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THE ROSEBUD COAL FIELD ROSEBUD AND CUSTER COUNTIES MONTANA

BY

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THE ROSEBUD COAL FIELD, ROSEBUD AND CUSTER COUNTIES, MONTANA

By W. G. Pierce

ABSTRACT

The Rosebud coal field, named from Rosebud Creek and the village of Rosebud, includes an area of about 1,050 square miles and forms a very small part of the subbituminous and lignite coal fields of eastern Montana and Wyoming and the western part of the Dakotas. It is an irregularly bounded tract lying south of the Yellowstone River in eastern Rosebud County and western Custer County and measures 50 miles from east to west and 28 miles from north to south. It adjoins the Forsyth coal field, on the west, the Ashland coal field, on the south, and the Miles City coal field, in part, on the north.

The southern part of the field and the Rosebud Creek-Tongue River divide, which passes northward nearly across the west-central portion of the field, include high timbered areas, but most of the field is timberless and contains badlands and rolling country. The highest altitude in the area is 3,475 feet, and the lowest is 2,400 feet on the Yellowstone River. The maximum relief in the field is therefore 1,075 feet.

The exposed rocks are continental and belong to the Lance (Tertiary?) and Fort Union (Tertiary) formations. A full section of the Tullock member of the Lance and several hundred feet of the underlying Hell Creek member of the same formation are exposed in the Rosebud Creek Valley. The Hell Creek member has a slight greenish tint and is practically non-coal-bearing, but otherwise it is similar lithologically to the Tullock member. The Lance is overlain conformably by the Fort Union formation, which is divided into a lower (Lebo) member and an upper (Tongue River) member. In the Rosebud Creek Valley the Fort Union and Lance formations are distinguished by differences in lithology, and the contact is marked by the base of the Big Dirty coal bed, but in the Tongue River Valley their separation is difficult. The contrast between the two members of the Fort Union formation—the somber-colored Lebo shale and the yellow sandy Tongue River member—is marked, but the contact is gradational through a zone 20 to 40 feet thick.

The formations exposed in the Rosebud coal field are almost flat-lying, and the maximum structural relief is only about 250 feet. The axis of a very shallow syncline trends northeastward, approximately following the valley of the Tongue River, and a slight anticlinal nose in the northwestern part of the field plunges southeastward. In addition there are a few small and superficial folds that may have been formed as a result of the movement of nearby slump blocks or landslides. Two formal faults, each with a throw of about 60 feet, were observed; they appear to be related to differential compaction of the underlying beds.

Gravel and terrace remnants occur in many parts of the Rosebud coal field. The terraces in the Yellowstone Valley are well preserved; those in the smaller

valleys are dissected and less distinct. Ten or more terraces, which are younger than the Flaxville Plain (Miocene or Pliocene), were recognized in the Yellowstone Valley. They are all of Pliocene (?) or Pleistocene age.

The drainage pattern in the Rosebud coal field, as well as elsewhere in eastern Montana, presents unusual features. In the areas where the streams flow northeastward the interstream divides lie southeast of the median line between the streams. Also, numerous streams abruptly change their trend from northeast to northwest. The suggested explanation for these features is that the region has been tilted toward the northwest, thus increasing the gradients of the northwestward-flowing streams and decreasing the gradients of the southeastward-flowing streams, thereby causing a shift of the interstream divides and probably piracy by some of the streams that were steepened. Presumably the tilting took place at a time when the region had a low relief.

This field contains an estimated total quantity of 1,171,000,000 tons of subbituminous coal in beds over 1½ feet thick, of which 85 percent is in the Tongue River member of the Fort Union formation. Of the total estimated tonnage, 30 percent is in beds from 1½ to 3 feet thick and 70 percent is in beds over 3 feet thick. There is no commercial mining in the field at present.

INTRODUCTION

Location and relations of the field.—The Rosebud coal field is in Rosebud and Custer Counties, in southeastern Montana. It is south of the Yellowstone River, between the Forsyth coal field, on the west, the Ashland coal field, on the south, and the Miles City coal field, on the north. It includes an irregular-shaped area of 1,050 square miles, which is crossed by the drainage basins of Rosebud Creek and the Tongue River. This field is a small part of the large subbituminous and lignite fields of eastern Montana and Wyoming and the western part of the Dakotas. It is named from the town of Rosebud and Rosebud Creek.

Figure 7 shows the location of this field and its relation to other coal-bearing fields that have been mapped and described in publications of the Geological Survey. The names of the fields and references to the Geological Survey publications in which they have been described are as follows:

Coal fields whose locations are shown in figure 7

No.	Field	Bulletin	No.	Field	Bulletin
1	Marmarth	775.	17	Baker	471-D.
2	Washburn	381-A.	18	Ekalaka	751-F.
3	New Salem	726-A.	19	Little Sheep Mountain	531-F.
4	Cannonball River	541-G.	20	Miles City	341-A.
5	Standing Rock and Cheyenne River.	575.	21	Forsyth	812-A.
6	Fort Berthold	381-A and 471-C.	22	Tullock Creek	749.
7	do	726-D.	23	Bull Mountain	647.
8	Williston	531-E.	24	Sheridan	341-B.
9	Sentinel Butte	341-A.	25	Powder River	381-B.
10	Northwestern South Dakota	627.	26	Little Powder River	471-A.
11	Culbertson	471-D.	27	Northward extension of Sheridan coal field.	806-B.
12	Scobey	751-E.	28	Gillette	796-A.
13	Fort Peck	381-A.	29	Ashland	831-B.
14	Sidney	471-D.	30	Big Horn County	856.
15	Glendive	471-D.	31	Pine Ridge	541-H.
16	Terry	471-D.	32	Rosebud	847-B.
			33	Richey-Lambert	847-C.

Previous investigations.—The general geologic features of this area have been known for many years through the work of several geologists, though none of the published reports give a detailed description of the geology or coal deposits. Dobbin [1] has mapped the geologic boundaries and coal beds in an area adjacent to the western boundary of the field. Bass [2] has made similar surveys of

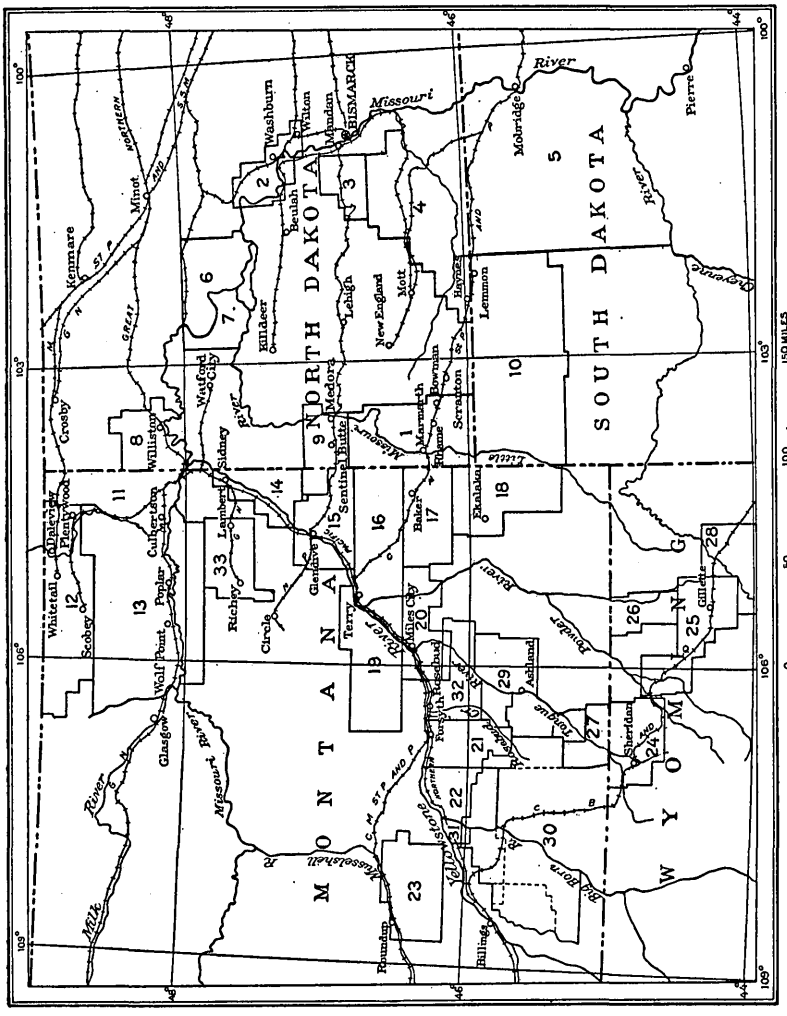


FIGURE 7.—Index map showing location of Rosebud coal field, Montana.

the Ashland field, adjoining the southern boundary. Renick [3] describes the principal geologic features in this and adjoining areas and gives information on wells and quantity and quality of the

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

[2] Bass, N. W., The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont.: U. S. Geol. Survey Bull. 831, pp. 19–105, 1932.

[3] Renick, B. C., Geology and ground-water resources of central and southern Rosebud County, Mont.: U. S. Geol. Survey Water-Supply Paper 600, 1929.

water. The oil possibilities of southeastern Montana, including the area of the Rosebud coal field, are discussed in a press notice by Dobbin and Thom.[4] The stratigraphy and broad structural features of eastern Montana have been described by Thom and Dobbin.[5] Rowe[6] has mentioned briefly the occurrence of coal in this area. Collier and Smith[7] mapped an area which joins this on the north, but four of the townships that are included in their report were mapped for further detail and are included in the present report.

Field work and acknowledgments.—During the summer of 1929 the southwestern part of the area was mapped by the writer, assisted by Roland W. Brown, D. A. Andrews, F. H. Kellogg, and T. D. Mundorf; and in the summer of 1930 the mapping was continued by the writer, assisted by A. W. Quinn, H. E. Thomas, T. D. Mundorf, and G. C. Sleight. George Newlin served as camp hand for the party during both summers.

The method of mapping employed was a combination of triangulation and stadia traverse, with a plane table and telescopic alidade. A triangulation net expanded from a measured base line was extended over the entire area and used for horizontal and vertical control. The positions of geographic features, geologic boundaries, outcrops of coal beds, and altitudes were largely determined by stadia traverses originating at triangulation points. The positions of the land lines were determined by locating numerous section corners. Altitudes in the field are based on bench marks established at Colstrip, Mont., by engineers of the Northern Pacific Railway and were subsequently checked with the United States Coast and Geodetic Survey bench marks along the Yellowstone River.

The splendid assistance and cooperation of the members of the party is deeply appreciated. The merchants and inhabitants of the region, through their friendly cooperation, were of material aid during the field work. The writer wishes to acknowledge the assistance of H. D. Miser, under whose direction the survey was made, and of A. A. Baker, who organized the party in 1929 and has given many valuable suggestions during the preparation of this report. He wishes also to express his appreciation to the Director of the Geological Survey for permission to submit this report, in essentially its

[4] Dobbin, C. E., and Thom, W. T., Jr., Oil possibilities in southeastern Montana: U. S. Geol. Survey Press Notice, January 1921.

[5] 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. Thom, W. T., Jr., The relation of deep-seated faults to the surface structural features of central Montana: Am. Assoc. Petroleum Geologists Bull., vol. 7, pp. 1–13, 1923.

[6] Rowe, J. P., Montana coal and lignite deposits: Montana Univ. Bull. 37, Geol. ser. 2, 1906.

[7] Collier, A. J., and Smith, C. D., The Miles City coal field, Mont.: U. S. Geol. Survey Bull. 341, pp. 36–61, 1908.

present form, to Princeton University as part of a dissertation for the degree of doctor of philosophy.

Land surveys.—All of the area included in the Rosebud field has been subdivided by surveys of the General Land Office. Some of the townships were surveyed between 1878 and 1891, the remainder between 1900 and 1913. During this later period resurveys and retracements were made in several of the townships that had been surveyed prior to 1891. Most of the corners established by the later surveys have remained undisturbed, but few of the corners established by the earlier surveys can be found. The section lines shown on the map that are based on these older surveys may therefore be somewhat in error.

Magnetic declination.—The normal magnetic declination in this field is between 16°30′ and 17°30′ to the east. In the course of plane-table mapping that involved triangulation for control and orientation, a notable departure from the normal declination was found to prevail in the northeast quarter of T. 4 N., R. 48 E., but the investigation was not extended into the adjoining townships. The declination at about 20 points in the northeast quarter of this township was determined, the readings were plotted, and the isogonic lines which were drawn through points of equal declination were found to trend north-northeast. The declination decreases from 16°30′ in the north-central part of the township to 14° in the northeastern part. An explanation for this declination was not found in the surface features or rocks of the area. Clinker, which abounds in portions of the coal field, commonly attracts the compass needle, but there is none within several miles of the northeast quarter of the township here described. About 150 miles farther west Knappen and Moulton [8] have noted compass deflections of as much as 7° and attribute them to magnetite grains in the tuffaceous beds of the Lance and Judith River formations.

GEOGRAPHY

LAND FEATURES

The Rosebud coal field lies within the portion of the Great Plains province described by Fenneman [9] as the Missouri Plateau unglaciated section. The characteristic surface features of the field are much-dissected plateaulike uplands, terraces, and badlands.

The uplands are confined to the southern part of the field and to the Tongue River-Rosebud Creek divide, which passes northward

[8] Knappen, R. S., and Moulton, G. F., Geology and mineral resources of parts of Carbon, Big Horn, Yellowstone, and Stillwater Counties, Mont.: U. S. Geol. Survey Bull. 822, p. 2, 1930.

[9] Fenneman, N. M., Physiographic divisions of the United States: Assoc. Am. Geographers Annals, vol. 18, no. 4, p. 277, 1928.

nearly across the west-central part of the field. They are covered with grass and trees, which increase their contrast with the lower treeless country, much of which contains badlands. The uplands are irregular in outline, their borders being intricately crenulated by reentrant valleys and spurs. Buttes are common along their margins. Among the most conspicuous ones are the Rosebud Buttes, in sec. 19, T. 5 N., R. 43 E., which are completely isolated from the upland area and rise 300 feet above the surrounding country. The descent from the uplands toward the valleys is usually steep near the uplands but flattens to irregular dissected slopes that merge with the valley bottoms.

The northeastern part of the field contains rather narrow valleys and low but rugged interstream divides. The divide between the Tongue River and Pumpkin Creek is sharp, and the adjacent valleys on both sides of the divide are intricately dissected and contain large areas of badlands. The divide between the Tongue and Yellowstone Rivers separates two distinct types of topography. The slope toward the Tongue River is steep and cut into badlands, but the slope toward the Yellowstone is gradual and covered by grass or trees.

The flood plain of the Yellowstone River is in places 2 miles or more wide and is bordered by a succession of gravel-covered benches which occupy a belt 4 miles wide on the south side of the river. Similar benches extend from the Yellowstone up the valleys of the Tongue River and Rosebud Creek and also occur along Pumpkin Creek, a tributary of the Tongue River. The flood plain of Rosebud Creek is about half a mile wide, and that of the Tongue River is about three-quarters of a mile wide. Pumpkin Creek has a meandering course in a rather narrow valley, with rough country on both sides.

Altitudes above sea level are shown at various places on plate 11, to give a general idea of the topography and relief. The highest points lie west of Rosebud Creek in secs. 19 and 30, T. 2 N., R. 42 E., where the altitude is between 3,425 and 3,475 feet. The lowest country is along the Yellowstone River, which is about 2,400 feet above sea level. The maximum relief in the field is about 1,075 feet, though no township has a relief of over 600 feet.

DRAINAGE AND WATER SUPPLY

The Yellowstone River, which forms part of the north boundary of the field, is the largest stream in the region. It heads in Yellowstone National Park and flows east and north across Montana to join the Missouri River near the North Dakota-Montana State line. As most of the water in the river is derived from the mountains to the west, the flow of water is largely independent of local climatic

conditions, and the river offers a reliable supply of water for irrigating the bottom land in its valley. From early pioneer days the Yellowstone Valley has been an important route of travel and the river a source of water supply for livestock and domestic use. The water is generally turbid, except in dry seasons. The gradient of the Yellowstone River in the area mapped is about 3.7 feet to the mile. The stream-gaging record of the Yellowstone at Miles City in 1923 [10] shows a maximum discharge of 53,300 second-feet in June and a minimum of 1,800 second-feet in December. Records of the Yellowstone at Intake, Mont., which is about 100 miles below Miles City, for the period 1903 to 1928,[11] show a maximum discharge of 159,000 second-feet June 21, 1921, and a minimum of 1,200 second-feet December 6 to 8, 1922, and January 6 and 7, 1923.

The Tongue River is the largest tributary of the Yellowstone River that crosses the Rosebud field. It heads in the Big Horn Mountains in northern Wyoming, flows northeastward, and empties into the Yellowstone River at Miles City, Mont. It is a clear stream except at high stages. During the spring, when its volume is tremendously increased by melting snow in the mountains and by rainfall, it becomes a treacherous river, cutting into its soft banks, scouring deep holes in its channel, and at times overflowing its banks and doing considerable damage in the fertile alluvial flats. It is from 200 to 300 feet wide and has a fall of about 7.7 feet to the mile. A Government gaging station at Decker, Mont., 65 miles south of the field, measured the discharge of the Tongue River between April and September 1928. During this period of 6 months, the maximum discharge was 3,730 second-feet in May, and the minimum was 210 second-feet in August. At low-water stages the river can be forded with a car where there is a solid bottom. At many places along its course water is diverted for irrigating the bottom lands. In 1914 a concrete dam was built across the river in sec. 16, T. 2 N., R. 45 E., but during an excessively dry year there is insufficient water to irrigate all the land that is normally supplied from the reservoir.

Rosebud Creek heads in the uplands known as the Rosebud and Wolf Mountains, in the eastern part of the Crow Indian Reservation, and flows in a general northeasterly direction until it enters the area, whence it flows north and a little west until it joins the Yellowstone River near Rosebud. The water is turbid but potable throughout the summer. The stream is confined to a narrow channel in the valley alluvium, which is rarely over 20 feet wide and 10 feet deep. It is from 2 to 5 feet deep, and its gradient is about 13 feet to the mile.

[10] Surface water supply of the United States, 1928, pt. 6: U. S. Geol. Survey Water-Supply Paper 666, p. 83, 1931.

[11] Idem, p. 84. Surface water supply of the United States, 1923, pt. 6: U. S. Geol. Survey Water-Supply Paper 566, p. 124, 1927.

Pumpkin Creek, a stream about 60 miles long, flows through the extreme eastern part of the Rosebud coal field and joins the Tongue River about 2 miles north of this area. As its source of supply is principally surface run-off, it does not carry water during prolonged dry seasons.

The smaller tributaries of the Yellowstone River that carry the surface run-off in the north-central part of the area are Sweeney, Graveyard, and Moon Creeks. Sweeney Creek, slightly larger than the other two, is about 18 miles in length.

There are several flowing artesian wells in the Yellowstone Valley. The Lott well, at Hathaway, is reported to be 460 feet deep and the water rises 6 feet above the surface; another water horizon was struck at 250 feet, and from it the water rose within 14 feet of the surface. Two other flowing wells have been sunk in the vicinity of Hathaway—one in the NW¼ sec. 22 and one in the N½ sec. 20, T. 6 N., R. 44 E. There are a few flowing wells in the vicinity of Rosebud, and several on the north side of the Yellowstone. Artesian water-bearing beds have been encountered at Miles City at depths of 140 and 425 to 525 feet, but some of the wells in the immediate vicinity of that place no longer flow because of the large consumption and the draw-down produced by rapid pumping.

In the Tongue River Valley two wells at depths of about 365 and 385 feet yield flows of water at the S–H ranch, in the NW¼ sec. 31, T. 3 N., R. 46 E. The initial head of water in the deeper well is reported to have been 25 feet above the surface, and there has been no appreciable decline in head since they were drilled in 1914. Flowing wells have been obtained both up and down the river from this place.

There are no flowing wells along Rosebud Creek in this field, but at the Bean ranch, in the NW¼ sec. 8, T. 1 N., R. 43 E., a drilled well yields a small flow. Renick [12] reports that in a drilled well 570 feet deep in sec. 8, T. 5 N., R. 42 E., the water rises to 3 feet below the surface.

Shallow dug wells yield sufficient water for domestic supply over most of the area. Water from the Lebo shale member is in general highly mineralized and unfit for drinking. Numerous springs issue from the base of the clinker where erosion has cut sharp valleys into it and also from the sides of valleys cut into the gravel benches in the Yellowstone Valley. Alkaline waters issue from springs and seeps along the contact of the Tongue River and Lebo shale members of the Fort Union formation. A small spring at locality 123, in sec. 4, T. 2 N., R. 44 E. (see pl. 11), issues from the Terret coal bed.

[12] Renick, B. C., Geology and ground-water resources of central and southern Rosebud County, Mont.: U. S. Geol. Survey Water-Supply Paper 600, p. 93, 1929.

As a whole, springs are not significant as a source of water supply in this field, as they are neither large nor of constant flow. The ground-water resources in the part of this field that lies in Rosebud County have been discussed in detail by Renick.[18]

TIMBER, CULTURE, AND SETTLEMENT

A fair growth of western yellow pine and juniper is present on the divide between Rosebud Creek and the Tongue River, on the high land in T. 2 N., R. 42 E., and on the southern part of the divide between the Tongue River and Pumpkin Creek. The timber is almost exclusively confined to the high clinker-capped areas and to the steep slopes below the clinker. A sawmill in sec. 7, T. 3 N., R. 45 E., provides some lumber for local consumption. It is interesting to note that the trees seem to thrive only on the sandy Tongue River member of the Fort Union formation. (See pl. 5, *A*, *B*.) Very little timber grows on the Tullock member of the Lance formation, which is also rather sandy. The Tullock member is at a lower altitude and does not have the rough, rocky slopes of the Tongue River member. Sparse growths of cottonwood, ash, ash-leaved maple, and buffaloberry trees are found along the major stream courses.

Several species of sagebrush and cactus are abundant. Spanish bayonet, greasewood, Russian thistle, and three-leaved sumac are rather common. Buffalo grass and spear grass are the more common monocotyledons.

Farming is principally confined to the bottom lands along the Yellowstone and Tongue Rivers and Rosebud Creek. Alfalfa and grain for forage are the chief crops. There is some dry farming on the divides and in the Sweeney Creek Valley. The rainfall is not sufficient for successful farming except in unusual years. The country is naturally adapted for grazing, which is the principal industry in this area.

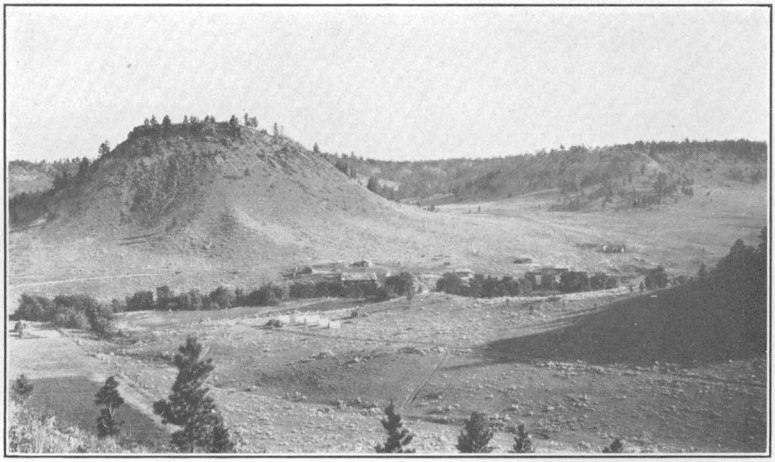
Rosebud is the largest town in the Rosebud coal field. The census of 1930 reports 351 inhabitants in the Rosebud district. The small settlement of Hathaway has a store, post office, and school. Miles City, which is at the junction of the Tongue and Yellowstone Rivers, outside the area of this report, is the trade center of a large part of this area. It is served by two transcontinental railroads—the Northern Pacific Railway and the Chicago, Milwaukee, St. Paul & Pacific Railroad—and had a population in 1930 of 7,175. Settlement is more dense along the Yellowstone River, Rosebud Creek, and the Tongue River, but although ranches are rather sparsely located over the entire area there are about 175 that are inhabited.

[18] Renick, B. C., op. cit.

ROUTES OF TRAVEL

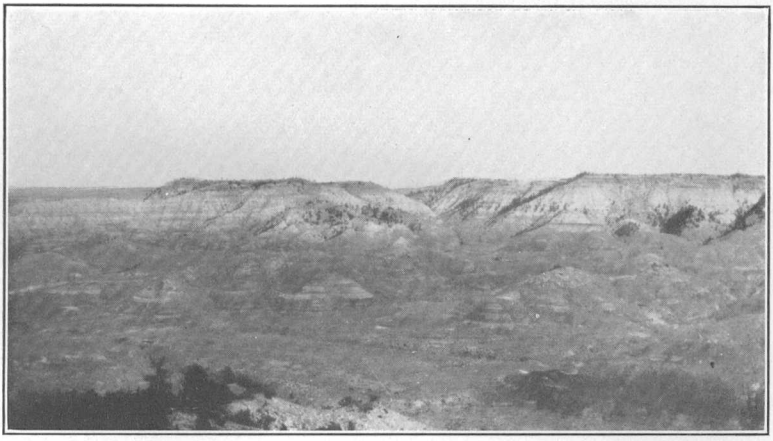
The transcontinental route of the Northern Pacific Railway follows the south bank of the Yellowstone River and that of the Chicago, Milwaukee, St. Paul & Pacific Railroad follows the north bank. A branch line of the Northern Pacific runs south to Colstrip, a coal-mining camp that lies about 3 miles west of the southwest corner of the Rosebud coal field. Construction work on the proposed line of the North & South Railroad, which was to follow the Tongue River from Miles City, Mont., to Sheridan, Wyo., stopped in 1923 and has not been resumed.

Several graded roads and numerous secondary roads provide access by automobile to many parts of the Rosebud coal field. United States Highway No. 10, also called the "Yellowstone Highway", follows the south side of the Yellowstone River and is an important tourist route. This highway is all gravel-surfaced and partly oiled between Miles City and Forsyth. A graded road follows the east side of the Tongue River from Miles City across the Rosebud coal field and continues southward to Ashland and Sheridan. A graded, gravel-surfaced road in the valley of Pumpkin Creek joins the Tongue River road about 2 miles north of the Rosebud coal field. The Pumpkin Creek road is an important stage route between Miles City and Volborg, Broadus, and other points. The area along Rosebud Creek is served by a graded road that runs in the bottom of the valley. About 6 miles south of Rosebud the road forks, one fork leading to Forsyth, which is 10 miles distant, and the other to Rosebud. From this fork, about 6 miles south of Rosebud, the road has been graveled to both Forsyth and Rosebud; it is also graveled southward from the forks to a point about midway across the area. In the southern part of the field it again forks; the east fork crosses the divide and follows Alfalfa Creek to the Tongue River and thence goes to Ashland; the other fork continues up Rosebud Creek, with forks leading to Ashland and Colstrip. A graded road from Rosebud traverses the Rosebud Buttes, but the grading ends about a mile south of the buttes. Grading was continued up the Sweeney Creek road in 1929 to the north line of T. 4 N., R. 44 E. A graded road begins in sec. 21, T. 3 N., R. 45 E., extends northeastward through the upper drainage basin of Moon Creek, and joins United States Highway No. 10 in the lower part of the Moon Creek Valley. A road from Hathaway leads up Graveyard Creek to its head. A wagon road along the Tongue River-Rosebud Creek divide and other roads leading to the various ranches in the area are frequently traveled.



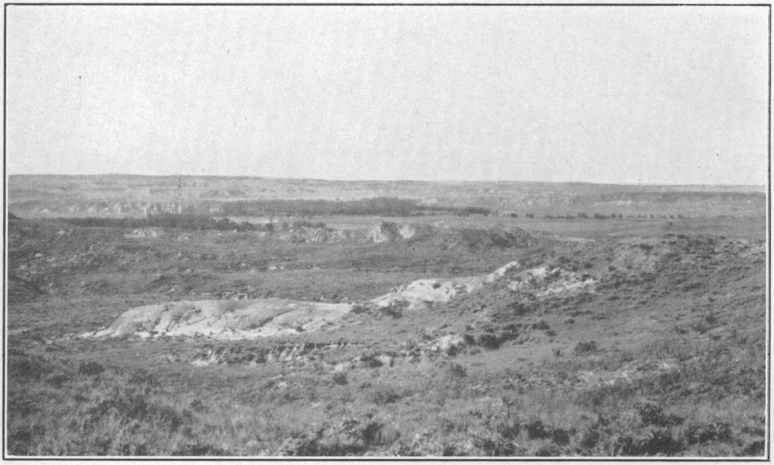
A. TYPICAL TOPOGRAPHY OF THE TONGUE RIVER MEMBER OF THE FORT UNION FORMATION, E½ SEC. 16, T. 5 N., R. 45 E., MONT.

The clinker formed by the burning of the Burley coal bed caps the ridge and the butte in the foreground The greater abundance of trees on the clinker-covered summits and on the steep slopes is characteristic.



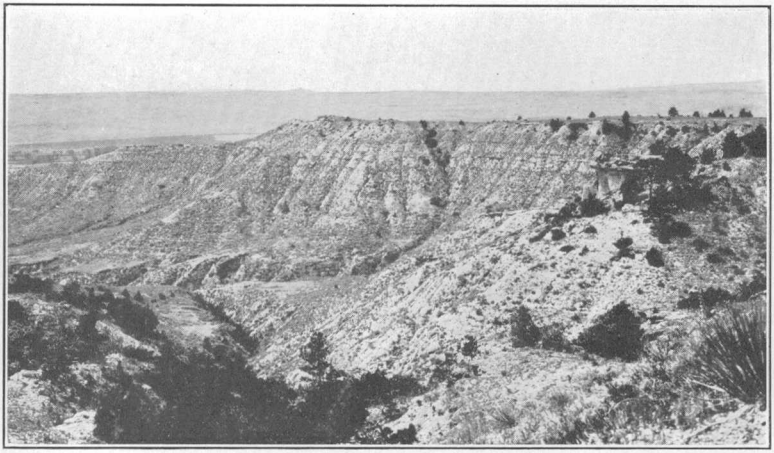
B. CONTACT OF THE TONGUE RIVER AND LEBO MEMBERS OF THE FORT UNION FORMATION NEAR THE WEST QUARTER CORNER OF SEC. 3, T. 5 N., R. 44 E.

The somber-colored shale of the Lebo member in the foreground forms badlands; the overlying lighter-colored beds in the distance are Tongue River. The clinker formed by the burning of the Burley coal bed caps the ridge.



A. VIEW LOOKING NORTH ACROSS THE TONGUE RIVER VALLEY FROM THE SW¼. SEC. 27, T. 4 N., R. 47 E.

Showing the wide valley of the Tongue River and outcrops of the Tullock member of the Lance formation.



B. BENCH AT THE TOP OF THE TULLOCK MEMBER OF THE LANCE FORMATION, SEC. 10, T. 5 N., R. 42 E.

Formed by stripping of the Lebo. The valley of Rosebud Creek appears in the background.

STRATIGRAPHY

The rocks that crop out in the Rosebud coal field belong to the Fort Union and Lance formations, with the exception of the Pleistocene gravel and recent alluvium along the streams. The Fort Union formation is of early Tertiary (Eocene) age, but the age of the underlying Lance formation has long been in controversy. Since the decision in 1914 by the Geological Survey to refer the Lance tentatively to the Tertiary, there has been considerable paleontologic and structural evidence which seems to warrant placing at least part of the Lance in the Cretaceous period. In this paper, however, the assignment heretofore adopted by the Geological Survey will be used, insamuch as studies of the age of the Lance are still in progress. The Lance formation has been subdivided into a lower member, the Hell Creek, and an upper member, the Tullock. The Fort Union formation is divided into the Lebo shale member (lower) and the Tongue River member (upper). The Tongue River member is the principal coal-bearing series in the field. Pleistocene gravel covers a series of benches in Yellowstone Valley and occurs to a lesser extent in other parts of the field. Alluvium in the Yellowstone, Tongue, and Rosebud Valleys is shown on plate 11 (in pocket).

TERTIARY (?) SYSTEM

LANCE FORMATION

The Lance formation was divided by Rogers and Lee[14] into two parts—an upper coal-bearing member, called the Tullock, and a lower, undifferentiated portion. The lower member was later named "Hell Creek" by Thom and Dobbin.[15] The areal mapping of these members was extended by Dobbin[16] eastward from the Tullock Creek field across the Forsyth coal field to the western boundary of the Rosebud coal field. Inasmuch as the division into two members had already been carried to the western boundary of the Rosebud coal field, the same division was extended into this field, though, as explained below, the division was difficult to make east of Rosebud Creek.

HELL CREEK MEMBER

The Hell Creek member crops out in the northwest corner of the Rosebud coal field, mostly in the lower part of the Rosebud Creek

[14] 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. 19–34, 1923.

[15] 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.

[16] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 812, pl. 7, 1929.

Valley, where about 300 feet of the member is revealed. It is probably present slightly below the surface in the lower parts of the Yellowstone and Tongue River Valleys. The upper part of the Hell Creek member as exposed in the Rosebud Creek Valley does not differ in topographic expression from the lower part of the overlying Tullock member of the Lance formation.

The upper part of the Hell Creek member in the Rosebud field does not contain great thicknesses of somber-colored clay and shale, such as occur in the member at its type locality on Hell Creek, in northern Garfield County. On the contrary, it is composed of light-colored sandy shale with a greenish-yellow tint and massive beds of white to light-tan sandstones. In the southern part of T. 5 N., R. 42 E., a slight difference in color between the Hell Creek and Tullock members can be noticed from a distance.

In the Tullock Creek coal field, where the Lance was divided into two members, the difference between them is distinct, but it becomes less and less distinct as they are traced eastward. In the Forsyth coal field the base of the Wright coal bed is mapped as the top of the Hell Creek member. The base of this same coal bed is also mapped as the top of the Hell Creek member, on the west side of Rosebud Creek in the Rosebud field. But on the east side of Rosebud Creek, in T. 6 N., R. 42 E., the Wright coal bed becomes discontinuous and finally disappears. Also, in this township the lithology of the Hell Creek member changes markedly from alternating beds of sandstone and shale to massive cross-bedded sandstones. These massive sandstones, which appear in the upper part of the Hell Creek member, are indistinguishable from the sandstones in the lower part of the Tullock member. These similar lithologic features persist north and east from this township, and in consequence it is necessary to draw there an arbitrary boundary between the Hell Creek and Tullock. If the contact in these directions were projected from the horizon of the Wright coal with a dip that accords with the regional dip of the strata, it would place the top of the Hell Creek member about 30 feet above the Yellowstone River, but inasmuch as there is no change in lithology upon which to base a separation of the Hell Creek and Tullock members, the thickness of the Tullock is arbitrarily increased to include these additional strata. Consequently, the contact is shown on the map as crossing the Yellowstone River a mile below the town of Rosebud.

TULLOCK MEMBER

The Tullock member forms the surface of much of the northern part of the Rosebud area. It crops out in the Yellowstone Valley but is partly concealed there by extensive gravel deposits. It crops out also in the valleys of the Tongue River (pl. 6, *A*) and Rosebud and

Pumpkin Creeks, extending southward slightly beyond the south line of T. 3 N.

The Tullock is composed of sandstone and shale, with a predominance of sandstone. The sandstones are light yellow, evenly bedded, and rarely massive. Two or locally three coal beds occur in the upper 100 feet; the most persistent bed is about 70 feet below the top.

A detailed section of this member was measured in the northwestern part of the field, where it is 264 feet thick. In the Tullock Creek field, which lies to the west, this member is from 290 to 300 feet thick. In regard to the lower boundary, Rogers and Lee[17] write:

> The base of the Tullock member is considered to be the base of coal bed A, the lowest in the Lance formation in this field. Bed A is fairly persistent through the western and central parts of the field and is generally thicker than 18 inches in these districts. * * * In much of the district east of Sarpy Creek [that is, in the eastern part of the field] coal bed A is absent, but bed C, which is 35 feet higher, is persistent. In this district, however, for the sake of uniformity, the base of the Tullock member was mapped at the horizon of bed A.

In the Forsyth coal field, according to Dobbin,[18] the Tullock member is between 240 and 270 feet thick, and the base of the member is placed at the base of the Wright coal bed.

Where the Wright bed is present in the Rosebud coal field, it is taken as the basal bed of the Tullock member. It corresponds to the bed of the same name in the Forsyth coal field and probably to bed C in the eastern part of the Tullock Creek coal field. In the Rosebud and Forsyth coal fields the Wright bed is generally a persistent marker, but variable in coal content, except east of Rosebud Creek. Here it is discontinuous and pinches out in the southern part of T. 6 N., R. 42 E. Along the Yellowstone River in T. 6 N., Rs. 43 and 44 E., slightly over 300 feet of strata are included in the Tullock member, because there is no horizon in the lower part at which a contact can be consistently drawn.

In the Rosebud Valley the top of the Tullock is marked in places by a resistant sandstone bed from 2 to 10 feet thick, which produces a bench. (See pl. 6, *B*.) In the western half of the field the Big Dirty coal bed, at the base of the overlying Lebo shale member, is persistent, and its base was mapped as the top of the Tullock. East of the Rosebud Creek-Tongue River divide the lithology of the upper part of the Tullock differs from that on the west side. East of the divide the Big Dirty coal bed is not very persistent, and the thin cross-bedded sandstones, which have a slight topographic expression at the top of the Tullock west of the divide, are not present. Also,

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[17] Rogers, G. S., and Lee, Wallace, Geology of the Tullock Creek coal field, Rosebud and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 749, pp. 30–31, 1923.

[18] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 812, pp. 10–12, 1929.

the middle and lower parts of the Tullock are still lithologically distinguishable from the Lebo shale east of the divide, but in the eastern part of the area the transition is so gradual that any contact line between the Tullock and the Lebo has to be drawn quite arbitrarily.

Fossil plants were collected from a sandstone in the Tullock member 50 feet below the Big Dirty coal bed, in the SW¼ sec. 12, T. 5 N., R. 43 E.

In the NW¼ sec. 33, T. 6 N., R. 42 E., a large block of sandstone float, probably from a bed near the base of the Tullock, contained many reptilian and fish fragments. Crocodilian vertebrae, turtle plates, and garpike (*Lepidosteus*) scales were very abundant in this sandstone block and are not uncommon in the Lance elsewhere.

Section of the Tullock member of the Lance formation in sec. 15, T. 5 N., R. 42 E.

	Feet
Lebo shale member of the Fort Union formation.	
Tullock member of the Lance formation:	
Sandstone, brown, in places forming rim rock	5
Shale, tan, sandy	13
Shale, gray, clay; concretionary layer at base 1 foot thick	10
Sandstone, with interbedded tan clay	6
Clay, gray	9
Sandstone, with interbedded white clay, capped by 6 inches of gray carbonaceous shale	11
Coal	3
Sandstone, cream-colored, with interbedded light-gray shale	14
Shale, gray, carbonaceous	5
Coal	1
Sandstone, white, with interbedded clay	14
Coal; gray carbonaceous shale above and below	1
Sandstone, with interbedded white clay	18½
Shale, brown	½
Sandstone, light-colored, with interbedded clay	2
Shale, brown, carbonaceous	1
Sandstone, cream-colored, shaly	3
Shale, brown, and coal	1
Sandstone	16
Shale, tan, sandy	16
Shale, brown, with streaks of coal	1
Sandstone, white, soft	8
Clay, gray	9
Shale, brown, and coal	3
Sandstone, white to tan, with interbedded sandy shale	49
Coal; brown shale above and below	1
Sandstone, cream-colored, with layer of hard brown sandstone 2 feet thick near top	40
Coal, Wright bed	½–3
Hell Creek member of the Lance formation.	
	264

A section of the upper 78 feet of the Tullock, measured in T. 5 N., R. 44 E., is given on page 59.

TERTIARY SYSTEM

FORT UNION FORMATION

The Fort Union formation can be easily separated into two members on lithologic differences. The dark shale of the Lebo, which is the lower member, presents considerable contrast to the overlying yellow sandy Tongue River member. The contact between the two is not everywhere sharp but may be transitional through a zone of 20 to 40 feet vertically.

LEBO SHALE MEMBER

Occurrence and character.—The Lebo shale member forms a large part of the surface of the Rosebud field east of Tongue River and occupies an irregular strip about 4 miles wide on the west side of the Tongue River Valley. It crops out on both sides of the Rosebud and Pumpkin Creek Valleys and also in the valleys of creeks tributary to the Yellowstone River, such as Sweeney, Graveyard, and Moon Creeks. In the Yellowstone Valley the Lebo shale member is partly covered by terrace gravel.

The Lebo shale is only loosely consolidated and is subject to rapid erosion. Where conditions are such that rapid removal of soft material may take place, badlands are formed. Smooth, rounded mounds of somber-colored shale, resembling haystacks in their general outline, are often produced by erosion of the Lebo shale. It is the author's opinion that considerable material, especially in the Lebo, is removed in suspension from below the surface—that is, percolating water carries with it the finer clay and silt particles. The result of this washing out of material is apparent from the small funnel-shaped depressions and tunnels developed in badland areas.

The Lebo shale member is composed of somber-colored shale beds, with lenses of gray and yellow sandstone. There are many ironstone concretion zones, ranging in thickness from an inch or two to a foot. The following sections show the lithology of the member. The first section is incomplete, but the second one includes a partial section of the members above and below the Lebo.

Section of the Lebo shale member of the Fort Union formation in the SE¼ sec. 28, T. 3 N., R. 43 E.

	Ft.	in.
Unrecorded beds at top of member	80±	
Sandstone, yellow	8	
Ironstone concretion bed		2
Shale, light yellow and gray	17	
Ironstone concretion bed		3

Section of the Lebo shale member of the Fort Union formation in the SE¼ sec. 28, T. 3 N., R. 43 E.—Continued.

	Ft.	in.
Shale, gray	5	2
Shale, dark	6	
Shale, gray	6	
Shale, black		6
Shale, gray	19	
Coal		8
Shale, gray	9	
Shale, black, with thin coal lenses		6
Shale, gray	3	
Ironstone concretion bed	1	
Shale, gray	5	
Ironstone concretion bed		3
Shale, gray	3	
Coal, impure (Big Dirty bed)	2	6
Tullock member of Lance formation.		
	167±	

Section of the Lebo shale member of the Fort Union formation, with partial sections of overlying and underlying beds, in the NE¼ sec. 1, T. 5 N., R. 44 E., beginning at locality 290 and extending northwest to Graveyard Creek

	Ft.	in.
Tongue River member of Fort Union formation:		
Clinker (Burley bed)	10	
Clay shale, gray	4	
Bone	1	2
Coal		10
Shale, sandy, partly concealed	23	
Sandstone, massive, fine-grained, cross-bedded, yellow to white	38	
Shale, sandy, gray	23	
Shale, yellow, calcareous, sandy	3	
Sandstone, massive, white to yellow	105	
	208	
Lebo shale member of Fort Union formation:		
Shale, somber-colored; contains ironstone concretions	42	
Sandstone, soft, buff; contains concretions	21	
Shale	29	8
Coal, bony		7
Shale	13	
Sandstone	5	
Coal and carbonaceous shale	1	6
Shale; contains ironstone concretions	19	4
Shale, carbonaceous, with streaks of coal	3	
Shale	3	
Bone		4
Shale; contains ironstone concretions	13	
Coal, impure		6
Shale, somber-colored	2	
Coal		4
Shale, somber-colored	18	
Coal, impure	1	5

Section of the Lebo shale member of the Fort Union formation, etc., in the NE¼ sec. 1, T. 5 N., R. 44 E.—Continued.

Lebo shale member of Fort Union formation—Continued.	Ft.	In.
Shale		7
Coal, impure		9
Shale	14	
Bone and impure coal	2	
Shale, somber-colored	3	
Total Lebo shale member	194	
Tullock member of the Lance formation:		
Fine-grained sandstone and light-gray shale	5	
Shale	3	
Coal, impure		7
Sandstone, with thin beds of shale	21	8
Coal		5
Shale	2	
Bony coal and shale	2	
Shale	17	
Sandstone, massive, buff	10	
Coal		4
Sandstone and shale	10	
Coal, bony	1	
Sandstone, fine-grained, yellow to buff	5	
	78	

The Lebo is variable in thickness. It reaches its maximum thickness in the central part of the area, where it is from 190 to 220 feet thick, but the average thickness is about 170 feet. This slight variation in thickness, however, has no significance, because the lower boundary in particular cannot be placed on a bed or stratum that is continuous over even a large part of the area. The Big Dirty coal bed is mapped as the basal bed of the Lebo in the western part of the area. In the Rosebud Creek Valley the difference in lithology between the Lebo shale and the underlying Tullock member makes the boundary easy to locate, but in the Tongue River Valley the change from predominantly shaly beds to more sandy beds is one of gradual transition. Here the Big Dirty coal bed cannot be located with certainty, for several beds of similar character exist. The base of a coal and shale bed that resembles the Big Dirty was therefore mapped as the base of the Lebo. Including this bed, the Lebo in the Tongue River Valley is about 200 feet thick. In the Pumpkin Creek Valley the coal beds are lenticular and the change in lithology is transitional through a thick zone, so there is no persistent horizon at which a contact can be drawn.

The top of the Lebo is not sharply defined, although there is a distinct change in lithology within a vertical distance of 25 or 30 feet. The somber-colored shale of the Lebo member grades upward into

the lighter-colored interbedded sandstone and shale of the Tongue River member (pl. 5, *B*). The most striking difference between the two members is the change in color. Locally a calcareous bed, about 1 foot thick, is present where the strata change from sandstone to shale. This calcareous bed is more resistant to erosion than the beds above and below and forms an inconspicuous bench. It may be that this calcareous bed was formed by the leaching of calcium carbonate from the overlying beds, the soluble material being carried downward by meteoric waters and precipitated when further movement was retarded by the shale.

Correlation eastward.—In the Ekalaka lignite field [19] the Tongue River member of the Fort Union formation is underlain by the Lance formation, which is composed of two members—the Ludlow lignitic member (upper) and the Hell Creek member (lower). (See pl. 9.) In the Rosebud field the Lebo shale member of the Fort Union formation and the Tullock member of the Lance formation become more and more alike in lithology as these members are traced eastward, until it becomes impracticable to separate them. Thom and Dobbin [20] have correlated these two members with the Ludlow lignitic member, which is in accord with the lithologic evidence in the Rosebud coal field, except that the Tongue River-Lebo contact apparently is rising eastward, so that the Ludlow may also include strata equivalent in age to the lower part of the Tongue River member of the Rosebud field. The report by Parker and Andrews [21] on the Mizpah coal field, which lies between the Rosebud and Ekalaka coal fields, may give additional information on these correlations. Thom and Dobbin [22] state that "east of the Powder River-O'Fallon Creek divide and along the Cedar Creek anticline it [Tullock member] is still recognizable, though thinner and lithologically more like the underlying Hell Creek member and overlying Lebo shale", but the writer believes that a lithologic distinction between the Lebo and Tullock members cannot be carried eastward beyond the Rosebud coal field.

In the Miles City coal field [23] the Tullock and Lebo members were undifferentiated, both of them being included in the lower member of the Fort Union formation. The relation of the members of the Fort Union and Lance formations mapped in the Rosebud field to the upper and lower members of the Fort Union section in the Miles City

[19] Bauer, C. M., The Ekalaka lignite field, southeastern Montana: U. S. Geol. Survey Bull. 751, p. 236, 1924.

[20] Thom, W. T., Jr., and Dobbin, C. E., Stratigraphy of Cretaceous-Eocene transition beds in eastern Montana and the Dakotas: Geol. Soc. America Bull., vol. 35, p. 492, 1924.

[21] Parker, F. S., and Andrews, D. A., The Mizpah coal field, Custer County, Mont. (in preparation).

[22] Thom, W. T., Jr., and Dobbin, C. E., op. cit., p. 492.

[23] Collier, A. J., and Smith, C. D., The Miles City coal field, Mont.: U. S. Geol. Survey Bull. 341, pp. 38–43, 1909.

field, which includes 250 feet of Lance strata, is shown in plate 9. The base of the Lebo member as mapped in the Rosebud coal field corresponds to coal bed C in the Miles City coal field. Thom and Dobbin also,[24] in a regional stratigraphic study, have placed the base of the Lebo shale member at coal bed C in the Miles City field.

TONGUE RIVER MEMBER

The Tongue River member of the Fort Union formation is exposed over about one-third of the area of the Rosebud coal field. It crops out on the Rosebud Creek-Tongue River and Tongue River-Pumpkin Creek divides and in the high region in the southwestern part of the field. This member contains the most valuable coal beds in this field, many of which have burned along their outcrops and formed thick clinkers. The clinker is more resistant to erosion than the rocks above or below, and consequently, where present, it has influenced the topographic expression of the member. The clinker commonly forms the resistant rim above steep slopes and caps buttes and ridges (pl. 5, *A*). Areas covered by clinker are shown on plate 11 (in pocket).

The Tongue River member is composed mainly of yellow sandstones, with beds of sandy shale, carbonaceous shale, and coal. There are a few rather lenticular, massive sandstone beds. The greater part of the member has been eroded, as the maximum thickness now present in the area is 400 feet. Bass [25] states, in regard to the thickness of the Tongue River member in the Ashland coal field:

> 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.

The total thickness of the Tongue River member in the northward extension of the Sheridan coal field is estimated by Baker [26] to be between 1,626 and 1,780 feet. The lower part of the member is gradational for 25 or 30 feet into the Lebo shale, but otherwise the change is marked. Along Cow Creek in T. 3 N., R. 45 E., the base of the Tongue River member has been placed arbitrarily: it was drawn at the same horizon rather than shifted vertically to follow the local transitions from sandstone to shale.

Fossil plants were collected at several localities from clinkered sandstones above the Terret and Burley coal beds.

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[24] Thom, W. T., Jr., and Dobbin, C. E., op. cit., p. 494.

[25] Bass, N. W., The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont.: U. S. Geol. Survey Bull. 831, p. 35, 1932.

[26] Baker, A. A., The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont.: U. S. Geol. Survey Bull. 806, p. 27, 1929.

Section of part of the Tongue River member of the Fort Union formation

Sec. 24, T. 2 N., R. 42 E.

	Ft.	in.
Clinker	20	
Ash of Rosebud coal bed	2	
Sandstone, soft, massive	35	
Ash of McKay coal bed	1	
Clay shale, buff and white	22	8
Sandstone, shaly, with thin coal beds	5	8
Shale, sandy	21	
Shale, carbonaceous, with streaks of coal	1	6
Shale, changing to sandstone in lower part	11	4
Coal	1	4
Shale	34	
Coal; Terret zone	4	8
Sandstone, massive	14	
Coal; Terret zone	1	11
Sandstone, massive, white, containing bed of ironstone concretions	17	
Coal		11
Sandstone and clayey sandstone	25	
Coal; Burley bed; top eroded	8+	

NW¼ sec. 7, T. 2 N., R. 43 E.

Burley bed.		
Sandstone and shale	55	
Coal		2
Brown-shale parting		1
Coal		7
Shale, brown, carbonaceous		6
Sandstone and shale	20	
Sandstone, hard, concretionary	2	
Sandstone and shale	22	
Shale, gray	11	
Shale, brown		6
Coal		4
Brown-shale parting		1
Coal		2
Shale, brown to gray	3	3
Coal		8
Bone		1
Coal		4
Shale, dark gray, and brown	2	1
Sandstone, buff, and shale, gray	10	
Shale, brown; carbonaceous streaks	1	6
Sandstone, with some shale	21	
Lebo shale member.		
	378	4

Section of part of the Tongue River member of the Fort Union formation at locality 450, sec. 18, T. 3 N., R. 45 E.

	Ft.	in.
Clinker	20+	
Ash of Terret coal bed	1	
Shale and sandstone	26	

Section of part of the Tongue River member of the Fort Union formation at locality 450, sec. 18, T. 3 N., R. 45 E.—Continued.

	Ft.	in.
Sandstone, calcareous	3	6
Shale and sandstone	27	6
Shale, brown		4
Coal; Burley bed	1	5
Shale, brown, with some fine yellow powder	1	6
Sandstone, buff, and shale	33	
Shale, light gray	1	
Coal		3
Sandstone and gray shale; sandstone predominant	16	6
Coal, dirty		2
Coal (in Trial Creek coal zone)	1	5
Sandstone and shale	30	
Lebo shale member.		
	163	7

Section of part of the Tongue River member of the Fort Union formation at locality 80, sec. 34, T. 2 N., R. 43 E.

	Ft.	in.
Clinker	20	
Ash bed (of Knoblock (?) bed of the Ashland field)	2	
Concealed	17	
Sandstone, with some ironstone concretions	20	
Sandstone and shale, interbedded	46	
Coal	2	3
Sandstone	2	
Shale, gray	10	
Coal, bone, and shale	1	6
Shale, gray	9	6
Sandstone, hard	2	6
Sandstone, gray to white, with some shale	8	6
Coal		6
Sandstone, gray to white, with some gray shale	29	6
Coal		3
Shale, brown and gray	1	3
Coal	2	1
Shale, gray, finely laminated	9	6
Sandstone, gray to white, cross-bedded	28	6
Concealed, probably sandstone in lower part	14	
Coal; Terret bed	5	
Shale, hard, brown, sandy		6
Concealed	16	
Sandstone, friable, massive	4	6
Shale, gray, and concealed slope	33	
Shale, black, carbonaceous		3
Coal; Burley bed	6	2
Clay, gritty		3
	292	6

Section of part of the Tongue River member of the Fort Union formation, beginning at locality 631, in the SE.¼ sec. 7, T. 3 N., R. 49 E.

	Ft.	in.
Clinker; Flowers bed	15	
Sandstone, light yellow, shaly	35	

Section of part of the Tongue River member of the Fort Union formation in the SE¼ sec. 7, T. 3 N., R. 49 E.—Continued.

Coal		8
Sandstone, light yellow, shaly	26	
Shale, gray	8	
Shale, brown	1	
Shale, gray	4	
Coal, fairly persistent		6
Shale, brown	1	
Shale, gray	3	
Shale, carbonaceous	1	2
Coal, impure, and shale	1	7
Shale, sandy	28	
Coal		4
Shale, gray	2	
Shale, sandy, light yellow	28	
Shale, light gray	5	
Sandstone, brown	3	
Shale, sandy, light yellow	16	
Shale, carbonaceous, with streaks of coal	1	
Coal	1	5
Shale, sandy, light yellow	10	
Sandstone, brown	1	
Lebo shale member.		
	192	8

TERTIARY (?) AND QUATERNARY DEPOSITS

TERRACE GRAVEL

The terraces along the Yellowstone River are better developed than those in the smaller stream valleys in this field and consequently were studied in greater detail. Twelve terraces, some as far as 8 miles south of the river, were distinguished on the south side of the Yellowstone Valley. These terraces are designated on plate 11 by letters—A for the lowest (youngest) terrace and L for the highest (oldest). Generalized intervals between the terraces in the Yellowstone Valley are as follows:

	Feet
Yellowstone River to A terrace	70
A terrace to B terrace	45
B terrace to C terrace	50
C terrace to D terrace	80
D terrace to E terrace	100
E terrace to F terrace	50
F terrace to G terrace	40
G terrace to H terrace	40
H terrace to I terrace	25
I terrace to J terrace	70
J terrace to K terrace	90
K terrace to L terrace	125
	785

The broadest terrace (D), in T. 6 N., Rs. 42 and 43 E., is about 245 feet above the Yellowstone River; terrace C, about 165 feet above the river, is also well defined.

Elsewhere than in the Yellowstone Valley data on terraces were obtained only incidentally to the coal mapping and are consequently incomplete. The correlations shown on plate 11 are therefore tentative and subject to revision. Seven terraces were recognized in the Pumpkin Creek Valley, the lower five of which correspond to those mapped by Bass [27] in an area adjoining on the south. Five or more terraces are present in the Tongue River Valley but are dissected and discontinuous in many places. Many terrace remnants occur in the Rosebud Creek Valley, but most of them are not shown on plate 11.

Alden,[28] on the basis of physiographic relations, correlates gravel deposits near Glendive, which are between 700 and 800 feet above the Yellowstone River, with the Flaxville gravel, of Miocene or Pliocene age. If dissection of the Flaxville Plain did not begin until early Pleistocene time, then the terraces below the Flaxville are Pleistocene (or younger). A small remnant of a gravel-covered terrace 700 feet above the Yellowstone River in the Forsyth coal field may correspond to the Flaxville Plain, according to Dobbin.[29] In the Rosebud field the highest terrace (L) is about 785 feet above the Yellowstone, so it is tentatively correlated as a remnant of the Flaxville also. Furthermore, the L terrace was found only in the southeast quarter of T. 5 N., R. 44 E., and occurs on the divide, instead of on the sides of valleys like the lower terraces. Remnants of the K terrace were found only in the same area as the L terrace, and possibly it too should be grouped with the pre-Pleistocene terraces, but because it occurs below and on both sides of the divide, it is grouped with the lower terraces. Inasmuch as no fossils were found in any of the terraces, the age classification of the higher terraces is tentative.

A large variety of igneous rocks from granitic to basic are found in the gravel of all the terraces. Quartzite is very abundant, and a few limestone pebbles 2 inches or less in diameter and one 6-inch cobble were noticed. Most of the igneous and quartzite pebbles were probably derived from the mountains far to the west and south, laid down on a plain above the present surface, and later reworked and gradually let down to their present position.

The terraces along the Yellowstone are made up almost entirely of foreign pebbles and cobbles, derived from igneous rocks and

[27] Bass, N. W., The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont.: U. S. Geol. Survey Bull. 831, pp. 44–47, 1932.

[28] Alden W. C., Physiographic development of the northern Great Plains: Geol. Soc. America Bull., vol. 35, no. 2, pp. 402–403, 1924.

[29] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 812, p. 22, 1929.

quartzites, whereas the terraces in some of the tributary valleys contain considerable material derived from local sources, especially clinker fragments. Several of the terraces, particularly the higher ones, contain moss agates.

The size of the material in the terraces varies laterally along the same terrace, as well as between different terraces, from fine sand to boulders 6 inches in diameter. Pebbles half an inch to 1 inch in diameter are common.

The gravel seems to be thicker in the terraces 300 feet or less above the stream beds. At the gravel pit near the airport north of Miles City the gravel in a terrace 290 feet above the Yellowstone is about 50 feet thick. At several places within the Rosebud area the gravel in the terraces less than 300 feet above the Yellowstone is 30 feet thick. The terraces higher than 300 feet above the river commonly have only a thin covering of gravel.

ALLUVIUM

The alluvial silt, sand, and gravel along the Yellowstone and Tongue Rivers and Rosebud Creek are the most recent deposits in the Rosebud coal field. As shown on plate 11, the belt of alluvium is about half a mile wide along Rosebud Creek, three-fourths of a mile wide along the Tongue River, and from 1 to 3 miles wide along the Yellowstone River, but it is cut into small tracts by the meandering of these streams. Alluvium is present also along Pumpkin Creek and many of the other smaller streams, but it is of smaller extent and less distinct than in the areas just mentioned. Although fine sand and silt are predominant, the alluvium is not the same in all places, its composition being dependent in part upon the local source rocks from which it is derived. For example, the alluvium in the Yellowstone Valley contains a noticeable amount of gravel, which is derived from the Pleistocene gravel terraces, whereas the alluvium in the Rosebud Creek and Tongue River Valleys contains a noticeable amount of clinker in areas near a source of clinker supply. The alluvial flats and bottom lands along the three major streams form some of the best farm land in the area. Alfalfa is the most common crop, but where the land is irrigated a variety of crops are grown.

STRUCTURE

RELATIONS AND CHARACTER

The strata in this field are nearly flat-lying. Almost everywhere the dips are so slight that the attitude of the beds can be determined only by accurate instrumental readings over areas several miles in extent. Coal beds constitute the most readily traceable horizons for

this work, but the intervals between them are not everywhere constant, and serious errors are introduced when altitudes on different coal beds are reduced to a common datum plane.

The Forsyth coal field, immediately west of this area, lies, according to Dobbin,[30] in a broad, shallow syncline which connects the Bull Mountain syncline and the Powder River Basin. Bass [31] says that in the Ashland coal field, which adjoins the Rosebud coal field on the south,

> The chief features * * * are a broad syncline 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.

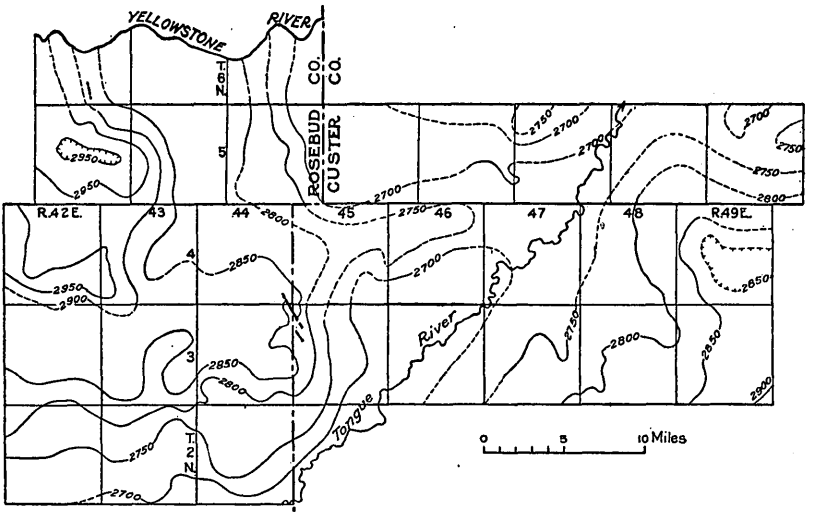


FIGURE 8.—Structure map of the Rosebud coal field.

Figure 8 shows the attitude of the strata in the Rosebud field. The contour lines are drawn on the base of the Lebo member of the Fort Union formation, which is marked by the base of the Big Dirty coal bed in the western part of the field. In the northern part, where the Lebo has been removed by erosion, the base of the member has been restored. The contour interval is 50 feet. Most of the altitudes used in preparing the map were observed on coal beds. In the eastern part of the field the coal beds are very lenticular, so where possible the contact between the Tongue River and Lebo members was used as a supplementary datum. The strata rarely dip more than 1°. The

[30] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 812, p. 22, 1929.

[31] Bass, N. W., The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont.: U. S. Geol. Survey Bull. 831, pp. 47–48, 1932.

few dips of 3° or more are all due to faulting or slumping, so far as could be ascertained.

The predominant structural features of the area are the Tongue River syncline, whose axis follows the Tongue River Valley, trending northeastward from T. 3 N., R. 46 E., to T. 5 N., R. 47 E., and the anticlinal nose that plunges southeastward from T. 5 N., R. 42 E., toward the Tongue River. Both limbs of the Tongue River syncline rise gradually, with numerous irregularities and undulations. Many of the undulations and depressions are too small to be shown on a sketch map. They do not have a definite system or pattern and are probably due to conditions of sedimentation and later differential compaction. The anticlinal nose in the northwestern part of the area is the reflection of minor undulations far out on the flank of the Porcupine dome, which is 30 miles northwest of this area. The maximum structural relief in the Rosebud coal field is 250 feet.

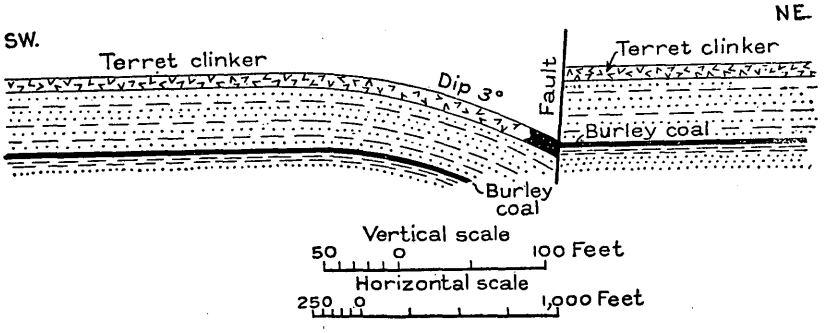
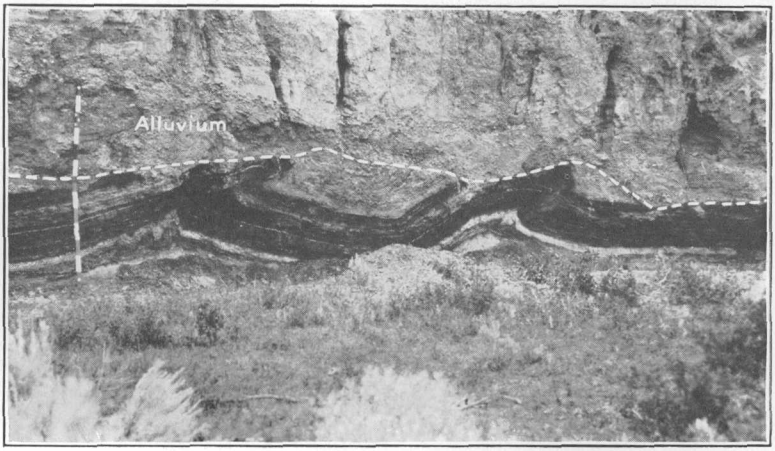


FIGURE 9.—A typical fault in the Rosebud coal field, near the northwest corner of T. 3 N., R. 45 E.

FAULTS

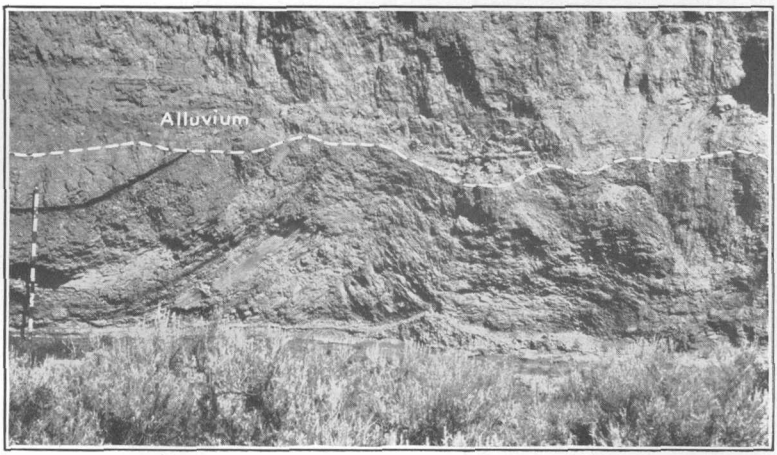
Two small normal faults were mapped in and near the northwest corner of T. 3 N., R. 45 E. (See pl. 11.) They are parallel, having a strike of N. 30° W., and are slightly offset. As the faults are concealed, their position is most easily determined by noting the vertical displacement of the Terret clinker, supplemented by tracing the Burley coal bed, below.

The more northerly fault, which is also the one that was traceable for the greater distance, was examined in detail. It has a maximum throw of 60 feet, with the downthrow on the southwest. Because of the throw and sequence of coal beds the Terret bed, which is generally burned, is nearly at the same horizon on the southwest side of the fault as the Burley bed on the northeast side of the fault. The actual fault plane was observed only at locality 223. This fault is of an unusual type, as shown in figure 9. Displacement appears to have occurred only on the downthrown side. A rise of about 3° SW. carries the displaced beds up to their normal posi-



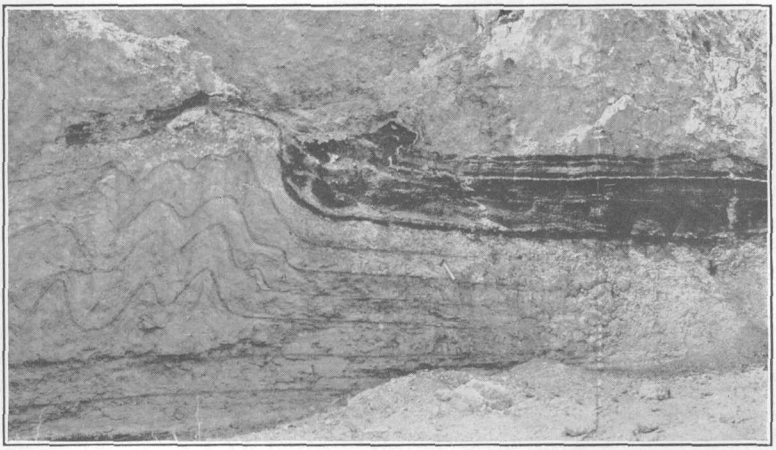
A. SUPERFICIALLY FOLDED COAL BED ON SWEENEY CREEK, SE¼ SEC. 27, T. 6 N., R. 43 E.

The contact between the overlying alluvium and the Tullock member of the Lance formation is indicated by a broken line. The stadia rod on the left is 13 feet high.



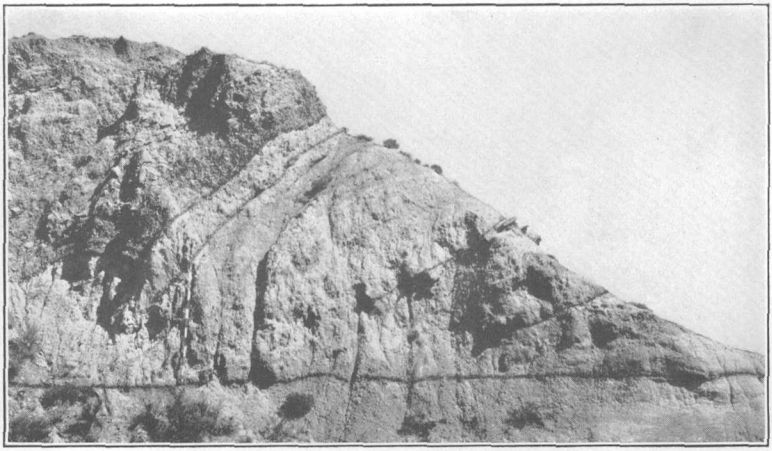
B. SUPERFICIAL FOLD EXPOSED ON COAL CREEK, SW¼ SEC. 30, T. 6 N., R. 44 E.

The folded beds of the Tullock member are truncated by alluvium about 3 feet above the top of the 13-foot stadia rod.



A. SUPERFICIAL FOLD INVOLVING A COAL BED IN THE TULLOCK MEMBER OF THE LANCE FORMATION, SEC. 14, T. 4 N., R. 47 E.

The shale a few feet below the folded coal bed is not folded; part of the coal bed has been removed by erosion and is overlain by alluvium.



B. SLUMP BLOCK OF STEEPLY DIPPING TONGUE RIVER STRATA RESTING ON HORIZONTAL LEBO BEDS, SEC. 23, T. 3 N., R. 47 E.

The base of the 13-foot stadia rod is on the plane of movement, which is a bedding surface. (See fig. 10 for a diagram of the slump.)

tion within 1,000 to 1,500 feet from the fault. It seems likely that the faulting took place before the burning of the Terret coal bed in the immediate vicinity of the fault, because the strata along part of the west or downthrown side of the fault are not baked or clinkered. The down-faulting at these places buried the coal, so that it could not get sufficient oxygen for burning. The more southerly of these two faults is poorly exposed, and little is known about it, but it is probably related and similar to the one just described.

In the NW¼ sec. 34, T. 6 N., R. 42 E., another fault of the same type has a throw of about 35 feet and strikes N. 10° W. The strata on the west side are downthrown and they dip toward the fault at a maximum angle of 3°. It is probable that there are several other faults in the area which are not shown on the map. In the SE¼ sec. 31, T. 4 N., R. 45 E., a dip of 3°30′ was noticed, and a similar fault was suspected but could not be found. Differences in the altitude of the coal beds in the southern part of sec. 33, T. 4 N., R. 44 E., suggest the possibility of a small concealed fault there.

The small throw and short linear extent of the faults suggest that they may not have a deep-seated origin. Inasmuch as they occur in loosely consolidated strata of continental origin, it seems quite likely that they may be due in some way to differential compaction of the underlying beds.

Faulting of the same type as here described has been noted by Rogers and Lee in the Tullock Creek coal field.[32]

SUPERFICIAL FOLDS AND SLUMPS

Three small asymmetric folds, one so sharply folded that displacement has occurred, were found in the Rosebud field. The views in plate 7, *A*, *B*, and plate 8, *A*, will convey the detail and size of these folds more accurately than a written description. One of the folds is exposed in a cut bank of Sweeney Creek in the SE¼ sec. 27, T. 6 N., R. 43 E.; another 3 miles to the east, in a cut bank of Coal Creek in the N½ sec. 31, T. 6 N., R. 44 E.; and the third, 25 miles southeast of the other two, in a tributary valley of the Tongue River in the SW¼ sec. 14, T. 4 N., R. 47 E.

These folds occur in an area of flat-lying strata, where the regional dip is about 10 feet to the mile. They are 25 to 100 miles from areas of large folds or structural deformation. All the folds are in the Tullock member of the Lance formation, which, either as a whole or in part, is not competent to transmit a thrust for any great distance.

The outstanding features of these folds may be summarized as follows: (1) They do not persist with depth. A close examination of

[32] 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, p. 52, 1932.

plate 8, *A*, shows that about 4 feet of the shale below the coal bed is folded, but the rest of the shale, to the bed of the creek, is not folded. The crest of the folded coal bed has been eroded and then covered with alluvium; (2) all three of the folds occur in the bottoms of valleys and are only slightly above the beds of the streams; their trends are parallel to the valleys in which they occur; (3) alluvium is present a few feet above each of the folds, but is not involved in the folding; (4) the pressure apparently has not come from the same direction in all the folds, for two of them are either asymmetric or overturned to the east and one is asymmetric in the opposite direction.

The writer has come to the conclusion that these folds are of surficial origin and are not connected with any regional deformation.

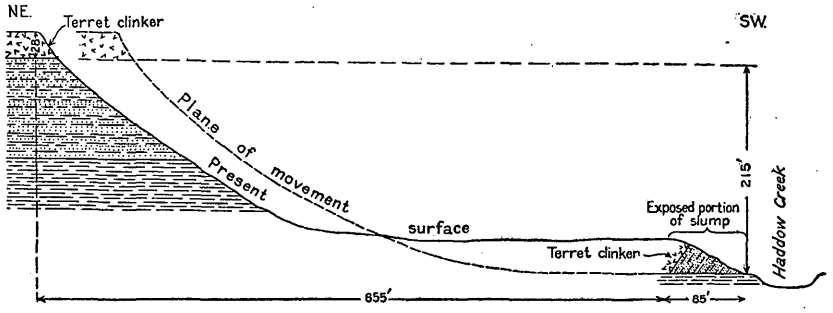


FIGURE 10.—Diagrammatic section of a slump in T. 3 N., R. 47 E., drawn to scale and normal to the plane of movement.

Although a search was made for evidence of some force that produced each individual fold, nothing of significance was found in their immediate vicinity. However, in the same general area an exposure of a slump revealed evidence which suggests a genetic relationship between slumping and surficial folds. The slump is in the southwest corner of sec. 13 and the northeast corner of sec. 23, T. 3 N., R. 47 E. In figure 10 the highest bed on the left is clinker of the Terret coal bed. Clinker from this same bed has moved down a vertical distance of 215 feet while moving a horizontal distance of 655 feet minus the amount of recession of the clinker escarpment since the slump began. The broken line indicating the plane of movement is drawn arbitrarily. A detailed view of the displaced block in the lower right corner of figure 10 is shown in plate 8, *B*. In this photograph the displaced block has moved from left to right. The beds dip 60° toward their original position, that is, into the plane of movement. The base of the stadia rod is on the plane of movement, which coincides with a horizontal bedding plane and is not an old erosion surface. As the movement has been on a bedding plane, the strata above it must have been shoved up in front of the slump block and have

produced a small superficial fold, which has since been removed by the erosion of Haddow Creek. If the movement was along a poorly lubricated surface, considerable drag would be expected, which might produce sharply overturned and ruptured folds, such as the one shown in plate 7, *A*. Such drag effect would also produce differential horizontal movement decreasing downward from the slump plane. Thus the superficial folds that occur in this field may be the result of slumping, acting in either of the two ways mentioned. The movement however may not have been of the same proportion and scale as that just illustrated but may have involved a much larger block which moved only a very short distance.

A landslide at a shale quarry in Cleveland, Ohio, that was accompanied by buckling and anticlinal folding is described by Van Horn.[33] He thought that vertical pressure was more effective than horizontal pressure in producing the folding. Bucher[34] describes some small folds near Cincinnati which he attributes to the pressure of flowing layers of shale beneath the fold, just as clay buckles or squeezes in the bottom of an excavation or in a coal mine. Another explanation[35] that has been offered for the origin of similar superficial folds is expansion caused by weathering and the action of meteoric waters. The superficial folding in the Rosebud field might be correlated with weathering action insofar as the location and character of the folds are concerned, for they occur in the bottoms of valleys with alluvium overlying them and they die out with depth, but the quantitative effectiveness of this process has not been tested. Glacial action has been advanced as the cause of other superficial folds but need not be considered here, as the Rosebud field lies outside the limits of any known ice sheet.

GEOMORPHOLOGY

In middle Tertiary time this region was probably an extensive plain of low relief, covered in many places by gravel. Regional uplift started cutting by the streams, followed by many interruptions in the erosion cycle. The successive terraces along the Yellowstone River and many of the other streams indicate several changes of baselevel or changes in gradient of the trunk streams. The Rosebud coal field was never covered by Pleistocene glaciers,

[33] Van Horn, F. R., Landslide accompanied by buckling and its relation to local anticlinal folds: Geol. Soc. America Bull., vol. 20, pp. 625–632, 1910.

[34] Bucher, W. H., The mechanical interpretation of joints: Jour. Geology, vol. 29, no. 1, pp. 18–23, 1921.

[35] Campbell, M. R., Rock folds due to weathering: Jour. Geology, vol. 14, no. 8, pp. 718–721, 1906. Croneis, Carey, Geology of the Arkansas Paleozoic area, with especial reference to oil and gas possibilities: Arkansas Geol. Survey Bull. 3, p. 336, 1930. Woolnough, W. G., "Stone rolls" in the Bulli coal seam of New South Wales: Royal Soc. New South Wales Jour. and Proc., vol. 44, pp. 334–340, 1910; Pseudotectonic structures: Am. Assoc. Petroleum Geologists Bull., vol. 17, no. 9, pp. 1098–1106, 1933.

but the margin of the farthest advance of the continental ice sheet—in late Pleistocene time—passed about 80 miles north of this field and crossed the Yellowstone River about 100 miles below Miles City. The ice blocked the mouth of the Yellowstone, the major stream in this section of Montana, and doubtless affected the development of the present surface features of the Rosebud coal field. A discussion of the origin, history, and development of the stream terraces that occur in many parts of the Rosebud field is beyond the purpose of this report; a more detailed report on the Pleistocene terraces in southeastern Montana is being prepared. The terraces and stream-worn gravel composed of material foreign to this region occur not only along the major streams but also along and at the heads of small streams, such as Sweeney, Graveyard, and Moon Creeks. Inasmuch as these small streams could never have transported the gravel from its original source in the mountains far to the west and south, the conclusion is reached that some of the material from an extensive Tertiary gravel-covered plain has been let down and forms part of the terrace deposits now present in this area. Erosion in the Rosebud field has removed this plain, which corresponds to either the Cypress Hills or the Flaxville Plain.

Many of the smaller streams have the apparently anomalous condition of a steep gradient combined with sharply meandering channels in alluvial valleys, for the streams are so heavily loaded with alluvial material that they are at grade, even though the gradient is steep.

The drainage pattern of the eastern part of Montana has several unusual features. The valleys of the Yellowstone, Tongue, and Powder Rivers and other streams are asymmetric, or, to express it in another way, the southeastward-flowing tributaries of these streams are short in comparison with the tributaries flowing northwest. This same general relation is found in the Rosebud field. The southeast tributaries of the Tongue River, for instance, are about twice as long as the northwest tributaries. Another unusual feature in the regional drainage pattern is the change in the course of streams from northeast to northwest. Figure 7 will serve to illustrate these northwest bends of streams—for example, the Powder River, the Tongue River, Rosebud Creek, and the Musselshell River. Similarly, Ash Creek, in the southeastern part of the Rosebud field, flows toward Pumpkin Creek until within 2 miles of it and then makes a turn of more than 90° and flows northwestward into the Tongue River. Although the headwaters of Ash Creek appear to have been tributary to Pumpkin Creek at one time, that time must have been back in the Pleistocene epoch, for there is no evidence of an ancient channel across the Ash Creek-Pumpkin Creek divide, and there are at least five terraces in the Pumpkin Creek Valley below this divide.

If the upper part of Ash Creek once flowed into Pumpkin Creek, there has been between 110 and 150 feet of downcutting by Ash Creek since it became a tributary of the Tongue River. Still another example in the Rosebud field is Moon Creek, in T. 5 N., R. 46 E., which flows northeastward toward the Tongue River in its upper part but turns abruptly and flows northward and northwestward into the Yellowstone River.

The asymmetric form of valleys that trend northeast and the change in stream trends from northeast to northwest suggest that the region has been tilted, the southeastern part rising in relation to the northwestern part. At the time of tilting this region was probably one of low relief with mature streams, so that only a small amount of tilting was necessary to produce the anomalies now present. This tilting would increase the gradients of small streams that were flowing northwestward into larger streams that presumably drained northeastward and would decrease the gradients of the small streams that were flowing southeastward into the same larger streams. The advantage possessed by the northwestward-flowing tributaries over the southeastward-flowing tributaries would cause the divides between major streams trending northeast to shift gradually toward the southeast and thus develop the asymmetric valleys that now exist. The abrupt change in trend from northeast to northwest of several streams of various sizes may be due, in large part, to piracy, which resulted also from tilting. The cutting power of the streams that flowed northwestward would be increased by a northwestward tilt, whereas the major streams, which are presumed to have been flowing northeastward, would not have their gradients affected by such a tilt. Consequently, some of the northwestward-flowing streams would, by headward erosion, cut back until they captured the waters of some northeastward-flowing streams. Possibly some of the large streams were diverted from their channels as a direct result of tilting, but this would require either a large amount of tilting or an area of extremely low relief, or a combination of the two. An additional result of tilting toward the northwest would be the tendency for some of the small valleys to develop with a prevalent northwest trend. The parallel northwest trend of the small valleys has been noted by Russell,[36] but he ascribes a different origin to them.

COAL

GENERAL SECTION

As the strata in this field are nearly flat lying, the oldest coals occur in the lower areas and the youngest at greater altitudes. Ex-

[36] Russell, W. L., Drainage alignment in the western Great Plains: Jour. Geology, vol. 37, no. 3, pp. 249–255, 1929.

cept for a few local lenses of coal less than 18 inches thick in the Hell Creek member of the Lance, the lowest coal stratigraphically is the Wright bed, the base of which is at the contact of the Tullock and Hell Creek members of the Lance formation. The Tullock member contains several thin coal beds, most of which are in the upper 100 feet. Coal in the lower part of the Tullock was mapped in T. 6 N., Rs. 42, 43, and 44 E.; T. 5 N., Rs. 48 and 49 E.; and T. 4 N., R. 47 E. The Big Dirty bed, at the base of the Lebo member of the Fort Union in the western part of the field, and local beds at the base of the Lebo in the eastern part of the field are of minor importance as a source of coal because of the impurity of the coal. Only at a relatively few places was the Big Dirty bed found to be of fair quality. The thickest and cleanest coal beds in this field are in the Tongue River member of the Fort Union formation. In this member the Burley and Terret coal beds are the two most important when both thickness and areal extent are considered. The Rosebud bed is the thickest coal bed in the field but is only of small lateral distribution in the southwestern part of the field.

The stratigraphic position of the coal beds in the Rosebud field and their relations to the coals of the Ashland, Forsyth, and Miles City fields are shown in plate 9. The coal beds present in these three adjoining fields extend into the Rosebud field, thus making correlation of beds among these four fields possible by actual tracing of the outcrops. The thickness of the principal coal beds of the Rosebud coal field and the average intervals between them are as follows:

Principal coal beds west of Tongue River in the Rosebud field

	Feet
Tongue River member of the Fort Union formation:	
Coal, Rosebud bed	20
Interval	30
Coal, McKay bed	5
Interval	145
Coal, Terret bed	12
Interval	50
Coal, Burley bed	6
Interval	50
Coal, in Trail Creek coal zone	2
Interval	60
Lebo member of the Fort Union formation:	
Interval, which, in T. 5 N., R. 46 E., and adjacent townships, contains coal from 1 to 2½ feet thick in a discontinuous bed, 90 to 100 feet below the top of the Lebo	170–190
Coal, Big Dirty bed	2½
Tullock member of the Lance formation:	
Interval, containing local coal beds principally in upper 100 feet	270
Coal, Wright bed	2
Hell Creek member of the Lance formation.	

Principal coal beds east of Tongue River in the Rosebud field

	Feet
Tongue River member of the Fort Union formation:	
Coal, Flowers bed	8
Interval	25–30
Coal, Haddow bed	2–5
Interval	40–75
Coal, Terret bed	9
Interval	25
Coal, Foster bed	1–2½
Interval	60–90
Lebo member of the Fort Union formation:	
Interval	200
Coal	0–2
Tullock member of the Lance formation:	
Interval, containing local coal beds from 1 to 3 feet thick in the upper 100 feet and lower 90 feet	290

THE COAL BEDS

The position of the outcrops of the different coal beds is shown on plate 11. Most of the numbers along the outcrop lines indicate the locations where the coal beds were measured and refer to coal sections given in the township descriptions and in plates 12 to 21 and figures 12 to 32. Plate 10 shows two generalized sections of the coal beds of the Rosebud field, one extending north-northeastward and the other eastward across the field. The abrupt termination of the Rosebud, McKay, and Flowers beds is due to their removal by erosion. Information is lacking on the coals in the Lance formation in the southwestern part of the field because they are covered, but inasmuch as the coal beds are probably thin and at considerable depth below the surface, they are not of economic value under present conditions.

The coal beds in the Tullock and Lebo members are thin and lenticular. Because of their lenticularity, their correlation is difficult and uncertain. Plate 11 shows some of these beds as continuous over many square miles of area, whereas in reality there are several discontinuous beds at slightly different stratigraphic horizons. On the graphic coal sections coal beds that may be discontinuous but occur at approximately the same stratigraphic horizon are also grouped. Figure 11, drawn from actual coal-section measurements, illustrates graphically the lenticularity of the coal in the lower part of the Tullock member of the Lance formation. These sections were measured on practically a straight line of outcrop along the Yellowstone River in T. 6 N., R. 43 E. From this figure it is evident that, unless the coal sections are measured at close intervals, erroneous correlations will be made. Partings in coal beds are often regarded as a criterion for correlation, but, as the figure illustrates, they are not infallible. The sandy parting present in the five center sections is equivalent to shale partings in the sections on the extreme left

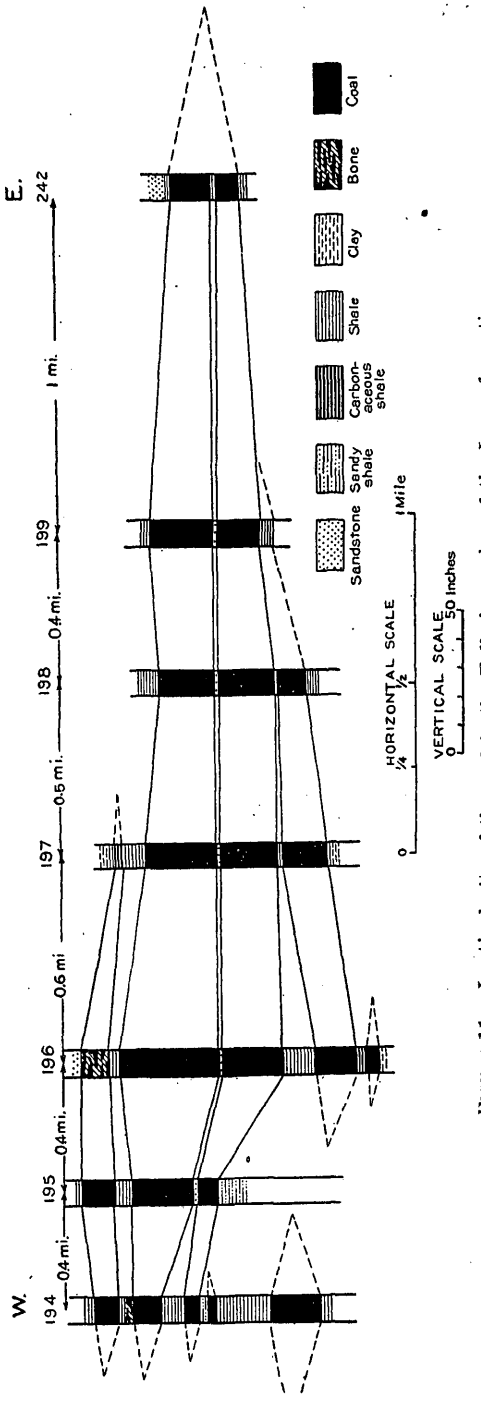


FIGURE 11.—Lenticularity of the coal in the Tullock member of the Lance formation.

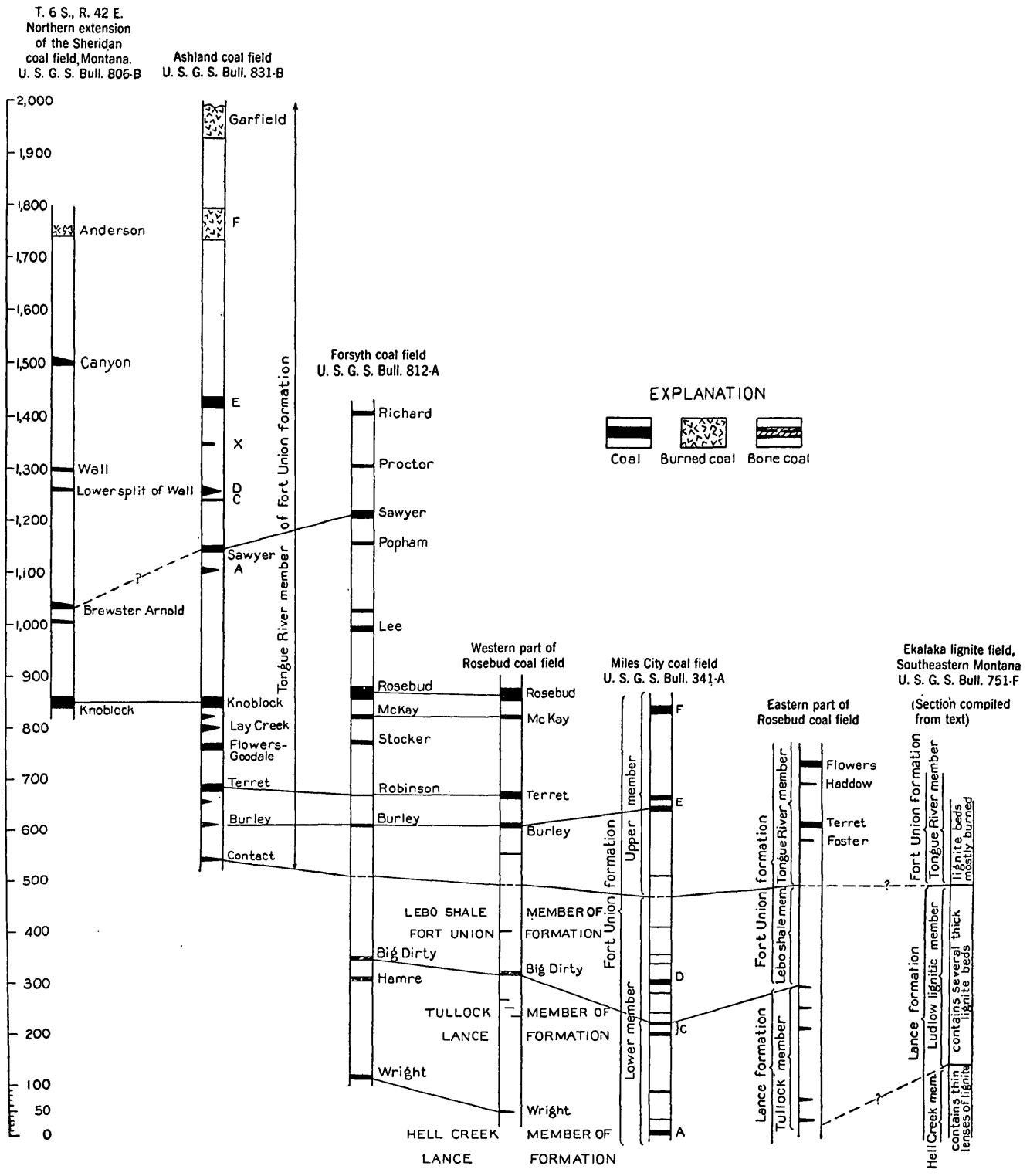
and right. The rapid change of strata above and below the coal beds is also illustrated by figure 11.

COALS OF THE TULLOCK MEMBER OF THE LANCE FORMATION

Wright bed.—The Wright bed crops out only in the northwestern part of the field. At locality 177 there is 3 feet of coal in this bed. At localities 7 and 163 it is about 2½ feet thick. At five of the remaining ten localities where sections were taken, the coal is only slightly over 18 inches thick, and at the other five localities the Wright bed contains less than 18 inches of coal. A thin but fairly persistent bed 25 feet above the Wright was measured at three places. Only at locality 2 does it contain 18 inches of coal. In the Forsyth field[37] the Wright bed is described as occurring at many places in two benches about 26 feet apart.

Coal beds in the lower part of the Tullock.—Along the Yellowstone River in parts of T. 6 N., Rs. 42, 43, and 44 E., several coal beds occur in the lower part of the Tullock member of the

[37] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 812, p. 26, 1929.



STRATIGRAPHIC POSITION OF THE COAL BEDS IN THE ROSEBUD COAL FIELD AND THEIR CORRELATION WITH PRINCIPAL COALS OF ADJOINING FIELDS.

Lance formation. The thickest and most extensive of these beds has a maximum thickness of 4 feet 9 inches of coal and a 1½-inch parting at locality 196, in T. 6 N., R. 43 E. It thins rapidly westward and gradually eastward from this locality. (See fig. 11.)

In the central part of T. 4 N., R. 47 E., a coal zone between 200 and 235 feet below the top of the Tullock member contains two coal beds 25 to 35 feet apart, which have a maximum thickness of about 3½ feet. The upper bed is generally dirty. The lower bed crops out at several places along the Tongue River; it contains about 3 feet of fair coal.

In the northeastern part of the field coal was found at only two localities in the lower part of the Tullock member. At these outcrops, on Johnson and Pumpkin Creeks, the coal is about 2 feet thick.

Coal beds in the upper part of the Tullock.—Coal in the upper 100 feet of the Tullock member of the Lance formation occurs in many places in the Rosebud field. Most of the coal is of poor quality, and none of the beds are thick.

In the Rosebud Creek Valley the coal in the upper part of the Tullock member is 50 to 85 feet below the top. In T. 5 N., R. 42 E., three beds in this zone, 45, 60, and 85 feet from the top of the Tullock member, range in thickness from 1½ feet or less to about 2½ feet. In T. 4 N., R. 43 E., a small drift mine has been operated for local supply at locality 157; the bed is 2 feet 10 inches thick and 75 feet below the top of the Tullock member. At locality 28, in T. 3 N., R. 42 E., there are two beds about 2 feet thick, 50 and 60 feet below the top of the Tullock member. About a mile farther north, at locality 27, in T. 4 N., R. 43 E., one of these beds contains 3 feet of coal, but still farther north and west it is less than 18 inches thick.

In the Tongue River Valley and the lower part of the Pumpkin Creek Valley thin coal beds are present in the upper 100 feet of the Tullock member. The beds are generally 3 feet or less in thickness; beds 5 feet thick are of local extent. Over half of the coal is impure, because of thin, irregular lenses and layers of carbonaceous shale and bone.

COALS OF THE LEBO SHALE MEMBER OF THE FORT UNION FORMATION

Big Dirty bed.—The coal bed at the base of the Lebo in the western part of the field is correlated with the Big Dirty bed of the Forsyth coal field.[38] In the Rosebud Valley the Big Dirty bed can be traced easily. Where it does not contain coal its horizon is marked by a carbonaceous shale bed 3 to 4 feet thick. In the Tongue

[38] Dobbin, C. E., op. cit., p. 26.

River Valley and eastward the bed is more discontinuous, and so the name "Big Dirty" is not used in that region.

The Big Dirty bed in this field is not as thick as it is in the coal fields to the west, and it is of poor quality. Numerous sections of this bed were measured, but at only a few places is the coal clean enough to be used for a domestic fuel. It is predominantly a carbonaceous shale bed from 2 to 5 feet thick, in which there are thin seams of coal grading almost imperceptibly into the shale. At locality 396, in T. 4 N., R. 46 E., the bed at the base of the Lebo contains 5 feet 3 inches of slightly dirty coal with a parting of shale 1 inch thick. About half a mile south of this place, however, at locality 400, the bed is more impure and does not contain 1½ feet of clean coal. In parts of the Rosebud Creek Valley a bed of shale and dirty coal occurs about 15 feet above the Big Dirty.

Bed at the base of the Lebo in the eastern part of the field.—A bed at the base of the Lebo in the Tongue River Valley and in part of the area east of this river is at the stratigraphic position of the Big Dirty bed and is similar to it but is discontinuous. The coal is generally dirty and unsuitable for mining.

Bed in the upper part of the Lebo.—A discontinuous coal bed 90 to 100 feet below the top of the Lebo member is mapped in the eastern part of T. 5 N., R. 46 E., and the western part of T. 5 N., R. 47 E. The coal is usually dirty and ranges from about 1 to 3 feet in thickness. It is equivalent to bed D of the Miles City coal field.

Local beds in the Lebo.—Local coal beds in the Lebo member are lenticular and impure and are thus not important as a probable source of coal. In the northeast corner of T. 5 N., R. 49 E., a bed about 3½ feet thick, which is between 50 and 75 feet above the base of the Lebo, has burned along its outcrop and formed clinker. The bed contains very little recoverable coal in this township.

In T. 4 N., R. 43 E., a local bed was mapped for a few miles; at locality 158 it contains 2 feet 8 inches of bony coal and 10 inches of clean coal. In T. 3 N., R. 47 E., a bed of coal in the Lebo has a maximum thickness of 1 foot 10 inches of clean coal.

COALS OF THE TONGUE RIVER MEMBER OF THE FORT UNION FORMATION

Bed at the base of the Tongue River member.—A thin coal bed is present at the base of the Tongue River member in T. 5 N., R. 46 E. On the west side of Moon Creek it is less than 1½ feet thick, and in the southeast corner of the township it has an average thickness of 2 feet in an area of about 1 square mile.

Trail Creek coal zone.—The Trail Creek coal, named from Trail Creek, is a fairly persistent bed in T. 2 N., R. 44 E. West and north of this township, however, it pinches out, but other coal beds occur

at nearly the same horizon and at lower horizons in the basal 60 feet of the Tongue River member. For convenience these coal beds are all grouped as the Trail Creek coal zone. The Trail Creek zone is restricted to the area between Rosebud Creek and the Tongue River. In the northern part of T. 2 N., R. 43 E., it contains two beds from 30 to 40 feet apart. The most persistent coal bed in the zone is generally about 50 feet below the Burley bed. The coal beds in the Trail Creek zone range from 1½ feet or less to 3½ feet in thickness.

Burley bed.—The Burley bed is correlated with the bed of the same name in the Forsyth and Ashland coal fields. It crops out only in that part of the Rosebud field lying west of the Tongue River. West of Rosebud Creek it is 5 to 8½ feet thick, but northward along the Tongue River-Rosebud Creek divide, it thins from 6 feet 2 inches in the southern part of T. 2 N., R. 43 E., to 3 feet in the northeastern part of the same township and less than 2 feet in the western part of T. 3 N., R. 44 E., where it is difficult to trace. In the extreme southern part of T. 4 N., R. 45 E., a bed at the same horizon as the Burley begins to thicken rapidly toward the north. It is not certain that this bed is the same as the Burley, in the southern part of the field, but for the purpose of clarity it is designated by the same name. This bed reaches a maximum measured thickness of 9 feet 6 inches at locality 229, in sec. 12, T. 4 N., R. 44 E.; north of this locality it has burned along the outcrop and formed a thick clinker, which is correlated with bed E of the Miles City field. The Burley coal is clean and of good quality. This bed contains more coal than any other bed in the Rosebud field.

Foster bed.—The Foster coal bed underlies a small area in the eastern part of T. 3 N., R. 47 E., and the western part of T. 3 N., R. 48 E. An interval of 28 feet between the Foster and Terret beds near the south line of these townships decreases to 16 feet 5 miles to the north. The Foster coal is usually in two beds from 1½ to 5 feet apart; the coal in one or the other of the beds is generally between 1½ and 2½ feet thick.

Terret bed.—The Terret coal bed, which is correlated with the Terret bed in the Ashland field, has burned along most of its outcrop and produced the clinker on the divide between Rosebud Creek and the Tongue River in this area. This bed averages 12 feet in thickness on the Rosebud-Tongue divide south of T. 4 N., and where unburned will yield valuable coal. A mile north of T. 3 N., Rs. 44 and 45 E., it splits up into thin coal beds. Also, on the west side of Rosebud Creek it splits and thins to less than 18 inches of coal. The Terret bed is within a few feet of the same stratigraphic horizon as the Robinson bed in the Forsyth field.

On the east side of the Tongue River the Terret bed is present in the eastern part of T. 3 N., R. 47 E., and the southwestern part of

T. 3 N., R. 48 E. It has burned along most of the outcrop, but the clinker is partly obscured by clinker of higher beds. East of the Tongue River the Terret coal has a maximum measured thickness of 10 feet and an average thickness of 8 feet, except east of the middle of T. 3 N., R. 48 E., where it thins rapidly eastward and becomes less than 18 inches thick.

On the west side of the Tongue River the Terret bed is 160 feet above the base of the Tongue River member; on the east side of the river the interval decreases to about 90 feet. This difference may possibly be due to a change in the stratigraphic position of the Tongue River-Lebo contact.

Haddow bed.—The Haddow coal bed is named from Haddow Creek, in T. 3 N., R. 47 E.; it occurs only near the head of this creek. The bed is of small areal extent and is about 2 feet thick, except in the extreme southeast corner of T. 3 N., R. 47 E., where it has a maximum thickness of 5½ feet.

Flowers bed.—The Flowers coal bed is the northern continuation of the Flowers-Goodale bed in the Ashland coal field. It is present in the southwestern part of T. 3 N., R. 48 E., and small outliers of clinker remain in the extreme eastern part of T. 3 N., R. 47 E. The coal is between 7 and 8 feet thick and is extensively burned along the outcrop. The Flowers bed is 60 feet above the Terret bed in the western part of the township and 35 feet above in the eastern part; it is the uppermost coal bed in the Tongue River member in the area east of the Tongue River.

McKay and Rosebud coal beds.—The McKay bed is about 145 feet above the Terret bed, and the Rosebud bed is 30 feet above the McKay. The McKay and Rosebud beds are the uppermost of the series of coal beds present in this field and occur only in T. 2 N., R. 42 E. Here, however, the Rosebud bed, which is over 20 feet thick, and the McKay bed, which is 5 feet or more thick, have been largely removed by erosion and burning. These two beds extend into both the Forsyth and Ashland coal fields.

PHYSICAL AND CHEMICAL PROPERTIES

The coal in the Rosebud coal field is of subbituminous rank. The coal in the Tongue River member of the Fort Union formation is of good grade, but that occurring in lower members and formations is poorer. The coal is shiny black, has a conchoidal fracture, and disintegrates and loses moisture when exposed to the air. There were no operating mines from which unweathered samples could be procured in this field; consequently samples for analysis were not obtained. Analyses of coals from nearby fields will, however, serve as an index of the values to be expected in this field. In the following table of analyses form A represents the composition of the

sample as received in the laboratory, form B the theoretical composition after all moisture has been eliminated, and form C the composition after both ash and moisture are removed. All the analyses were made in the laboratory of the United States Bureau of Mines at Pittsburgh, Pa.

Analysis of coal from fields near the Rosebud field

Location	Laboratory no.	Air-drying loss	Form of analysis	Proximate				Ultimate					Heating value	
				Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units
Colstrip, Mont., composite of 4 analyses, Rosebud bed, sec. 34, T. 2 N., R. 41 E.	A19659..	6.6	A	24.1	28.4	40.2	7.3	0.7	6.2	53.6	0.7	31.5	5,050	9,090
			B	-----	37.4	53.0	9.6	1.0	4.7	70.6	1.0	13.1	6,644	11,960
			C	-----	41.4	58.6	----	1.1	5.2	78.1	1.1	14.5	7,350	13,230
Miles City, Mont., average of 2 samples from Kircher bed.	5694 and 5780.	16	A	29.6	27.7	33.4	9.4	.7	----	-----	----	-----	4,221	7,598
			B	-----	39.3	47.4	13.3	1.0	----	-----	----	-----	5,992	10,786
			C	-----	45.3	54.7	----	1.1	----	-----	----	-----	6,910	12,437
Sheridan, Wyo., composite of 12 analyses, Monarch bed.	25224....	11.7	A	23.8	32.4	40.5	3.3	.4	6.5	55.3	.9	33.7	5,213	9,383
			B	-----	42.5	53.1	4.3	.5	5.1	72.5	1.2	16.4	6,843	12,317
			C	-----	44.5	55.5	----	.5	5.3	75.8	1.2	17.1	7,154	12,877
Scranton, N. Dak., sec. 24, T. 131 N., R. 100 W.	A45697..	21.6	A	41.2	24.8	26.9	7.1	1.4	7.2	37.8	.6	45.9	3,617	6,510
			B	-----	42.2	45.8	12.0	2.4	4.5	64.3	1.0	15.8	6,150	11,070
			C	-----	47.9	52.1	----	2.8	5.1	73.1	1.1	17.9	6,989	12,580
Roundup, Mont., composite of 2 analyses, Roundup bed, secs. 23-25, T. 8 N., R. 25 E.	A31560..	7.5	A	13.2	28.7	49.8	8.3	.5	5.6	62.6	1.0	22.0	6,011	10,820
			B	-----	33.1	57.3	9.6	.6	4.8	72.1	1.1	11.8	6,922	12,460
			C	-----	36.6	63.4	----	.6	5.3	79.8	1.3	13.0	7,661	13,790

The coal in the Tongue River member of the Fort Union formation in the Rosebud field probably is similar chemically to that at Colstrip, Mont. (no. A19659). The older coals should correspond more closely with those near Miles City, Mont. (nos. 5694 and 5780). The difference in the chemical composition and properties in the coals from west to east may be seen by a comparison of the analyses of samples from Roundup, Colstrip, and Miles City, Mont., and Scranton, N. Dak.

COAL CLINKER

The coals in the Tongue River member of the Fort Union formation, especially the Terret, Rosebud, Flowers, and Burley beds, have burned along their outcrops, so that the overlying beds are baked and reddened. After the burning has extended in from the outcrop a few feet, the heat is transmitted to the overlying strata. The sandstones and shales overlying the burned coal are fused and baked for several tens of feet vertically. The exact distance is largely dependent upon the thickness of the coal bed and the cracks and openings available for oxygen to reach the burning coal and for gases to escape. Clinker 50 feet thick is not uncommon. The character of the clinker depends not only on the intensity of the heat but also on the kind of rock. For instance, a

sandstone bed only a few feet above the burning coal may be only slightly altered, while a bed of shale or sandy shale above this may be fused. The beds below a burned coal bed appear to be unchanged. Spontaneous combustion seems to be the cause of most of the burning, although ignition may occasionally have been due directly or indirectly to lightning or human agency. Locally the ash bed of the Terret coal has been cemented by lime, forming a bed of hard white porous rock about a foot thick. The physical and chemical effects accompanying the formation of clinker are discussed more completely by Rogers.[39]

The limits of the clinker or baked rock on the surface are taken as an index of the extent of burning. As the Burley, Terret, Flowers, and Rosebud beds are extensively burned, the estimated limit of burning of these beds is shown on plate 11.

Many of the smaller coal beds are oxidized along their outcrop, but no clinker is formed. A bed of soft red sooty material a few inches thick may be all that remains at the outcrop of a 3-foot coal bed that has been oxidized. This slow oxidation does not extend in far from the outcrop and occurs more commonly in coal beds 3 feet or less in thickness. There does not appear to be any accompanying change in the overlying or underlying strata. The ash from these oxidized beds is different from that at the base of the clinker. The oxidation of these thin coal beds probably never reached the kindling temperature. The oxidized outcrop is indicated on the map in the same way as the burned outcrop.

QUANTITY OF COAL

In the accompanying table the estimated coal tonnage is given both by beds and by townships. In making these estimates, there were two important factors that could not be determined with a fair degree of accuracy—the extent to which the coal beds have been burned under cover, and the amount of coal contained in beds less than 3 feet thick. The first factor was determined as accurately as possible by a study of the field conditions, but drilling will be necessary for more precise information. The second factor is largely one of interpretation and affects the tonnage estimates of coal in the Lebo member of the Fort Union formation and the Tullock member of the Lance formation. The coal in these two members is extremely variable in thickness and purity; a bed which at one locality is 3 feet thick may not contain 1½ feet of clean coal half a mile away. In estimating the quantity of coal in these members, a minimum figure rather than a maximum was used. A maximum

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

figure, which would include probable coal beds entirely concealed by cover, would increase the estimate several times. Such beds, however, are similar to those that are known from outcrop measurements and are not of much economic importance, although their aggregate quantity over large areas may run into millions of tons. For the townships in which coal in the Lebo and Tullock members does not crop out no estimate of the quantity of coal which they may contain is given.

Estimated quantity of coal in Rosebud field, by beds and townships, in millions of tons

	Fort Union formation							Lance formation		
	Tongue River member						Lebo member	Tullock member		
	Rosebud	McKay	Foster	Terret	Burley	Trail Creek [1]	Big Dirty and local beds	Upper part of Tullock	Middle and lower Tullock, including Wright	Total
T. 6 N., R. 42 E. (fractional)	------	------	------	------	------	------	------	------	1	1
T. 5 N., R. 42 E.	------	------	------	------	------	------	4	10	20	34
T. 4 N., R. 42 E.	------	------	------	------	------	------	5	3	6	14
T. 3 N., R. 42 E.	------	------	------	------	15	------	3	4	------	22
T. 2 N., R. 42 E.	33	14	------	1	171	7	------	------	------	226
T. 6 N., R. 43 E. (fractional)	------	------	------	------	------	------	------	------	10	10
T. 5 N., R. 43 E.	------	------	------	------	------	------	------	------	------	------
T. 4 N., R. 43 E.	------	------	------	------	2	9	1	10	------	22
T. 3 N., R. 43 E.	------	------	------	------	2	1	10	14	------	27
T. 2 N., R. 43 E.	------	------	------	32	52	28	------	------	------	112
T. 6 N., R. 44 E. (fractional)	------	------	------	------	------	------	1	------	1	2
T. 5 N., R. 44 E.	------	------	------	------	10	------	1	------	------	11
T. 4 N., R. 44 E.	------	------	------	3	14	8	------	------	------	25
T. 3 N., R. 44 E.	------	------	------	85	46	14	------	------	------	145
T. 2 N., R. 44 E.	------	------	------	131	79	36	------	------	------	246
T. 5 N., R. 45 E.	------	------	------	------	4	5	------	------	------	9
T. 4 N., R. 45 E.	------	------	------	8	100	2	------	------	------	110
T. 3 N., R. 45 E.	------	------	------	4	7	------	------	------	------	11
T. 2 N., R. 45 E. (fractional)	------	------	------	------	------	------	------	------	------	------
T. 5 N., R. 46 E.	------	------	------	------	------	3	9	------	------	12
T. 4 N., R. 46 E.	------	------	------	------	------	------	3	------	------	3
T. 3 N., R. 46 E.	------	------	------	------	------	------	1	1	------	2
T. 5 N., R. 47 E.	------	------	------	------	------	------	1	3	4	8
T. 4 N., R. 47 E.	------	------	------	------	------	------	2	1	8	11
T. 3 N., R. 47 E.	------	------	2	2	------	------	1	2	------	7
T. 5 N., R. 48 E.	------	------	------	------	------	------	3	9	1	13
T. 4 N., R. 48 E.	------	------	------	------	------	------	------	6	1	7
T. 3 N., R. 48 E.	[2] 16	[3] 2	1	49	------	------	------	------	1	69
T. 5 N., R. 49 E.	------	------	------	------	------	------	3	8	------	11
T. 4 N., R. 49 E.	------	------	------	------	------	------	1	------	------	1
T. 3 N., R. 49 E.	------	------	------	------	------	------	------	------	------	------
	------	------	3	315	502	113	49	71	53	1,171

[1] Includes "bed below Burley" in T. 5 N., R. 45 E., and "bed at base of Tongue River" in T. 5 N., R. 46 E.
[2] Flowers.
[3] Haddow.

The estimated quantity of coal in beds over 1½ feet thick in the Rosebud coal field is 1,171,000,000 tons. Of this total about 85 percent is in the Tongue River member of the Fort Union formation

and 15 percent is in the Lebo member of the Fort Union formation and the Lance formation. Most of the 15 percent occurring in the Lebo member and the Lance formation is in beds between 1½ and 3 feet thick. Of the total estimated tonnage about 30 percent is in beds from 1½ to 3 feet thick, and 70 percent is in beds over 3 feet thick.

OUTLOOK FOR DEVELOPMENT

There are no mines operating on a commercial scale in this field. Small amounts of coal are taken from a few small mines and open pits to supply fuel for local domestic use. At the Snyder mine, in the NE¼ sec. 31, T. 2 N., R. 44 E., and the Haddow Creek mine, in the SW¼ sec. 32, T. 3 N., R. 48 E., the coal is taken out of open pits on the Terret bed. At the Pierson mine on the Rosebud bed, in the SW¼ sec. 19, T. 2 N., R. 42 E., a few wagon loads of coal a year are taken from natural exposures in the banks of Pony Creek. A small drift has been opened in the Burley bed at locality 280, in the SE¼ sec. 35, T. 5 N., R. 45 E. Open-pit prospects on the Burley bed at localities 41, 151, 153, and 229 have supplied some coal.

In parts of the field that are some distance from the coal beds in the Tongue River member the coal in the Lance formation is used locally. At the Sand mine, at locality 157, in the NW¼ sec. 29, T. 4 N., R. 43 E., two parallel drifts 30 feet apart have been run in about 75 feet on a coal bed which is about 3 feet thick. The small mines in coal beds in the Tullock member along the Yellowstone River have been abandoned for many years.

Mining on a commercial scale will probably be restricted to the beds in the Tongue River member, such as the Rosebud, Flowers, Terret, and Burley beds. Of these the Terret and Burley beds are of most importance in this field. The unburned Terret coal on the Rosebud Creek and Tongue River divide is under 100 feet or more of cover. Areas where the cover is 50 feet or less are small, so there is little opportunity for large-scale open-pit mining. The Terret bed in the NW¼ sec. 20, T. 3 N., R. 48 E., is overlain by 60 feet or less of cover; the coal is about 8 feet thick. In the northwestern part of T. 2 N., R. 42 E., the Burley bed is overlain by less than 50 feet of cover over an area of 2 to 3 square miles; the coal is from 5 to 8 feet thick. In T. 4 N., R. 45 E., the Burley bed, from 5 to 9 feet thick, underlies a considerable area, in most of which it is overlain by more than 50 feet of cover. Small areas of the Burley bed, which are overlain by 50 feet or less of cover, are also indicated on plate 11, in the western part of T. 2 N., R. 43 E., and the southern part of T. 5 N., R. 45 E.

The quantity of coal in the Rosebud field is not great enough to warrant construction at the present time of the transportation facil-

ities necessary for commercial production. The coal beds are neither as thick nor of as large horizontal extent as those of the adjoining Forsyth and Ashland coal fields, with which the Rosebud coal would have to compete. At Colstrip, Mont., in 1929, coal was being mined from an open cut at the rate of 4,000 tons a day for use in the locomotives of the Northern Pacific Railway. A total of 10,000,000 tons had been blocked out, which at that rate of production would take from 8 to 10 years to mine.

DETAILS BY TOWNSHIPS

In the following pages the area is described by townships, which are taken in order from north to south, beginning with the western tier of townships. The geography and geology are briefly discussed and details of the coal not given in the preceding pages are described. The locality numbers mentioned in the text are shown on plate 11 and are numbered consecutively, beginning in the northwest corner of the area and following up the drainage on the west side of Rosebud Creek and down the drainage on the east side, then following the other streams in a similar manner, progressing eastward across the field to the northeast corner. The sections of the coal beds measured at these localities are shown graphically in plates 12 to 21 and figures 12 to 32.

T. 6 N., R. 42 E. (fractional).—A succession of stream terraces covers all of the fractional part of T. 6 N., R. 42 E., south of the Yellowstone River. There are a few dry farms on the flat terraces, and the fertile soil produces

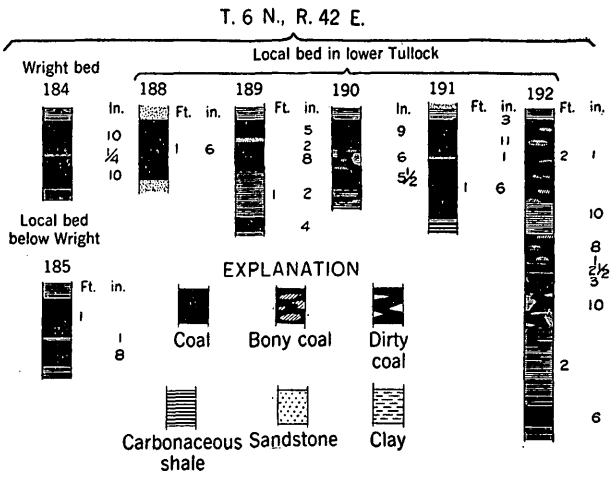


FIGURE 12.—Sections of coal beds in T. 6 N., R. 42 E.

large crops in years of adequate rainfall. The broadest terrace stands about 250 feet above the Yellowstone. The maximum relief is about 450 feet.

The Hell Creek member of the Lance formation crops out extensively in this township. It is overlain by the Tullock member of the Lance formation,

which crops out in most of the eastern part of the township. The lower part of the Tullock contains some massive beds of sandstone and a few thin coal beds. The Tullock member is overlain by the Lebo shale member of the Fort Union formation in the southeast corner of the township. A belt of alluvium of irregular width borders the Yellowstone River and Rosebud Creek.

The Wright bed, at the base of the Tullock member of the Lance formation, contains 20 inches of coal, with a ¼-inch parting in the middle, at locality 184. The bed is not traceable northward from this locality. A local bed below the Wright at locality 185 contains 20 inches of coal. A local coal bed in the lower part of the Tullock crops out in secs. 13, 14, and 24. Coal sections were measured at localities 188, 189, 190, 191, and 192; at three of these localities it contains less than 18 inches of coal. This bed is thin and through much of its extent is of poor quality. The Big Dirty bed, at the base of the Lebo, is present only in sec. 35. No sections were measured in this township, but, to judge from sections measured in the township adjoining on the south, the Big Dirty bed probably does not contain 18 inches of clean coal.

Coal for local consumption has been produced from a small drift mine on the local bed in the lower part of the Tullock member at locality 191, but this mine has been abandoned for some time.

T. 5 N., R. 42 E.—Rosebud Creek flows northward almost through the center of T. 5 N., R. 42 E. With the exception of the West Fork of Rosebud Creek, the tributaries are small, but they cut deep valleys, which head in badlands of the Lebo member of the Fort Union. The Tongue River member of the Fort Union formation crops out in a small area in secs. 13 and 24. The Lebo member of the Fort Union crops out in the highlands in the eastern part of the township. Over the rest of the township are beds belonging to the Tullock and Hell Creek members of the Lance formation. A section of the Tullock member measured in sec. 15 is given on page 56. Badlands are predominant, vegetation is scarce, grazing land is poor, and farming is restricted to the bottom lands along Rosebud Creek.

The township as a whole is poor in coal and does not contain beds worth mining on a commercial scale. All the beds are characterized by extreme variability in thickness and a low grade of coal. The Wright coal bed, at the base of the Tullock, was measured at localities 1, 3, 5, 7, 170, 172, 173, 177, 178, and 182. It is nowhere over 3 feet in thickness and at some places is less than 18 inches. At locality 177 a drift was opened on the Wright bed but is now abandoned. At the Lore mine, which is outside this township, in the NE¼ sec. 2, T. 5 N., R. 41 E., the Wright bed contains 2 feet 8 inches of clean coal. At locality 8 the Wright bed is less than 18 inches thick. A bed 25 feet above the Wright is fairly persistent and at locality 2 contains 18 inches of coal but more commonly contains shale interbedded with the coal, or a very thin bed of coal, as shown by secs. 4 and 169. Four beds that occur 20, 45, 60, and 85 feet below the top of the Tullock member of the Lance locally contain 18 inches or more of coal. As all of them crop out on a steep slope, they have been mapped by one outcrop line, which represents a coal zone rather than a single coal bed. Sections of these coal beds were measured at localities 168, 176, and 180. At locality 6, in the SW¼ sec. 30, the following section, beginning about 60 feet below the top of the Tullock member, shows several thin beds:

	Ft.	*in.*
Shale, carbonaceous, with thin coal streaks	4	
Sandstone, cream-colored, argillaceous, becoming lighter at base	37	
Shale, carbonaceous, and coal	1	6

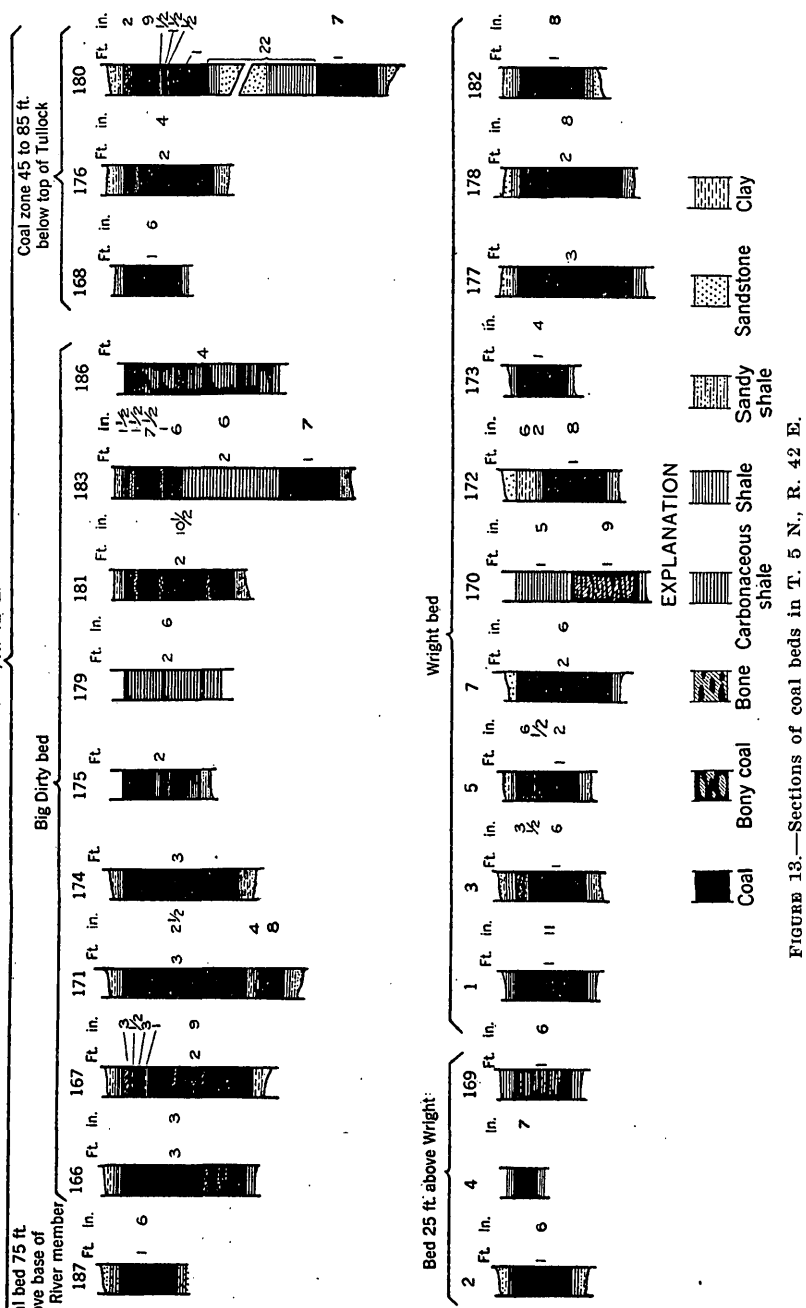


FIGURE 13.—Sections of coal beds in T. 5 N., R. 42 E.

	Ft.	in.
Shale, white, clay	4	6
Coal and carbonaceous shale	2	6
Sandstone, tan and white, argillaceous	14	
Coal and carbonaceous shale	4	
Sandstone, tan, with interbedded sandy shale	28	6
Coal		7
Sandstone, light, argillaceous	3	6
Shale, brown, carbonaceous	7	
Coal and carbonaceous shale		6
Interval to Wright bed, at base of Tullock	100±	

The Big Dirty bed, at the base of the Lebo shale member, contains from 2 feet to 5 feet 7 inches of coal, shale, and bone at localities 166, 167, 171, 174, 175, 179, 181, 183, and 186. Because of its impurity, it is of doubtful commercial value. At locality 187 a local coal bed 18 inches thick is present about 75 feet above the base of the Tongue River member.

T. 4 N., R. 42 E.—Rosebud Creek flows northward along the east edge of T. 4 N., R. 42 E. West of and above the alluvial flats bordering Rosebud Creek a series of sandstones and shales form a conspicuous escarpment through which the tributaries of Rosebud Creek have cut narrow valleys; farther west the surface of the township is a series of rounded somber-colored shale hills. The township is deeply dissected by erosion, and there are large areas of badlands. Vegetation is sparse.

The top of the Hell Creek member of the Lance formation crops out along Rosebud Creek, in the northeast corner of the township. The overlying Tullock member of the Lance formation crops out in about half of the area. The upper part of this member is marked by a series of sandstones and shales, which are more resistant to erosion than the overlying beds and therefore form a bench or escarpment. Above this escarpment occurs the Lebo shale member of the Fort Union formation, which crops out on the ridges in the western part of the township. Only a few small areas of rocks belonging to the Tongue River member of the Fort Union formation remain in the highest parts of the township. Stream gravel mantles nearly all the higher hills.

The Wright bed, at the base of the Tullock member of the Lance formation, crops out only in the northeast corner of the township. At locality 163 it is 3 feet thick, with a 1-inch parting near the top. A few wagon loads of coal have been taken from the outcrop in the east bank of Rosebud Creek at this locality. At localities 10 and 11 the coal is less than 18 inches thick. A shale bed from 25 to 30 feet above the Wright contains 1 foot or more of coal in a few places. From 185 to 220 feet above the Wright, or 50 to 85 feet below the top of the Tullock member, is a coal zone, which at localities 12 and 23 contains about 18 inches of coal. At locality 27, 300 feet east of sec. 36, a bed in this zone contains 3 feet of coal, but as this bed is traced northwestward into this township it changes to black shale with thin seams of coal. The Big Dirty bed contains from 3 feet to 5 feet 8 inches of dirty coal, shale, and bone at localities 9, 13 to 22, and 26. In a few places it carries coal that is clean enough to burn, but as a whole this bed is so dirty that it is questionably classifiable as a fuel. At locality 22, in sec. 31, a small quantity has been mined. A local coal bed about 50 feet above the base of the Lebo at locality 25, in sec. 36, is extremely variable in coal content and generally consists of black shale and soot, with a few inches of coal.

T. 3 N., R. 42 E.—T. 3 N., R. 42 E., lies on the west side of the Rosebud Creek Valley and is largely drained by West Cottonwood, Sprague, and Udie Creeks,

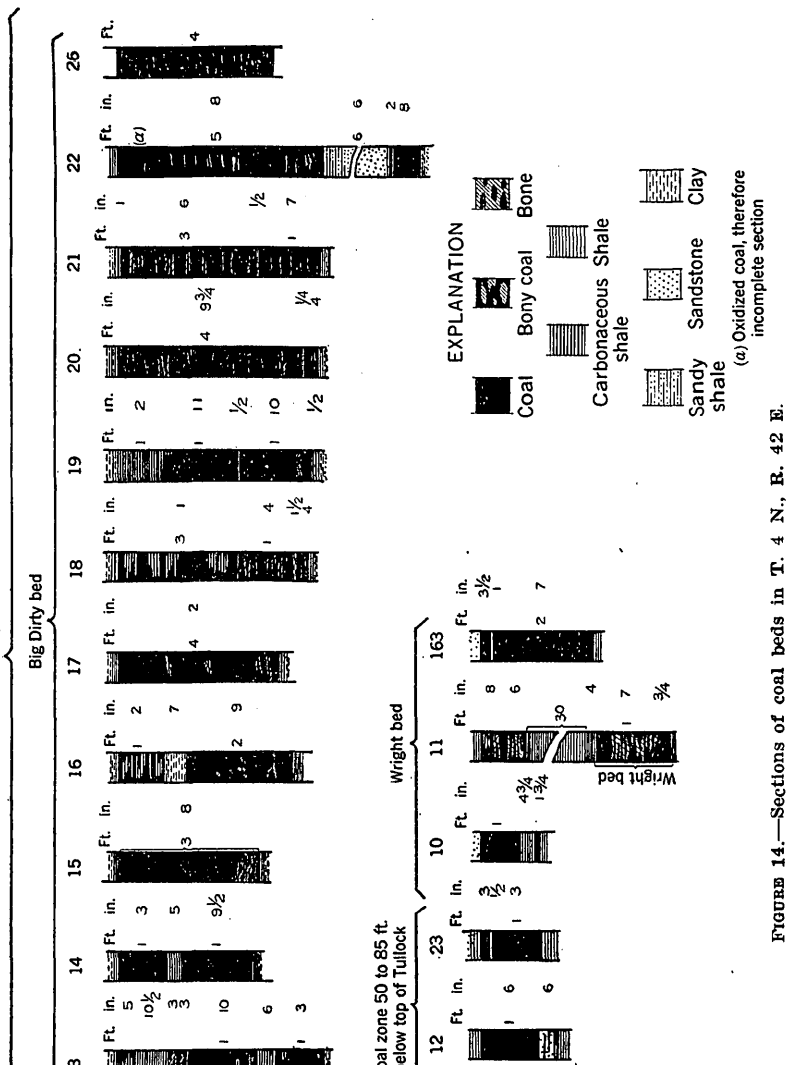


FIGURE 14.—Sections of coal beds in T. 4 N., R. 42 E.

which are tributaries of Rosebud Creek. The southwest quarter of the township is steeply rolling and grass-covered, but the remainder of the township is greatly dissected and practically barren of vegetation.

The Tongue River member of the Fort Union crops out in the southwestern part of this township and along the divides between the principal streams. The Lebo shale member of the Fort Union formation is exposed in the valleys and gives rise to barren and sparsely vegetated areas. The Tullock member of the Lance formation crops out along four stream courses in the eastern part of the township.

A thin coal bed in the zone 50 to 85 feet below the top of the Tullock member is the lowest coal bed exposed in this township. It crops out only in sec. 1, where it was measured at locality 28. The Big Dirty bed, at the base of the Lebo shale member of the Fort Union formation, crops out on the east and north sides of the township and usually contains about 3 feet of dirty coal. The impurities in this bed make it of doubtful commercial value, but a section was measured at locality 32. The Burley bed, in the lower part of the Tongue River member, is about 7 feet 6 inches thick at locality 24, in sec. 18, but the area underlain by good coal is less than 100 acres. At locality 33 there is a very small area underlain by a bed of coal 2 feet thick which is 40 feet above the Burley bed. It is at approximately the horizon of the Terret bed, which forms the thick clinker east of Rosebud Creek, and of the Robinson bed, which has been mapped in T. 2 N., R. 41 E., in the Forsyth coal field. This bed is not of economic value, however, because of its extremely small lateral extent.

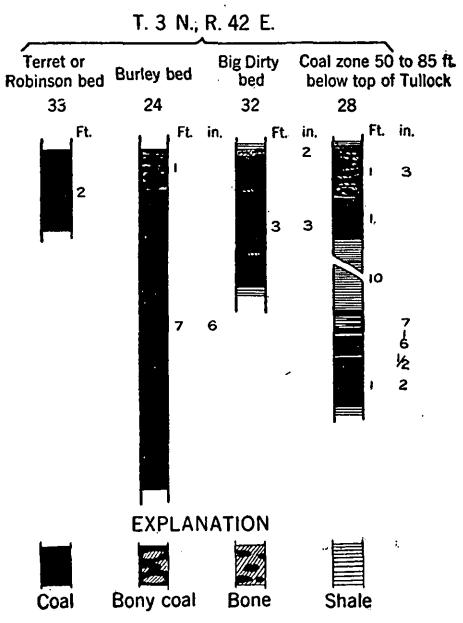
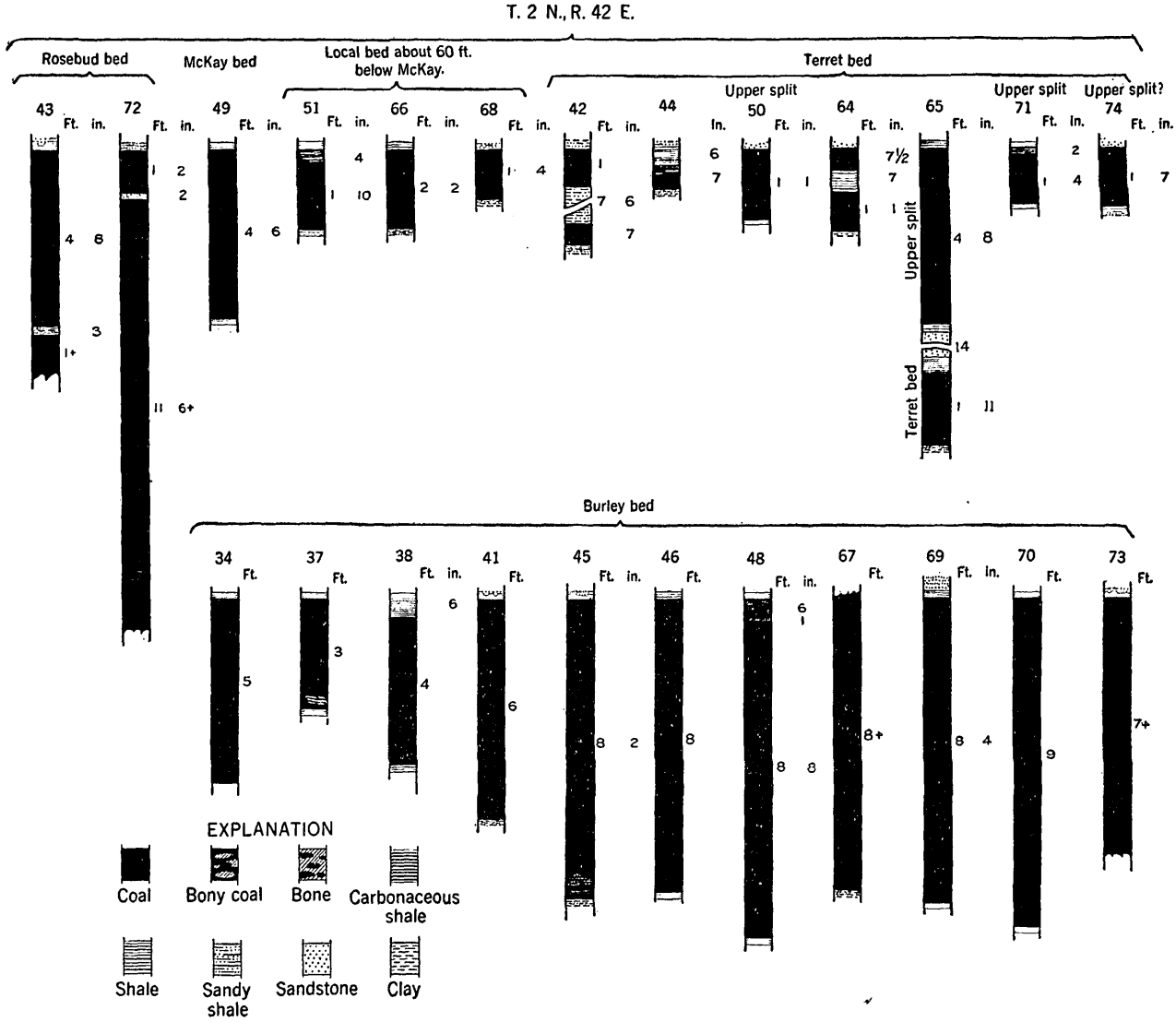


FIGURE 15.—Sections of coal beds in T. 3 N., R. 42 E.

T. 2 N., R. 42 E.—The surface of T. 2 N., R. 42 E., is drained by four eastward-flowing tributaries of Rosebud Creek—from north to south Spring Creek, a small valley known locally as "The Break", Pony Creek, and the North Fork of Cow Creek. The divides between these valleys are capped by erosional remnants of Rosebud clinker, on which there are growths of yellow pine and juniper. As a whole, the topography of the township is rough, for the valleys below the clinker-capped divides are deep, and there are numerous buttes.

The Lebo member of the Fort Union formation is exposed in a small area along Spring Creek in the northeast corner of the township. The Tongue River member crops out in the remainder of the township. A partial section of the Tongue River member measured in sec. 24 is given on page 62.

The Burley bed is the lowest coal mapped in the township and ranges in thickness from 3 to 9 feet. The coal has few partings and is of good quality. In the eastern part of the township it averages 8 feet or more in thickness, and in the northern part it is from 5 to 6 feet thick. It is not exposed in the



SECTIONS OF COAL BEDS IN T. 2 N., R. 42 E.

southwestern part of the township, where it is overlain by thick cover. Along the eastern tier of sections the Burley coal is, for the most part, burned or oxidized along the outcrop. West of this the coal is generally covered by smooth grassy slopes. Sections were measured at localities 34 (locality 143 of Dobbin[40]), 37, 38, 41, 45, 46, 48, 67, 69, 70, and 73. The Terret bed, about 50 feet above the Burley bed, is split into two or more thin coal beds; on the east side of Rosebud Creek it is 10 to 15 feet thick. In this township the greatest thickness of coal observed is in the upper split of this bed, at locality 65, where there is 4 feet 8 inches of coal. Coal sections were measured at localities 42, 44, 50, 64, 65, 71, and 74. Several of these were made to show the westward thinning of the Terret bed. At locality 40 there is only 6 inches of coal. The thin coal beds at localities 40, 42, and 44 are from 75 to 100 feet above the Burley bed and possibly are not a part of the Terret bed. At locality 39, 2 feet of interbedded coal and shale occur at the horizon of the Terret bed, at approximately the same stratigraphic position as the Robinson bed of the Forsyth coal field, in T. 2 N., R. 41 E. These two beds (Terret and Robinson) appear to be approximate stratigraphic equivalents, but different names are used because it seems probable that the Robinson bed of the Forsyth coal field thins toward the east, as it approaches this township, until it becomes less than 18 inches thick. A local coal bed about 60 feet below the McKay bed occurs in three small isolated outcrops in or near sec. 13. Coal sections taken at localities 51, 66, and 68 show that this coal is from 16 to 26 inches thick. A mile and a half west of locality 68 it contains less than 18 inches of coal. The area in which this bed occurs is so small that it is not of economic value. The McKay bed, in T. 2 N., R. 41 E. (in the Forsyth coal field[41]), is over 6 feet thick and from 8 to 21 feet below the Rosebud bed. In the northwestern part of T. 1 N., R. 42 E. (in the Ashland coal field[42]), the McKay bed is from 7 to 9 feet thick and from 7 to 30 feet below the Rosebud bed. The McKay bed, where unburned, is usually concealed by clinker of the Rosebud bed. At locality 49 a coal bed 4 feet 6 inches thick occurs 33 feet below the ash of the burned Rosebud bed. This bed is correlated with the McKay bed. It is believed to be at least 4 feet 6 inches thick and to lie about 30 feet below the Rosebud bed in a large area in the southwestern part of this township, although additional outcrops to substantiate this belief were not found. Where the McKay bed is unburned, its areal distribution will correspond approximately with that of the Rosebud clinker. Unburned coal in the Rosebud bed is confined to less than 2 square miles in the western part of the township. Two outcrops of the Rosebud bed were found—one at the Pierson mine, at locality 72, near which the coal is reported to have been burning for nearly 10 years, and the other at locality 43. Complete thicknesses could not be measured on either of these outcrops, but from the development work at Colstrip, 2 miles west of this township, a thickness of 20 feet or more may be inferred. The average amount of cover on the Rosebud bed in secs. 19 and 30 is 150 feet and in sec. 34 is 100 feet.

Coal for local domestic use has been mined from the Burley bed at the McKay mine at locality 41, in sec. 7. Areas underlain by the Burley bed in the northwestern part of the township, on the north and south sides of Spring Creek, appear to be favorable for open-cut mining. The coal ranges from 5 to 8 feet in thickness, and the areas in which the cover does not

[40] Dobbin, C. E., The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont.: U. S. Geol. Survey Bull. 812, pl. 10, 1929.

[41] Idem, p. 53.

[42] Bass, N. W., The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont.: U. S. Geol. Survey Bull. 831, p. 63, 1932.

exceed 50 feet are shown on plate 11. At the Pierson wagon mine, at locality 72, the coal is obtained from an exposure in the banks of Pony Creek.

T. 6 N., R. 43 E. (fractional).—That part of T. 6 N., R. 43 E., which lies within the Rosebud coal field is covered by a series of terraces, which are now partly dissected by Butte, Sweeney, and Coal Creeks. The highest point in this part of the township is in sec. 32; it is 500 feet above Yellowstone River.

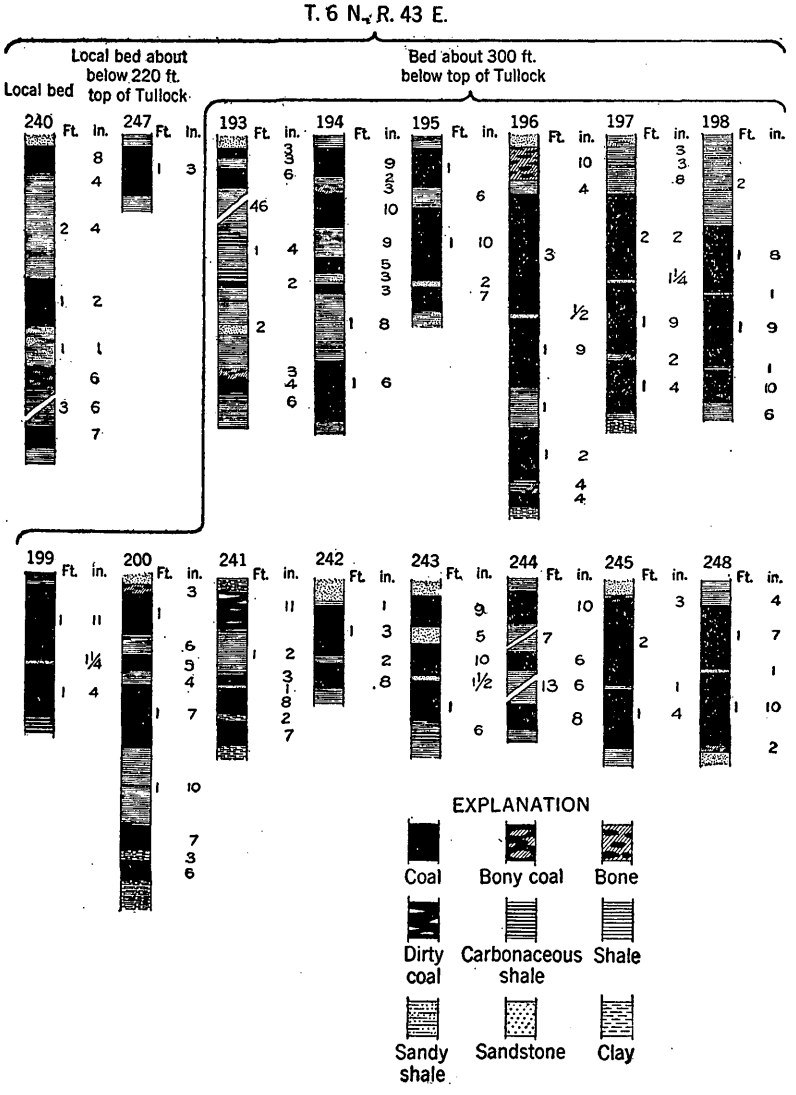


FIGURE 16.—Sections of coal beds in T. 6 N., R. 43 E.

The Tullock member of the Lance formation, in many places concealed by a thin veneer of terrace gravel, covers practically all of the township that lies south of the Yellowstone River. All the coal beds that have been mapped are in the lower part of this member. The Tullock member is overlain by the Lebo shale member of the Fort Union formation, which crops out in the

highlands in the southeast and southwest corners of the township, in parts of the southern tier of sections. Only a small area of alluvium is present on the south side of the Yellowstone.

A coal zone about 300 feet below the top of the Tullock member is shown on plate 11 but is not as continuous as shown by the outcrop line. Coal sections at localities 194 to 199 and 242 are on the same bed. (See fig. 11.) This bed thins out west of locality 194 and is probably represented by the lower coal and shale bed at locality 193. A short distance east of locality 242 the coal bed ends abruptly, probably being cut out by a stream channel. A soft sandstone is present at the horizon of the coal bed. At locality 243 a coal bed is present at approximately the same horizon as the bed at locality 242. It is of variable thickness, as shown by secs. 243, 244, 245, and 248. A section of a local bed about 220 feet below the top of the Tullock was measured at locality 247, and another local bed was measured at locality 240. Neither of these beds contains 18 inches of coal. No sections were measured on the Big Dirty bed at the base of the Lebo, which crops out only in the southern part of the township. To judge from sections measured in the township adjoining on the south, the Big Dirty bed probably does not contain 18 inches of clean coal.

None of the coal in this part of the township was being mined at the time the survey was made. The mine workings at locality 245, consisting of two drifts, have been abandoned for many years. A small drift mine is operated sporadically at locality 199 to produce coal for local consumption. The small open-pit wagon prospect between localities 198 and 199 has not been used for a long time.

T. 5 N., R. 43 E.—Sweeney Creek and its tributaries drain all except about 4 square miles of T. 5 N., R. 43 E. An escarpment of the Tullock member borders this creek across the township. The escarpment is just above the level of the stream near the Horton ranch, in sec. 31, T. 5 N., R. 44 E., but rises to a height of 150 feet above the stream in sec. 3, where Sweeney Creek leaves the township. Above the escarpment are somber-colored shales dissected into badlands. A picturesque feature of this township is the group of sharp, high red-capped peaks in secs. 18 and 19, known as the Rosebud Buttes. They rise 300 feet above the surrounding country and are erosion remnants capped by the resistant clinker formed by the burning of the Burley bed. The surface of the township as a whole is rough and dissected by many sharp, deep valleys. The maximum relief is 650 feet.

Rocks belonging to the Tullock member of the Lance formation are exposed along Sweeney Creek in a strip 2 miles wide in the northern part and narrowing to about 1 mile in the southeastern part, and also in several valleys along the west border of the township. The Lebo shale member of the Fort Union formation forms the surface rock over a wide area on both sides of Sweeney Creek and in the southwest corner of the township. A maximum of 300 feet of strata belonging to the Tongue River member remains on the Rosebud-Sweeney Creek divide in the southwestern part of the township. Terrace gravel covers many of the hills on the west side of Sweeney Creek.

The township is practically devoid of coal beds 18 inches or more in thickness. A coal bed less than 18 inches thick, 60 feet below the top of the Tullock member, near the Jackson ranch in sec. 24, has been utilized as an emergency source of domestic fuel. The Big Dirty bed does not contain 18 inches of coal at any of the exposures examined. The sections measured at localities 202, 205, 206, 238, and 239 show the character of this bed. At locality 201 the Big Dirty bed contains less than 18 inches of coal, and at localities 203 and 204 it is practically all carbonaceous shale. There are no coal beds 18 inches or more thick

in the Lebo member above the Big Dirty bed. There are two small isolated areas containing coal in the Trail Creek zone in sec. 31, but no sections of it were measured in this township. About a quarter of a mile south of sec. 31, at locality 165, the Trail Creek zone contains 2 feet of coal and 15 inches of impure coal. Erosion has removed the Burley and Terret beds in this township.

T. 4 N., R. 43 E.—Rosebud Creek, which crosses the southwestern part of T. 4 N., R. 43 E., and its tributaries drain all of this township except about 6 square miles in the northeastern part, which is drained by tributaries of Sweeney Creek. The west side of the Rosebud-Sweeney Creek divide is deeply cut by erosion, forming a strip of barren badlands surmounting an inconspicuous escarpment and extending in a northwesterly direction across the middle of the township. The east side of the divide slopes away gently and is covered with vegetation. The maximum relief is about 500 feet.

Erosion has cut deeply into the Tullock member of the Lance, exposing a complete section of this member in the western part of the township. The somber-colored shales of the Lebo member of the Fort Union, which overlie the Tullock member, crop out principally in this township as an irregular band along the west side of the Rosebud-Sweeney Creek divide. The lower part of the Tongue River member caps this divide.

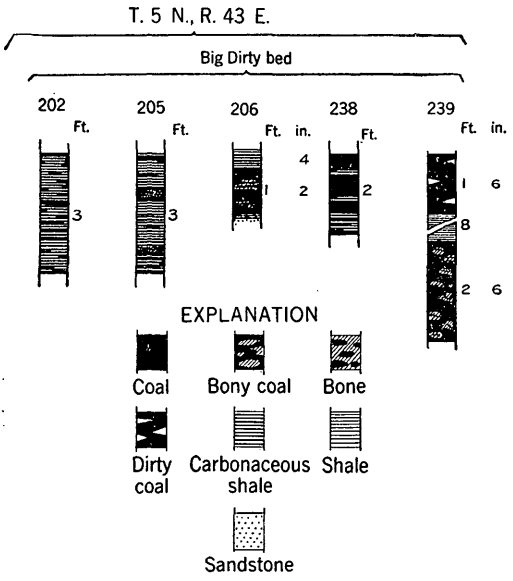


FIGURE 17.—Sections of coal beds in T. 5 N., R. 43 E.

No outcrops of the Wright bed, at the base of the Tullock member of the Lance, were found in this township, but about a quarter of a mile west of sec. 7, at locality 163, there is 2 feet 7 inches of clean coal exposed. From 190 to 225 feet above the Wright bed, or 50 to 85 feet below the top of the Tullock member, is a coal zone which, at locality 27, contains a coal bed 3 feet thick with a ¾-inch parting. Southward this bed splits into two beds 8 feet apart, each bed containing 2 feet or less of somewhat impure coal. This bed underlies a little over half of sec. 31. On the east side of Rosebud Creek, at the Sand mine, a section was measured on a coal bed 70 feet below the top of the Tullock member, at locality 157. This bed thins northward to less than 18 inches. Half a mile south of the south township line a bed at approximately the same horizon contains a few inches more of coal than at the Sand mine. If this is a continuous bed through secs. 29 and 32, it will average about 3 feet in thickness. The Big Dirty bed, at the base of the Lebo, does not contain coal 18 inches or more in thickness. A section measured at locality 164 shows 3 feet 7 inches of coal and shale interbedded. A coal section measured at locality 158 on a local bed in the Lebo member, about 35 feet above the Big Dirty, is shown on the map in secs. 21 and 22, but the coal is dirty and of little importance. The coal in the Trail Creek zone is about 50 feet above the base of the Tongue River member. The maximum thickness of clean coal observed is 2 feet 10 inches. Coal sections were meas-

ured at localities 152, 159 to 162, and 165. In the NE¼ sec. 26 there is a bed of coal and shale less than 18 inches thick, 25 feet below the Trail Creek bed. The Burley bed is the thickest coal bed in the township, but practically all of it has been removed by erosion. It remains only in a few high knobs and peaks in secs. 13, 14, and 25. At locality 153, where some coal has been mined, this bed is 10 feet thick, clean, and of good quality.

The coal in the Tullock member has been mined only at locality 157, in sec. 29. Here two parallel drifts 30 feet apart have been run in 75 feet. The drifts are untimbered except at the entrance. Some coal has been taken from the Burley bed at an open pit at locality 152, known locally as the Cass mine.

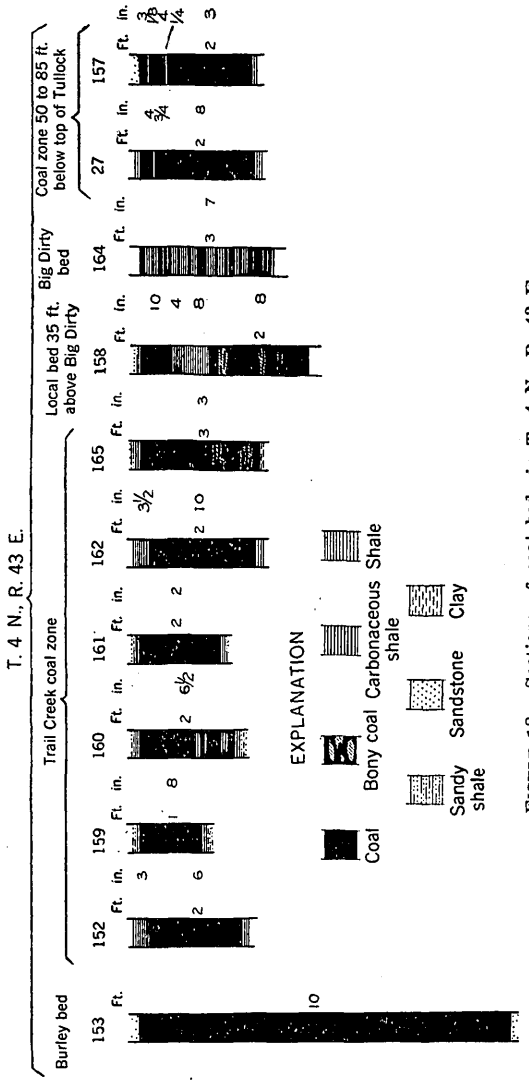


FIGURE 18.—Sections of coal beds in T. 4 N., R. 43 E.

T. 3 N., R. 43 E.—Rosebud Creek flows north across T. 3 N., R. 43 E. Along both sides of the valley is an escarpment bordering a bench or plateau half a mile to 1 mile wide. Above the bench is a zone of badlands, ranging from a few hundred feet to more than a mile in width. The highest part of this township lies near the east border, where clinker-capped buttes rise above the badland slopes. The relief is about 550 feet.

The Tullock member of the Lance formation crops out in the escarpment along Rosebud Creek, and the top sandstone of this member floors the wide bench above the escarpment. The Lebo shale member of the Fort Union formation crops out extensively in the badlands on both sides of the valley of Rosebud Creek. A section of the Lebo member was measured in sec. 28 and is given on pages 57–58. From 200 to 300 feet of the Tongue River member overlies the Lebo in the eastern part of the township.

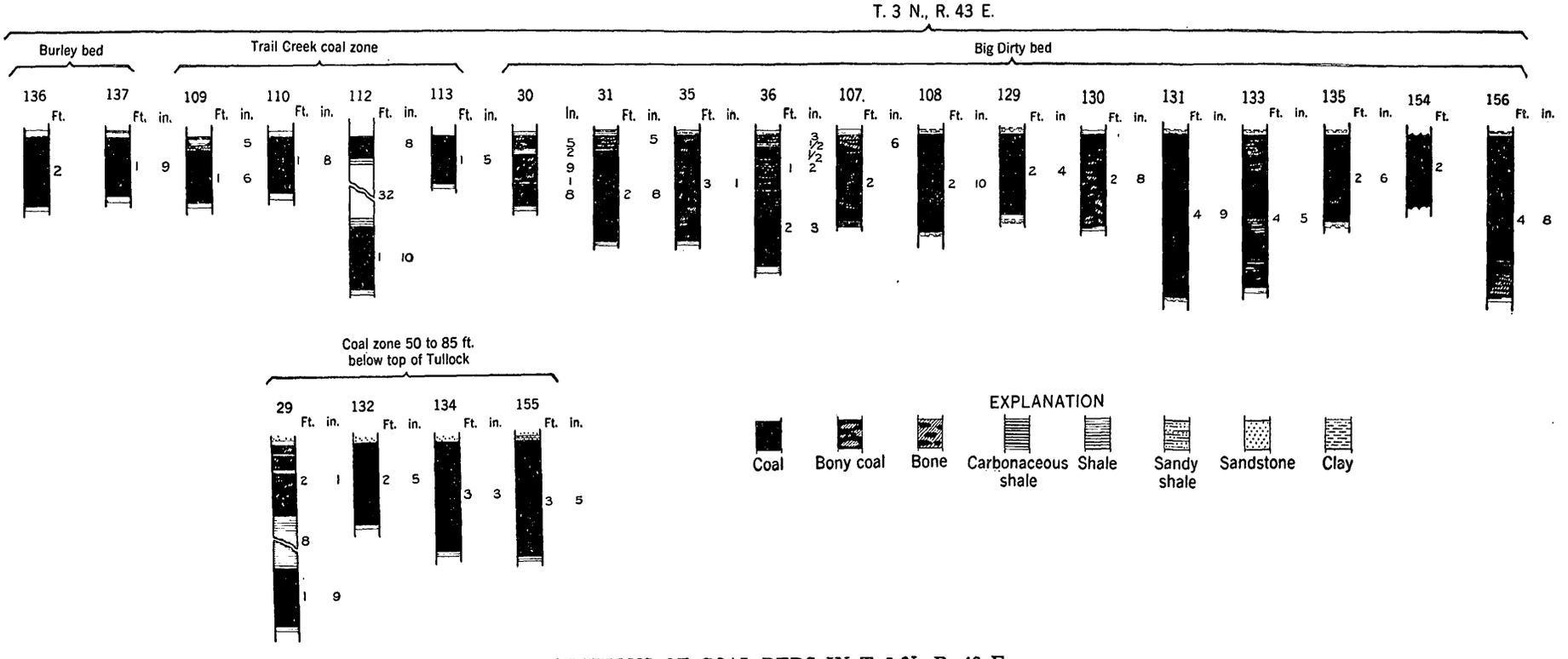
Coal in the zone 50 to 85 feet below the top of the Tullock member crops out only in the northwestern part of the township, along Rosebud Creek. Sections measured on the east side of Rosebud Creek, at localities 132, 134,

and 155, appear to be on a continuous bed, which thins southward. A section measured on the west side of Rosebud Creek, at locality 29, indicates that this bed splits into two parts, and the coal in both of these splits pinches out westward in the adjoining township, near locality 28. Sections of the Big Dirty bed were measured at localities 30, 31, 35, 36, 107, 108, 129, 130, 131, 133, 135, 154, and 156, but, as this coal bed is extremely variable in quality and in many places contains over 50 percent of bone and shale, it is regarded as of doubtful commercial value. At locality 156 a local bed about 2 feet thick, with a 2-inch parting in the middle, occurs 20 feet above the Big Dirty bed. Coal sections of beds in the Trail Creek zone were measured only in secs. 35 and 36, at localities 109, 110, 112, and 113. Coal sections 109, 110, and 113 probably correspond with the lower coal at 112. Beds from 1 to 2 feet thick may be present in this zone in secs. 13 and 24. The Burley bed occurs in parts of secs. 13, 24, and 36. In the township adjoining on the south the Burley bed thins northward, so it is not certain that the Burley bed continues northward to localities 136 and 137, but as the coal at these places is at approximately the same horizon as the Burley bed, the name is used. Practically all of the Terret bed has burned and formed the clinker in the eastern part of the township.

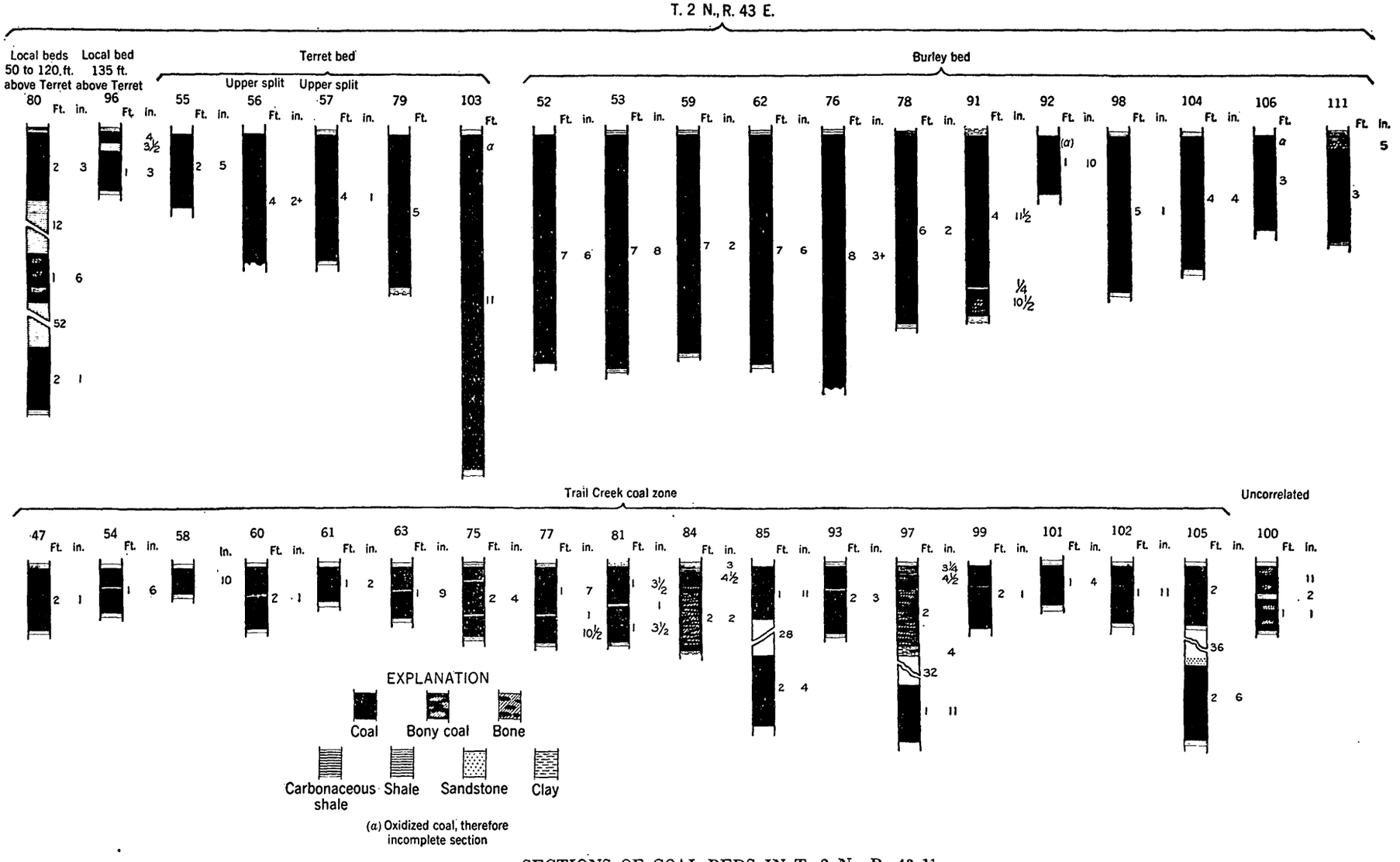
T. 2 N., R. 43 E.—Rosebud Creek flows northward through a broad valley across the middle of T. 2 N., R. 43 E. The sides of the valley rise gradually to high clinker-capped mesas and ridges, which are several hundred feet above the valley. The upland in the eastern part of the area is an undulating tableland, which has been partly dissected by deep ravines. Several gravel-covered terrace remnants and small areas of badlands occur on the west side of Rosebud Creek.

The uppermost part of the Tullock member of the Lance formation probably extends for a short distance into this township along Rosebud Creek. Overlying this is the Lebo shale member of the Fort Union formation. The Tongue River member of the Fort Union covers over half of the township; a section measured in sec. 7 is given on page 62.

The maximum thickness of the Trail Creek coal zone is 45 feet, and the lowest coal in it is 20 feet or more above the base of the Tongue River member. One or more coal beds of small lateral extent occur in this zone. As one bed pinches out, another comes in at a slightly higher or lower horizon. None of the beds in this zone are over 2½ feet thick, and commonly they are 2 feet or less. Coal sections were measured in this zone at localities 47, 54, 58, 60, 61, 63, 75, 77, 81, 84, 85, 93, 97, 99, 101, 102, and 105. An uncorrelated coal section measured at locality 100 probably belongs in the lower part of this zone. In the west tier of sections the Burley bed, which is about 50 feet above the top of the Trail Creek zone, is over 7 feet thick, and on the east side of Rosebud Creek, at locality 78, it is 6 feet 2 inches thick. This bed thins northward and is about 3 feet thick in the extreme northeastern part of the township. The coal is of good quality. Sections were measured at localities 52, 53, 59, 62, 76, 78, 91, 92, 98, 104, 106, and 111. At localities 92 and 106 the upper part of the Burley bed is oxidized, so that a short distance back from the outcrop the coal is probably thicker. In the northern part of the township the Terret bed is about 125 feet above the Burley bed; in the southern part, 70 feet above the Burley. On the east side of Rosebud Creek the Terret bed is burned along its outcrop, except in the southeastern part of the township. A section measured at locality 103 shows 11 feet of good quality coal, the top part of which is slightly oxidized, but in the southern part of the township, at locality 79, this bed has thinned to 5 feet. Coal sections measured at localities 55, 56, and 57 show that the Terret bed thins even more on the west side of Rosebud



SECTIONS OF COAL BEDS IN T. 3 N., R. 43 E.



SECTIONS OF COAL BEDS IN T. 2 N., R. 43 E.

Creek and splits into two parts. The area underlain by this bed west of Rosebud Creek is very small, being restricted to about 75 acres in the southern part of sec. 18 and very small areas in sec. 31. Coal beds above the Terret are not of economic importance in this township. On a high butte at locality 80 three local beds were found above the Terret, the lowest 50 feet above it. The thickness of the beds and the intervals between them are shown in the plotted coal section. The high buttes in sec. 35 are capped by clinker, probably formed from the Knoblock bed, which occurs in the Ashland coal field At locality 96 a local bed 135 feet above the Terret contains 15 inches of coal.

None of the coal in this township is mined. Two areas west of Rosebud Creek, which are underlain by the Burley bed under less than 50 feet of cover, are shown on plate 11. The coal at these localities is 7 feet or more thick. In secs. 10 and 11 the Burley bed underlies about 25 acres in which the cover is less than 50 feet; the coal is 5 feet thick.

T. 6 N., R. 44 E. (fractional).—Yellowstone River, which flows northeastward across T. 6 N., R.°44 E., is bordered on the south by a flood plain ranging in width from a few hundred feet to over 2 miles. A series of dissected terraces cover most of the area south of the alluvial flood plain. The maximum relief is about 500 feet. Much of the bottom land along the river is under cultivation, and good crops are raised if there is sufficient rainfall. About 600 acres of alluvial bottom land between the Northern Pacific Railway and the Yellowstone River is irrigated by pumping water from the river.

The Tullock member of the Lance formation borders the flood plain of the Yellowstone River and extends up Graveyard, Iron Jaw, and Coal Creeks. The Tullock member is overlain by the Lebo shale member of the Fort Union formation. Small remnants of the Tongue River member of the Fort Union formation overlie the Lebo in secs. 27 and 34.

The outcrop of coal beds in the lower part of the Tullock member is practically confined to Coal Creek. Three coal beds crop out in the cut banks along this creek. The bed at locality 246 cannot be traced up the creek, but the measured section of the bed at locality 248, in T. 6 N., R. 43 E., is similar to it. The bed at locality 246 is 30 feet lower in altitude than the bed at locality 248, and it seems probable that there has been a slight dislocation between these two points. The bed at locality 248 is about 300 feet below the top of the Tullock. The coal in the local bed about 280 feet below the top of the Tullock is less than 18 inches thick at the two places it was measured—localities 249 and 255. Sections of the local bed about 240 feet below the top of the Tullock were measured at localities 250, 254, and 256. The coal bed at the base of the Lebo is generally too dirty and impure to be used as a fuel; occurrences of fairly clean coal 18 inches or more in thickness are extremely local in extent. Coal sections were measured at localities 253, 260 to 266, 295, and 296.

None of the coal in this part of the township is being mined. A small drift mine at locality 246 has been abandoned for a number of years.

T. 5 N., R. 44 E.—A dissected clinker-capped divide extends northwestward from the southeast corner of T. 5 N., R. 44 E. The surface of the township is rough, with the area of irregular and jagged clinker-capped buttes and escarpments in the central and southeastern portions surrounded by sharply dissected semi-badlands. The maximum relief is about 650 feet.

The Tullock member of the Lance formation crops out on Graveyard, Iron Jaw, Coal, and Sweeney Creeks. The Lebo shale member of the Fort Union formation crops out in a band of irregular width in the western and northern parts of the township. The lower part of the Tongue River member crops out on the divide. The burning of the Burley coal bed, in the Tongue River

member, has produced a thick red clinker, which forms a resistant cap rock on buttes and ridges along the divide. A stratigraphic section of the Tullock member of the Lance formation and the Lebo and Tongue River members of the Fort Union formation, measured in the NE¼ sec. 1, is given on pages 58–59.

The Tullock member does not contain any coal beds that are exposed in this township. The quality of the coal in the bed at the base of the Lebo is extremely variable. Sections were measured at localities 237, 251, 252, 257,

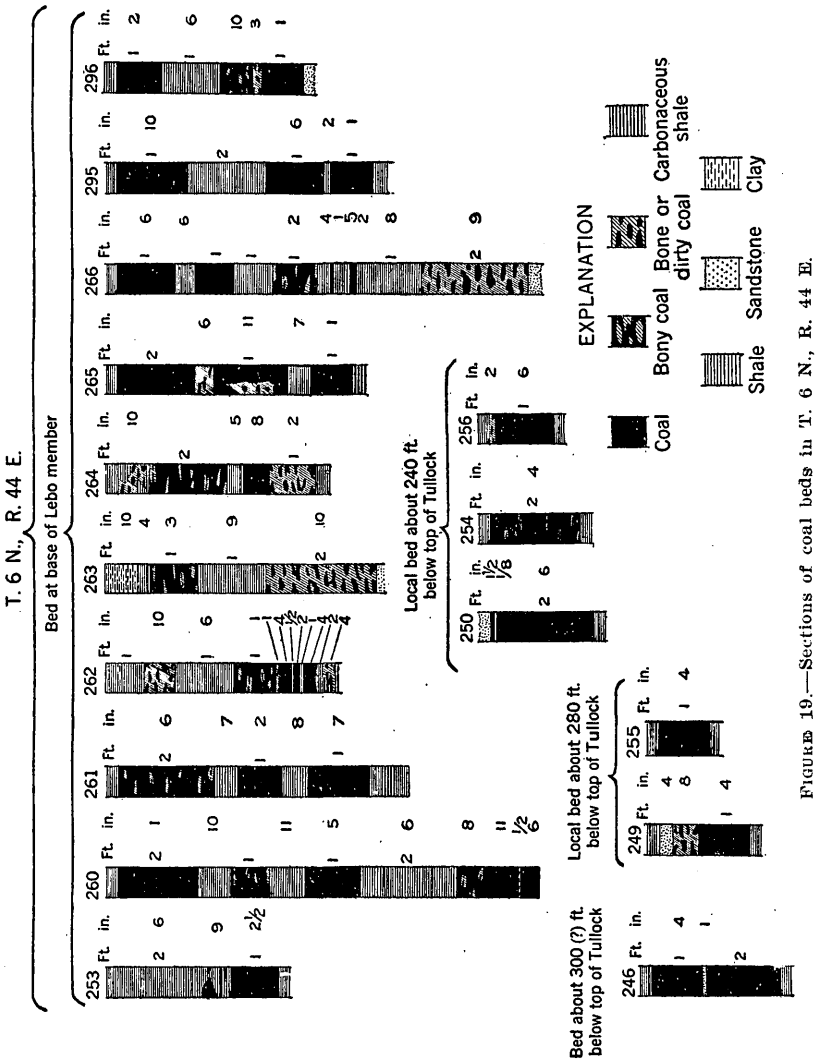


FIGURE 19.—Sections of coal beds in T. 6 N., R. 44 E.

258, 259, and 267; they represent two beds 5 to 15 feet apart, which were undifferentiated in the field. A local bed 45 feet above the base of the Lebo, measured at locality 268, is of small horizontal extent. Most of the Burley bed has been removed by erosion or burned, but some coal remains on the divide in secs. 25, 26, 35, and 36. The coal has burned along the outcrop, and measurements were not obtainable in this township. A mile south of this township, however, the Burley bed is between 8½ and 9½ feet thick, and it

probably continues northward with about the same thickness. A bed in the Terret zone, about 85 feet above the Burley bed, contains 4 feet 6 inches of coal at locality 236, a few hundred feet south of the south township line, in sec. 6, T. 4 N., R. 45 E. This bed thins northward from the south township line. It is restricted to part of secs. 35 and 36.

T. 4 N., R. 44 E.—T. 4 N., R. 44 E., occupies the upper part of the drainage area of Sweeney Creek. The land is gently rolling, supports a good growth of grasses suitable for grazing, and is in part under cultivation. Long, gradual slopes and wide valleys are characteristic surface features of the township.

The upper part of the Tullock member of the Lance formation is exposed for about a mile along Sweeney Creek in sec. 3. Above this, in a rough semicircle, the Lebo shale member of the Fort Union formation crops out. The Tongue River member of the Fort Union is exposed in nearly three-fourths of the township and contains the coal beds of economic importance. The beds are practically flat-lying, except in close proximity to faults. A normal fault in sec. 36 is described in the section on structure (p. 68); an exposure of the

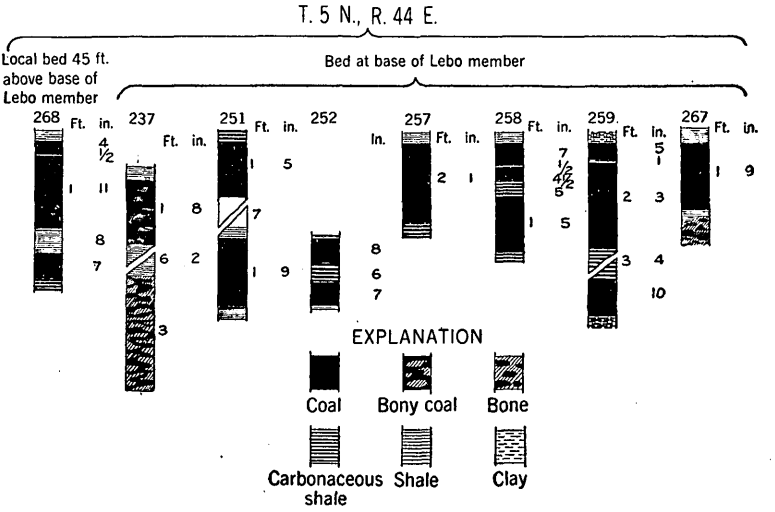


FIGURE 20.—Sections of coal beds in T. 5 N., R. 44 E.

fault surface was found at locality 223. In the southern part of sec. 33 there is some irregularity in the position of the coal beds, which may possibly be due to a small concealed fault.

The bed at the base of the Lebo shale member, which is the lowest coal exposed in this township, is variable in coal content, is dirty, and is not important as an economic source of coal. A section was measured at locality 210. A coal bed 6 inches thick occurs in the Lebo member at locality 207. In the Trail Creek zone, at locality 147, there is a coal bed 14 inches thick, but as it is slightly oxidized at the top, its true thickness is probably greater than this. A coal bed 2 feet 6 inches thick, which is higher stratigraphically in this zone, was measured at locality 152, a mile west of this township. These sections are probably on two different beds in the Trail Creek zone, the bed at locality 147 having thinned to the northwest. Sections of coal beds in the Trail Creek zone were measured in the Sweeney Creek drainage area at localities 208, 209, and 217. A maximum of 2 feet 2 inches of poor coal was found in this zone. Seven inches of coal, which has been oxidized, was found in the lower part of this zone at locality 211. There is

14 inches of coal from 40 to 60 feet below the Burley bed at locality 224. In the extreme southern part of the township the Burley bed is about 3 feet thick, but it increases northward to 9 feet 6 inches in sec. 12 and is of good quality. This bed crops out in the southern tier of sections (except sec. 31) and in secs. 25 and 12. There are two isolated outcrops in secs.

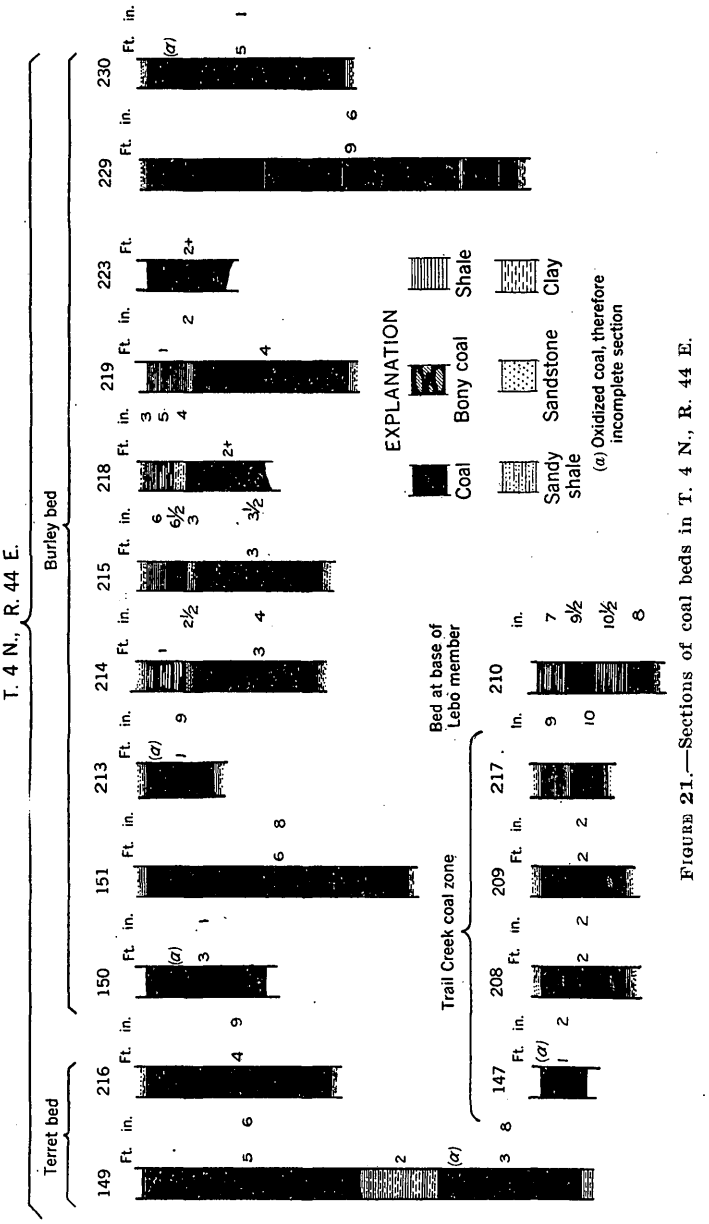


FIGURE 21.—Sections of coal beds in T. 4 N., R. 44 E.

29 and 30. The limits of workable coal in these last-named sections is less than indicated by the outcrop lines on the map, because of oxidation along the outcrop. Coal sections of the Burley bed were measured at localities 150, 151, 213, 214, 215, 218, 219, 223, 229, and 230; at localities 151 and 229

coal has been mined from open pits. The Burley bed at locality 223 is cut off to the southwest by a fault and is concealed by alluvium in the creek. The Terret bed occurs only in the southern part of the township. It is about 60 feet above the Burley bed and has burned and formed a red clinker along much of its outcrop. Unburned coal in the Terret bed does not underlie a very large area. It is 4 feet 9 inches thick at locality 216, and at locality 149 there is 5½ feet of coal underlain by 2 feet of shale and then 3 feet 8 inches of coal, which is slightly oxidized.

T. 3 N., R. 44 E.—The Rosebud Creek-Tongue River divide passes through the middle of T. 3 N., R. 44 E., in a northerly direction. The rather flat top of the divide is bordered by an irregular clinker escarpment. The valleys on both sides of the divide are sharp and deep, and the rugged slopes are covered with timber. The relief is about 400 feet.

The upper part of the Lebo shale member of the Fort Union formation is exposed in the valleys of tributaries of the Tongue River and Rosebud Creek, on the east and west sides of the township, respectively. Overlying this conformably are the yellow and buff sandstone and gray shale of the Tongue River member, which is the surface formation over most of the township and contains all the coal beds. The normal fault in sec. 1 is described on pages 68–69.

The Trail Creek coal zone is not a single bed, but includes several discontinuous coal beds in the lower 60 feet of the Tongue River member. The most persistent coal bed is about 50 feet below the Burley bed. All the beds in this zone are thin and relatively unimportant. Sections of the coal beds in the Trail Creek zone were measured at localities 118, 120, 126, 127, 128, 144, 453, 454, 455, 457, 459, 461, and 466; the coal beds at localities 144 and 454 are in the lower part of this zone. The 3½ feet of coal at locality 127 thins rapidly to the southwest. At locality 114 a bed in the Trail Creek zone has been oxidized, and 5 feet below it is a bed of coal and shale about 1 foot thick. The Burley bed is generally from 50 to 60 feet below the thick Terret clinker, but in the southeastern part of the township the interval is about 90 feet. Its thickness ranges from less than 18 inches to 4 feet 4 inches; the thicker and cleaner coal occurs on the west side of the divide. Sections of the Burley bed were measured at localities 117, 119, 121, 122, 125, 138 to 141, 143, 145, 146, 148, 212, 220, 452, 456, 458, 462, 463, and 465. The coal at localities 122 and 125 seems to be oxidized, so the sections are probably not accurate. The Burley bed crops out at locality 464 and at a spring at locality 142, but no sections were measured. The Burley bed is probably not a continuous single bed over the entire township, as the grouping of sections in plate 15 implies. The coal sections of the Burley bed in the southwest corner of the township are on a continuous bed, as are also those in the northwest corner, but the coal may or may not be continuous between these two places. Some of the Burley coal sections in the eastern part of the township are probably on discontinuous beds. The Terret bed has burned along practically all of its outcrop and has formed a thick clinker that covers a large part of the surface of the township. Where unburned, the coal in this bed is 9 feet or more thick. Coal sections were measured at localities 221 and 460, and an outcrop was noticed at locality 124. At locality 221 there is 9 feet of coal and at the base more than 1 foot of ash and coal that was burning at the time of the field investigation in 1929. In the township south of this one the maximum thickness of the Terret bed is 15 feet.

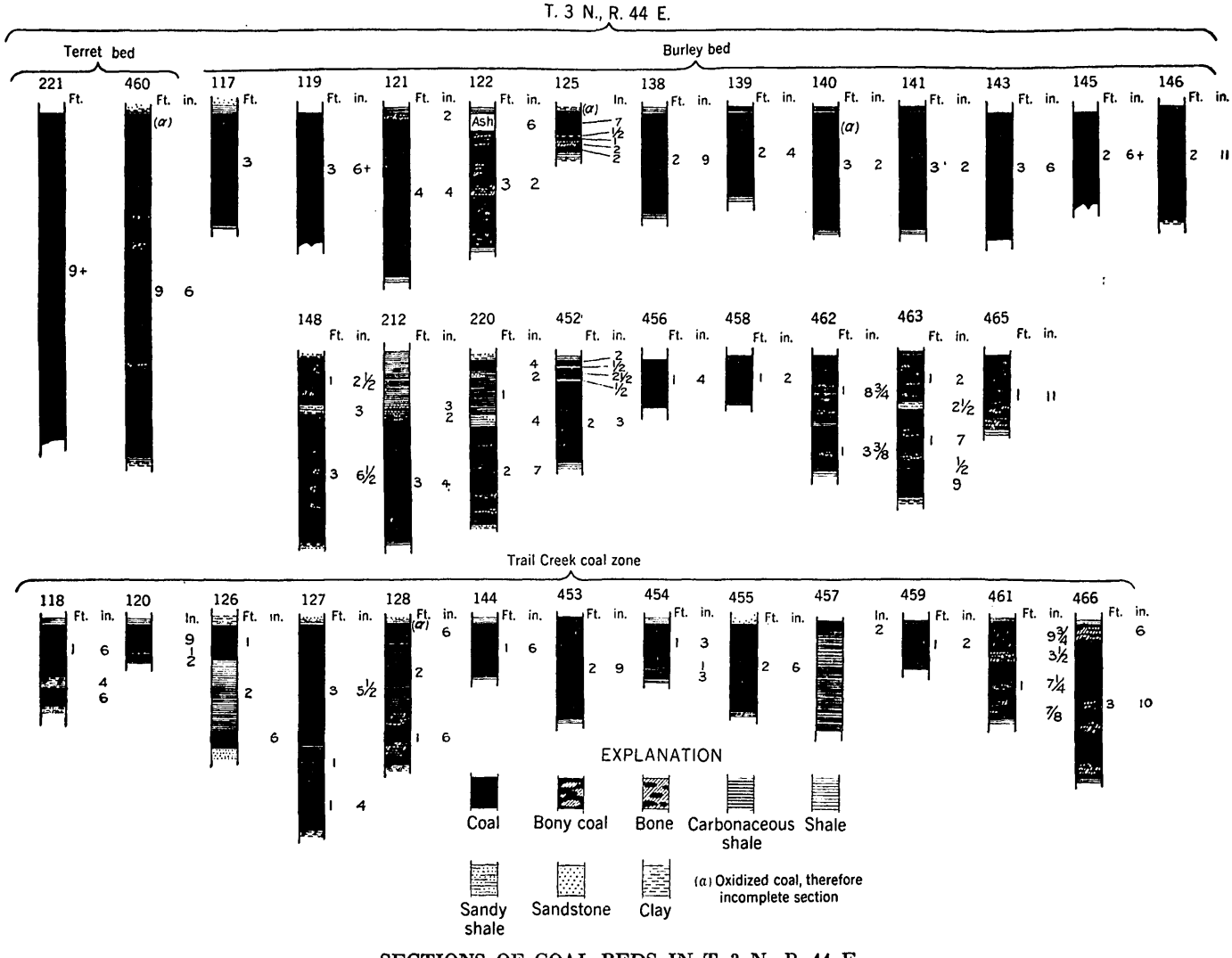
The Terret bed is the best one for development in this township. The estimate of the limit of the burning of the Terret bed is rather indefinite, but unburned

coal underlies narrow strips along the main divide and the minor divides. The cover is between 100 and 150 feet. A small, impure coal bed in the Trail Creek zone has been prospected at locality 466.

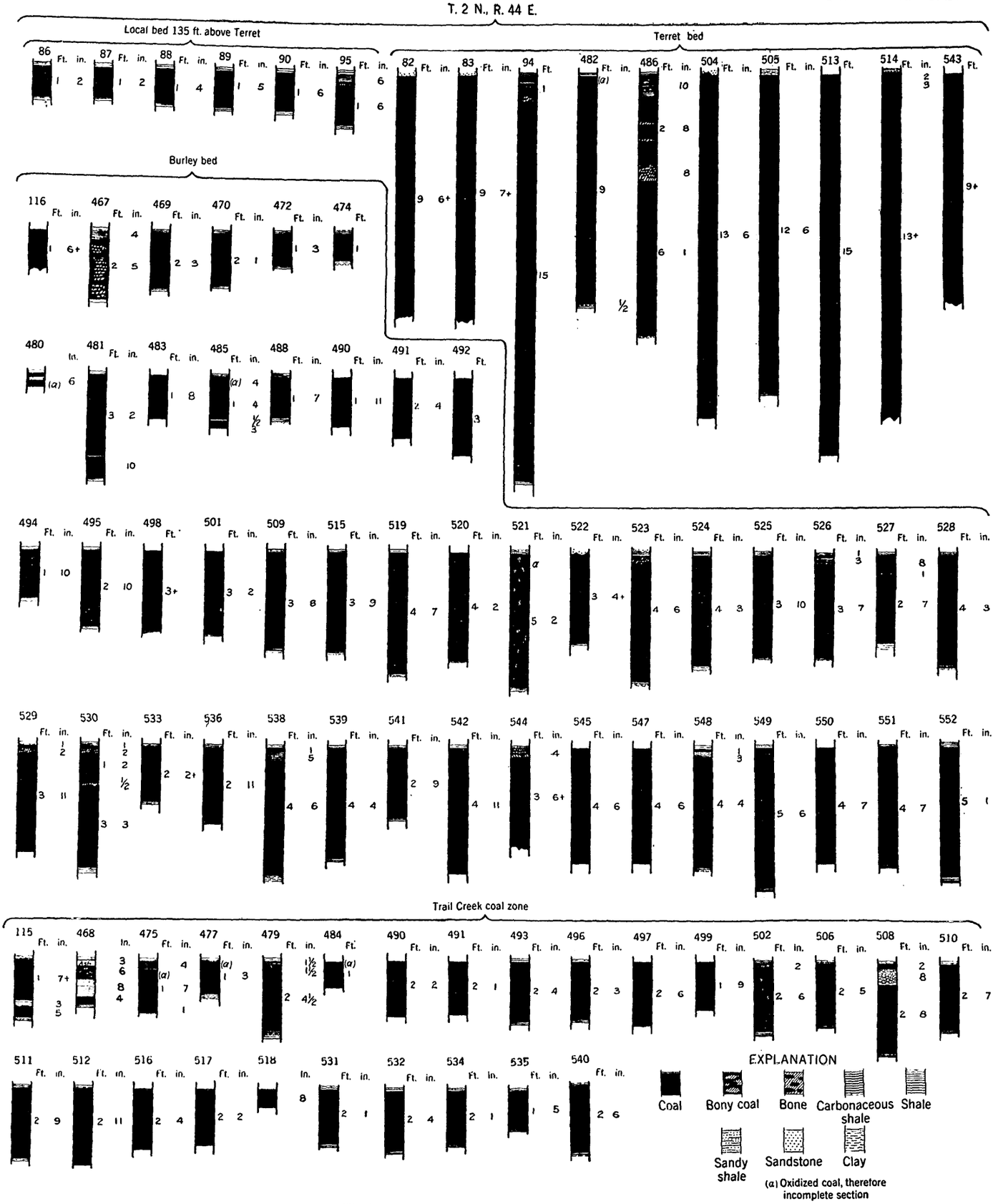
T. 2 N., R. 44 E.—The Rosebud-Tongue River divide follows an irregular northerly course through T. 2 N., R. 44 E. The surface of the township is that of an upland of moderate relief trenched by deep valleys. The burning of the Terret coal bed has produced a red clinker, which is more resistant to erosion than the underlying strata, and consequently forms the protecting cap above a steep slope along an irregular escarpment. The steep slopes are covered with yellow pine and juniper. The maximum relief is about 600 feet.

The upper part of the Lebo shale member of the Fort Union formation is exposed in the valleys of tributaries of the Tongue River, on the east side of the township. Overlying this conformably are the yellow and buff sandstone and gray shale of the Tongue River member, which are present at the surface over most of the township.

All the coal beds cropping out in this township occur in the Tongue River member of the Fort Union formation. The lowest coal is in the Trail Creek zone, which includes several discontinuous coal beds. The most persistent bed is about 60 feet above the base of the Tongue River member and is the bed that is usually denoted by the outcrop line on plate 11. The maximum measured thickness of the coal in this zone is 2 feet 11 inches, and its average thickness is about 2 feet. Coal sections were measured at localities 115, 468, 475, 477, 479, 484, 490, 491, 493, 496, 497, 499, 502, 506, 508, 510, 511, 512, 516, 517, 518, 531, 532, 534, 535, and 540. At localities 471 and 507 the persistent bed in the Trail Creek zone is oxidized along the outcrop. At locality 537 there is 8 inches of coal, 44 feet below the persistent bed in the Trail Creek zone and about 15 feet above the base of the Tongue River member. It is convenient to refer the coal in the Trail Creek zone to the Terret bed, which lies above it, because of the widespread extent and distinctiveness of the Terret clinker. The interval between the Trail Creek coal and the Terret bed increases to the west; at localities 493 and 496, in sec. 23, the interval is 77 feet; at locality 510, in sec. 21, it is 100 feet. The Terret-Burley interval remains constant at about 50 feet through these same sections. At locality 490, in sec. 24, the coal in the Trail Creek zone is 77 feet below the Terret bed; 36 feet below the persistent coal bed in the Trail Creek zone, or 103 feet below the Terret bed, there is 8 inches of coal, then a 6-foot interval and 8 inches more of coal. This horizon may pass into the Trail Creek coal in sec. 21 (locality 510), which is 100 feet below the Terret. At locality 517 the Trail Creek coal is 2 feet 2 inches thick and 90 feet below the Terret bed. A few hundred feet east, at locality 518, it is only 8 inches thick. The Burley coal bed is from 35 to 50 feet above the persistent coal bed in the Trail Creek zone and crops out in secs. 5, 6, and 30 and along the east side of the divide. Only a partial section was measured at locality 116, where a spring issues from the Burley bed, but coal sections measured a short distance outside the township show that the Burley coal in this vicinity is from 3 to 4 feet thick. The Burley bed is the thickest, from 4 to 5½ feet, and of the best quality in the southwest quarter of the township. At locality 474 the Burley bed is only 1 foot thick, and at locality 476 it contains only 6 inches of coal. It thickens west of sec. 12, however, and at locality 481 contains 4 feet of coal. At localities 478, 480, and 500 the Burley bed is oxidized at its outcrop, so that measurements of its real thickness were not obtained. The Burley coal is partly exposed at locality 503. Coal sections were measured at localities 116, 467, 469, 470, 472, 474, 480, 481, 483, 485, 488, 490, 491, 492, 494, 495, 498, 501, 509, 515, 519 to 530, 533, 536, 538, 539, 541, 542, 544, 545, and 547 to 552. In the northeastern part of the township



SECTIONS OF COAL BEDS IN T. 3 N., R. 44 E.



SECTIONS OF COAL BEDS IN T. 2 N., R. 44 E.

the interval between the Terret and Burley beds increases from 50 feet to about 75 feet. The Terret bed is present only in a narrow strip along the divide between the Tongue River and Rosebud Creek. It is the thickest coal bed in the township, containing from 9 to 15 feet of clean coal. It has burned along practically all of its outcrop and has formed the thick clinker that covers a large part of the surface of the township. Coal sections were measured at localities 82, 83, 94, 482, 486, 504, 505, 513, 514, and 543. At locality 513 the coal is poorly exposed, so that the measurement of 15 feet of coal is only approximate. At locality 123 a spring issues from the Terret bed, which is unburned there, and at localities 487 and 546 the Terret coal crops out but was not measured. A local bed 18 inches or less in thickness occurs 135 feet above the Terret in secs. 7, 18, and 19, on which the coal sections at localities 86 to 90 and 95 were measured. This bed is too thin to be of economic value and is also of small lateral extent.

Coal for local supply is obtained from surface workings on the Terret bed at the Snyder mine, in the northeast corner of sec. 31. The total thickness of the coal here could not be ascertained, but it is more than 9½ feet, and about 160 acres has 50 feet or less of cover. The cover over the Terret bed on the divide is generally between 100 and 200 feet.

T. 5 N., R. 45 E.—The greater part of T. 5 N., R. 45 E., lies in the drainage area of Graveyard Creek. The surface of this township presents varied topography—in the northwest and northeast corners, typical badlands; in the central and southwestern parts, sparsely wooded buttes and ridges capped by clinker; in the eastern part, gently undulating grassland, parts of which are under cultivation. This township is also described in the report on the Miles City coal field.[43]

The Lebo member of the Fort Union formation appears in the lower parts of the area—in the Graveyard Creek Valley and the valleys in the northeast corner of the township. The Tongue River member of the Fort Union formation crops out in the remainder of the township.

No coal beds 18 inches or more in thickness were found in the Lebo member. A coal bed about 15 feet below the Burley occurs in the northern part of the township, mainly in secs. 2, 3, 4, 5, 9, 10, and 11. This bed thins to less than 18 inches south of a line between localities 285 and 290. The northern limit is not known, but a section measured in T. 5 N., R. 46 E., seems to indicate that it does not extend far to the northeast. In secs. 3, 4, and 9, where best exposed, it has a thickness of 2 to 3 feet. Sections were measured at localities 284 to 289, 291 to 294, 297, and 298. The Burley bed, about 190 feet above the base of the Tongue River member of the Fort Union formation, is the thickest coal bed in the township, but practically all of it has been burned. Unburned coal remains in parts of secs. 31, 32, 35, and 36. A small area in secs. 35 and 36 is underlain by coal under 50 feet or less of cover. The Burley is of variable thickness, ranging from 2 to 6½ feet; sections were measured at localities 271, 280, 282, 283, 299, and 315. A coal bed about 15 feet above the Burley bed occurs in the southern part of the township, in secs. 31 and 35. The maximum measured thickness of the bed is 2 feet, and its horizontal extent is small. Sections were measured at localities 270 and 281.

A small drift mine in the Burley bed, at locality 280, has been operated to obtain fuel for local use.

T. 4 N., R. 45 E.—An irregular divide, which separates the drainage basins of Sweeney and Graveyard Creeks on the northwest and the Tongue River on the southeast, extends diagonally across T. 4 N., R. 45 E., from the northeast

[43] U. S. Geol. Survey Bull. 341, pp. 36–61, 1907.

corner. Along the main divide and the minor divides between tributary streams the surface is rugged and covered with pine timber. The maximum relief is slightly over 400 feet.

The Lebo shale member of the Fort Union formation is exposed in an area of about 2 square miles in the southeast corner of the township. The overlying Tongue River member crops out in the rest of the township. The red clinker in the southwestern part of the township was formed by the burning of the Terret coal bed, and that in the northern part by the burning of the Burley coal bed.

The Trail Creek zone, which contains the lowest coal cropping out in the township, is 19 inches or less in thickness and about 65 feet below the Burley bed. Sections were measured at localities 423 and 428. The Burley bed is only

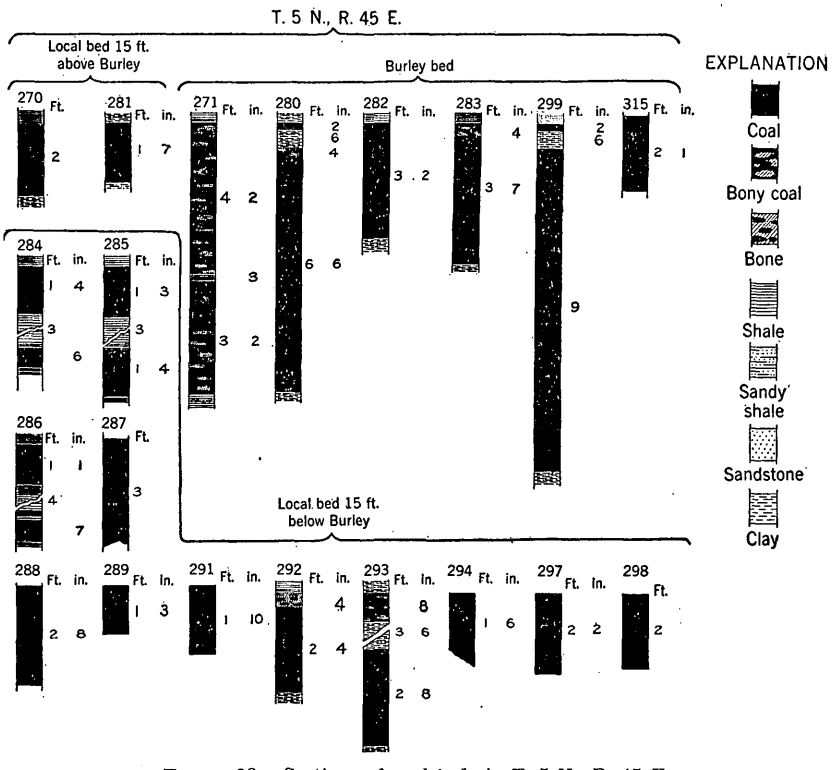
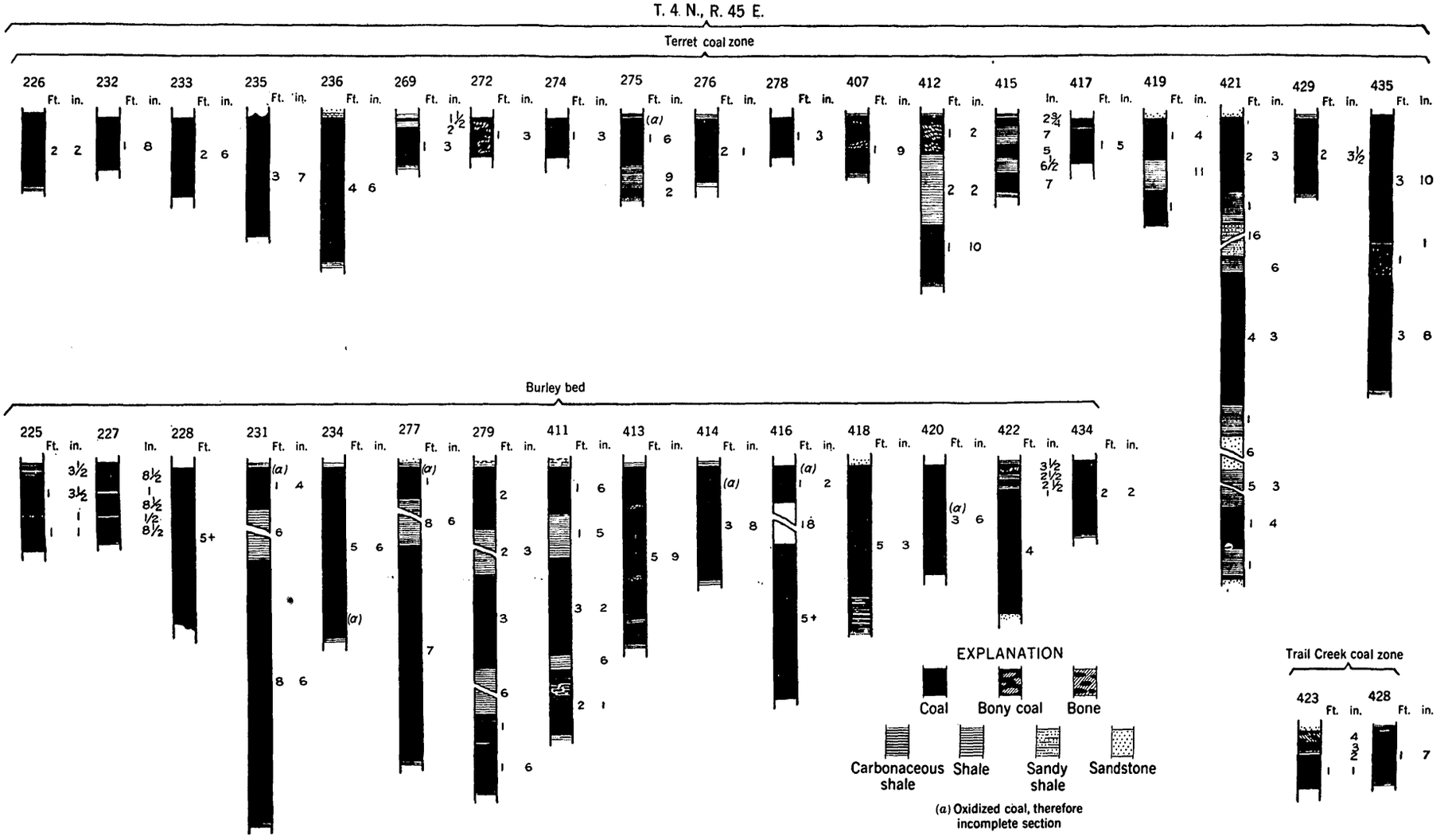
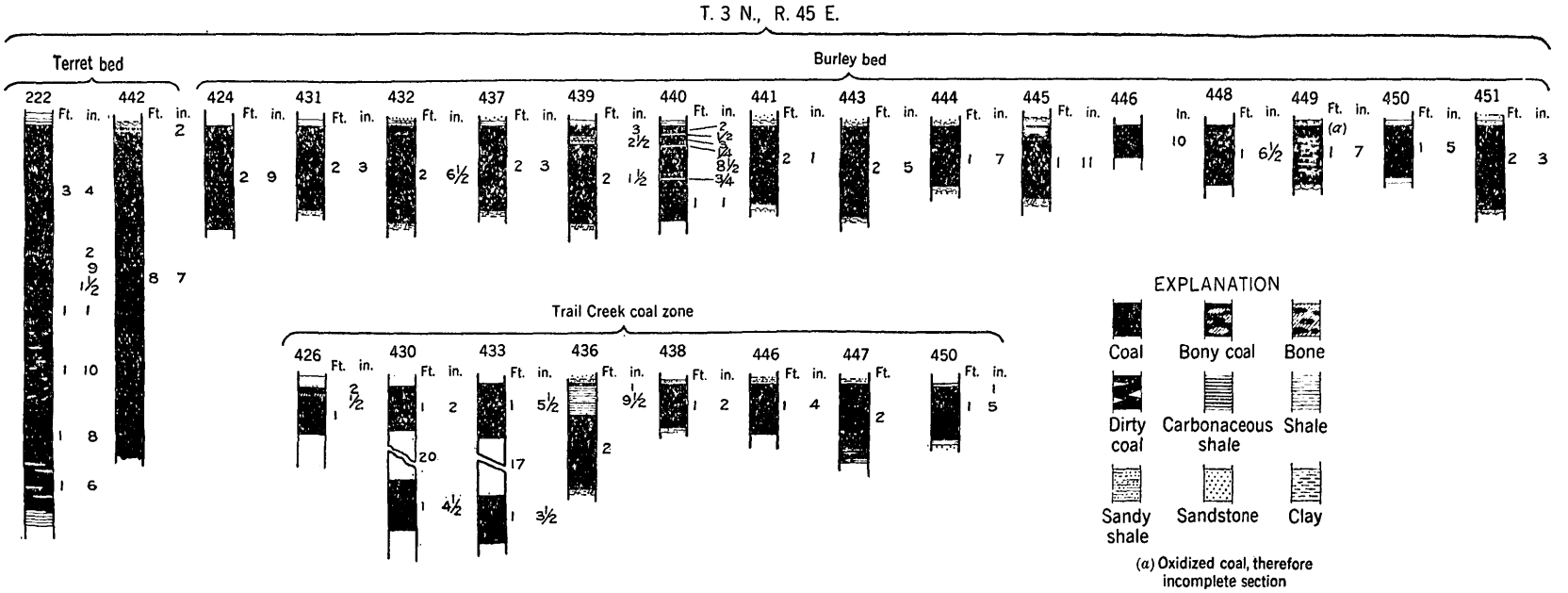


FIGURE 22.—Sections of coal beds in T. 5 N., R. 45 E.

about 2 feet thick in the southwestern part of the township but thickens to as much as 8½ feet in the northern part. Coal sections of the Burley bed were measured at localities 225, 227, 228, 231, 234, 277, 279, 411, 413, 414, 416, 418, 420, 422, and 434. There is a split in the bed at locality 231. At locality 277 the split is still present and the lower coal bed has thinned to 7 feet. Still farther east, at locality 279, the bed is split into three parts. The uppermost bed at locality 279 is probably a higher bed, not found at the other two localities just mentioned. A local resident states that at locality 273 the coal is more than 9 feet thick. At locality 413 four coal beds, each less than 18 inches thick, occur within 20 feet below the Burley bed. In the southwestern part of the township the Terret bed has burned along most of its outcrop. At locality 435 this bed is about 60 feet above the Burley and con-



SECTIONS OF COAL BEDS IN T. 4 N., R. 45 E.



SECTIONS OF COAL BEDS IN T. 3 N., R. 45 E.

tains 7½ feet of fairly good coal in two beds separated by 1 foot of impure coal near the middle. Northeast of this locality the Terret bed splits into several parts. At locality 421 there are three beds in this zone. The separate splits of the Terret bed could not be traced individually, so that all the coal beds that lie above the Burley bed are included in the Terret zone. The coal section at locality 226 includes only one of the splits, but one or more splits are probably concealed near it. Coal beds in the Terret zone were measured at localities 226, 232, 233, 235, 236, 269, 272, 274, 275, 276, 278, 407, 412, 415, 417, 419, 421, 429, and 435. The coal included in this zone in secs. 5, 6, 8, 9, and 10 is about 125 feet above the Burley bed, which is twice the interval between the Burley and Terret beds in the southwestern part of the township. The Terret zone contains several coal beds, some of which are of only local extent, and includes thin beds which are higher stratigraphically than the Terret bed and are not connected with it.

The Burley and Terret beds are the only ones thick enough to be minable. The Burley bed has not been mined in this township. Areas from a quarter of a mile to half a mile wide parallel to the outcrop, with less than 50 feet of cover, may offer stripping possibilities. A small amount of coal has been mined from the Terret zone at locality 236 in sec. 6. The bed is 4½ feet thick, but the area which it underlies near this locality is small.

T. 3 N., R. 45 E.—The northwest corner of T. 3 N., R. 45 E., is crossed by the divide between the Tongue River and Sweeney Creek, a tributary of the Yellowstone River, and the Tongue River flows northeastward across the southeast corner of the township. Near the divide the surface is rugged and the steep slopes are covered with yellow pine and juniper. The southeastern half of the area is largely grass-covered and more rolling, with some badlands. The maximum relief is about 600 feet.

The Tullock member of the Lance formation crops out in a narrow strip along the Tongue River in the southeast corner of the township. The overlying Lebo shale member of the Fort Union formation crops out extensively in the southeastern and eastern parts of the townships. The contact between the Lebo member and the overlying Tongue River member is generally transitional through a vertical distance of 20 to 30 feet, but beyond these limits the lithologic contrast is marked. Along Cow Creek this transition from somber-colored shale to sandstone is irregular. In mapping, the contact has been drawn arbitrarily, at the average horizon of lithologic change, rather than following the vertical variations. The outcrop of the Tongue River member is confined principally to the higher land in the northwestern part of the township. A section of the Tongue River member measured in sec. 18 is given on pages 62–63. The two en échelon faults in secs. 6 and 7 are described on pages 68–69.

The Lebo shale member contains no coal beds of economic value. A bed of shale and dirty coal presumably lies at its base, but it was not observed in the poor exposures along the Tongue River. Coal beds in the Trail Creek zone, which is from 30 to 60 feet above the base of the Tongue River member, range from less than 18 inches to 2 feet in thickness. Coal sections were measured at localities 426, 430, 433, 436, 438, 446, 447, and 450. At localities 430 and 433 thin beds occur about 20 feet below the more persistent bed in the Trail Creek zone. The coal at locality 447 is 2 feet thick, but the bed is only of local extent. The coal in the Trail Creek zone is not of sufficient thickness to be of economic value. The Burley bed is 40 to 60 feet above the Trail Creek zone and is usually from 50 to 60 feet below the Terret clinker. The coal is 2½ feet or less in thickness. Sections of the Burley bed were measured

at localities 424, 431, 432, 437, 439, 440, 441, 443 to 446, and 448 to 451. At locality 427, which is only 33 feet below the clinker formed by the lower split (?) of the Terret bed, the Burley bed is oxidized along its outcrop, so that only a red band a few inches thick marks its horizon. Most of the coal in the Terret bed has been destroyed by burning, and a thick red clinker has formed above it as a result. Some unburned Terret coal may remain in parts of secs. 5, 7, 8, 15, 16, and 17, but the lateral extent of the bed at any place is small. Coal sections were measured at localities 222 and 442.

T. 2 N., R. 45 E. (fractional).—The Tongue River, which flows northeastward across T. 2 N., R. 45 E., supplies water for irrigating the fertile bottom lands along the northwest side of the river. From the river the surface rises through a series of gravel-covered terrace remnants to the high clinker-capped buttes and ridges in the northwestern part of the township. The maximum relief is about 500 feet.

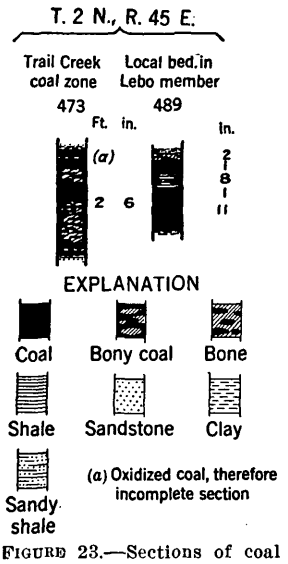


FIGURE 23.—Sections of coal beds in T. 2 N., R. 45 E.

The Tullock member of the Lance formation occurs only in a very small area in the northeast corner of the township. It is overlain by the Lebo shale member of the Fort Union, which is the surface formation over most of this fractional part of the township. The Tongue River member caps ridges in the northwestern part of the township but has a total area of outcrop of only about 2 square miles.

The township contains no coal of economic value. No exposures of the dirty coal bed at the base of the Lebo were found. At locality 489 a local coal bed in the Lebo member contains only 11 inches of clean coal. A coal section of the Trail Creek bed measured at locality 473 shows 2½ feet of impure coal oxidized in the upper part. In sec. 7 there may be coal from 1½ to 2 feet thick at the Trail Creek or Burley horizons, but no outcrops were found. All of the Terret coal has burned and formed the red clinker in secs. 5, 7, 18, and 19.

T. 5 N., R. 46 E.—The surface of the greater part of T. 5 N., R 46 E., consists of rolling grass lands, but rough badland areas predominate in secs. 3, 4, 5, and 6, the east tier of sections, and the S½ sec. 35. Much of the northwestern half of the township is made up of gently sloping terraces, covered with a thin layer of gravel. Rather sharp valleys have been cut in these terrace slopes. The maximum relief is about 400 feet.

The upper 40 feet of the Tullock member of the Lance formation crops out on Moon Creek, in the northeast corner of the township. The Lebo shale member of the Fort Union formation, which is 190 to 220 feet thick and consists principally of somber-colored shale, although locally thick beds of sandstone occur in it, crops out in about half of the township. The contact between the Lebo and Tongue River members of the Fort Union is marked over much of this township by a thin coal bed. The Tongue River member crops out in the southern and western parts of the township. This township is also described in the report on the Miles City coal field.[44]

[44] U. S. Geol. Survey Bull. 341, pp. 36–61, 1907.

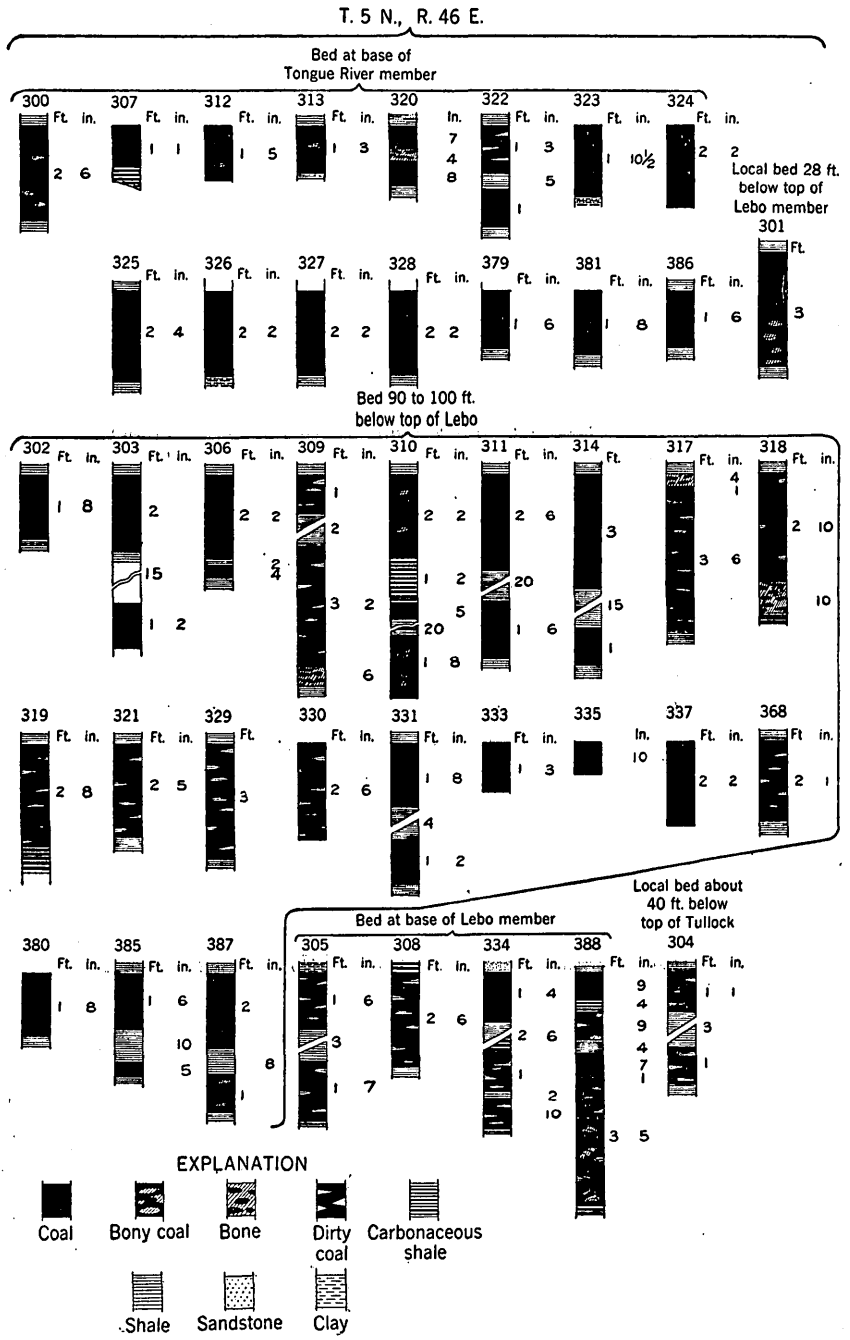


FIGURE 24.—Sections of coal beds in T. 5 N., R. 46 E.

In general the strata are flat-lying, but dips of 30 to 45 minutes were measured between localities 333 and 337. It is difficult to ascertain the structure, because of the lack of a persistent horizon. In sec. 25 there is an indication of a small arch. These slight dips probably become insignificant with depth.

In the N½ sec. 4 there has been some deformation during sedimentation. Small superficial faults of short horizontal and vertical extent are associated with beds dipping at a maximum of 45°. The steep dips persist for only a few feet. Some thin coal beds end abruptly against sandstone, at some places cut by an old stream channel and in other places terminated by slight displacement. Extreme cross-bedding is common. Compaction after deposition may also have caused some of the displacements and irregularities.

The Tullock member of the Lance formation does not contain any coal over 18 inches thick at outcrops in this township; a section of a thin local bed about 40 feet below the top of the Tullock was measured at locality 304. The coal bed at the base of the Lebo member of the Fort Union formation, which is approximately equivalent to bed C of the Miles City coal field and the Big Dirty bed, crops out along Moon Creek, in the northeast corner of the township, and at the southern edge of sec. 36. The coal is of poor quality, as shown by the sections measured at localities 305, 308, 334, and 388. At locality 384, in the township adjoining on the south, this bed contains 4 feet 3 inches of fair coal, but it changes to impure coal a short distance from that locality. A coal bed, which is equivalent to bed D of the Miles City coal field, occurs 90 to 100 feet below the top of the Lebo member. Its average thickness is about 2½ feet, but it is very dirty and only locally contains coal of fair quality. It thins out in secs. 1 and 12. Coal sections were measured at localities 302, 303, 306, 309, 310, 311, 314, 317, 318, 319, 321, 329, 330, 331, 333, 335, 337, 368, 380, 385, and 387. A local bed 28 feet below the top of the Lebo member was measured at locality 301. The coal at the base of the Tongue River member is thickest in secs. 25 and 36, where its average thickness is about 2 feet 2 inches. Elsewhere in the township it is less than 18 inches thick. Sections were measured at localities 300, 307, 312, 313, 320, 322 to 328, 379, 381, and 386.

T. 4 N., R. 46 E.—The Yellowstone-Tongue River divide extends a little north of east through the northern tier of sections in T. 4 N., R. 46 E. Moon Creek drains the small area north of this divide, and the area south of it is drained by southeastward-flowing tributaries of the Tongue River. In the northern and northwestern parts of the township the surface is rolling and grass-covered and some land is under cultivation; the surface of the remainder of the township is largely badlands with considerable relief. The maximum relief is 500 feet.

The Tullock member of the Lance formation is exposed along the Tongue River and the lower parts of its tributaries, in the southeastern part of the township. The Lebo shale member of the Fort Union formation, from 170 to 200 feet thick, forms the surface rock over half of the township. The lower part of the Tongue River member of the Fort Union formation crops out principally on the divide in the northwestern part of the township.

No coal 18 inches or more in thickness was found in the Tullock member. At locality 406, about 100 feet below the top of the Tullock member, 8 feet of carbonaceous shale with streaks of coal is exposed on the north side of Forest Creek. The coal at the base of the Lebo member is generally so dirty that it can be disregarded as a source of coal. The bed contains the best

coal at locality 396, where there is 5 feet 3 inches of somewhat impure coal, but coal of this thickness is of only small lateral extent. Sections on this bed were also measured at localities 395, 400, and 401. The Burley bed underlies only a small area in secs. 6 and 7. At locality 316 only thin beds of coal were found at the Burley horizon. In the township west of this one the Burley bed contains as much as 8 feet of coal, but measured sections show that it splits into three parts and becomes thinner toward the east. The Burley bed is probably not more than 2 feet thick in this township. At locality 410 there are several coal beds from 6 inches to a foot thick in the Tongue River member.

T. 3 N., R. 46 E.—The Tongue River flows northeastward across the center of T. 3 N., R. 46 E. Beyond the flood plain in the northwest half of the township the surface is largely badlands. Gravel-covered benches are present for a few miles southeast of the Tongue River. The maximum relief is about 450 feet.

The Tullock member of the Lance formation crops out in a narrow strip along the Tongue River and extends a few miles up the tributary valleys. The overlying Lebo shale member of the Fort Union formation, which is about 170 feet thick, is the surface rock in most of the remaining area of the township. The Tongue River member of the Fort Union formation crops out in a small area in the southeastern part of the township.

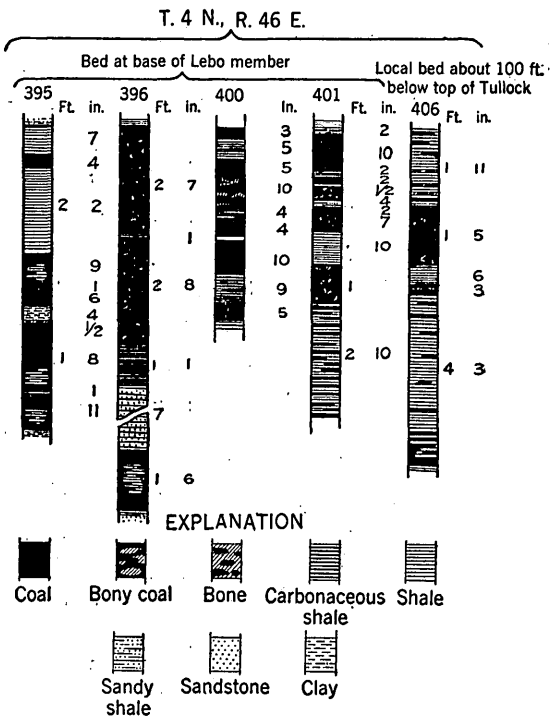


FIGURE 25.—Sections of coal beds in T. 4 N., R. 46 E.

The coal that occurs from 40 to 160 feet below the top of the Tullock member is so lenticular that any single bed is traceable for only a short distance. For convenience in treatment it is grouped into a single bed, but in reality it is a coal zone. The coal at localities 409, 553, and 556 is 40 to 70 feet lower stratigraphically than the coal indicated by the outcrop line on plate 11 at localities 408, 425, 557, 559, 566, and 568. The coal indicated by the outcrop line is a discontinuous bed 40 to 110 feet below the top of the Tullock. A small amount of coal has been taken out at locality 566 for local supply. A coal bed at the base of the Lebo was measured at localities 558, 560, and 561, where it had a maximum thickness of 22 inches. The outcrop of a local bed about 85 feet below the top of the Lebo member is not shown on the map, inasmuch as the bed varies a great deal in thickness; sections measured at localities 554 and

555 show that it is between 14 inches and 2 feet thick. All of the Terret coal in the Tongue River member has burned.

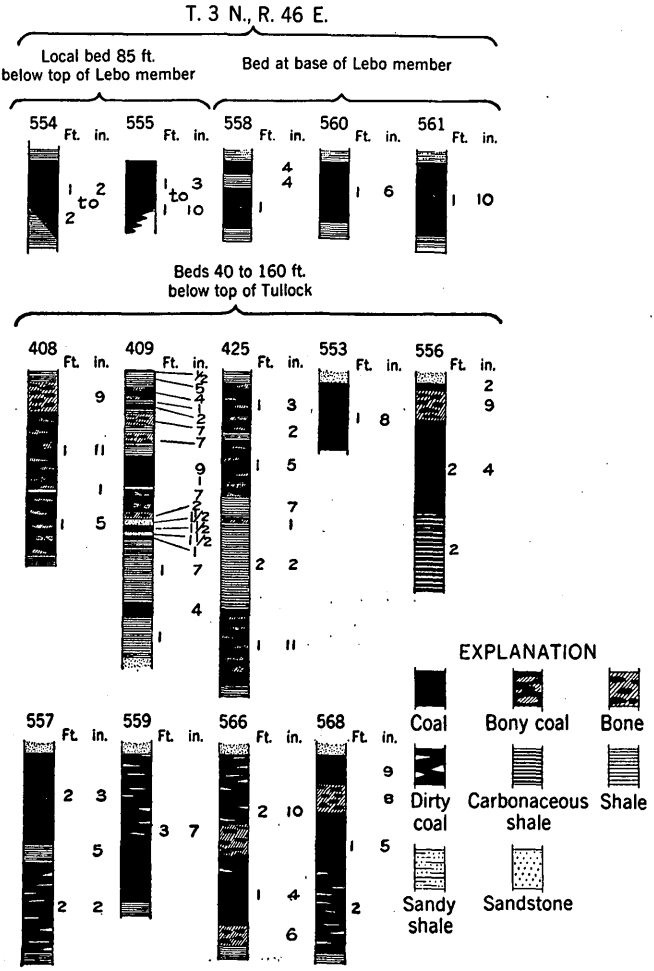
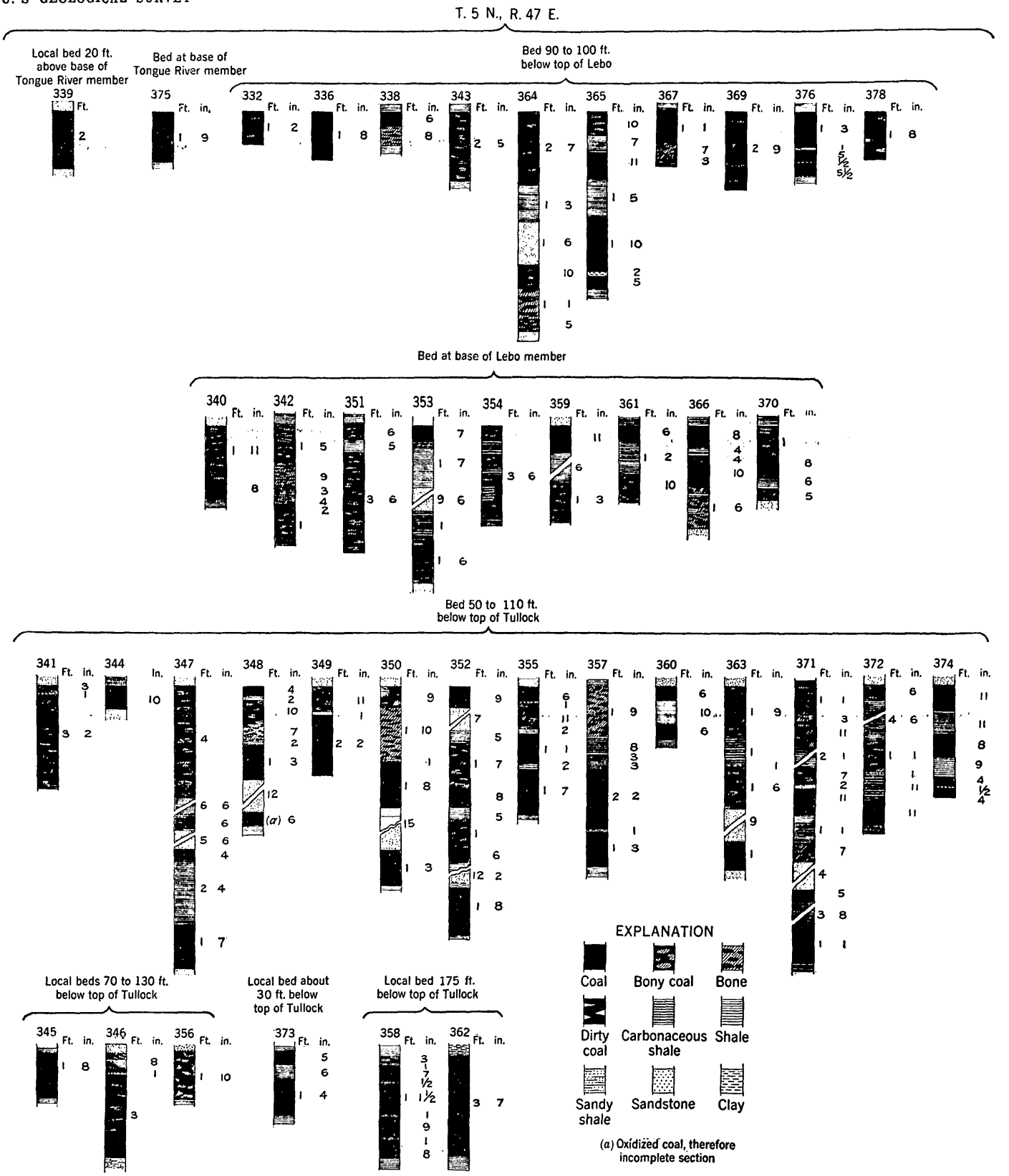


FIGURE 26.—Sections of coal beds in T. 3 N., R. 46 E.

T. 5 N., R. 47 E.—The Tongue River flows northeastward across the southeast corner of T. 5 N., R. 47 E. With the exception of the bottom lands along the river, the surface of the township is rough and deeply dissected by erosion. Badlands are common. The maximum relief is about 525 feet.

The Tullock member of the Lance formation crops out on both sides of the Tongue River and is the surface formation in more than half of the township; about 230 feet of this member is exposed. The Lebo member, composed of about 200 feet of somber-colored shale, with some sandstone beds and ironstone concretions, overlies the Tullock member and crops out in the western part of the township. An irregular, dirty coal bed is arbitrarily taken as the base of the Lebo, for the Lebo and Tullock are very similar in appearance, and any boundary line between them is an artificial one. The Tongue River member of the Fort Union formation crops out in areas of moderate extent in the west-



SECTIONS OF COAL BEDS IN T. 5 N., R. 47 E.

ern part of the township. This township is also described in the report on the Miles City coal field.[45]

Several coal beds occur in the Tullock member, but they are not of economic value. A local coal bed about 175 feet below the top of the Tullock, which crops out only on Thorp Creek, contains the best coal in this township. Sections were measured at localities 358 and 362; at locality 362 it contains 3 feet 7 inches of coal, but to judge from the other coal beds in the Tullock member, this bed probably does not extend very far horizontally without becoming of poorer quality. Sections of local beds 70 to 130 feet below the top of the Tullock were measured at localities 345, 346, and 356, and a local bed about 30 feet below the top of the Tullock was measured at locality 373, but their outcrops were not mapped. The coal bed 50 to 110 feet below the top of the Tullock is a coal zone rather than a single persistent bed; the locations of the discontinuous beds in this zone are represented on plate 11 by a continuous line of outcrop. The coal is variable in thickness and quality and only locally is over 2 feet thick. The small partings, bone, and shale in the coal render it of little value as a coal bed. Sections were measured at localities 341, 344, 347 to 350, 352, 355, 357, 360, 363, 371, 372, and 374. A bed at the base of the Lebo consists of 2½ to 3 feet of carbonaceous shale, with thin beds of impure coal. Only locally does it contain 18 inches of fair coal. The sections measured at localities 340, 342, 351, 353, 354, 359, 361, 366, and 370 show the character of this bed. The coal bed 90 to 100 feet below the top of the Lebo, which is equivalent to bed D of the Miles City coal field, is also impure and of little value. Sections were measured at localities 332, 336, 338, 343, 364, 365, 367, 369, 376, and 378. Parts of this bed have burned in the southwestern part of the township and formed a clinker. The coal at localities 364 and 365 is grouped with the bed 90 to 100 feet below the top of the Lebo, but actually it is lower stratigraphically and probably represents small local beds.

A coal bed at the base of the Tongue River member occurs in parts of secs. 30 and 31 and is from 1 foot 9 inches to 2 feet 2 inches thick. A section was measured at locality 375. A local bed about 20 feet above the base of the Tongue River member is of small horizontal extent and only 2 feet thick. A section was measured at locality 339.

T. 4 N., R. 47 E.—The Tongue River flows northeastward across the middle of T. 4 N., R. 47 E. Except for the alluvial bottom land along the river, the surface of the township is rough. Badlands are common in the northwestern and southeastern parts. The maximum relief is about 450 feet.

About 240 feet of the Tullock member of the Lance formation is exposed in the Tongue River Valley. The Lebo shale member of the Fort Union formation crops out in the northwestern and southeastern parts of the township.

A local coal bed in the Tullock, 35 feet below locality 614, contains 3½ feet of coal. Coal at this horizon also crops out in the bed of the Tongue River at locality 615, 25 feet below the Tullock bed shown on the map at locality 611. At the outcrop in the Tongue River near locality 611 there is about 3 feet of good coal, partly covered by water. A coal bed about 200 feet below the top of the Tullock is mapped in secs. 10, 12 to 16, and 23. The cleanest and thickest coal in this bed is at locality 611. Sections were measured at localities 382, 392, 610 to 614, 616, 617, and 618. The coal thins to less than 18 inches northeastward across sec. 13. Another local bed, about 130 feet below the top of the Tullock, that crops out a few feet above the Tongue River was measured at

[45] U. S. Geol. Survey Bull. 341, pp. 36–61, 1907.

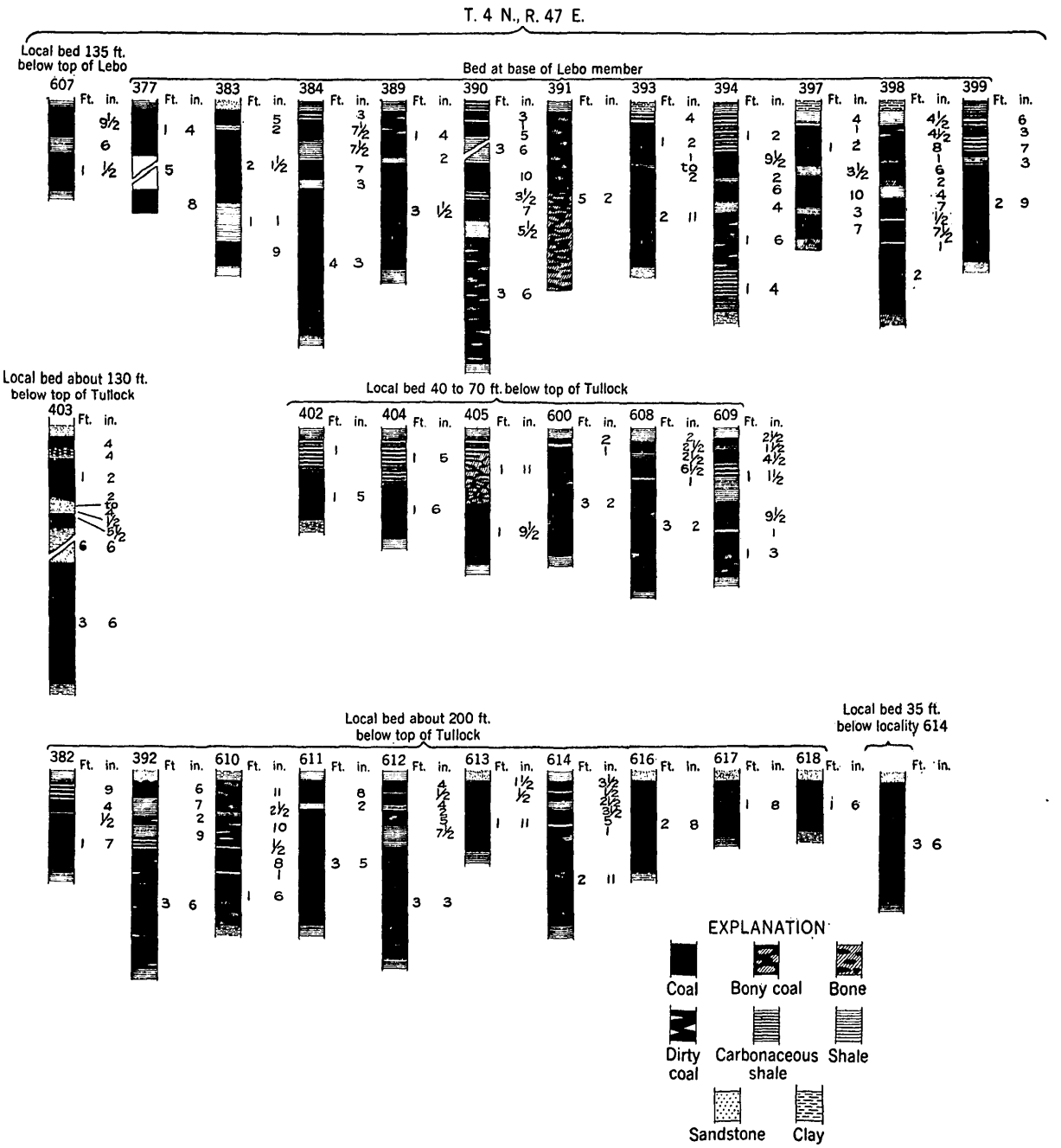
locality 403. It is concealed by alluvium and therefore traceable only a short distance. A local coal bed 40 to 70 feet below the top of the Tullock is mapped in the southwestern part of the township. The coal is discontinuous, impure, and variable in thickness. Sections were measured at localities 402, 404, 405, 600, 608, and 609. A coal bed at the base of the Lebo is present only in the northwestern part of the township. Locally it contains a thickness of several feet of fair coal, but generally the bed is dirty and contains several partings. Sections were measured at localities 377, 383, 384, 389, 390, 391, 393, 394, 397, 398, and 399. Above localities 608 and 609, in sec. 28, a coal bed near the base of the Lebo was measured. This bed is 22 feet above the bed at locality 608; it contains 2 feet 3 inches of coal but its horizontal extent is small. About 16 feet above this bed, at locality 609, is a bed of coal 10 inches thick. A local bed 135 feet below the top of the Lebo, measured at locality 607, in sec. 35, contains 22 inches of coal with a 6-inch parting.

A few wagon loads of coal a year are taken from the bed that crops out in the Tongue River near localities 611 and 615. The bed at the base of the Lebo has been prospected at locality 384.

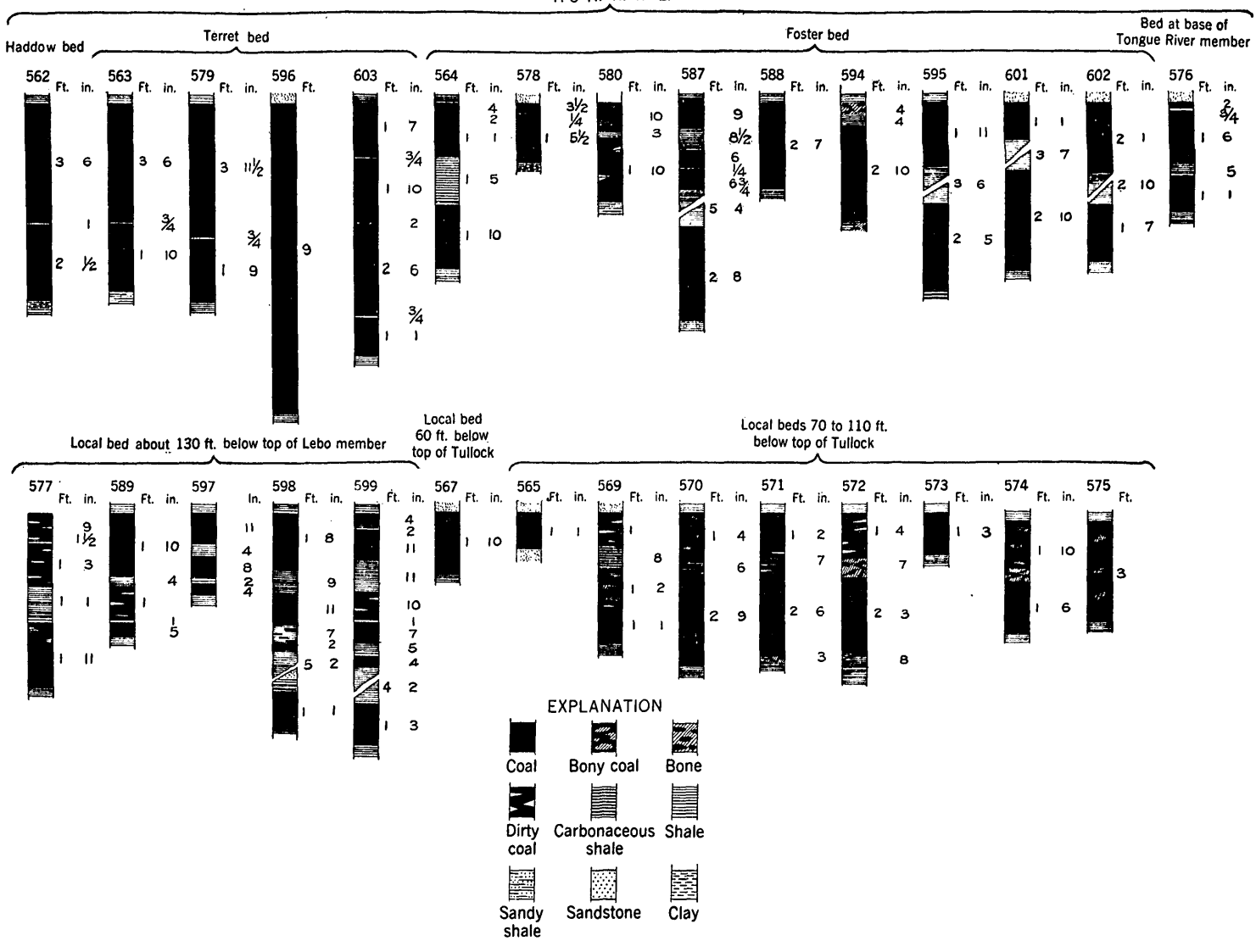
T. 3 N., R. 47 E.—The Tongue River flows northeastward through the northwest corner of T. 3 N., R. 47 E., and the township is drained by northwestward-flowing tributaries of the river. The surface of the township is rough and broken. Badlands are common in the central and northeastern parts and are present to a lesser extent elsewhere. Steep-sided clinker-capped buttes rise above the surrounding surface in the eastern and southeastern parts of the township. The total relief is about 450 feet.

The Tullock member of the Lance formation crops out along the Tongue River and along numerous smaller valleys near the north and west sides of the township. The Lebo shale member of the Fort Union formation crops out in the greater part of the township. The lower part of the member is similar in lithology to the underlying Tullock beds. The Tongue River member of the Fort Union formation is present in the eastern part of the township and extends northwestward along the divides.

The local coal bed 70 to 110 feet below the top of the Tullock, which crops out in the extreme western part of the township, is discontinuous, is variable in thickness and purity, and does not include an important reserve of coal. Clean coal 18 inches thick is of only local horizontal extent. Sections were measured at localities 565 and 569 to 575. A local bed 60 feet below the top of the Tullock was observed only at locality 567, in sec. 18; the bed is only 22 inches thick and was not mapped. Sections of a local bed about 130 feet below the top of the Lebo were measured at localities 577, 589, 597, 598, and 599, but the coal is generally of poor quality; the thickest coal in this bed is 20 inches thick where it is unbroken by partings. The Tongue River member contains the thickest coal beds in the area, but they are of slight horizontal extent and are usually burned along their outcrops. A local bed at the base of the Tongue River member was observed only at locality 576. The Foster bed, which is about 28 feet below the Terret bed, in places consists of two beds 3 to 5 feet apart. The total coal ranges from 1 foot 9 inches to 4½ feet; the maximum measured thickness of coal not separated by partings, however, is 2 feet 10 inches. The Foster bed is generally unburned along the outcrop. Sections were measured at localities 564, 578, 580, 587, 588, 594, 595, 601, and 602. The Terret bed is the thickest coal bed in this township, but it is of small horizontal extent. Burning along its entire outcrop has further reduced the quantity of available coal. The area underlain by the Terret coal consists of isolated outliers and narrow strips on and in the interstream divides. The



SECTIONS OF COAL BEDS IN T. 4 N., R. 47 E.



SECTIONS OF COAL BEDS IN T. 3 N., R. 47 E.

exact area of available coal in this bed is undetermined, because the limit of burning is unknown. Inasmuch as the areas are small and not easily accessible, the coal in this bed in this township is not considered of as much value as the measured sections might indicate. The bed is between 5½ and 9 feet thick. Sections were measured at localities 563, 579, 596, and 603. The Terret bed is present in parts of secs. 13, 24, 25, 35, and 36. The Haddow bed, named from Haddow Creek, is present in only small areas in sec. 13 and the eastern part of secs. 24, 25, and 36. At locality 562, which is 300 feet south of the south line of sec. 36, the Haddow bed contains 5½ feet of coal, but it thins northward and eastward from this locality. At locality 585, in sec. 30, T. 3 N., R. 48 E., it contains only 2 feet of coal. The Haddow bed contains between 2 and 5 feet of coal in a small area in the eastern part of sec. 36. In the remaining areas in this township in which it occurs this bed is probably not much over 2 feet in thickness, and perhaps less. The Haddow bed is about 50 feet above the Terret bed.

T. 5 N., R. 48 E.—The Tongue River flows northeastward across the northwest corner of T. 5 N., R. 48 E., and the surface of the township is drained by several of its northwestward-flowing tributaries, including Pumpkin Creek, which crosses the northeast corner of the township. Except for the broad alluvial flat along the Tongue River and the valley floor of Pumpkin Creek, the surface of the township is deeply dissected by erosion. Badlands are common, and vegetation is scarce. The maximum relief is about 540 feet.

The Tullock member of the Lance formation crops out over much of the township. The Lebo member of the Fort Union formation is between 160 and 190 feet thick and crops out extensively between Nelson and Pratt Creeks and between Pratt and Pumpkin Creeks. The Tongue River member is present in a small area in secs. 22 and 23, and a few remnants occur in sec. 36. This township is also described in the report on the Miles City coal field.[46]

A local bed about 250 feet below the top of the Tullock, which crops out at locality 664, on Pumpkin Creek in sec. 3, contains 2 feet of clean, solid coal, the best coal found in this township. A coal bed 45 to 85 feet below the top of the Tullock member occurs in the north-central part of the township and in small areas in secs. 30 and 32. Generally the bed is about 70 feet below the top of the Tullock and consists of 1 to 2 feet of coal in an impure coal and shale bed. The thicknesses of over 5 feet at localities 645 and 657 are exceptional and are only of local extent. The coal in the upper part of the Tullock may be completely absent in places and reappear at a slightly higher or lower horizon; consequently, this coal, which is represented as a single bed on the map, is really a zone with a maximum thickness of 40 feet. Sections were measured at localities 642, 645, 654, 655, 657, 658, 660, 662, 663, 665 to 668, 670, and 673. A bed at the base of the Lebo is extremely variable in purity and thickness. The large amount of shale and bone in the bed render it of little value. Sections were measured at localities 641, 643, 644, 648, 650 to 653, 656, 659, 661, 669, 671, and 672. A coal section of a series of local beds in the Lebo was measured at locality 649; each bed of coal is less than 18 inches thick. The lowest coal is about 30 feet above the base of the Lebo.

The coal at locality 657 has been prospected, but none of the coal in this township is mined.

T. 4 N., R. 48 E.—The Tongue River flows northeastward across the northwest corner of T. 4 N., R. 48 E. Northwestward-flowing tributaries of the river have cut deep valleys which are separated by sharp narrow divides. Badlands are common in this township. The maximum relief is about 500 feet.

[46] U. S. Geol. Survey Bull. 341, pp. 36–61, 1907.

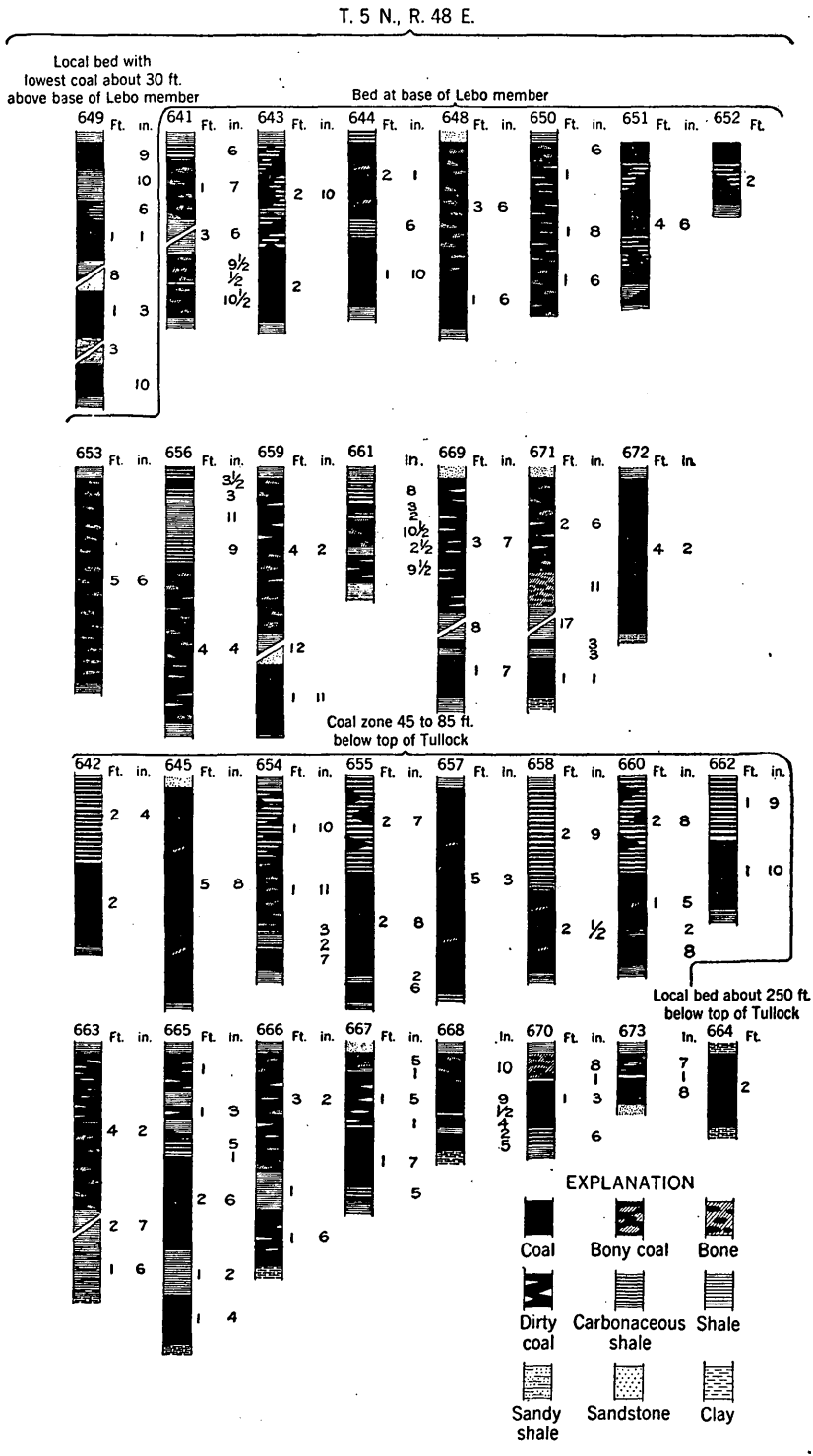


FIGURE 27.—Sections of coal beds in T. 5 N., R. 48 E.

The Tullock member of the Lance formation crops out in the valleys of Ash and Nelson Creeks and the Tongue River. The Lebo shale member of the Fort Union formation, from 160 to 180 feet thick, crops out on the divides between the tributary streams of the Tongue River. The Tongue River member is present in small areas in the eastern part and the southwest corner of the township.

A local bed about 100 feet below the top of the Tullock, measured at locality 619, in sec. 35, is of little value because of the impurity of the coal. The extent of another local bed about 220 feet below the top of the Tullock mem-

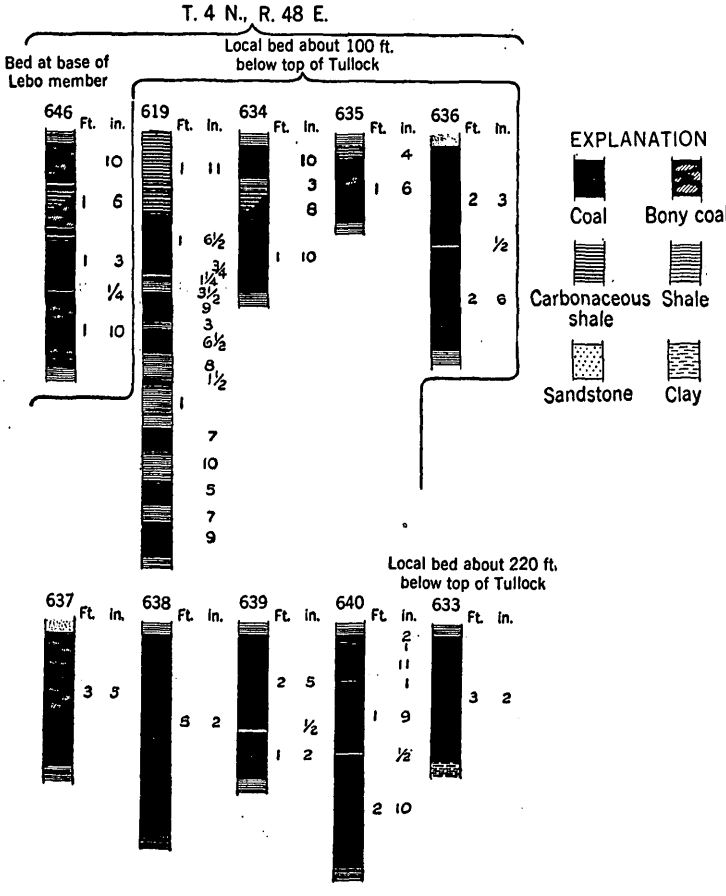


FIGURE 28.—Sections of coal beds in T. 4 N., R. 48 E.

ber, in sec. 6, is concealed by alluvium; at locality 633 it contains 3 feet 2 inches of coal. A local coal bed about 100 feet below the top of the Tullock is mapped in secs. 1, 2, 3, 11, and 12. At locality 638 it contains 5 feet 2 inches of coal. At locality 645, a few hundred feet north of sec. 1, this bed is 5 feet 8 inches thick, but the coal is somewhat impure. Sections were measured at localities 634 to 640. East of the east township line this bed becomes very impure. A measured section at locality 647, T. 4 N., R. 49 E., is shown in figure 31. A coal bed at the base of the Lebo was found only in sec. 1; a section was measured at locality 646.

None of the coal in this township is mined. The local bed about 100 feet below the top of the Tullock in the northeastern part of the township and the local bed in sec. 6 contain the best coal.

T. 3 N., R. 48 E.—In the northeastern half of T. 3 N., R. 48 E., there are several wide, gravel-covered terraces surmounting areas of badlands. The surface rises toward the southwest to clinker-capped buttes and ridges. The total relief is about 500 feet.

The upper part of the Tullock member of the Lance formation crops out on Ash Creek, in the northeastern part of the township. The overlying Lebo shale member of the Fort Union formation also crops out extensively in the northeastern half of the township. The Tongue River member of the Fort Union crops out in the southwestern half and contains all the coal beds of any economic value.

Sections of the coal bed at the base of the Lebo were measured at localities 621, 622 and 632. The coal is very dirty and of little value. The Foster bed, about 120 feet above the base of the Tongue River member in the southwest corner of the township and 70 feet above the base 3 miles to the north, is in few places over 18 inches thick and generally consists of two thin beds separated by 1 to 5 feet of shale. It is present only in parts of some of the western tier of sections of this township. In sec. 30 the Foster bed is 27 feet below the Terret; north of this section the interval decreases to 16 feet. Coal sections were measured at localities 584, 590, 604, 605, 606, and 620a. The Terret bed, the thickest and most valuable coal bed in the township, is burned along most of its outcrop. It is about 9 feet thick in parts of secs. 17 to 20, 28, and 29 to 33, and apparently thins rapidly east of locality 626. Sections were measured at localities 581, 583, 591, 593, 620, 624 to 627, 629, and 630. The Flowers bed, which lies above the Terret, is also clinkered along its outcrop. The interval between it and the Terret bed decreases to the northeast. In the southwest corner of the township this interval is 80 feet; it decreases to 70 feet and finally to 50 feet in the northwestern part of the township; and it decreases eastward to 35 feet at locality 626. The Haddow bed is not a valuable coal bed in this township. The average thickness is between 2 and 3 feet. It thickens southwest of this township; at locality 562, in sec. 1, T. 2 N., R. 47 E., it is 5½ feet thick. The Haddow bed is 25 to 30 feet below the Flowers; it is mapped only on the west side of the divide, in secs. 19, 30, 31, and 32. The Flowers bed is about 150 feet above the base of the Tongue River member and is the highest coal in this township. It has burned along its entire outcrop, so that measurements of its thickness are difficult to obtain. Areas of workable coal in this bed are present on the divide in parts of secs. 19, 20, 27, 28, 29, 32, 33, and 34. The average thickness of the bed is nearly 8 feet. Coal sections were measured at localities 586, 592, and 623.

Coal is mined in the fall from the open pits on the Terret bed, in the Southwest corner of sec. 32, at locality 581, to obtain fuel for local consumption. The mine is made accessible by a poor road up Haddow Creek. An area in sec. 20, which is underlain by the thick Terret bed under less than 60 feet of cover, may be suitable for open-cut mining. A small area of the Flowers bed in the SW¼ sec. 33 is overlain by less than 50 feet of cover.

T. 5 N., R. 49 E.—Pumpkin Creek, meandering a great deal in its narrow flood plain, flows northwestward across T. 5 N., R. 49 E. A strip of alluvium about half a mile wide is present along the creek, but is not shown on plate 11. Badlands are common in the southwestern and northeastern parts of the area. The maximum relief is about 375 feet.

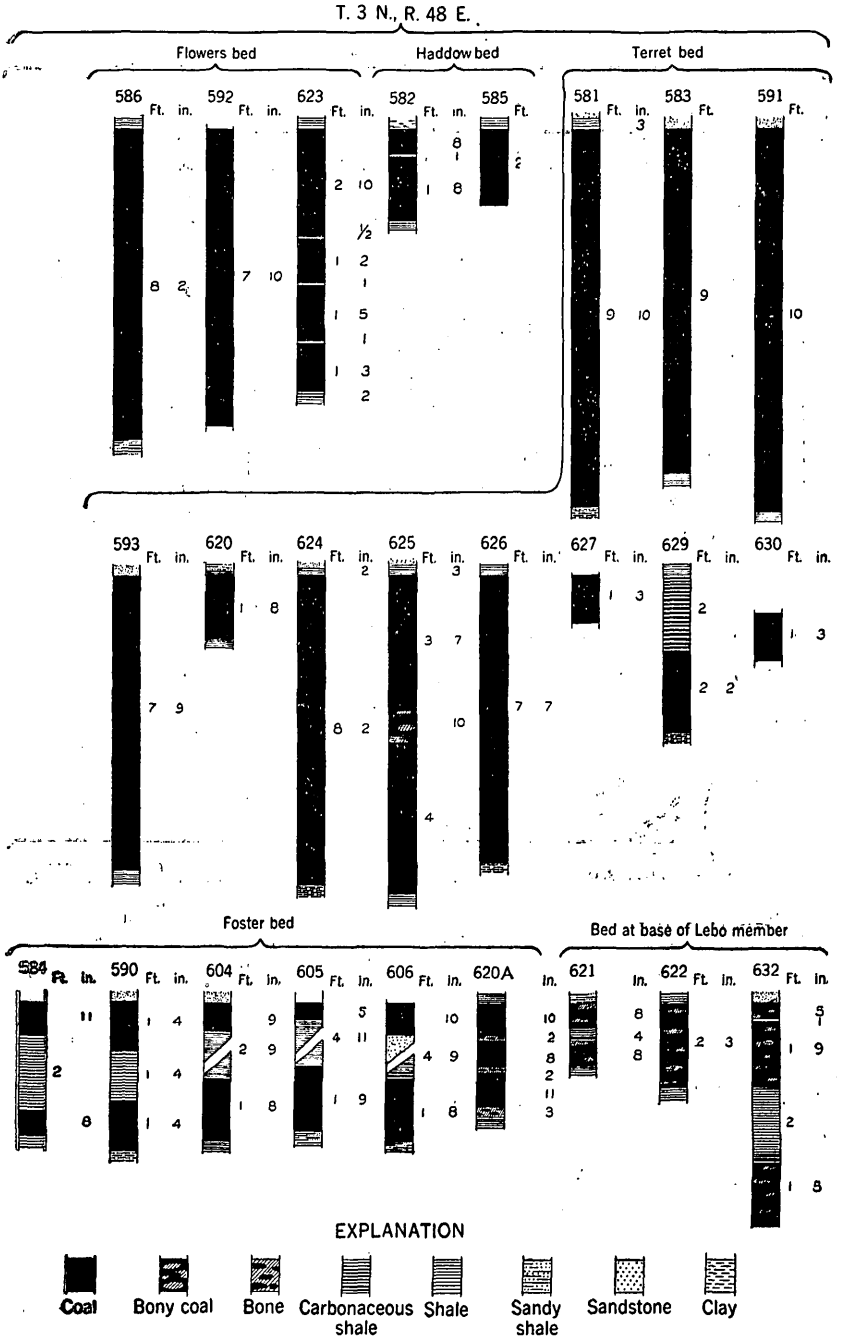


FIGURE 29.—Sections of coal beds in T. 3 N., R. 48 E.

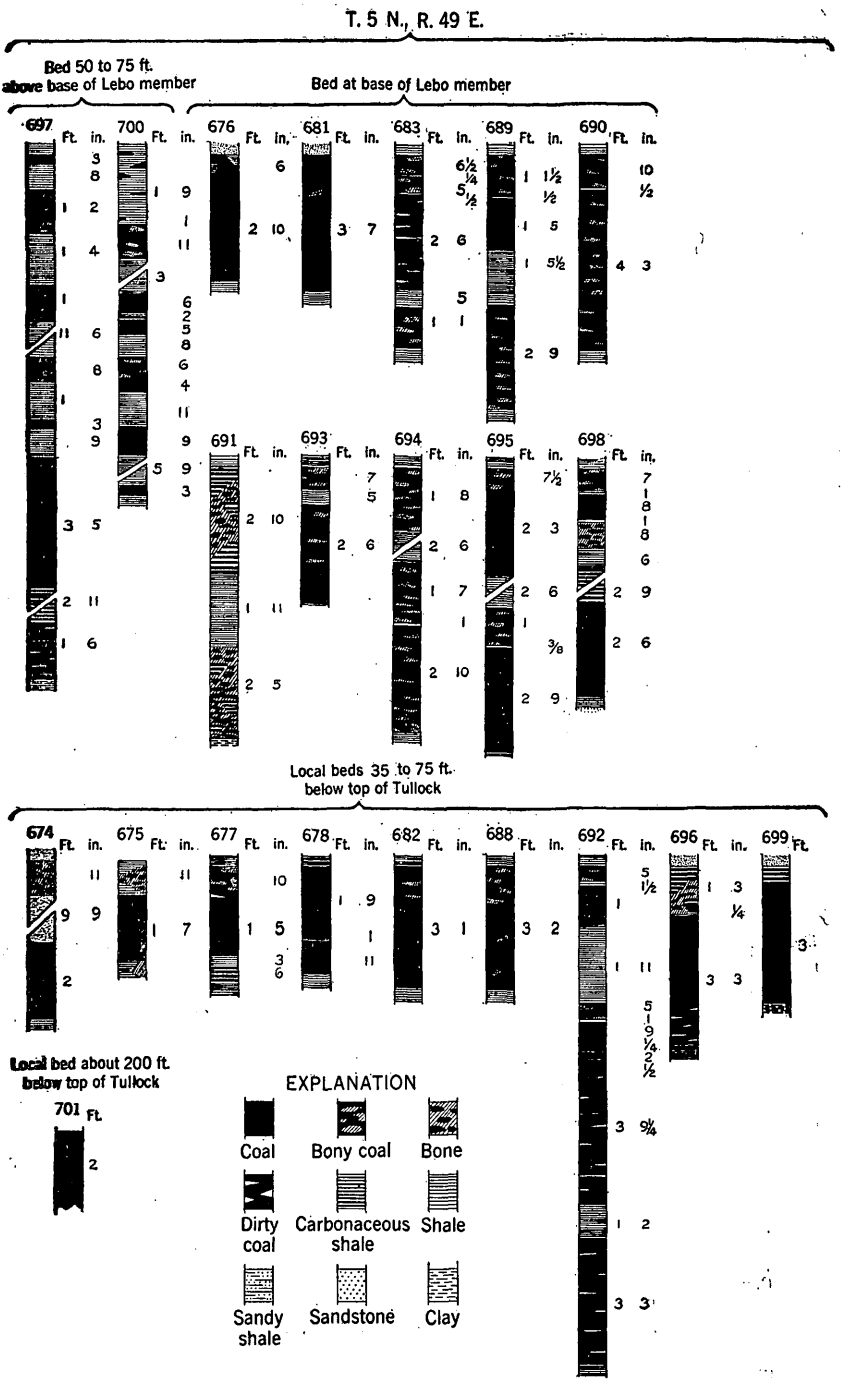


FIGURE 30.—Sections of coal beds in T. 5 N., R. 49 E.

The Tullock member of the Lance formation, which contains a coal zone from 35 to 70 feet below the top, crops out over most of the township. The Lebo shale member of the Fort Union formation crops out in the northeastern and southwestern parts.

A local coal bed about 200 feet below the top of the Tullock member is incompletely exposed on Johnson Creek at locality 701, in sec. 6, but contains 2 feet of fair quality coal. The coal in the zone 35 to 75 feet below the top of the Tullock is variable in thickness but is generally between 2 and 3 feet thick and rather impure. Although the coal in this zone is discontinuous, it is grouped in figure 30 as a single bed. It occurs in the northeastern and southwestern parts of the township and in several isolated areas. Sections were measured at localities 674, 675, 677, 678, 682, 688, 692, 696, and 699. A coal

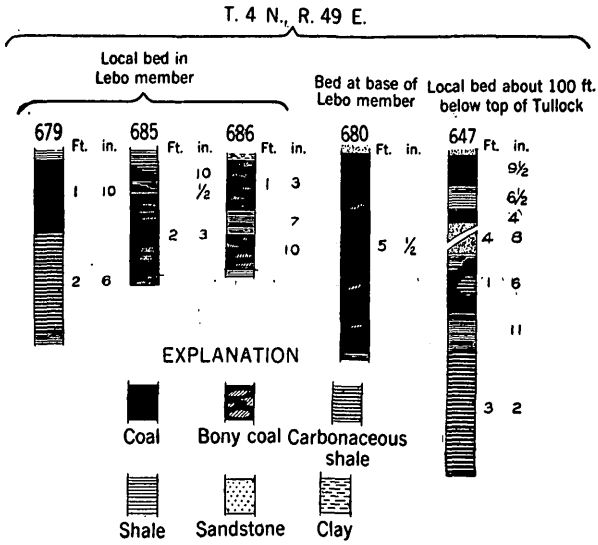


FIGURE 31.—Sections of coal beds in T. 4 N., R. 49 E.

bed at the base of the Lebo, which is present in the northeastern and southwestern parts of the township, is generally dirty and of little value. Sections were measured at localities 676, 681, 683, 689, 690, 691, 693, 694, 695, and 698. A coal bed from 50 to 75 feet above the base of the Lebo crops out in secs. 1, 11, and 12. It has burned along most of its outcrop and produced clinker. Because of the small area underlain by coal in this bed, it is not of value as a source of coal in this township. Sections were measured at localities 697 and 700.

T. 4 N., R. 49 E.—The divide between Pumpkin Creek and the Tongue River crosses the western part of T. 4 N., R. 49 E. The surface of the divide is a rolling upland with a few clinker-capped buttes rising above the general level. Areas of badlands occupy the greater part of the rest of the township. The maximum relief is about 650 feet.

The Tullock member of the Lance formation crops out along the valleys on the north and east sides of the township. The Lebo member of the Fort Union formation, which is the surface formation in the greater part of the township, is composed of 180 to 200 feet of somber-colored shale with local lenses of sandstone. The lithology of the Tullock and Lebo is so similar that any boundary between them is an artificial and arbitrary one. The Tongue River member of the Fort Union formation is present on the divide in the west half of the township.

A section of a local coal bed about 100 feet below the top of the Tullock was measured in sec. 7, at locality 647. The bed is less than 18 inches thick, but it may thicken westward. (See T. 4 N., R. 48 E.) The coal bed at the base of the Lebo contains less than 18 inches of coal, except near locality 680. Here it contains 5 feet of coal that is impure, but this thickness is only of local extent. At locality 681, in sec. 32, T. 5 N., R. 49 E., this bed has thinned to 3 feet 7 inches and the coal is dirty. Sections of local beds in the Lebo were measured at localities 679, 685, and 686, but the beds are thin and of no value. The bed at locality 679 is about 40 feet above the base of the Lebo; the beds at localities 685 and 686 are about 60 and 100 feet, respectively, below the top of the Lebo.

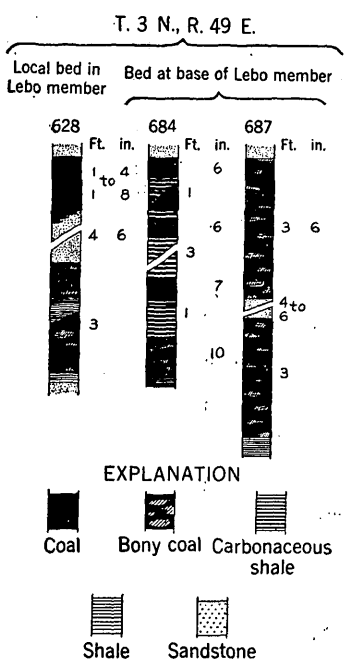


FIGURE 32.—Sections of coal beds in T. 3 N., R. 49 E.

This township contains very little coal, and none of it is mined. The coal bed near the east line of sec. 4 has been prospected.

T. 3 N., R. 49 E.—The highest parts of the surface of T. 3 N., R. 49 E., are the clinker-capped buttes and ridges on the divide between Pumpkin Creek and Ash Creek, in the western part of the township. The west slope of the divide is steep and cut into badlands at several places. The slope east of the divide is fairly steep, but mostly grass-covered, with scattered areas of badlands. Along the west side of Pumpkin and Ash Creeks there are broad areas of smooth terrace topography. Very few of the original section corners were found, so the section lines shown on plate 11 are only approximate.

The Tullock member of the Lance formation crops out on Pumpkin Creek in the eastern part of the township. The contact between the Tullock and the overlying Lebo member of the Fort Union formation is arbitrarily drawn 200 to 220 feet below the top of the Lebo, but is of little significance or importance for recognition in the field. The Tongue River member crops out on the divide between Ash and Pumpkin Creeks and in the southwest corner of the township. A section of the Tongue River member measured at locality 631 is given on pages 63–64.

No coal beds containing 18 inches or more of clean coal were found in this township. A section was measured on a local bed in the Lebo at locality 628. The coal at the base of the Lebo, measured at localities 684 and 687, is too impure to be of value as a fuel.

A very small amount of coal has been taken from a local bed about 75 feet below the top of the Lebo in the Cabin Creek and Rough Creek Valleys. This bed is less than 18 inches thick.