THE ASHLAND COAL FIELD, ROSEBUD, POWDER RIVER, AND CUSTER COUNTIES, MONT.

By N. W. Bass

ABSTRACT

The Ashland coal field, named from the village of Ashland, embraces an area of 975 square miles in southwestern Custer County, southeastern Rosebud County, and northwestern Powder River County, southeastern Montana. Its northern boundary is 25 miles south of Miles City, and its southern boundary is between 35 and 40 miles north of the Montana-Wyoming State line. The transcontinental railroads nearest to the field are the Northern Pacific and the Chicago, Milwaukee, St. Paul & Pacific, both of which run along the Yellowstone River through Miles City.

The surface of the Ashland field consists of a series of great benches resulting from the effect of erosion on flat-lying strata of sharply varying degrees of resistance. It ranges in altitude from about 2,650 feet on the Tongue River, the largest stream, to about 4,350 feet. The highest points are Liscom Peak, Home Creek Butte, and the Cook Creek Mountains.

Native grasses grow in all parts of the area, and a thin to fairly dense stand of yellow pine occurs on the highlands, a portion of which is included in the Custer National Forest. More than 90 per cent of the area is used for grazing livestock; part of the rest is dry farmed and part is irrigated.

The exposed rocks are flat-lying or nearly so in all parts of the area and consist of shale and sandstone and many beds of coal, which are contained in the Lance (Tertiary?) and Fort Union (Tertiary) formations. In addition there are deposits of stream-laid gravel at several different levels.

The Tullock member, the uppermost member of the Lance formation, is exposed in a small area along the Tongue River in the northern part of the field. It is conformably overlain by 1,300 to 1,750 feet of strata of the Fort Union formation. The lower 150 or 160 feet of this formation is composed of somber shale belonging to the Lebo shale member. The rest of the formation, known as the Tongue River member, is composed of 1,150 to 1,600 feet of shale, sandy shale, sandstone, and coal beds. The Tongue River member is the surface formation in most of the Ashland coal field and contains all the coal beds of commercial value.

Small remnants of stream-gravel terraces that occur about 1,100 feet above the Tongue River may be of Oligocene or Miocene (?) age. They consist predominantly of cobbles and pebbles of dense quartzite. Igneous rocks ranging from granite to dunite are present. Gravel about 600 feet above the Tongue River is possibly of Miocene or Pliocene (?) age. It contains fragments of baked rocks and sandstone of the Tongue River member in addition to the types found in the higher terraces. Stream-deposited Pleistocene gravel beds as much as 300 feet above the present stream levels are present in isolated patches bordering nearly all the main stream valleys. Except in a very few localities, these terraces occur only on the west sides of the valleys.

The coal resources of the Ashland field are large, being estimated at about 10,750,000,000 tons. Numerous townships contain five to eight coal beds with average thickness greater than 6 feet. Outcrops of coal beds 10 feet thick are common, and beds 20 to 25 feet thick occur in several localities and are continuous with these thicknesses throughout areas of several square miles. The coal is of subbituminous rank, is fairly brittle, breaks with a conchoidal fracture, and slacks when exposed to the atmosphere. The Tongue River Valley interposes a wide gap in the extensive region occupied by the thick coal beds, and correlation of beds on one side of the valley with those on the other is difficult. At present there are no railroads in this field, and consequently mining operations are small. Mining on a commercial scale will be feasible when proper transportation facilities are available.

In this report detailed descriptions are given for each township. These include a brief description of the geology, measured sections of the coal beds, estimates of cover, and a discussion of areas and beds that are favorable for utilization.

INTRODUCTION

PURPOSE OF THE WORK

The detailed information concerning the coal deposits of the Ashland field set forth in this report has been obtained in the course of an investigation that has been conducted both as a part of the United States Geological Survey's general systematic study of western coal lands and as an aid in the administration of the public lands. With the information obtained on the location of outcrops, the number, distribution, and thickness of coal beds, the accessibility of the coal, and the thickness of the overburden, the public lands of the region are classified as to their coal value; coal-bearing lands are differentiated from noncoal-bearing lands; and the administration of the coal-land leasing law is facilitated. Under this law, coal-prospecting permits may be issued for lands that are not definitely known to contain coal beds of workable thickness and good quality, and leases are issued for lands wherein thick coal beds are known to be present. The type of information gathered permits the separation of lands suitable for direct lease from lands that require prospecting to establish the existence of workable deposits of coal. This information also provides a basis for dividing the leasing lands into units of a size and shape that will provide for economical exploitation of the coal. Data concerning the depth of burial of thick coal beds and the types of material composing the overburden inform the administrative officers as to the size and location of tracts that can be mined by strip mining, which under favorable conditions is an economical method of recovering coal. Data concerning the thickness and quality of the coal beds, the accessibility of the outcrops, and the type of roof and floor materials constitute valuable information that is made available to anyone who may at some future time desire to select sites for underground mining.

Interest in the exploitation of coal in this region was stimulated in 1922 and 1923 by the partial construction of a railroad along the Tongue River Valley and by the initiation of a large strip-mining operation by the Northern Pacific Railway at Colstrip, a few miles west of this field. The Colstrip operation is a very successful large-scale undertaking and has demonstrated that coal in this part of Montana favorably situated for mining by this method can be recovered at a very low cost. By firing its locomotives throughout this part of its system with Colstrip coal the Northern Pacific Railway has proved the feasibility of using coal of this rank for steaming.

The field examination revealed a number of localities where thick coal beds similar in rank and quality to the Colstrip coal lie at sufficiently shallow depth to permit mining by stripping.

FIELD WORK AND ASSISTANCE

This report contains the results of the work of three field seasons, in 1923, 1927, and 1928. The project was under the supervision of W. T. Thom, jr., and C. E. Dobbin in 1923, C. E. Dobbin in 1927, and H. D. Miser in 1928, each of whom visited the field and made valuable suggestions. In 1923 Mr. Thom spent several days mapping in the field. The writer was assisted in the field work in 1923 by J. B. Stone, R. F. Flint, P. D. Torrey, and Bert Bass; in 1927 by N. F. Stull, C. B. Hunt, E. B. Manger, H. C. Tan, and Glenn Urick; and in 1928 by C. B. Hunt, F. H. Kellogg, T. D. Mundorf, and George J. Newlin. Whatever merit this report contains should be shared by each of these men, and it is with pleasure that the writer takes this opportunity to express his appreciation for their efficient cooperation. He is under particular obligations to Mr. Stull, who not only carried forward independently a part of the field mapping in 1927 but also assisted in the office compilation of the data obtained and the writing of the township reports describing the coal deposits. Mr. Hunt was with the field parties two years and is responsible for much of the mapping of the area covered in 1928.

The cordial treatment and many kindnesses shown at all times by the ranchers throughout the district and by the townspeople in Ashland contributed greatly toward the success and enjoyment of the work. Forest Supervisor Alva Simpson and Forest Ranger O. E. York supplied excellent maps of the Custer National Forest that were of great aid.

The field mapping was carried out with plane tables and light telescopic alidades. The area was mapped in township units on a scale of 2 inches to the mile, the greater part by the intersection method,

projected from a series of carefully measured base lines. In 1923 townships in the western part of the field were mapped by stadia traverses from section corners, the land net having been platted on the field sheets from the plats of the General Land Office. One township in the northeastern part of the field was mapped by this method in 1928. Altitudes were projected from temporary bench marks established in the Tongue River Valley by engineers of the proposed North & South Railroad.

Sections of the coal beds were measured from natural exposures wherever these were available and elsewhere by prospecting with miner's picks and shovels. Plate 10, *B*, shows a geologist prospecting coal in the Ashland field.

The geologic party lived in camp and used saddle horses for transportation in the field. Light automobile trucks were used for moving camp equipment and hauling supplies.

In some of the more rugged parts of the field in the Custer National Forest the positions of clinker beds were sketched, using as a base a map furnished by the Forest Service. This map supplied the base for Ts. 2 and 3 S., R. 47 E., and parts of other townships.

PREVIOUS WORK

A considerable part of this field was covered by a reconnaissance made by Wegemann [1] in 1908. The oil possibilities of southeastern Montana, including the area of the Ashland coal field, were set forth in a press notice prepared by Dobbin and Thom [2] in 1921. The stratigraphy and structural relations of this general region were discussed by Thom and Dobbin [3] in 1924. Coal deposits in the Tongue River Valley between Brandenburg, Mont., and the Wyoming-Montana boundary, including a part of the Ashland coal field, were described by the writer [4] in a press notice in 1924.

A report on the geology with special reference to the coal deposits in the Forsyth coal field, which joins the Ashland field on the west, was prepared by Dobbin.[5] The geology of an area including the upper Tongue River Valley, about 15 miles southwest of the southwest corner of the Ashland field, is described by Baker.[6] Rogers

[1] Wegemann, C. H., Notes on the coals of the Custer National Forest, Mont.: U. S. Geol. Survey Bull. 381, pp. 108–114, 1910.

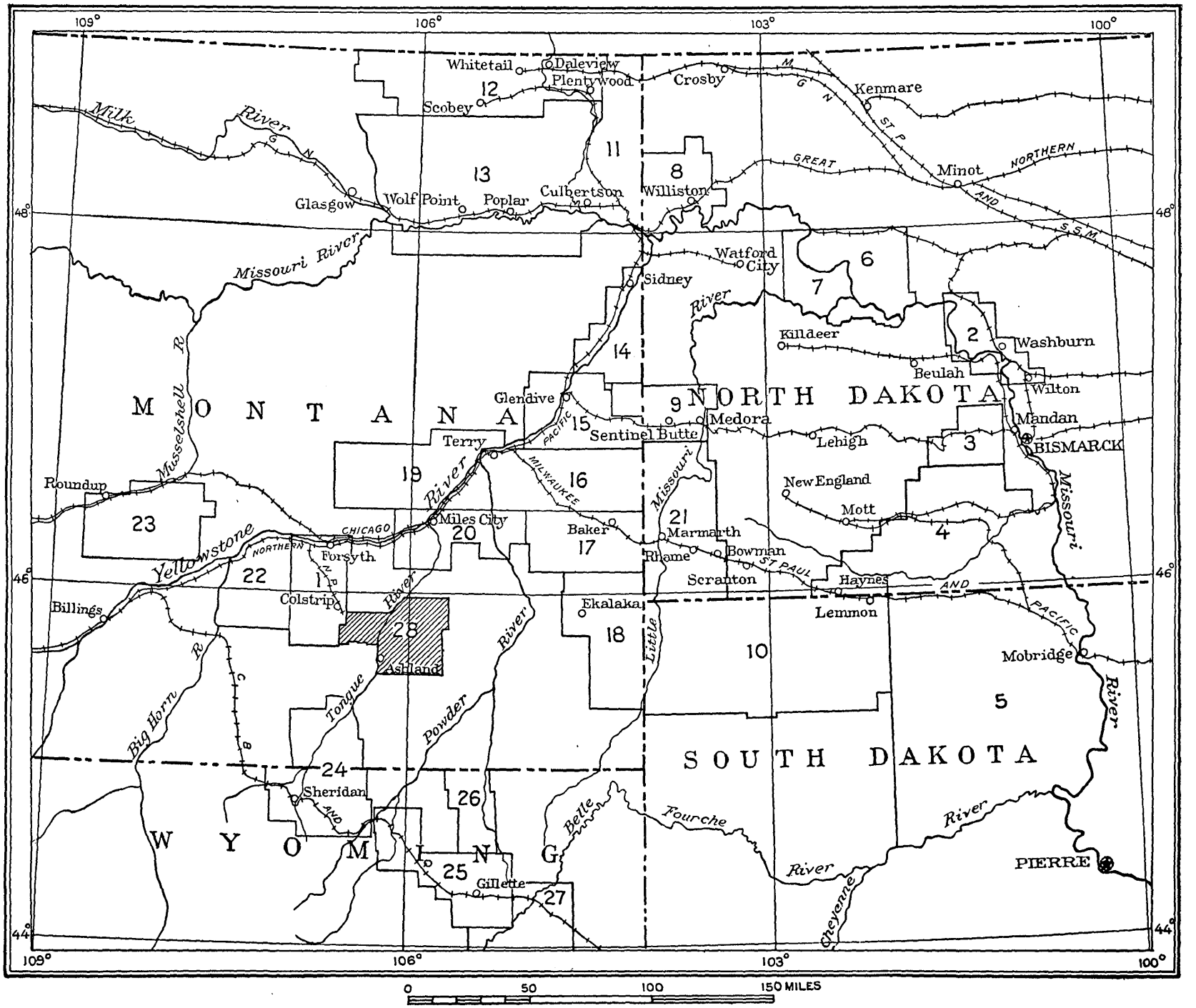
[2] Dobbin, C. E., and Thom, W. T., jr., Oil possibilities in southeastern Montana: U. S. Geol. Survey Press Mem. 30544, January, 1921.

[3] 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, pp. 481–506, 1924.

[4] Bass, N. W., Coal in Tongue River Valley, Montana: U. S. Geol. Survey Press Mem. 16748, Feb. 12, 1924.

[5] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 812, pp. 1–55, 1929.

[6] Baker, A. A., The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont.: U. S. Geol. Survey Bull. 806, pp. 15–67, 1928.



INDEX MAP SHOWING LOCATION OF ASHLAND COAL FIELD, MONTANA

For explanation of numbers see p. 23.

and Lee[7] described the Tullock Creek field, which lies 25 miles west of the Ashland field and involves the coal-bearing rocks present in this field.

GEOGRAPHY

LOCATION OF THE FIELD

The Ashland field is an arbitrarily bounded tract containing 975 square miles in southeastern Montana. Its northern boundary is 25 miles south of Miles City and its southern boundary is between 35 and 40 miles north of the Montana-Wyoming State line. It includes parts of Custer, Rosebud, and Powder River Counties. Specifically, the field includes part of T. 2 N., R. 45 E.; all of T. 2 N., Rs. 46 to 48 E.; Ts. 1 N. and 1 S., Rs. 42 to 48 E.; parts of T. 2 S., Rs. 42 to 44 E.; T. 3 S., R. 44 E.; and Ts. 2 and 3 S., Rs. 45 to 48 E. Ashland, from which the field is named, is a small town in the extreme southwestern part. This field is but a small portion of an extensive coal-bearing region that lies in southeastern Montana and northeastern Wyoming. The location of the field and its relation to this extensive coal region are shown on Plate 4. The names of the fields indicated by numbers on this map and the Geological Survey bulletins in which they are described are shown in the following table:

Coal fields whose locations are shown on Plate 4

No.	Field	Bulletin	No.	Field	Bulletin
1	Forsyth	812-A	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	20	Miles City	341-A
7	do	471-C, 726-D	21	Marmarth	775
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, 806-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	Gillette	796-A
14	Sidney	471-D	28	Ashland	831-B

ACCESSIBILITY

The transcontinental railroads nearest to the field are the Northern Pacific and the Chicago, Milwaukee, St. Paul & Pacific, which run along the Yellowstone River 25 miles north of the northern boundary of the field. A branch line of the Northern Pacific Railway was built in 1923 into T. 2 N., R. 41 E., to afford transportation facilities for the thick coal deposits being exploited there to supply fuel for the locomotives of the railway. Colstrip, the terminus of this

[7] 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, 1923.

branch, is only 3 miles west of the western boundary of the Ashland field. The grade for a proposed railroad along the Tongue River Valley passing through this field was partly built in 1923. This road was projected from Casper, Wyo., through Sheridan, Wyo., where it would cross the Chicago, Burlington & Quincy Railroad, thence down the Tongue River to Miles City, where it would connect with the transcontinental lines.

Several graded automobile roads traverse the Ashland field. One follows the Tongue River Valley northeastward to Miles City, the chief supply point for the district. Southwestward this road leads to Sheridan, Wyo. A fork of the Miles City road leaves the main road in T. 1 S., R. 44 E., and runs northwestward across the Rosebud Creek and Tongue River divide, joining a gravel road in the Rosebud Creek Valley, thus affording access northward to Forsyth, the county seat of Rosebud County. Southward the Rosebud road leads toward Sheridan, Wyo., and a graded branch road connects Colstrip with this road near Lee post office. A well-graded road leads eastward from Ashland, near the southwest corner of the field. One branch of this road extends up Otter Creek; the other branch follows the east fork of Otter Creek and thence runs northeastward down Little Pumpkin Creek toward Miles City. The interior of the field is served by fairly well kept dry-weather roads.

SETTLEMENT

Ashland, a settlement of about 25 families, in the extreme southwestern part, is the only town in the coal field here described. There is a small store on Rosebud Creek near Lee post office, in the western part of the field, and another at Volborg post office, on Pumpkin Creek in the extreme eastern part. Ashland is served with mail daily except Sunday by stage from Forsyth, Mont., and three times a week by stage from Sheridan, Wyo. Brandenburg, Stacey, and Loesch post offices receive mail by stage from Miles City three times a week. Lee post office receives mail daily by stage from Forsyth. The most thickly settled part of the field lies within a radius of 10 miles of Ashland. The region at the head of Little Pumpkin Creek, in Ts. 2 and 3 S., R. 47 E., sustains more occupied ranches than any other area of comparable size in this field except the area around Ashland. The field as a whole contains an average of about eight occupied ranches to each township.

CLIMATE [8]

The climate is semiarid, but there is sufficient moisture during most years to make the raising of crops by dry-farming methods

[8] Many of the data on climate and vegetation have been taken from an unpublished report by L. R. Brooks in the files of the conservation branch, U. S. Geol. Survey.

fairly successful on the more favorable soils. Total failures are experienced in some years, and good results in other years, the controlling factors being the amount and distribution of the rainfall. The average annual precipitation is about 14 inches, 70 per cent of which falls in the period from April to September, the remainder largely as snowfall during the winter. The average figures, however, fail to depict the true conditions, because of the annual variations from the average. Only a very small part of the entire area is farmed, and a small acreage once farmed and now abandoned testifies to the semiarid conditions that prevail here.

The precipitation is noticeably greater on the highlands of the interstream areas than in the valleys and is somewhat greater in the southern part of the field than in the northern part. The effect of the lower rainfall in the north is most noticeable in late summer. In many years the vegetation in the northernmost part of the field is brown and cured a month or more before that in the southern part.

Warm days and cool nights are characteristic of the summers; the winters are cold. Temperatures as low as 40° below zero are not unusual but are of short duration. The range in temperature in a year is commonly as much as 125°. Temperatures below freezing occur in the fall on the average as early as the middle of September and in the spring as late as the last week in May.

VEGETATION

The entire area supports a fair growth of native grasses, and the highlands carry a thin to fairly dense stand of western yellow pines. The chief grass species are needle grass, grama, wheat grass, June grass, bunch grass, and nigger wool. Black sage, valley sage, and matchweed are common shrubs. The pines are particularly partial to areas underlain by clinker (rocks that have been baked by the burning of underlying coal beds), and throughout the field pines grow chiefly along the edges of the plateaus where the clinker beds crop out. In most of the area the timber is too small to supply saw logs, but in the highlands between Pumpkin Creek and Tongue River considerable merchantable timber is available. The Bidwell sawmill, in sec. 20, T. 2 S., R. 47 E., is exploiting this timber. Cottonwoods are abundant in the Tongue River bottom lands, and a few clumps of ash and box elder occur along all the stream courses. Chokecherry, western service berry, and buck brush are common at higher altitudes, where the rainfall is more abundant. The clay soils and the vegetative types that go with them, such as wheat grass and black sage, are most abundant in the northernmost part of the field and predominate in the area immediately underlain by the Lebo shale.

DRAINAGE AND WATER SUPPLY

The greater part of the coal field is drained by the Tongue River, the chief stream in this part of the State and a tributary of the Yellowstone River. Rosebud Creek, also a tributary of the Yellowstone, drains the westernmost part of the field, and Pumpkin Creek and its tributary Little Pumpkin Creek drain the easternmost part. Some of the chief tributaries of the Tongue River in this area are Beaver, Liscom, and Foster Creeks and Otter Creek with its tributaries East Fork and Home Creek. The Tongue River varies greatly in flow, ranging from a small stream at low water to a raging torrent that covers the bottom lands from bluff to bluff in times of flood. Otter Creek contains flowing water throughout some years, but in others its channel is dry during parts of the summer. The other streams have an intermittent flow. Although the level and rolling surfaces in the area are fairly well covered with vegetation, which retards surface run-off, parts of the area are characterized by steep barren slopes where the run-off is very rapid. Consequently after a rain the area as a whole is drained fairly rapidly, and the percentage of run-off is relatively high. However, many gulches are fed by strong springs in their upper reaches and contain running water throughout the year in parts of their courses.

Springs of potable water, most of which issue from coal beds, are abundant in all the higher parts of the field. Potable well water is obtained in most parts of the field, and the wells in the Tongue River and Otter Creek Valleys have an artesian flow. Many wells in the northernmost part of the field yield water that is laden with alkaline salts and is fit only for stock. Many springs in this part of the field yield bad water, issuing largely from beds in the Lebo shale. Potable water can be obtained here, however, by drilling through the Lebo shale into water-bearing coal beds and sandstone in the underlying Lance formation.

UTILIZATION

More than 90 per cent of the area here described is used for the grazing of livestock, chiefly cattle, horses, and sheep. Grazing within the Custer National Forest is utilized chiefly by ranchers who live within the forest or within a radius of 5 miles of it. The area as a whole will support about 1,000 head of cattle to the township. Stockmen raise hay, chiefly alfalfa, for winter feeding. Cattle and sheep are nearly always fed through the winter, but horses frequently graze throughout the year. The chief loading points for stock going to market are Miles City and Rosebud, 30 and 60 miles north of the field. In recent years Colstrip, 3 miles northwest of the northwest corner of this field, has received a large share of the stock shipments

from the western part of the field. Most of the stock is shipped in September and October.

A small percentage of the area is dry farmed, and a yet smaller area bordering the Tongue River and Otter and Little Pumpkin Creeks is irrigated. The chief crops raised are wheat, oats, barley, flax, corn, and alfalfa hay and seed. Some native grass is cut for hay. Aside from the unfavorable climatic conditions, the principal factor that retards the development of farming is the remoteness of the area from markets. Trucking costs to the railroad are 40 to 75 cents per 100 pounds for small grains and $1 per 100 pounds for alfalfa seed. The higher rate is collected for provisions and supplies coming into the area as well as for hogs hauled to market. Under all these conditions farming alone has not yet proved highly successful, but the raising of stock supplemented by sufficient farming to provide winter feed for the stock is a very remunerative occupation.

The vast coal resources of the field have not been exploited except locally to supply fuel for near-by ranches. The timber has been and is being cut in a small but systematic manner under the supervision of the Forest Service. The clinker beds are used locally to supply road-surfacing material.

SURFACE FEATURES

In a broad way this area is but a small portion of an extensive dissected plateau that occupies this general part of Montana. Viewed in more detail the surface consists of a series of great benches or steps, the highest of which form the flat-topped but narrow divides between the major streams and constitute the remaining remnants of a once more widely extended plateau surface, and the succeeding steps in turn are the remaining parts of expansive upland plains at lower levels. This steplike series of upland plains results from the regular processes of erosion operating on flat-lying strata of sharply varying degrees of resistance. A hard bed or series of hard beds resists erosion much longer than the intervening soft, nonresistant beds and remains to floor a plainlike surface from which the overlying soft beds are stripped. As thick coal beds that occur in the stratigraphic succession are uncovered by erosion they burn along the outcrops and for considerable distances back from the crop lines, and the great heat produced in the burning bakes the beds overlying the coal to a very resistant slag or porcellanite called clinker. The resulting clinker beds are in many places more than 100 feet thick and commonly are 20 to 40 feet thick. These clinker beds form the floors for a considerable distance back from the edges of the widespread plateaus and benchlike surfaces. It is because of their presence that the plateau surfaces are there. Steep barren

slopes descend from the clinker ledge of one plateau rim to the next plainlike surface below.

The surface of much of the Ashland field is intricately dissected. The highest divides are narrow, and the slopes adjacent to the streams are rough. The upper courses of the streams are steep-sided rock gulches 100 feet and more deep; in the lower courses the valley floors are half a mile to 1½ miles wide, bordered by lines of bluffs capped by thick clinker beds. Back from the rims the great benches have gently rolling surfaces. The surface of the platform floored by the Knoblock clinker, one of the most extensive in the area (pl. 5, *A*), is an excellent example. Nearly everywhere back from the serrated edge the plateau has a gently undulating grass-covered surface. This upland may be seen on the East Fork road east of Ashland; in the vicinity of Colstrip, just west of this field; in the central part of T. 1 N., R. 45 E.; and in the central part of T. 1 N., R. 46 E. The margins of these benches have been dissected into a myriad of irregular narrow spurs and isolated buttes with flat tops formed by resistant clinker beds capping steep barren slopes of less resistant sandstone and shale. These flat-topped buttes and ridges form the most characteristic topographic feature of the region underlain by the Tongue River member, which includes the greater part of the Ashland coal field. Their red clinker caps, surmounted with a fringe of green pines and succeeded below by cream-colored rocks that form the steep barren slopes, indeed form a striking picture.

There is enough variation in the several parts of the exposed stratigraphic section to produce somewhat contrasting topographic features, even where the extremely resistant beds of clinker are not present. A surface of moderate relief characterizes the area underlain by the Lebo shale member, which is composed essentially of beds of soft clay shale. Badlands prevail in parts of the Lebo area, and much of its surface consists of rounded hills with bare shale slopes. It presents a surface that is considerably dissected but lacks prominent irregularities. There is, however, in the Lebo shale area, no rugged country with marked relief similar to that which characterizes the surface of the Tongue River member. The contrast between the surface features of the areas underlain by these two members is well illustrated in the Foster Creek Valley in T. 2 N., R. 47 E., and in the Tongue River Valley in T. 2 N., R. 45 E. The slopes upward from the stream flood plains ascend gradually across a hummocky surface of moderate relief in the Lebo shale to the contact of the Lebo and Tongue River members, where there is a sharp rise and an abrupt change to intricately dissected, rough lands of marked relief.

Certain zones within the Tongue River member that are composed of soft, nonresistant beds of shale simulate the surface types char-

acteristic of the Lebo. Such a series of beds occupies the interval of 100 feet above the Sawyer coal bed and forms the surface bordering Little Pumpkin Creek in the northern part of T. 2 S., R. 47 E. The surface here is considerably dissected, more so than a typical Lebo surface, but exhibits much less relief than the typical surface formed on most parts of the Tongue River member. These nonresistant sediments prevail throughout an interval several hundred feet thick above the Sawyer coal bed in T. 3 S., R. 48 E., and serve as an admirable illustration of the influence exerted by the character of the sediments on the resulting surface forms. In the part of this township where this thick series of soft, nonresistant beds crops out the surface consists of an expansive area of gentle slopes and undulating hills of low relief. West of this township this stratigraphic series is composed of interbedded hard and soft strata of sandstone and shale, and the surface forms developed are rugged slopes, irregular ridges, and buttes of marked relief.

A still different type of surface is produced on a thick series of shale, soft shaly sandstone, friable sandstone, and carbonaceous shale that occurs between the E and F coal beds throughout most of their area of outcrop in the field. The resistance to erosion of the sedimentary types represented in this series varies somewhat but not sufficiently to produce markedly differing surface forms. Rather sharply conical hills, with nearly barren slopes banded gray, black, and light cream-colored, are the characteristic land forms of this series of beds and served as one of the chief criteria used in correlating the coal beds of this part of the section from one locality to another. The conical hills east of Beaver Creek in the easternmost part of T. 2 S., R. 46 E., and those north of East Fork in the N. ½ sec. 29 and the S. ½ sec. 20, T. 2 S., R. 46 E., are examples of these land forms.

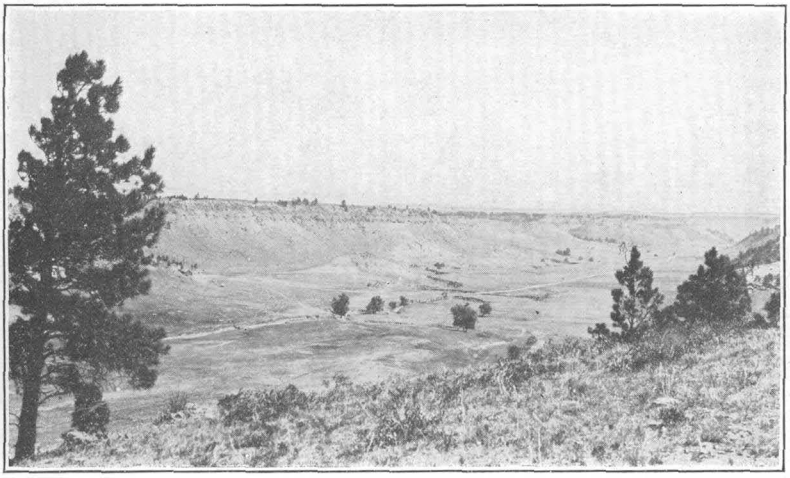
The erosion of the massive sandstones, which attain more than 100 feet in thickness, results in great sandstone knobs, "stone Johnnies," "toadstools," and a great variety of pinnacles that remain standing long after the surrounding areas have been reduced to rolling surfaces. Such forms are characteristic of several horizons in the Tongue River member, one of which is close above the Knoblock coal, and another between the Knoblock and Rosebud beds. These forms are common and yet striking features in many parts of the field. A view of a sandstone pinnacle is shown in Plate 6, *B*. Other examples occur in secs. 9, 16, and 21, T. 1 S., R. 43 E.; secs. 15, 22, 25, and 26, T. 1 S., R. 42 E.; sec. 34, T. 1 S., R. 45 E.; and secs. 21 and 22, T. 1 N., R. 46 E. These features are much more numerous in the western and northwestern parts of the field than in the eastern part, because massive sandstones are much more prevalent there, changing eastward into beds of more shaly character.

The larger stream valleys form narrow meandering strips of level land incised as boxlike channels below the benches and interbench slopes. The Tongue River Valley is from 1 to 2 miles wide and throughout most of its course across this field is bordered by bluffs that rise 150 feet or so to the ledge of the Knoblock clinker. The flood plain of the river is half a mile to a mile wide. The confining bluffs recede several miles in the northern part of the field, flaring outward where the stream enters the soft nonresistant beds of the Lebo shale member. Throughout most of its course through this field Rosebud Creek has bordering slopes that rise with a gentle gradient for a mile or more from the stream. Upstream, however, it is confined by high bluffs. Pumpkin Creek is bordered by bluffs capped by a thick clinker bed in T. 2 S., R. 48 E., but in T. 3 S., R. 48 E., where the stream is flowing above the horizon of this clinker, the valley slopes are gently graded and rise gradually for several miles. Most of the other larger streams in the field flow in comparatively flat-floored valleys bordered by steep slopes that terminate above by clinker ledges. The flood plains of Otter, Rosebud, Pumpkin, Little Pumpkin, Beaver, Liscom, and Foster Creeks range between a half and a quarter of a mile in width.

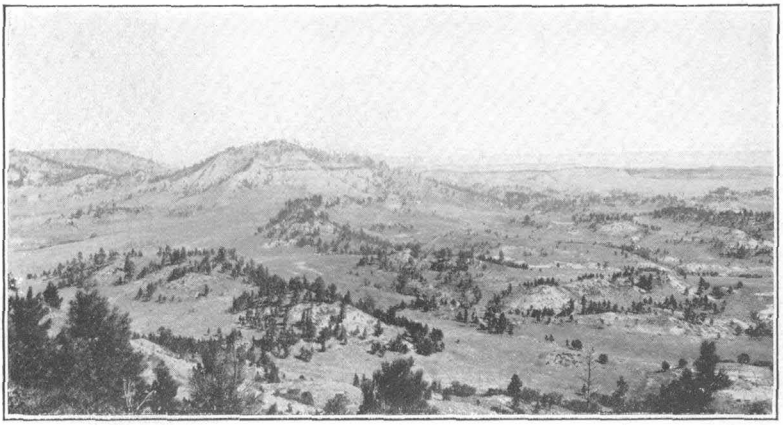
Well-defined terraces marking old stream levels border the present flood plains of several of the streams. Nearly everywhere the terrace occurs on the west side of the stream, probably indicating that the region has been tilted eastward subsequent to their formation. Only a few remnants, and these of very small extent, were found east of the stream courses. The terraces are best preserved in the valleys of the Tongue River and Liscom, Foster, Little Pumpkin, and Pumpkin Creeks. Four distinct surfaces are preserved along Pumpkin Creek, but in most of the other localities only two levels could be distinguished. Widely separated remnants of very small extent representing much older stream levels than any of those bordering the present streams were seen 300, 500, and 1,000 to 1,200 feet above the present stream levels.

Below all these terrace levels there is a widespread surface bordering essentially all stream courses in the field about 20 feet above the present flood plains. It is well exhibited near the Forsyth road at the mouth of Hart Creek, in the SE. ¼ sec. 10, T. 1 N., R. 44 E. Recent flood-plain deposits as much as half a mile wide border the larger streams. Each of these surfaces marks a stage in the long history of the streams as they have slowly eroded away the rocks of this region.

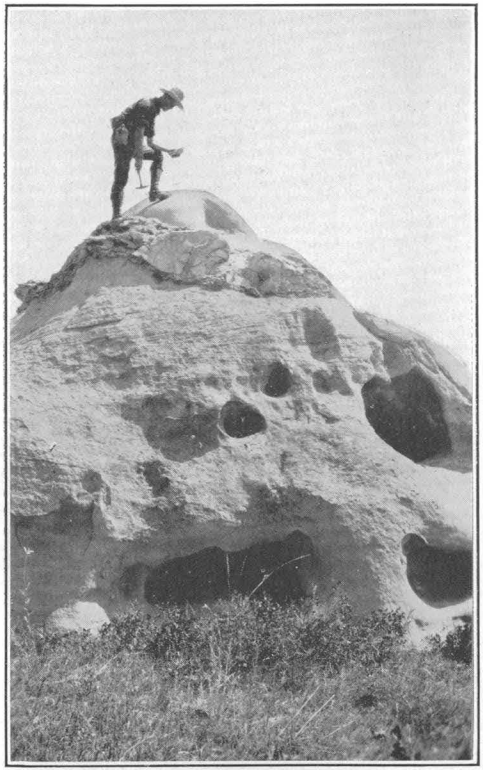
The altitude of the surface in the Ashland field ranges between about 2,650 feet on the Tongue River where it leaves the field, near the northeast corner of T. 2 N., R. 45 E., to about 4,350 feet



A. LAY CREEK VALLEY IN T. 1 S., R. 44 E.
The Knoblock clinker caps the bluffs and forms the table-land in the distance.

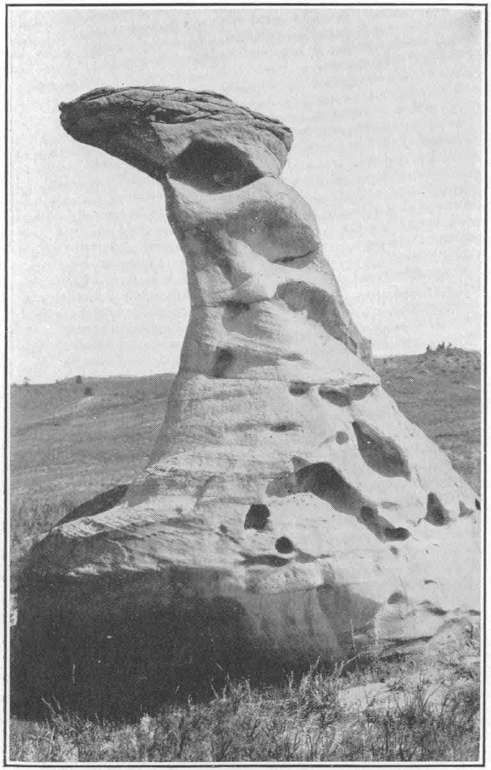


B. A CHARACTERISTIC SURFACE IN THE ASHLAND COAL FIELD



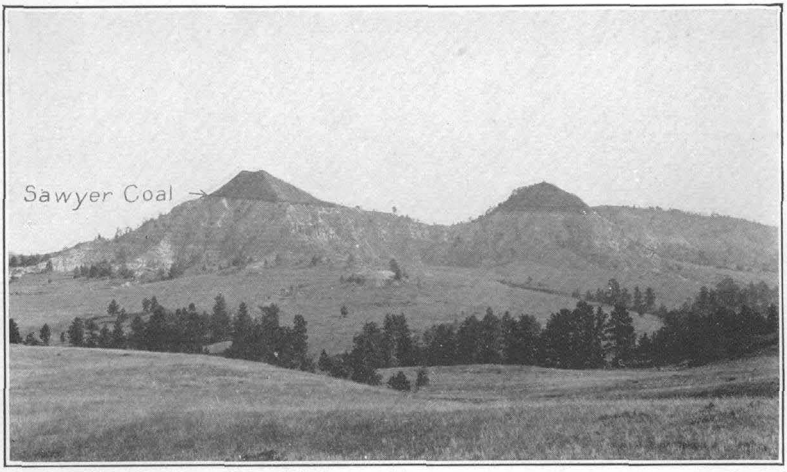
A. EROSION REMNANT OF MASSIVE SANDSTONE IN THE TONGUE RIVER MEMBER

Swirl of calcareous mudstone is present near the top.



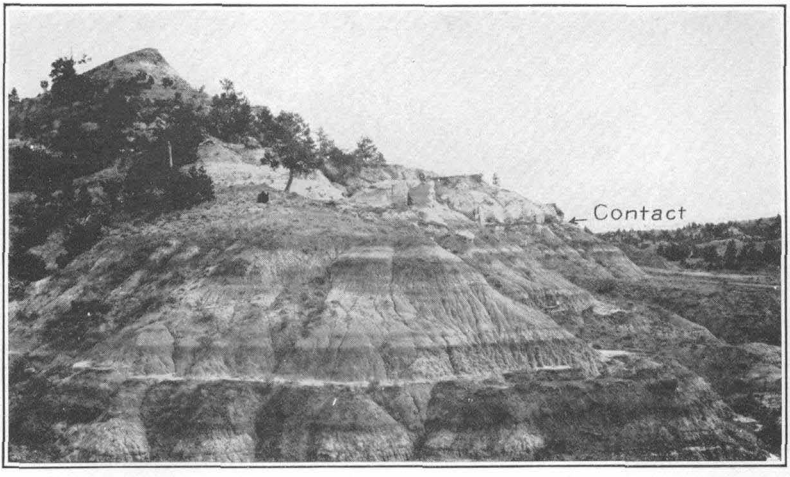
B. PEDESTAL OF TONGUE RIVER SANDSTONE CROSS-BEDDED TOWARD THE SOUTHEAST

Pits are solution cavities.



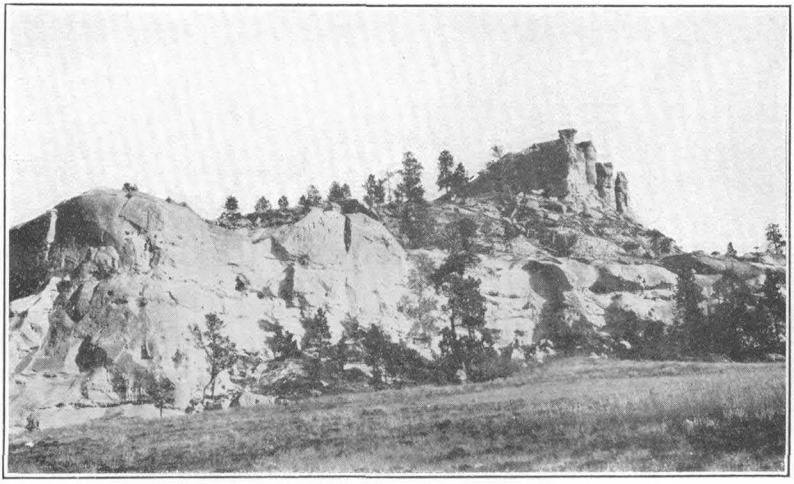
A. ROCKS BETWEEN THE KNOBLOCK COAL BED AND THE D CLINKER BED IN SOUTHERN PART OF T. 1 S., R. 45 E.

The Knoblock bed crops out in the creek in the foreground, and the D bed caps the peak. Note the contrast between the dark clay beds above the Sawyer coal bed and the light sandy beds below it.

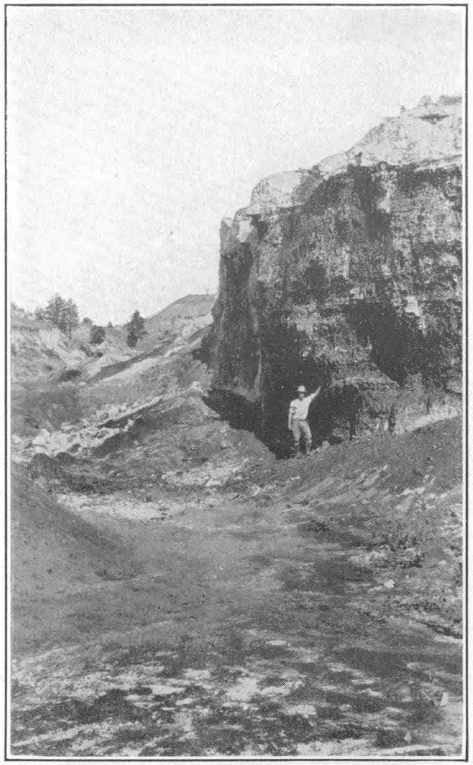


B. CONTACT OF THE LOWERMOST TONGUE RIVER BEDS AND THE UPPERMOST PART OF THE LEBO SHALE IN T. 2 N., R. 45 E.

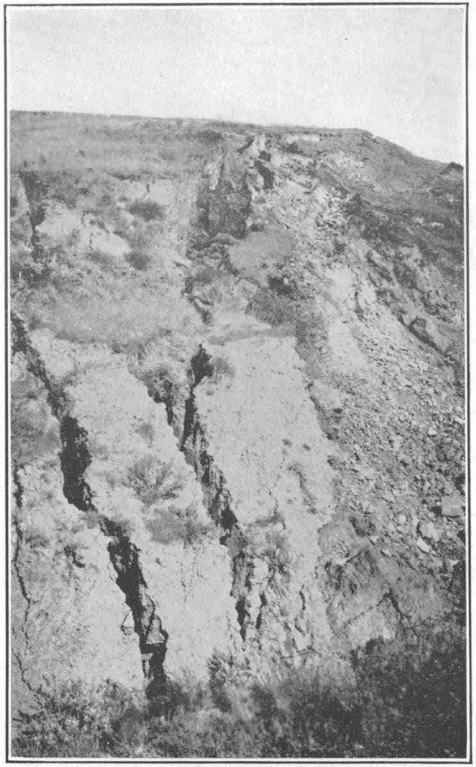
A. FINELY LAMINATED CROSS-BEDDING IN THICK BED OF SANDSTONE IN TONGUE RIVER MEMBER



B. THICK SANDSTONE IN TONGUE RIVER MEMBER

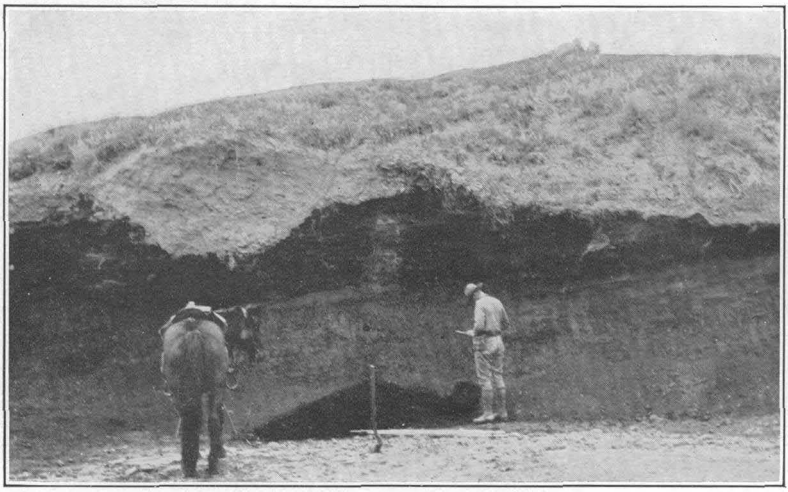


A. EXPOSURE OF ROSEBUD COAL BED ONE-FOURTH MILE WEST OF THE WESTERN BOUNDARY OF THE ASHLAND COAL FIELD

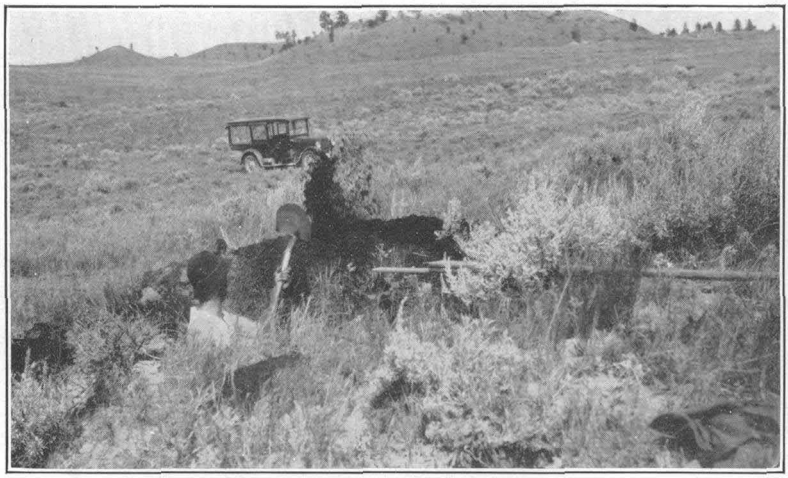


B. SLUMPING OVER A BURNING OUTCROP OF THE KNOBLOCK COAL BED

Near this point the coal bed is 27 feet thick.



A. NATURAL OUTCROP OF THE SAWYER COAL BED NEAR THE WOOD RANCH, IN T. 1 S., R. 43 E.



B. GEOLOGIST PROSPECTING COAL BED IN AREA OF LOW RELIEF, ADAPTED TO MINING BY STRIP-MINING METHODS

at the summits of Liscom Peak, in sec. 18, T. 1 S., R. 47 E.; Home Creek Butte, in sec. 4, T. 3 S., R. 47 E.; and the Cook Creek Mountains, in the central part of T. 2 S., R. 46 E. Ashland is about 2,900 feet above sea level, Brandenburg about 2,775 feet, and Stacey about 3,325 feet.

GEOLOGY

STRATIGRAPHY

TERTIARY (?) SYSTEM

LANCE FORMATION

Only the uppermost 15 to 25 feet of the Lance formation crops out in the Ashland coal field, and even this part occupies the surface of only a very narrow strip of land bordering the Tongue River in the northeastern part of T. 2 N., R. 45 E. The rocks exposed consist of lenticular beds of cream-colored friable sandstone, sandy shale, clay shale, and two very thin coal beds. Dobbin[9] has described this formation in the Forsyth coal field as ranging between 870 and 945 feet in thickness, the lower two-thirds, which contains no workable coal, being known as the Hell Creek member,[10] and the upper third, which is coal bearing, being designated the Tullock member.[11] The Hell Creek member consists of massive sandstone in the lower part grading upward into greenish-gray and light-tan sandy shale and clay shale. The Tullock member is composed of very light tan calcareous sandstone, sandy shale, shale, and coal beds. It resembles the Tongue River member of the overlying Fort Union formation, but lacks for the most part the very thick zones of baked rocks that are so numerous in the Tongue River member.

On Rosebud Creek a few miles northwest of the north boundary of the Ashland field the uppermost part of the Tullock member is contrastingly different in lithology and topographic expression from the overlying Lebo shale, but on the Tongue River a few miles east of this locality these differences are not manifest. As a whole the upper part of the Lance formation in the Tongue River area contains a larger percentage of sandstone beds than the Lebo shale, which is composed essentially of somber-colored to dark-gray clay shale with a few lenticular beds of sandstone and a few thin coal beds. The sandstones in the Tullock are lenticular, and the pre-

[9] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 812, p. 8, 1929.

[10] 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, pp. 491–492, 1924.

[11] 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. 29–34, 1923.

vailing type of sediment is somber-colored and dark-gray clay shale, so that in most exposures it is difficult to separate the two formations. The field work involving these formations has progressed from west to east, and divisions made farther west, where these units differ distinctly in lithologic character, have been extended eastward and when carried into the Tongue River Valley are scarcely distinguishable. It seems probable that a worker commencing his studies in the Tongue River Valley would divide the sediments at the base of the present Tongue River member and place the Lebo shale and Lance formation in one unit. The lithologic similarity between the Lebo shale and Lance formation extends farther eastward than the Tongue River Valley of the northern part of the Ashland field. Thom has called attention to this condition near Miles City, and a reconnaissance examination in the Powder River Valley near Broadus, 50 miles southeast of the Ashland field, failed to disclose an adequate basis for separation of the rocks below the Tongue River member of the Fort Union formation.

TERTIARY SYSTEM

FORT UNION FORMATION

That part of the Fort Union formation present in the Ashland field ranges between 1,300 and 1,750 feet in thickness and occupies the surface of nearly the entire area. It is divisible into two members—the Lebo shale, occupying the lowermost 150 to 160 feet, and the Tongue River member, including the remainder. These members correspond to the divisions of the formation made by Rogers and Lee [12] in the Tullock Creek coal field, which is 25 miles west of the Ashland field. Dobbin [13] mapped these two members in the Forsyth coal field, which intervenes between the Ashland and Tullock Creek fields. In the Ashland field the lithologic difference between the two members is noteworthy and the topographic expression of the two members is markedly different. Inasmuch as the strata in this field are essentially flat lying, the beds crop out in regular sequence, the oldest beds in the formation occupying the surface in the areas of lowest altitude and the youngest beds occupying the points of highest altitude. The general slope of the area is northward, hence the Lebo shale is the surface formation in the stream valleys in the northern part of the field. The uppermost Fort Union beds present cap Liscom Peak, in sec. 18, T. 1 S., R. 47 E.; the Cook Creek Mountains, in T. 2 S., Rs. 45 and 46 E.; and Home Creek Butte and other buttes in T. 3 S., R. 47 E.

[12] Rogers, G. S., and Lee, Wallace, op. cit., pp. 35–43.
[13] Dobbin, C. E., op. cit., pl. 7, pp. 14–20.

LEBO SHALE MEMBER

Soft clay shale that weathers somber-colored or dark gray to black, interbedded with clay shale of somewhat lighter color, a few lenticular beds of sandstone, and a few thin coal beds make up the Lebo shale member. Several zones in the member contain ironstone concretions composed largely of iron carbonate that weathers rusty brown, the fragments of which lie thickly scattered upon the weathered surfaces and lend a rusty hue to certain ill-defined bands in the slopes. The Lebo shale produces soil that supports little vegetation, and much of its surface has no soil cover but is exposed as bare shale. Because of the heavy clayey character of the soil that is present and the scanty rainfall the grasses that cover irregular patches of the surface are seared by the sun's heat to a straw-brown color early in the summer. No trees grow on the Lebo shale. The relief is moderate, though the surface is somewhat dissected. Badland surfaces are common. On the whole, the region underlain by the Lebo shale member presents a dull, barren, lifeless, and depressing scene.

The appearance of the Lebo shale is in distinct contrast with that of the very light colored sandy beds of the overlying Tongue River member. A view of the contact beds is shown in Plate 7, *B*. The Lebo lacks the thick ledges of red rock formed by burned coal beds which are a striking feature of the Tongue River member. Moreover, the physical expression of the Lebo shale differs sharply from that of the overlying member. Much of the surface of the Lebo shale consists of rounded low hills or hummocks with barren slopes to which the varying shades of gray of the beds give a banded appearance. Some beds resist erosion much longer than most of the material, which is soft and is rapidly removed by erosion. These harder layers form rather inconspicuous rim rocks and flat-topped low buttes. A sandy zone forming the uppermost few feet of the member develops flat-topped narrow ridges resembling railroad grades, and flat-topped buttes occur through nearly all of the area of outcrop of this part of the member in the Ashland field. These ridges and buttes are particularly conspicuous east of the Miles City road in secs. 6 and 7, T. 1 N., R. 45 E.

The lower boundary of the Lebo shale is not sharply defined in the Tongue River Valley in the northern part of this field. In the Rosebud Creek Valley, a few miles north of the northwestern part of the field, however, the Lebo is rather abruptly terminated below by ledge-forming beds of tan sandstone constituting the uppermost beds of the Lance. The upper boundary is more sharply defined throughout the Ashland field. Almost throughout the area of its outcrop the uppermost few feet of the Lebo is composed of ledge-forming

dull-tan beds of calcareous sandstone or light yellowish-tan beds of hard limy shale. At this horizon changes from limy sandstone to limy shale commonly occur within a horizontal distance of a few feet. Below this cap rock are the very dark colored clay shale beds. Above this cap rock in most localities the much lighter cream-colored sandstone, sandy shale, and tan shale of the overlying Tongue River member crop out in distinct contrast. In some localities, such as the valley of Liscom Creek in T. 2 N., R. 45 E., and the Tongue River Valley in the southern part of T. 1 N., R. 44 E., the lowermost part of the Tongue River member contains a large percentage of drab shale, and the sediments near the contact of the two members are not so sharply different in aspect. In most localities the land forms developed on the two members are sufficiently different in character to aid in the detection of the contact. The gently rising slopes that traverse the subdued surface of the Lebo are abruptly broken at the contact and rise to the rugged forms that characterize the Tongue River member.

Rogers and Lee[14] report that microscopic examination of rock specimens collected from the Lebo shale in the Tullock field, 25 miles west of the Ashland field, showed that although much of the shale is too fine for microscopic determination most of it contains a considerable percentage of quartz in very fine grains. They state that much of the sandstone contains 30 to 50 per cent of brown volcanic glass, considerably altered and devitrified. Quartz, some feldspar, generally kaolinized, and chlorite make up the remainder of the sandstone.

TONGUE RIVER MEMBER

The Tongue River member is composed of shale, sandy shale, sandstone, and coal beds and has a total thickness in this field ranging between 1,150 and 1,600 feet. The most striking feature of the member is the presence of zones of ledge-forming red rock that were not originally of this color or character but have been changed by baking produced by the burning of thick coal beds along their outcrops and for a considerable distance back from the crop lines. The prevailing color of the rocks of the member where not changed by burning is very light tan to cream color. The sandstone beds, many of which reach more than 100 feet in thickness, are massive and of very light color. (See pl. 8.) The shale beds are prevailingly gray on fresh exposures but weather light tan, and the sandy shale beds are of an only slightly deeper tan than the massive sandstones. The red color of the baked zones forms a striking contrast with the very light background furnished by the weathered surface of the intervening parts of the member.

[14] Rogers, G. S., and Lee, Wallace, op. cit., p. 36.

The Tongue River member is thickest in the western part of the field. It also contains a much greater proportion of sandstone in the western than in the eastern part. This variation in thickness and lithologic character continues westward and eastward outside the field. The thick massive sandstones that form striking outcrops of nearly white cliffs, great rounded knobs, and a variety of pinnacles in the western part of the Ashland field and the southern part of the adjacent Forsyth field, give way eastward to sandy shale, shale, and thin-bedded sandstone. The greatest amount of thinning is believed to take place in the lowermost 600 feet of the member. The interval between the Knoblock coal and the base of the member is about 400 feet in the Rosebud Creek Valley, 300 feet in the Tongue River Valley, and 150 feet in the Pumpkin Creek Valley. The interval between the Knoblock coal bed and the Sawyer bed above it is about 225 feet in the southeastern part of T. 1 S., R. 42 E., and the southwestern part of T. 1 S., R. 43 E., 300 feet east of the Tongue River in T. 1 S., R. 45 E., and 150 feet in the Pumpkin Creek Valley in T. 2 S., R. 48 E. The section above the Sawyer coal thins eastward only a slight amount. Stratigraphic sections measured on the north slope of Garfield Peak, west of the Tongue River, and on the west slope of the Cook Creek Mountains in the south-central part of the field indicate that this upper series of beds has thinned eastward between these two localities only about 50 feet, and compiled sections measured in the Pumpkin Creek Valley indicate that the series is only slightly thinner in that locality. Although the total thickness of 1,600 feet applies to the westernmost part of the field and 1,150 feet to the easternmost part, the decrease in thickness is believed not to take place uniformly, but at least a considerable part of it apparently occurs in the easternmost part of R. 47 E. From that locality eastward the lower part of the member thins rapidly.

No information concerning southward changes in thickness was obtained, but the lithologic change in this direction is marked. Much of the sandstone of the member is replaced southward by shale, and thick coal beds are replaced by thin coal lenses and carbonaceous shale beds, the change taking place chiefly in about the middle of T. 3 S. From 10 to 12 miles farther south sandstone beds and thick coal beds again appear. Most of the member has been removed by erosion in the region north of the Ashland field, and positive data concerning its character there are not available.

The massive sandstone beds that are so conspicuous in the Tongue River member commonly weather in cliffs with cavernous faces below ledges of clinker, or as large knobs and pinnacles. Views of sandstone pinnacles are shown in Plate 6. The substance of the sandstone is mostly fine-grained quartz but includes some feldspar

and mica and minor amounts of other minerals. It also contains a comparatively large percentage of slightly iron-stained clay, which with calcium carbonate forms a weak cementing material. On the whole the beds are very friable, although sufficiently firm to stand in cliff faces 50 to 75 feet high and in pinnacles 20 to 30 feet high. Locally an individual thick sandstone bed may be replaced by beds of sandy shale and shale, but the dominant characteristic is the widespread occurrence and continuity of the thick sandstone beds. In general they are not lenticular bodies of local extent, such as might be deposited by the filling of river channels, but rather have an extensive sheetlike occurrence. The thick sandstones above and below the Knoblock coal and the thick sandstone a short distance above the E coal, which extend throughout many square miles, are typical examples.

Most of the material of the thick sandstone beds is comparatively homogeneous, but swirls and zones of much coarser irregular-sized material are common; and clay pellets ranging from less than one-eighth of an inch to an inch or more in diameter are abundant in these zones. Iron concretions are also more abundant here, although also present in the finer and more uniform parts of the beds.

In much of the massive sandstone no distinct bedding planes can be seen throughout thicknesses of 30 to 50 feet or more, but finely laminated cross-bedding dipping most commonly eastward and southeastward at angles as great as 20° is prevalent. The cross-bedding is discernible only on exposed surfaces that have been weathered so as to bring out the fine laminae in slight relief. (See pl. 8, *A*.) The swirls and zones of heterogeneous material weather away much more rapidly than the main body of the sandstone, resulting in indentations, notches, pits, and caverns, often referred to as blow holes. Observations in the field indicate that the material that occupied the pit spaces has been removed largely by solution rather than by wind, which is often credited with being the active agent. In some localities concretions were seen partly weathered out of massive sandstone; others were completely loosened but still lay within the cavities, and the outermost material of the concretions had been removed, leaving the main concretionary masses intact. Many of the cavities are coated with a thin deposit of white salt, precipitated by the evaporation of moisture issuing from the interior of the sandstone body.

Iron concretions ranging from less than a quarter of an inch to more than 6 inches, but chiefly about 1 to 2 inches in diameter, occur in the sandy beds throughout the member, but are particularly abundant on weathered exposures of the swirls and zones of heterogeneous material of clay pellets, sand, and shale particles. Concre-

tions of this type averaging about an inch in diameter are particularly abundant in the lowermost foot of a thick sandstone that directly overlies the Flowers-Goodale coal bed. Many of the concretions are composed of pyrite and marcasite, altering to limonite.

Numerous sandy zones in the lowermost 300 feet of the member have characteristics that are common features in the Lance formation but not common in most of the Fort Union beds. Many of the beds consist of sandstone concretions 5 to 15 feet long and 2 to 4 feet in diameter, and the laminae in many are greatly distorted. Rogers [15] describes this feature of contorted bedding as characteristic of the Lance formation in the region west of this field. Many of the concretions are 1 to 2 feet thick and almost perfectly log-shaped. Sandstone lenses 4 to 8 feet in diameter and 50 to 300 feet long are relatively common features of this lower part of the member. In some places only one long lens may be present, but in others there are two to four of them with parallel trends and each separated from the next by distances of 10 to 15 feet.

Beds of impure limestone 6 inches to 3 feet thick occur in the Tongue River member, most of them in the zones that are composed largely of shale beds. They very commonly contain an abundance of fossil leaves. These beds, because of their hardness, resist erosion longer than adjacent beds and so form small ledges. A relatively pure fossiliferous fresh-water limestone, of local occurrence, was seen about half a mile south of the Kelsey ranch house, in sec. 33, T. 1 S., R. 47 E.

In detail the beds in the Tongue River member are not continuous over wide areas, but groups of beds maintain certain distinguishing characters throughout distances of 50 miles and more. Some of the thick sandstone beds extend almost continuously over several townships. Comparatively thick units composed essentially of shale beds persist with distinguishable features throughout the field. Numerous thick coal beds are present over extensive areas, and the ledge-forming clinker beds that result from the burning of the coals along the outcrops nearly everywhere in the region form key beds that separate the member into divisions convenient for describing its several parts and useful in the field mapping. The chief coal beds and corresponding clinkers with the intervening stratigraphic units are shown in the generalized table below:

Coal beds and intervening strata in Tongue River member

	Feet
Garfield clinker, 100+ feet thick. Remnants cap highest points in field.	
Friable sandstone and shale (?). Mostly concealed	200

[15] Rogers, G. S., and Lee, Wallace, op. cit., pp. 25–26.

	Feet
F clinker, 25 to 100 feet thick. Caps Tongue River-Pumpkin Creek divide.	
Interbedded shale and sandstone. Thick massive sandstone in lower half; upper half mostly shale. The whole relatively soft rocks forming steep slopes and cone-shaped hills	315
E coal group and clinker. Clinker 25 to 75 feet thick. Widespread.	
Interbedded shale and sandstone, very light colored	85
X coal and clinker. Clinker 20 to 40 feet thick. Present in Elk Ridge slopes in eastern part of field and locally elsewhere.	
Interbedded sandstone and shale, cream-colored	75
D coal and clinker bed. Clinker bed prominent in central part of field. Clinker as much as 75 feet thick.	
Friable sandstone and shale	20–30
C coal and clinker. Coal contains abundant silicified stumps. Clinker bed prominent only in Little Pumpkin Creek Valley.	
Badland; banded somber-colored light and dark gray shale and silty friable sandstone; contains abundant gastropods and bivalve shells at several horizons	85
Sawyer coal and clinker. Clinker 25 to 85 feet thick. Widespread.	
Cream-colored sandstone, with minor amounts of sandy shale	40
A coal and clinker. Present in eastern part of field.	
Interbedded sandstone and shale. Thick massive sandstone in lower half. Thins eastward	150–220
Knoblock coal and clinker. Widespread. Forms bluffs at Ashland and bordering Tongue River Valley. Clinker 50 to 100 feet thick.	
Interbedded sandstone and shale, very light tan	60–100
Flowers-Goodale coal and clinker. Present in north-central part of field. Rosebud coal and clinker present at about this horizon in westernmost part of field.	
Interbedded sandstone and shale, very light tan	40–80
Terret coal and clinker.	
Interbedded sandstone and shale, very light tan	75–150
Lebo shale.	

That part of the section described above as occurring below the Knoblock clinker is distinguished in the field primarily by its position with respect to the Knoblock clinker. Individual beds and series of beds within this part can be distinguished and traced across areas the size of townships, and some of the coal beds are believed to be continuous over even greater areas. There are a number of coal beds in this part of the section, not shown in the table, that extend throughout areas of several square miles. Massive sandstone beds that form prominent cliffs below the thick ledge of the Knoblock clinker along the Tongue River Valley and increase in thickness and prominence westward are characteristic of the upper part of this group. A series of interbedded sandstone, sandy shale,

shale, and coal beds varying in percentages of the several rock types make up the lower part. The percentage of sandstone and sandy beds and the total thickness of this group are greater in the western part of the field than in the eastern part. The increasing shaly character of the beds eastward is well shown in numerous exposures of almost bare rock in the steep slopes bordering the Lebo lowland of the Foster Creek Valley in T. 2 N., R. 47 E., and the subdued relief of the surface in T. 2 S., R. 48 E., underlain by this series of beds indicates an even greater preponderance of soft rocks in the easternmost part of the field. This series shows a considerable percentage of sandstone beds and sandy shale beds west of the Tongue River in T. 1 N., R. 44 E., and in the Rosebud Creek Valley in T. 1 S., R. 42 E. The Rosebud clinker is a prominent feature on the west side of the Rosebud Creek Valley in the westernmost part of the field but is of little prominence east of Rosebud Creek and apparently dies out farther eastward. The Flowers-Goodale clinker occurs near the Rosebud horizon and forms a prominent ledge east of the Tongue River throughout the north-central and northeastern parts of the field. The Terret clinker, about 140 feet above the base of the member, is the most prominent clinker throughout the northern part of T. 1 N., R. 44 E., and T. 2 N., Rs. 45–48 E.

The Knoblock clinker, produced by the burning of the Knoblock coal, is the most widespread prominent clinker in the field. It caps the continuous line of bluffs bordering the Tongue River Valley from a point about 4 miles below Brandenburg upstream past Ashland to the Knoblock ranch, south of the field, in T. 5 S., R. 43 E. This clinker is particularly prominent on Otter Creek near Ashland and for several miles southeastward (upstream). The clinker attains more than 100 feet in thickness and forms the floor and serrated rugged ledge of a plateau that extends from the region south of Ashland and northward, covering an extensive area west of the Tongue River and an area from 4 to 10 miles or more wide on the east side of the river as far as T. 1 N., R. 45 E., where it swings eastward and continues with diminishing prominence to the easternmost part of the field.

The rocks between the Knoblock and Sawyer clinkers contain a large proportion of very light colored sandstone. In many localities a thick massive sandstone occupies most of the lowermost 150 feet of this interval and forms large knobs and pinnacles of a great variety of shapes that stand on the undulating surface of the Knoblock plateau. These pinnacles are particularly abundant near the Gilge ranch, in secs. 34 and 35, T. 1 S., R. 45 E.; secs. 20, 21, and 28, T. 1 N., R. 46 E.; and secs. 9, 16, and 21, T. 1 S., R. 43 E. The A coal bed is present locally in the central and eastern portions of

the field and occurs in association with very light colored beds that are predominantly sandstone. Throughout the field the beds that occupy the uppermost 50 feet of this interval and immediately underlie the Sawyer coal and clinker are sandy and very light colored, with a somewhat yellowish hue, forming a distinct contrast with the somber-colored clay beds that immediately overlie the Sawyer bed. Plate 7, *A*, shows the contrasting appearance of these units somewhat less distinctly than they appear in the field. In some parts of the field sandstone occupies most of the unit below the Sawyer, and in other parts shale beds form an appreciable percentage of the total, but the very light tan color of the weathered exposures prevails and serves admirably with the somber hues of the shale above as a criterion for identifying the Sawyer coal bed throughout the field. These beds are clearly exposed on the East Fork road in secs. 10, 11, and 12, T. 3 S., R. 45 E., in the south creek bank south of Mosger's ranch, in secs. 6 and 7, T. 3 S., R. 46 E., and in the clinker-capped bluff along Pumpkin Creek in T. 2 S., R. 48 E.

The strata succeeding the Sawyer coal through an interval about 85 feet thick form a unit that maintains its character throughout a greater area than any other group of beds in the section. The interval is composed largely of somber-colored clay beds that form badlands. At several horizons there are beds of friable, very fine grained silt or silty sandstone that is also dull gray in color and shale beds rich in fresh-water gastropod remains associated with a fresh-water bivalve that has the general appearance of a mussel shell. Ocherous limonitic concretions half an inch to 3 inches in diameter, elongated parallel with the bedding planes, also occur at several horizons. There are numerous thin beds that weather rusty brown, probably owing to an abundance of contained limonite. In the upper part of the unit one to three beds of coaly carbonaceous shale 1 to 2 feet thick occur in most localities. Limy mudstone 6 to 12 inches thick weathering into hard ledge-forming beds is present in two beds in the upper part of the unit. Much of the clay of the unit forms a hard, sharply irregular crust about an inch thick that surfaces the barren slopes. Other parts of the unit weather to a spongy barren surface. The unit is thin bedded, and the varying shades of gray give the exposures a finely banded appearance. This unit is unlike some others in the Tongue River member in that individual thin beds and groups of beds can be traced rather widely. Its characters indicate that it accumulated as fine mud in a quiet body of water.

Except for the C coal bed, the strata that occur in the interval of 185 feet above the badland shale have few distinguishing features.

The C coal bed contains an abundance of silicified stumps that are partly carbonized and occur throughout much of the outcrop of this bed in the Ashland field. Most of the stumps stand upright in the coal. They range between 1½ and 4 feet in diameter, and their presence destroys the commercial value of the coal. Between the C and E beds the rocks consist of interbedded light-tan shale and sandstone that have no distinguishing features by which they can be traced far. The coal beds in the unit were mapped by continuous tracing or determining their relations to the underlying C bed or the overlying E bed.

The E clinker is one of the most prominent and widespread clinkers that occurs in the higher lands of the field. It was probably formed by the burning of several coal beds closely associated, rather than one thick bed. It is well exposed in the southern part of T. 2 S., R. 46 E., where it forms a rugged tree-clad ledge about a third of the way up the slope on the south side of the Cook Creek Mountains. It forms a prominent ledge in Elk Ridge, in T. 2 S., Rs. 47 and 48 E., where it is the first clinker below the crest of the ridge, which is formed by the F clinker.

Above the E clinker is a series of beds 315 feet thick that has several distinguishing features. The lower half of the unit contains a massive light-tan sandstone that attains more than 100 feet in thickness and forms conspicuous ledges and cliffs in the steep slopes that lie between the E and F clinkers. Above this sandstone the beds are composed mostly of soft rocks, shale, carbonaceous shale, and friable sandstone. These beds form steep barren slopes below the F clinker ledge and sharply cone-shaped hills out from the main slopes. The alternating light and dark color of the shale, sandstone, and carbonaceous shale and their occurrence at comparatively regular intervals 3 to 25 feet apart give these hills a striking banded appearance.

The F clinker is one of the thickest clinker beds in the field. It caps the greater part of the highland forming the divide between Beaver Creek and East Fork, the main divide between Pumpkin Creek and the Tongue River, and the Elk Ridge divide, between Little Pumpkin and Pumpkin Creeks. The East Fork road to Stacey traverses the upper surface of this clinker from about the junction with the Beaver Creek road, in the SE. ¼ sec. 24, T. 2 S., R. 46 E., to the junction with the Whitetail ranger station road, about three-quarters of a mile farther northeast. It is this clinker that forms the thick red ledges near the Sutton ranch house, near the south quarter corner of sec. 28, T. 2 S., R. 47 E., and caps the rugged hills above the Whitetail ranger station.

The beds between the F and Garfield clinkers are not well exposed. Partial exposures indicate that they are composed of soft rocks, presumably shale, sandy shale, and sandstone, similar to the underlying beds.

The Garfield clinker floors an expansive timbered plateau in the northern part of the Northern Cheyenne Indian Reservation, immediately south of the southwestern part of the Ashland field, where it is about 100 feet thick. It is about 60 feet thick on Garfield Peak, in sec. 5, T. 2 S., R. 43 E., from which it derives its name. Only a few isolated remnants of this clinker bed remain in the Ashland field. It caps a few knobs in the Cook Creek Mountains, in the east-central part of T. 2 S., R. 45 E.; Liscom Peak, in sec. 18, T. 1 S., R. 47 E.; Home Creek Butte, in sec. 4, T. 3 S., R. 47 E.; and several knobs in the central part of T. 3 S., R. 47 E.

OLIGOCENE OR MIOCENE (?) GRAVEL

Small remnants of stream terraces that are about 1,100 feet above the present Tongue River at Ashland were seen not far below the crest of the Pumpkin Creek-Tongue River divide, in the NE. ¼ sec. 22 and the SW. ¼ sec. 35, T. 2 S., R. 47 E., at altitudes of 4,050 and 3,990 feet, respectively. The material composing the deposits consists largely of cobbles and pebbles of rock types foreign to the bedded rock of the region, presumably derived from rocks of the Big Horn Mountains in Wyoming. The prevailing rock is a dense quartzite. A large assortment of igneous rocks ranging from granite to dunite, including a considerable amount of basalt, some silicified wood, and a few cobbles of vein quartz form much of the material. The cobbles are 5 inches in maximum diameter, but the most abundant range between 1 and 2½ inches. Most of the cobbles and pebbles are well rounded and oblong to flattish. Some quartzite cobbles have retained their original general shape, but the edges and corners are well rounded. A few cobbles of vein quartz are angular. At the locality in sec. 22 the gravel is cemented in the clinkered material of the F clinker.

There are few data available to indicate the age of these stream-terrace remnants. They may have been deposited at approximately the same time as high terraces in Ts. 3 and 4 N., R. 39 E., 1,050 to 1,100 feet above the level of the Yellowstone River, in the Forsyth coal field. Dobbin[16] has correlated these deposits with those occurring near Terry, Mont., 1,200 feet above the Yellowstone, which Alden[17] states may be Oligocene or Miocene in age.

[16] Dobbin, C. E., op. cit., p. 21.

[17] Alden, W. C., Physiographic development of the northern Great Plains: Geol. Soc. America Bull., vol. 35, p. 396, 1924.

MIOCENE OR PLIOCENE (?) GRAVEL

A gravel-covered surface a little less than a square mile in extent occurs in secs. 5 and 8, T. 2 N., R. 48 E., at an altitude of a little less than 3,300 feet, which is about 600 feet higher than the Tongue River near Garland, in T. 3 N., R. 46 E. The material is composed of well-rounded cobbles and pebbles and finer fragments of baked rocks and sandstone of the Tongue River member, and smoothly rounded cobbles and pebbles of rocks foreign to this locality. Quartzite is the commonest type, but there is considerable chert, granite, basalt, and other igneous rocks. The largest cobbles seen were 5 to 6 inches in diameter, and the most abundant size ranged between 1 and 2½ inches.

The height of this terrace above the present stream levels suggests that it may have been deposited at about the same time as the Flaxville bench, described by Alden[18] as being of probable Miocene age, deposition probably continuing, according to him, into Pliocene and perhaps even later time.

An isolated butte in sec. 36, T. 2 N., R. 47 E., is capped by gravel composed largely of igneous rocks, quartzite, and siliceous wood, in which the largest cobbles are 6 inches in diameter. The hill stands on the crest of the divide at an altitude of 3,165 feet. The divide between Foster Creek and its east fork is capped by gravel in secs. 15 and 10, T. 2 N., R. 47 E., at altitudes of 3,083 and 3,040 feet, respectively. The material composing these deposits shows greater effects of weathering than that of the terraces that lie at lower altitudes and form benches bordering the valley bottoms, and on this basis its age is tentatively assigned to the approximate time, or possibly a little later, of the deposition of the terrace in the northwestern part of T. 2 N., R. 48 E.

QUATERNARY SYSTEM

PLEISTOCENE GRAVEL

Stream-deposited gravel beds as much as 300 feet above the present stream levels are present in isolated patches along nearly all the main stream valleys in the Ashland field. Except in a very few localities the terraces occur only on the west sides of the valleys. They are best developed along the Tongue River and Little Pumpkin, Pumpkin, and Liscom Creeks. The most prominent terrace along the Tongue River is about 120 to 130 feet above the present flood plain. At the northernmost locality, in sec. 15, T. 2 N., R. 45 E., the terrace is 150 feet above the river. A second bench about 40 feet below the main terrace is developed in the northern part of T. 2 S.,

[18] Alden, W. C., op. cit., pp. 401–402.

R. 44 E.; and there is a very narrow terrace (not shown on pl. 3) about 40 to 50 feet above the main one in the north half of T. 1 S., R. 44 E. In sec. 12, T. 2 N., R. 45 E., a small remnant of a gravel bench occurs at a level 60 feet above that of the main terrace in sec. 15. The material composing these gravel deposits is in general similar to that found at higher levels, except that it is not so coarse and contains an abundance of hard fossiliferous limestone cobbles and pebbles and more chert than the higher gravel, and the igneous pebbles are predominantly granite, although many igneous rock types are represented. There is an appreciable content of Fort Union rocks. Much of the material ranges from about half an inch to 1½ inches in diameter and is smoothly rounded. At one locality the main gravel deposit is 12 feet thick and is overlain by 5 to 8 feet of silt, and at another locality the main bench contains about 12 feet of gravel.

Probably the best-preserved gravel deposits occur along the west side of Pumpkin Creek, particularly in T. 3 S., R. 48 E., where four distinct benches can be recognized. But few remnants of these benches remain in T. 2 S., R. 48 E., where the stream is confined between bluffs capped by a thick, resistant clinker bed. In T. 3 S., R. 48 E., the terraces were formed on soft shale beds offering relatively slight resistance to the eastward migration of the stream channel. Four benches can be found in some parts of Ts. 1 S. and 1 N., R. 48 E., but in other parts only two are prominent, bordering Little Pumpkin Creek although three were seen in several localities. The correlations of these terraces indicated on Plate 3 should be regarded merely as suggested relationships, because only meager data concerning the gravel deposits were obtained in the field. Individual terraces in theTongue River drainage basin are not correlated with those in the Pumpkin and Little Pumpkin Creek basins. The material composing these deposits on Pumpkin and Little Pumpkin Creek differs from that bordering the Tongue River by an almost entire absence of limestone and the presence of a larger percentage of Fort Union material—sandstone, clinker fragments, etc. Some of the Fort Union material has only rounded edges, but most of it is well rounded. The proportion of rocks foreign to this locality is probably less than 5 per cent in these deposits. The material ranges from a fraction of an inch to 6 inches in diameter. About half the total is less than half an inch in diameter; cobbles 1 to 1½ inches in diameter are abundant. The thickness of gravel on any one bench was estimated to be about 10 to 15 feet.

West of the Wilbur Titus ranch, in T. 3 S., R. 48 E., the surface of the highest terrace mapped is at an altitude of 3,515 feet, about 260 feet above the stream bank near the ranch house. In secs. 10 and 15 the uppermost bench is at an altitude of 3,420 feet; 55 feet below

it is a well-developed terrace nearly half a mile wide; 22 feet lower is a slightly developed bench; and 50 feet still lower is a strongly developed bench that can be followed almost continuously through this township. This lowest bench lies about 90 feet above the present flood plain. What are believed to correspond with three of the benches of this series were recognized in sec. 34, T. 1 N., R. 48 E., and secs. 1 and 2, T. 1 S., R. 48 E. The lowermost one is about 90 feet above the present flood plain of Pumpkin Creek, the second 65 feet higher, and another 55 feet above the second. The highest of the three is at an altitude of 3,195 feet in sec. 2 and 3,205 feet in sec. 13, T. 1 S., R. 48 E. Remnants of a terrace that lies 100 feet higher were seen in secs. 3 and 23, T. 1 S., R. 48 E.

The lower of two benches that occur in sec. 1, T. 1 N., R. 48 E., has been cemented with limonite and calcium carbonate into a conglomerate about 2½ feet thick.

A series of terraces bordering the Little Pumpkin Creek Valley on the west are tentatively correlated with those on Pumpkin Creek. In sec. 13, T. 2 S., R. 47 E., there are two prominent terraces and an intermediate, less pronounced bench. The highest is 240 feet and the lowest 120 feet above the present flood plain of Little Pumpkin Creek. In sec. 35, T. 1 S., R. 47 E., the lowest prominent terrace is 90 feet above the flood plain of Little Pumpkin Creek, the next bench is 100 feet higher, and a third is about 75 feet above the second. These are assumed to correspond with the first, third, and fourth benches mapped on Pumpkin Creek in T. 3 S., R. 48 E., although this should be considered only a suggested possible correlation.

Two terraces south of Foster Creek in the northern part of T. 1 N., R. 47 E., are composed of material similar to that found along the Pumpkin and Little Pumpkin benches. The lower one is about 100 feet and the upper one about 200 feet above the flood plain of Foster Creek.

Gravel deposits were seen at one locality on Lay Creek, in the SW. ¼ sec. 16, T. 2 N., R. 46 E., where a small part of a bench is preserved 185 feet above the present level of the creek.

A prominent terrace borders the Liscom Creek Valley on the southwest in T. 1 N., R. 45 E. The terrace has a fairly steep slope toward the valley and has a maximum width of three-quarters of a mile. In the NE. ¼ sec. 15 it is 140 feet above the present bottom lands, and 30 feet below it is a second bench that is not very prominently developed. All material composing the deposits in these benches appeared to be derived from near-by Fort Union rocks. Much of it ranged in size from fine material to cobbles 3 to 4 inches in diameter. The cobbles and pebbles are for the most part well rounded, although a small proportion have only rounded edges. Aside from this material there are a few blocks of sandstone with

rounded edges and corners a foot in maximum diameter and angular blocks of clinker attaining 3 and 4 feet. The thickness of the deposit was estimated at 10 to 15 feet.

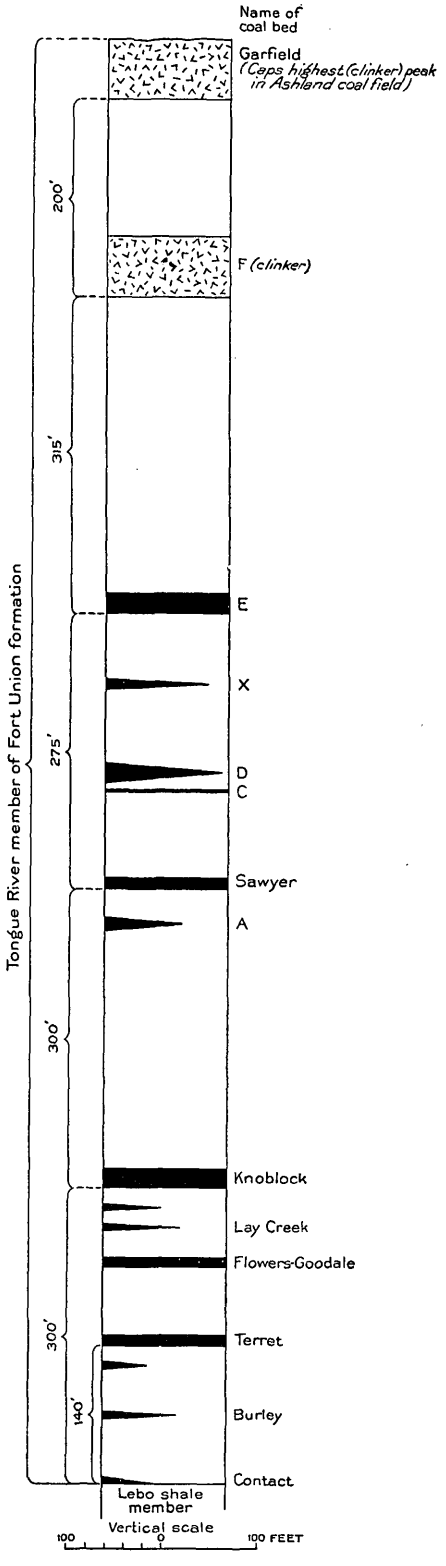
In the western part of the field gravel beds were seen at a few localities. The most prominent terraces lie 100 to 130 feet above the present drainage channels. A terrace at about this relative position was seen southeast of Miller Creek in the northeastern part of T. 1 S., R. 42 E., and west of Greenleaf Creek in Ts. 1 N. and 1 S., R. 43 E. The lower part of the gravel deposit bordering Miller Creek is cemented with limonite and calcium carbonate into a conglomeratic bed about 3½ feet thick.

All these terrace benches that lie less than 300 feet above the present flood plains were probably formed at the time the Yellowstone River was depositing the great gravel benches that now stand 100 to 300 feet above its present level and are so well developed south of the river east of Forsyth, in Rosebud County. According to Alden[19] these terraces were formed in Pleistocene time.

A lower and so later stream-laid deposit borders practically all the main streams in the field and can be seen on most of the lesser drainage channels. Its surface stands 20 to 30 feet above the present flood plains. These deposits are composed largely of a heterogeneous mixture of material derived for the most part from the local region. Lenses composed of angular fragments of baked sandstone and shale alternate with lenses of sand, gravel, and clay. Mr. D. W. Hogan, of Ashland, has a large tooth that was found in the bed of a small arroyo about 4 miles northwest of Ashland. At this locality several large bones were found 20 feet above the arroyo bed, where they were embedded in silt and clay interbedded with lenses of angular fragments of baked sandstone and shale of the terrace that lies about 30 feet above the flood plain. Presumably the tooth was deposited with the bones and fell to the creek bed when the material containing it recently slumped off. Other teeth were found in gravel beds that occur at a lower level and in the present flood plain of the Tongue River near Ashland. The tooth found at the first locality and photographs of other teeth and of the bones found at the first locality were sent to Dr. J. W. Gidley, of the United States National Museum, who reported as follows:

> The tooth is a second lower molar of the mammoth, *Elephas* cf. *E. columbi*. The others shown in the photograph seem to belong to the same species. This species ranged in time throughout most of the Pleistocene.
>
> The bone at the right in the photograph is a rib, the second or third from the front, of a mammoth or mastodon; the others are not clearly enough shown to determine what they are but probably are parts of the same animal.

[19] Alden, W. C., personal communication.



GENERALIZED SECTION SHOWING POSITIONS OF PRINCIPAL COAL BEDS IN TONGUE RIVER MEMBER OF FORT UNION FORMATION

The section is more representative of the central part of the field than of other parts.

The tooth found near the bones is well preserved and appears not to have been transported far. It could very readily have been carried down from an earlier and higher terrace deposit, however, and still be in its present excellent state of preservation. The teeth found in the gravel deposits at a lower level near the river are also well preserved, and it seems certain that they must have been transported from a higher and earlier terrace, because this lower deposit lies within the present flood plain of the river and is believed to be definitely of Recent age.

The bench which lies 20 to 25 feet above the present flood plain and which contained the large bones and probably one tooth is provisionally assigned to very late Pleistocene time.

RECENT ALLUVIUM

A deposit of silt, sand, and clay with lenses of gravel and rubble has been and is still being laid down in the flood plains of all the main streams. The tributary drainage courses contain a greater percentage of the coarser material. The flood plain of the Tongue River averages about three-quarters of a mile in width, those of Otter Creek and Pumpkin Creek about half a mile each, and those of several other streams about a quarter of a mile each. Sand and gravel have been mined from the alluvium of the Tongue River near Ashland for foundations and other concrete construction. In general the material is rather silty and requires washing for best results.

SOILS

The soil types in the Ashland field are largely controlled by the distribution of the rock types. The soils derived from most of the Tongue River beds are light-tan sandy loams. Those derived from the somber-colored clay beds of the Lebo shale and the clay beds that overlie the Sawyer coal bed are heavy clay soils that support only a scant vegetative growth. The soils of the Tongue River bottom lands are dark colored, owing to a larger proportion of humus there. Soil that contains an appreciable percentage of material derived from the baked rock of the clinker beds has a reddish-tan color.

STRUCTURE

The strata in this field lie so nearly flat that their very slight deviations from horizontality can not be seen with the eye. The chief features[20] involving the Ashland coal field are a broad syncline

[20] Thom, W. T., jr., The relation of deep-seated faults to surface structural features of central Montana: Am. Assoc. Petroleum Geologists Bull., vol. 7, pp. 1–13, 1923. Thom, W. T., jr., and Dobbin, C. E., unpublished structural map of eastern Montana in United States Geological Survey files.

plunging gradually northeastward, its axis following the Tongue River Valley, and a northwestward-trending downfold that crosses the Tongue River syncline near Ashland. The Tongue River syncline constitutes the major syncline between the Black Hills uplift, far to the southeast, and the Porcupine dome, to the northwest near Forsyth. The axis of the Ashland syncline passes about 2 miles south of Ashland and continuing northwestward may connect with the syncline described by Dobbin [21] as passing through Castle Rock and the northeast corner of T. 1 S., R. 41 E. This syncline is the chief structural feature separating the Big Horn uplift, on the south, and the Porcupine dome, on the north. The artesian flow from drilled water wells in the valleys of Otter Creek and the Tongue River is a natural result of this regional structure. The buried water-bearing strata dip toward the valleys from the east, west, and south, and are thus at a higher altitude than the mouths of the wells. Consequently when a water-bearing bed of the stratified rocks of the region (not the sand and gravel beds of the river bottoms) is tapped by a bore hole in one of these valleys the water rises, seeking the level at which it is held in the surrounding area.

In the general vicinity of Ashland a low anticlinal fold parallels the Ashland syncline on the south, crossing the Tongue River near the south boundary of the field. On the Tongue River half a mile south of the boundary, however, the rocks resume their rise upstream, which continues for many miles. The Knoblock clinker, which is near stream level on the Tongue River about half a mile south of the south boundary of the field, rises higher and higher for several miles southward, approaches the river level again at the Knoblock ranch, in T. 5 S., R. 43 E., and forms the river bed opposite the Three Circle ranch, near Birney. The cross section of an anticlinal fold appears on Otter Creek a few miles south of the south boundary of the field, where the Knoblock clinker rises from a position below stream level in a low, broad arch, forming a red escarpment in the east bank of the stream. This may be the southeastward continuation of the anticlinal fold that crosses the Tongue River at the south boundary of the field. A gently dipping anticlinal fold plunging westward is shown by Thom's map to be present near Coalwood, east of this field, and its west end crosses the northern parts of T. 1 S., Rs. 45–48 E.

The occurrence of stream gravel confined almost wholly to the west sides of the stream courses probably indicates that the region has been tilted eastward subsequent to and perhaps during the deposition of the gravel beds in Pleistocene time.

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[21] Dobbin, C. E., op. cit., pp. 22–23.

The field examination revealed only three localities where the rocks are faulted. A northwestward-trending fault, in which the rocks on the north have been displaced downward about 75 feet relative to those on the south, appears in the strata associated with the Sawyer clinker in the SW. ¼ sec. 33, T. 1 S., R. 43 E. The fault surface dipping very steeply northward is clearly exposed in a small gulch tributary to Lay Creek. A hundred feet to the north the rocks dip toward the fault, but the beds in close proximity to the fault surface are sharply curved upward, as a result of the drag of the beds on the fault surface during the fault movement. The rocks associated with the Sawyer coal are faulted near the coal outcrop in the NW. ¼ sec. 32 of this same township, but here the south side is the downthrown side. The exact amount of the throw was not determined, but it was estimated to be 50 feet or less. Each of the faults is of the normal type, and it is interesting to note that they occur in general alinement with the Lake Basin fault zone, which extends slightly south of east across southern Montana, and whose western extremity is 150 miles west of this locality. These small faults in T. 1 S., R. 43 E., trend more nearly parallel with the trend of the zone as a whole than with the most common trend of the individual faults.

A northwestward-trending fault appears in the ridge capped by the Knoblock coal bed and clinker in the W. ½ sec. 25, T. 1 N., R. 43 E. The beds on the north have been displaced downward about 40 feet relative to those on the south. North of the fault throughout an area about a quarter of a mile wide the rocks dip at a low angle southwestward toward the fault.

In many places great masses, including the F clinker and the rocks immediately below it, have slid part way down the steep slopes, leaving large bare rock surfaces exposed above rock masses that tilt away from the slopes. A great scar on the northeast side of Liscom Peak, in sec. 18, T. 1 S., R. 47 E., marks a rock slide that is said to have occurred about 25 years ago. Others have occurred in recent years near the Kelsey ranch, in sec. 32, T. 1 S., R. 47 E. Several slides have occurred on the east slope of Elk Ridge, in T. 2 S., R. 48 E. Tilted pine trees that rode down the slope with the displaced rock masses bear witness of the recent occurrence of many of the slides.

ECONOMIC GEOLOGY

OIL AND GAS POSSIBILITIES

Many of the geologic conditions commonly regarded as favorable for the accumulation of oil and gas are not present in this part of Montana. The region is underlain by adequate reservoir beds and

possible source beds for petroleum products. The horizon of the sandstone beds that yield gas near Baker, Mont., is probably not more than 2,500 feet beneath the surface in parts of the Ashland coal field, and the lower part of the Colorado group, which contains the oil-bearing strata in many of the Wyoming fields, could be reached by drilling to a depth of 6,000 feet. However, the attitude of the exposed strata indicates structural conditions that are unfavorable for the accumulation of oil and gas; there are no pronounced anticlines, domes, or other structural features in which oil and gas would be likely to have been trapped. Although it can not be said that oil or gas will never be found in the Ashland coal field, the facts revealed by the field study fail to disclose reasons for advising the expenditure of money in prospecting for these substances in the near future.

PORCELLANITE OR CLINKER

Enormous supplies of road-surfacing material and railroad ballast are available in the thick layers of clinker formed by the burning of thick coal beds. This material where properly applied forms an excellent roadbed, and it appears probable that within only a few years the main roads in this entire region will be surfaced with "scoria," as the clinker is called locally. No binder is added to the clinker, as there is sufficient fine material present to serve the purpose for road surfacing. Clinker is used very successfully for railroad ballast by the Chicago, Burlington & Quincy Railroad in northern Wyoming, and it appears reasonable to assume that should the proposed North & South Railroad in the Tongue River Valley be completed this material will serve as ballast there.

COAL

The coal resources of the Ashland field are enormous. Almost any area the size of a township picked at random in the field would contain several coal beds of workable thickness. Numerous townships contain five to eight coal beds with average thickness greater than 6 feet each. Outcrops of coal beds 10 feet thick are common, and beds 20 to 25 feet thick occur in several localities (see pls. 9, *A*, and 10, *A*) and are continuous with these thicknesses throughout areas of several square miles. In general the coal beds are remarkably free from partings. All the thicker coal beds occur in the Tongue River member of the Fort Union formation. The approximate stratigraphic positions of the coals that are most widespread in the field are given in the accompanying generalized columnar section (pl. 11), which is most representative of the central part of the field.

The Tongue River Valley interposes a wide gap in the extensive region occupied by the thick coal beds, and correlation of some of the beds on one side of the valley with those on the other is difficult. Several coal beds can be correlated with reasonable assurance; for some other beds correlations have been suggested, but the beds have been designated by different names west and east of the river. There are numerous other beds that are of only local occurrence and so are not correlated except locally.

COAL WEST OF TONGUE RIVER

The chief coal beds that occur west of the Tongue River are named, from the lowermost upward, the Burley, Terret, McKay, Rosebud, Knoblock, Lee, and Sawyer beds. The Garfield clinker caps Garfield Peak in T. 2 S., R. 43 E., and it is probable that the E and F beds, which are widely distributed east of the river, are represented in the slopes of the peak. Several other coal beds occur locally, being particularly abundant in the lowest 250 feet of the Tongue River member.

The Burley bed is 120 feet above the base of the Tongue River member on Rosebud Creek but was seen cropping out as a thick bed only in the northern part of T. 1 N., R. 43 E., and the northwestern part of T. 1 N., R. 44 E.

The Terret bed was named from a small mine that supplies coal to the Terret ranch, on Beaver Creek, in T. 1 S., R. 45 E., east of the Tongue River. The bed is present in workable thickness west of the Tongue River in the northwestern part of T. 1 N., R. 44 E., and the northeastern part of T. 1 N., R. 43 E. Northeastward from these localities the Terret bed is believed to extend for many miles along the Rosebud Creek-Tongue River divide. The Snyder Creek mine, in the southeastern part of T. 2 N., R. 43 E., outside the Ashland field, which supplies coal to an extensive area, is worked in the Terret bed. Southward the bed appears to pinch out in the southern part of T. 1 N., R. 44 E. It was seen again on Lay Creek, in the southwestern part of T. 1 S., R. 44 E., and mapped for several miles north and south of this locality.

The names of the McKay and Rosebud beds are taken from the Forsyth coal field,[22] where the Rosebud bed is being exploited by the strip mine of the Northern Pacific Railway at Colstrip, 3 miles west of the western boundary of the Ashland field. The Rosebud bed occurs at about the position of the Flowers-Goodale bed shown in Plate 11. The McKay bed occurs 15 to 40 feet beneath the Rosebud bed in the vicinity of Colstrip and in the Rosebud Creek

[22] Dobbin, C. E., op. cit., pp. 27–28.

Valley. Each of these two beds is more than 10 feet thick in the northwestern part of T. 1 N., R. 42 E. Southeastward up the Rosebud Creek Valley the beds become irregular in thickness and in places are entirely absent. Southeast of Rosebud Creek in T. 2 S., Rs. 42 and 43 E., both beds are present locally but are of irregular thickness. Coal lenses that probably represent these beds occur on Greenleaf Creek in the northeastern part of T. 1 S., R. 43 E., and the southwestern part of T. 1 N., R. 43 E., but northeastward they are replaced by carbonaceous shale and other rock types. A thick coal that is believed to represent the Rosebud coal is found in the northwestern part of T. 1 S., R. 44 E., in the slopes leading eastward to the Tongue River. Southward and northward this coal again disappears.

The Knoblock bed was named from the Knoblock ranch, on the Tongue River in T. 5 S., R. 43 E., outside the Ashland field, where coal has been mined from the bed for many years.[23] It has been traced largely by the thick clinker produced by the burning of the coal almost throughout its outcrop in the Ashland field. The westernmost limit of the bed is in secs. 22 and 27, T. 1 S., R. 42 E. In the Rosebud Creek Valley it occurs about 400 feet above the base of the member, but in the Tongue River Valley it is only about 300 feet above the base. The bed averages about 20 feet in thickness in the western part of T. 1 S., R. 43 E. It has burned throughout most of the eastern part of this township and the western part of T. 1 S., R. 44 E. It is present in the narrow divide that trends northeastward through the eastern part of T. 1 N., R. 43 E., but it thins rapidly toward the north.

The Lee bed was named by Dobbin[24] in the Forsyth field. It occurs about 165 feet beneath the Sawyer clinker and is present only in parts of T. 1 S., R. 42 E.

The Sawyer bed was also named by Dobbin[24] in the Forsyth field. This coal is the most definitely recognizable coal bed in the entire section and has been traced from the Forsyth field eastward to and beyond the eastern edge of the Ashland field—more than 50 miles due east. It is recognized chiefly by the badland somber-colored clay beds that overlie it and the very light tan sandy beds that underlie it. This bed occupies the high land in the extreme southern part of the area west of the Tongue River, where it ranges in thickness between 10 feet and a little more than 20 feet. It occurs about 225 feet above the Knoblock bed in this region.

Coal beds occur above the Sawyer bed in a small rugged area in the vicinity of Garfield Peak, in T. 2 S., R. 43 E. Representatives

[23] Bass, N. W., Coal in Tongue River Valley, Mont.: U. S. Geol. Survey Press Mem. 16748, February 12, 1924.

[24] Dobbin, C. E., op. cit., p. 28.

of the E and F beds are probably present. The Garfield clinker caps the peak. Because of their inaccessible position and small area these beds are of little importance here. They are described in somewhat more detail in the description of T. 2 S., R. 43 E.

COAL EAST OF TONGUE RIVER

The most valuable coal beds east of the Tongue River are listed in the graphic section, Plate 11, but there are other beds that attain large thicknesses and extend throughout areas of several square miles. The distribution of each thick bed is described in the following paragraphs.

Although the Terret coal is the lowest thick bed in the coal-bearing member that has a wide distribution, there are coal beds below it that are of local value. In Ts. 1 and 2 N., R. 47 E., in the Foster Creek Valley, a coal bed that lies 30 to 40 feet beneath the Terret bed is in places 5½ feet thick and maintains a thickness greater than 3½ feet throughout several square miles. In T. 2 N., R. 48 E., the base of the Tongue River member is occupied by a coal bed, called the Contact bed, that locally attains a thickness of nearly 4 feet. Other beds are present locally in this part of the stratigraphic section and are described in the detailed account of the townships.

The Terret bed averages 8 to 10 feet in thickness throughout several townships. The clinker produced by the burning of this bed is most prominent in T. 2 N., Rs. 45 to 48 E. It caps the rugged country between Lay and Foster Creeks in T. 2 N., Rs. 46 and 47 E., and between Foster Creek and its east fork in T. 2 N., R. 47 E. In the easternmost part of the field the bed was traced southward up Pumpkin Creek nearly to the south line of T. 1 N., R. 48 E. It was not traced continuously southwestward up the Tongue River, but coal occurring at the approximate horizon of the Terret bed was mapped intermittently as far south as Ashland. The Terret bed occurs about 150 to 160 feet above the base of the Tongue River member in the Tongue River Valley, 140 feet above the base in the Lay Creek Valley, and 75 feet above the base in the easternmost part of the field.

The Flowers mine, in sec. 29, and the Goodale mine, in sec. 28, T. 1 N., R. 45 E., both small wagon mines, supply coal to a number of ranches on the Tongue River. They are in the same coal bed, which ranges between 60 and 100 feet below the Knoblock clinker and is called the Flowers-Goodale bed in this report. The clinker produced by the burning of this bed was traced almost continuously northeastward from the mines across T. 1 N., Rs. 45 to 47 E., and Ts. 1 and 2 N., R. 48 E. In the easternmost part of the field it was traced southward to the Little Pumpkin Creek Valley in the north-

ern part of T. 1 S., R. 48 E. South of Little Pumpkin Creek no coal or clinker was found at this horizon, and none was shown by the record of a well drilled in the central part of T. 1 S., R. 48 E. Southwestward from the Flowers and Goodale mines the bed was mapped intermittently up the Tongue River Valley nearly to the south boundary of the field. This coal occurs at the approximate position of the Rosebud bed west of the Tongue River and may represent that bed east of the river.

The Lay Creek bed lies about midway between the Flowers-Goodale and Knoblock beds and is present locally near the heads of tributaries of Lay Creek in the southwestern part of T. 1 N., R. 46 E. The coal is of irregular thickness and quality and so is of little value except locally.

The Knoblock bed was mapped throughout the field. The thick clinker of this bed caps bluffs extending from the Tongue River and Otter Creek Valleys southwest and southeast of Ashland, northward past Brandenburg, eastward to the Pumpkin Creek Valley, and thence southward to the northeastern part of T. 2 S., R. 48 E. In the western two-thirds of the field the coal of this bed averages approximately 20 feet in thickness; eastward it thins to about 8 to 10 feet, and at the easternmost extremity of the field it appears to thin rather rapidly and may be absent a short distance east of the boundary. Throughout most of the field the bed is composed of good quality coal nearly free from partings of foreign material. In T. 1 N., Rs. 46 and 47 E., however, the coal bed includes thin layers of dull and possibly dirty coal. It is noteworthy that the coal of this bed has burned at only a few of the places where it appears to contain dirty coal, although elsewhere in the field it has burned almost continuously throughout a wide strip of country bordering the crop line. The Knoblock bed is 400 feet above the base of the Tongue River member in the Rosebud Creek Valley, in the westernmost part of the field; 300 feet above the base in the Tongue River Valley; and 150 feet above the base in the Pumpkin Creek Valley, in the easternmost part of the field.

The A bed is present in only a small part of the field. It ranges between 35 and 100 feet below the Sawyer bed. It is 12 feet thick in sec. 6, T. 2 S., R. 46 E., where it lies nearly 100 feet beneath the Sawyer bed. On Little Pumpkin and Pumpkin Creeks in the eastern part of the field, in Ts. 1 and 2 S., Rs. 47 and 48 E., and T. 3 S., R. 48 E., it is more than 15 feet thick in places and lies about 35 feet below the Sawyer bed. It may actually coalesce with the Sawyer bed east of the Pumpkin Creek Valley.

The Sawyer bed was traced almost continuously across the field. Throughout much of its area it averages about 10 feet in thickness,

although it is much thicker in several localities. It appears to thin rapidly northward in the northwestern part of T. 1 S., R. 47 E., and the southern part of T. 1. N., R. 46 E., where it occurs high in the rugged slopes and so would be of little value even if of large thickness. The very thick clinker of this bed can be seen capping rugged hills stretching for miles westward from the western boundary of the Ashland field and is the most prominent feature of the landscape eastward from the eastern boundary. West of the Tongue River the Sawyer bed is 225 feet above the Knoblock bed; in the vicinity of the Cook Creek Mountains, immediately east of the Tongue River, the interval between the two beds is 300 feet, and eastward from this locality it decreases to 150 feet in the Pumpkin Creek Valley, in the easternmost part of the field.

The C bed is of little economic importance because it contains an abundance of silicified, partly carbonized tree stumps and fragments of logs that destroy the value of the bed. It has a fairly wide distribution, however, in Ts. 1 and 2 S., Rs. 45 to 48 E., and the ever-present silicified stumps served to aid in the identification of beds in this part of the section.

The D bed is thickest in the central part of the field, where it attains 20 feet. Its clinker bed is particularly prominent in T. 2 S., Rs. 45 and 46 E., and T. 1 S., R. 46 E. The C and D beds are represented on Plate 3 by a single line in most localities.

The X bed occurs locally 80 to 90 feet beneath the E bed, chiefly in the west-central part of T. 2 S., R. 46 E., and in Elk Ridge, in T. 2 S., Rs. 47 and 48 E.

The E bed or more properly group of beds is widespread in occurrence. The clinker bed is as much as 75 feet thick and forms a prominent ledge high in the slopes of the rugged ridges in Ts. 2 and 3 S., Rs. 45 to 48 E. In most localities the coal of this group of coal beds is situated in rugged country that is rather difficult to approach. It is not uncommon to find one bed of the group to be 15 to 20 feet or more thick.

The F bed is known chiefly as a thick clinker bed. Coal was seen at this horizon at only one locality, although the very thick clinker of the bed indicates that the coal is probably also thick. The clinker forms the divide between Beaver and East Fork Creeks, the divide between Beaver and Little Pumpkin Creeks, the divide between Pumpkin and Otter Creeks, and Elk Ridge, between Little Pumpkin and Pumpkin Creeks. A few coal beds of local extent occur between the E and F beds, but none were deemed of sufficient importance to map, in view of the abundance of thick beds near by.

The Garfield clinker is a thick mass of baked rock that remains only as a cap on a few of the highest knobs in the field. No coal was

seen at this horizon, it having been entirely burned. This clinker caps Liscom Peak, in sec. 18, T. 1 S., R. 47 E.; the Cook Creek Mountains, in T. 2 S., R. 45 E.; and Home Creek Butte and other buttes in T. 3 S., R. 47 E. Only one coal outcrop (location 741, in sec. 32, T. 2 S., R. 47 E.), was seen in the beds between the F and Garfield clinkers.

CHARACTER OF THE COAL

Physical properties.—The coal in the Ashland field is a bright black clean coal on fresh exposure. It is fairly brittle and breaks with a conchoidal fracture. In these respects it is unlike the coal mined near Miles City, which is tough, dull, and somewhat woody in appearance. The coal in the Ashland field occurs in thick beds that are remarkably free from partings. When exposed to the atmosphere it rapidly loses a part of its moisture and breaks down or "slacks" into small irregular-shaped particles. It is chiefly this property that distinguishes the Ashland and other coals of subbituminous rank from coals of the next higher, or bituminous rank.[25] If this coal is stored in closed bins it will retain a large part of its moisture and remain in large lumps for several weeks. Ranchers state that the uppermost few inches of the coal stored in an ordinary ranch coal house will "slack" but that the larger part of the pile will stand without conspicuous slacking for several months. For commercial trade coal of this rank is commonly shipped in closed cars if destined for delivery at greater distances than about 100 miles.

Chemical properties.—There were no mines operating in unweathered coal at the time of the writer's examination of the Ashland field, hence it was impracticable to procure samples of unweathered coal for chemical analyses. In the following table are given analyses of coal from near-by districts that contain coal which is in general similar to that of the Ashland field and one analysis of weathered coal from the Holt mine, in the Ashland field. Form A represents the composition of the sample as it is received in the laboratory. Form B shows the theoretical composition of the coal after all the moisture has been eliminated. Form C represents the composition of the coal as it would be if all the ash and moisture were removed. Forms B and C are not obtained by direct analysis but are the result of recalculation of Form A and represent conditions that do not actually exist in nature.

The analysis of the coal from Colstrip, Mont., is probably most representative of coal in the Ashland field, the Colstrip locality being only 3 miles from the Ashland field boundary. The samples

[25] Campbell, M. R., The coal fields of the United States: U. S. Geol. Survey Prof. Paper 100–A, p. 7, 1917.

at Colstrip, however, were obtained from the strip pit, where the coal has only about 50 feet of overburden and so may be slightly deteriorated by weathering. A comparison shows that the Colstrip samples contained a little greater percentage of moisture and ash and had a lower heating value than those from Sheridan, Wyo. The Sheridan samples were collected from underground workings. It is probable that if fresh coal samples could be obtained from deeply buried workings in the Ashland field the analyses would not differ widely from those of the Sheridan coals.

Analyses of samples of coal from the Ashland field and other near-by fields

Laboratory No.	Source	Air-drying loss	Form of analysis	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Heating value	
									Calories	B. t. u.
19659	Forsyth, Mont., Rosebud bed, Colstrip mine, sec. 34, T. 2 N., R. 41 E., composite of 4 analyses.	6.6	A	24.1	28.4	40.2	7.3	.7	5,050	9,090
			B	------	37.4	53.0	9.6	1.0	6,644	11,960
			C	------	41.4	58.6	-------	1.1	7,350	13,230
	Williston, N. Dak., average of 7 mine samples. U. S. Geol. Survey Bull. 531, pp. 100-101.	30.9	A	41.5	26.9	26.2	5.3	.63	3,512	6,320
			B	------	46.0	44.8	9.1	1.08	6,011	10,820
			C	------	50.7	49.3	-------	1.20	6,612	11,902
	Glendive, Mont., field. Snider mine. Average of 5 samples. U. S. Geol. Survey Bull. 471, p. 274.	13.9	A	32.9	26.6	32.9	7.49	1.04	4,056	7,300
			B	------	39.7	49.1	11.21	1.55	6,038	10,870
			C	------	44.7	55.3	-------	1.75	6,776	12,197
	Miles City, Mont. Average of 5 samples from Kircher bed.	17.9	A	30.1	27.5	33.4	9.05	.68	4,195	7,551
			B	------	39.3	47.7	12.95	.98	5,994	10,789
			C	------	45.1	54.8	-------	1.12	6,917	12,452
	Sheridan, Wyo. Average of 20 mine samples.	10.4	A	23.3	32.2	41.1	3.46	.35	5,194	9,350
			B	------	41.9	53.6	4.51	.45	6,771	12,188
			C	------	43.9	56.1	-------	.48	7,091	12,756
29466	Red Lodge, Mont	6.3	A	11.3	33.6	44.5	10.6	.72	5,795	10,440
			B	------	37.9	50.2	11.9	.81	6,535	11,760
			C	------	43.0	57.0	-------	.92	7,420	13,360
15130	Bear Creek, Mont	3.0	A	10.0	33.9	44.8	11.3	2.26	5,885	10,590
			B	------	37.7	49.8	12.5	2.51	6,535	11,760
			C	------	43.1	56.9	-------	2.87	7,475	13,450
	Bull Mountain, Mont. Average of 9 mine samples. U. S. Geol. Survey Bull. 647, pp. 51-53.	6.5	A	15.0	29.9	48.8	6.29	.58	5,974	10,754
			B	------	35.2	57.4	7.41	.69	7,026	12,651
			C	------	38.0	61.9	-------	.75	7,624	13,662
A42289	Holt mine,[a] Ashland, Mont	6.8	A	27.3	27.5	41.3	3.9	.4	5,011	9,020
			B	------	37.8	56.8	5.4	.6	6,889	12,400
			C	------	40.0	60.0	-------	.6	7,283	13,110

[a] Coal under only 30 feet of cover and thus somewhat weathered.

The coal of the Ashland field is an excellent domestic fuel if used reasonably soon after mining and if not stored in the open where it is exposed to varying atmospheric conditions. The Northern Pacific Railway has demonstrated that this coal makes satisfactory fuel for railroad locomotives. This company uses the output of the Colstrip mine, which is 3 miles west of the Ashland field, for its locomotives throughout several hundred miles of its main line.

UTILIZATION OF THE COAL

At present the chief coal mining in the Ashland field is carried on by ranchers at innumerable places in the field to supply a few tons for their own use. The usual practice is to shoot the coal from a pit in a creek bank. Nearly all the coal obtained is somewhat weathered, but it is reported to be excellent fuel for domestic use. Short tunnels have been driven underground in a few localities in the field. Two, known as the Weaver and Holt mines, are near Ashland and supply much of the coal used by the residents there.

Because of lack of transportation facilities the coal of the Ashland field will probably remain unexploited, except for local use, for an indefinite time. Should a railroad be built into the field, it is almost certain that some mining on a commercial scale would be done. Probably some of the areas where coal in thick beds lies at shallow depth and so is adaptable to recovery by strip mining, would be developed first. Many of the larger areas of this type are shown by ruled lines on Plate 3 and described in the detailed township descriptions. Reported costs of strip mining in the region and reported costs of underground mining with mechanical loaders in coal mines at Sheridan, Wyo., indicate that coal in the Ashland field can be mined by stripping for 25 to 50 cents a ton and mined by underground methods for $1 or less a ton. On Government-owned coal of the rank and quality found in this field the present royalty for large-scale operation is 10 cents a ton.

TONNAGE ESTIMATES OF COAL RESERVES [26]

The greater part of the coal of this area, estimated to contain 10,757,749,000 tons, occurs in five beds—bed A, 865,197,000 tons; the Flowers-Goodale bed, 1,013,547,000 tons; the Terret bed, 1,360,292,000 tons; the Sawyer bed, 2,270,645,000 tons; and the Knoblock bed, 2,896,506,000 tons. The combined coal content of these beds is 8,406,187,000 tons, or 78 per cent of the total for the area.

In computing these tonnages a planimeter was used to determine the areas underlain by each bed; the thicknesses were computed from relatively few complete sections of each bed; and no allowance was made for coals underlying each township but not exposed in it. Consequently, it is apparent that the possibility for error in these estimates is great, and it seems likely that the figures given above are in all probability too low.

[26] Calculated by Thomas A. Hendricks.

Estimated tonnage of coal in the Ashland field, by beds

	Short tons		Short tons
Contact	36, 040, 000	Sawyer	2, 270, 645, 000
Burley	41, 900, 000	C	31, 167, 000
Terret	1, 360, 292, 000	D	325, 148, 000
McKay	174, 826, 000	X	171, 882, 000
Flowers-Goodale	1, 013, 547, 000	E	721, 650, 000
Rosebud	325, 477, 000	Cook	45, 774, 000
Lay Creek	110, 560, 000	F	110, 383, 000
Knoblock	2, 896, 506, 000	Miscellaneous	225, 363, 000
Lee	31, 392, 000		
A	865, 197, 000	Total	10, 757, 749, 000

Estimated tonnage of coal in the Ashland field, by townships

Township and coal bed	Calculated average thickness	Estimated area	Tonnage
	Ft. in.	*Acres*	
T. 1 S., R. 43 E.:			
McKay	8	5,052	72, 749, 000
Rosebud	10	3,875	69, 750, 000
Knoblock	20	8,408	302, 688, 000
Sawyer	13	1,239	28, 993, 000
			474, 080, 000
T. 2 S., R. 43 E.:			
Knoblock	20	2,889	104, 004, 000
Sawyer	10	2,076	37, 368, 000
Local beds	7	318	4, 007, 000
			145, 379, 000
T. 1 N., R. 44 E.:			
Burley	4 6	3,668	29, 711, 000
Terret	4	1,059	7, 625, 000
Knoblock	18	208	6, 739, 000
Miscellaneous	3	200	3, 780, 000
			47, 855, 000
T. 1 S., R. 44 E.:			
Terret	7	1,162	14, 641, 000
McKay	7	3,460	43, 596, 000
Knoblock	10	363	6, 534, 000
Flowers-Goodale	5 6	761	7, 533, 000
Rosebud	13	2,283	53, 422, 000
Miscellaneous	3	654	3, 532, 000
			129, 258, 000
T 1 N., R. 42 E.:			
McKay	7	1,228	15, 472, 000
Rosebud	15	1,010	27, 270, 000
			42, 742, 000
T. 1 S., R. 42 E.:			
McKay	6 6	2,076	24, 289, 000
Rosebud	7	12,750	160, 650, 000
Knoblock	10	3,927	70, 686, 000
Lee	5	3,488	31, 392, 000
Sawyer	16	675	19, 440, 000
			306, 507, 000
T. 2 S., R. 42 E.: Sawyer	18	2,789	90, 364, 000
T. 1 N., R. 43 E.:			
Burley	4 6	1,505	12, 189, 000
McKay	4	200	1, 440, 000
Terret	5 6	1,816	17, 979, 000
Rosebud	6	1,332	14, 385, 000
Knoblock	6 6	848	9, 922, 000
			55, 905, 000

Estimated tonnage of coal in the Ashland field, by townships—Continued

Township and coal bed	Calculated average thickness	Estimated area	Tonnage
	Ft. in.	*Acres*	
T. 2 S., R. 44 E.:			
Terret	2	1,500	5,400,000
McKay	6	1,600	17,280,000
Flowers-Goodale	6	1,200	12,960,000
Knoblock	18	1,131	36,644,000
			72,284,000
T. 3 S., R. 44 E.:			
Terret	5 6	519	5,137,000
Flowers-Goodale	4 6	3,114	25,223,000
Knoblock	10	2,664	47,952,000
			78,312,000
T. 2 N., R. 45 E.:			
Bed 125 feet below Terret	3	700	3,780,000
Bed 85 feet below Terret	2	700	2,520,000
Terret	20	20	252,000
			6,552,000
T. 1 N., R. 45 E.:			
Terret	8	15,105	217,512,000
Flowers-Goodale	7 6	7,315	98,753,000
Bed 30 feet below Knoblock	5 6	2,603	25,769,000
Knoblock	15 6	3,610	100,719,000
			442,753,000
T. 1 S., R. 45 E.:			
Terret	9	600	9,720,000
Flowers-Goodale	9	15,432	249,998,000
Bed 40 feet below Knoblock	6	400	4,320,000
Knoblock	20	8,082	290,952,000
Sawyer	10 6	50	945,000
			555,935,000
T. 2 S., R. 45 E.:			
A	2	100	360,000
Sawyer	14	17,369	437,699,000
C	3	40	216,000
D	6	4,498	48,578,000
E	10	7,335	132,030,000
Cook	10	2,543	45,774,000
F	8	1,592	22,925,000
			687,582,000
T. 3 S., R. 45 E.:			
Knoblock	25	14,306	643,770,000
Sawyer	10	2,629	47,322,000
			691,092,000
T. 2 N., R. 46 E.:			
Bed 115 feet below Terret	2	100	360,000
Bed 40 feet below Terret	5	800	7,200,000
Terret	7	2,457	30,958,000
Flowers-Goodale	3	113	610,000
			39,128,000
T. 1 N., R. 46 E.:			
Terret	10	20,336	336,048,000
Flowers-Goodale	7	16,632	209,563,000
Knoblock	8	10,508	151,315,000
Lay Creek	5	11,982	107,838,000
			834,764,000
T. 1 S., R. 46 E.:			
Flowers-Goodale	6	7,266	78,473,000
Knoblock	9	18,494	299,603,000
Sawyer	9	4,083	66,145,000
D	14	1,695	42,714,000
E	18	433	14,029,000
Miscellaneous	6	346	3,737,000
			504,701,000

Estimated tonnage of coal in the Ashland field, by townships—Continued

Township and coal bed	Calculated average thickness	Estimated area	Tonnage
	Ft. in.	*Acres*	
T. 2 S., R. 46 E.:			
A	12	600	12, 960, 000
Sawyer	10	21, 521	387, 378, 000
D	10	12, 992	233, 856, 000
X	7	1, 500	18, 900, 000
E	12	7, 958	153, 893, 000
F	8	536	7, 718, 000
			814, 705, 000
T. 3 S., R. 46 E.:			
Sawyer	5	19, 116	172, 044, 000
C	2 6	996	4, 482, 000
X	3	1, 488	8, 035, 000
E	4	4, 014	28, 900, 000
Miscellaneous	8	761	10, 958, 000
			224, 419, 000
T. 2 N., R. 47 E.:			
Bed 35 feet below Terret	4	5, 216	51, 912, 000
Terret	7	4, 120	37, 555, 000
			89, 467, 000
T. 1 N., R. 47 E.:			
Bed 35 feet below Terret	4	5, 104	41, 500, 000
Terret	11	17, 312	342, 777, 000
Flowers-Goodale	9	11, 094	179, 723, 000
Knoblock	9	2, 921	47, 320, 000
Bed 14 feet above Knoblock	2	26	94, 000
Lay Creek	2	756	2, 722, 000
			617, 403, 000
T. 1 S., R. 47 E.:			
Knoblock	10	21, 988	395, 784, 000
A	10	14, 186	255, 348, 000
Sawyer	5	9, 342	84, 078, 000
E	16	2, 733	78, 710, 000
Miscellaneous	4	5, 795	41, 724, 000
			855, 644, 000
T. 2 S., R. 47 E.:			
Sawyer	8	21, 556	310, 406, 000
C	2 6	5, 882	26, 469, 000
X	4	5, 276	37, 987, 000
E	11	13, 307	263, 479, 000
F	10	1, 557	28, 026, 000
			666, 367, 000
T. 3 S., R. 47 E.:			
Miscellaneous	3	3, 010	16, 254, 000
F	10	2, 873	51, 714, 000
			67, 968, 000
T. 2 N., R. 48 E.:			
Contact	3 6	5, 292	33, 340, 000
Terret	7	13, 684	172, 418, 000
Flowers-Goodale	8	3, 742	53, 885, 000
Knoblock	7	151	1, 903, 000
Local bed	4	246	1, 771, 000
			263, 317, 000
T. 1 N., R. 48 E.:			
Contact	2 6	600	2, 700, 000
Terret	6	15, 025	162, 270, 000
Flowers-Goodale	8	4, 442	63, 965, 000
Knoblock	7	200	2, 520, 000
			231, 455, 000
T. 1 S., R. 48 E.:			
Flowers-Goodale	3 6	5, 216	32, 861, 000
Knoblock	10	6, 728	121, 104, 000
A	15	1, 795	48, 465, 000
Sawyer	12	1, 380	29, 808, 000
E	10	113	2, 034, 000
			234, 272, 000

Estimated tonnage of coal in the Ashland field, by townships—Continued

Township and coal bed	Calculated average thickness	Estimated area	Tonnage
T. 2 S., R. 48 E.:	*Ft. in.*	*Acres*	
Knoblock	7	20,345	256,347,000
A	10	11,314	203,652,000
Sawyer	12	11,072	239,155,000
X	6	3,237	34,960,000
E	10	2,491	44,838,000
			778,952,000
T. 3 S., R. 48 E.:			
A	10	19,134	344,412,000
Sawyer	10	17,750	319,500,000
E	6	346	3,737,000
Miscellaneous	4	311	2,239,000
			669,888,000

TOWNSHIP DESCRIPTIONS

T. 1 N., R. 42 E.

Rosebud Creek and its tributaries drain T. 1 N., R. 42 E.; the chief tributaries are Cow Creek and Hay and Miller Coulees, from the northwest, and Greenleaf and Miller Creeks, from the southeast. Rosebud Creek flows northeastward in a broad valley having a gentle slope on its southeast side and a much steeper slope on its northwest side. This valley is bordered on the northwest by an irregular line of flat-topped buttes and ridges that are capped by the clinker of the Rosebud coal bed and rise 200 feet above the valley bottom. The tributary coulees have comparatively broad valleys bordered by steep slopes that rise to the clinker-capped buttes and ridges.

Aside from a narrow belt of Recent alluvium along Rosebud Creek the rocks that occupy the surface of the township belong to the lowermost 300 feet or so of the Tongue River member. The Rosebud and McKay coal beds, separated by an interval of 15 to 40 feet, are the only valuable coals that crop out in this township. The beds occur about 300 feet above the base of the Tongue River member. They underlie parts of the divides between the North and South Forks of Cow Creek and between Hay Coulee and the South Fork of Cow Creek. Although the Rosebud coal is burned out and now forms a thick clinker on the crest of parts of these divides, a fairly large tract of unburned coal remains in secs. 7, 17, and 18. Partial sections of the bed measured at locations 1, in the SW. ¼ sec. 7, and 2, in the SW. ¼ sec. 29 (pl. 3), and results reported from many drill holes indicate that the bed is from 15 to 25 feet thick where it is not burned. The records of drill holes in secs. 6, 7, 16, and 17 indicate that the coal of the Rosebud bed is unburned in a somewhat greater part of these two divides than is shown on Plate 3. On the basis of the drill records it seems probable that several small tracts in sec. 6, the N. ½ sec. 7, the E. ½ sec. 17, and the central part of sec. 16 also may actually contain unburned Rosebud coal, although shown on the map as burned. Many of the coal-bearing tracts in these sections, however, are probably of small extent and so of little or no commercial value. Aside from the sections measured in this township exposures only short distances to the west, in the adjacent township, furnish information as to the thickness of the Rosebud and McKay beds. On South Fork a few hundred feet west of the west boundary of sec. 7 13 feet of the Rosebud bed is exposed, the upper part having been removed by

erosion. The entire Rosebud bed is exposed in the NE. ¼ sec. 24, T. 1 N., R. 41 E., less than half a mile west of the west boundary of sec. 19, where it is 28 feet thick. Near by the McKay bed is 10 feet thick. A view of the outcrop of the Rosebud coal at this locality is shown in Plate 9, *A*. The McKay coal bed lies from 7 to 30 feet below the Rosebud bed and ranges from 7 to 9 feet in thickness in the divide between the North and South Forks of Cow Creek, but it thins toward the south and is believed to be absent in the southern part of the township. It is represented in Plate 12 by sections 3 to 10, measured at localities that are readily accessible for wagons and trucks. It is believed that lenticular coal beds lie below the McKay bed in this township, but their presence was not established by the surface examination.

Near the rim of the upland between Hay Coulee and the South Fork of Cow Creek, in secs. 7, 17, and 18, and the South Fork Valley in the W. ½ sec. 7, extending into sec. 12 of the township adjacent on the west, the Rosebud coal is under a maximum cover of 60 feet and can be taken out by strip mining on the gentle slopes. Along the crest of the divide, however, the cover thickens to as much as 150 feet, necessitating the employment of underground mining. The McKay bed may be mined by stripping in a small area along the south bank of the South Fork of Cow Creek in secs. 7 and 8 and in the valley floor in the W. ½ sec. 7.

T. 1 S., R. 42 E.

The flood plain of Rosebud Creek in T. 1 S., R. 42 E., is about a quarter of a mile wide, and its valley is approximately 2½ miles wide with gently graded slopes that end abruptly in bluffs rising about 350 feet to a clinker-capped plateau formed on the Sawyer clinker. The valuable coal beds that crop out in the township are the McKay, Rosebud, Knoblock, Lee, and Sawyer. (See pl. 13.)

Coal in north half of township.—A bed of local extent, questionably correlated with the Burley bed, occurring below the Rosebud and McKay horizons, is about 1 foot 6 inches thick at locations 11 and 12, in sec. 4, and location 13, in sec. 5, but was not mapped in detail along Rosebud Creek because of its thinness and impure character. The McKay bed probably underlies the divide between Rosebud and Miller Creeks in the northeastern part of the township. It was prospected at location 14, in the SW. ¼ sec. 13, where only the uppermost 6 feet of the bed was uncovered. On the eastern slope of Miller Creek the position of the Rosebud bed is marked by a few scattered outcrops of clinker, and near the northeast corner of sec. 13 the coal is replaced by a thick bed of carbonaceous shale. The lowermost 7 feet of the Rosebud bed was uncovered at location 24, in the SE. ¼ sec. 14, and it is reported to be 23 feet thick in a drilled well at location 26, in the W. ½ sec. 14, though this thickness may represent both the Rosebud and McKay beds. At location 15, in the NE. ¼ sec. 12, a coal bed 7 feet 8 inches thick is questionably correlated with the McKay bed, though it may represent the Rosebud coal instead. Weathered coal 6 feet thick, believed to represent the McKay bed, was uncovered at location 16, in the SE. ¼ sec. 2. This bed could not be traced southwestward up the Rosebud Creek Valley, although it may be present but concealed in the gentle sod-covered slopes.

The Rosebud bed is at least 4 feet 2 inches thick at location 17, in the S. ½ sec. 2; 9 feet 3 inches thick at location 18, in the SW. ¼ sec. 11; 11 feet 5 inches thick at location 19, in the NE. ¼ sec. 15; and more than 6½ feet thick at location 20, in the SW. ¼ sec. 15. The clinker produced by this bed was traced southwestward and found to become less prominent toward Rose-

bud Creek. At location 21, in the NE. ¼ sec. 17, a bed 1 foot 4 inches thick appears to represent the Rosebud coal, and at location 22, in the SW. ¼ sec. 8, it is 5½ feet thick, but within a few hundred feet on each side of this outcrop it thins to a few inches and in places is absent. On the northwest slope of the Rosebud Creek Valley a small part of secs. 5 and 6 is underlain by the Rosebud bed, where a thickness of more than 6½ feet is indicated by an exposure at location 23, in the NW. ¼ sec. 6, but locally it appears to be entirely replaced by sandstone and carbonaceous shale. At location 25 a thin bed correlated with the Lee coal in the south half of the township is 1 foot 2 inches thick.

It is reported that a well in the NW. ¼ sec. 10 struck 18 feet of coal at a depth of 50 feet, and that one in the SE. ¼ sec. 8 struck 20 feet of coal at a depth of 70 feet. According to report, each of three wells drilled near the Lynch ranch house, in the SW. ¼ sec. 8, struck three beds of coal at the approximate depths of 50 feet, 85 feet, and between 125 and 160 feet. The uppermost bed was reported to be about 12 feet thick, the middle bed 10 feet, and the lowest bed 8 feet. It is quite possible, however, that carbonaceous shale or bone was mistaken for coal by the driller.

Coal in the south half of the township.—The Knoblock, Lee, and Sawyer coal beds, all occurring above the Rosebud and McKay beds, are present in the south half of the township. The Knoblock bed is 400 feet above the base of the Tongue River member, the Lee bed 60 feet higher, and the Sawyer bed 165 feet higher.

The Lee bed is mined at the Lynch mine, in the SE. ¼ sec. 25, T. 1 S., R. 41 E., less than half a mile west of the west boundary of this field. At this locality only the upper 7 feet of the coal bed is exposed, the lower part being concealed. This bed appears to have thinned rapidly northeastward from this locality, and at location 27, in the SW. ¼ sec. 19, a coal that is correlated with the Lee bed is but 1 foot 4 inches thick, though at location 28, in the NE. ¼ sec. 19, it is 7 feet thick. In the slopes of the east branch of Downey Coulee in sec. 20 it is replaced by sandstone and carbonaceous shale, but it thickens rapidly toward the southeast and contains about 7 feet of coal at locations 29 to 36, in secs. 21, 22, 27, and 28. The bed could not be found farther east than the S. ½ sec. 27. The Knoblock bed is more than 7 feet thick near the head of the east branch of Downey Coulee at locations 37 and 38, in sec. 29, but at location 39, in the SE. ¼ sec. 20, it contains less than 2 feet of coal, overlain by a thick bed of carbonaceous shale which also encircles the large butte standing in the NE. ¼ sec. 20. In the southwestern part of sec. 22 massive sandstone is found at the horizon of this bed. Coal was seen at this horizon at location 40, in the SW. ¼ sec. 14, and at location 41, in the NE. ¼ sec. 23, and the bed thickens southeastward to a maximum of 15 feet at the Bradley mine (location 42), in sec. 25. Near by, at location 43, the uppermost 3½ feet of the bed is exposed, and at location 44, near the George Wood ranch house, 7 feet 10 inches of the middle part of the bed was uncovered. A small exposure of this bed that was not prospected occurs at location 45, in the SE. ¼ sec. 24, and reveals 2½ feet of coal, the base and top of the bed being concealed. At location 46 it contains 8½ feet of coal in two benches separated by 11½ feet of clay; the upper bench is 5½ feet thick.

The Sawyer bed is burned throughout the greater part of the southern third of this township, and its clinker now caps an intricately dissected plateau standing several hundred feet above the surrounding lowlands. The Sawyer bed is unburned at location 47, in the SW. ¼ sec. 33, and is 16 feet 3 inches thick. A northward-trending prong of a high plateau crosses secs. 30, 31, 32,

and 33, and unburned rock at the surface indicates that the Sawyer coal bed is unburned beneath much of this part of the plateau, as outlined on Plate 3. Although the Sawyer bed is relatively thick and its coal is of good quality it is generally inaccessible and therefore of minor present value.

Possible utilization.—The most favorable location for strip mining in this township is the divide between Rosebud and Miller Creeks, in the northern part of sec. 14, where the maximum cover of the Rosebud coal probably does not exceed 60 feet. It is probable that the Rosebud bed and possibly the McKay bed underlies the terrace in secs. 2 and 11 at shallow depth. A small area in the Miller Creek Valley in secs. 13, 23, and 24 is believed to contain the McKay bed at no greater depth than 50 feet. It is physically possible to strip the Rosebud coal in the S. ½ sec. 15 and parts of secs. 16, 21, and 22, but there is considerable doubt as to the thickness of the coal. Relatively small tracts bordering the outcrops of the Lee bed in secs. 15, 22, 27, and 28 and of the Knoblock bed in secs. 22, 24, 25, 26, and 27 can be mined by stripping.

T. 2 S., R. 42 E.

Only the part of T. 2 S., R. 42 E., lying north of the Cheyenne Indian Reservation was examined. This area has a very rugged surface, characterized by box canyons with nearly vertical walls 250 feet or more high, capped by clinker of the burned Sawyer coal. The area is of little economic value except for grazing. Many large springs, most of them at the horizon of the Sawyer bed, furnish an ample supply of water for stock. Unburned Sawyer coal 8 feet thick crops out at the head of one of the forks of Miller Creek, in the S. ½ sec. 1, about a quarter of a mile south of the Cheyenne Indian Reservation boundary, at location 48. A complete section of the bed was measured at location 49, in the NE. ¼ sec. 4, where it contains 18 feet 8 inches of coal. Unbaked rock at the surface indicates that the Sawyer coal is unburned not far back from the outcrop of its clinker bed, and the probable limit of its burning is shown by a dotted line on the map. Although the Sawyer bed is more than 18 feet thick, it is of slight present economic value here because of its inaccessibility. (See pl. 14.)

T. 1 N., R. 43 E.

The greater part of T. 1 N., R. 43 E., is rolling, grass-covered country sloping gently northwestward toward Rosebud Creek. The eastern part of the township is occupied by a narrow ridge that stands about 400 feet above the surrounding country and makes the divide between Rosebud Creek and the Tongue River.

The rocks that crop out in the township include part of the Tongue River member of the Fort Union formation, within which lie the Burley, Terret, McKay, Rosebud, and Knoblock coal beds. The Burley bed is about 120 feet above the Lebo shale in the Rosebud Creek Valley. At location 50, north of the township boundary, this bed is 6 feet 2 inches thick. At location 51, in the SW. ¼ sec. 9, it contains 4 feet 9 inches of impure coal. A coal bed about 3½ feet thick crops out at location 52, in sec. 19, and location 53, in sec. 18, and probably represents the Burley bed, though no precise correlations could be made because of lack of exposures. It is reported that two beds of coal, each 11 feet thick, were penetrated at depths of 126 and 147 feet in a well at the Bradley ranch, in the NW. ¼ sec. 30.

The Rosebud and McKay beds are of little economic importance in this township. They occur as thin lenses in the southwestern part. The maximum

observed thickness of the McKay bed is 6 feet at location 54, in the SE. ¼ sec. 32. This bed is 2 feet 10 inches thick at location 55, in the NW. ¼ sec. 34, and near by at location 56 the Rosebud bed is 6 feet 8 inches thick but split into two benches by a parting 9 inches thick. At location 57, in the SE. ¼ sec. 35, on the east slope toward the Tongue River, the McKay bed is 2½ feet thick. The Rosebud and McKay beds appear to be absent in the highland that extends northeastward through the easternmost part of the township.

The Knoblock bed has burned and formed a thick clinker in the southeastern part of the township but northward is for the most part unburned in an irregular elongated area near the top of the divide. The thickness of the bed varies considerably as shown at locations 58 to 65. (See pl. 14.) This coal is under small cover in much of this area and can be mined by stripping. The coal-bearing tracts are of small extent, however, and because of its situation so near the crest of the divide, where it has undoubtedly been subjected to alternate wetting and drying for a long time, it appears probable that the coal has deteriorated somewhat.

The Terret bed was seen only in the northeastern part of the township. Its thickness was measured at location 124, in the NE. ¼ sec. 12.

T. 1 S., R. 43 E.

The relief in T. 1 S., R. 43 E., is about 300 feet in the northern part and about 800 feet in the southwestern part. The broad plateau floored by the clinker of the Knoblock coal occupies much of the area. Greenleaf Creek has a comparatively broad valley flanked by steep slopes terminated above by the ledge of the Knoblock clinker. The township contains a large tonnage of coal in the McKay, Rosebud, Knoblock, and Sawyer beds.

Coal in the slope toward Rosebud Creek.—The Rosebud bed is more than 10 feet thick at location 66, in the SW. ¼ sec. 8 (see pls. 3 and 15), and can be advantageously stripped over part of the section. About a mile farther up the arroyo, at location 73, in the SE. ¼ sec. 17, the uppermost 10½ feet of the Knoblock coal bed is clearly exposed. The uppermost 4½ feet of the Rosebud bed was uncovered at location 67, in the N. ½ sec. 8, and the uppermost 7 feet 5 inches of the Rosebud bed was prospected at location 68, in the NE. ¼ sec. 8. Near by, at location 69, a coal bed containing several thick partings is exposed above the coal of location 68. It is possible that this upper bed actually represents the Rosebud bed and that the coal of location 68 is the McKay bed. About half a mile to the east, at location 74, the uppermost 25 feet of the Knoblock bed is exposed, the base of the bed being concealed. In the NE. ¼ sec. 4 a bed containing 3 feet 5 inches of dirty coal at location 70 is correlated with the Rosebud bed. A thin bed of dirty coal occurs above this horizon at locations 71 and 72, in the NE. ¼ sec. 4. An isolated exposure of the Rosebud bed shows 3½ feet of coal at location 97, in the NW. ¼ sec. 6.

Coal in Greenleaf Creek Valley.—The McKay bed ranges between 7 and 16 feet in thickness in parts of sec. 3, as represented by sections 75 to 77, Plate 15. The Rosebud bed is 8½ feet thick at location 78, in the SE. ¼ sec. 3. Near by, at location 79, in the NE. ¼ sec. 10, a bed that occurs locally a short interval above the Rosebud bed is 2 feet 10 inches thick. A partial section of the Rosebud bed was measured at location 80, east of Greenleaf Creek, and the bed above it was measured close by at location 81. The Knoblock bed is as much as 20 feet thick at its outcrops on the west slope of Greenleaf Creek. All or part of the bed was measured at locations 82, in the SE. ¼ sec. 4; 83, in the NE. ¼ sec. 10; 84, in the SE. ¼ sec. 10; 85, in the NE. ¼ sec. 16; 86, in

the W. ½ sec. 15; and 87, in the E. ½ sec. 21. A coal bed 20 feet thick is reported to have been struck at shallow depth in a well drilled at location 88, in the NW. ¼ sec. 22. This probably represents the Rosebud or McKay bed. A coal bed that occurs a short distance below the Knoblock clinker is partly exposed near the highway in the NE. ¼ sec. 14. The Sawyer bed is more than 16 feet 9 inches thick, the uppermost part of the bed having been eroded, at location 89, in the NW. ¼ sec. 32, where it is mined by local ranchers. A fault trending southeast cuts the coal bed at this locality, and the beds on the north have been elevated with respect to those on the south.

Coal in the east slope toward Tongue River.—The Knoblock bed is 13 feet 8 inches thick at location 90, and the Rosebud bed is more than 27 feet thick at location 91, in the SE. ¼ sec. 1. The Knoblock bed is burned throughout much of the eastern third of the township, but it is almost certain that thick coal beds underlie the clinker-covered plateau at shallow depth. The Knoblock bed is 23 feet thick at location 92, in the SW. ¼ sec. 35, and measurements of the thickness of the Sawyer bed at locations 93 to 96 show it to range between 7⅓ and 18½ feet in secs. 33 to 35.

Utilization.—Except the outcrops of the Sawyer coal in secs. 34 and 35, practically all coal outcrops in this township described above are accessible to coal wagons. Coal in comparatively thick beds is available for strip mining in parts of secs. 18, 7, 8, 9, 10, 3, 15, 16, 21, and 22, where it underlies the surface at depths less than 50 feet. Small tracts on Lay Creek in secs. 25 and 36 also contain coal at shallow depth.

T. 2 S., R. 43 E.

That part of T. 2 S., R. 43 E., which was examined comprises approximately the northern tier of sections of the township, a rugged country near Garfield Peak. The lowest coal exposed is the Knoblock bed, which was measured at only two places. (See pl. 16.) The bed is more than 23 feet thick at location 98, in the NW. ¼ sec. 11, and near by, at location 99, a little more than 10 feet of the bed crops out. It can be recovered by strip mining over approximately 100 acres in this vicinity. The Sawyer bed, averaging about 10 feet in thickness, was measured at locations 100 to 103, in secs. 3 and 4. This bed can be mined by stripping in sec. 10, in the northern part of the Indian reservation. Owing to their almost inaccessible position high in the rugged slopes near Garfield Peak, coal beds above the Sawyer bed are believed to be of but little commercial importance in this township, and so only meager information concerning them was obtained. A coal bed of local extent, having a maximum observed thickness of 4½ feet, is present about 250 feet above the Sawyer bed and was measured at locations 104 and 105, in secs. 4 and 5. About 100 feet higher is a bed that averages about 8 feet in thickness at locations 106 to 109, in secs. 5 and 6, and the clinker formed by the burning of this bed can be traced almost continuously throughout the rugged slopes in the vicinity of Garfield Peak. This bed, or possibly the one exposed at locations 104 and 105, probably represents the E bed in the central part of the Ashland field. A series of beds composed of shale, carbonaceous shale, and thin coals that have been burned along the crop line occurs about 300 feet above the 8-foot coal and probably represents the F bed in the central part of the field. The clinker of this coaly zone crops out about 200 feet below the capping clinker of Garfield Peak and forms a series of knobs capping the ridge that trends westward from the peak. A thick carbonaceous shale bed that contains some coal has burned and forms a red ledge in the slope about 80 feet below the F(?) clinker. Garfield Peak is capped by a clinker 60 feet thick which forms an extensive plateau farther

south, in the Cheyenne Indian Reservation. It is designated the Garfield clinker. There are no mines or prospects in this township, and with the possible exception of the Knoblock bed in secs. 2 and 3 this area offers no attractive prospects for present development.

T. 1 N., R. 44 E.

The Tongue River flows northeastward across the east half of T. 1 N., R. 44 E. Its largest tributary here is Beaver Creek, which occasionally carries water the year through. The other tributaries are relatively short and are dry except for a few hours after rains. There are no large springs in this township. Water is found at shallow depths in dug wells in the Tongue River bottoms and along the larger tributary streams. Drilled wells at the old Milligan ranch and at the Ball ranch, in the Tongue River bottoms, have an artesian flow of soft water, probably derived from sandstone beds in the upper part of the Lance formation.

The flood plain of the Tongue River is between half a mile and a mile wide. It is bordered by gentle slopes formed on the soft, readily eroded rocks of the Lebo shale member. The alternately bedded hard and soft beds of the Tongue River member occupy the surface of most of the township and form more rugged features. The stream divides are characterized by flat-topped clinker-capped buttes and ridges that rise with steep, almost barren, slopes 200 feet and more above the valleys. Rolling densely sodded prairie characterizes much of secs. 19, 20, 29, 30, and parts of secs. 7, 8, 17, and 18. The most rugged parts of the township are in secs. 4, 5, 6, 25, 31, 32, 35, and 36.

Aside from a belt of Recent alluvium bordering the Tongue River and forming the bottom lands and a few remnants of gravel terraces along the Tongue River Valley, the entire township is occupied at the surface by the Lebo shale and Tongue River members of the Fort Union formation. The Lebo shale occupies a comparatively narrow zone, however, on each side of the alluvial flat of the Tongue River, narrows southward up the river, and disappears beneath the alluvium a short distance south of the south boundary of the township. The Tongue River member occupies the surface of the remainder of T. 1 N., R. 44 E., but only the lowermost 350 feet of the member is present. The two chief clinkers are those produced by the burning of the Knoblock coal bed in the southern part of the township and the Terret coal in the northwestern part of the township.

If the coal resources in this township are compared with those of many near-by townships they appear to be relatively unimportant. Nevertheless, there is a large tonnage of coal present in parts of the township in at least three beds of workable thickness in the Tongue River member. (See pl. 17.) The thicker beds crop out several miles away from the Tongue River and so are not so well situated for early exploitation as coal farther up the river, should the proposed railroad along the Tongue River Valley be built. Furthermore, there are no large tracts in this township where thick coal lies at a depth sufficiently shallow to permit mining by stripping. The Tongue River Valley lands that lie below the outcrops of the chief coal beds may be underlain at shallow depth by coal beds in the Lance formation, concerning which no specific information was obtained in this field examination.

At location 110, in the NW. ¼ NE. ¼ sec. 3, there is a coal bed 1 foot 5 inches thick about 40 feet below the top of the Lebo shale, but this bed was not mapped. A coal bed 70 feet below the Terret clinker, probably representing the Burley bed, present in T. 1 N., R. 43 E., was prospected at a number of

places in sec. 4 and found to average about 4½ feet in thickness and to contain coal of good quality. A bone parting a few inches beneath the top of the bed persists throughout the region. The coal below the parting is 4 feet 8 inches thick at location 111, in the NW. ¼ NE. ¼ sec. 4, and 3 feet 11 inches thick at location 112, in the NW. ¼ NW. ¼ sec. 4. The bed crops out at locations 113 and 114, in the NW. ¼ sec. 4, but its thickness was not measured. At location 115, in the SW. ¼ NW. ¼ sec. 4, there is 4 feet 4½ inches of coal below the parting; at location 116, near the center of the S. ½ N. ½ sec. 4, 4 feet 7½ inches; and in a partial section measured at location 117, in the SE. ¼ NE. ¼ sec. 4, 3 feet. The coal at location 117 has been partly burned. No outcrops of this bed were seen on the south side of Little Alfalfa Creek in the S. ½ sec. 4, but it is probably present beneath the surface in the SW. ¼ and a part of the SE. ¼ of the section. At all localities mentioned this bed is under considerable cover a short distance back from the line of outcrop, which occurs in the steep slope that descends from the ledge formed by the clinker of the Terret coal. In sec. 4 the Terret bed has been destroyed by burning except in a very small area on the ridge in the NW. ¼. In sec. 5 the Burley bed contains 4 feet 2 inches of clean coal at location 118, near the northeast corner; crops out but was not measured at location 119, in the SE. ¼ NE. ¼; and is 5 feet thick at location 120, near the center of the E. ½. The Terret bed probably contains workable coal throughout the NW. ¼ sec. 5. It is exposed a short distance northwest of the center of sec. 6 at location 121, where 7½ feet of coal, including a 2-inch parting of shale, was uncovered, the base of the bed being concealed. Only 2 feet 11 inches of coal was found at what is believed to be the horizon of this bed at location 122, in the SW. ¼ sec. 6. The Burley bed was prospected at location 123, in sec. 6, where the main bench is 5 feet 3 inches thick.

The Terret bed was measured at location 124, just west of the west line of sec. 7, where it is 5½ feet thick. It crops out, but its thickness was not determined, at location 125, in the NW. ¼ sec. 7. At location 126 in the SW. ¼ sec. 7 it consists of several benches of coal separated by shale partings; the upper chief bench is 2 feet 8½ inches thick and the next below 3 feet 10 inches thick, and the two are separated by 2 feet 3 inches of carbonaceous shale. The bed contains two coal benches separated by 3 feet 4 inches of shale at location 127, in the SW. ¼ sec. 7. No outcrops of the Burley bed were seen in the gentle sod-covered slopes that occupy the E. ½ sec. 7, but it is very probable that the bed is present there. The bed was measured at location 128, in the W. ½ sec. 16, where the main bench is 3 feet 11 inches thick.

The Burley bed was prospected at location 129, in the NW. ¼ sec. 17, where the principal bench contains 3 feet 2 inches of coal. Prairie-dog mounds in the SE. ¼ SE. ¼ sec. 17 contain coal that was probably brought up from this bed. The bed is 3 feet 4 inches thick at location 130, in the NE. ¼ sec. 18, and 3 feet 3½ inches thick at location 131, near the center of sec. 18. The Terret bed is exposed but was not prospected and measured at location 132, in the NE. ¼ sec. 20. At location 133, in the NW. ¼ NW. ¼ sec. 21, it measures a little more than 9 feet, and the thickest bench is 6 feet thick.

A coal bed 3½ feet thick, in the lowermost part of the Tongue River member, occupies a small butte at location 139, in the NW. ¼ sec. 28, and may be present in parts of the SW. ¼. A coal bed 2 feet 4 inches thick is exposed at location 140, in the east-central part of sec. 30. This bed occurs at the same general horizon as that exposed at location 139, in the NW. ¼ sec. 28. The Knoblock clinker occupies parts of the S. ½ sec. 30, and the Terret and other coal beds

below the Knoblock bed may be present but were not seen. The Knoblock coal is exposed at location 141, in the NW. ¼ sec. 31, where more than 19 feet 4 inches of coal, with the base concealed and the bed split into two benches by a parting, was uncovered. This bed is probably unburned in the central part of the divide that trends east-west across sec. 31.

A coal bed 2 feet 5 inches thick occurring a short distance above the base of the Tongue River member crops out at location 134, in the west-central part of sec. 24. This bed was not traced far beyond this outcrop. The Knoblock coal has burned and forms a prominent clinker in parts of sec. 25. A thin coal bed, provisionally correlated with the Flowers-Goodale bed, 75 feet below the base of the Knoblock clinker was seen at locations 135 and 136, in the NE. ¼ of this section. It was measured only at location 135, where it is 4 feet thick including a 5-inch parting. The Terret bed, which is here 150 feet below the Knoblock clinker, is 4 feet thick at location 137, in the west-central part of sec. 25, and this bed was exposed but not prospected at location 138, in the east-central part of this section. The Terret coal bed is 3 feet 9 inches thick at location 142, near the middle of the E. ½ sec. 35, and a coal bed 2 feet 11 inches thick occurs 110 feet below the Terret bed near by at location 143. The main bench of the Terret bed is 3 feet 9 inches thick at location 144, in the west-central part of sec. 36. It is exposed but not prospected at location 145, in the north-central part of sec. 36.

T. 1 S., R. 44 E.

The surface of T. 1 S., R. 44 E., is occupied in large part by a plateau formed on the thick clinker of the Knoblock coal bed, through which the Tongue River has cut a trough about 2 miles wide. The Tongue River flood plain ranges between half a mile and a mile in width, and the bordering bluffs rise about 250 feet above the bottom land. Remnants of terraces below the plateau surface representing higher levels of the river bed border the flood plain. Although the plateau formed on the Knoblock clinker occupies much of the township it has been intricately dissected by tributaries of the Tongue River.

Aside from the gravel terraces, the alluvium bordering the Tongue River, and a very small area of the Lebo shale near Brandenburg, the entire township is underlain at the surface by the lower part of the Tongue River member, in which several valuable coal beds occur. (See pl. 18.) The Knoblock bed, which here lies a little more than 300 feet above the base of the member, has burned nearly throughout the area it occupies. The Rosebud bed, occurring about 100 feet below the base of the Knoblock clinker, is present in the northwestern part of the township; and the Flowers-Goodale bed, believed to occur at the approximate horizon of the Rosebud bed, is present east of the Tongue River in the eastern part of the township. A coal bed that may be the McKay bed (of the Rosebud Creek Valley) occurs 142 feet below the base of the Knoblock clinker on Lay Creek. It is possible, however, that this bed is equivalent to the Terret bed, which has a wide occurrence east of the Tongue River in the north-central part of the field and west of the Tongue River in T. 1 N., R. 44 E. Although these correlations appear correct, the beds can not be traced continuously from the west to the east side of the Tongue River in T. 1 S., R. 44 E., and so they are named from localities on each side of the river rather than projecting the names across the valley.

Several coals occur locally below these principal beds, but little effort was made to correlate them because they appear to be lenticular and can not be traced continuously through long distances.

Coal outcrops in T. 1 S., R. 44 E.

West of Tongue River

No.	Location	Coal bed	Approximate thickness	Remarks
			Ft. in.	
146	NE. ¼ sec. 4	Below McKay	3 6	Local coal lens. More than 200 feet below Knoblock.
147	N. ½ sec. 6	McKay	5+	Upper part of bed eroded.
148	do	Rosebud	15	Accessible.
149	NW. ¼ sec. 6	Knoblock	13 6	Do.
150	do	do	5 6+	Upper part eroded. Accessible.
151	E. ½ sec. 6	do	7 1	Accessible.
152	NE. ¼ sec. 7	Rosebud	12 6	Do.
153	SE. ¼ sec. 8	Below McKay	3 4	Little value.
154	NW. ¼ sec. 21	do	3 9	May be same bed as that at location 153.
155	SE. ¼ sec. 21	do	3	Coal lens below bed of location 154.
156	SE. ¼ sec. 20	McKay (?)	6+	Correlation doubtful. May be Rosebud.
157	do	do	2 6	Correlation doubtful.
158	NE. ¼ sec. 28	Below McKay	1 3	Probably same bed as at location 154
159	do	do	2 9	Below the bed of location 154.
160	NW. ¼ sec. 27	do	1 7	Same as bed at location 159.
161	E. ½ sec. 28	do	1 3	Do.
162	SW. ¼ sec. 28	do	1 9+	Probably same as bed at location 154.
163	SE. ¼ sec. 29	do	1 11	Do.
164	do	do	1 3	Do.
165	SE. ¼ sec. 30	McKay	1 10+	Does not represent full thickness.
166	NW. ¼ sec. 30	do	8+	Accessible. Not full thickness.
167	do	Rosebud		Coal smut in soil indicates a thick bed here.
168	SW. ¼ sec. 30	McKay	7 10	142 feet below Knoblock.
169	NW. ¼ sec. 33	do	7 6	Near highway.
170	do	do	7 7	Do.
171	W. ½ sec. 33	Below McKay	1 11	
172	NW. ¼ sec. 33	(?)	2	Near horizon of McKay.
173	SW. ¼ sec. 33	(?)	2 2	Do.
174	do	(?)	2 1	Do.
175	SW. ¼ sec. 32	(?)	2 3	Probably below McKay.

East of Tongue River

176	SE. ¼ sec. 1	Below Terret	2 2	Of little or no present value.
327	NE. ¼ sec. 13	Flowers-Goodale	7 10+	
177	SE. ¼ sec. 11	Below Terret	2 11	
178	do	do	3	Same as bed at location 177.
179	SW. ¼ sec. 11	do		Reported to be coal in river bed about 25 feet above base of Tongue River member.
180	NE. ¼ sec. 14	do	3 4	
181	W. ½ sec. 14	do	3 4	Same as bed at location 180.
182	do	do	3 9	Do.
183	do	do	4 3	Do.
184	SW. ¼ sec. 14	Flowers-Goodale	3 7	Small area of unburned coal.
185	do	Terret?	3 6	Correlation somewhat uncertain.
186	NW. ¼ sec. 23	Below Terret	2	Bed not correlated.
187	N. ½ sec. 26	Knoblock	9 6	Small area of unburned coal.
188	NE. ¼ sec. 27	Below Terret	3 9	Local lens.
189	SW. ¼ sec. 26	Flowers-Goodale	7	
190	do	Terret	7	
191	NW. ¼ sec. 35	do	5 9+	
192	SE. ¼ sec. 26	do	7 4+	
193	do	Flowers-Goodale	4+	
194	NW. ¼ sec. 36	Terret	7 9	
195	do	do	5 8	
196	SW. ¼ sec. 36	do	7 2+	
197	do	do	7 2	
198	E. ½ sec. 35	do	6 6	
199	NE. ¼ sec. 35	do	3 2+	
200	NW. ¼ sec. 35	do	2 5	
201	E. ½ sec. 34	Below Terret	1 9	Local lens.
202	do	do	2	Do.

T. 2 S., R. 44 E.

In T. 2 S., R. 44 E., the Tongue River has a flood plain from half a mile to a mile wide bordered on each side by bluffs of light-tan sandstone and shale capped by the thick clinker of the Knoblock coal, the valley forming a trough through an extensive plateau formed on the Knoblock clinker. Except for

the alluvium and gravel beds of the river valley the lower part of the Tongue River member occupies the entire surface. Only that part of this township that is outside the Northern Cheyenne Indian Reservation was mapped. Valuable coal beds are present in most of the mapped area, but difficulty was experienced in tracing beds continuously over long distances, probably owing to a lack of coal exposures rather than an absence of coal. (See pl. 19.)

Coal west of Tongue River.—A coal bed 7 feet thick that may represent the McKay bed or occur a short interval beneath the McKay horizon was prospected at location 203, in the NE. ¼ sec. 5. A thick coal bed occurs 60 feet below the Knoblock clinker bed in sec. 6. It appears to lie somewhat above the horizon of the Rosebud coal but may actually represent that bed. It is more than 14 feet thick and, being under thin cover, can be recovered by stripping in a small area. It was measured at locations 204 and 205. A coal bed assumed to be correlative with the McKay bed occurs 160 feet below the Knoblock clinker and has been mined in a small way at location 207, in sec. 7, within the Indian reservation, where it is 6 feet 1½ inches thick. The uppermost 3 feet 2 inches of the bed was uncovered at location 206, in the NE. ¼ sec. 7.

Coal east of Tongue River.—A bed that possibly represents the Terret bed is about 2 feet thick at locations 208 to 210, in the E. ½ sec. 3. The Flowers-Goodale bed is 4 feet 6 inches thick at location 211, in the SE. ¼ sec. 2. In the NE. ¼ sec. 11 the Flowers-Goodale bed was seen at location 212 and the Terret bed at locations 213 and 214. The Flowers-Goodale bed crops out at location 215, in sec. 12, and the Knoblock bed is nearly 27 feet thick and is unburned as yet at location 216, in sec. 12, but is on fire near by. A thin coal of no value occurs at the horizon of the Terret bed at locations 217 to 219 and 221, in secs. 10 and 11. The Flowers-Goodale bed is 6½ feet thick at location 220, in sec. 10. A coal lens of local extent occurs between the Flowers-Goodale and Knoblock horizons at location 222, in the NW. ¼ sec. 14. The Terret bed is about 4 feet thick at locations 223 and 224, in sec. 14, and at location 225, in sec. 22. It is a little more than 4 feet thick near the George J. Newlin place, at location 226, in sec. 26. The Flowers-Goodale bed is 3 feet thick at location 227, in the W. ½ sec. 26, and the Terret bed is 3 feet 3 inches thick in the bluff face at location 228, in the NW. ¼ sec. 35.

T. 3 S., R. 44 E.

That part of T. 3 S., R. 44 E., lying east of the Tongue River is included in the Ashland coal field. Its surface consists of a dissected plateau formed on the clinker of the Knoblock bed and rising about 300 feet above the Tongue River and its principal tributary, Otter Creek. Ashland, from which this coal field is named, is in this township.

Alluvium of Recent age occupies the valley bottoms of Otter Creek and the Tongue River. Rocks in the lower part of the Tongue River member occupy the surface of the remainder of the area. The central part of the township lies in the trough of a broad syncline trending northwestward, the axis of which is about 2 miles south of Ashland. The axis of a low anticline, likewise trending northwestward, crosses the NE. ¼ sec. 35 and sec. 27. Rocks near the Tongue River in sec. 33 appear to dip at a low angle southwestward to a point about half a mile south of the boundary of the township and then rise again upstream. The axis of a gentle anticline trending southwestward, at right angles to the folds just described, crosses secs. 35 and 36 and extends into T. 4 S., R. 44 E.

Coal beds of workable thickness (see pl. 20) crop out at several localities in this township, some of which have supplied coal to residents of Ashland,

and it is reported that drilled wells at Ashland penetrated thick coal beds. A well drilled somewhere in sec. 1 is reported to have struck a coal bed at shallow depth that is 25 feet thick, presumably the Knoblock bed. The Terret bed is 5 feet thick at an old mine at location 229, in the NW. ¼ sec. 2, and near by at location 230 the Flowers-Goodale bed is 4½ feet thick. A coal bed that is provisionally correlated with the Flowers-Goodale bed is about 4½ feet thick at location 231, in the NE. ¼ sec. 11. The Flowers-Goodale bed has been mined for several years at the Weaver mine, at location 232, southeast of Ashland, and most of the coal has been sold in Ashland. A tunnel has been driven about 500 feet in this bed, which averages a little more than 4 feet thick. The burnt outcrop of this bed makes a red band around the flagpole knoll and along the slope south of the buildings in the southern part of Ashland. The bed is 4 feet thick where it was uncovered in the slope back of Newlin's house, at location 233, and has thinned to 3½ feet at location 234, in the SE. ¼ sec. 10. The Terret coal is 5 feet 8 inches thick at the Holt mine, location 235, three-quarters of a mile west of Ashland. This mine supplies coal in Ashland. A coal of local extent, 75 feet beneath the Knoblock bed, crops out in the bank of the Tongue River at location 236, in the SW. ¼ sec. 22, where the uppermost 2 feet of the bed was exposed at the time of the examination. Half a mile downstream, at location 237, it is 4 feet 9 inches thick, but within a few hundred feet to the north it is replaced by massive sandstone. A local lens about 20 feet above this bed crops out at locations 238 and 239 and contains about 4 feet of coal but is replaced within a short distance by sandstone.

The Knoblock bed is burned out over the greater part of the township, and its clinker bed caps the bluffs along the Tongue River and Otter Creek. As shown on Plate 3, it is unburned over approximately four sections in the southeastern part of the township. Smut in the roadside in the SE. ¼ sec. 22 and sections of part of the bed at locations 240 and 241, in secs. 27 and 33, indicate that it is more than 6 feet thick and occurs in two benches, the lower of which in places is unburned. The rocks above the Knoblock bed consist of somber-colored shale and sandstone. Several lenses of thin impure coal containing an abundance of fossil wood crop out at locations 242 to 244, in secs. 35 and 36.

T. 2 N., R. 45 E.

The Tongue River flows from the southwest corner northeastward diagonally across T. 2 N., R. 45 E. Like other streams in this part of Montana, it has a broad valley where it crosses the Lebo shale member, which occupies the surface southeast of the river. The principal tributaries entering the Tongue River from the southeast are Liscom, Cook, and Hay Creeks, which contain flowing water only parts of the year. The lower reaches of their valleys are broad and gentle slopes characteristic of Lebo shale surfaces, but they become narrower upstream, where they are cut in the Tongue River member. The surface in the southeastern part of the area is comparatively rugged. The interstream areas are intricately dissected into buttes and ridges with steep, barren rock slopes. The total relief is a little greater than 350 feet.

The uppermost few feet of the Lance formation, which contains two very thin beds of coal, crops out on the east side of the Tongue River in the northeasternmost part of the township. The Lebo shale member of the Fort Union formation, about 160 feet thick, occupies a zone about a mile wide bordering the Tongue River bottom lands and extends 4 miles or more up the tributary stream valleys. The Tongue River member occupies the higher lands.

The lowest coal bed that was mapped is 58 feet above the base of the Tongue River member. At 40 feet above this bed is another coal that was mapped in part of this township. The interval between this upper bed and the base of the Terret clinker is 85 feet. The Terret bed is 183 feet above the base of the Tongue River member and is the lowest thick coal bed in this general region. It has been destroyed by burning in the area it occupies in the part of this township that was mapped (southeast of the Tongue River). A few thin coal beds are present in the Lebo shale member, but none were thought to be of sufficient thickness to justify mapping them. The thickest bed seen was 2 feet thick. Thin beds occur in the uppermost part of the Lance formation where it is exposed in sec. 1. It is probable that coals of only slightly greater thickness are present in the Lance formation at shallow depths beneath this township. It is further probable that beds of coal other than those found and mapped occur below the Terret bed in the Tongue River member, but they were not seen. The coal beds in this part of the member are irregular in thickness and occurrence and are in few places, if anywhere, burned along the outcrop. They are consequently less readily traced in mapping, and it is probable that there is more coal in this part of the stratigraphic succession than is shown on the map.

The Terret coal was probably a thick bed in this township before it was destroyed by burning. The clinker of this bed ranges between 10 and 40 feet in thickness. A little unburned coal remains at location 245, in the E. ½ sec. 35, where the upper 4½ feet of the bed was uncovered. The total thickness of the bed was not determined, and the coal there has practically no commercial value because it underlies only a very small tract. A small knob of greatly weathered coal of this bed is exposed at location 246, in the SW. ¼ sec. 25, where at least 6 feet of coal powder was seen.

The coal bed 85 feet beneath the Terret bed is too thin to be worked but was mapped throughout a part of this township. It is 2 feet 5 inches thick at location 247, 2 feet 3 inches at location 248, and 1 foot 9 inches at location 249, all in the N. ½ sec. 35. This bed is only 1 foot 7 inches thick at location 250, in the SW. ¼ sec. 25, and 2 feet ½ inch thick at location 251, in the SE. ¼ sec. 26. The coal bed that occurs 40 feet lower, or 125 feet beneath the Terret clinker, is 2 feet 8 inches thick at location 252, in the SE. ¼ sec. 34. This bed crops out but was not measured at locations 253 and 254, in the SW. ¼ sec. 35. It was not measured elsewhere in the township. (See pl. 21.)

T. 1 N., R. 45 E.

Almost the entire area of T. 1 N., R. 45 E., is drained northwestward by streams tributary to the Tongue River, which flows northeastward across the northwesternmost part of the township. Liscom and Goodale Creeks are the chief tributary streams, and they contain water only parts of the year. The surface of the township is extremely rough, the maximum relief being approximately 900 feet. The chief feature is a broad plateau formed on the resistant clinker produced by the burning of the Knoblock coal bed. This plateau is intricately dissected everywhere except in the south-central part of the township, where steep-sided hills capped by the D clinker rise 450 feet or more above the level of the Knoblock plateau, to an altitude of about 3,700 feet. The extreme northwestern part of the township is underlain at the surface by the Lebo shale and alluvium of the Tongue River bottom lands and presents a surface of low relief. Two rather prominent gravel terraces parallel Liscom Creek on its southwest side.

The uppermost 50 feet of the Lebo shale is exposed in the northwestern part of the township, and about 850 feet of the lower part of the Tongue River member occupies most of the remainder of the area. The valuable coal beds are in the Tongue River member, although coal in the Lance formation, which underlies the Lebo shale, may be present at shallow depth. The Lance coals are of particular interest in the northwestern part of the township, where the Tongue River coals have been eroded away. The principal coal beds that crop out are the Terret bed, which is 140 to 150 feet above the base of the Tongue River member and has a maximum thickness greater than 12 feet; the Flowers-Goodale bed, which is about 225 feet above the base of the member and averages about 9 feet in thickness, and the Knoblock bed, which is 285 to 300 feet above the base of the Tongue River member and has a maximum observed thickness of 27 feet. Higher beds including the Sawyer coal are present, but they are thin and of relatively little value in this township. (See pl. 22.)

The surface of this township is so rugged that wagons or cars can be used only along the chief drainage channels. The localities where coal is exposed are therefore readily accessible only in that region that lies on the same general slope as the outcrop. The township is, accordingly, divisible into three natural units—that part which drains westward directly into the Tongue River, roughly the western third; that part which slopes northeastward toward Liscom Creek, in general the central and southeastern part; and that part which slopes southwestward toward Liscom Creek, the northeastern part.

Coal in the western third of the township.—The western part of the township contains a number of outcrops of thick coal beds, and coal is mined at two localities to supply much of the coal used by ranchers of the vicinity. The Terret bed is the lowest thick bed seen, but the strata beneath the Terret coal are not well exposed and it may be that coal beds are present in this part of the section but concealed. The Terret bed is 7 feet 4 inches thick at an exposure at the foot of a sandstone cliff near the road in the SW. ¼ sec. 19 (location 255), and the Flowers-Goodale bed is exposed higher up the slope at this locality. Coal of the Terret bed shows in prairie-dog mounds on the north side of the gulch in the NE. ¼ NE. ¼ sec. 30. The Flowers mine, in the Flowers-Goodale bed, is farther up the north fork of this gulch, near the center of sec. 29 (location 256). The main bench of the coal bed is there 7 feet 8 inches thick. The mine consists of a vertical face forming the bank of the creek from which coal has been shot and hauled in wagons. A poor road leads to the exposure. This coal bed is exposed by the side of the main road that leads to Beaver Creek, at location 257, in the NW. ¼ sec. 29. The uppermost 7 feet 7 inches of the bed was uncovered, but the base was not disclosed. Westward from this locality, over a steep-sided ridge, a coal bed 4 feet 11 inches thick that is doubtfully correlated with the Flowers-Goodale bed is exposed at location 258. At location 260, in the NW. ¼ sec. 32, this bed is more than 4 feet 8 inches thick, the base of the bed being concealed. The Flowers-Goodale bed is 8 feet 6 inches thick at location 297, in the SE. ¼ sec. 32.

The Knoblock coal has burned throughout most of this part of the township, and its resulting clinker bed forms the thickest and most prominent clinker in the vicinity. A few exposures of unburned coal of this bed were seen in sec. 32, and the bed is believed to contain unburned coal throughout parts of secs. 21, 27, 28, 29, and 32 to 36. The lower 5 feet 5 inches of the Knoblock bed is exposed at location 259, in the S. ½ sec. 29. At location 261, in

the NE. ¼ sec. 32, the thickest bench of the Knoblock bed seen has 9 feet 3 inches of coal exposed, the upper part of the bench having been eroded away. Its original total thickness is not known, but measurements in the general region indicate that it was probably between 20 and 30 feet thick. These exposures of the Knoblock coal are difficultly accessible because of their location far up deep gulches walled on both sides by cliffs of the Knoblock clinker. A coal bed that is probably the Flowers-Goodale bed occurs 50 feet beneath the Knoblock clinker and was prospected at location 262, in the NE. ¼ SW. ¼ sec. 33, where 7 feet 9 inches of coal was exposed, the upper part of the bed being concealed. It can be reached fairly readily from the Beaver Creek road. A thin coal bed high on the steep slopes of the rugged hills in the NW. ¼ sec. 33 was measured at location 263. It may represent the Sawyer bed. It is 3 feet 3 inches thick but because of its situation is of no present practical value. These high hills are capped by a thick clinker produced by the burning of the D coal bed. The clinker is as much as 100 feet thick and lies roughly 700 feet above the base of the Tongue River member.

The Flowers-Goodale bed is exposed on Goodale Creek near the northwest corner of sec. 28, at the Goodale mine (location 264). The uppermost 9 feet 3 inches of the bed was exposed, the base of the bed being concealed where coal has been shot from the creek bank by local ranchers. A short distance upstream from the Goodale mine a thin coal bed of no value is exposed, just below the Knoblock clinker. A partial exposure of the Terret bed, showing 6½ feet of coal, was seen at location 265, about a mile downstream from the Goodale mine. Six feet of coal representing part of the Flowers-Goodale bed was uncovered at location 266, in the W. ½ sec. 20. A coal bed 2½ feet thick occurring about 100 feet below the Knoblock clinker is exposed at location 267, in the SW. ¼ sec. 8, and a bed of like thickness is exposed near by at location 268, near the horizon of the Knoblock bed. The thin bed at location 268 probably does not represent the chief bench of the Knoblock bed.

Coal in the central and southeastern parts of the township.—The most valuable coal beds in the central and southeastern parts of the township are the Knoblock, Flowers-Goodale, and Terret beds. The Knoblock bed is as much as 27 feet thick, the Flowers-Goodale bed more than 9 feet, and the Terret bed at least 12½ feet. A fourth coal bed, about 30 feet beneath the principal Knoblock bench, is present in parts of the area.

Coal outcrops in central and southeastern parts of T. 1 N., R. 45 E.

No.	Location	Coal bed	Approximate thickness	Remarks
			Ft. in.	
271	NW. ¼ sec. 16	Terret	12 6+	Accessible.
272	NE. ¼ sec. 15	do	4+	Do.
273	SE. ¼ sec. 15	do	6 6+	Moderately difficult of access.
274	do	do	5 6	Difficultly accessible.
275	SW. ¼ sec. 15	do	9	Accessible.
276	SE. ¼ sec. 16	Knoblock	21	Accessible and mined.
277	SE. ¼ sec. 21	do	11 4+	Difficultly accessible.
278	NE. ¼ sec. 27	do	11+	Do.
279	do	Flowers-Goodale	7 6+	Accessible.
280	N. ½ sec. 26	do	8 2+	Accessible (Pope mine). Coal shot from creek bank.
281	SE. ¼ sec. 27	Knoblock	20+	Difficultly accessible.
282	SW. ¼ sec. 27	Bed 30 feet below Knoblock.	5 5+	Accessible.
283	do	Knoblock	24 6+	Do.
284	do	do	27+	Do.
285	SW. ¼ sec. 24	Flowers-Goodale	(a)	Do.

[a] Not measured.

Coal outcrops in central and southeastern parts of T. 1 N., R. 45 E.—Continued

No.	Location	Coal bed	Approximate thickness	Remarks
			Ft. in.	
286	SE. ¼ sec. 26	Bed 30 feet below Knoblock.	2	
287	do	Knoblock	9 4+	Difficultly accessible.
288	NW. ¼ sec. 36	Bed 30 feet below Knoblock.	7 2+	Accessible.
289	SE. ¼ sec. 35	Knoblock	16+ in 2 benches.	Do.
291	NW ¼ sec. 36	Bed 30 feet below Knoblock.	7 5+	Difficultly accessible.
292	NE. ¼ sec. 36	Knoblock	7 6+	
293	Center of sec. 36	do	9 2+	Do.

Coal in the northeastern part of the township.—The three chief beds found elsewhere in this township are present also in the northeastern part. No outcrops of the Knoblock bed were seen, however, as it has been destroyed by burning throughout most of its area. The Flowers-Goodale bed thins eastward and is of less value in the northeastern part of the township than elsewhere. The Terret bed maintains its workable thickness and good quality of coal.

Coal outcrops in northeastern part of T. 1 N., R. 45 E.

No.	Location	Name of coal bed	Approximate thickness of coal bed	Remarks
			Ft. in.	
294	NE. ¼ sec. 1	Terret	[a]	Accessible.
295	SW. ¼ sec. 1	do	9 8	Do.
296	NE. ¼ sec. 2	do	5 8+	Do.
269	SW. ¼ sec. 2	do	[a]	Do.
270	SW. ¼ sec. 13	do	8 3	Do.
290	SE. ¼ sec. 24	Flowers-Goodale	6 4	Do.

[a] Exposed but not measured.

T. 1 S., R. 45 E.

Almost the entire surface of T. 1 S., R. 45 E., is drained by Beaver Creek, which trends northwestward across the northern part of the township and discharges into the Tongue River a few miles northwest of the northwest corner. The bottom lands bordering the creek are in places half a mile wide but average about a third of a mile; they are bordered by narrow strips with gentle slopes terminated abruptly by steep slopes that rise 100 to 150 feet to flat-topped buttes and ridges capped by clinker beds. The surface of most of the remainder of the township is rough and characterized by dissected clinker-capped plateaus and buttes.

Aside from a narrow belt of Recent alluvium bordering Beaver Creek and forming the bottom lands, the entire township is occupied at the surface by the Tongue River member of the Fort Union formation. This member is composed of interbedded light cream-colored sandstone, sandy shale, gray, drab, and tan shale, and coal beds. The coal beds have been burned throughout most of their outcrops, and the rock that originally lay above the coal now forms thick ledges of clinker. The lowest rocks exposed occupy the surface in the extreme northwestern part of the township and probably lie about 50 feet above the base of the Tongue River member. The stratigraphically highest beds exposed are a little more than 700 feet above the base of the

member and cap the buttes in the southeastern and extreme northeastern parts of the township. The lowermost 550 feet of the exposed interval consists of about two-thirds sandstone and one-third sandy shale, shale, and coal beds. The uppermost 150 feet is nearly all somber-colored badland shale with minor amounts of sandy shale.

The chief coal beds that crop out in this township (see pl. 23) are listed in the table below:

Coal beds in T. 1 S., R. 45 E.

	Feet
Sawyer coal bed	10±
Interval	260
Knoblock coal bed	25—
Interval	40
Coal bed, not named, present locally	4–6½
Interval	30
Coal bed, not named, present locally	6
Interval	18
Flowers-Goodale coal bed	12±
Interval	25
Terret coal locally present	9½±

It is probable that the Knoblock coal is potentially the most valuable coal bed in this township, although more readily accessible lower beds are of greater present value. The Knoblock coal occurs about 300 feet above the base of the Tongue River member and underlies about 8,000 acres in this township. Measured sections indicate that it may average 20 feet in thickness. The clinker formed by the burning of this bed is the thickest and most prominent clinker bed in the township. It extends southwestward beyond the township as a cap to the steep slopes on each side of the Tongue River Valley for nearly 20 miles up the river. The Flowers-Goodale bed occurs about 100 feet below the Knoblock coal and is the most widely exposed thick coal bed in this township. The Terret coal, which is locally of value, lies 140 feet beneath the Knoblock bed. It is probable that the Terret bed is much more widely distributed than the map (pl. 3) indicates but that it fails to crop out in the sod-covered slopes that characterize this part of the stratigraphic section. A bed of workable thickness occurring 45 feet and another 80 feet beneath the Knoblock bed are exposed locally in the extreme western part of the township. The only thick bed of coal occurring above the Knoblock bed in this township is the Sawyer bed, separated from the Knoblock by an interval of about 260 feet. It occurs only in isolated buttes high in the steep slopes, where it is practically inaccessible and so is of little or no value.

Coal outcrops in T. 1 S., R. 45 E.

North of Beaver Creek

No.	Location	Coal bed	Approximate thickness	Remarks
			Ft. in.	
298	E. ½ sec. 12	Terret	8 5	Accessible.
299	NE. ¼ sec. 12	Knoblock	6 6+	In steep slope. Only small unburned tract.
300	NE. ¼ sec. 1	do	7 11+	Accessible.
301	SW. ¼ sec. 1	Flowers-Goodale	8 8	Do.
302	NE. ¼ sec. 2	do	7 5	Do.
303	W. ½ sec. 4	do	2 4	Of no value.

Coal outcrops in T. 1 S., R. 45 E.—Continued

South of Beaver Creek

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
304	SE. ¼ sec. 13	Flowers-Goodale	6+		Accessible.
305	SW. ¼ sec. 13	do	6+		Do.
306	NE. ¼ sec. 24	Knoblock	4+		Upper part of bed eroded away. Small stripping area.
307	SE. ¼ sec. 22	Flowers-Goodale	5	7+	Accessible.
308	SW. ¼ sec. 26	Knoblock	11	6+	Do.
309	Center of sec. 26	Sawyer	10	6	Near top of isolated butte.
310	NE. ¼ sec. 34	Knoblock	7	6+	Top and base concealed.
311	NW. ¼ sec. 34	Above Knoblock	1	5	Of no value.
312	SW. ¼ sec. 27	do	2		Few feet above Knoblock bed.
313	NE. ¼ sec. 21	Flowers-Goodale	4	10	Accessible.
314	do	do	6	6	Do.
315	SE. ¼ sec. 16	Terret	9+		Small wagon mine (Terret mine).
316	N. ½ sec. 16	Flowers-Goodale	6	6+	Accessible.
317	SE. ¼ sec. 17	do	12		Do.
318	SW. ¼ sec. 16	40 feet below Knoblock	5	6	Do.
319	Center of sec. 17	Flowers-Goodale	10	8	Do.
320	NW. ¼ sec. 17	do	9+		Do.
321	do	do			Exposed but thickness not measured.
322	NE. ¼ sec. 20	Knoblock	24	6	Includes 9-inch shale parting.
323	E. ½ sec. 18	Flowers-Goodale	10	3	
324	NW. ¼ sec. 18	do	10	10	
325	do	do	5	6+	Base concealed.
326	SW. ¼ sec. 18	do	9	5+	Do.
328	NE. ¼ sec. 19	40 feet below Knoblock	6	2	
328	do	80 feet below Knoblock	6+		
329	NW. ¼ sec. 30	Flowers-Goodale	9	3	
330	NE. ¼ sec. 30	45 feet below Knoblock	5	7	
331	SE. ¼ sec. 29	Knoblock	9+		Base concealed.
332	NE. ¼ sec. 31	do	15+		Forms creek bank.

T. 2 S., R. 45 E.

The surface of T. 2 S., R. 45 E., is rugged, the maximum relief being about 1,300 feet. The Cook Creek Mountains, a narrow, intricately dissected ridge capped by thick clinkers of the Garfield and F beds, trends northwestward from the middle of the eastern edge of the township. The northeast third of the township drains northward into Beaver Creek, the western third and northwestern part drain westward into the Tongue River, and the southern part drains southward into the East Fork of Otter Creek. The streams carry water only part of the year and have narrow, gorgelike channels.

Rocks of the Tongue River member occupying the interval between the Knoblock coal, which is about 300 feet above the base, and the uppermost baked rocks of the Garfield clinker, which is 1,450 to 1,500 feet above the base, occur in this township. Several thick beds of coal are present in this series (see pl. 24), and their positions are shown in the following generalized section:

Coal beds in T. 2 S., R. 45 E.

	Feet
Garfield clinker (caps Cook Creek Mountains)	100
Interval (contains locally coal bed 7 feet thick)	200
F clinker (coal rarely exposed)	50
Interval	100
Cook clinker (coal locally 10 feet thick)	20
Interval	160
E clinker (coal 10 to 18 feet thick)	25
Interval	150
D clinker (present locally)	10

	Feet
Interval (contains C coal bed locally)	100
Sawyer clinker (coal 10 to 18 feet thick)	25
Interval	220
Knoblock clinker (coal not exposed)	40
	1,200

Because of the rugged surface the coal outcrops can be readily approached only by way of certain drainage channels. The approximate northeast quarter of the township is accessible from the Beaver Creek Valley by way of Ash Creek but is practically inaccessible from the south and southwest except by saddle horse. The approximate northwest quarter of the township can be reached best through the Tongue River Valley and the northwestward-trending stream channels tributary to the Tongue River. The south half of the township can be reached from the East Fork road that crosses the northern part of the adjacent township on the south.

Coal outcrops in T. 2 S., R. 45 E.

Northeast quarter of township

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
333	NE. ¼ sec. 12	Sawyer	(a)		Old pit. Small stripping area. Readily accessible.
334	E. ½ sec. 2	do	7	6+	Base concealed. Accessible.
335	SE. ¼ sec. 2	D	6	3+	Do.
336	NE. ¼ sec. 2	C	2	11	Contains silicified wood of no value.
337	do	C	2	9	Contains silicified wood.
338	do	C	3	10	Do.
339	do	C	3	5	Do.
340	do	C	3	11	Do.
341	NE. ¼ sec. 10	Between D and E	4	11	Dull tough coal. May be X bed.
342	SE. ¼ sec. 10	E	11	2+	Accessible. Also an upper coal bench.
343	S. ½ sec. 11	45 feet below F	3	2	
344	SE. ¼ sec. 3	D	7	4+	Small tonnage mined.
345	do	D	5	1+	
346	W. ½ sec. 3	Sawyer	9	6+	Base concealed.
347	NW. ¼ sec. 3	A	2	6	
348	NE. ¼ sec. 3	A	1	2	
349	NE. ¼ sec. 4	A	2	2	
350	NE. ¼ sec. 3	140 feet below Sawyer.	3	6	Thin coal bed of no value.
351	NW. ¼ sec. 4	D	3	5	D bed thins rapidly to west.

Northwest quarter of township

352	SE. ¼ sec. 5	Sawyer	5+		Stripping area. Probably 10 feet thick.
353	SW. ¼ sec. 4	D	5	10	
354	NE. ¼ sec. 9	E	10		Lower bench is 5 feet 7 inches.
355	SE. ¼ sec. 9	Between Cook and E beds.	4	2+	Inaccessible.
356	NE. ¼ sec. 16	Cook	18	6+	Middle part covered.
357	NW. ¼ sec. 15	F	7	7	
358	SE. ¼ sec. 4	F	8	4	Inaccessible.
359	W. ½ sec. 5	Sawyer	13	6	Difficultly accessible.
360	SE. ¼ sec. 5		2	3	Correlation uncertain. Possibly the D bed.
361	N. ½ sec. 8	Sawyer	14		
362	SE. ¼ sec. 8	do	10	2	Coal bed 3 feet 2 inches thick occurs here 29 feet below the Sawyer bed.
363	NW. ¼ sec. 16	E	3	8	Two coal benches; upper bench 2 feet 6 inches thick.
364	NE. ¼ sec. 17	Sawyer	5+		Upper part of bed burned.
365	SW. ¼ sec. 16	E	10	4	Lower bench 8 feet 7 inches thick.
366	do	Cook	10	4+	Inaccessible.
367	SE. ¼ sec. 17	Sawyer	9	5½	

[a] Not measured.

Coal outcrops in T. 2 S., R. 45 E.—Continued

South half of township

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
368	S. ½ sec. 20	Below Sawyer	3	1	
369	SW. ¼ sec. 16	E	3	7½+	
370	W. ½ sec. 21	D	4	10+	Correlation not sure. Readily accessible.
371	NW. ¼ sec. 28	D	5	8	Correlation not sure.
372	Center of sec. 28	D	4	7	Do.
373	NE. ¼ sec. 28	E	5	5	
374	SE. ¼ sec. 30	Sawyer			Bed probably about 15 feet thick. 5 feet struck in well at 47 feet. Stripping area.
375	NW. ¼ sec. 32	do	4	6+	Upper part eroded. Stripping area.
376	SW. ¼ sec. 32	do	4	6+	Do.
377	do	do	8	4+	Do.
378	SE. ¼ sec. 33	do	12+		Reported to be 23 feet thick. Mined. Readily accessible. Small tract can be strip mined.
379	NW. ¼ sec. 34	Above Sawyer	4	11	Several partings, of little value.
380	SW. ¼ sec. 27	E	3	10	
381	NW. ¼ sec. 34	X	4	8	Difficultly accessible.
382	SE. ¼ sec. 27	E	6	6+	Accessible.
383	SW. ¼ sec. 23	Cook	5+		Difficultly accessible
384	do	do	7+		Do.
385	do	F	3	8	
386	W. ½ sec. 23	F	3	5	
387	SE. ¼ sec. 22	Cook	5	7	
388	E. ½ sec. 25	D	4		Accessible.

There is approximately 500 acres in the southwestern part of the township where the Sawyer coal bed lies 50 feet or less beneath the surface, and an additional 150 acres where the coal has a cover between 50 and 75 feet thick, the whole being thus adaptable to mining by stripping. The overburden is composed largely of soft but gummy clay shale grading upward into loosely cemented sandstone. The coal in the tract probably averages about 15 feet in thickness. The region is easily reached from the Ashland-Stacey highway and is about 5 miles from the proposed right of way of the North & South Railroad. Another but less accessible stripping area is located in sec. 5. There are no mines in operation in the township, but a little coal has been mined by ranchers at location 378, in the SE. ¼ sec. 33.

T. 3 S., R. 45 E.

Otter Creek, a perennial stream, flows northwestward across the southwestern part of T. 3 S., R. 45 E., in a nearly level flood plain about three-quarters of a mile wide. Home Creek and East Fork, tributaries of Otter Creek, have flood plains that are in places a quarter of a mile wide. On the whole, the relief in this township is moderate. The rise from the stream bottom lands is abrupt, but the interstream areas are broad, gently sloping uplands. The difference in altitude from the lowest point on Otter Creek to the highest hills near the southeast corner of the township is probably less than 500 feet. The northern part of the township, particularly the northeastern part, is characterized by steep-sided, flat-topped buttes capped by the clinker of the Sawyer coal. All the bedrock exposed in the township, except the alluvium along the streams, belongs in the Tongue River member of the Fort Union formation, the lowest beds being a little more than 250 feet above the base of this member. There is little doubt that this entire township is underlain by thick beds of coal (see pl. 25), although a considerable part of it contains no thick beds at the surface. The Knoblock coal is the lowest thick bed that crops out, but it is burned along its crop line throughout the township. Al-

though no exposures of coal in this bed were seen, its great thickness is indicated by the records of several water wells that have penetrated the coal at shallow depths. The Sawyer bed, which occurs about 250 feet above the Knoblock coal, is the most valuable bed exposed. It attains 20 feet or more in thickness in the northern part of the township but thins rapidly southward, becoming too thin for economical mining near the south boundary. Wells in the Home Creek Valley report 30 to 40 feet of coal that is probably the Knoblock bed.

Coal outcrops in T. 3 S., R. 45 E.

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
389	SW. ¼ sec. 1	Sawyer	11		Readily accessible. 4-inch parting.
390	NW. ¼ sec. 2	do	6	6+	Top and base concealed. Accessible.
391	NW. ¼ sec. 3	do	9	1+	Base concealed. Reported to be 16½ feet thick. Coal mined. 1-inch parting.
392	NE. ¼ sec. 17	do	6+		Small tract of unburned coal.
393	NW. ¼ sec. 8	do	4	6+	Near highway. Coal weathered.
394	SE. ¼ sec. 13	do	9	2	Coal weathered. 2-inch parting.
395	SE. ¼ sec. 25	do	3	10	Accessible.
396	NW. ¼ sec. 36	do	3	6	Do.
397	SW. ¼ sec. 36	do	2	10	Do.
398	S. of sec. 36	do	2	8	Do.
399	S. of sec. 35	do	2	4	Do.
400	NW. ¼ sec. 35	do	3	1	Do.

T. 2 N., R. 46 E.

Northwestward-trending tributaries of the Tongue River, of which Lay Creek is the chief, drain the western three-fifths of T. 2 N., R. 46 E. The surface of the easternmost tier of sections slopes eastward toward Foster Creek, which is also a tributary of the Tongue and traverses the adjacent township on the east. The maximum relief in this township is a little greater than 400 feet. The surface is a dissected plateau formed at the level of the clinker produced by the burning of the Terret coal bed. The plateau surface is now greatly dissected, and only remnants with extremely rugged margins remain. Only the divide extending northwestward through secs. 14, 23, and 26 rises above the Terret plateau. Lay Creek flows in a comparatively broad valley with gentle slopes bordered by rough lands that rise abruptly to the clinker rim of the Terret plateau.

The uppermost 10 to 20 feet of the Lance formation crops out near the Tongue River in the northwestern part of the township; the entire thickness of the Lebo shale member of the Fort Union formation and the lowermost 250 to 300 feet of the Tongue River member are present in this township. The Lance beds include two coal beds that are too thin to be of commercial value. The Lebo shale member, which is well exposed in secs. 5, 6, and 7, contains a few thin beds of coal, none of which were mapped. The Tongue River member contains the only valuable coal beds that crop out in this township. (See pl. 26.)

The thickest bed is the Terret coal, which lies between 140 and 150 feet above the base of the Tongue River member. It has burned throughout most of the part of this township that it underlies, and valuable unburned coal of this bed yet remains only in the central parts of the broader stream divides. It probably averages about 8 feet in thickness. Workable coal in beds believed to be of comparatively local extent occur below the Terret bed. Such beds were

mapped in secs. 2, 10, and 15. Thin coal beds rarely crop out in the types of slopes prevailing in this lower part of the Tongue River member, and so it is probable that workable coal is present elsewhere in the township but is not exposed. The Flowers-Goodale bed, which lies above the Terret bed, occurs in several small tracts on the crest of the divide in secs. 13, 14, 23, 25, 26, and 36 but is of relatively little value. In most localities this bed is under so thin a cover that the coal is badly weathered.

The results of the examination indicate that only a relatively small part of this township can be said definitely to be underlain by workable coal. It is possible, however, that workable Lance coals lie at shallow depth beneath the surface of much of the area.

Coal outcrops in T. 2 N., R. 46 E.

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
401	NE. ¼ sec. 2	40 to 50 feet below Terret	4	4	Accessible but far from road.
402	do	do	2	2½+	Do.
403	NW. ¼ sec. 10	Probably same as above	5	5	Difficultly accessible.
404	SW. ¼ sec. 10	do	4	1	Do.
405	NW. ¼ sec. 15	do	3	11	Do.
406	do	do	4	7	Do.
407	do	do	5	1	Do.
408	NE. ¼ sec. 13	Terret	5	7	Accessible.
409	NE. ¼ sec. 23	Flowers-Goodale	3	10	Somewhat difficult to reach.
410	W. ½ sec. 24	Terret	(a)		Do.
411	SW. ¼ sec. 23	do	9	7+	Accessible.
412	NE. ¼ sec. 26	do	5	10	Do.
413	SW. ¼ sec. 26	do	9	5	Do.
414	NW. ¼ sec. 36	Flowers-Goodale	2		Not of value.
415	W. ½ sec. 36	Terret	2+		Accessible. Can be stripped. Bed probably about 9 to 10 feet thick.
416	S. ½ sec. 35	About 115 feet below Terret.	2		Of no value.
417	NW. ¼ sec. 33	do	2	3	Of no present value.
418	SW. ¼ sec. 32	Terret	5+		At top of steep slope.
419	E. ½ sec. 31	Probably same as bed at location 417.	2	2	Of no present value.
420	NE. ¼ sec. 29	Terret	6		Small unburned tract at top of steep slope.
421	SW. ¼ sec. 30	do	5	7	Accessible.

[a] Exposed, not measured.

T. 1 N., R. 46 E.

The western fourth of T. 1 N., R. 46 E., drains northwestward into Liscom Creek, which crosses the southwestern part of the township and flows northward through the eastern part of the adjacent township on the west. The easternmost sixth of the township is drained northward by tributaries of Foster Creek, which is one of the large tributaries of the Tongue River and flows through the adjacent township on the east. The remainder of the township drains northward to Lay Creek, also a tributary of the Tongue River. The surface of this township ranges in altitude from a little less than 3,000 feet to a little more than 3,700 feet. The lowest point is on Lay Creek where it leaves the township, in the NW. ¼ sec. 2. The highest points are in the extreme southern part of the township, in the SE. ¼ sec. 34 and the S. ½ sec. 35. The surface is characterized by a gently rolling grassy upland that occupies much of the central part of the township. Clinker-capped, rugged hills rise above this upland in parts of secs. 27, 28, 29, and 33 to 36. The northern third and southwestern fifth of the township are in general rugged.

In these parts the streams have incised steep-sided gulches below the upland of the central part, and clinker beds produced by the burning of thick coal beds crop out as rock ledges capping a series of benches descending below the central upland. Some of the stream divides are broad and have a rolling grassy surface similar to that of the central upland; other interstream areas are narrow and greatly dissected.

Rocks that occur in the interval between about 50 feet and 750 feet above the base of the Tongue River member of the Fort Union formation occupy the surface. Three thick coal beds crop out in numerous localities and maintain fairly regular thicknesses and good-quality coal throughout the area. (See pl. 27.) Other coal beds are present but are not so regular in occurrence and thickness. The three thick beds are the Terret coal, which is about 10 feet thick and occurs 140 feet above the base of the member; the Flowers-Goodale coal, 90 feet higher, which averages about 9 feet in thickness; and the Knoblock coal, 80 to 100 feet still higher, which ranges between 5 and 20 feet. About halfway between the Flowers-Goodale and Knoblock beds is a coal called the Lay Creek bed that is of irregular occurrence but in some localities in this township is as much as 6 feet thick and contains good-quality coal. Several relatively thin coal beds including the Sawyer coal occur in the uppermost part of the exposed strata, but as they lie high in steep slopes in the rugged hills that occupy the southern part of the township, they are almost inaccessible and are considered of no practical value.

Inasmuch as the outcrops of the thick coal beds of the township are most easily approached by the roads and trails that traverse the creek valleys, the descriptions of the localities where the measurements of the beds were made will be grouped in three divisions with relation to the surface features, the easternmost part of the township, occupied by the valley of a fork of Foster Creek; the Lay Creek drainage basin; and the westernmost part of the township, which drains northwestward into Liscom Creek.

Coal in the easternmost part of the township.—There are several outcrops of three thick coal beds in the valley of a fork of Foster Creek that flows northward through the easternmost part of the township. The valley is wide with gentle slopes, so that the coal is readily accessible. An automobile road that leads southward toward Stacey post office (sec. 26, T. 1 S., R. 47 E.) and northward toward the Miles City highway traverses the valley. The outlet for the coal would be northward down the fork of Foster Creek to sec. 1, thence northwestward over a low divide into the Lay Creek Valley road, which joins the Miles City highway near the mouth of Lay Creek, in T. 2 N., R. 46 E. The Terret bed probably averages about 10 feet in thickness and, to judge from its appearance at numerous exposures in this general region, is composed of good-quality coal. In most localities it has a shale roof. The Flowers-Goodale bed is composed of excellent coal in most of this area, although it contains a few streaks of tough and bony coal at an exposure in sec. 24, and has a roof of massive white sandstone. It may be available for mining by stripping in a small area along the range line in the NE. ¼ sec. 25. The Knoblock bed probably averages 7 to 8 feet in thickness but contains a few thin streaks of earthy coal that probably raise the ash content of the coal to a fairly high figure, although not high enough to destroy its usefulness for the purposes for which this coal is ordinarily utilized. The coal in a considerable tract of land in the W. ½ sec. 25, NW. ¼ sec. 36, and E. ½ sec. 26 could be mined by stripping.

Coal outcrops in eastern part of T. 1 N., R. 46 E.

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
422	SE. ¼ sec. 12	Terret	9	10+	Accessible; near automobile road.
423	SE. ¼ sec. 13	Knoblock	9		Of little value. Weathered coal.
424	SE. ¼ sec. 24	Flowers-Goodale	8	1+	Readily available.
425	SE. ¼ sec. 25	Knoblock	7	3+	Readily accessible. Small tract can be stripped.
426	do	30 feet below Knoblock	3	11	Readily accessible, but thicker bed at same locality.
	SW. ¼ sec. 25	Knoblock	9	3	Accessible. 50 to 100 acres can be stripped.

Coal in the Lay Creek drainage basin.—The head tributaries of Lay Creek drain most of the north half of the township, except the extreme western and eastern parts, and extend far into the southeast quarter. There are numerous outcrops of thick coal beds in this area. The outlet for much of this coal if hauled over the existing trails and roads would be down Lay Creek to the Miles City road. Coal from the southeastern part of the township might better be taken around by the road that traverses the easternmost part of the township and joins the Lay Creek road in the adjacent township on the north.

Coal outcrops in Lay Creek drainage basin, T. 1 N., R. 46 E.

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
428	SE. ¼ sec. 10	Terret	4+		Readily accessible. Probably about 10 feet thick.
429	SW. ¼ sec. 10	Flowers-Goodale	4	1+	Accessible.
430	SW. ¼ sec. 11	Terret	8	7+	Close by an automobile road.
431	SW. ¼ sec. 15	Flowers-Goodale	3+		Badly weathered coal.
432	NE. ¼ sec. 21	Lay Creek	5	5	Accessible.
433	do	Knoblock	6	7	Accessible. Coal is tough; probably contains high ash content.
434	SW. ¼ sec. 15	do	6	6	Accessible. Coal somewhat dirty.
435	NW. ¼ sec. 22	do	4	6	Do.
436	SW. ¼ sec. 14	do	6		Bed in 2 benches. There may be more coal below that measured. Accessible.
437	SW. ¼ sec. 13	Flowers-Goodale	5		Somewhat difficult to approach. Lower bench 2 feet thick. Has been mined.
438	SW. ¼ sec. 24	do	6	1+	Accessible. Small area susceptible to strip mining.
439	SW. ¼ sec. 23	Lay Creek	3	3	Bed is irregular in thickness.
440	NE. ¼ sec. 27	do	4	5	Accessible. Small stripping area.
441	SW. ¼ sec. 26	Knoblock	6+		Do.
442	SE. ¼ sec. 27	do	2	6½	Difficultly accessible. Total thickness of bed probably not seen.
443	NW. ¼ sec. 10	Terret	5	2+	Readily accessible. Some coal has been mined here. Small area can be stripped.
444	SE. ¼ sec. 9	Flowers-Goodale	4	6+	Readily accessible.
445	NW. ¼ sec. 16	Knoblock			Exposed. Not measured.
446	NE. ¼ sec. 16	do	3	11+	Accessible.
447	SE. ¼ sec. 8	do	6	7+	Badly weathered coal in 2 benches. Accessible.
448	NW. ¼ sec. 9	do	2	4	Probably only upper bench exposed.
449	SW. ¼ sec. 4	Terret	10	11+	Readily accessible. Small area can be strip mined.
450	SE. ¼ sec. 5	Flowers-Goodale	4+		Weathered coal in sod.
451	NW. ¼ sec. 5	Terret	12	7+	Readily accessible. 40 acres or more can be strip mined.
452	NE. ¼ sec. 8	Flowers-Goodale	9	9+	Accessible.
453	do	Lay Creek	4	1	Difficultly accessible.
454	NW. ¼ sec. 8	Flowers-Goodale	7	6	Do.
455	do	Lay Creek	3	9	Accessible. May not be full thickness.
456	do	do	6	7	Accessible. Uncommonly thick for this bed.

The principal beds are the Terret, which averages about 11 feet in thickness and is persistent and regular; the Flowers-Goodale, which is about 10 feet thick, is persistent and regular, and has an excellent roof of sandstone; the Lay Creek

bed, which is in places a little more than 6 feet thick but is irregular in thickness and occurrence; and the Knoblock bed, which is 8 to 10 feet thick but contains a small percentage of earthy coal that diminishes its value.

Coal in the western part of the township.—Thick coal beds crop out in the northwestern and extreme western parts of this township, where the upland that occupies most of the township descends abruptly to the narrow gulches that are tributary to the Liscom Creek Valley of the adjacent township on the west. The Knoblock coal bed crops out in the greatest number of localities but other valuable coal beds are exposed. The Knoblock coal is readily accessible and is of workable thickness throughout. In parts of the area the bed consists of two thick benches of coal, but the lower bench is not very extensive. A few thin streaks of earthy coal are present in the bed at nearly all outcrops. Although these earthy layers are too thin to be discarded in mining, it is believed that their presence does not raise the ash content so high as to prohibit the use of the coal for domestic consumption and for steaming. The gently rolling surface that rises with a low grade back from the outcrop of this bed at many places, particularly in the E. ½ sec. 19 and the SE. ¼ sec. 18 makes it possible to mine the coal by stripping. The Lay Creek bed is extremely variable in thickness and at most outcrops is less than 5 feet thick, which is thinner than the Knoblock, Flowers-Goodale, and Terret beds. The Flowers-Goodale bed is probably 9 feet or more thick in this locality, is regular in thickness and quality, and contains hard black, shiny coal of apparently excellent quality, overlain by a bed of sandstone that should make a good roof for underground mining. The Terret bed crops out only in the extreme northwestern part of the area. It is probably more than 6 feet in thickness and is composed of excellent coal. A fair-sized area in the W. ½ sec. 6 and extending into secs. 1 and 36 of the adjacent township on the west contains this coal under a cover of less than 50 feet, with a gently rising surface up to 100 feet and more, offering possibilities for strip mining.

Coal outcrops in western part of T. 1 N., R. 46 E.

No.	Location	Coal bed	Approximate thickness	Remarks
			Ft. in.	
457	NE. ¼ sec. 7	Terret	6 5+	Accessible. Small area can be stripped.
458	NW. ¼ sec. 6	do		Not exposed. Shows area that can be strip mined.
459	NW. ¼ sec. 7	Flowers-Goodale	10 4+	Difficultly accessible.
460	W. ½ sec. 7	Lay Creek	9 8+	Do.
461	SW. ¼ sec. 7	Knoblock	19 11	Difficultly accessible. Coal in two benches.
462	NW. ¼ sec. 18	do	20 6	Accessible. Coal in two benches.
463	SW. ¼ sec. 18	Flowers-Goodale	5 3	Accessible.
464	NE. ¼ sec. 19	Knoblock	7+	Do.
465	do	do	8+	Accessible. Coal can be strip mined.
466	Center sec. 19	do	13 4	Accessible. Coal in two benches. Coal can be mined by stripping.
467	W. ½ sec. 19	do	7 11	Accessible. Coal has few dirty streaks.
468	NW. ¼ sec. 19	do	(a)	Accessible.
469	do	do	8+	Accessible. Coal contains few dirty streaks.
470	SE. ¼ sec. 19	do	7 10	Do.
471	SW. ¼ sec. 19	100 feet above Knoblock.	2 5	Accessible. Bed of relatively no value. Not mapped here.
472	NW. ¼ sec. 30	Knoblock	7	Somewhat inaccessible. Lower bench is carbonaceous shale.
473	W. ½ sec. 30	Flowers-Goodale	7 1+	Accessible. Excellent coal exposed in creek bank.
474	NW. ¼ sec. 30	Lay Creek	10	Of no value. Indicates that Lay Creek bed is irregular in thickness.
475	NE. ¼ sec. 31	Knoblock	7 4+	Readily accessible to Liscom Creek Valley road.
476	SW. ¼ sec. 32	Lay Creek	4 5	Accessible.

a Not measured.

T. 1 S., R. 46 E.

The southwestern two-thirds of T. 1 S., R. 46 E., is drained by Beaver Creek, an intermittent stream that flows in a broad valley with gently sloping sides bordered by steep slopes and clinker ledges. Liscom Creek and its tributaries drain the northeastern third of the township. The relief is pronounced. The divide between Liscom and Beaver Creeks stands as an intricately dissected narrow plateau remnant bordered by cliffs and precipitous slopes descending 300 to 400 feet to the Liscom Creek and Beaver Creek Valleys. The crest of the divide in the eastern part of the township stands 500 to 600 feet above the valley floors.

A stratigraphic section about 800 feet thick, occurring between 50 and 850 feet above the base of the Tongue River member, occupies the surface of this township. The highest beds are present on the Liscom-Beaver Creek divide in the easternmost part of the township. The section includes several thick coal beds (see pl. 28), of which the chief are the Terret, Knoblock, Sawyer, D, and E. Because of its occurrence as a thick bed of good-quality coal in readily accessible localities, the Knoblock bed is probably of greatest present value.

Coal outcrops in T. 1 S., R. 46 E.

Beaver Creek drainage basin

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
477	SW. ¼ sec. 7	Terret	7	8+	Readily accessible. Few acres can be strip mined.
478	SE. ¼ sec. 7	Knoblock	5	6+	Upper and lower parts of bed burned.
479	SE. ¼ sec. 6	do	8	6+	Accessible.
480	do	Flowers-Goodale	4	6+	Do.
481	W. ½ sec. 6	do	6	6	Accessible. A coal bed 2 feet 8 inches thick occurs 35 feet below.
482	Center of sec. 7	Knoblock	5+		Partly burned. Not full thickness.
483	S. ½ sec. 8	do	4+		Coal powder.
484	SE. ¼ sec. 8	do	9	7	Accessible.
490	SW. ¼ sec. 9	Sawyer	11	5	Situated high in precipitous slope.
491	SE. ¼ sec. 9	do	11	8	Situated high in steep slope.
492	NE. ¼ sec. 16	do	9	7	Do.
485	SE. ¼ sec. 16	Knoblock	11	1	Accessible.
486	NW. ¼ sec. 19	Flowers-Goodale	5+		Do.
487	E. ½ sec. 27	Knoblock	9	8	Coal mined. Large stripping area.
488	N. ½ sec. 35	Below Sawyer	4+		May represent the A bed.
489	S. ½ sec. 36	Sawyer	5	8+	
493	NE. ¼ sec. 26	D	18	4½	Inaccessible.
494	SE. ¼ sec. 23	D	14	11	Do.
495	SW. ¼ sec. 24	E	12	6½	Inaccessible. Two other benches.
496	N. ½ sec. 24	E	13	8½+	Inaccessible. Not full thickness.
497	do	E	18	2	Inaccessible. 2-inch parting.
498	S. ½ sec. 14	E	18		Inaccessible.

Liscom Creek drainage basin

499	SE. ¼ sec. 13	E	17	7	Inaccessible. 2-inch parting.
500	NW. ¼ sec. 13	Sawyer	3	9	Difficultly accessible.
501	NW. ¼ sec. 11	do			Thick bed of soot.
502	SW. ¼ sec. 3	do	9	9	Situated high in steep slope.
503	NW. ¼ sec. 4	Knoblock	7	8	Accessible.
504	NW. ¼ sec. 9	Sawyer	8	6	Situated high in steep slope.
505	SE. ¼ sec. 5	do	10	6	Do.
506	NE. ¼ sec. 8	D	10	2+	Inaccessible. Small unburned area.

Coal has been mined for many years from an open pit at location 487, in the E. ½ sec. 27. The coal lies under cover of less than 50 feet in a comparatively large area in the vicinity of the mine and of 100 feet or less in a larger area.

The rocks overlying the coal consist of shale and sandstone. An area of considerable extent contains this same coal bed at shallow depth on Liscom Creek in secs. 1 and 2, but the meager data available indicate that the coal bed there probably does not exceed 9 or 10 feet in thickness.

T. 2 S., R. 46 E.

The surface of T. 2 S., R. 46 E., is rugged. The two chief drainage channels are Beaver Creek in the northern part and East Fork of Otter Creek in the southern part. The divide between these two streams consists of a narow ridge with steep, rugged slopes, trending eastward a short distance south of the middle of the township. The maximum relief is a little less than 1,000 feet.

The rocks that occupy the surface comprise a section about 1,000 feet thick belonging to the Tongue River member, the lowest rocks being about 350 feet above the base of the member. Several thick coal beds crop out; the chief ones are the Sawyer, D, and E beds. (See pl. 29.) The A bed is in places 12 feet thick and the X bed is 6 to 8 feet thick, but both are present only in parts of the township. The Sawyer bed averages 9 to 10 feet in thickness, the D bed attains 20 feet, and the E bed consists of several benches of coal each 6 feet or more thick. The clinker of the F bed caps the ridge forming the divide between Beaver Creek and East Fork, but no unburned coal of this bed was seen.

Coal outcrops in T. 2 S., R. 46 E.

Beaver Creek drainage area

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
507	E. ½ sec. 1	D	8		Accessible.
508	W. ½ sec. 1	Sawyer	7	2+	Do.
509	SW. ¼ sec. 1	do	6	5+	Do.
510	NE. ¼ sec. 12	C	4	5+	Do.
511	do	C	4+		Accessible but contains abundant silicified wood.
511	do	D	7	11	Accessible.
512	E. ½ sec. 2	D	5	8	Small unburned tract.
513	SW. ¼ sec. 2	Below A	5+		Accessible.
514	SE. ¼ sec. 11	Sawyer	9	6	Accessible near highway. Small stripping area.
515	SW. ¼ sec. 11	do	2	2+	Accessible stripping area.
516	NW. ¼ sec. 14	X	5	7	Accessible.
517	NE. ¼ sec. 15	D	2	2	Accessible. Not full thickness.
518	SE. ¼ sec. 10	D	7		Accessible.
519	W. ½ sec. 9	Sawyer	7	4+	Do.
520	NW. ¼ sec. 9	D	8		Situated on steep slope. Small unburned area.
521	NE. ¼ sec. 4	Sawyer	6+		Accessible.
522	NW. ¼ sec. 4	A	1	8½+	Accessible, of little value.
523	S. ½ sec. 5	Sawyer	8+		Accessible.
524	NW. ¼ sec. 8	D	2	11+	Do.
525	E. ½ sec. 7	X	5+		Accessible. Base concealed.
526	NW. ¼ sec. 17	X	7	6	Accessible.
527	do	X	7		Do.
528	NE. ¼ sec. 18	E	6	6+	High in slope. Only part of one bench exposed.
529	SE. ¼ sec. 7	E	8	4+	Accessible.
530	NE. ¼ sec. 7	50 feet above E	4	3	Difficultly accessible.
531	N. ½ sec. 6	A	12		Small mine.
532	SW. ¼ sec. 6	Sawyer	23		Accessible.
533	Center of sec. 6	D	6+		C bed 20 feet below is 3 feet thick.
534	NW. ¼ sec. 18	E	14	8+	Accessible.
535	SW. ¼ sec. 18	50 feet above E	3	4½	Of little value. May be same as bed at location 530.
536	NW. ¼ sec. 18	do	3	1½	
537	do	do	3		

Coal outcrops in T. 2 S., R. 46 E.—Continued

East Fork drainage area

No.	Location	Coal bed	Approximate thickness	Remarks
			Ft. in.	
555	SW. ¼ sec. 19	Cook	4 5	Inaccessible.
556	SW. ¼ sec. 19	....do	3 4	Do.
538	NW. ¼ sec. 31	D	4	Accessible.
539	SW. ¼ sec. 30	E	5 1	High in bluff. Only 1 bench of bed.
540	SE. ¼ sec. 30	D	6	Accessible. Includes 11-inch parting.
541	SW. ¼ sec. 31	Sawyer	10 10+	Accessible.
542	SE. ¼ sec. 31	....do	14 9	Small mine.
543	NE. ¼ sec. 31	....do	16 4+	Accessible.
544	NW. ¼ sec. 32	D(?)	2 9+	Coal in two benches.
545	SW. ¼ sec. 29	D	5 11	Accessible.
546	NE. ¼ sec. 29	E	10 8+	Do.
547	SW. ¼ sec. 28	Between E and D	3 10	Accessible. May be bed X.
548	SE. ¼ sec. 32	Sawyer	9 7½	Accessible.
549	NE. ¼ sec. 33	D	5 5+	Do.
550	SE. ¼ sec. 28	E	9 9	Somewhat difficult to reach. Includes two partings of 1 foot each.
551	SW. ¼ sec. 27	X	5 3	
552	NW. ¼ sec. 35	X	4 3	
553	NW. ¼ sec. 35	X	4 5	
554	SW. ¼ sec. 35	E(?)	4 9+	High in slope.
554a	SW. ¼ sec. 35	Local	4 2	

T. 3 S., R. 46 E.

The surface of T. 3 S., R. 46 E., is drained largely by East Fork of Otter Creek and Home Creek, and the extreme southern part by Threemile Creek, all three tributaries of Otter Creek. The southern third and northeastern third of the township have a rugged surface; the remainder is rolling to moderately dissected. The valleys are wide, and the interstream ridges are comparatively narrow. The ridge south of Home Creek rises 600 feet above the valley bottom, but the highland in secs. 1 to 4 is not at so high an altitude except in sec. 1.

A series of rocks about 800 feet thick belonging to the Tongue River member of the Fort Union formation occupies the surface of the township, the lowest beds exposed occurring about 400 feet above the base of the member. This part of the section contains a number of thick coal beds in most of the Ashland field, but in this township the coal beds thin rapidly southward and in the southern part of the township are of relatively little value. The Knoblock bed may be an exception because records of wells in the general region indicate that this bed maintains its great thickness southward. It lies below the surface of the entire township. The Sawyer bed is present with workable thickness in the northwestern part of this township but thins rapidly southward until south of Home Creek it is of little value. The D bed is absent or of only local occurrence. The E bed forms a fairly prominent clinker, but the coal exposures seen at this horizon show relatively thin beds. Other beds are present locally. (See pl. 30.)

Coal outcrops in T. 3 S., R. 46 E.

No.	Location	Coal bed	Approximate thickness	Remarks
			Ft. in.	
557	NE. ¼ sec. 2	E	4 1	Somewhat inaccessible.
558	do	X	3+	Accessible.
559	NW. ¼ sec. 2	Local	2 4	Do.
560	SW. ¼ sec. 2	E	4 5	Inaccessible.
561	SE. ¼ sec. 3	E	4 5	Do.
562	NE. ¼ sec. 3	E	2 9	Do.
563	SW. ¼ sec. 3	E	3 10	Do.
564	SW. ¼ sec. 4	E	4	Do.
565	do	C	5 3	Contains silicified wood. Two benches. Of no value.
566	N. ½ sec. 5	Sawyer	8 11+	Accessible. Coal somewhat dull. Stripping area.
567	W. ½ sec. 5	do	7 6+	Do.
568	SW. ¼ sec. 5	do	5+	Do.
569	NE. ¼ sec. 6	do	8+	Accessible but small unburned tract.
570	N. ½ sec. 18	do	8+	Accessible.
571	NE. ¼ sec. 17	A	8 6	Accessible. Small pit mine.
572	SW. ¼ sec. 9	Sawyer	7 8	Accessible. Small mine.
573	SE. ¼ sec. 9	do	6	Accessible.
574	W. ½ sec. 15	Sawyer?	2 8½	May not be full thickness.
575	NW. ¼ sec. 10	E	3 5	Inaccessible.
576	NW. ¼ sec. 8	Sawyer	5 6+	Stripping area.
577	SW. ¼ sec. 1	E	2 3+	Of no value.
578	SE. ¼ sec. 1	E	2 10	Do.
579	SE. ¼ sec. 26	70 feet above E	3 9+	Two benches. Inaccessible.
580	SW. ¼ sec. 26	E	3 4	Do.
581	SW. ¼ sec. 23	E	4 5+	Do.
582	S. ½ sec. 28	E	3 11	Dirty coal. Inaccessible.
583	SE. ¼ sec. 29	E	6 10	Do.
584	NW. ¼ sec. 21	Sawyer	2 10	Accessible.
585	SE. ¼ sec. 19	do	3 2	Do.
586	do	do	5 1	Do.
587	SW. ¼ sec. 19	do	3 9	Do.
588	SW. ¼ sec. 30	do	3 2	Do.
589	do	do	3 1	Do.
590	SW. ¼ sec. 33	E	4 6	Two coal benches. Inaccessible.
591	NE. ¼ sec. 33	90 feet above E	15 6	Three coal benches. Inaccessible.
592	SW. ¼ sec. 34	E	8 6	Inaccessible.
593	SW. ¼ sec. 35	E	2+	Several thin benches. Inaccessible.

T. 2 N., R. 47 E.

T. 2 N., R. 47 E., is drained by Foster Creek and its east fork, which trend north to northwest across the township and contain water only parts of the year. Each of these streams has a wide valley with gentle slopes produced by erosion of the soft rocks of the Lebo shale. From the Lebo lowlands the surface rises abruptly to an intricately dissected rough country carved in the interbedded hard and soft rocks of the Tongue River member. Much of the rugged part of the area is composed of dissected, steep-sided ridges and flat-topped buttes capped by the Terret clinker. The maximum relief is a little less than 400 feet. The southeastern part of the township, however, has a relatively smooth to rolling upland surface floored by rocks that lie above the Terret coal bed in the Tongue River member.

Only parts of this township contain coal cropping out at the surface in beds thick enough to be of present commercial value. (See pl. 31.) The thickest coal bed seen is the Terret bed, which lies about 140 feet above the base of the Tongue River member. Measurements made at numerous localities show that this bed averages more than 6 feet in thickness and is present in the highlands in the southeast sixth of the township, in a narrow strip which occupies the interstream area between Foster Creek and its east fork, and in the extreme northeastern and southwestern parts of the township. Workable coal beds occur in the Tongue River member beneath the Terret coal, but these

lower coal beds are not thick enough to be attractive for exploitation until after the thicker beds of the region have been used. The thickest of these lower beds occurs between 30 and 40 feet below the Terret bed. Coal at this general horizon was mapped throughout much of the township as one bed, although it is probable that the coal reported does not actually represent a single bed but rather two or more beds that occur in the same stratigraphic zone. This coal zone is 38 feet below the Terret bed in secs. 18, 19, and 30, the interval becoming less toward the south. In sec. 33 a coal bed of similar thickness to that in sec. 18 occurs 30 feet below the Terret clinker and was mapped as the same bed as that 38 feet below the Terret bed in sec. 18. The coal reported as this bed on the east side of Foster Creek occurs between 35 and 40 feet beneath the Terret bed. In secs. 33 and 34 a coal bed between 1½ and 2 feet thick was seen about 40 feet above the base of the Tongue River member but was not mapped. It is possible that other coal beds in this lower part of the Tongue River member are present but were not seen in outcrop. No coal more than 18 inches thick was seen in the Lebo shale member. Workable coal beds may be present at shallow depths in the Lance formation, but no definite data as to the Lance coals were obtained.

Coal outcrops in T. 2 N., R. 47 E.

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
594	NE. ¼ sec. 1	Terret	4		Rugged region. Difficultly accessible.
595	Near center of sec. 1	35 feet below Terret	3		Do.
596	W. ½ sec. 13	do	2	5	Coal poor.
597	NW. ¼ sec. 10	Terret	2	5+	Coal partly burned. Situated at top of hill.
598	do	do	3	10	Crops out on steep slope.
599	do	35 feet below Terret	3	10	Do.
600	SW. ¼ sec. 10	do	3	6	Accessible.
601	do	Terret	5	2+	Difficultly accessible. A lower bench 3 feet 7 inches not included.
602	S. ½ sec. 15	do	5	10+	Difficultly accessible. A lower bench of 3 feet 8 inches not included.
603	NE. ¼ sec. 22	do	5	8	Accessible.
604	SW. ¼ sec. 24	do	7	2+	Readily accessible. Small area can be mined by stripping.
605	E. ½ sec. 23	do	7	8+	Readily accessible.
606	SE. ¼ sec. 26	do	5	6+	Do.
607	SE. ¼ sec. 25	35 feet below Terret	1	10	Accessible.
608	NE. ¼ sec. 36	Terret	6+		Do.
609	SW. ¼ sec. 22	35 feet below Terret	3	4	Weathered coal.
610	NW. ¼ sec. 26	do	3	5	Accessible.
611	NW. ¼ sec. 35	do	3	9½	Do.
612	do	do	3	7	Do.
613	do	do	3	7	Do.
614	NE. ¼ sec. 35	do			Exposed thickness not measured.
615	SE. ¼ sec. 34	do	3	11	Accessible.
616	SW. ¼ sec. 36	do	4	6	Do.
617	SE. ¼ sec. 35	Terret	5	9+	Accessible. Small area can be stripped.
618	SE. ¼ sec. 33	35 feet below Terret	5	5	Accessible.
619	do	Terret	9+		Do.
620	S. ½ sec. 33	do	6+		Do.
621	do	35 feet below Terret	4	5+	Do.
622	SW. ¼ sec. 32	Terret	6	4+	Do.
623	do	35 feet below Terret	3	8	Crops out in steep slope of small cone-shaped hill.
624	S. ½ sec. 30	do	2	4½	Accessible. Thins southward. In the S. ½ sec. 33 is 1 foot 6 inches thick.
625	N. ½ sec. 29	do	5	5	Accessible.
626	S. ½ sec. 19	do	3	9	Do.
627	Center sec. 19	Terret	5	4	Small hill underlain by this bed. Coal weathered. Bed probably somewhat thicker than shown.
628	SE. ¼ sec. 18	35 feet below Terret	3	7	Crops out in a steep slope.

T. 1 N., R. 47 E.

The surface throughout much of T. 1 N., R. 47 E., is rugged, although tracts several square miles in extent have a relatively smooth surface. The southwest quarter of the township contains much smooth land. Its surface consists of a gently rolling sod-covered upland floored by rocks above the Knoblock coal bed. The extreme southeastern part and the valley of Foster Creek are other areas that have a relatively smooth surface. The clinkers of the burned Terret, Flowers-Goodale, and Knoblock coal beds have exerted the greatest influence on the surface features. The clinker bed of the Flowers-Goodale coal is particularly prominent and makes up much of the rugged land of the township. Foster Creek and its tributaries drain nearly the entire township, but the extreme southeastern part drains eastward into Pumpkin Creek, which lies about 6 miles east.

The valuable coal beds are the Terret, which averages about 10 feet in thickness and occurs 140 feet above the base of the Tongue River member; the Flowers-Goodale, which averages about 9 feet and occurs 80 feet higher; and the Knoblock, which is between 6 and 13 feet thick and occurs 90 feet above the Flowers-Goodale bed. (See pl. 32.) A fairly persistent coal that is of workable thickness in parts of the township occurs 30 to 35 feet below the Terret bed. The Lay Creek bed, occurring midway between the Flowers-Goodale and Knoblock beds, is present irregularly but is of little or no value. To judge by appearance at the outcrops the Flowers-Goodale bed probably contains the best coal in the township. This bed is composed of hard black, shiny coal containing no partings. It maintains its thickness and is persistent throughout an extensive area and has a good roof of sandstone. The coal of the Terret bed is also of good quality but in most outcrops appears to have been weathered to a greater extent than the coal in the Flowers-Goodale bed. The quality of the coal of the Knoblock bed is not so high as that of the other two. This bed contains several thin streaks of dirty coal, which doubtless lend a high percentage of ash to the coal bed as a whole.

There are several localities in this township containing thick coal less than 50 feet beneath the surface, affording opportunity for mining by stripping. The Terret bed is favorably suited for strip mining in the easternmost part of the northeast quarter of the township and extending eastward into the western part of the adjacent township. The overburden is composed largely of clay shale. The Flowers-Goodale bed can be mined by stripping in parts of secs. 7, 8, 17, 18, 19, 20, 25, 30, and 36. The overburden here is relatively soft sandstone and soft shale, mostly sandstone. The Knoblock bed can be stripped in sec. 35, where the overburden is sandstone and sandy shale, probably mostly sandstone.

Coal outcrops in T. 1 N., R. 47 E.

North half of township

No.	Location	Coal bed	Approximate thickness	Remarks
			Ft. in.	
629	NE. ¼ sec. 1	Terret	6+	Excellent coal. Accessible. Stripping area.
630	do	35 feet below Terret	2 10	Accessible.
631	do	do	3 1+	Do.
632	SE. ¼ sec. 1	Terret	5 6+	Accessible. Large stripping area.
633	East quarter corner sec. 12.	do	9	Reported at depth of 20 feet in dug well.
634	NE. ¼ sec. 14	do	7+	Accessible.
635	SE. ¼ sec. 15	do	6 6+	Do.
636	NE. ¼ sec. 15	35 feet below Terret	3 6+	

Coal outcrops in T. 1 N., R. 47 E.—Continued

North half of township—Continued

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
637	NE. ¼ sec. 15	35 feet below Terret			Coal dust on prairie-dog mounds.
638	SW. ¼ sec. 10	Terret			Coal blossom. Not measured.
639	S. ½ sec. 10	do	6	8+	Accessible.
640	SE. ¼ sec. 3	35 feet below Terret	3	5	Do.
641	NE. ¼ sec. 4	do	4	11	Do.
642	do	do	5	2	Do.
643	do	Terret	8	6+	Do.
644	do	35 feet below Terret	3	1	Do.
645	NE. ¼ sec. 5	do	4	8	Do.
646	SW. ¼ sec. 4	do	4	5	Do.
647	SE. ¼ sec. 5	Terret	8	9	Weathered coal. Somewhat difficult to approach.
648	NE. ¼ sec. 9	do	7+		Accessible.
649	do	35 feet below Terret	3	6	Do.
650	SW. ¼ sec. 9	Terret	8+		Do.
651	NW. ¼ sec. 17	Flowers-Goodale	5	6+	Accessible. Stripping area.
652	do	do			Outcrop not measured.
653	NE. ¼ sec. 17	Lay Creek	1	8	Bed of no value.
654	Center sec. 17	Knoblock			Not measured.
655	NW. ¼ sec. 17	Flowers-Goodale			Not measured. Stripping area.
656	NE. ¼ sec. 18	do	6	6+	Accessible. Stripping area.
657	do	do	8	2+	Do.
658	SE. ¼ sec. 18	Knoblock	8	8	Accessible. Coal in two benches.
659	SW. ¼ sec. 17	Lay Creek	2	2	Accessible. Bed badly split by partings.
660	N. ½ sec. 18	Knoblock	8	2	Coal in two benches. Weathered.
661	SE. ¼ sec. 7	do	7	6+	Do.
662	SE. ¼ sec. 7	Lay Creek	3	2	Accessible.
663	S. ½ sec. 5	Flowers-Goodale	7	8+	Do.
664	do	Terret	11	3	Do.
665	NE. ¼ sec. 7	do	7	6+	Accessible. Small area can be stripped.
666	do	do	7+		Do.
667	SE. ¼ sec. 6	do	13	3	Do.
668	do	do	10+		Do.
669	SW. ¼ sec. 5	do	6+		Do.
670	NW. ¼ sec. 5	do	5+		Do.
671	do	35 feet below Terret	3	7	Do.

South half of township

672	SW. ¼ sec. 24	Flowers-Goodale	8	5+	Accessible.
673	Center sec. 24	Knoblock	7	1+	Difficultly accessible. Coal somewhat dirty.
674	NE. ¼ sec. 26	do	12	1	Accessible but only a small tract of unburned coal.
675	NW. ¼ sec. 35	do	12	4	Accessible. Stripping area.
676	South line sec. 35	do	11	8	Accessible from south.
677	SE. ¼ sec. 33	do	4	6	Accessible.
678	do	do	8	10	Do.
679	E. ½ sec. 32	do	3+		Accessible. Bed probably much thicker.
680	N. ½ sec. 32	do	6	1+	Accessible. Coal somewhat weathered. Probably contains a few dirty streaks although not seen here.
681	SE. ¼ sec. 30	do	8	8	Accessible. Coal contains a few dirty streaks.
682	do	do	8	4+	Do.
683	NE. ¼ sec. 30	do	9	6	Do.
684	do	do	6	6+	Do.
685	SW. ¼ sec. 19	Flowers-Goodale	3	3½+	Accessible. Stripping area.
686	NW. ¼ sec. 29	Knoblock	8	8	Accessible.
687	do	do	9	1	Do.
688	do	14 feet above Knoblock.	2	2	Do.
689	do	do	2	2	Do.
690	do	Lay Creek	1	11½	Accessible. Bed of no value.
691	SW. ¼ sec. 20	Knoblock	7	5+	Accessible. Coal contains a few dirty streaks.
692	NE. ¼ sec. 29	do	5+		Do.
693	do	do	9	3½	Do.
694	NW. ¼ sec. 28	do	8	5	Do.
695	do	do	5	6+	Do.
696	NE. ¼ sec. 20	Flowers-Goodale	3+		Accessible. Excellent quality. Stripping area.
697	do	do	8	10+	Do.
698	N. ½ sec. 20	Knoblock			Coal dust in grass. Thickness not measured.

T. 1 S., R. 47 E.

The surface of T. 1 S., R. 47 E., except the westernmost tier of sections, drains eastward into Little Pumpkin Creek. The westernmost part lies at the heads of tributaries of Beaver and Liscom Creeks, which flow northwestward into the Tongue River. The relief in the northeastern third of the township is moderate, and the surface is for the most part a rolling prairie. Except for the wide valley of Little Pumpkin Creek the remainder of the area is rugged, the maximum relief being about 1,250 feet. Liscom Peak, an erosion remnant capped by the Garfield clinker, the stratigraphically and topographically highest clinker in the Ashland coal field, stands in sec. 18. There are five clinker beds that exert a widespread influence on the surface features in this township. The surface consists of a series of benches or great steps floored with the resistant baked rock that forms the thick clinker zones. The edges of the broad steps are intricately dissected, and immediately below each clinker rim or ledge is a steep slope, which is followed by a more gentle slope toward the next lower bench.

Several thick coal beds crop out in this township, and other coal beds that occur below the beds exposed probably underlie it. (See pl. 33.) The chief outcropping coals are the Knoblock, A, Sawyer, C, and E beds. The F clinker bed is of great thickness but occurs only in small tracts capping the high rugged ridges in the westernmost part of the township. No appreciable amount of unburned coal remains in this bed. A small remnant of the Garfield clinker bed caps Liscom Peak. The Knoblock bed is probably 10 to 15 feet thick. The A coal is 12 to 15 feet thick in the southeasternmost part of the township, about 6 feet thick in the central part, and thins rapidly northward. The Sawyer bed is 5 to 7 feet thick in the southern part of the township and as far northward as secs. 8 and 9 but thins to 3 feet in the NW. ¼ sec. 5. The C bed forms a pronounced clinker, but the coal contains much siliceous wood, which renders it unminable except by very small wagon operations. The E bed is between 12 and 20 feet thick. It lies rather high in the slopes, and roads would have to be built to gain access to most of its outcrops. Several beds of local extent occur between the C and E beds, one of which supplies coal to ranchers from a small pit at location 721, in the SE. ¼ sec. 29.

In a few tracts coal occurs in a thick bed at shallow depth beneath the surface and should be available for strip mining. The Knoblock bed is estimated to be 12 feet or more thick and to lie less than 50 feet beneath the surface in a tract of about 500 acres in secs. 2, 11, and 12 and in a somewhat smaller tract in secs. 13 and 14. It is probable that this coal bed is at shallow depth beneath the bottom lands of Little Pumpkin Creek in secs. 26 and 35, embracing a strip of land averaging between a quarter and half a mile wide and nearly 2 miles long.

Coal outcrops in T. 1 S., R. 47 E.

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
699	NW. ¼ sec. 5	Sawyer	2	9	Bed of little value.
700	SE. ¼ sec. 6	E	16	10	Only a small tract of coal land.
701	NW. ¼ sec. 8	E	12	7	Includes two partings.
702	E. ½ sec. 8	Sawyer	4		
703	SE. ¼ sec. 8	D	3	1	
704	NW. ¼ sec. 17	Above D	3	2	Not easily accessible.
705	do	E	10+		
706	NW. ¼ sec. 16	Sawyer	6+		Accessible.
707	E. ½ sec. 15	A	5	2	Do.
708	NW. ¼ sec. 13	Knoblock	6	2+	Accessible stripping area.

Coal outcrops in T. 1 S., R. 47 E.—Continued

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
709	NE. ¼ sec. 22	A	6	4+	Accessible.
710	NW. ¼ sec. 21	Sawyer	6	7+	Do.
711	SW. ¼ sec. 21	E	9	2+	Rather inaccessible.
712	NW. ¼ sec. 20	E	15	7+	Includes one parting.
713	SW. ¼ sec. 18	E	19	7	Rather inaccessible.
714	W. ½ sec. 18	E	12+		Do.
715	NE. ¼ sec. 27	Sawyer	5	9	Accessible.
716	SW. ¼ sec. 28	C or D(?)	4	2	
717	SW. ¼ sec. 34	E	11	6+	Do.
718	E. ½ sec. 33	E	12	6+	Do.
719	SE. ¼ sec. 32	Below E	2	7+	
720	NE. ¼ sec. 32	Local bed	4	10	Of little value here.
721	SE. ¼ sec. 29	do	4	1+	Mined. Reported to be 7½ feet thick.
722	NW. ¼ sec. 30	E	18	8	Lower bench 14 feet thick. High in hills. Road would have to be built to make mining possible.
723	SE. ¼ sec. 25	A	13	7	Rather difficult to reach.
724	do	Sawyer	5		May not be full thickness.
725	SW. ¼ sec. 36	do	7	2½	Accessible.

T. 2 S., R. 47 E.

Little Pumpkin Creek and its west fork drain most of the surface of T. 2 S., R. 47 E. The northwesternmost part drains westward into Beaver Creek, and the southwesternmost part drains westward into the East Fork of Otter Creek. There are four prominent clinkers exposed, and these form a series of steps in a fairly rugged surface. The highest, the F clinker, is 4,000 to 4,100 feet above sea level and caps an intricately dissected plateau forming the divide between Little Pumpkin and Beaver Creeks and the East Fork of Otter Creek. The F clinker bed, which is in places 100 feet thick but is commonly only 30 to 40 feet, crops out as a vertical-walled ledge capping steep slopes. Below this in steplike succession are the ledges of the other clinker beds, with more gentle slopes between them. The maximum relief in the township is about 1,000 feet, and the relief in the vicinity of the outcrop of the F clinker is greater than 300 feet in half a mile. The Whitetail ranger station is in sec. 17, and the Bidwell sawmill, which supplies lumber to this region, is in sec. 20.

The southern part of the township marks a general east-west zone south of which the main coal beds in the Tongue River member of the Fort Union formation appear to thin rapidly and some beds actually disappear. Numerous thick coal beds are present under parts of this township, however. (See pl. 34.) The lowest thick coal that crops out is the A bed, which is 15 feet thick where it is exposed a short distance northeast of the northeast corner of this township. The Sawyer bed averages more than 8 feet in thickness where exposed. The C bed contains an abundance of silicified wood fragments and stumps, which render it practically worthless commercially. It forms a prominent clinker bed in the Green Creek Valley, in the northern part of the township. A bed that is believed to represent the D bed is more than 7 feet thick on Green Creek but fails to maintain an appreciable thickness southward. A prominent clinker produced by the burning of the X bed crops out in the western slope of Elk Ridge, in the northeastern part of this township. Coal was seen at this horizon at only a few localities. The E group appears to consist of one bed averaging about 11 to 12 feet in thickness and several closely associated thin beds. Its clinker forms a prominent ledge in the Elk Ridge slope. The F clinker caps the rugged high land in the western and southern

parts of the township. No coal was seen at this horizon, although it is believed that thick coal is present where there is appreciable cover over the bed and the coal is unburned. For convenience of description the township has been divided into several parts corresponding to the natural divisions made by the stream valleys.

Coal in the northeastern part of the township, east of Pumpkin Creek.—The A and Sawyer coal beds underlie the northeastern part of this township, probably as thick beds. (See locations 723, 724, and 725, in the southeastern part of T. 1 S., R. 47 E.) The C bed is present but is of practically no value, as it contains abundant silicified stumps in the coal. The X coal has burned along the outcrop, and so has the coal of the E group. One bed of the E group is exposed at location 726, in the NE. ¼ sec. 1, where it is 2 feet 1 inch thick. Near by, at location 727, a similar thickness was measured. These measurements are believed not to represent the main E bed, because elsewhere near by the main bed is about 12 feet thick. At location 728, in the SE. ¼ sec. 1, the C bed contains 2 feet 5½ inches of coal that is "shot through" with streaks of bone and silicified wood. The X bed is 4 feet 9 inches thick at location 729, in the NE. ¼ sec. 12, and near by at location 730 the main bench of the E bed is 10 feet 10 inches thick. The coal at location 730 is much weathered, and the bed is present only in a small knob capping a relatively narrow ridge.

Coal in the Green Creek area.—A thick stratigraphic section is present on Green Creek in the northern part of the township, and burned rocks marking the position of six coal beds form ledges in the slopes, although only a very few outcrops of coal were seen. The clinker bed of the C coal is particularly prominent. The A bed does not crop out, but burned rocks at its position are exposed on the south side of the creek on the line between secs. 2 and 3. The Sawyer bed was prospected at location 731, in the NE. ¼ sec. 3, where 5 feet 10 inches of coal was uncovered. A coal bed 5 feet 9 inches thick is locally present in the NW. ¼ sec. 2 about 30 feet above the Sawyer bed. It was prospected at location 732. The C bed is 3 feet 4 inches thick at location 733, and the X bed is 2 feet 9 inches thick at location 734, in the NW. ¼ sec. 10. The main bed of the E group is more than 7 feet thick at location 735, in the SW. ¼ sec. 3. The C bed is but 2 feet thick at location 736, in the NW. ¼ sec. 9. At an old prospect at location 737, in the SE. ¼ sec. 5, a coal exposure that appears to be the D bed shows 3 feet of coal. The total thickness of the bed was not determined because the coal face was partly concealed by débris, but the bed is reported by Wegemann[27] to be more than 7 feet thick. Coal was being mined here in 1908 at the time of Wegemann's examination. Coal has been mined from a bed that probably represents the D bed on the north side of the main stream in the SE. ¼ sec. 5, but the locality was not visited.

Coal on the West Fork of Little Pumpkin Creek.—Very little coal was seen in the valley of the West Fork of Little Pumpkin Creek. Some coal has been mined for local ranch use from the C bed near the southwest corner of sec. 11. The coal is reported to contain much "rock" here and to be of little value. It was not measured at this locality but elsewhere near by was seen to contain much silicified wood and to be of practically no value. Coal of the E group was seen at location 738 in the S. ½ sec. 14. The bed is 7 feet thick and is overlain by 5 feet of carbonaceous shale. The E group goes under the creek bed near the Whitetail ranger station, in the N. ½ sec. 17. Several benches

[27] Wegemann, C. H., Notes on the coals of the Custer National Forest, Mont.: U. S. Geol. Survey Bull. 381, p. 113, 1910.

of coal are reported to crop out here, the thickest one about 7 feet thick, and some coal has been mined from the creek bank.

Coal was reported to crop out about half a mile southeast of the Scott ranch house, but this locality was not examined in detail. A bed about 3 feet thick shows at location 739 in the road cut in the NE. ¼ sec. 19, north of the Bidwell sawmill. This bed is estimated to be 75 to 100 feet below the F clinker and is of little value.

Coal in the Little Pumpkin Creek area.—A bed of good-quality coal more than 6 feet thick was seen at location 739 A, in the NE. ¼ sec. 23, where a small tonnage of coal had been mined several years ago. This bed could not be definitely correlated with any of the beds seen elsewhere in the district. It occurs about 55 feet below the E group. Coal that is believed to belong to the E group was prospected in the SW. ¼ sec. 26 at location 740, where 6 feet 3 inches of coal was uncovered without finding the base of the bed. Coal between the D and E beds crops out in the road bed near the center of the S. ½ sec. 25 but was not prospected to determine its thickness.

Coal in the southwestern part of the township.—The prominent clinker of the F coal is 50 to 100 feet thick throughout much of the southwestern part of the township. Unburned coal in the F bed probably underlies parts of secs. 28, 29, 30, 31, 32, and 33, but no outcrops of the F coal were seen. A coal estimated as being 150 feet above the F bed was seen at location 741, in the NW. ¼ sec. 32. Some coal has been mined at this locality, and the bed is reported to be 4 feet thick, but only 2 feet of the upper part of the bed was exposed at the time of the examination. Several benches of the E group were prospected at location 840, in the SW. ¼ sec. 18, near the head of one of the tributary gulches of Beaver Creek. Good-quality coal in thick beds is present here, but the locality is not as accessible as other localities on Beaver Creek that contain coal in thick beds.

T. 3 S., R. 47 E.

The surface of T. 3 S., R. 47 E., ranges in altitude between about 3,550 and 4,360 feet above sea level. It consists for the most part of rugged ridges capped by the F clinker, forming the divides between tributaries of Otter Creek on the west and tributaries of Pumpkin Creek on the east. A few knobs capped by the Garfield clinker, which is 200 feet above the F clinker, stand on the main divide. The slopes descending eastward in the eastern part of the township are more abrupt than those descending westward in the western part, probably owing to a decrease eastward in the percentage of sandstone beds in the stratigraphic section, thus exposing less resistant beds on the east than on the west.

The uppermost 800 feet of the Tongue River beds of this field crop out in this township. Although it is believed that thick coal beds in the Tongue River member underlie the surface of the entire township at relatively shallow depths, very few outcrops of workable coal beds were seen. Much of the surface is occupied by the F clinker and the rocks that occur in the 300 feet next below it. Home Creek Butte, in sec. 4, and a few knobs in the central part of the township are capped by the Garfield clinker. Although no definite information as to the thickness of the F coal bed was obtained, the thick clinker that persists at this horizon probably indicates that a considerable thickness of coal is present in the several tracts wherein the F beds probably contain unburned coal. The interval of 400 to 450 feet next below the F bed appears to contain very little coal in thick beds. The coal of the E group, which occurs in this

interval, has thinned greatly from its large thickness in the region to the north and northwest. Few measured coal sections were obtained. (See pl. 35.) At location 742, in the W. ½ sec. 12, a coal bed that occurs about 100 feet below the base of the F clinker is 2 feet 7 inches thick. At location 743, in the NW. ¼ sec. 14, a thin coal about 50 feet above the F horizon is present locally. The outcrop of a thin coal that may be one of the beds of the E group was mapped for a short distance through secs. 12 and 13. This bed is much thinner than it is a few miles farther north and is believed to be of practically no value here. A coal that occurs 60 feet below this bed is mined by local ranchers at location 744, a short distance south of the east quarter corner of sec. 13. The bed is 4 feet 4 inches thick, but the lowermost 6 inches contains bony coal. At location 745, in the NE. ¼ sec. 23, a coal bed 3 feet thick is exposed, and a short distance south of it and below this bed is 1½ feet of coal at location 746. These two beds are estimated to be about 200 and 230 feet below the F clinker. A coal 2 feet 3 inches thick is present locally in the NE. ¼ sec. 25, at location 747, and another bed of the same thickness but believed to be somewhat lower stratigraphically was seen at location 748, in the SE. ¼ sec. 25. These two beds appear to occur in the interval between the C and E beds of the townships to the north. The coal is of practically no value.

Several coal beds are locally present below the F clinker in the southwestern part of the township. The bed 100 feet below F is 2 feet 3 inches thick at location 749, in the SE. ¼ sec. 33. A bed 200 feet below F at location 750, in the SW. ¼ sec. 31, contains 5 feet 5 inches of coal, but the locality is difficult to reach. At location 751, in the NW. ¼ sec. 30, a bed 300 feet below F, which is about the stratigraphic horizon of the E bed of adjacent townships, is 3 feet 4 inches thick. Coal 3 feet thick is exposed at location 752, in the NW. ¼ sec. 29, in a bed that is 380 feet below F. This bed was mapped through the NE. ¼ sec. 19. At location 753, near the north quarter corner of sec. 29, 2 feet 10 inches of coal is exposed in a bed that is 330 feet below the F clinker. The coal bed 100 feet below the F clinker is 2½ feet thick at location 754, in the SE. ¼ sec. 18. One bench of the F bed or group is 4 feet 5 inches thick at location 755, in the SE. ¼ sec. 17. The outcrop occurs near the top of a steep slope that rises 300 feet above the valley.

T. 2 N., R. 48 E.

The surface of T. 2 N., R. 48 E., is characterized by relatively broad valleys separated by steep-sided rugged ridges in the eastern half and westernmost sixth. Much of the remaining area is a rolling grassy upland. The ridges are capped by clinker beds produced chiefly by the burning of the Flowers-Goodale and Terret coal beds. The eastern two-thirds of the area drains eastward by tributaries of Pumpkin Creek, and the western third drains westward by tributaries of Foster Creek. The divide between these two drainage systems trends a little west of north through the middle of the south half of the township and a short distance west of the middle of the north half.

The Lebo shale member crops out in the lower portions of the valleys in the easternmost part of the township, and the lowermost 300 feet of the Tongue River member of the Fort Union formation occupies the remainder of the surface.

The valuable coal beds present (see pl. 36) are in the Tongue River member. The two chief beds are the Terret bed, which here occurs 70 feet above the base of the member and averages about 8 feet in thickness, and the Flowers-Goodale bed, which is 75 feet higher in the section and averages about 7 feet thick. Coal occurs locally about midway between the Terret and Flowers-Goodale beds. It is exposed in a few localities in sec. 6 but is of no great

value. The Knoblock coal is present 72 feet above the Flowers-Goodale bed but is unburned in only a small tract near the crest of the main divide in the central part of the township. The clinker formed by the burning of this bed is the highest clinker capping the ridges in sec. 21. A coal of little value occurs at the base of the member in parts of the township. It crops out in several localities in Cottonwood Valley, in secs. 24 and 25.

The Knoblock coal bed is under less than 50 feet of cover in a relatively small tract in sec. 16, where it could be mined by stripping. Its location on the crest of the divide, where the coal has probably been subjected to alternate wetting and drying for a long time, makes it seem probable that the coal has deteriorated. The Flowers-Goodale bed is less than 50 feet beneath the surface in parts of secs. 9, 4, and 5 and could possibly be mined by stripping there.

Coal outcrops in T. 2 N., R. 48 E.

West half of township

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
756	SE. ¼ sec. 5	Flowers-Goodale	5	11+	Accessible. Stripping area.
757	North of northeast corner sec. 6.	Terret	7	9+	Excellent coal. Small wagon mine supplies several ranchers. Bed reported to be 12 feet thick.
758	NE. ¼ sec. 6	Local bed	4	6	Accessible.
759	E. ½ sec. 6	Flowers-Goodale	5	9+	
760	SE. ¼ sec. 6	Local bed	3	6	Lenticular bed.
761	do	Terret	7	9	Good quality. Accessible. A coal bed 2 feet thick, including a bone parting 2 inches thick. Occurs here 30 feet below Terret bed.
762	NE. ¼ sec. 7	do	8	3	Good quality. Accessible.
763	E. ½ sec. 7	Local bed	2	6	Bed not mapped here.
764	SE. ¼ sec. 7	Terret	7	8	
765	NW. ¼ sec. 17	do	7	7	Accessible.
766	do	do	8		1 foot, slightly bony.
767	NW. ¼ sec. 21	Knoblock	5	1	Coal partly oxidized. True thickness may be greater.
768	do	Flowers-Goodale	7		Accessible.
769	SE. ¼ sec. 20	do	6	9	Do.
770	Center sec. 20	Terret	6	2+	Accessible. Mined.
771	NE. ¼ sec. 19	do	9	1	Accessible.

East half of township

772	SE. ¼ sec. 13	Contact		11	Coal of no value.
773	NW. ¼ sec. 14	Terret	5	2+	Readily accessible. A few wagon loads of coal have been mined here.
774	NW. ¼ sec. 22	do	6	1½	Accessible. Coal badly weathered.
775	NE. ¼ sec. 26	do	4	11	Coal slightly dirty.
776	SW. ¼ sec. 24	Contact	5	5	Dirty coal, of no value.
777	NW. ¼ sec. 24	do	4	6	Coal of little value.
778	N. ½ sec. 25	do	5	2	Do.
779	E. ½ sec. 24	do	5	8	Do.
780	SE. ¼ sec. 26	do	5	5	Do.
781	NE. ¼ sec. 35	do	5		Do.
782	SE. ¼ sec. 27	Terret	6	3	Accessible.
783	S. ½ sec. 27	Flowers-Goodale	4	7+	Very small tract of coal. Burned elsewhere near by.
784	SE. ¼ sec. 21	Knoblock	7	6	Do.
785	NE. ¼ sec. 34	Terret	6	4	Accessible.
786	Center sec. 34	Flowers-Goodale	7	8	Do.

T. 1 N., R. 48 E.

The surface of T. 1 N., R. 48 E., consists of the wide, nearly level valley floor of Pumpkin Creek in the easternmost part, flanked on the west by wide, gently sloping tributary valleys and rugged intervalley ridges. The ridges are capped by the resistant clinkers produced by the burning of the Flowers-Goodale and Knoblock coal beds. The clinker beds crop out as serrated ledges above precipitous slopes that descend 100 feet, more or less, to the gentle slopes

that occupy the lower parts of the valleys. The maximum relief in the township is a little less than 500 feet.

Rocks of the Fort Union formation occupy most of the area. The uppermost 100 feet of the Lebo shale or lower member occurs in the lower part of the Pumpkin Creek Valley. Its uppermost part is exposed in secs. 1 and 12, where it consists essentially of banded gray, somber-colored, and black badland clay shale. A lenticular bed of white sandstone, in the Lebo shale member, crops out in a few localities in sec. 1. There are a few thin beds of coal in the Lebo shale, but none more than 2 feet thick were seen. The lowermost 380 feet of the Tongue River member is present. Alluvium of Recent age occupies a strip about half a mile wide along Pumpkin Creek and much narrower tracts along tributary streams. Rather extensive deposits of gravel laid down by Pumpkin Creek when it was flowing at higher levels than at present, border the bottom lands on the west and form distinct terraces, which are particularly well developed in sec. 34.

The valuable coal beds (see pl. 37) are all in the Tongue River member. The lowermost coal bed mapped is the basal bed of the member and lies directly upon the Lebo shale. It is a little less than 3 feet thick in secs. 1 and 12. The Terret coal, which is 140 to 150 feet above the base of the member in the region a few miles to the west, is only 70 feet above the base in this township. The Flowers-Goodale bed is 150 feet above the base of the member, and the Knoblock bed ranges between 60 and 80 feet above the Flowers-Goodale. The Terret and Flowers-Goodale beds contain most of the valuable coal of this township. Coals in the Lance formation probably underlie the area at shallow depth, but no information concerning the thickness of these beds was obtained. The Terret bed is more than 7 feet thick throughout most of the township, and the Flowers-Goodale bed is probably also of greater thickness than 7 feet, though no complete exposures of this bed were seen. The Knoblock bed has burned except in a few very small tracts. Two comparatively large tracts in the central and southern parts of the township are underlain, at depths less than 50 feet, by the Terret coal and offer attractive localities for mining by stripping. These tracts are shown on the map (pl. 3) by ruled lines. The overburden is composed of relatively soft beds of shale and sandstone.

Coal outcrops in T. 1 N., R. 48 E.

No.	Location	Coal bed	Approximate thickness		Remarks
			Ft.	*in.*	
787	NE. ¼ sec. 1	Contact	2	8	Not of much value.
788	SE. ¼ sec. 1	do	2	3½	Do.
789	W. ½ sec. 1	do			Exposed in dog holes. Not measured.
790	SE. ¼ sec. 2	Terret	5	1	Accessible.
791	do	do	6	6	Coal is tough and brown.
792	NW. ¼ sec. 12	do	4	6	
793	NE. ¼ sec. 11	do			Coal in dog holes. Not measured.
794	NW. ¼ sec. 14	do	7	4	Accessible.
795	SE. ¼ sec. 10	do	6	9	Good-quality coal. Readily accessible.
796	do	do	6	2+	Do.
797	NE. ¼ sec. 8	Flowers-Goodale	7	4+	Good-quality coal. Readily accessible. Coal in a few acres could be strip mined.
798	NE. ¼ sec. 5	Knoblock	5	1	Accessible. Coal weathered.
799	NE. ¼ sec. 7	do	5	3	Do.
800	Center sec. 18	Flowers-Goodale	6	3+	Small tract of unburned coal in field of clinker.
801	NE. ¼ sec. 19	do	6	1+	Accessible.
802	Center sec. 19	Knoblock	10	2	Weathered coal. Accessible.
803, 804	SE. ¼ sec. 16	Terret			Exposed in dog holes. Not measured.
805	SW. ¼ sec. 15	do	8	9	Stripping area.
806	NW. ¼ sec. 27	do	7	5	Good quality. Accessible.
807	NW. ¼ sec. 33	do	4	5	Stripping area.
808	NE. ¼ sec. 36		3	2	Bed not correlated with any other in the field.

T. 1 S., R. 48 E.

Except in the southernmost and northwesternmost parts the relief in T. 1. S., R. 48 E., is moderate. Little Pumpkin Creek, which flows northeastward across the north half of the township, has a wide valley flanked on the southeast by gently rising slopes to an area of broad, terraced surfaces and undulating slopes that occupies much of the central and eastern parts of the township and forms the interstream area between Little Pumpkin Creek and Pumpkin Creek, which lies half a mile to a mile east of the eastern boundary. The northwesternmost and southernmost parts of the township are rugged, the surface consisting of intricately dissected mesas and broad benches floored by resistant clinkers produced by the burning of thick coal beds, chiefly the Sawyer and Knoblock beds.

Rocks that occur between about 50 and 700 feet above the base of the Fort Union formation occupy the surface of the township. Relatively broad bottom lands along Little Pumpkin Creek are composed of alluvium of Recent age, and rather extensive terrace-gravel deposits of Pleistocene (?) age border the bottom lands on the northwest and the bottom lands of Pumpkin Creek in the easternmost part of the township. Several coal beds, some as much as 15 feet thick, crop out in this township. (See pl. 37.) They have burned almost everywhere along the outcrop, and it is only in deep gulches that have been fairly recently cut through to fresh coal back of the burned zone that coal exposures were seen. In this township it is difficult to obtain accurate measurements between beds in the lower part of the section, because their outcrops are widely separated. It is known from measurements made in the region several miles to the northwest and north, however, that the intervals between beds diminish eastward. It is the writer's belief, based in large part on measurements made in T. 1 N., R. 48 E., that the Flowers-Goodale bed, the lowest coal seen in outcrop in this township, is about 140 to 150 feet above the base of the member and that the Knoblock bed is about 75 feet higher. The A bed is about 140 to 150 feet above the Knoblock, and the Sawyer bed is 35 feet above bed A. The clinker bed of the E coal group is approximately 290 feet above the Sawyer bed.

The Flowers-Goodale bed was seen at only one exposure. It has burned throughout parts of sec. 3, and its outcrop southwestward up the Little Pumpkin Valley was concealed in the sod-covered slopes. At location 809, in the NW. ¼ sec. 2, a coal bed 3 feet 4 inches thick, believed to represent the Flowers-Goodale bed, was uncovered. No outcrops of this bed were seen on the south side of Little Pumpkin Creek, and so it is not known whether the coal continues so far southward. This bed is of widespread occurrence northwest of this township, where it is regular in thickness and good quality of coal. If present on the south side of Little Pumpkin Creek it should be available for mining by stripping throughout an extensive area, including much of the N. ½ sec. 19, the N. ½ sec. 20, the S. ½ and E. ½ E. ½ sec. 18, part of the NW. ¼ and most of the S. ½ sec. 17, the W. ½ sec. 16, and a large tract in secs. 14, 23, 22, and 15. The record of a well drilled on the Howard Merchant ranch, in the SW. ¼ sec. 22, indicates that this coal bed does not extend as far south as the locality of the well. The log as furnished by the driller is quoted below:

Log of well on Howard Merchant ranch

	Feet
Yellow sand and clay	0–20
Brown sandy clay	20–25
Light-green shale	25–79

	Feet
Black shale	79–84
Coal	84–86
Gray sandstone; 2 gallons of water a minute	86–92
Gray shale	92–100
Coal	100–102
Black shale	102–105
Gray sandy shale	105–130
Dark-gray shale	130–150
Dark-gray sandstone; 4 gallons of water a minute	150–155
Coal	155–160
Dark sticky shale	160–170
White sandy shale	170–175
Coal	175–180
Black shale	180–195
White clay (soapstone)	195–215
Gray-brown sandstone; 15 gallons of soft water a minute	215–232

The clinker bed of the burned Knoblock coal forms a prominent ledge in the northwesternmost part of the township, and measurements of the bed in this general region indicate that it contains a large thickness where unburned in parts of secs. 4, 5, and 6. A partial section of this bed was measured at the old Bartholomew mine (location 810), in the SW. ¼ sec. 18, where the uppermost 9½ feet of the bed is exposed. The old mine consists of a tunnel driven possibly 100 feet or more into the hillside in the coal bed about 60 feet beneath the top of a ridge that is capped with river gravel. The tunnel was caved partly shut, no coal having been mined here for a number of years. A partial section of one bench of this bed showing 6 feet 4 inches of coal was seen in an isolated remnant of unburned coal amidst a field of clinker in the SW. ¼ sec. 21, at location 811.

The A coal is cleanly exposed in a vertical bank at location 812, in the SE. ¼ sec. 30, where some coal has been mined by gouging it from the bank. The outcrop is in a narrow, steep-sided coulee and rather difficult to reach with coal wagons. The bed is 15 feet 3 inches thick and consists of good-quality coal. The Sawyer bed is 9 feet 10 inches thick at a natural exposure in the NW. ¼ sec. 32, at location 813. The uppermost 13½ feet of this bed is exposed at location 814, in the NE. ¼ sec. 33. The Knoblock bed is more than 7 feet 4 inches thick at location 815, in the S. ½ sec. 34, where a partial section of the bed was measured. Locations 814 and 815 are both readily accessible to wagons.

T. 2 S., R. 48 E.

The surface of most of T. 2 S., R. 48 E., is rugged, although Pumpkin Creek, which flows northeastward through the eastern part, has a valley 1 to 1½ miles wide. The almost level valley floor is flanked on both sides by steep slopes that rise to flat-topped ridges and hills capped by the thick clinker produced by the burning of the A and Sawyer coal beds. These two coal beds are separated by only a small interval and appear to have burned together in most localities and formed one thick bed of clinker. A high, rugged range of hills, known as Elk Ridge, trending slightly east of north through the western part of this township, separates the drainage basins of Pumpkin Creek and its chief tributary, Little Pumpkin Creek, which crosses the township adjacent on the west. The slopes on the west and east sides of this ridge are extremely steep. Landslides have been fairly numerous in the higher parts of the ridge

Some very recent landslides have occurred on the east slope in sec. 19, where great blocks of the F clinker and material for 100 feet below it have slid down the slope about 15 feet. The relief adjacent to Elk Ridge is in many places as much as 500 feet in a mile. The coulees descending from the ridge are 50 to 150 feet deep, with precipitous banks. The maximum relief in the township is a little less than 1,000 feet.

Aside from the alluvium along Pumpkin Creek and a few remnants of terrace gravel deposits bordering the Pumpkin Creek bottom lands on the west, the rocks that occupy the surface belong to the Tongue River member of the Fort Union formation. The total section exposed is about 900 feet thick, extending upward from a horizon about 200 to 250 feet above the base of the member.

Several thick coal beds crop out in the township; the chief ones are the Knoblock bed, a little less than 300 feet above the base of the Tongue River member; the A bed, which is here about 140 to 150 feet above the Knoblock; the Sawyer bed, 35 feet higher; the X bed, about 85 feet above the Sawyer bed; and the E group, 95 feet higher. (See pl. 37.) The clinker of the F bed caps Elk Ridge, and its base is 315 feet above the base of the clinker of the E beds. The A and Sawyer beds have burned extensively and formed a single thick clinker that is prominently exposed on both sides of Pumpkin Creek, capping a series of steep-sided ridges and hills. Each of these beds is believed to attain 15 feet in thickness and to contain coal of good quality. The X bed was seen only in parts of the slopes of Elk Ridge, and apparently thins southward. The E group contains at least one thick bench of coal and other thinner benches in the northern part of Elk Ridge, but thins southward. No unburned coal was seen at the F horizon.

A comparatively large tract along the Pumpkin Creek Valley may be underlain at shallow depth by coal of the Knoblock bed in sufficient thickness to warrant mining of the coal by stripping. Very little information concerning the thickness of this bed or the quality of the coal was obtained here because of lack of exposures, but the uppermost 6 feet of the bed was uncovered near the north quarter corner of sec. 24. The area shown by ruled lines on the map is worthy of prospecting to determine its value as a coal-stripping tract.

For convenience in describing the details of measured sections of the coal beds the township has been separated into districts.

Coal in the eastern slope of Elk Ridge.—The Sawyer coal is more than 12 feet inches thick at location 816, in the NW. ¼ sec. 4, where it is accessible to coal wagons. The main bed of the E group is 12 feet 8 inches thick, including a 1-foot parting, at location 817, in the NW. ¼ sec. 5, but this locality is not readily accessible. A coal bed 5 feet thick, probably not representing the full thickness, believed to be correlative with the Sawyer bed, was uncovered at location 818, in the NE. ¼ sec. 9, a locality that is accessible to wagons. One bench of the E bed is 5 feet 4 inches thick and another bench 12 feet above is 3 feet thick at location 819, in the N. ½ sec. 17. At location 820, in the SW. ¼ sec. 17, the main bench of the E bed is 12 feet 4 inches thick, and at location 821, in the SE. ¼, the thickest bench seen is 6 feet thick. These localities are fairly difficult to reach by wagon or truck. One bench of the Sawyer coal is 6 feet thick at location 822, a readily accessible locality in the E. ½ sec. 16. A coal that may be the C or X bed occurs about 100 feet above the Sawyer coal, in parts of secs. 16 and 21. This bed is 2 feet 8 inches thick at location 823, in the SE. ¼ sec. 16; it is 3 feet 4 inches thick at location 824 and 3 feet 6 inches thick at location 825, both in the NE. ¼ sec. 21. One bench of the E group is exposed at location 826, in the NW. ¼ sec. 20, where 8 feet of coal was uncovered.

The X bed, 95 feet below bed E, is 6 feet 4 inches thick at location 827, near the center of sec. 20. A thin bed between the Sawyer and X beds is 2 feet 7 inches thick at location 828, in the NE. ¼ sec. 29. What is probably the main bench of the X bed contains 6 feet 4 inches of rather poor coal at location 829, in a readily accessible locality in the NW. ¼ sec. 29. At location 830, in the E. ½ sec. 33, 6 feet 2 inches of the upper part of the A coal was uncovered. This locality is readily accessible, and a very small tract here is capable of being stripped for coal.

Coal east of Pumpkin Creek.—The A and Sawyer coal beds have been removed by erosion throughout most of the part of the township east of Pumpkin Creek, and in the areas where they remain they have been burned and formed a thick clinker. The only exposure of thick coal seen in this part of the township is in the N. ½ sec. 24, at location 831, where the upper 6 feet 2 inches of a coal bed probably representing the Knoblock was uncovered 140 feet below the base of the combined A and Sawyer clinkers. Near by at location 832, the upper 4 feet 10 inches of the Sawyer bed is exposed in a small isolated tract containing unburned coal.

Coal in the west slope of Elk Ridge.—The X, E, and F clinkers are fairly prominent on the west slopes of Elk Ridge. The E and X clinkers diminish in thickness southward and almost disappear where their horizon crosses the west boundary of the township in sec. 30, probably indicating that the E and X coals also thin rapidly southward. A clinker bed between the X and E clinkers is fairly prominent in parts of secs. 30 and 19, but no coal was seen at this horizon. The only coal exposure of commercial importance seen in the western part of the township is that at the Gold mine (location 833), in the W. ½ sec. 7, worked in the E bed. The main coal bench here is 11 feet 9 inches thick and contains coal of good quality. A tunnel has been driven about 150 feet in the bed.

T. 3 S., R. 48 E.

T. 3 S., R. 48 E., is drained by Pumpkin Creek, which flows northeastward in a wide valley with slopes that ascend at a gentle grade for miles on each side of the stream. Except in the northwesternmost part of the township the relief is moderate, and the area as a whole is characterized by a gently rolling treeless surface. Terrace surfaces at four levels, two of which are much more widespread than the others, are particularly well preserved bordering the Pumpkin Creek bottom lands on the west.

Rocks occurring between 350 and 1,150 feet above the base of the Tongue River member occupy most of the surface of the township. Except for the uppermost 200 feet and the lowermost 100 feet of this section the strata are composed largely of shale beds that weather gray and grayish tan. A few thick coal beds are present (see pl. 37), and there are numerous thin beds of carbonaceous shale and coal.

It is highly probable that this entire township is underlain at shallow depth by thick coal beds in the Tongue River member, but there are relatively few outcrops of thick coal. The A and Sawyer beds, which lie 35 to 40 feet apart and occur about 450 feet above the base of the Tongue River member, have burned along their outcrops in the northeastern part of the township and formed in most places a single bed of clinker that is as much as 75 feet thick and in some places two clinker beds that crop out in parallel lines in the slopes. It is believed that each of these coal beds is very thick where unburned. The upper or Sawyer bed was prospected at location 835, in the NE. ¼ sec. 10, and 9 feet of coal was uncovered without disclosing the base of the bed. Mr.

Wilbur Titus, who lives in the SE. ¼ sec. 28, reported that his well was drilled through 56 feet of coal without striking bottom. The coal was struck at a depth of 100 feet and may represent only the Sawyer bed or the combined Sawyer and A beds. Mr. Sam Hogland, who lives in the NW. ¼ sec. 14, reported that a thick coal bed was struck in his well at a depth of 150 feet. This probably represents the Knoblock bed. The well at the Camp ranch, in the SW. ¼ sec. 24, was drilled to a depth of 93 feet and according to Mr. Camp struck no coal. This well starts a short interval below the A bed and did not penetrate deep enough to strike the Knoblock bed.

There appears to be little valuable coal in this township above the Sawyer bed. The strata consist of gray and drab clay shale for several hundred feet above the Sawyer horizon and contain numerous beds of carbonaceous shale and only a few very thin coal beds. At location 836, near the center of sec. 6, a coal bed that is tentatively correlated with the E coal of the region to the north is more than 4 feet 8 inches thick. This outcrop is at the foot of a very steep slope that rises to the F clinker. Other coal outcrops in the region are more readily accessible for mining. Two relatively thin coal beds were seen in the steep slope below the F clinker bed in the SW. ¼ sec. 6, at location 837; one bed 3 feet 10 inches thick was prospected 110 feet below F clinker; and a bed 2 feet thick was uncovered 30 feet lower. At location 838, in the NW. ¼ sec. 7, 2 feet 11 inches of coal was uncovered in a bed that occurs 60 feet below the clinker correlated with the E group of the region to the north. A coal bed of local extent and occurring at the general horizon that falls between the C and E beds of the township to the northwest has been mined in a small way in the S. ½ sec. 34. At location 839 the bed is 3 feet thick.

The soft nonresistant beds that overlie the Sawyer coal form a gently sloping surface receding from the Sawyer outcrop nearly everywhere, offering several areas capable of being mined by stripping. A rather extensive area in which the Sawyer and possibly the A bed may be so situated lies in the valley of Pumpkin Creek from a point about opposite the Titus ranch downstream to the outcrop of the bed. Another area is in sec. 25 southeast of the Camp ranch. Here the surface above the assumed positions of the outcrops of the A and Sawyer beds rises very gently to the south, west, and east. Conditions favorable for strip mining may extend northward for a mile or more beyond the Camp ranch house in a narrow tract along the outcrop. Few positive data on these tracts were obtained in the examination because of a dearth of coal outcrops, but the facts learned suggest that the areas warrant thorough prospecting to determine the coal available at shallow depth. A small tract in the vicinity of the Edmonson ranch, in the NW. ¼ sec. 10, and extending northwestward up the coulee, probably contains thick coal less than 50 feet beneath the surface. A similar condition exists in the northernmost parts of secs. 3 and 4 and along the coulee in the northern part of sec. 15. The overburden in all these localities is largely clay shale.

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