitude at the base of the Smith coal bed. The structure section on Plates 28 and 29 shows the attitude of the beds along a line across the area.

Dips as high as 17° were recorded, but the higher dips are local, and the strata quickly flatten to dips of less than 3° . Some of the higher dips may be due to slumping of the strata. The slight dip of the beds in most of the area can have little influence on mining, except in so far as mines are planned to utilize natural grades for drainage and haulage.

The structural high point of the strata is in the southwest corner of T. 6 S., R. 39 E., at the crest of an anticlinal nose that extends westward into the mountains in the Crow Indian Reservation and plunges southeastward until it dies out in the valley of Tongue River. From the crest of this anticline the strata dip southeastward, with small irregularities, to T. 10 S., R. 42 E., giving a maximum structural relief of about 1,100 feet and an average dip of about 40 feet to the mile.

Nearly at right angles to the trend of the eastward-plunging anticlinal nose described above is a belt of low folds trending about N. 75° E. and extending from the southwest corner of the area to the northeast corner of T. 7 S., R. 42 E. The belt is 2 to 6 miles wide and includes several minor folds, few of which are continuous for more than 5 or 6 miles. Between upfolds and adjacent depressions the maximum relief is about 150 feet. The Absaroka Oil & Gas Co. drilled a deep test well for oil in the SE. $\frac{1}{4}$ sec. 16, T. 9 S., R. 40 E., near the crest of a low anticline, and is said to have found traces of gas and oil, but the well was abandoned after reaching a depth of 3,485 feet.

Only three small faults were seen in the area. In the river bluff east of the Tainter ranch, in the SW. $\frac{1}{4}$ sec. 22, T. 7 S., R. 41 E., there is an eastward-trending fault with a throw of about 35 feet, dropped on the south. The same fault appears in the north bank of Fourmile Creek near an abandoned coal prospect about a quarter of a mile west of the ranch house. The dip of the fault plane is 40° S. This fault lies at the intersection of the southeastward-plunging anticlinal nose and the edge of the northeastward-trending belt of folds. In the NE. $\frac{1}{4}$ sec. 13, T. 8 S., R. 42 E., there is another small fault with a strike of N. 80° E. and a downthrow of 22 feet on the south. The Dietz No. 1 coal bed, which crops out in the bed of the gulch north of the fault, is dropped below the level of the gulch south of the fault and reappears at a lower level in the same gulch and in the bed of P K Creek near the east range line. A third fault, which trends a few degrees east of north, is present in sec. 32, T. 8 S., R. 40 E., and sec. 5, T. 9 S., R. 40 E. The rocks are shattered, but there is practically no displacement. The presence of even small faults elsewhere in the area is doubtful, as the slight deformation to which the rocks have been subjected would not cause widespread faulting.

PHYSIOGRAPHY

The northward extension of the Sheridan coal field is an uplifted area now in process of dissection. In early Tertiary time this region was a rolling plain of low relief. The general level of the plain was then raised, and the streams began to dissect it actively. That the elevation of the land took place intermittently is indicated by the presence of gravel-covered benches and stream-cut terraces along Tongue River, the major stream.

The nearly level uplands that form the tops of the divides in the southwestern part of the area may be remnants of the old erosion surface. These divides present a sky line that appears even and unbroken to an observer at the plane of the surface or slightly lower (pl. 6), the surface sloping gently toward the southeast at about the same rate as the underlying rocks. This agreement between the inclination of the surface and that of the underlying rocks suggests either that the surface was tilted at the same time as the underlying rocks were tilted or that the present surface is due to stripping of the rocks above a resistant sandstone. No gravel was found on this surface. East of Tongue River there is no similar surface, but at several places high above the level of the river rounded pebbles of igneous rock foreign to the area were found.

The stream valleys are narrow and deep (pls. 7, A, and 8, A), and the streams are actively eroding. Rosebud Creek has a gradient more than twice that of Tongue River and consequently is cutting more actively. This relation has now existed for some time, for Rosebud Creek has captured the headwaters of Leaf Rock Creek, a tributary of Tongue River, and it is believed by the writer that the part of the Rosebud Creek drainage system above the big bend in T. 7 S., R. 39 E., was once connected with Leaf Rock Creek and Tongue River, through the gap in the divide that is crossed by the Sheridan-Forsyth road, Rosebud Creek having cut its valley headward until it captured the upper part of Leaf Rock Creek and diverted it to the north. There is also evidence of stream piracy in other parts of the area.

COAL

DISTRIBUTION AND CORRELATION OF THE COAL BEDS

As the strata in the northward extension of the Sheridan coal field dip only slightly, the several coal beds crop out in regular order from the lowest to the highest. The lowest coal bed known in the area is the Knoblock, which is reported to crop out in the bed of Tongue River in the bend of the river below the Brown ranch, better known as the Three Circle ranch, in sec. 1, T. 6 S., R. 42 E. The Brewster-Arnold, Wall, Canyon, and Dietz No. 1 coal beds and some thin

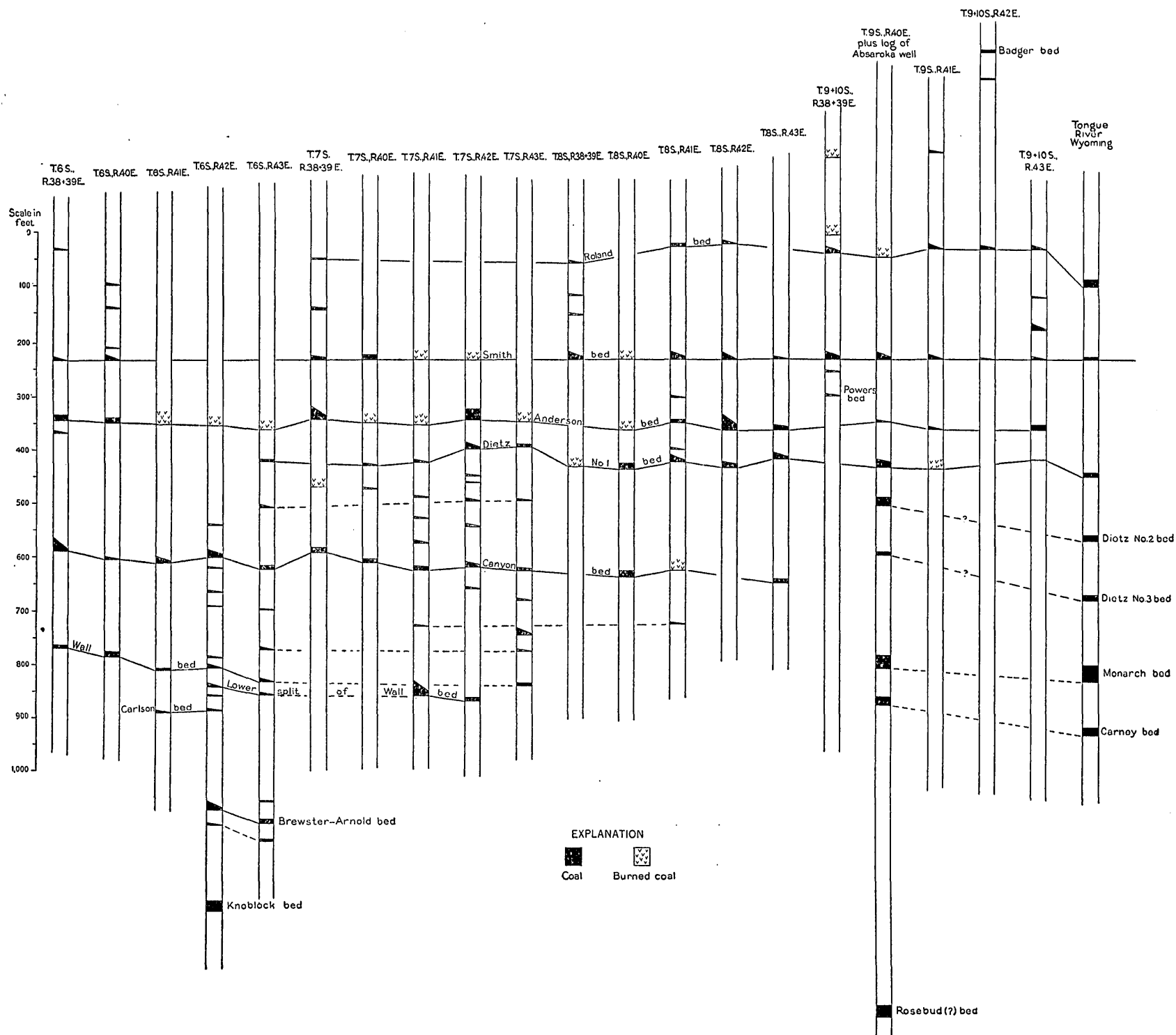


DIAGRAM SHOWING BY TOWNSHIPS THE STRATIGRAPHIC POSITION OF THE COAL BEDS IN THE NORTHWARD EXTENSION OF THE SHERIDAN COAL FIELD, MONTANA, AND THEIR CORRELATION WITH THE COAL BEDS THAT CROP OUT ALONG TONGUE RIVER, IN WYOMING

local beds crop out in the bed of the river at successively higher levels. Owing to their slight southeasterly dip and the fall of the river these coal beds rise above the river toward the north and rim the valley. As the coal beds are burned at the outcrop throughout most of the area, their positions in the valley walls are commonly marked by prominent bands of red clinker. The top of the clinkered mass also forms a bench in many places because of its resistance to erosion. Above the Dietz No. 1 are higher coal beds, the most persistent of which are the Anderson, Powers, Smith, and Roland. Above the Roland bed two or more thin coal beds are found in the southern part of the area. Associated with this series are several minor beds of coal, most of them thinner and less persistent than those named above, though some may be traced for long distances. (See pl. 9.)

Generalized section of the coal beds in the northward extension of the Sheridan coal field

Badger bed.	Feet
Interval-----	180
Local coal bed.	
Interval-----	180
Roland bed.	
Interval-----	195
Smith bed.	
Interval-----	70
Powers bed.	
Interval-----	60
Anderson bed.	
Interval-----	65
Dietz No. 1 bed.	
Interval-----	200
Canyon bed.	
Interval-----	180-230
Wall bed.	
Interval-----	235
Brewster-Arnold bed.	
Interval-----	170
Knoblock bed.	

The figures given above are averages derived from several measurements which have a considerable range. The diagram (pl. 9) shows the stratigraphic relations of the coal beds by a composite section for each township, and these sections also give evidence that the interval between coal beds is not uniform.

The use of the same names for some of the coal beds in this area that were used for coal beds in the Sheridan field¹⁴ is based upon a

¹⁴ Taft, J. A., The Sheridan coal field, Wyo.: U. S. Geol. Survey Bull. 341, pp. 123-150, 1909.

correlation by Bass.¹⁵ The Smith and the Dietz No. 1 beds are definitely correlated with the beds of the same names in the Sheridan field. The Roland bed is believed to be correlatable with the Roland bed in the Sheridan field, although the interval north of the State line is about 75 feet greater. The coal beds in the part of the section below the Dietz No. 1 bed can not be definitely correlated, but the relations shown in Plate 9 suggest that the Canyon bed may be equivalent to the Dietz No. 3 bed and that the upper and lower branches of the Wall bed may be equivalent to the Monarch and Carney beds. The Brewster-Arnold and Knoblock beds, which are exposed below the Wall bed in the northeastern part of the area, are not correlated with any beds exposed south of the State line.

The coal beds described below contain the principal coal resources of the region, but other beds are developed locally. The local beds can not be considered commercially important, but at many places they supply domestic fuel for the ranches in the immediate vicinity.

Badger bed.—The Badger bed crops out in Tps. 9 and 10 S., R. 42 E., near the top of the divide between Tongue River and Hanging Woman Creek. The coal underlies only a small area, under a maximum of about 120 feet of cover, and is not an important part of the coal reserve. The average thickness is about 7 feet, but at every place where a section was measured the coal is split by at least one parting.

Roland bed.—The Roland bed is the uppermost of the thick and persistent coal beds and underlies the high divides in the southern half of the area. West of Tongue River its clinker forms a prominent bench about 50 feet below the level of the old erosion surface and thus may easily be recognized high on the sides of all the valleys. East of Tongue River the coal is usually unburned at the outcrop and does not crop out in definite relation to a surface feature, as it does west of the river, but the horizon may usually be recognized by the presence above the coal of a highly fossiliferous sandstone 30 to 60 feet thick. The greatest thickness of the Roland coal was found at the mine of John Bell (locality 309), in the SW. $\frac{1}{4}$ sec. 8, T. 9 S., R. 39 E., where 13 feet of coal is exposed, and Mr. Bell reports that 4 or 5 feet additional is concealed below the level of the creek. Northward from this locality the coal thins, and in the northern part of T. 8 S., R. 39 E., it is only 2 feet thick. The bed is 6 to 9 feet thick at nearly every point where it was measured as far east as Hanging Woman Creek, but east of this creek the bed could not be recognized and is probably absent. Along the divide between Tongue River and Hanging Woman Creek the coal bed was traced into the central part of T. 8 S., R. 42 E., but in the western part of

¹⁵ Bass, N. W., Coal in Tongue River Valley, Mont.; Interior Dept. Press Notice 16748, 1924.

section 22 there is no coal at the horizon of the Roland bed. It thickens to 7 feet in the southwestern part of the same township.

Smith bed.—The coal bed definitely correlated with the Smith bed of the main Sheridan field is economically important. It underlies a large part of the area between Tongue River and Hanging Woman Creek. West of Tongue River the largest reserve of coal in this bed is in the southern part of the area, but some coal underlies the high divides northward to the line of the Cheyenne Indian Reservation. Unburned coal is exposed at few places, but scattered measurements indicate that its greatest thickness is in the southwestern part of the area. The coal is 20 feet 4 inches thick at locality 290, near the north quarter corner of sec. 4, T. 9 S., R. 39 E. It thins toward the north and east but is commonly 7 to 10 feet thick. In the southeastern part of T. 8 S., R. 42 E., east of Hanging Woman Creek, in T. 8 S., R. 43 E., the coal is 2 to 3 feet thick, and in the southeast corner of the area mapped the bed is probably missing.

The Smith bed is underlain in the southern part of the area by a soft steel-gray sandstone that at a distance resembles a shale outcrop and weathers into badlands similar to those formed by sandstone in the Lebo shale member of the Fort Union. As a similar sandstone is not associated with any of the other coal beds, it is locally a good horizon marker.

Powers bed.—The Powers bed is present only in the southwest corner of the area and is so named because coal for use at the Powers ranch is mined from this bed at locality 312, in the NE. $\frac{1}{4}$ sec. 23, T. 9 S., R. 39 E. The coal is 6 to 10 feet thick along the valley of Squirrel Creek, but it was not correlated with any of the beds that crop out north or south of the Squirrel Creek drainage area.

Anderson bed.—The Anderson bed, or the clinker from the burning of the bed, is found in most of the area here described. The bed is absent in the southwestern part but thickens toward the north and northeast to form one of the thickest beds found in the area. In the part of the northern half of the area where it has not been removed by erosion the coal has been almost completely destroyed by burning, and the clinker now caps most of the high ridges. Unburned coal underlies the divide between Tongue River and Rosebud Creek. Near its passage below stream level in First Creek the coal is 27 feet 6 inches thick, and at other localities the bed is 20 feet or more thick. North and northeast of Deer Creek this bed averages 10 to 15 feet in thickness and contains a large part of the reserve of coal present in the area.

Dietz No. 1 bed.—In this extension of the Sheridan coal field, as in the main part of the field, the Dietz No. 1 is a valuable coal bed. It is thick for several miles north from the State line but is thin or

absent under most of the northern half of the area. It is not present west of Tongue River in the north half of the area, and east of the river it could not be traced in Tps. 6 and 7 S., R. 42 E., on the west side of the Tongue River-Hanging Woman Creek divide. The bed is thickest near its point of passage below stream level in Tongue River in T. 9 S., R. 40 E., where several measurements show the coal to be from 10 to 16 feet thick. North of T. 9 S., R. 40 E., the surface rocks for several miles have been clinkered from the burning of the Dietz No. 1 and the overlying Anderson and Smith beds. The bed continues as a thick bed as far as the eastern boundary of the area mapped and is 13 feet thick at the Stroud Creek mine, in the NE. $\frac{1}{4}$ sec. 2, T. 8 S., R. 43 E. In many places the clinker from the burning of the Dietz No. 1 bed has merged with the clinker from the burning of the overlying Anderson bed, and it is difficult to establish the presence of two beds. The average thickness of the Dietz No. 1 coal bed is probably between 8 and 12 feet where it is under cover in the southern half of the area.

Canyon bed.—Except for several thin local coal beds, the Canyon is the next below the Dietz No. 1. It has been correlated by Bass¹⁸ with the Dietz No. 2 of the main Sheridan field, but this correlation is questionable, as it is impossible to trace the bed from one area to the other, and the interval between the Canyon and the Dietz No. 1 beds is about 100 feet greater than the interval between the Dietz No. 1 and Dietz No. 2 beds. The Canyon is perhaps rather to be correlated with the Dietz No. 3 bed of the main Sheridan field, on the basis of stratigraphic intervals, but the bed may not be exactly equivalent to any of the beds that crop out south of the State line, so it is here called the Canyon bed. Near the mouth of Spring Creek, in the southern part of T. 8 S., R. 40 E., numerous prospect holes have shown the presence of a coal bed near the surface averaging about 20 feet in thickness. This may be the equivalent of the Dietz No. 2 and above the Canyon bed, but no bed of similar thickness above the Canyon crops out along the Tongue River Valley farther north.

The Canyon bed has a large areal extent in the northward extension of the Sheridan coal field. If the bed that crops out near the mouth of Pearson Creek is the Canyon bed it is the southernmost exposure of that bed. The bed dips north below the level of the river and reappears near the east range line of T. 8 S., R. 40 E. Thence it can be traced, usually by the clinker marking its outcrop, northward along Tongue River and tributary valleys to the northern boundary of the area. The Canyon bed also crops out along the valley of Rosebud Creek.

¹⁸ Bass, N. W., op. cit.

This bed is irregular in thickness but includes a considerable reserve of coal. The thickest measurement was obtained at locality 42, in the NW. $\frac{1}{4}$ sec. 27, T. 6 S., R. 39 E., where the coal is 24 feet 4 inches thick. On the west side of Rosebud Creek at locality 2, in the SE. $\frac{1}{4}$ sec. 30 of the same township, the bed is only 6 feet 3 inches thick, with a shale parting 1 foot 10 inches thick near the middle. The average thickness of the coal throughout the area is between 6 and 11 feet.

Wall bed.—The Wall bed is divided into upper and lower benches in the northeastern part of the area, but there are at least two other beds locally associated with them, and it is difficult to make a definite correlation where the outcrops are poor. The stratigraphic position of these beds suggests a correlation with the Monarch and Carney beds in the main Sheridan field.

The outcrop of the Wall bed passes below stream level in the Tongue River Valley in the southern part of T. 7 S., R. 41 E. Northward from this point it forms a prominent clinker along Tongue River and the tributary valleys to the north boundary of the area, except along the valley of Hanging Woman Creek, where the Wall bed consists of several thin coal beds, and no prominent clinker is formed. Along the valley of Rosebud Creek in T. 6 S., R. 39 E., the burning of this bed has also produced a prominent clinker. It is the lowest clinker with the exception of a local clinker on the west side of the valley in sections 5 and 6.

The thickness of the Wall bed varies, but at nearly every locality where it is exposed it is a thick bed, and it contains a notable part of the reserve of coal in this field. Where it was measured the coal is thickest near its point of disappearance below stream level in the Tongue River Valley at locality 152, in the SW. $\frac{1}{4}$ sec. 14, T. 7 S., R. 41 E., where it is 32 feet thick. In the northeast corner of the area the bed is split into several thin beds, some of which are locally thickened. The coal is more than 6 feet thick at almost every place where it was measured, and in many places it is more than 10 feet thick.

The Wall bed probably persists as a thick bed south from the point where it passes below stream level in the Tongue River Valley, as its greatest thickness was measured there. As it appears to be equivalent to the Monarch and Carney beds, a thick coal bed at this horizon may underlie the entire area. The Monarch and Carney beds are thick where they are penetrated by the Absaroka well in T. 9 S., R. 40 E., and the Wall bed, at approximately the same horizon, is thick where the bed disappears below the level of the river about 13 miles northeast of the well.

Brewster-Arnold bed.—The Brewster-Arnold coal bed is about 235 feet stratigraphically below the Wall bed and is exposed only in the

northern part of the area. The bed is named from the mine on the Brewster-Arnold ranch, at locality 552, in the SE. $\frac{1}{4}$ sec. 23, T. 6 S., R. 43 E. This bed is tentatively correlated with the Sawyer bed of the Forsyth coal field. Within the portion of the Tongue River coal field described in this report the Brewster-Arnold bed forms the lowest prominent and persistent clinker south of Cooke Creek in the Tongue River Valley. It disappears below the level of Tongue River in sec. 30, T. 6 S., R. 42 E.

The maximum thickness of the coal was found at locality 101, in the SE. $\frac{1}{4}$ sec. 29, T. 6 S., R. 42 E., where the coal is at least 17 feet thick, and its base is concealed below the water level. At this location coal is blasted from the bank by local ranchers. The Brewster-Arnold bed disappears below the level of Tongue River a short distance south of locality 101. North of this locality many observations show the coal to be from 10 to 12 feet thick except at locality 69, where it is possible that only the upper "split" was measured.

Knoblock bed.—The Knoblock coal bed is stratigraphically about 170 feet below the Brewster-Arnold coal bed. It crops out for about a mile along the river bank near the line between Tps. 5 and 6 S. At locality 67, in the SE. $\frac{1}{4}$ sec. 34, T. 5 S., R. 42 E., 8 feet 4 inches of coal is exposed above the level of the water in Tongue River. Several drilled wells have penetrated the bed and have shown it to be 20 feet thick as far north as Birney.

PHYSICAL PROPERTIES

The coal of the Sheridan field is a subbituminous coal of good grade. It lies in thick beds, usually free of partings, and the content of ash is believed to be small. This coal is black and lustrous and does not exhibit pronounced woody texture. It begins to lose its moisture as soon as it is mined, and if exposed to a hot sun or to rain it will disintegrate rapidly, but it may be stored in a tight bin as long as a month without disintegrating. It is liable to spontaneous combustion, however, if stored in large quantity. The coal makes a satisfactory fuel if used promptly and close to the place where it is produced. Because of its abundance and accessibility this coal is used in the railroad locomotives traversing the region, but special grates are required to burn the coal, which has partly "slacked" by the time it is used.

CHEMICAL PROPERTIES

No samples of coal were collected within the area here described, as unweathered coal could not be obtained without excessive delay and expense. A fairly good index to the quality of the coal, however, is afforded by the analyses of four samples of fresh coal col-

lected from mines at Acme, Carneyville, Dietz, and Monarch, a short distance south of the State line. The analyses of the air-dried samples from these mines average about 14 per cent in moisture, 4 per cent in ash, and 10,458 British thermal units in heating value. Additional information regarding the quality of the coal in this area is given by laboratory sample 26149, which was collected from a prospect in the Crow Indian Reservation, and by laboratory sample 95879, which was obtained by Bass from the Brewster-Arnold mine, in the area here described. These two analyses may, however, represent slightly weathered coal and consequently are not entirely trustworthy. To afford a comparison between this coal and the coal with which it must compete in the market, some analyses of coal produced elsewhere in the region are included in the following table. All the analyses were made in the laboratory of the United States Bureau of Mines at Pittsburgh, Pa.

Analyses of samples of coal from the Sheridan coal field and some competing districts

Location	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
Acme mine, Wyo	25258	13.2	A C D	25.41 41.83 43.79	31.20 53.69 56.21	40.05 4.48 46	3.34 4.48 46	0.34 46	---	---	---	---	5,071 6,799 7,118	9,128 12,238 12,812
Mine No. 1, Carneyville, Wyo.	25305	11.1	A C D	22.11 40.10 41.67	31.23 56.14 58.33	43.73 3.76 39	2.93 3.76 41	.30 39	---	---	---	---	5,157 6,621 6,880	9,283 11,918 12,384
Mine No. 7, Dietz, Wyo.	25294	11.9	A C D	24.56 41.43 43.77	31.25 53.23 56.23	40.16 5.34 45	4.03 5.34 48	.34 45	---	---	---	---	5,076 6,729 7,109	9,137 12,112 12,796
Mine at Monarch, SE. ¼ sec. 24, T. 57 N., R. 85 W., Wyo.	25313	8.6	A C D	20.85 42.64 44.84	33.75 52.45 55.16	41.51 4.91 35	3.89 4.91 35	.26 33	---	---	---	---	5,337 6,743 7,091	9,607 12,137 12,764
Prospect in sec. 33, T. 7 S., R. 37 E., Mont.	26149	14.8	A C D	22.52 41.56 44.46	32.20 51.92 55.54	40.23 6.52 42	5.05 6.52 42	.30 39	---	---	---	---	5,050 6,518 6,972	9,090 11,732 12,550
Brewster-Arnold mine, sec. 23, T. 6 S., R. 42 E., Mont.	95879	9.7	A C D	27.3 39.8 42.5	28.9 53.9 57.5	39.2 6.3 ---	4.6 6.3 ---	.6 4.7 9	6.4 70.7 5.0	51.4 1.4 77.5	1.0 16.1 1.5	36.0 13.7 17.1	4,917 6,761 7,217	8,850 12,170 12,990
Strip mine at Colstrip, sec. 34, T. 2 N., R. 41 E., Mont.	A10685	5.4	A C D	22.3 37.2 41.2	28.9 53.0 58.8	41.2 9.8 ---	7.6 9.8 1.2	.8 1.1 5.0	6.0 4.5 5.4	54.2 69.7 77.3	.8 1.0 1.2	30.6 13.9 15.3	5,161 6,633 7,356	9,290 11,940 13,240
Bear Creek, sec. 31, T. 7 S., R. 21 E., Mont.	18694	3.6	A C D	11.74 38.60 42.66	34.07 51.89 57.34	45.80 9.51 1.64	8.39 9.51 2.10	1.68 4.76 5.26	50.60 68.61 75.82	56.1 1.85 2.04	1.63 13.37 14.78	22.24 33.7 14.78	5,977 6,772 7,484	10,759 12,190 13,471
Mine No. 4, Red Lodge, sec. 27, T. 7 S., R. 20 E., Mont.	29468	5.5	A C D	11.20 39.49 46.46	35.07 45.50 53.54	40.40 15.01 1.39	13.33 15.01 1.64	1.23 1.39 ---	---	---	---	---	5,623 6,332 7,450	10,121 11,398 13,410
Big Vein mine, Roundup, SE. ¼ sec. 4, T. 7 N., R. 26 E., Mont.	A2839	10.9	A C D	15.7 37.2 40.4	31.4 54.9 59.6	46.2 7.9 ---	6.7 7.9 1.2	1.0 4.9 5.4	5.9 72.6 78.8	61.2 1.2 1.3	1.0 12.2 13.3	24.2 12.2 13.3	5,956 7,061 7,667	10,720 12,710 13,800
Shields mine, near Gillette, sec. 28, T. 50 N., R. 71 E., Wyo.	87553	18.8	A C D	30.8 43.8 47.3	30.3 49.0 52.7	33.9 7.2 ---	5.0 7.2 ---	.3 4 4	6.7 4.7 5.1	47.8 69.1 74.5	.7 1.0 1.1	39.5 17.6 18.9	4,511 6,528 7,033	8,120 11,750 12,660

BURNING OF THE COAL BEDS

Detailed information as to the extent and thickness of the coal beds is somewhat difficult to obtain in fields whose coal has the composition of that found in the Sheridan coal field. There has been widespread burning of the coal beds along their outcrop in the northward extension of the Sheridan field, and the presence of coal is in many places indicated only by the presence of clinkered sedimentary rocks, which give the color to what the inhabitants of the region call the "red shale hills." The thickness and the color of the clinker may indicate roughly the thickness of the coal, on the assumption that a thick coal bed will burn longer than a thin one and will fuse a greater thickness of sediments and impart deeper colors—deep reds and purples—to the slags. This criterion, however, can be used only in a general way. Although the clinkered sediments effectively conceal the coal beds, they facilitate the tracing and correlation of the several beds. The line of outcrop shown on the map does not represent unburned coal only but indicates also the line at which the coal bed would intersect the surface if unburned. The approximate distance from the outcrop back to the unburned coal is determinable on some beds by observing the limit of the clinker on the surface. Where this is possible a dotted line has been drawn on plates 28 and 29 to show the limit of the clinker. If the rocks are exposed on a steep hillside such a line has not been drawn, for it would almost coincide with the line of outcrop.

Where the coal in closely adjacent beds has been burned the clinker from the burning of one bed merges with the clinker from the burning of the bed above, and it is impossible either to differentiate the coal beds or to estimate how much, if any, of the coal remains unburned. The surface of all of T. 8 S., R. 40 E., and parts of T. 8 S., R. 39 E., and T. 7 S., Rs. 39 and 40 E., is covered with clinker from the burning of three or more thick coal beds in a stratigraphic interval of 200 feet. It is probable that the upper bed, under shallow cover, is the only one burned throughout the area. The burning of coal beds and its physical and chemical effects on the overlying sedimentary rocks have been rather fully discussed by Rogers.¹⁷

FOSSIL WOOD

Logs and pieces of wood, some carbonized, some silicified, and some impregnated with compounds of iron but still retaining their fibrous structure, are present in abundance in the coal. The carbonized wood lies parallel to the bedding planes and forms lines of

¹⁷ Rogers, G. S., and Lee, Wallace, *Geology of the Tullock Creek coal field, Rosebud and Big Horn Counties, Mont.*: U. S. Geol. Survey Bull. 749, pp. 81–85, 1923. Rogers, G. S., *Baked shale and slag formed by the burning of coal beds*: U. S. Geol. Survey Prof. Paper 108, pp. 1–10, 1918.

weakness, so that many fracture planes of the coal show a covering of carbonized wood. Carbonized wood burns readily, and its presence is not detrimental to the coal. The silicified wood is usually associated with the thinner coal beds and those that are split by many partings and contain poor coal. Conditions that favor the silicification of wood are not favorable for the accumulation of coal. Plate 7, *B*, is made from a photograph of a silicified tree stump that is standing upright in a coal bed and was apparently silicified as rooted. The stump is 6 feet in diameter at the small end. Silicified wood occurs also in the SE. $\frac{1}{4}$ sec. 11, T. 7 S., R. 39 E., where there is a thick series of shale beds but practically no coal. At one horizon in the shale there are a large number of prostrate silicified logs and upright silicified tree stumps. The shale has been eroded, and now the surface of the ground is strewn with logs oriented in all directions, and the logs crossing one another with the stumps standing among them present a picture comparable to a modern windfall.

Probably the fallen trees and the stumps were quickly buried by mud, which has since been compacted into shale, and during this compacting the logs were compressed to an oval cross section and were bent where one lies across another. Silicified wood was noted in many places, but that which occurs at the two localities mentioned above is the most distinctive. Specimens impregnated with different iron compounds show various hues of red, orange, and yellow and have an attractive pattern in cross section. Such fossil wood has been used for making table tops and similar ornamental articles.

MINING

OPERATING MINES

Active mining in the northward extension of the Sheridan coal field is confined to small-scale operations providing coal for local domestic use. Practically every coal bed more than 3 or 4 feet thick has been mined in a small way, but usually the operations are crude and the pits or entries soon cave for lack of adequate timbering. A few of these mines have been worked for many years.

One of the largest of the wagon mines is Black's mine, at locality 271, in sec. 22, T. 9 S., R. 40 E., where an entry about 300 feet long has been driven from the side of a small coulee near the bank of Tongue River. Several rooms have been turned from this entry, which is about 8 feet wide by 7 feet high and is untimbered, some coal having been left for a roof. Some coal is mined at Black's mine each winter to supply part of the local demand. On the ranch of A. K. Craig, at locality 285, in sec. 14, T. 9 S., R. 39 E., an entry 6 to 7 feet wide and 6 to 9 feet high has been driven about 250 feet

into the hillside, and one room has been turned from the main entry. The entry is timbered at intervals, but as only the lower part of the bed is mined, several feet of coal is left as a roof. Not much coal is produced from this mine at present. At locality 312, in sec. 23, T. 9 S., R. 40 E., the Powers mine consists of an entry about 150 feet long, timbered for 30 feet at the entrance. At locality 42, in sec. 27, T. 6 S., R. 39 E., there is a mine with an entry between 125 and 150 feet long and one large room. The entry has been timbered, but coal has been taken from the roof above the timbers, making them practically useless. Coal is taken from this mine each winter. At locality 552, in the SE. $\frac{1}{4}$ sec. 23, T. 6 S., R. 42 E., coal has been mined for many years to supply domestic fuel for the Brewster-Arnold ranch. The main entry is between 250 and 300 feet long, and several rooms have been turned off. The entry is timbered for 30 feet at the mouth. The Stroud Creek mine, at locality 751, in the NE. $\frac{1}{4}$ sec. 2, T. 8 S., R. 43 E., is also one of the large wagon mines, and coal has been mined there for several years to obtain domestic fuel for the O. W. ranch. An entry, timbered for 50 feet from the mouth, has been driven about 200 feet. A short distance from the mouth the entry widens as coal is taken from the sides and roof. Coal is so plentiful in the area that almost every homesteader or rancher has dug one or more pits or entries to obtain his supply without hauling the coal from a larger mine that is used in common with several other families.

FUTURE MINING

Both north and south of the northward extension of the Sheridan coal field lie other areas containing large reserves of coal. On the south are the main Sheridan coal field and the Gillette field, which are crossed by the Chicago, Burlington & Quincy Railroad. In both of these fields large-scale mines have been opened, and immense reserves of coal are available in close proximity to the railroad. North of the area the two railroads in the Yellowstone River Valley pass through large areas of coal-bearing rocks, in some of which coal mining is already established. The Northern Pacific Railway makes accessible the coal at Red Lodge and Armells Creek, and the Chicago, Milwaukee & St. Paul Railway supplies transportation for coal produced in the vicinity of Roundup. There are also along both these railroads other areas which are capable of large coal production. Any coal marketed from the northward extension of the Sheridan coal field would, by necessity, be shipped over these railroads and therefore would have to compete with coal of about the same quality from these other fields. In view of the reserves still available adjacent to existing railroads, the coal in this part

of the Sheridan field should be regarded as a large reserve for future use, except as there may be local areas presenting especially favorable conditions for mining near such railroads as may be built across the field here described.

Areas favorable for strip mining.—Small tracts in this area are underlain by thick beds of coal to which access may be had by stripping off the thin overburden of soil and sedimentary rock. North of this area, on Armells Creek, in sec. 35, T. 2 N., R. 41 E., large-scale strip mining of the Rosebud coal bed near the base of the Tongue River member has been in progress since 1924 and has demonstrated that where the overburden is not too great coal adjacent to railroad lines can be mined in large quantities at a lower cost by strip mining than by the usual underground methods.

The localities that offer the best possibilities of strip mining lie along Tongue River where the river has widened its valley and removed most of the overburden from certain coal beds in small areas. The three largest areas where a thick coal bed may be present at a depth of less than 100 feet are shown on the map—one in secs. 1, 11, 12, 13, and 14, T. 6 S., R. 42 E.; another in secs. 33 and 34, T. 8 S., R. 40 E., and secs. 2, 3, 4, 11, and 15, T. 9 S., R. 40 E.; and a third near the mouth of Deer Creek, in secs. 12, 13, and 14, T. 9 S., R. 40 E.

The Knoblock bed underlies parts of the northern area at a maximum depth of 100 feet and in most places at a depth of less than 60 feet. The surface is a broad flat sloping gently eastward in a major eastward bend of the river. It is reported that a drilled well in the SE. $\frac{1}{4}$ sec. 1, T. 6 S., R. 42 E., struck 20 feet of coal 20 feet below the surface, and that a lower bench variously reported as from 10 to 19 feet thick lies 10 feet below the upper bench.

In the southern part of the area the possible stripping ground west of Tongue River extends from the valley of Spring Creek southward along the west side of the river. The greater part of the area is in the valley of Spring Creek and a small tributary south of Spring Creek, but alluvial flats farther south are also included. The lower part of the valley of Spring Creek and that of a small tributary south of it are wide and have a low stream gradient and are separated by a ridge that rises not more than 50 feet above the bottoms of the valleys. The quantity of coal that underlies this possible stripping area can not be determined from surface exposures, and therefore systematic drilling will be necessary before any large mining operation can be safely undertaken. Part of the area, near the mouth of Spring Creek, has already been prospected by drilling, but delay in the construction of the North & South Railway has caused development to be postponed.

The area east of Tongue River may be underlain by the Dietz No. 1 bed at a depth of less than 50 feet. A well in the NW. $\frac{1}{4}$ sec. 13, T. 9 S., R. 40 E., is reported to have penetrated more than 30 feet of coal, the top of which was less than 30 feet from the surface. The strata dip to the southeast and pass under thick cover in that direction a short distance from the well.

Other tracts observed in which the coal could be mined by striping are probably so small that the initial expenditure for equipment is not warranted.

Drift mining.—The coal in the ridges between the large tributaries of Tongue River can be mined from entries made on the outcrops of the beds. The coal beds slope very gradually and the structure-contour map (fig. 3) shows the general slope of the beds, so that for any given location of mine workings the direction and approximate angle of dip of the coal bed can be determined and the most favorable direction and grade for the haulageway can be established.

Transportation.—No railroad crosses any part of this area, and to transport coal mined on a commercial scale at the present time spur lines 20 miles or more in length must be constructed. Such lines would be used almost exclusively for carrying coal, as there are no local settlements or industries that would supply any large volume of freight or passenger traffic. However, the projected North & South Railway extending from Miles City, Mont., to Sheridan, Wyo., would be an important connecting link between points on existing railroads and would supply transportation either to the north or to the south for coal mined in this area. It is doubtful whether a large coal-mining industry can be established in the northward extension of the Sheridan field until such a railroad is built.

Room for spur tracks of moderate grade is available in the valley bottoms of most of the larger tributaries of Tongue River, such as Cook, Whitten, Bull, Prairie Dog, Canyon, Fourmile, Spring, Squirrel, Badger, Deer, Anderson, Harris, Dead Man, Wall, and Hanging Woman Creeks, and coal from mines along these creeks could be carried to a main railroad line in the Tongue River Valley.

DETAILS BY TOWNSHIPS

In the following pages the area is described by townships, which are taken in order from west to east, beginning with the northern tier of townships. The locality numbers mentioned in the text are shown on the maps (pls. 28 and 29), and the sections of the coal bed measured at these localities are shown graphically on Plates 10 to 27 and Figures 4 to 9.

T. 5 S., R. 41 E. (fractional).—In T. 5 S., R. 41 E., Cooke Creek forms the southern boundary of the Tongue River-Northern

Cheyenne Indian Reservation, and only the portion of the township south of the creek was mapped. The coal beds are burned at the outcrop almost everywhere, and few measurements of the coal could be obtained. The clinker from the burning of the Brewster-Arnold bed occupies the valley of Cooke Creek at the east range line, and the clinkers at the outcrops of the Wall, Canyon, and Anderson beds and three local coal beds were mapped in the southwestern part of the township. No measurements of the Wall bed could be made because of the clinker.

The Canyon bed was measured at locality 57, where the coal is 9 feet 7 inches thick. The local beds above the Canyon bed were each measured at one locality (localities 56, 54, and 55, from the lowest to the highest bed) and contain from 4 feet 8 inches to 7 feet 6 inches of coal. The Anderson coal bed formerly capped the divide south of Cooke Creek, but now the coal in this bed appears to be entirely burned, as the divide is capped with clinker. (See fig. 4.)

The Wall and Canyon beds contain the principal supply of coal, and the higher local beds are not important. Below the level of Cooke Creek, near the east range line, the Brewster-Arnold bed could be reached by a short shaft, and a large reserve of coal in that bed could thus be made available.

T. 5 S., R. 42 E. (fractional).—Beyond the narrow alluvial flats in the bends of Tongue River in T. 5 S., R. 42 E., the surface of the ground rises to a broad bench nearly 300 feet above the river. The bench is from half a mile to $1\frac{1}{2}$ miles wide. Above it the surface rises rapidly to the high interstream divide.

The lowest coal bed that crops out in the township is the Knoblock bed, which is exposed along the river bank in sections 33 and 34. At locality 67 there is 8 feet 4 inches of coal visible, with the base concealed below the level of the river. Coal is taken from this bank for local use. What is apparently the same coal bed was struck in a well at the Logan ranch, in the SW. $\frac{1}{4}$ sec. 25. Mr. Logan reported that 20 feet of coal at a depth of 20 feet was struck in this

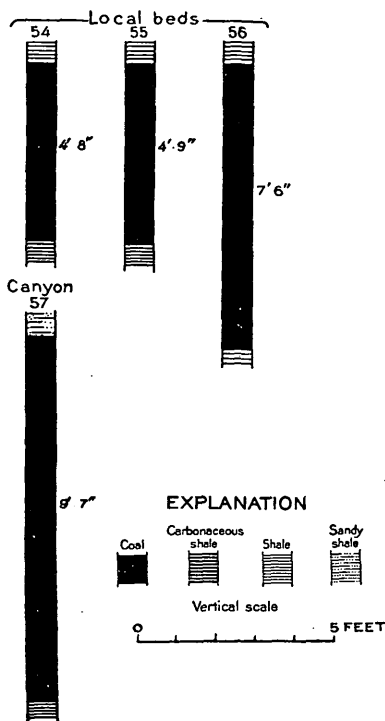


FIGURE 4.—Sections of coal beds in T. 5 S., R. 41 E., Mont.

well and that this coal also forms the bed of the river opposite the ranch house. A coal bed about 30 feet above the Knoblock bed crops

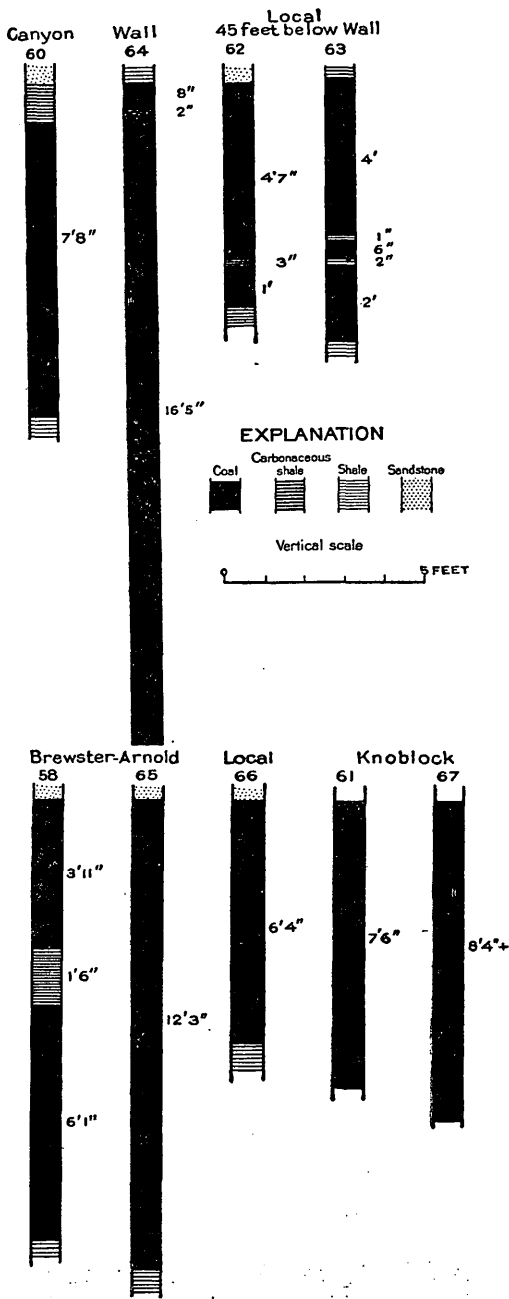


FIGURE 5.—Sections of coal beds in T. 5 S., R. 42 E., Mont.

out in a coulee at locality 61, near the south quarter corner of section 26. The coal is 7 feet 6 inches thick. The Brewster-Arnold bed is about 100 feet below the top of the broad bench described above. A thick clinker from the burning of the coal bed rims the bench, but the greater part of the bench is underlain by coal in this bed. The base of the clinker goes below the alluvium in the valley of Cooke Creek in the NW. $\frac{1}{4}$ sec. 21, but the clinker forms a prominent red wall along the edge of the alluvium for nearly 3 miles farther along the valley. Measurements of the coal were obtained at localities 58, 59, 65, and 66. At locality 58 there is a small mine that supplies coal for some of the neighboring ranches. At locality 59, across Cooke Creek from the mine, about 3 feet of the top of the bed is exposed where the coal has been taken out by a homesteader.

The Brewster-Arnold bed is 6 to 12 feet thick where measured in this township, and it may be assumed to contain a large reserve of coal under cover. The Wall bed was measured only at locality 64, where the coal is 16 feet 11 inches thick. Elsewhere the outcrop of the coal is

concealed by the clinker. About 45 feet below the Wall bed is a local lens of coal that was measured at localities 62 and 63. This bed has a thickness locally of about 6 feet, but the coal is split by several partings and is of little value. The Canyon bed was measured only at locality 60, where the coal is 7 feet 8 inches thick. The Anderson bed is the highest coal bed represented. No measurements were obtained on this coal bed, and it is believed to be entirely burned in this township, as the ridge is capped by a massive purple and red clinker formed by its burning. (See fig. 5.)

The Knoblock, Brewster-Arnold, Wall, and Canyon coal beds all contain large coal reserves, but in this township the position of the Canyon and Wall coal beds, high on the ridge, makes the coal inaccessible. The Brewster-Arnold bed offers the best possibilities for mining.

T. 6 S., R. 38 E. (fractional), and T. 6 S., R. 39 E.—The valley of Rosebud Creek is narrow, and the sides of the valley rise steeply 400 or 500 feet. The eastern third of T. 6 S., R. 39 E., is on the high rounded grass-covered divide between Tongue River and Rosebud Creek, where exposures of the coal beds are rare. The portion of the township west of Rosebud Creek is steep, rugged, and locally timbered.

The lowest coal bed exposed in T. 6 S., R. 38 E. (fractional), and T. 6 S., R. 39 E., makes a clinker low on the west side of the valley near the north township line. This local coal bed was measured only at locality 1, where 8 feet 1 inch of coal, having two thin shale partings near the top, is exposed. The coal is not exposed on the east side of the valley. The lowest persistent coal bed is the Wall bed, which is marked by a prominent clinker that extends the length of the township along both sides of the valley of Rosebud Creek. Only at locality 49 was this bed found unburned, and there the coal is 5 feet 6 inches thick. Where the Wall bed crops out in the townships on the east the coal is thick, and it may be assumed to be thicker here than the single measurement indicates. Above the Wall are the Canyon, a local bed found at locality 41, the Anderson bed, the Smith bed, and a thin local bed high on the divide. Measurements of the coal in the Canyon bed were made at localities 2, 38, 42, 52, and 53 and reveal thicknesses ranging from 5 feet to more than 24 feet of coal. Only one measurement (at locality 41) was made on the local bed above the Canyon bed. Measurements at localities 46, 48, and 51 show a maximum thickness of the Anderson bed of about 13 feet. The Smith bed is exposed only at localities 43 and 50, where it is about 7 feet thick. The highest coal bed exposed is a thin local bed, which was measured in isolated outcrops at localities 44, 45, and 47. As it is not possible to trace this upper coal bed continuously on the rounded grassy slopes, these measurements may not represent the

same bed. The Wall, Canyon, Anderson, and Smith coal beds contain important reserves of coal in these townships. (See pl. 10.)

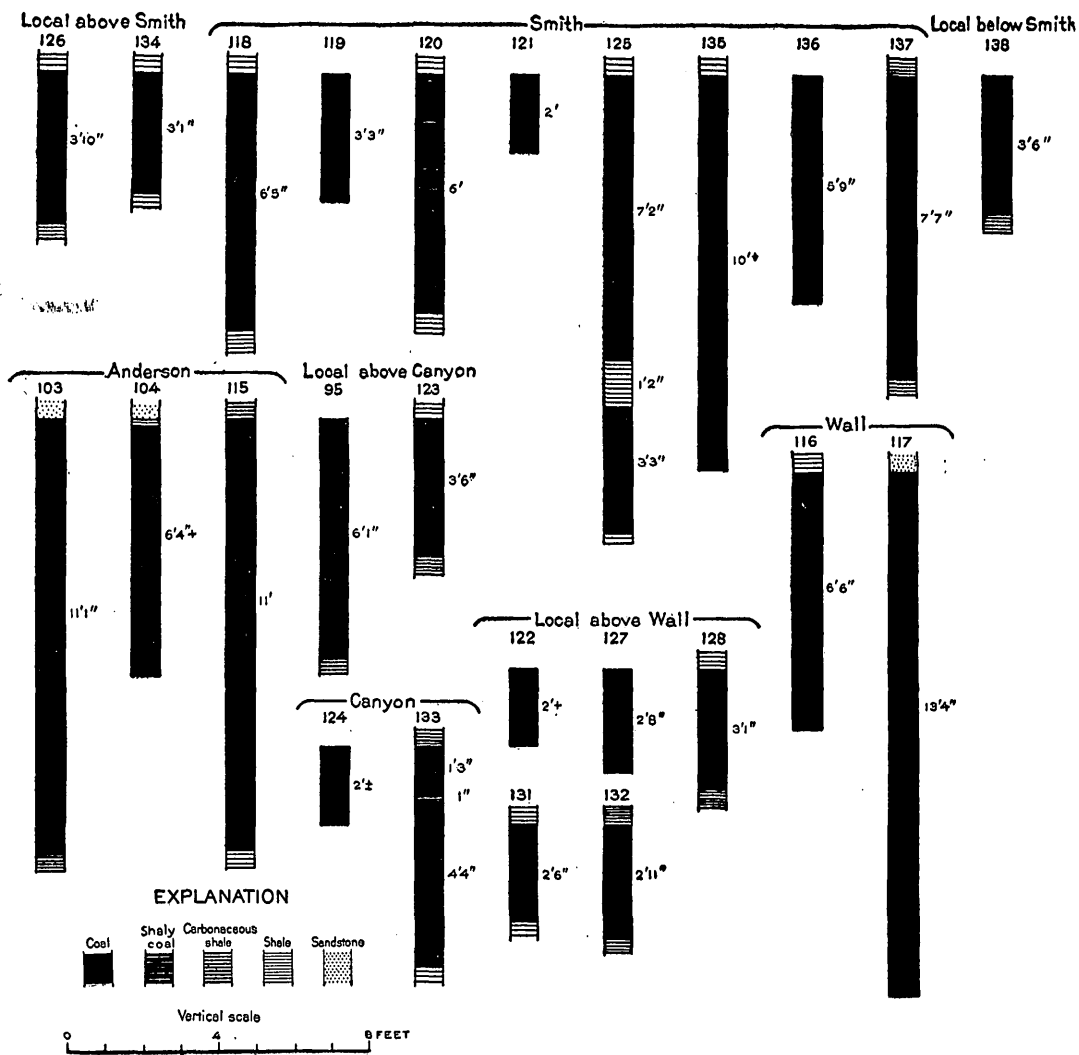
At the Holmes mine, locality 53, the Canyon bed is mined for ranch use and the bed is reported to be more than 6 feet thick. At locality 42 one of the largest mines in the area has been opened on the Canyon bed, and it supplies much of the domestic coal used near Kirby. The entry is 125 to 150 feet long and is about 6 feet wide and 8 feet high. It has been timbered, but coal has been mined from the roof above the timbers, leaving pillars of coal a foot or two high. One large room has been turned from the main entry. The coal contains water at the mine. At locality 38, near the point where the Canyon bed goes below the level of Dry Creek, a small entry has been made on the bed on the Johnson ranch. The entry was at the level of the creek, and as the water caused trouble the mine was abandoned, and the mouth of the entry is now caved. At locality 46, where the Anderson coal goes below the surface in Dale Creek, an entry about 25 feet long has been driven on the bed. Near locality 51 Mr. Hill has dug a well that struck the Smith coal at a depth of 36 feet. The thickness of coal is not known, as the well obtained water without penetrating the coal bed.

T. 6 S., R. 40 E.—Most of T. 6 S., R. 40 E., is on the upland that forms the Tongue River-Rosebud Creek divide. The surface of the greater part of the township is therefore of moderate relief and has the rounded grass-covered and locally timbered slopes typical of this part of the divide. In the southeastern part of the township the relief is greater and the valleys more precipitous, especially those of the tributaries of Canyon Creek.

The lowest coal bed exposed is the Wall bed, which crops out on the north fork of Canyon Creek. At successively higher levels a local bed, the Canyon bed, a local bed above the Canyon, the Anderson bed, a local bed above the Anderson, the Smith bed, and a local bed above the Smith are exposed. Burning at the outcrop has concealed the several coal beds throughout most of their extent, but a few measurements of the coal were obtained. The Wall bed crops out at localities 116 and 117 and has a maximum observed thickness of 13 feet. A local bed above the Wall bed is about 3 feet thick at localities 122, 127, 128, 131, and 132. The Canyon bed is about 6 feet thick at locality 133, and 2 feet of the top of the bed is exposed at locality 124. The local bed above the Canyon bed is from $3\frac{1}{2}$ to 6 feet thick at localities 95 and 123. The Anderson bed was measured at localities 51, 103, 104, and 115 and ranges in thickness from 6 to 11 feet. The local bed below the Smith was measured only at locality 138 and has a thickness of $3\frac{1}{2}$ feet, and the Smith bed was measured at localities 118-121, 125, and 135-137, where it ranges from 2 feet to over 11 feet in thickness. A local bed above the Smith bed con-



SECTIONS OF COAL BEDS IN T. 6 S., RS. 38 AND 39 E., MONTANA



tains less than 4 feet of coal at localities 126 and 134, though the two measurements may not have been made on the same bed. (See pl. 11.)

Of this series of coal beds, the Wall, Canyon, Anderson, and Smith beds contain the chief reserves of coal. The other beds are locally thickened and contain an available supply of domestic coal but are not adequate for large-scale mining.

T. 6 S., R. 41 E.—In T. 6 S., R. 41 E., the valleys have been cut about 500 feet below the general level of the interstream areas. Successively higher beds of coal crop out along the sides of the valleys, but the coal is almost everywhere burned at the outcrop, and although the several beds can readily be traced by the clinker, there are few places where the thickness of the coal can be measured.

The lowest bed in this township is a local bed called the Carlson, which crops out on Bull Creek near the east line of the township. Measurements of the bed at localities 93, 98, and 99 show about 4 feet of coal. Mr. Carlson has driven three entries on this bed, but has abandoned each of them because of the inflow of water and increasing impurity of the coal. Next above the Carlson bed is the Wall bed. The clinker from this bed is widespread in the township, but only partial sections of the bed could be measured at localities 94 and 109, where less than 4 feet of coal is exposed. A thin lens of coal developed locally contains 2 feet 10 inches of coal at locality 129. Except where this lens occurs, the Canyon bed is next above the Wall. Through most of the township the Canyon coal bed forms a clinker high on the sides of the valley, and only the narrow ridges between the streams are underlain by coal. The thickness of coal in the Canyon bed ranges from 2 feet 3 inches to over 12 feet at localities 96, 97, 102, and 105–108. A local bed above the Canyon contains from 4 to 6 feet of coal split by shale partings at localities 113 and 114. The Anderson bed has been entirely burned in this township, and its clinker caps the ridges. (See fig. 6.)

Of the beds exposed in T. 6 S., R. 41 E., the Wall bed contains the largest reserve of coal, though the Canyon bed is thick in the parts of the township where it has not been removed by erosion. The local beds are thin and are usually split by partings, so that they are of little importance where several thick beds of coal are present.

T. 6 S., R. 42 E.—Tongue River flows northeastward across T. 6 S., R. 42 E., and many short tributary valleys join the main valley. These tributary valleys with the high intervening ridges make the surface of this township among the most rugged in the area described in this report. The surface rises in a series of benches from the broad valley of Tongue River to the tops of the interstream ridges.

The Knoblock coal bed is the lowest bed found in this township. It crops out at locality 67, just north of the north line of the town-

ship, in T. 5 S., R. 42 E., and is reported to lie in the bed of the river northeast of the Brown ranch, in the SE. $\frac{1}{4}$ sec. 1. The Brown ranch is on the edge of a large flat that is underlain by the Knoblock bed at an average depth of about 60 feet. It is stated that a drilled well at the Brown ranch struck 20 feet of coal at 20 feet below the surface and that a lower bench, variously reported to be from 10 to 19 feet thick, is 10 feet below the upper bench.

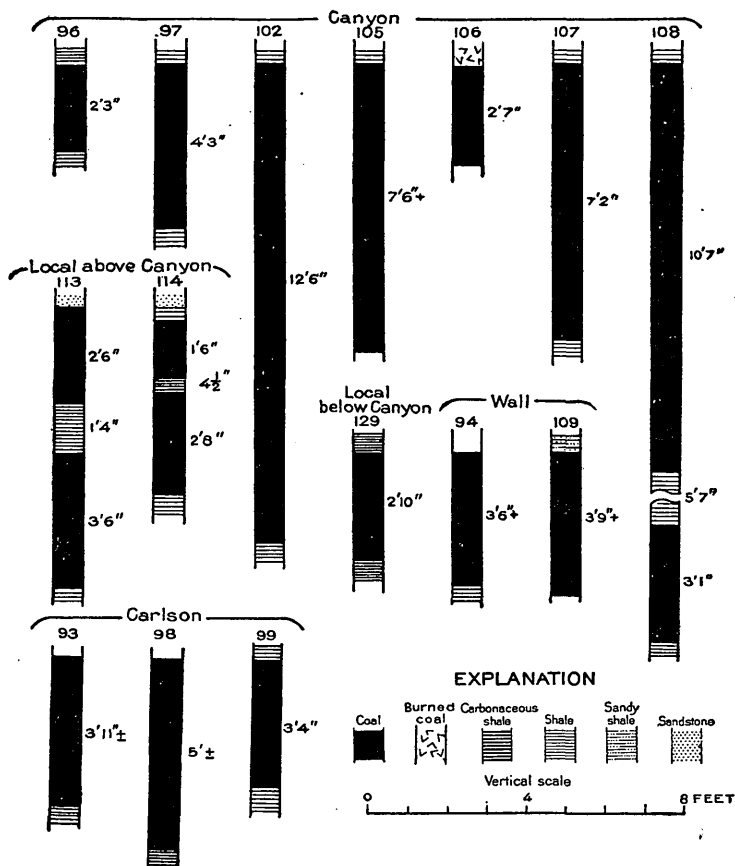


FIGURE 6.—Sections of coal beds in T. 6 S., R. 41 E., Mont.

The part of the flat that may be underlain by the Knoblock bed at a depth of less than 100 feet, and hence adapted to mining by stripping the overburden, is outlined on Plate 28. A thin bed, found only at locality 75, contains 2 feet 9 inches of coal. The Brewster-Arnold bed, 171 feet above the top of the Knoblock bed, forms the lowest prominent clinker along the west side of Tongue River in this township. The clinker rims a broad bench west of the river. Back of the bench the surface rises abruptly to the benches formed

by the clinker from the burning of the higher beds. The thickness of the coal in the Brewster-Arnold bed ranges from 5 feet to over 17 feet at localities 68, 69, 78, 80, 100, 101, 522, 525, and 552. An upper split of the Brewster-Arnold bed is 4 feet thick at locality 553. The next thick and persistent coal bed above the Brewster-Arnold is the Wall bed, but sections were obtained on two local coal beds below the Wall bed. Some coal has been taken from a shallow pit in the Carlson bed at locality 92, where the coal is 4 feet 7 inches thick. There is a local coal bed 45 feet below the Wall bed, along the valley of Tongue River, which ranges from 4 feet to almost 7 feet in thickness at localities 70, 76, 77, and 79. The Wall bed is widely burned, and the clinker from this bed forms a prominent bench west of the river; but east of the river it is split into a group of beds, none of which forms a prominent clinker. Measurements of the thickness of the coal at localities 72, 73, 81, 83, and 87 west of the river show from 3 to 14 feet of coal. The lower split was measured at localities 523, 526, 527, 534, 538, 546, and 551 and ranges in thickness from 5 to 12 feet. The upper split was measured at localities 524, 528, 533, 535, 539, 543, 546, 547, 549, and 559, where it averaged about 6 feet in thickness. A local bed about 20 feet above the Wall contains about 4 feet of coal at localities 542 and 539. There are several local coal beds between the Wall and Canyon beds. One about 90 feet below the Canyon is about 3 feet thick at localities 74, 82, 84, 86, and 88-91. Another bed 70 feet below the Canyon contains 4 feet or less of coal at localities 541 and 544, and a bed 20 feet below the Canyon is about 3 feet thick at locality 530. The maximum thickness in any of these beds is 4 feet 2 inches. The Canyon coal bed has been largely removed by erosion, although the higher ridges are still underlain by it. Measurements of the thickness of coal in the Canyon bed at localities 71, 85, 529, 532, 536, 537, 540, 545, and 548 show from 4 to 14 feet of coal. Above the horizon of the Canyon coal the surface continues to rise steeply to the inter-stream ridges, which are capped by thick red to purple clinker formed by the burning of the coal in the Anderson bed. In this township all the coal in the Anderson bed has been burned. (See pl. 12.)

The largest reserves of coal in T. 6 S., R. 42 E., are in the Knoblock, Brewster-Arnold, and Wall coal beds. The Canyon bed is thick, but it has small areal extent. Some coal has been mined from the Brewster-Arnold bed at localities 101, 522, and 552. The coal is dug from a cut bank along the river at locality 101 and from a small entry at locality 522. The entry of the Brewster-Arnold mine at locality 552 has been driven nearly 300 feet into the hillside. At locality 92 some coal has been mined from the Carlson bed.

T. 6 S., R. 43 E. (fractional).—The surface of the part of T. 6 S., R. 43 E., here described rises steeply from the valley of Hanging Woman Creek to the high divide between this creek and Tongue River, and several short, steep gulches empty into Hanging Woman Creek.

The lowest coal bed known in the area is the Knoblock bed. It does not crop out but is reported to be 20 feet thick in the school-house well at Birney. The Brewster-Arnold bed, 170 feet above the top of the Knoblock bed, contains about 10 feet of coal at localities 557, 558, and 562. A local bed 30 feet below it contains less than 5 feet of coal at localities 558 and 561, and an upper bench of the Brewster-Arnold bed contains about 4 feet of coal at localities 560 and 565-567. Next above the Brewster-Arnold are the Wall and associated beds. A local bed 25 feet below the Wall bed is about 5 feet thick at localities 559, 568, and 572, and the main bed has an average thickness of about 5 feet at localities 555, 563, 564, 569, and 579. A thin bed 50 feet above the Wall contains about 4 feet of coal at localities 556, 570, 571, 573, and 580-586. The Canyon and overlying beds are present in only a fraction of the part of T. 6 S., R. 43 E., here described, as they crop out high on the narrow divide. The Canyon bed is about 9 feet thick at localities 576 and 587. A local bed, less than 3 feet thick, 75 feet below the Canyon, was measured at locality 578. A coal bed between the Dietz No. 1 and Canyon beds is about 6 feet thick at localities 588 and 589. Above this bed the Dietz No. 1 crops out and averages about 5 feet in thickness at localities 574, 575, and 577. It was not recognized west of the divide between Tongue River and Hanging Woman Creek, and in this township it is usually burned at the outcrop and the clinker merges with that of the Anderson bed, which caps the flat-topped divide. All the coal in the Anderson bed has been burned. (See pl. 13.)

The Knoblock and Brewster-Arnold beds contain the most accessible and largest reserves of coal in this township. Some coal has been mined from the Brewster-Arnold bed at a cut bank of Hanging Woman Creek at locality 562.

T. 7 S., R. 38 E. (fractional), and T. 7 S., R. 39 E.—Rosebud Creek has cut a deep, narrow valley in the northwest third of the area, but west of the big bend in sec. 22, T. 7 S., R. 39 E., the valley is wide and shallow. East of the divide between Rosebud Creek and Tongue River the surface slopes southeast and the streams are not deeply incised, so the relief is small.

The lowest coal bed that crops out at the surface in T. 7 S., Rs. 38 and 39 E., is the Wall bed, which passes below the surface of Rosebud Creek near the north township line. The coal is burned at the outcrop, and no sections were measured. Above the Wall the Canyon coal bed is unburned at the outcrop at two localities. The coal is

more than 12 feet 5 inches thick at locality 5, where some coal has been taken from a cut bank. At locality 39 the Canyon coal is almost 9 feet thick where it is brought to the surface by an anticlinal fold that extends northwestward from this point and crosses Rosebud Creek half a mile north of Dry Creek. In the upper part of the valley of Dry Creek there is a clinker of a local bed above the Canyon bed. As the coal is everywhere burned at the outcrop, no measurements of it could be made. In the northern part of the townships the Anderson bed has formed the high clinker on the sides of the valley of Rosebud Creek. Measurements of the thickness of the coal in this bed range from $8\frac{1}{2}$ feet to over 24 feet at localities 3, 6, 7, 34, 36, 37, and 40. The Smith coal bed, marked by the massive sandstone underlying it, is next above the Anderson, and its average thickness is about 8 feet at localities 8, 9, 10, 29, 30, 37, 175, 176, and 178. Above the Smith bed in the southwest corner of T. 7 S., R. 39 E., and the fractional part of T. 7 S., R. 38 E., there is a thin but persistent coal bed whose outcrop is marked by springs. Its average thickness at localities 11, 16, 19, 22-24, 32, 33, 180, 181, 183, and 184 is about 4 feet. The Roland bed is the highest coal bed exposed in these townships and averages about $2\frac{1}{2}$ feet in thickness at localities 12-15, 17, 18, 20, 21, 25-28, 31, 35, 177, 179, 182, 185, 186, and 202. The coal is thickest at locality 186, where it measures 3 feet 4 inches. (See pl. 14.)

The coal beds known to contain valuable reserves of coal in these townships are the Canyon, Wall, Anderson, and Smith beds. Small openings have been made at a few localities to obtain domestic coal. At locality 6 C. A. Rugg has opened a small mine on the Anderson bed and at locality 176 there is a shallow pit in a cut bank where W. L. Adsit obtains his domestic fuel from the Smith bed. A small entry has been driven on the Smith bed at locality 29 by E. E. Kobold, but little coal has been mined.

Tps. 7 and $7\frac{1}{2}$ S., R. 40 E.—Canyon and Fourmile Creeks have cut deep valleys in the northern part of T. 7 S., R. 40 E. The sides of the valleys are steep, but the divide between these two streams is wide, grass covered, and of moderate relief. South of Fourmile Creek the rocks at the surface are almost entirely clinkered, and this portion of the township is part of the larger area extending southward where the several coal beds have burned and fused the overlying rocks.

The lowest coal bed that crops out at the surface in T. 7 S., R. 40 E., is thin and lies below the Canyon bed in the valley of Canyon Creek. Measurements of its thickness at localities 130, 145, 146, 147, and 159 show about 3 feet of coal. Of the important coal beds, the Canyon is the lowest one that crops out in this township, and it is

about 6 feet thick at localities 141, 144, 161, and 165. Thin local beds above the Canyon contain about 2 feet of coal at localities

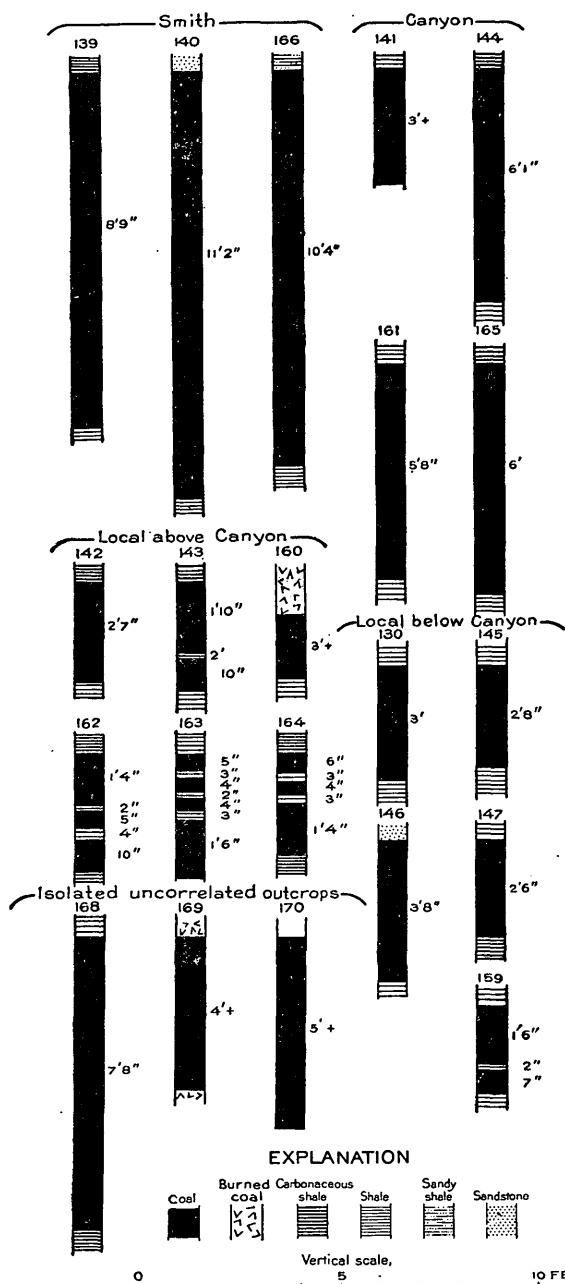


FIGURE 7.—Sections of coal beds in T. 7 S., R. 40 E., Mont.

142, 143, 160, and 162–164. The burning of the coal in the Anderson bed has formed a marked clinker high on the sides of the valleys of Canyon and Four-mile Creeks and has prevented any measurement of the thickness of the coal. The Smith coal bed is about 115 feet above the Anderson and is usually underlain by a massive sandstone that facilitates recognition of the bed. The average thickness of the coal at localities 139, 140, and 166 is about 10 feet. At locality 140 is a wagon mine where many ranchers obtain their supplies of domestic fuel. South of Fourmile Creek, in sec. 27, T. 7 S., R. 40 E., in the midst of the clinker area, an outcrop of a coal bed that appears to be the Anderson contains about 7 feet of coal at localities 168 and 170. Entries have been driven at these localities but are now badly caved. Another uncorrelated exposure of coal in

the midst of the area of clinkered rocks contains about 4 feet of coal at locality 169, in section 30. (See fig. 7.)

Tps. 7 and 7½ S., R. 41 E.—Tongue River flows northeastward across Tps. 7 and 7½ S., R. 41 E., and in the southwestern part of its course flows through a narrow, steep-walled valley that is commonly called Tongue River Canyon. Canyon and Fourmile Creeks, entering Tongue River from the west, and Harris Creek, from the east, occupy large valleys that offer access to the parts of the townships remote from the river. The sides of the Tongue River Valley and its large tributary valleys rise in a series of benches that are due to the resistance to erosion of the clinkers produced by burning coal beds.

The lowest valuable coal bed exposed in these townships is the Wall bed, which goes below the level of Tongue River near the center of T. 7 S. Some faulting and locally steepened dips obscure the relation of the Wall to overlying beds in sec. 22, T. 7 S., R. 41 E. North of the point where the bed appears above the level of Tongue River burning of the coal has produced a thick clinker. At locality 152 the Wall bed is 32 feet thick, and at localities 110, 111, and 150 it ranges in thickness from 9 to 15 feet. A local bed crops out at locality 153. A thin coal bed above the Wall contains from 3 to 6 feet of coal at localities 167, 171, 474, and 476 but is usually broken by one or more shale partings. A still higher coal bed, below the Canyon, is about 2 feet thick at localities 112, 148, 151, and 154. The Canyon bed, the next important bed above the Wall, could be measured at few places, as the coal is nearly everywhere burned at the outcrop. The thickness of coal at localities 149, 155, 156, 483, and 502 is about 12 feet. Several local beds are present in the interval between the Canyon and the overlying Dietz No. 1 bed, and measurements of their thickness were made at localities 157, 158, 477, 478, 482, 484, 499, and 501. None of these beds could be traced far, although some of them are as much as 8 feet thick. The Dietz No. 1 bed is not a valuable coal bed in these townships, as it thins toward the northwest, and west of the river no coal was found at this horizon. Measurements of the coal east of the river were made at localities 485, 487, and 488, where it is 4 to 6 feet thick. Clinker from the burning of the Anderson bed caps the high ridges on both sides of Tongue River. Partial measurements of the Anderson bed at localities 481 and 486 show 12 and 14 feet of coal, respectively. Above the Anderson clinker are several outliers of clinker formed by the burning of the Smith bed. All of the coal in this bed has been burned. (See pl. 15.)

The principal reserve of coal in these townships is in the Wall and Canyon beds and in lower beds that do not crop out.

T. 7 S., R. 42 E.—The surface of T. 7 S., R. 42 E., is deeply dissected by streams draining east or west from the high, nearly level divide between Hanging Woman Creek and Tongue River. East of the divide the area is drained by several short, deep gulches; west of the divide the area is drained by Harris, Dead Man, and Wall Creeks, which flow through broad valleys except near the divide, where the valleys are narrow and steep walled. The relief is about 800 feet.

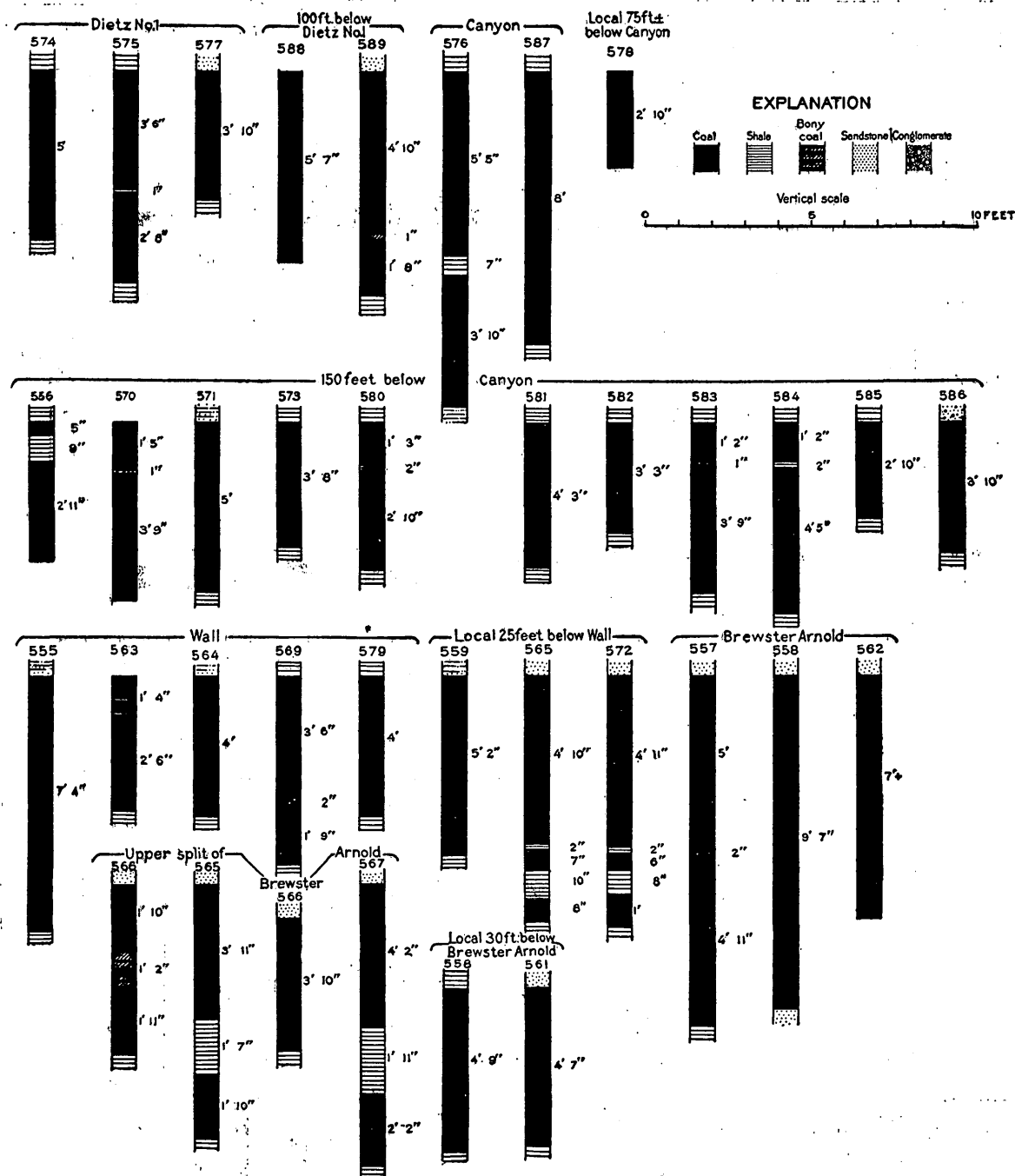
The lowest coal bed exposed at the surface in this township is the Wall bed, which was named from Wall Creek, where it forms a prominent clinker. A lower bed correlated with the Brewster-Arnold is reported to be 14 feet thick in a well drilled in the NW. $\frac{1}{4}$ sec. 6. The Wall bed is nearly everywhere burned at the outcrop and could be measured only at locality 521, where it is over 8 feet thick. A thin local bed about 40 feet below the Canyon bed is 1 to 3 feet thick at localities 511, 512, 518, 520, 531, and 610. The Canyon coal bed was measured at localities 503, 504, 510, 519, 609, 612, and 624. The coal is 6 to 12 feet thick where it crops out west of the divide, but east of the divide it is 3 to 5 feet thick. The coal is probably 6 to 8 feet thick in most of the area where it is under cover. In the SE. $\frac{1}{4}$ sec. 31, at locality 491, a coal bed about 8 feet thick crops out in a cut bank of a tributary of Harris Creek. Local beds above the Canyon and below the Dietz No. 1 contain from 2 to 7 feet of coal at localities 496, 505, 513, 514, 590, 608, 611, 625, and 630. The next valuable coal bed above the Canyon is the Dietz No. 1, which ranges in thickness from $2\frac{1}{2}$ to 13 feet at localities 495, 497, 498, 500, 506, 507, 509, 515-517, 631, and 633. West of the divide in the northern part of the township no coal was found at this horizon. Almost all the coal in the Anderson bed, which overlies the Dietz No. 1, has been burned, and the thick clinker caps most of the main divide and the interstream ridges. Unburned coal was measured at localities 508, 632, and 634, but the coal that crops out at locality 508 may not be the main Anderson bed. At locality 632 the coal is more than 20 feet thick, but at locality 634 a measurement of only part of the bed showed a thickness of 8 feet. Clinker from the burning of the Smith bed caps the higher parts of the divide in the southern part of the township. (See pl. 16.)

Some coal has been mined by Ernest Richards at locality 491, where a short entry has been made on a local bed.

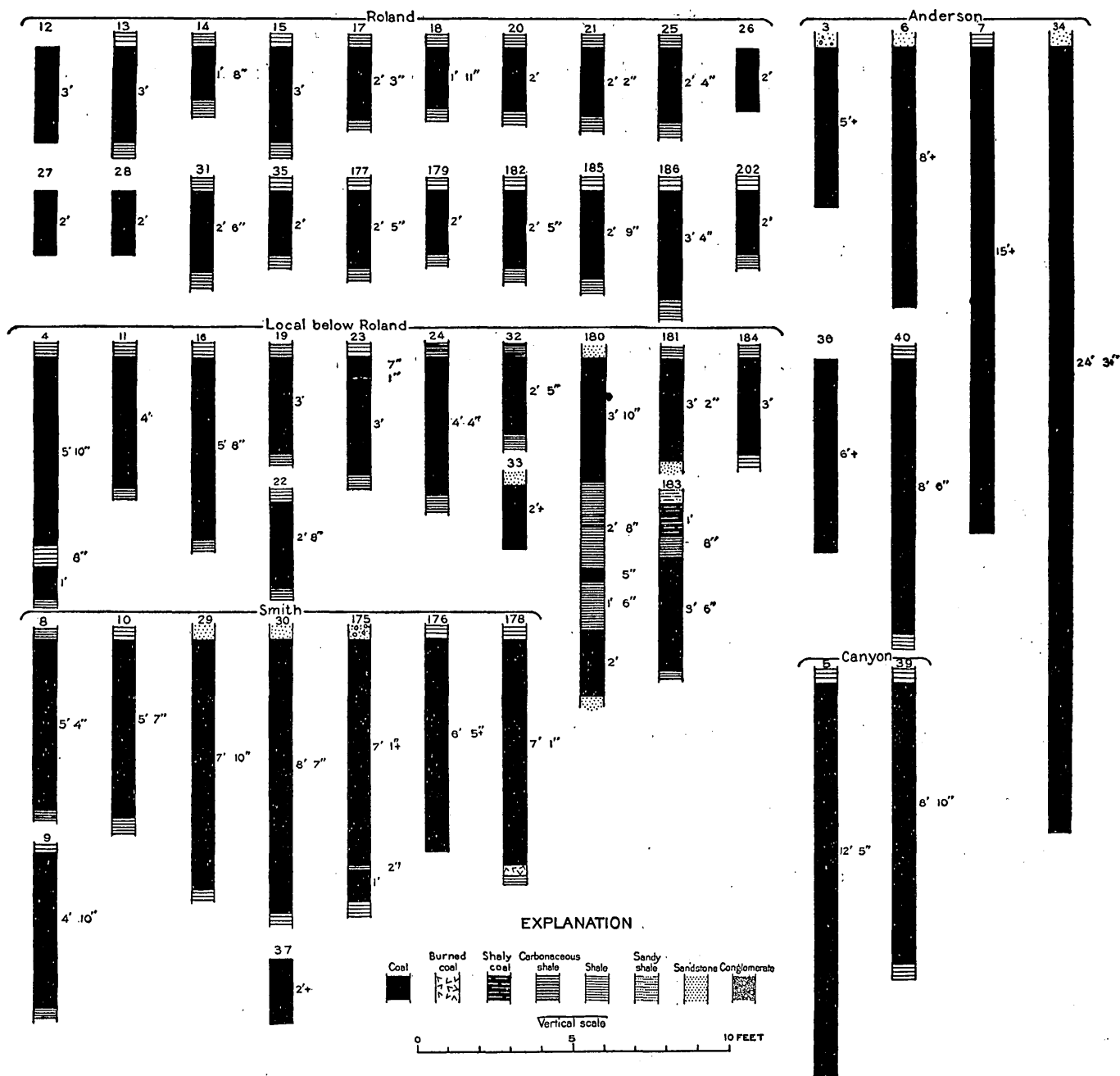
T. 7 S., R. 43 E. (fractional).—The narrow strip along the west side of T. 7 S., R. 43 E., that is described in this report includes the steep valley wall on the west side of Hanging Woman Creek. Several deep, narrow gulches dissect the valley wall, and the intervening ridges rise nearly to the same height as the main divide in the township to the west.



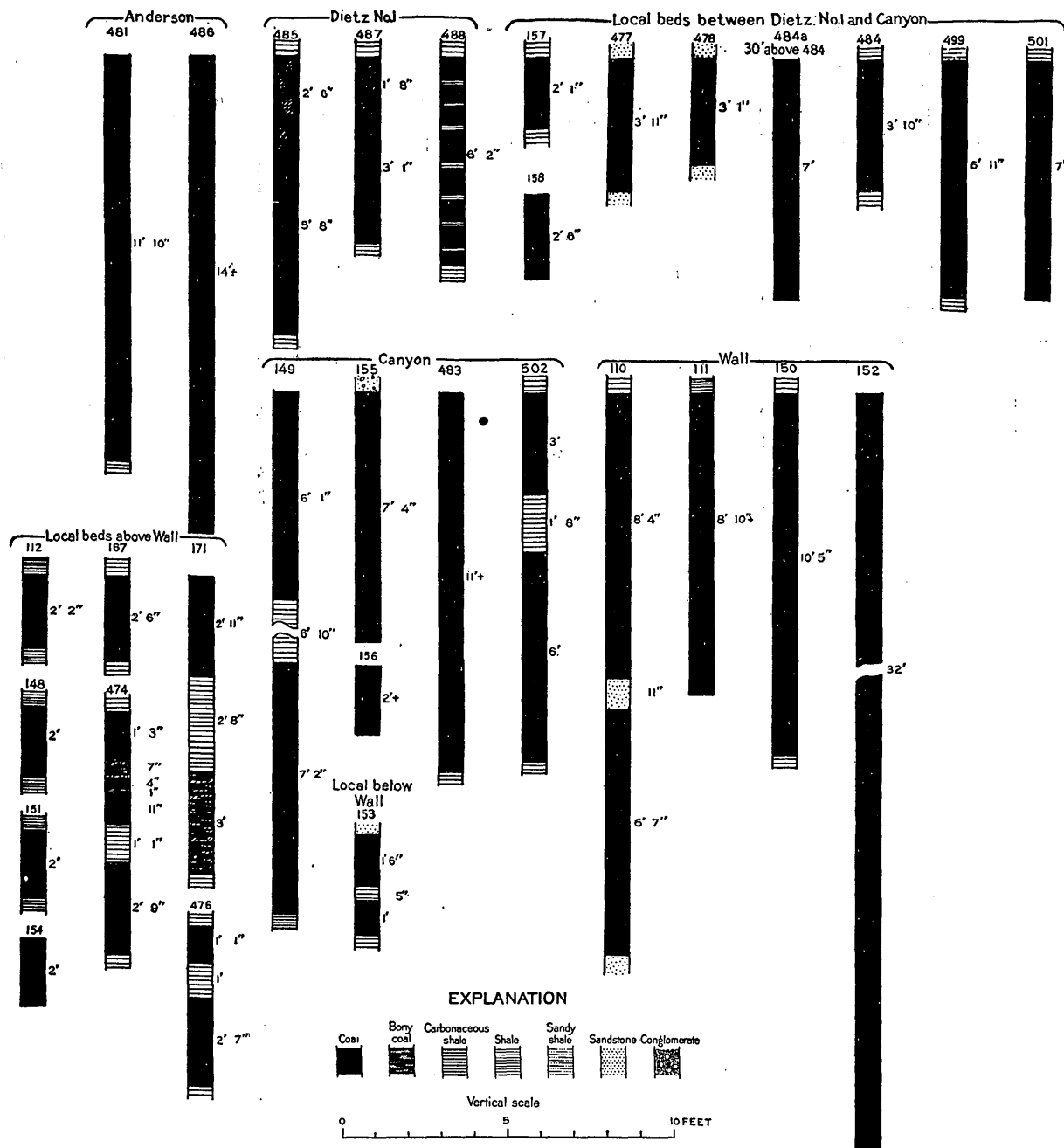
SECTIONS OF COAL BEDS IN T. 6 S., R. 42 E., MONTANA



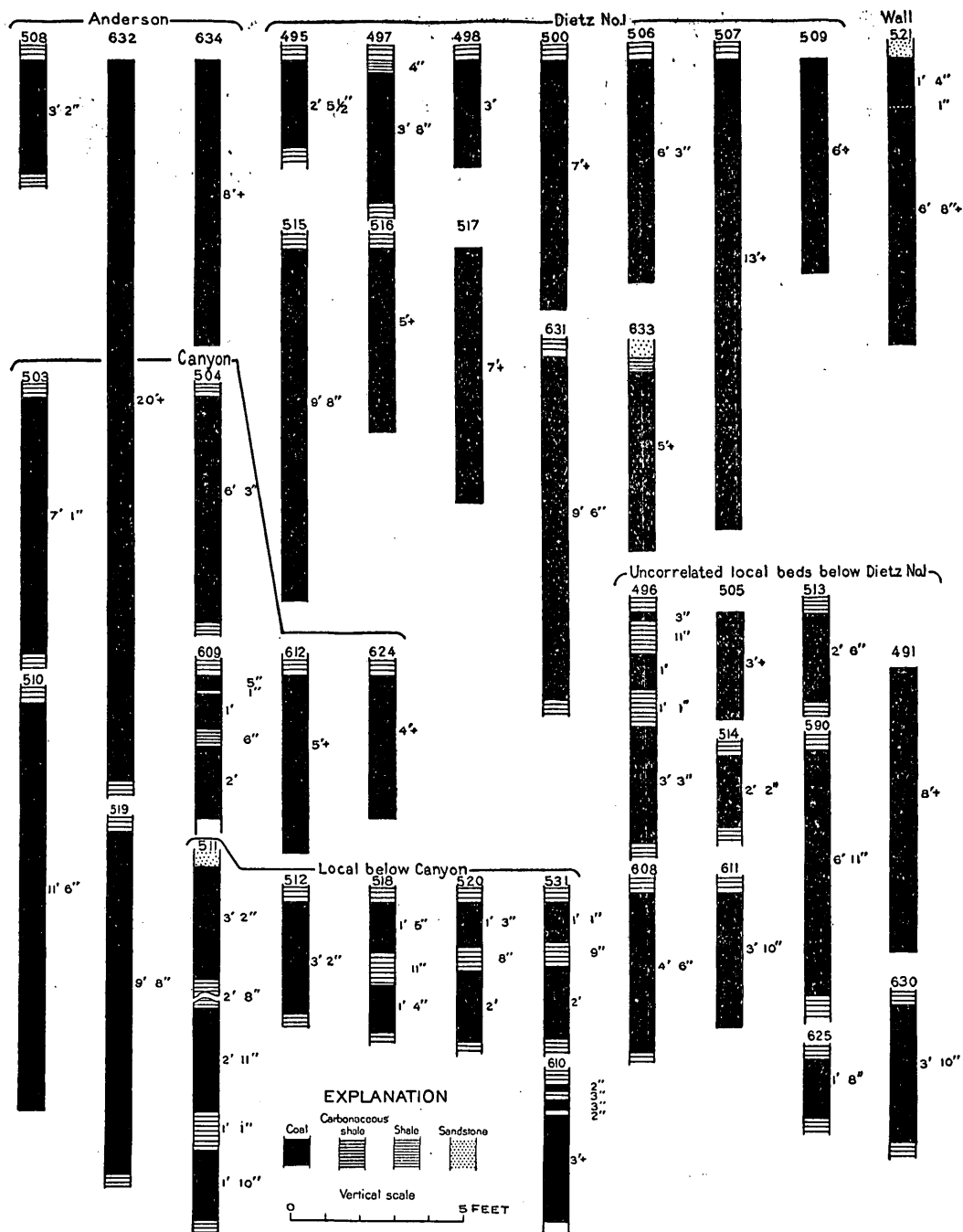
SECTIONS OF COAL BEDS IN T. 6 S., R. 43 E., MONTANA



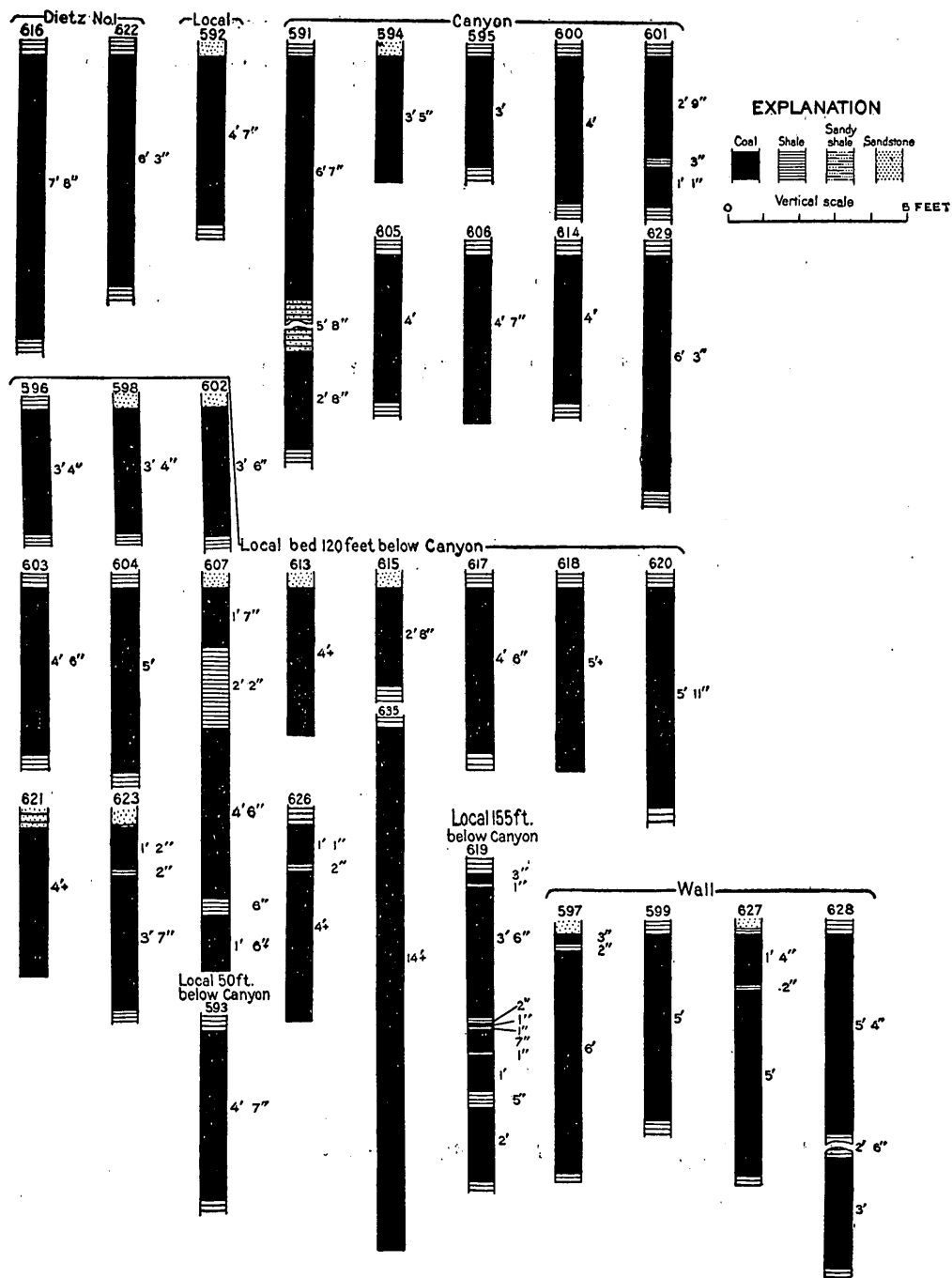
SECTIONS OF COAL BEDS IN T. 7 S., RS. 38 AND 39 E., MONTANA



SECTIONS OF COAL BEDS IN TPs. 7 AND 7½ S., R. 41 E., MONTANA



SECTIONS OF COAL BEDS IN T. 7 S., R. 42 E., MONTANA



SECTIONS OF COAL BEDS IN T. 7 S., R. 43 E., MONTANA

The lowest coal beds exposed in this township are several thin beds that were not traced throughout the township. Correlation of the outcrops is made on the basis of the interval below the Canyon bed. About 200 feet below the Canyon a coal bed correlated with the Wall averaged about 6 feet in thickness at localities 597, 599, 627, and 628. At locality 619 a coal bed about 155 feet below the Canyon is about 7 feet thick, although it is split by several partings. A bed about 120 feet below the Canyon ranges in thickness from 3 to 14 feet at localities 596, 598, 602-604, 607, 613, 615, 617, 618, 620, 621, 623, 626, and 635. At locality 593 a local coal bed 50 feet below the Canyon is 4 feet 7 inches thick. The thickness of the Canyon coal bed was measured at localities 591, 594, 595, 600, 601, 605, 606, 614, and 629. It thins northward from 6 feet 3 inches at locality 629 to 3 feet at locality 595. About 130 feet above the Canyon a local bed contains 4 feet 7 inches of coal at locality 592. The Dietz No. 1 bed is below the Anderson clinker, which caps the high interstream ridges. The coal was measured at localities 616 and 622, where it is about 7 feet thick. In the northern part of the area the clinker from the burning of the Dietz No. 1 bed merges with that of the Anderson bed. All the coal in the Anderson bed has been burned. (See pl. 17.)

Some coal has been mined from three small entries near locality 621.

T. 8 S., R. 38 E. (fractional).—The divides between the streams in T. 8 S., R. 38 E., are broad, nearly flat, and covered with grass. Only the coal beds in the upper part of the Tongue River member are exposed. The lowest coal bed that crops out is the Smith bed, which is about 12 feet thick at localities 201, 218, 219, and 297. There is a wagon mine at locality 218, from which a little coal is obtained each winter. A coal bed above the Smith and below the Roland is persistent through most of this township and is 2 to 6 feet thick at localities 203, 205, 214, and 216, in the northern part of the township, where the coal is thickest. The Roland bed crops out about 60 feet below the level of the flat-topped interstream areas. The bed is only locally burned at the outcrop, and measurements of the coal at localities 204, 206, 207, 211-213, 215, 217, 220, 232-239, 293, 294, 298, and 299 showed from 1 foot 6 inches to 6 feet of coal. The coal in the Roland bed is thinner at the north and thickens southward, as shown on Plate 18. The Smith coal bed is the only persistently thick bed in this township and the only bed known to contain notable reserves of coal.

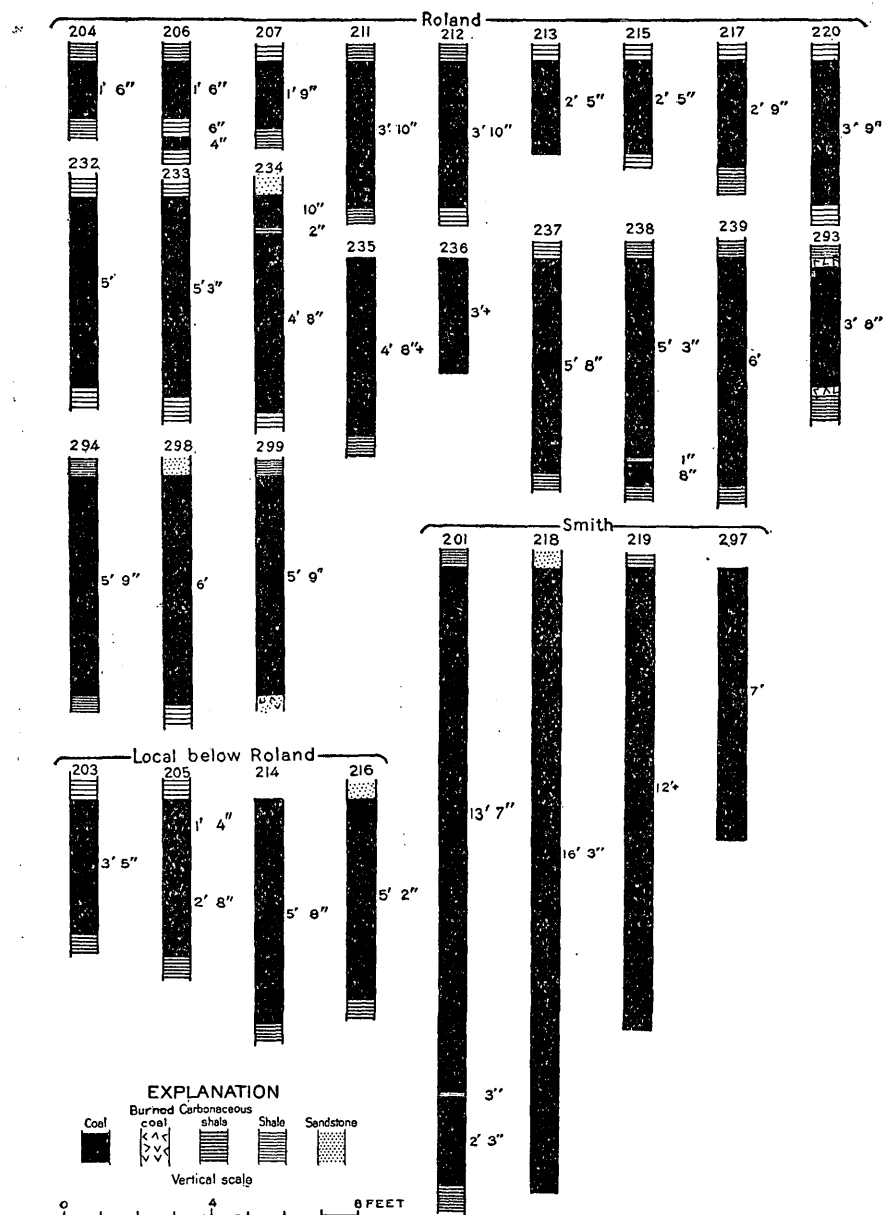
T. 8 S., R. 39 E.—Several broad, steep-walled valleys cross T. 8 S., R. 39 E., and in the southern and western parts of this township are separated by broad, flat-topped, grass-covered divides. Exclusive of one or two peaks that rise above the general level of the divides, the relief is about 300 feet.

The Dietz No. 1 coal bed is not exposed in this township, but a clinker from the burning of this bed extends a short distance into the township in the valley of the South Fork of Spring Creek. At the ranch of O. A. Miller, in section 24, a drilled well is reported to have struck the Dietz No. 1 coal at a depth of 70 feet. A coal bed below the Smith was measured at locality 230, where there is 3 feet 9 inches of coal, with the base concealed in the creek. No coal was noted at the same horizon elsewhere. The Smith bed is the lowest of the persistent beds exposed in the township and ranges in thickness from 7 to 17 feet at localities 190, 196, 197, 225-227, 229, 240, 243-249, 251, 291, and 295. Several entries have been made on the bed at locality 190, but at present not much coal is mined there. At locality 225 a small pit dug in the upper part of the coal is now caved. A short entry has been made at locality 295 by P. G. Fraser. Mr. Fraser formerly obtained his coal at an entry at locality 291, but that entry is now caved. Above the horizon of the Smith coal bed and below the Roland coal beds are one or more thin beds that were measured at localities 187, 191-195, 199, 200, 209, 210, 222, 228, 231, 241, 242, 252, 253, and 292. The coal at most of these localities is less than 3 feet thick and is badly split by shale partings. The uppermost bed that crops out in T. 8 S., R. 39 E., is the Roland bed. The coal in this bed is nearly everywhere burned at the outcrop, and the clinker forms a prominent rim at the top of the valley wall in the southern and western part of the township. The thickness of the coal at localities, 198, 208, 221, 223, and 224 averages about 5 feet. All these localities are in the northern part of the township, and the evidence in adjoining townships indicates that the Roland coal thickens toward the south. In the part of the southern half of this township which is underlain by the Roland bed the coal is probably 6 feet or more thick. (See pl. 19.)

The Smith bed contains the largest reserves of coal in this township, though the Roland coal also is important.

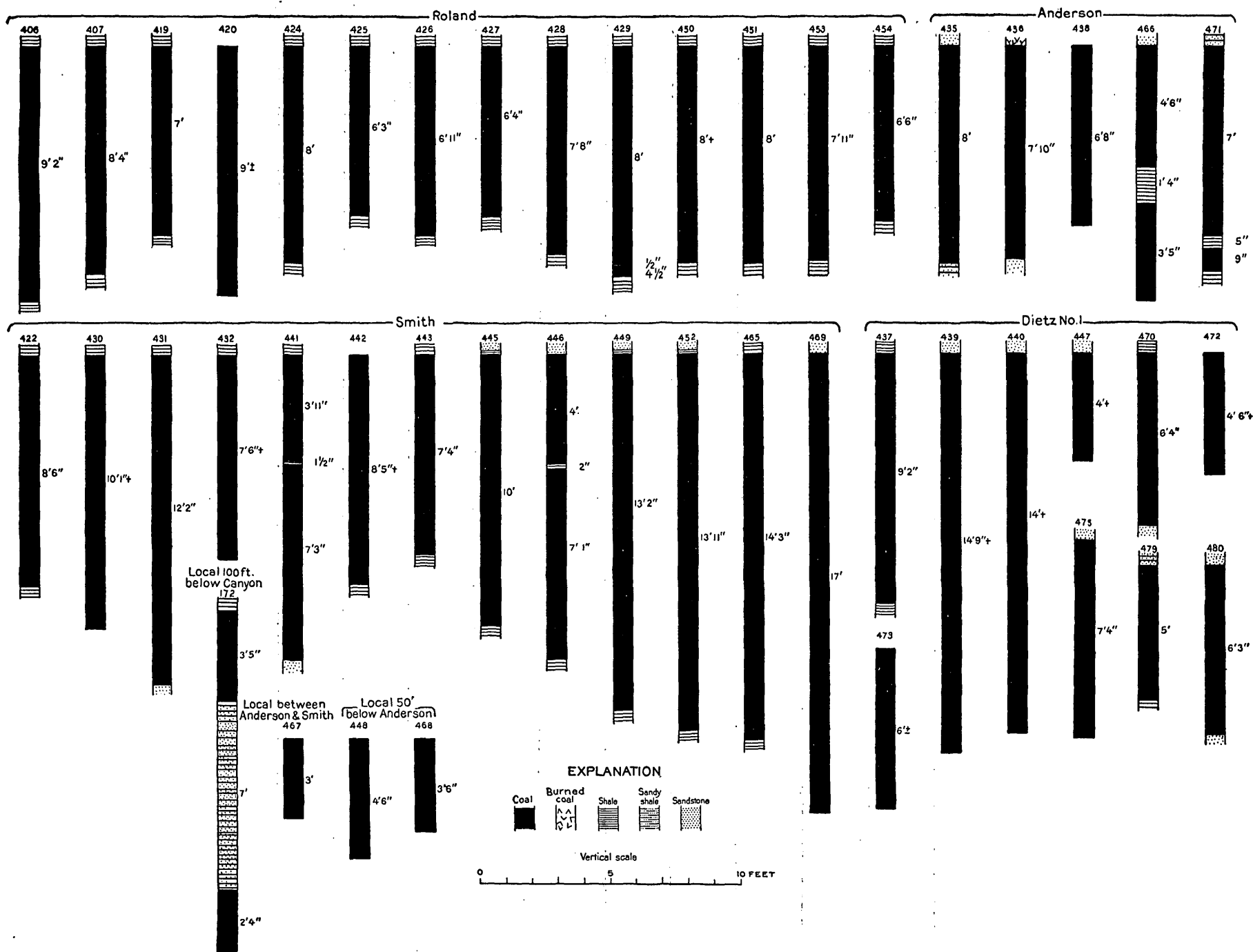
T. 8 S., R. 40 E.—Practically all of T. 8 S., R. 40 E., is included in the section of the area where most of the surface rocks are clinkered from the burning of several coal beds. Doubtless the burning in much of this section does not extend far from the outcrop, and thick coal beds could be found near the surface. However, the coal is concealed, and diamond-drill prospecting would be necessary to determine its thickness and purity and the most advantageous places to mine it.

The lowest coal bed that crops out in this township is the Canyon bed, which is 11 feet 2 inches thick at locality 444, where a short entry has been made. No other measurements of this bed were obtained. The coal bed reported to be about 20 feet thick beneath the flat at the mouth of Spring Creek may be the Canyon or perhaps a higher bed. The Dietz No. 1 bed contains from 7 to 15 feet of coal at locali-

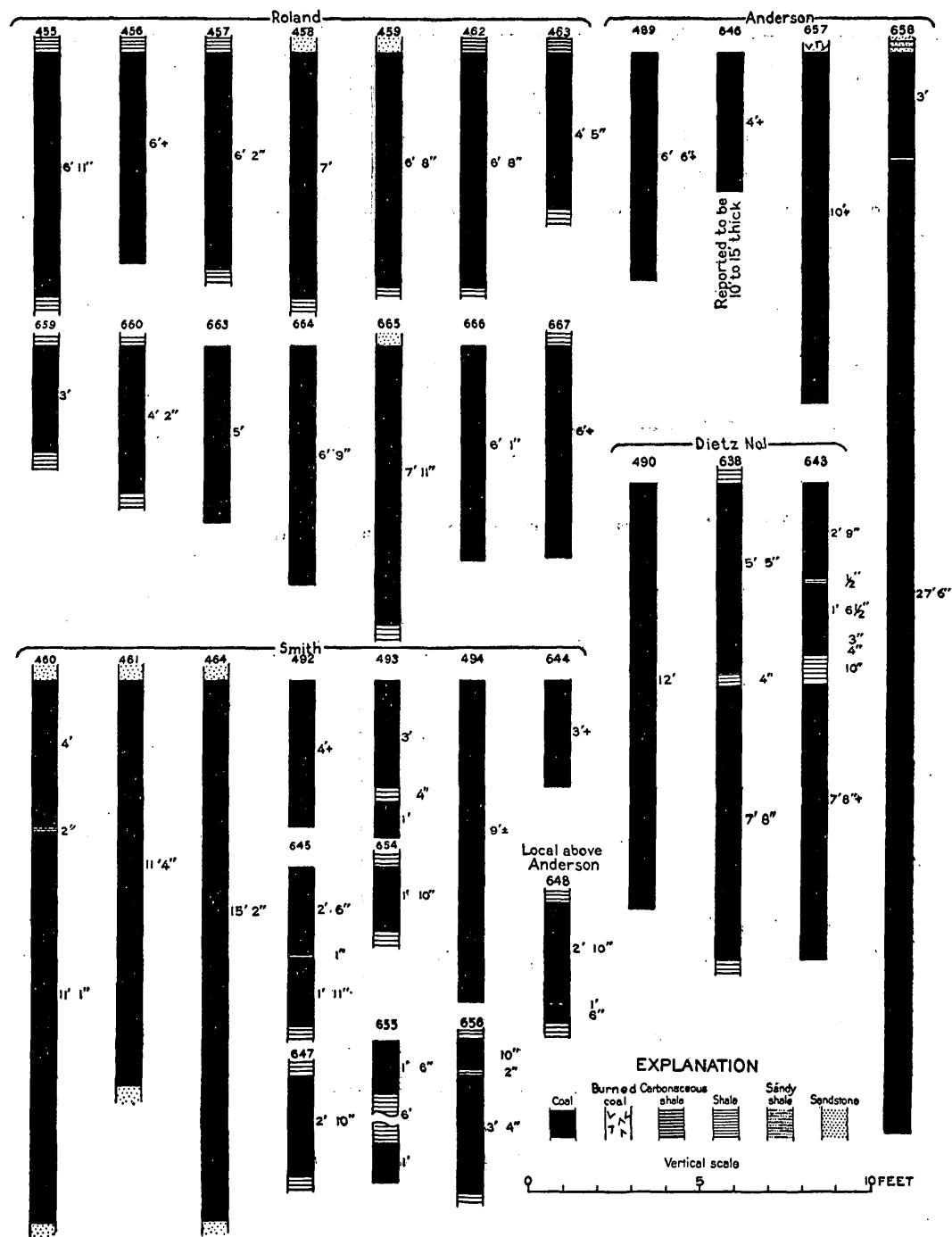


SECTIONS OF COAL BEDS IN T. 8 S., R. 38 E., MONTANA

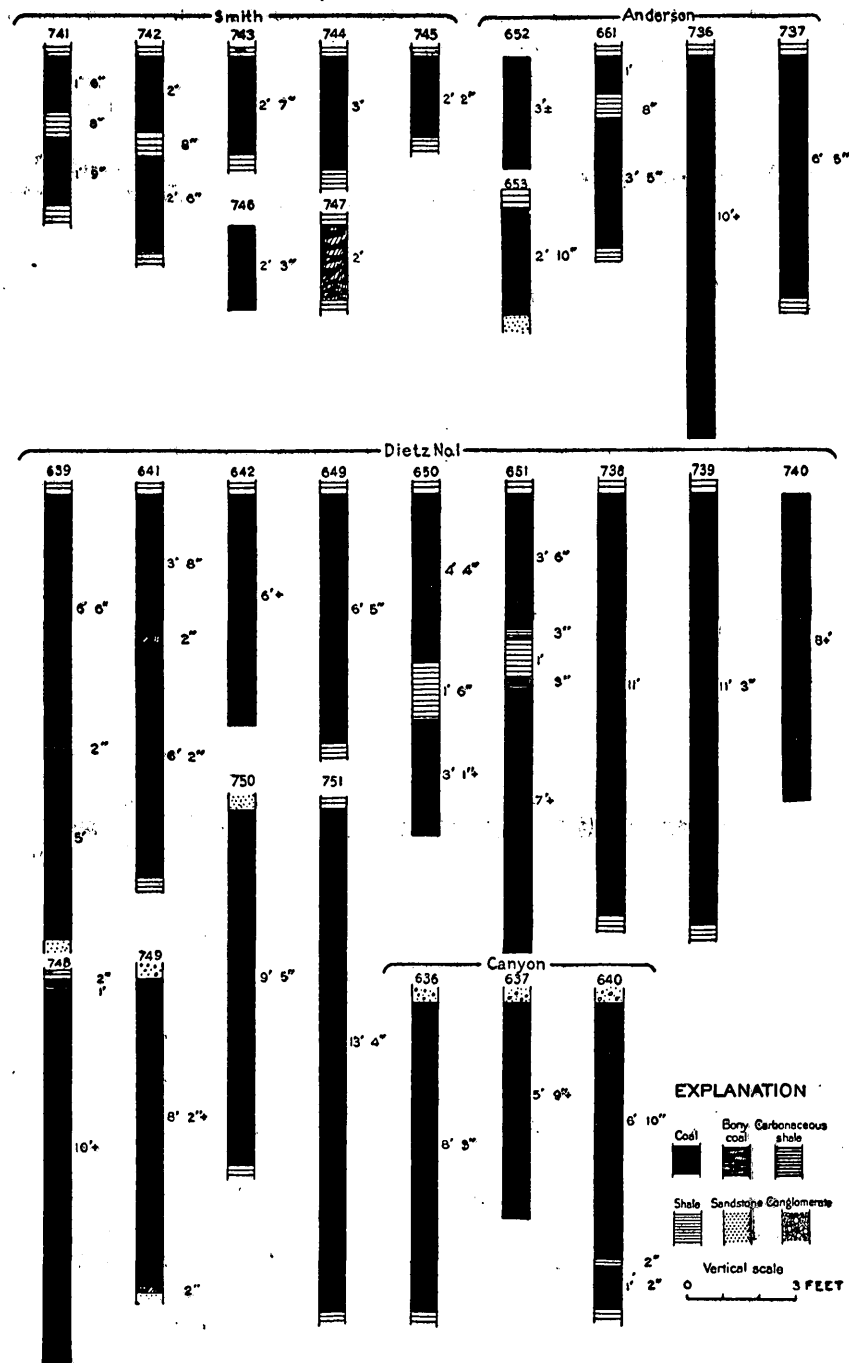




SECTIONS OF COAL BEDS IN T. 8 S., R. 41 E., MONTANA



SECTIONS OF COAL BEDS IN T. 8 S., R. 42 E., MONTANA



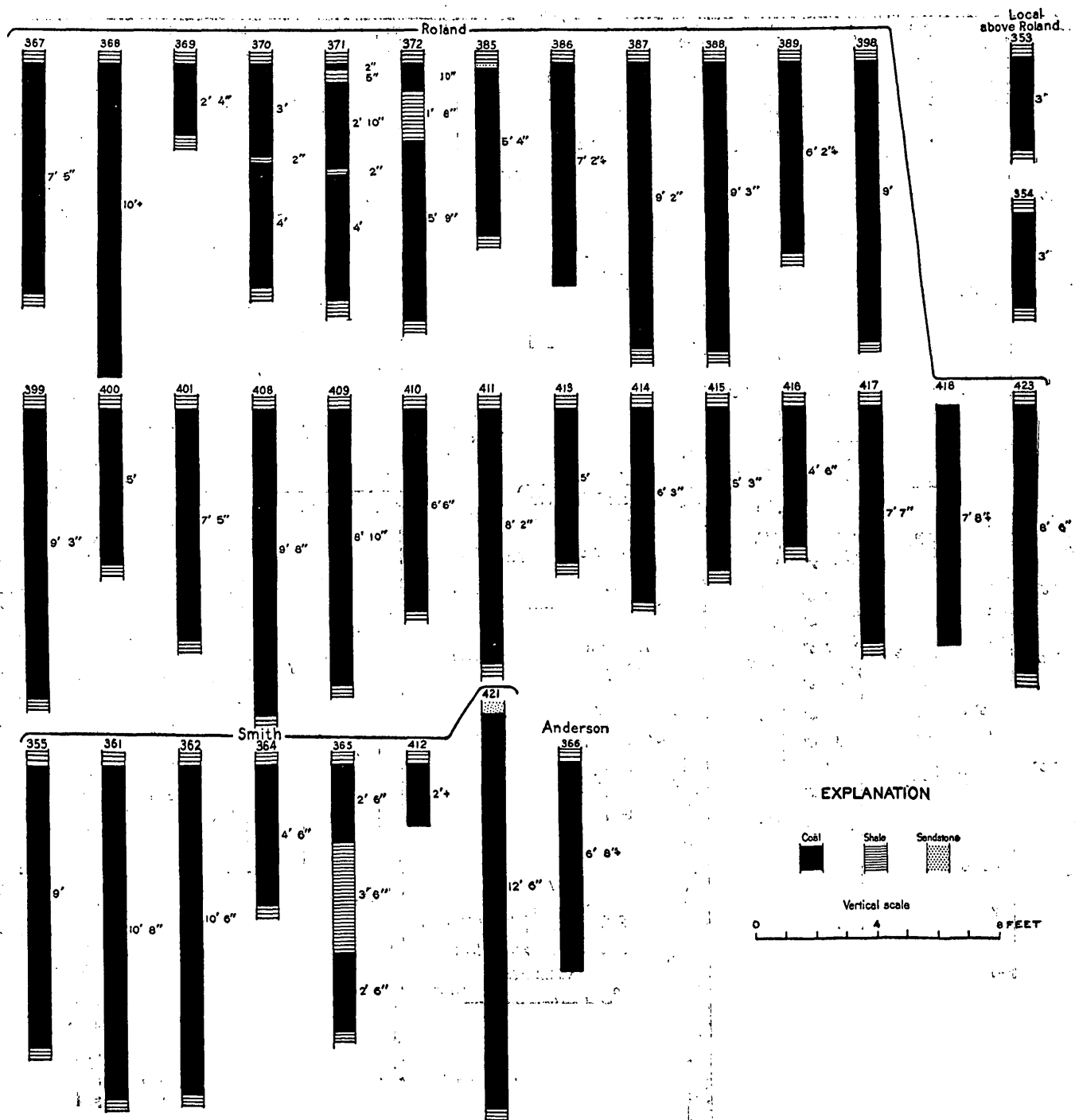
SECTIONS OF COAL BEDS IN T. 8 S., R. 43 E., MONTANA



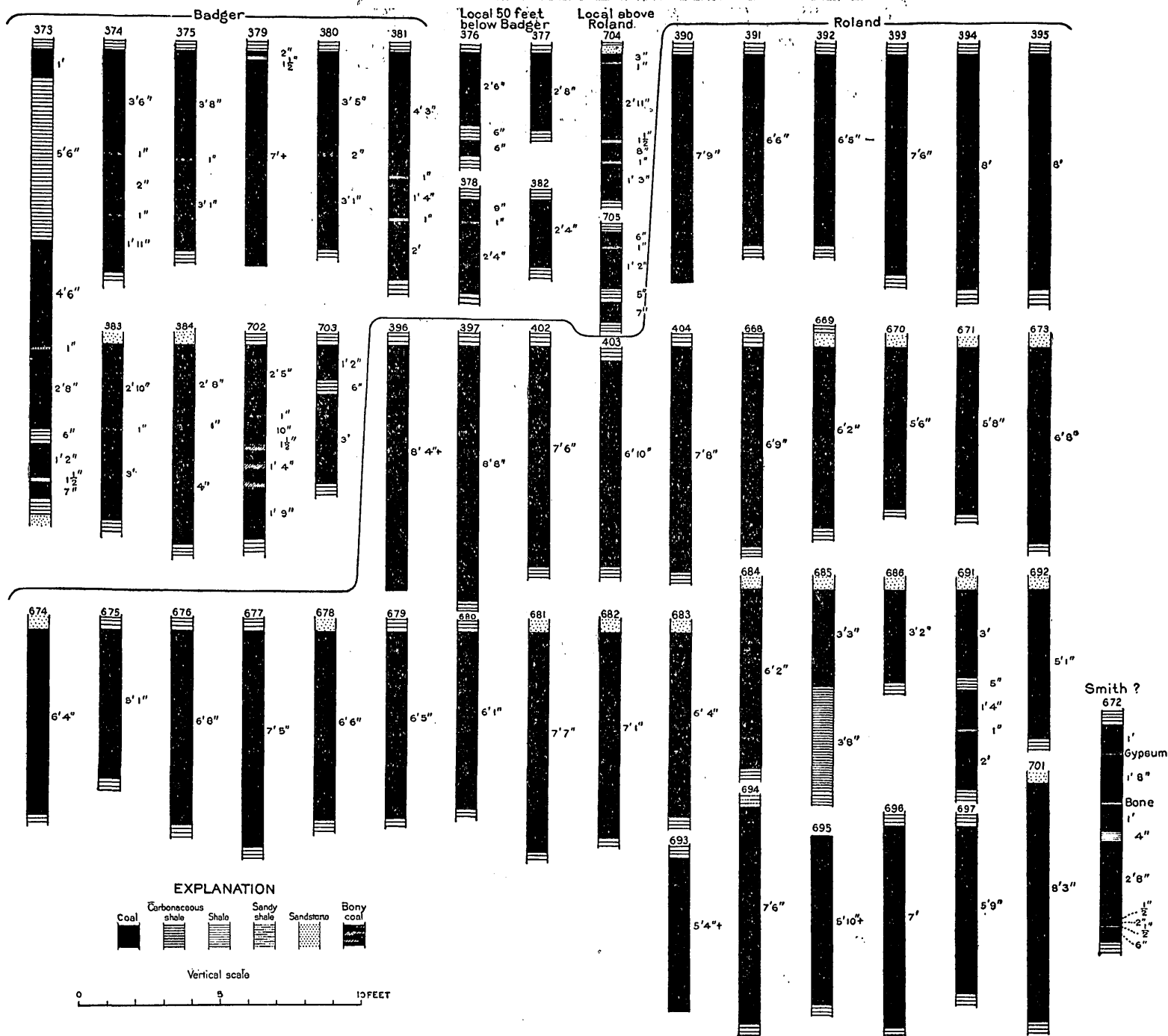
SECTIONS OF COAL BEDS IN T. 9 S., R. 39 E., MONTANA



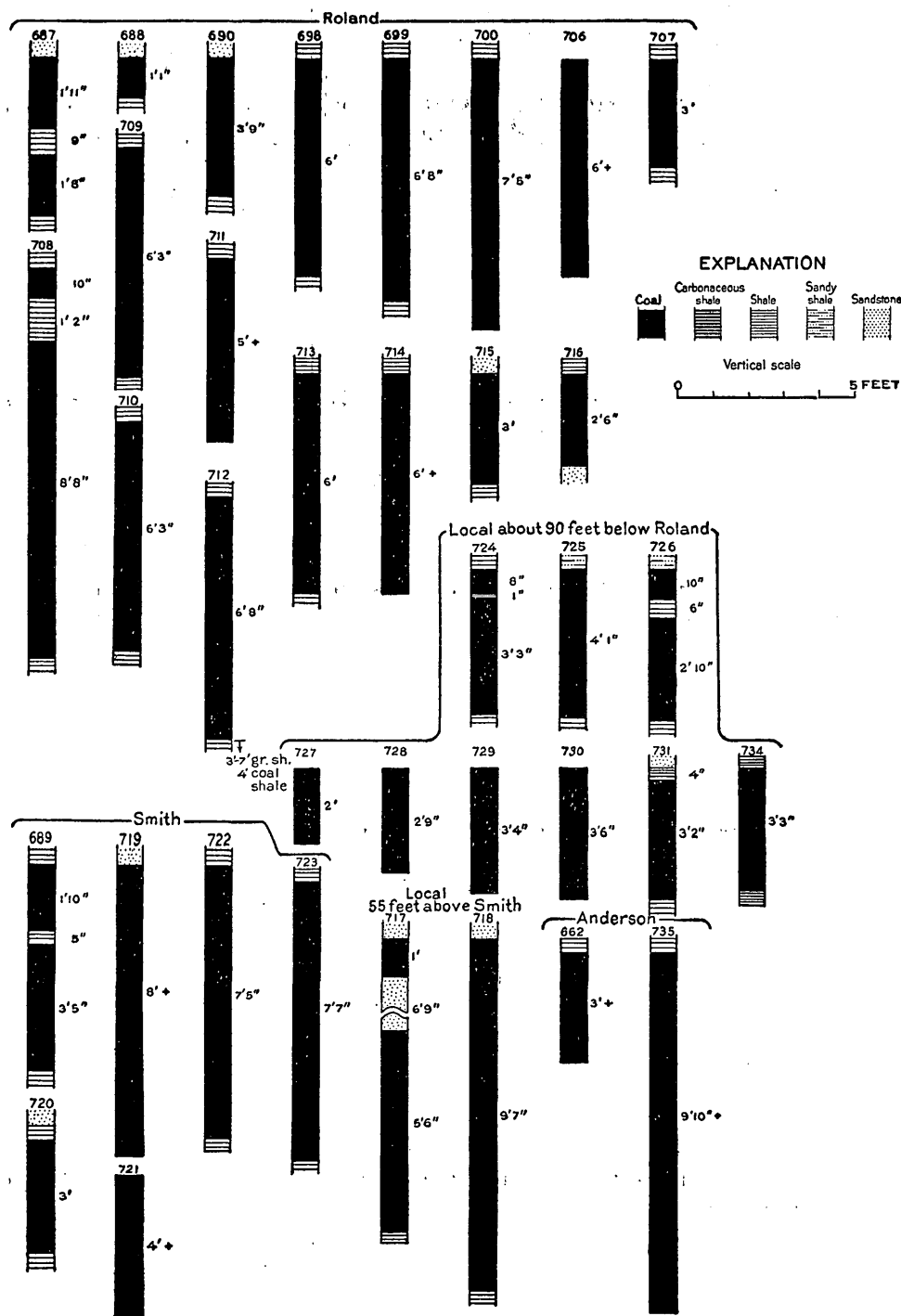
SECTIONS OF COAL BEDS IN T. 9 S., R. 40 E., MONTANA



SECTIONS OF COAL BEDS IN T. 9 S., R. 41 E., MONTANA



SECTIONS OF COAL BEDS IN TPS. 9 AND 10-S, R. 42 E., MONTANA



SECTIONS OF COAL BEDS IN TPs. 9 AND 10 S., R. 43 E., MONTANA

ties 188, 189, 433, and 434, where it crops out near the river in the southern part of the township. At localities 173 and 174 are outcrops of coal within the area where most of the surface rocks are clinkered, and the coal beds were not correlated. Some coal has been mined at both localities. Above the Dietz No. 1 the Anderson, Smith, and Roland beds are represented by some of the clinkered rocks. All the coal in the Roland bed and most of that in the Smith bed but not all of that in the Anderson bed had been burned. (See fig. 8.)

T. 8 S., R. 41 E.—The part of this area lying in *T. 8 S., R. 41 E.*, includes the canyon of Tongue River in the northwest corner and the divide between Tongue River and Hanging Woman Creek in the southeast corner. The relief is about 900 feet. Anderson Creek has cut a deep valley across the northern half of the township and affords access to the part remote from the river.

Several valuable coal beds crop out in this township. The lowest coal bed exposed is a local bed which was mined at locality 172 to supply fuel during the grading for the North &

South Railway. It contains coal in an upper bench 3 feet 5 inches thick and a lower bench 2 feet 4 inches thick, separated by 7 feet of sandy shale. The Canyon bed is the lowest one of the persistent beds that crop out, but it is burned at the outcrop, and no measurements of its thickness were made. The Dietz No. 1 bed was measured at localities 437, 439, 440, 447, 470, 472, 473, 475, 479, and 480 and ranges in thickness from 5 to 15 feet, thinning toward the north. A local bed

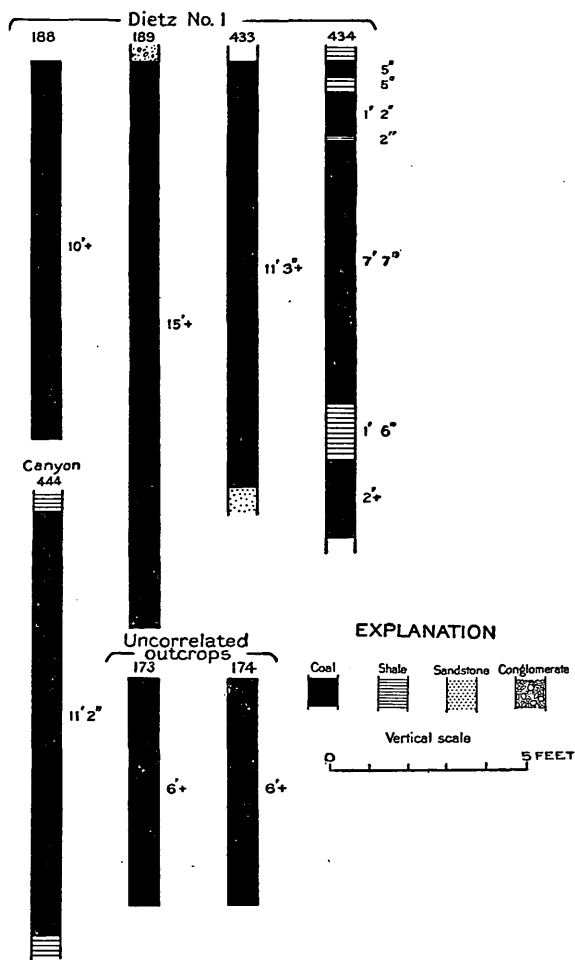


FIGURE 8.—Sections of coal beds in *T. 8 S., R. 40 E.*, Mont.

above the Dietz No. 1 contains about 4 feet of coal at localities 448 and 468. The Anderson bed has burned at the outcrop nearly everywhere, forming a prominent clinker. At localities 435, 436, 438, 466, and 471 the coal is unburned and averages about 7 feet 6 inches in thickness. A local bed between the Anderson and Smith contains 3 feet of coal at locality 467. The Smith bed at localities 422, 431, 432, 441-443, 445, 446, 449, 452, 465, and 469 ranges in thickness from 7 to 17 feet. The Roland bed, which underlies a small area in the southeastern part of the township, averages about 8 feet in thickness at localities 406, 407, 419, 420, 424-429, 450, 451, 453, and 454. (See pl. 20.)

There are no mines in this township, but some coal for domestic fuel is taken from the Dietz No. 1 bed at a cut bank in Coal Creek near locality 439.

T. 8 S., R. 42 E.—The surface of T. 8 S., R. 42 E., is dissected by deep valleys which head against the narrow ridge forming the divide between Tongue River and Hanging Woman Creek. The southern part of the area is treeless, but the steep slopes in the northern part bear small stands of timber.

The Roland, Smith, Anderson, and Dietz No. 1 are the principal coal beds in T. 8 S., R. 42 E. All the beds except the Roland are nearly everywhere burned at the outcrop, and few measurements of the coal could be made. The Dietz No. 1, measured at three widely separated localities (490, 638, and 643), is at least 12 feet thick. The bed is absent where the horizon is exposed along Wrench Creek in section 1, but its absence is local, as the bed is thick both east and west of section 1. The Anderson bed is the next above the Dietz No. 1 and is believed to be thick where under cover, although only four measurements could be made, and three of them are incomplete. At locality 658 the coal is 27 feet 6 inches thick, with 3 feet of impure coal at the top. Incomplete measurements showing from 4 to 10 feet of coal were made at localities 489, 646, and 657. A local bed above the Anderson is about 3 feet thick at locality 648. The Smith bed, measured at localities 460, 461, 464, 492-494, 644, 645, 647, and 654-656, is over 15 feet thick in the western part of the township but thins eastward, and no coal was found at this horizon in the southeast corner. The Roland bed underlies the divide in the southwest corner of the township. It is about 6 feet thick at localities 455-459, 462, 463, 659, 660, and 663-667. The coal thins northeastward, and there is no coal at this horizon where it crosses the divide in section 22. (See pl. 21.)

Some coal is mined each winter from the Smith bed at locality 460 and the Dietz No. 1 bed at locality 643. At each place the coal is mined from a cut bank, and no entries have been made. The coal is burning at locality 643, and at the present rate of advance of the burning all the coal at the outcrop will have been burned in the near

future. A small fault cuts the bed east of locality 643 and will limit the burning in that direction. The same coal bed, dropped down by the fault, crops out lower in the same gulch and in P. K. Creek near the east range line.

T. 8 S., R. 43 E.—In T. 8 S., R. 43 E., the sides of the valley of Hanging Woman Creek rise steeply 200 feet or more above the broad valley floor to the edge of a wide clinker-capped bench. Several streams have cut deep valleys in this bench, and these, together with the many gulches that have cut into the bench, make a rugged country that is accessible only with difficulty.

The lowest coal bed that crops out in this township is the Canyon bed, which is 6 to 8 feet thick at localities 636, 637, and 640. The Dietz No. 1 bed is the next valuable bed above the Canyon and averages about 11 feet in thickness where it was measured, at localities 639, 641, 642, 649-651, 738-740, and 748-751. It includes a large part of the reserve of coal in this township. The clinker from the burning of the Anderson bed caps the broad bench on each side of the valley of Hanging Woman Creek. Only a small part of the township is underlain by unburned coal in the Anderson bed. Measurements of the coal at localities 652, 653, and 661, 736, and 737 showed it to range from 2 feet 10 inches to over 10 feet, but the bed measured at localities 652, 653, and 661 is probably a lower split of the Anderson bed. The highest coal bed that crops out in this township is a thin bed correlated with the Smith. Its thickness at localities 741-747 ranges from 2 to 5 feet. A well drilled for water at the O. W. ranch, in section 16, is reported to have penetrated several coal beds within 500 feet of the surface. (See pl. 22.)

An entry about 200 feet long has been made at locality 751 to obtain domestic fuel for the O. W. ranch. No other mines have been opened in this township.

Tps. 9 and 10 S., R. 38 E. (fractional).—The parts of Tps. 9 and 10 S., R. 38 E., included in this report form a narrow strip along the boundary of the Crow Reservation north of the Wyoming line. The northern half of the strip is mainly on the grassy upland, and the southern half is cut by Tanner, Youngs, and Little Youngs Creeks.

The upper coal beds crop out around the edge of the upland in the northern half of the strip, but they have been eroded from the lower ridges in the southern half. The lowest coal bed that crops out is the Smith bed, which is burned at the outcrop in most places. Its thickness could be determined only at localities 296, 345, and 348, where it averages about 6 feet. Above the Smith coal bed a local bed is 10 feet 8 inches thick at locality 349, in the SE. $\frac{1}{4}$ sec. 36, T. 9 S. The Roland is the next persistent bed above the Smith coal bed. Its outcrop rims the upland that forms the divide between

Squirrel and Tanner Creeks, but it is nearly everywhere burned at the outcrop. At localities 346 and 347 the coal is 9 to 13 feet thick. The coal in the Roland bed is thicker in this part of the area than in the townships farther north that have been described. The high-

est coal bed is a bed above the Roland on the north side of Tanner Creek. It is everywhere burned at the outcrop, and its thickness could not be determined. This bed does not underlie a large area, for it can not be traced much more than a mile to the east in the next township, and no coal is found at the same horizon on the sides of the Squirrel Creek Valley. (See fig. 9.)

The Roland and Smith coal beds contain the chief reserves of coal in this strip.

T. 9 S., R. 39 E.—The deep, narrow valleys of the streams that drain the surface of T. 9 S., R. 39 E., are separated by broad grassy divides of small relief. The valleys have been cut about 300 feet below the surface represented by the inter-stream areas.

The lowest coal beds that crop out in the township are two local lenses in the southern part. The lower one is about 6 feet thick at localities 323, 327, 328, and 330. The coal in the upper bed ranges in thickness from 3 to 6½ feet at localities 324–326, 329, 331, and 332. Farther west a coal bed ranges from 4 to 10 feet on isolated outcrops at localities 333, 334, 350, and 351. These outcrops may or may not be all on one coal bed. An entry has been driven about 40 feet at locality 334. The Powers coal bed is the lowest persistent coal bed, though it could not be traced in the southern part of the township in the valley of Youngs Creek. The thickness of the coal in the Powers bed ranges from 4 to 12 feet at localities 287, 301–303, and 312–322. The coal is split

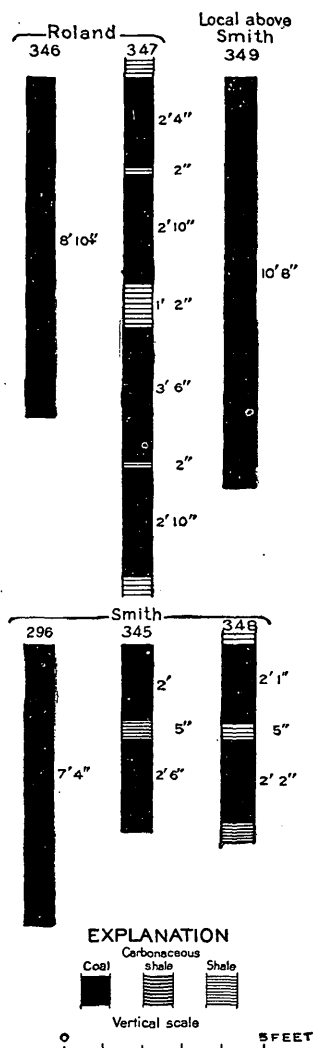


FIGURE 9.—Sections of coal beds in T. 9 S., R. 38 E., Mont.

into two branches by a shale parting at locality 313. Southward the parting increases and the lower bench of coal is the principal bench. Beyond locality 316 the lower split only is shown in Plate 23. The Smith bed is the next one above the Powers bed and contains large reserves of coal. The bed is 6 to 20 feet thick at localities 262,

283-286, 288-290, 300, 304-308, 310, 311, 335, 336, and 338-340. The Roland coal underlies the larger interstream areas, and the clinker formed by the burning of the coal at the outcrop makes a prominent band at the edge of the upland. The coal is 4 to 13 feet thick at localities 254, 309, 337, and 342-344. Above the Roland are two coal beds of small areal extent. The lower bed forms a clinker near the top of the peak in the SW. $\frac{1}{4}$ sec. 22 and is 5 feet 5 inches thick at locality 341. The highest coal bed in the township forms a clinker on the north side of Tanner Creek, but no sections of the coal were measured.

The Powers, Smith, and Roland coal beds contain the greater part of the reserves of coal in this township. The small mine at locality 334 has been mentioned. The largest mine is on the Craig ranch at locality 285, where an entry has been driven 250 feet. The Powers mine, at locality 312, is on the Powers bed, and the entry has been driven about 150 feet. An entry in the Powers bed at locality 313 is now caved. Small timbered entries have been driven in the Powers bed at locality 317 and in the Smith bed at locality 338. Where the coal goes below the surface in the south fork of Squirrel Creek, John Bell has driven a short entry on the Roland coal bed.

T. 9 S., R. 40 E.—Tongue River flows through a wide, open valley across T. 9 S., R. 40 E. Several large tributaries have also cut wide valleys. West of the river the interstream ridges are rugged and are marked by high buttes.

The lowest coal bed crops out near the mouth of Pearson Creek, and a partial section shows over 5 feet at locality 250. This bed was not definitely correlated and may be either the Canyon or the Dietz No. 2 bed. It is reported to be 20 feet thick beneath the tract included in this township and extending into T. 8 S., R. 40 E., which is outlined on the map as a possible area for mining the coal by stripping the overburden. The next higher coal bed is the Dietz No. 1, the burning of which has formed a large area of clinkered rocks in the northern part of the area. This bed is $8\frac{1}{2}$ to 20 feet thick where it crops out along the river bank at localities 271, 274, 275, 352, 360, and 363. Elsewhere the outcrop of the coal is either burned or concealed by soil. At locality 271 is the mine of Mr. Black, which is one of the largest mines in the area. The main entry is about 300 feet long, and several rooms have been turned on both sides of it. Considerable coal for local use is taken from this mine each winter. Above the Dietz No. 1 a bed 4 feet thick that crops out at locality 359 may be the Anderson bed. A local bed less than 3 feet thick was measured at localities 276 and 277. The Smith bed is about 14 feet thick where it crops out in this township, but it underlies only the high ridges and does not include a large reserve of coal. Its thickness was measured at localities 255-261, 263-270, 272, 273, 278-282,

and 356-358. Mines have been opened on the Smith bed at localities 272 and 280. The entry at locality 272 is about 50 feet long. There are no valuable coal beds above the Smith bed in this township. The Roland bed caps high buttes on the interstream ridges, but the coal is all burned at the outcrop, and the area where this coal may be unburned is small. A thin coal bed occurs below the Roland bed in sections 7 and 8, but no measurements of it were made. (See pl. 24.)

A well drilled for oil in the SE. $\frac{1}{4}$ sec. 16 by the Absaroka Oil & Gas Co. reached a depth of 3,485 feet and, according to reports, obtained showings of oil and gas. The strata reported to have been penetrated by the well and the probable correlation of the coal beds encountered are briefly described in the following abridged well record:

*Record of well No. 1 of the Absaroka Oil & Gas Co. in sec. 16,
T. 9 S., R. 40 E., Mont.*

	Feet
Sand, yellow and white-----	12-155
Coal (Dietz No. 1 bed of Sheridan coal field)-----	155-202
Fire clay, white-----	202-218
Shale-----	218-258
Coal, water bearing (Dietz No. 2 bed)-----	258-273
Fire clay-----	273-290
Sand, clay, and shell lime-----	290-360
Coal (Dietz No. 3 bed)-----	360-366
Fire clay, white-----	366-395
Sandstone and clay-----	395-552
Coal (Monarch bed)-----	552-577
Clay and shale-----	577-630
Coal in three benches, total thickness 16 feet, water bearing (Carney bed)-----	630-665
Shale, thin sandstone, shell lime, and thin coal-----	665-1,165
Sandstone, water bearing-----	1,165-1,230
Coal and shale; lower coal bench 22 feet thick (possi- bly equivalent to Rosebud bed of Forsyth field)-----	1,230-1,260
Shale, gray and brown-----	1,260-1,550
Sandstone, shale, and thin coal-----	1,550-1,940
Shale, sandy, and dry sand-----	1,940-2,230
Shell, hard; gas-----	2,230-2,233
Shale, brown, and thin water-bearing sand-----	2,233-2,785
Water-bearing sand and thin shale-----	2,785-3,290
Shale, brown, and gray slate-----	3,290-3,485

All or part of the thick series of shale beds at a depth of 1,260 to 1,550 feet may be the Lebo shale member of the Fort Union formation. Below a depth of 1,550 feet it is difficult to distinguish the formations, but the lithology suggests the Tullock member of the Lance formation from 1,550 to 1,940 feet and the Hell Creek member of the Lance from 1,940 to 2,785 feet. The water-bearing sandstone from 2,785 to 3,290 feet may be the Fox Hills sandstone. Below the sandstone is 195 feet of shale that would accordingly represent the top of the Pierre.

T. 9 S., R. 41 E.—From the broad valley of Deer Creek, which crosses the northern part of T. 9 S., R. 41 E., the surface rises steeply to the north, but more gently to the south, to the high ridge called the Badger Mountains, near the State line. On the south side of the Badger Mountains the surface slopes steeply to the valley of Badger Creek, south of the State line.

The lowest coal bed that crops out in this township is the Dietz No. 1, which forms a prominent clinker near the bottom of the Deer Creek Valley in the northwest corner of the township. The coal is burned at the outcrop, and no measurements could be made. A partial section of the Anderson bed shows 7 feet of coal at locality 366, and the clinker from the burning of this bed was traced along the south side of the valley of Deer Creek. In the northwest corner of the township the clinkers from the burning of the Dietz No. 1, Anderson, and Smith beds have merged. The thickness of the Smith bed ranges from $4\frac{1}{2}$ to $12\frac{1}{2}$ feet at localities 355, 361, 362, 364, 365, 412, and 421. The Roland bed is about 7 feet thick in the eastern part of the township, but the horizon of this bed was not recognized in the high land in the southwestern part. The coal was measured at localities 367–372, 385–389, 398–401, 408–411, 413–418, and 423. Near the top of the high ridge in the southwest corner of the township a local bed in the Wasatch formation is 3 feet thick at localities 353 and 354. (See pl. 25.)

Tps. 9 and 10 S., R. 42 E.—The surface of Tps. 9 and 10 S., R. 42 E., is a treeless divide dissected by many deep valleys which drain either into Deer Creek and Tongue River or into Hanging Woman Creek. Near the east range line the valleys become shallow and are wide and open.

The lowest coal bed that crops out in these townships is tentatively correlated with the Smith bed. It is about 7 feet thick and split by many partings at locality 672. The Roland bed is about 6 feet thick at localities 390–397, 402–404, 668–671, 673–686, 691–697, and 701. A local bed above the Roland was measured at localities 704 and 705 and is from $2\frac{1}{2}$ to 5 feet thick, but is split by several shale partings. The Badger bed is about 380 feet above the Roland and underlies the divide near the State line. It is about 7 feet thick at localities 373–375, 379–381, 383, 384, 702, and 703. About 50 feet below the Badger a bed contains $2\frac{1}{2}$ feet of coal at localities 376–378 and 382. (See pl. 26.)

Some coal has been mined from an entry about 150 feet long in the Badger bed near the house of E. J. Cooper, on the south line of sec. 4, T. 10 S., R. 42 E. A small pit has been dug on the Roland bed at locality 695 to obtain domestic fuel.

Tps. 9 and 10 S., R. 43 E.—The valley of Hanging Woman Creek where it crosses Tps. 9 and 10 S., R. 43 E., is broad and shallow. Trail, Corral, and Waddle Creeks enter Hanging Woman Creek from wide tributary valleys. Nearly everywhere the slopes are gentle, and the surface of these townships is less rugged than the rest of the area described in this report.

The clinker from the burning of the Dietz No. 1 bed extends into NE. $\frac{1}{4}$ sec. 4, T. 9 S., but the lowest coal bed that crops out is the Anderson, which forms a prominent clinker near the north line of T. 9 S., R. 43 E. Partial sections of the bed at localities 662 and 735 showed from 3 to 10 feet of coal. The Smith bed could not be traced in these townships, but isolated outcrops of a coal bed tentatively correlated with the Smith contain from 3 to 8 feet of coal at localities 689 and 719–723. A coal bed almost 10 feet thick measured at localities 717 and 718 would thus be a local bed above the Smith. About 90 feet below the Roland bed there is a local bed which contains from 2 to 4 feet of coal at localities 724–731 and 734. The Roland bed underlies a small area in the southwestern part of T. 9 S. and contains from 1 to 9 feet of coal at localities 687, 688, 690, 698–700, and 706–716. East of Hanging Woman Creek the horizon of the Roland bed could not be recognized, but a coal bed 2 feet 3 inches thick with a 3-inch shale parting crops out at locality 733 and may be at the horizon of the Roland. A lower coal bed 4 feet 5 inches thick crops out at locality 732. (See pl. 27.)

QUANTITY OF COAL

The quantity of coal which is believed to underlie the northward extension of the Sheridan coal field is stated in the accompanying table, but the figures are intended to show the order of magnitude of the coal reserve rather than the exact tonnage. The extensive burning of the coal at the outcrop and the absence of diamond-drill prospecting make it impossible to prepare detailed and precise estimates of the gross quantity of coal present within the area mapped, and it is possible that more complete exploration of the field will show that the present estimate of 38,500,000,000 short tons is too low and should be increased.

Much of the estimated tonnage of coal is in beds that are assumed to be persistent many miles from their outcrop. However, there are enough data as to the beds which have a great length of outcrop to justify the assumption of their extension under cover to the limits of the area and to estimate with a fair degree of accuracy the amount of coal contained in them. Nearly three-fifths of the estimated tonnage of coal is included in undifferentiated lower beds. The Wall bed is assumed to be persistent under cover and to be correlatable

with the Monarch and Carney beds, the lowest valuable beds that crop out in the Sheridan field. The aggregate thickness of the Monarch and Carney beds is about 40 feet in the main Sheridan field and where they were penetrated by the well of the Absaroka Oil & Gas Co. in T. 9 S., R. 40 E. At the northeastern limit of the area the thick Brewster-Arnold and Knoblock coal beds, besides thinner beds, lie below the Wall bed, and in the aggregate they include 35 to 45 feet of coal. As there are no thick coal beds below the Monarch and Carney where they crop out in the main Sheridan field, the Brewster-Arnold and Knoblock beds must thin southward if the correlation of the Wall with the Monarch and Carney beds is correct. For the northern part of the area, where the lower beds are not exposed, their aggregate thickness was assumed to be 30 feet, which is probably moderate, and this thickness is assumed to decrease progressively toward the west and south. All the thin local beds are not included in the estimate, as many of them were measured at only one locality each, and their extent could not be determined, but the amount of coal included in these beds is negligible in comparison with the gross tonnage.

Estimate of unburned coal in the northward extension of the Sheridan coal fields

	Total coal in all beds (tons)	Percentage of coal by beds											
		Badger	Roland	Smith	Powers	Anderson	Dietz No. 1	Canyon	Wall	Brewster-Arnold	Knoblock	Local beds	Undifferentiated lower beds
T. 5 S., R. 41 E.....	1,100,000,000							12.8	22.4				64.8
T. 5 S., R. 42 E.....	300,000,000							5.6	14.4	32.5	47.5		
T. 6 S., Rs. 38 and 39 E.....	1,500,000,000			3.3		10.9		16.3	13.8				55.7
T. 6 S., R. 40 E.....	2,000,000,000			3.3		13.1		11.9	20.4				51.3
T. 6 S., R. 41 E.....	1,650,000,000							5.5	14.4				80.1
T. 6 S., R. 42 E.....	1,350,000,000						0.3	5.5	11.2	22.9	60.1		
T. 6 S., R. 43 E.....	100,000,000						1.6	5.2	7.1	25.1	56.6	4.4	
T. 7 S., Rs. 38 and 39 E.....	1,700,000,000		0.3	6.1		16.2		20.2	18.0			.6	38.6
Tps. 7 and 7½ S., R. 40 E.....	1,900,000,000			.5		3.9		18.3	24.9				52.4
Tps. 7 and 7½ S., R. 41 E.....	1,300,000,000							8.8	29.3				61.9
T. 7 S., R. 42 E.....	1,950,000,000					3.6	6.6	10.3	16.2				63.3
T. 7 S., R. 43 E.....	350,000,000						2.7	3.7	9.8			6.2	77.6
T. 8 S., R. 38 E.....	500,000,000		3.4	26.8		12.9							55.2
T. 8 S., R. 39 E.....	2,100,000,000		1.6	10.1			17.1	13.3				1.1	56.8
T. 8 S., R. 40 E.....	1,650,000,000						8.3	16.1					75.6
T. 8 S., R. 41 E.....	2,200,000,000		1.2	6.1		7.0	12.5	17.2					56.0
T. 8 S., R. 42 E.....	2,650,000,000		1.3	7.2		15.1	18.1	12.4					45.9
T. 8 S., R. 43 E.....	2,100,000,000			.6		7.8	16.3	15.7					59.6
Tps. 9 and 10 S., R. 38 E.....	350,000,000		7.6	8.0			13.4	13.4					57.6
T. 9 S., R. 39 E.....	1,900,000,000		3.2	10.1	5.2		14.3	14.3					52.9
T. 9 S., R. 40 E.....	2,700,000,000		.1	2.4			17.5	18.7					61.3
T. 9 S., R. 41 E.....	2,400,000,000		2.1	6.3		3.2	20.1						68.3
Tps. 9 and 10 S., R. 42 E.....	2,250,000,000	0.3	8.5	9.0		9.1	18.3						54.8
Tps. 9 and 10 S., R. 43 E.....	2,500,000,000		1.3	4.6		14.7	18.3						61.1
	38,500,000,000	.02	1.3	4.3	.3	5.8	10.0	11.1	7.3	1.2	2.7	.2	55.8

