The Coalwood Coal Field Powder River County Montana

By ROBERT P. BRYSON

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The geology and fuel resources of a part of the Powder River Basin

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THE COALWOOD COAL FIELD, POWDER RIVER COUNTY, MONTANA

By ROBERT P. BRYSON

ABSTRACT

The Coalwood coal field, named from Coalwood Post Office in the western part of the field, is an area of about 650 square miles in the northeast corner of Powder River County. It lies within the Great Plains geomorphic province, but, having a total relief of slightly more than a thousand feet, it is by no means a featureless plain. The Powder River flows northward across the field in a broad, alluviated valley. The climate of the region is semiarid; stock raising and some dry farming are the chief industries. There are no communities within the field, but Broadus, the Power River County seat, is only about 5 miles to the south.

Several thousand feet of nonmarine sedimentary strata of late Cretaceous and early Tertiary age comprise the bulk of the rocks exposed within the Powder River Basin. Of these strata, about 1,350 feet are represented in the Coalwood field by beds that are devoid of marked structural or lithologic discontinuity. The nonmarine beds of the Powder River Basin are underlain by older rocks that crop out in places at the margin of the basin, and locally they are overlain by terrace deposits of later Tertiary and Quaternary age.

As in the areas previously mapped in this region, the nonmarine sedimentary strata are subdivided partly on the basis of differences in color and grain size and partly by means of the stratigraphic position of the coal beds. Three lithologic units are recognized. The lowest of the three, a buff to greenish-gray unit more than 225 feet thick, contains dinosaur remains but no significant coal beds; it is placed in the Hell Creek formation. The middle unit, a somber brownish-gray to gray unit 375 feet thick, contains lenticular coal beds but no dinosaur remains and is referred to as the lower member of the Fort Union formation. The uppermost unit, a buff to yellowish-gray unit 750 feet thick, contains several persistent and important coal beds and is equivalent to the lower part of the Tongue River member of the Fort Union formation.

Over most of the field the strata exposed at the surface are very nearly horizontal, dipping a degree or less in a general northwesterly direction. Regional geologic relationships suggest that the crest of the Black Hills uplift extends northwestward in a gentle arc from the vicinity of the Wolf Creek anticline toward Porcupine Dome, passing through the Coalwood field in the vicinity of Powderville. Most of the field thus lies on the crest and the west flank of this gently northwestward-plunging anticlinal uplift. Gentle folding early in the Tertiary was sufficient to reverse the initial dips of the beds, which were toward the east.

Oil and gas possibilities have been tested by one exploratory hole, which was drilled to a depth of 8,991 feet and abandoned in 1945. A small deposit

of bentonite or bentonitic clay was found in the lower member of the Fort Union formation. Extensive deposits of clinker, suitable for road metal and similar uses, are available in the western part of the field.

The coal in the Coalwood field is dark brown to nearly black and where scratched or crushed gives a brown streak or powder; it tends to be fairly tough rather than brittle. In much of it the original woody texture is well preserved. When freshly exposed to the air it dries quickly, cracks into small fragments, and within a few weeks slacks to a fine powder. Available chemical analyses establish the rank of the coal as lignite, closely approaching subbituminous C coal in rank. Small amounts are mined for domestic fuel, but the distance from any market has discouraged greater development to date.

Estimated reserves in beds 30 or more inches thick are about 1,600 million tons, of which more than four-fifths are contained in two beds—the Sawyer and the Broadus—in four townships in the southwest corner of the field, where more than nine-tenths of the reserves are located.

INTRODUCTION

The Coalwood coal field comprises an arbitrarily bounded area of about 650 square miles in the northeast corner of Powder River County. It extends about 18 miles south from the Custer County line and about 36 miles west from the Carter County line across the valley of the Powder River and the upper drainage basin of Mizpah Creek into the drainage basin of Pumpkin Creek. The area adjoins the Mizpah coal field to the north, the Ashland coal field to the west, the Birney-Broadus coal field to the south, and the Ekalaka coal field to the east. The location of the Coalwood coal field and of other coal fields in southeastern Montana and adjacent parts of Wyoming, South Dakota, and North Dakota that are described in bulletins of the U. S. Geological Survey is shown on figure 3.

EARLY EXPLORATION IN THE AREA

The presence of coal beds in the general region has been known for more than a century. In the summer of 1806, while the explorers Lewis and Clark temporarily were following separate routes on the return journey of their expedition, Clark led a party down the Yellowstone River, passing within about 50 miles of the Coalwood field. The following excerpts from his journal (Thwaites, ed., 1905), with notes in brackets by the present author, record some of his observations on coal in the region through which he was passing:

Monday 28th July 1806.

[Between the mouth of Rosebud Creek and the mouth of the Tongue River]

* * * in the evening I pass[d] Straters of Coal in the banks on either Side those on the Star[d] Bluffs was about 30 feet above the water and in 2 vanes from 4 to 8 feet thick, in a horizontal position. the coal contained in the Lar[d] Bluffs is in Several vaines of different hights and thickness. this coal or carbonated wood is like that of the Missouri of an inferior quallity. * * *

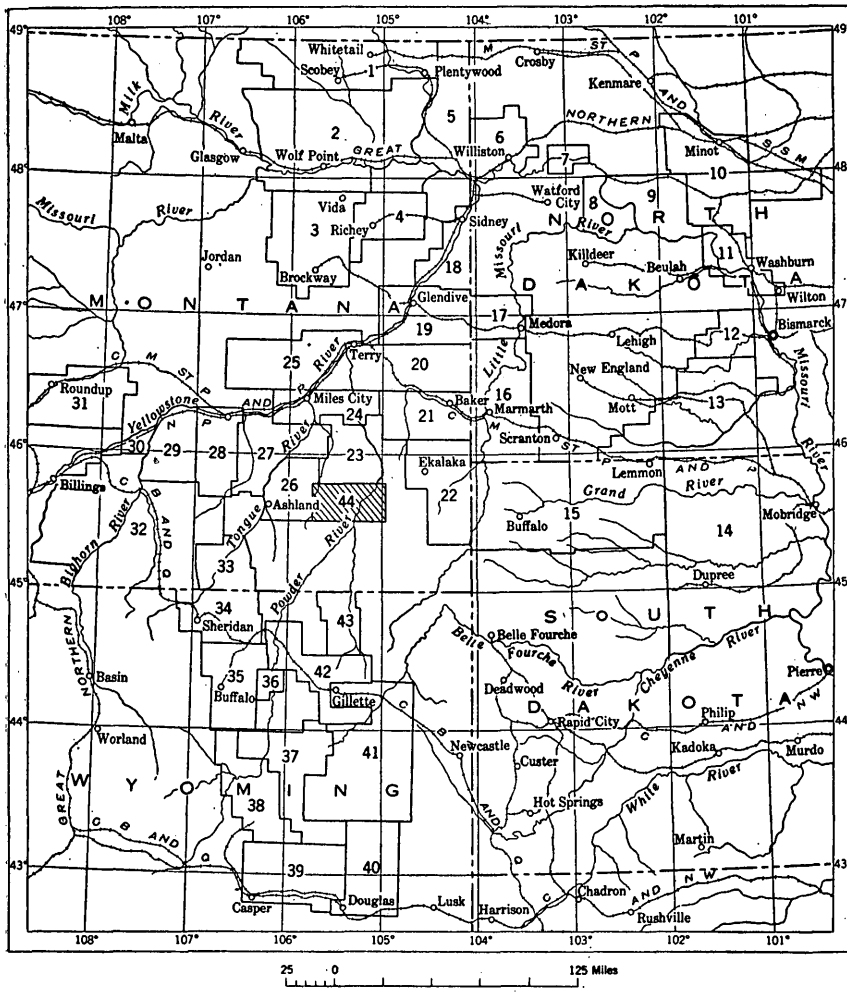


FIGURE 3.—Index map showing the location of the Coalwood coal field, Montana, and of other coal fields in southeastern Montana and adjacent parts of Wyoming, South Dakota, and North Dakota described in bulletins of the U. S. Geological Survey.

	Bulletin
1. Scobey	751-E
2. Fort Peck	381-A
3. McCone County	905
4. Richey-Lambert	847-C
5. Culbertson	471-D
6. Williston	531-E
7. Nesson anticline	691-G
8. Fort Berthold	726-D
9. Fort Berthold	381-A, 471-C
10. Minot	906-B
11. Washburn	381-A
12. New Salem	726-A
13. Cannonball River	541-G
14. Standing Rock and Cheyenne River	575
15. Northwestern South Dakota	627
16. Marmarth	775
17. Sentinel Butte	341-A
18. Sidney	471-D
19. Glendive	471-D
20. Terry	471-D
21. Baker	471-D
22. Ekalaka	751-F
23. Mizpah	906-C
24. Miles City	341-A
25. Little Sheep Mountain	531-F
26. Ashland	831-B
27. Rosebud	847-B
28. Forsyth	812-A
29. Tullock Creek	749
30. Pine Ridge	541-H
31. Bull Mountain	647
32. Big Horn County	856
33. Northward extension of Sheridan	806-B
34. Sheridan	341-B
35. Buffalo	381-B
36. Barber	351-I
37. Pumpkin Buttes	806-A
38. Sussex	471-F
39. Glenrock	341-B
40. Lost Spring	471-F
41. Gillette	796-A
42. Powder River	381-B
43. Little Powder River	471-A
44. Coalwood	973-B

Tuesday 29th July 1806.

[Between the mouth of Rosebud Creek and the mouth of the Tongue River]

* * * great quantities of coal in all the hills I passed this day. * * * below this [Tongue] river and on the Star.d Side at a few Miles from the Rochejhone [Yellowstone] the hills are high and ruged containing Coal in great quantities. * * *

Friday 30th July 1806.

[Between the mouth of the Tongue River and the mouth of the Powder River]

* * * here is the first appearance of Birnt [clinker] hills which I have seen on this river. they are at a distance from the river on Lar.d Side. * * *

Saturday 31st of July 1806.

[Below the mouth of the Powder River, after camping near its mouth]

* * * great quantities of Coal or carbonated wood is to be seen in every Bluff and in the high hills at a distance on each side. * * *

Detailed studies and mapping of coal beds, such as have been completed in surrounding fields, were not undertaken in the Coalwood field until 1946.

PRESENT INVESTIGATION

Investigation of the coal deposits and geology in the Coalwood coal field was undertaken as part of a comprehensive survey of the mineral resources within the Missouri River Basin area. It was also part of the systematic survey of Western coal lands conducted for many years by the U. S. Geological Survey for the purpose of classifying the public lands and determining their mineral resources and other geologic features. Although attention was directed chiefly toward the location of coal outcrops and measurement of the thickness of coal beds as a basis for determining coal reserves and localities favorable for coal mining, the area was examined carefully for other possible mineral resources. In the report some data are recorded for deposits of bentonitic clay and of road metal, both gravel and clinker. The distribution of flowing wells, an important source of water supply in the area, also is indicated.

The land in this part of Montana has been surveyed and subdivided, and section corners and quarter corners have been marked with set stones or iron pipes, by the U. S. Bureau of Land Management. Lines of elevations have been surveyed and bench marks set by the U. S. Coast and Geodetic Survey along the Broadus-Powderville road east of Powder River, along the Broadus-Miles City road, and from the latter road along one that leads westward to the Crow Indian Agency. The valley of the Powder River recently has been topographically surveyed by the Geological Survey and mapped with 10-foot contours as part of a program by the U. S. Bureau of Reclamation to irrigate this part of the valley.

The present report is based upon field work done during the summer of 1946 by the writer with the assistance of Wilbert H. Hass,

Robert B. Neuman, Wilds W. Olive, and J. Keith Rigby. Olive later assisted in the office work of preparing the map and plotting coal sections from the field maps and notes.

Field mapping was done on aerial photographs, enlarged to a scale of approximately 1:23,000, which had been taken in the summer and fall of 1944. Where coal beds were exposed already or could be exposed by shallow trenching, they were examined and their thicknesses measured about every half mile along their lines of outcrop. As shown by the distribution of numbered localities on the map (fig. 3), some coal beds rarely are exposed, especially those beds that have been burned extensively. On the map the line of outcrop of each coal bed is shown where it actually is exposed and also where it is inferred, either from outcrops of clinker produced by its burning or from its position relative to recognizable stratigraphic units exposed nearby. Intervals between coal beds were determined by hand leveling. Water wells were located, and the rates of flow for flowing wells were recorded as reported by nearby residents.

Mapping was transferred from the photographs and compiled by personnel of the Topographic Division of the Geological Survey, with a reduction in scale to 1:31,680, on a base prepared by radial triangulation, after which the land subdivisions of the Bureau of Land Management were superimposed somewhat arbitrarily upon the compiled map (pl. 1).

GEOGRAPHY

LAND FEATURES

The Coalwood field is part of the Great Plains geomorphic province. However, it is by no means a featureless plain. The altitude of the highest part of the Pumpkin Creek-Mizpah Creek drainage divide, in the western part of the field, is estimated to be about 3,835 feet, and that of the lowest point, on the Powder River at the north edge of the field, is 2,768 feet. The total relief of the field is therefore slightly more than a thousand feet. West of the Powder River drainage divide the land surface, which is drained by northward-flowing Pumpkin and Mizpah Creeks and their tributaries, has moderate to low relief. Broad alluviated valleys are separated by gently sloping divides which locally are moderately dissected, forming sharper ridges, small mesas, or buttes. Eastward from the drainage divide to the valley of the Powder River this mature land surface has been dissected by short, steep streams tributary to the Powder River, forming the breaks west of the river. The broad, open alluviated valley, in which the Powder River flows in a slightly entrenched meandering channel, is about 2 miles wide. East of the Powder River the shorter tributary streams have dissected the areas they drain, but the larger tributaries follow

slightly entrenched, meandering channels in open alluviated valleys. Between these valleys the slopes generally are gentle but locally are dissected, forming a somewhat less mature land surface than that west of the Powder River divide.

DRAINAGE AND WATER SUPPLY

With its headwaters in the Big Horn Mountains more than 100 miles to the southwest, the Powder River—"a mile wide and an inch deep"—is the only permanently flowing stream in the Coalwood field and is itself reduced to little more than a trickle in the driest fall and winter months. Even this small flow is occasionally confined to the gravels beneath its channel. Flow is heavy during the period March-July, as a result of the spring thaw and early summer rains, and is light during the period October-February. The discharge of the Powder River has not been gaged within the Coalwood coal field, but the average annual discharge is estimated to be about 620 second-feet.

Mizpah and Pumpkin Creeks flow most of the year, but at times in late summer and fall the only water is in standing pools, which drain through the channel gravels. Smaller tributary streams are intermittent except for short distances below springs, which frequently are found where coal beds crop out, or below flowing wells. Thus very little water is obtained directly from surface sources of supply. In recent years, however, numerous small earthen dams have been constructed to hold runoff from small areas for watering stock or to divert water for irrigation. Some water is pumped from the Powder River for irrigation in the valley. Many shallow wells have been dug or drilled in the bottoms of tributary valleys to ground water where it is close below the surface. In the valley of the Powder River many deeper wells have been drilled to tap artesian supplies in either the basal part of the Hell Creek formation or—more likely—the underlying Fox Hills formation, at depths of 400 to 600 feet. Of these wells, those in the bottom of the valley are flowing wells.

CLIMATE AND VEGETATION

The semiarid climate and the vegetation in the Coalwood coal field are similar to those in other parts of southeastern Montana. The average annual precipitation is about 14½ inches, about half of which occurs in the 3 months of May, June, and July, when local torrential rains are common, at times accompanied by violent hailstorms. Only about a fourth of the annual precipitation occurs in the 6 months from October through March. The mean yearly temperature is about 45.7° F. The maximum temperature of about 100° F. and the minimum of about −25° F. in 1946, the year in which the field

work was done, are representative of the expectable range in temperature. Prevailing winds are from the west and northwest.

Although there are no weather stations within the Coalwood coal field, weather data on the surrounding area are available from U. S. Weather Bureau stations, of which the nearest are at Ashland, Broadus, Ekalaka, and Garland. The Ashland station is about 36 miles southwest of the field, the Broadus station 5 miles to the south, the Ekalaka station 22 miles to the east, and the Garland station 19 miles to the northwest. Climatologic data from yearly reports of these stations are summarized in tables 1 and 2.

Everywhere except on the steepest slopes the land is covered with buffalo grass and other grasses—sparse where the soil is thin, more abundant elsewhere—and sagebrush. Thickets of buckbrush, chokecherry, wild rose, and other shrubs are common where ground water will support them: near springs, in shallow draws cutting clinker or sandstone beds, and along the larger creeks. Cottonwood trees and scrub boxelder line the banks and flood channels of the Powder River. Creeping juniper is a common shrub on some gravel terraces, and on steep slopes it marks the base of gravel or clinker beds. Western yellow pine and scattered cedar, forming a thin forest cover limited to areas of clinker and coarse sandstone, are found in the western part of the field and, in a few small areas, near its eastern edge.

LAND UTILIZATION AND SETTLEMENT

Stock raising and dry farming are the chief occupations of those who live in this part of southeastern Montana. Most of the land is used for the grazing of cattle, sheep, or horses, which at times graze in company with scattered bands of antelope. Of the dry-farming crops, hay for winter stock feeding is important. Wheat, corn, some alfalfa, and other crops are grown in smaller amounts. Small, favorably located areas in the valleys of Pumpkin Creek, Mizpah Creek, and the Powder River are irrigated, with resultingly larger and more dependable yields.

Because the land as a whole will support only 20 to 30 head of cattle to a section, individual ranches commonly include several sections and houses are widely separated. There are no communities within the Coalwood field. However, post offices are maintained at Coalwood, where there is a general store and a gas pump; at Olive, where there is a gas pump; and at Powderville (since 1946 moved about a mile north of the location shown on plate 1), where there is a gas pump. Broadus, the Powder River County seat, which has a population of between 300 and 400, is only about 5 miles south of the field. This town and Miles City, about 50 miles to the northwest, are the principal supply centers.

TABLE 1.—*Precipitation (in inches) at U. S. Weather Bureau stations in vicinity of Coalwood coal field*

Station	Length of record (years)	Mean yearly precipitation	Mean monthly precipitation											
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Ashland (36 miles southwest of field)	20	15.78	0.64	0.49	1.05	1.76	2.31	3.11	1.61	1.16	1.10	1.26	0.77	0.52
Broadus (5 miles south of field)	16	15.62	.50	.41	.72	1.53	2.64	3.72	1.78	1.04	1.15	.89	.76	.48
Ekalaka (22 miles east of field)	50	13.39	.38	.30	.68	1.05	2.17	2.90	1.84	1.49	1.20	.74	.34	.30
Garland (19 miles northwest of field)	25	12.91	.45	.40	.67	1.16	2.06	2.68	1.53	.96	1.05	.90	.53	.52

TABLE 2.—*Temperature (° F.) at U. S. Weather Bureau stations in vicinity of Coalwood coal field*

Station	Length of record (years)	Highest temperature (1946)	Lowest temperature (1946)	Mean yearly temperature	Mean monthly temperature											
					Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Ashland (36 miles southwest of field)	20	101	−25	46.4	21.8	24.8	32.8	44.8	55.4	63.0	73.0	70.6	60.4	49.8	33.4	27.1
Broadus (5 miles south of field)	16	100	−25	45.8	20.3	22.9	32.2	45.4	55.8	64.3	71.8	70.2	60.1	49.0	33.3	24.5
Ekalaka (22 miles east of field)	47	99	−26	44.4	18.4	20.1	31.3	43.8	53.8	63.4	71.6	69.3	59.2	46.6	32.7	22.6
Garland (19 miles northwest of field)	23	100	−24	46.0	17.8	23.0	33.8	46.6	57.0	65.0	73.6	70.3	59.4	48.5	33.7	22.8

ROUTES OF TRAVEL

The nearest railroad stations are about 50 miles to the northwest of the Coalwood field, at Miles City, on the main lines of the Northern Pacific Railroad and the Chicago, Milwaukee, St. Paul & Pacific Railroad.

Access to the field is gained most readily from U. S. Highway 212, a graded road, in part asphalt- and in part gravel-surfaced, that leads southward from Miles City across the Coalwood coal field to Broadus and continues southeastward to Belle Fourche, S. Dak. Where it crosses the Coalwood coal field it is gravel-surfaced except for 6 or 7 miles at the southern edge of the field, where it is asphalt-surfaced. Coalwood and Olive Post Offices are located on this highway. Graded county roads lead from Highway 212, crossing the field and also following the valleys of Pumpkin Creek, Mizpah Creek, the Powder River, and Crow Creek. With other dirt roads and trails they form a network from which a car or truck can be driven—with care—to within a fraction of a mile of most parts of the field.

GENERAL GEOLOGY

STRATIGRAPHY

GENERAL DISCUSSION

RECOGNITION OF STRATIGRAPHIC UNITS

The problem of correlating the various formations present in eastern Montana, western North Dakota, and adjacent parts of Wyoming and South Dakota has confronted geologists for at least half a century.

Conditions of deposition changed as the western shore line of the Upper Cretaceous sea, in which the thick marine beds comprising the Pierre shale were deposited, receded eastward across the region. The Pierre shale was followed by a near-shore and shore-line facies of deposition resulting in the Fox Hills sandstone, and that in turn was followed by uninterrupted deposition of extensive thick deposits of lagoonal and fluviatile sediments during latest Cretaceous and early Tertiary time.

Early investigators subdivided these nonmarine deposits, in each area where they are mapped, either on the basis of differences of general color and of grain size or on the basis of the stratigraphic position of the lignite beds, although they recognized that the subdivisions so made did not represent distinct time horizons even within the limits of a single map area. Even so, correlations of the units thus defined have subsequently been attempted over wide unmapped areas, and formation or member names have been extended in use far from the type localities. Determinations of the units made from fossils in one

area have many times been extended into other areas in which specific age determinations could not be made, on the assumption that the attempted lithologic correlations over wide unmapped areas were correct.

The extent to which ecology and conditions of accumulation, rather than age, have determined fossil occurrences in these nonmarine deposits still is uncertain in the minds of many geologists. Vertebrate fossils that are regarded as diagnostic of late Cretaceous age have been found locally in the lower deposits, and others regarded as diagnostic of early Tertiary age have been found at a few localities in the upper deposits. Invertebrate fossils which to date have not been determined to be diagnostic of age have been found at numerous localities in the upper deposits and also in the lower deposits. Plant fossils, a few of which are regarded as diagnostic of late Cretaceous age and a few of which are thought to indicate early Tertiary age, also have been found in the lower and upper deposits, respectively.

In the Coalwood coal field, as in areas previously mapped, subdivisions of the nonmarine sedimentary deposits have been made on the basis of differences in color and grain size and by means of the stratigraphic position of the lignite beds. Correlations within the field, and with other areas in the region, have been made on the basic assumption that the lignite beds provide the most reliable datum planes available. These correlations are shown on plates 2 and 6 and figure 4 and are discussed in the pages that follow. Age assignments for these subdivisions within the Coalwood coal field, made subsequently, are in accord with all the available fossil evidence (summarized in table 3).

SEQUENCE OF STRATIGRAPHIC UNITS

Of the several thousand feet of nonmarine sedimentary strata of late Cretaceous and early Tertiary age that comprise the bulk of the rocks exposed within the Powder River Basin, about 1,350 feet are represented by strata exposed within the arbitrarily defined limits of the Coalwood coal field. These strata are underlain by older strata, which crop out at the margin of the basin but concerning which data are available within the basin only from a very few deep wildcat oil wells. They are overlain by terrace deposits of later Tertiary and Quaternary age.

The strata exposed in the Coalwood coal field are divided into three lithologic units. Of these the lowest, buff to greenish-gray unit, which contains dinosaur remains but no significant coal beds, is placed in the Hell Creek formation. The middle, somber, brownish-gray to gray unit, which contains some significant (though lenticular) coal beds but no dinosaur remains, is referred to as the lower member of the Fort Union formation. These beds are regarded as likely lateral

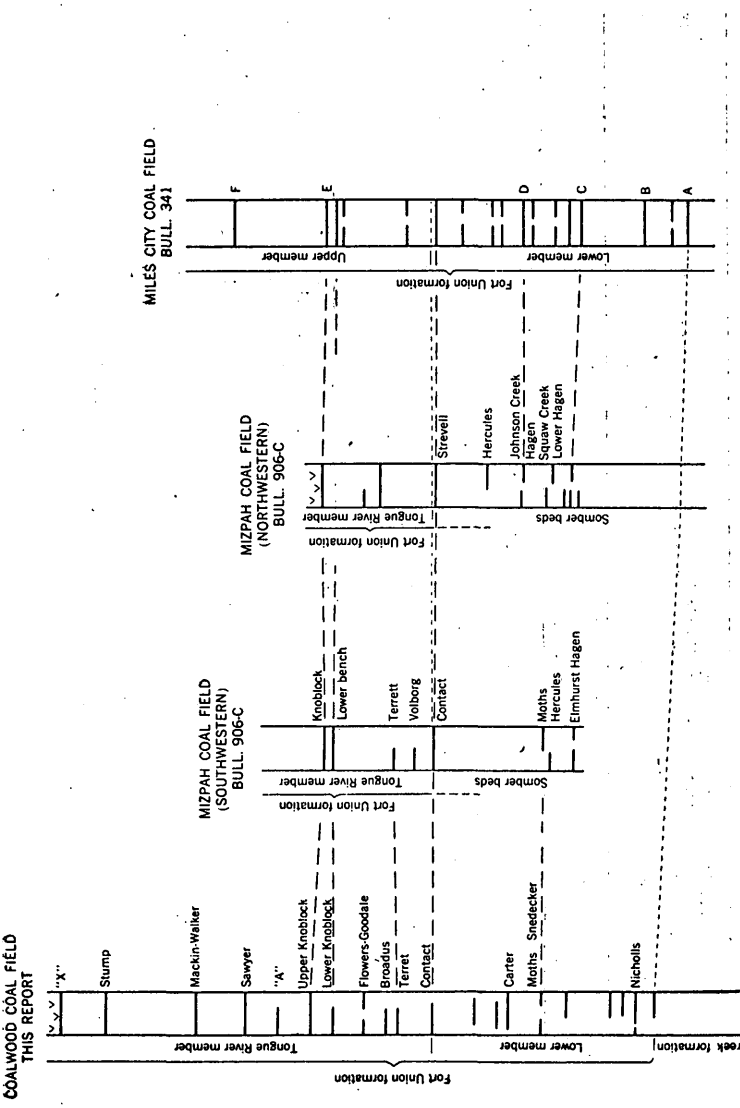


FIGURE 4.—Diagram showing suggested correlations of selected coal beds (by heavy dash), Coalwood coal field, Mont. and of named stratigraphic units (by light dash) with those in fields to the north.

TABLE 3.—*Fossil localities and collections in Coalwood coal field*

Fossil-locality number (shown on pl. 1)	Geographic location	Fossils	Stratigraphic position (see explanation, pl. 1)
fl–1	SE. corner sec. 26, T. 2 S., R. 49 E.	Identified by Teng-Chien Yen: *Viviparus retusus* (Meek and Hayden). *Lioplacodes limnaeiformis* (Meek and Hayden). *Campeloma nebrascensis* (Meek and Hayden). *Goniobasis nebrascensis producta* (White). "*Unio*" sp.	Lower **Tfut** (about 500 feet above base of **Tfut**; about 75 feet above Mackin-Walker coal bed).
fp–2	SE. corner sec. 14, T. 1 S., R. 50 E.	Identified by Roland W. Brown: *Platanus raynoldsi* Newberry. *Sapindus grandifoliolus* Ward.[1]	Basal **Tfut**.
fp–3	NE¼ sec. 32, T. 1 S., R. 50 E.	Identified by Roland W. Brown: *Cercidiphyllum arcticum* (Heer) Brown (leaves, fruits, and seeds). *Betula* sp. *Corylus fosteri* Ward. *Onoclea sensibilis fossilis* Newberry. *Equisetum* sp. *Cabomba inermis* (Newberry) Hollick.[1] *Viburnum asperum* Newberry. *Quercus* sp. *Sapindus grandifoliolus* Ward.[1] *Laurus* sp.	Lower **Tfut** (about 325 feet above base of **Tfut**, in clinker overlying Sawyer bed).
fp–4	Sec. 20, T. 3 S., R. 50 E.	Identified by Roland W. Brown: *Viburnum antiquum* (Newberry) Hollick.	Lower **Tfut** (about 225 feet above base of **Tfut**; about 25 feet above Knoblock? coal bed).
fl–5	NW¼ cor. SW¼ sec. 32, T. 1 S., R. 51 E.	Identified by Teng-Chien Yen: *Viviparus retusus* (Meek and Hayden). *Campeloma nebrascensis* (Meek and Hayden). *Goniobasis nebrascensis producta* (White). "*Unio*" sp.	Reworked (in terrace deposit overlying uppermost **Tful**). Very little evidence of abrasion during transportation.
fl–6	NW¼ sec. 29, T. 2 S., R. 51 E.	Identified by Teng-Chien Yen: *Viviparus retusus* (Meek and Hayden). *Campeloma nebrascensis* (Meek and Hayden). *Goniobasis nebrascensis producta* (White).	Reworked (in terrace deposit overlying upper **Tful**).

fp–7	NW¼ sec. 11, T. 1 S., R. 52 E.	Identified by Roland W. Brown: *Taxodium occidentale* Newberry. *Paranymphea crassifolia* (Newberry) Berry.[2] *Cercidiphyllum arcticum* (Heer) Brown. Insect wing.	Uppermost **Tful**.
fv–8	NW¼ sec. 11, T. 2 S., R. 52 E.	Identified by C. Lewis Gazin: *Bison bison* (Linnaeus).[3]	In arroyo wall, 6 feet above top of alluvial valley fill, near head of tributary valley.
fp–9	NW¼ sec. 11, T. 3 S., R. 52 E.	Identified by Roland W. Brown: *Paranymphea crassifolia* (Newberry) Berry.[2] *Celastrus taurinensis* Ward. *Platanus* sp. *Cercidiphyllum arcticum* (Heer) Brown. *Viburnum antiquum* (Newberry) Hollick. *Credneria daturaefolia* Ward.	Lower (basal?) **Tful**.
(4)	NW¼ sec. 13, T. 1 N., R. 53 E.	Identified by C. Lewis Gazin: *Meniscoessus* sp. Identified by Charles W. Gilmore: Ceratopsian fragments. Carnivorous dinosaur. *Champsosaurus* sp. Turtles. Crocodile. *Lepisosteus* sp. (5)	Upper (uppermost?) **Khc**.
fv–10	Sec. 34, T. 1 S., R. 53 E.	Mammoth tooth reported found.	Alluvium.
fv–11	SW¼ sec. 34, T. 1 S., R. 53 E.	Part of mammoth skull reported found.	Alluvium.
fv–12	Sec. 35, T. 1 S., R. 53 E.	Identified (tentatively) by Roland W. Brown: Lower jaw of duck-billed dinosaur.	Alluvium (reworked from Cretaceous).
fp–13	NW¼ sec. 6, T. 2 S., R. 53 E.	Identified by Roland W. Brown: *Paranymphea crassifolia* (Newberry) Berry.[2]	Basal **Tful** (about 25 feet above base of **Tful**, in clinker overlying Nicholls coal bed).
fp–14	Sec. 14, T. 2 S., R. 53 E.	Identified by Roland W. Brown: *Thuja interrupta* Newberry.[2]	Lower **Tful** (about 100 feet above base of **Tful**, in a carbonaceous shale).

[1] Occurs most abundantly in the later half of the Paleocene.
[2] Occurs most abundantly in the earlier half of the Paleocene, but not in the Cretaceous.
[3] Recent or Pleistocene; cannot be distinguished from living form.
[4] Locality not shown on plate 1; fossils described were collected by W. C. Warren and D. C. Duncan about 7 miles north of Powderville.
[5] Upper Cretaceous assemblage. However, at this locality the mammalian material, comprising only a few individual multituberculate teeth, is associated with remains of fishes and amphibians that are of long age range and Cretaceous dinosaur bone fragments that are water-worn.

966073—52——2

TABLE 3.—*Fossil localities and collections in Coalwood coal field*—Continued

Fossil-locality number (shown on pl. 1)	Geographic location	Fossils	Stratigraphic position (see explanation, pl. 1)
fv-15	NW¼ sec. 6, T. 2 S., R. 54 E.	Identified by C. Lewis Gazin: Mammals: Multituberculates: *Meniscoessus* cf. *robustus*. *Cimolomys* cf. *gracilis*. Marsupials: Didelphid marsupial cf. *Pediomys* sp. Three other species not determined. Identified by David H. Dunkle: Reptiles: *Aspideretes* sp.? (carapace and plastron fragments). *Brachychampsa* cf. *montana* Gilmore (teeth). *Champsosaurus* sp.? (vertebrae). Ceratopsian teeth (gen. et spec. indet.). Amphibians: Various vertebrae and skeletal parts of known but undescribed salamanders and frogs. Fish: *Mylodaphus bipartitus* Cope (teeth). *Lepisosteus* sp.? (scales and vertebrae). *Papichthys* sp.? (vertebrae). *Styleomylodon lacus* Russell (dentigerous plates). Various skull elements of an undetermined amioid fish. [5]	Upper (uppermost?) **Khc**.
fv-16	NE¼ sec. 14, T. 2 S., R. 54 E.	*Lepisosteus* sp.? (scales). *Champsosaurus* sp.? (limb fragments).	Upper **Khc**.
fp-17	SW¼ sec. 28, T. 2 S., R. 54 E.	Identified by Roland W. Brown: *Paranymphaea crassifolia* (Newberry) Berry.[2] *Cercidiphyllum ellipticum* (Newberry) Brown.[6]	Basal **Tful** (about 25 feet above base of **Tful**, in clinker overlying Nicholls coal bed).
fv-18	SW¼ sec. 7, T. 1 S., R. 55 E.	*Diceratops* skull reported found.	Upper **Khc**.

[2] Occurs most abundantly in the earlier half of the Paleocene, but not in the Cretaceous.
[5] Upper Cretaceous assemblage. However, at this locality the mammalian material, comprising only a few individual multituberculate teeth, is associated with remains of fishes and amphibians that are of longer range and Cretaceous dinosaur bone fragments that are water-worn.
[6] Occurs most abundantly in the earlier half of the Paleocene, but also in the Cretaceous.

equivalents of the Tullock and Lebo members of the Fort Union formation, although they were not differentiated in the Coalwood coal field. The uppermost, buff to yellowish-gray unit, which contains several persistent and important coal beds, is equivalent to the lower part of the Tongue River member of the Fort Union formation. The stratigraphy is summarized in the accompanying charts, and descriptions and correlations are given in detail in the following pages.

Time equivalence of lithologic units represented by stratigraphic names used in several Montana and North Dakota coal fields

<table>
<tr><th>Forsyth coal field (Bull. 812-A)</th><th>Rosebud coal field (Bull. 847-B)</th><th>Ashland coal field (Bull. 831-B)</th><th>Mizpah coal field (Bull. 906-C)</th><th>Coalwood coal field (this report)</th><th>Ekalaka coal field (Bull. 751-F)</th><th>Marmarth coal field (Bull. 775)</th></tr>
<tr><td>Tongue River member</td><td>Tongue River member</td><td>Tongue River member</td><td>Tongue River member</td><td>Tongue River member</td><td>Tongue River member
? — ?</td><td>Tongue River member</td></tr>
<tr><td>Lebo shale member</td><td>Lebo shale member</td><td>Lebo shale member</td><td rowspan="2">Somber beds</td><td rowspan="3">Lower member</td><td>Ludlow lignitic member</td><td rowspan="2">Ludlow lignitic member</td></tr>
<tr><td>Tullock member</td><td>Tullock member</td><td rowspan="2"></td><td rowspan="2">Hell Creek member</td></tr>
<tr><td>Hell Creek member</td><td>Hell Creek member</td><td>Sandstone member</td><td>Hell Creek formation</td><td>Hell Creek member</td></tr>
</table>

Rocks exposed in Coalwood coal field

System	Series	Formation and member		Description and correlation	Thickness (feet)
Quaternary.	Recent (and Pleistocene ?).	Alluvium.		Flood-plain deposits and valley fill of silt, sand, and gravel in valleys of Powder River and chief tributaries. Contains mammoth remains (reworked ?).	0–30
Quaternary and Tertiary.	Pleistocene and Pliocene or Miocene.	Terrace deposits.		River deposits of sand and gravel, some from local sources and others from sources outside field. Some high-level deposits may be equivalent to Flaxville gravel farther north.	0–15
Tertiary.	Paleocene.	Fort Union formation.	Tongue River member.	Light-yellow to light-gray, buff-weathering, thick-bedded, in part cross-bedded and calcareous sandstones and siltstones, light-buff to light-gray shales, brown to black carbonaceous shales, and persistent coal beds. Equivalent to lower part of Tongue River member in areas to north, west, and south.	750
			Lower member.	Somber, brownish-gray to gray, thin-bedded, in part cross-bedded and calcareous sandstones, siltstones, shales, and clays, with smaller amounts of buff sandstones and shales, brown to black carbonaceous shales, and thin lenticular coal beds. Massive or cross-bedded buff to greenish-gray friable sandstones at or near base. Equivalent to lower part of Ludlow formation (Ludlow lignitic member [1] of Lance formation) and underlying upper part of Hell Creek formation (Hell Creek member [1] of Lance formation) in Ekalaka lignite field to east and to the Lebo member and underlying Tullock member (Tullock formation,[1] Tullock member [1] of Lance formation) of Fort Union formation in areas to north and west.	375
Cretaceous.	Upper Cretaceous.	Hell Creek formation.		Massive or cross-bedded buff to greenish-gray friable sandstones (locally included at top), gray to greenish-gray shales and clays, and brown carbonaceous shales. Contains dinosaur remains. Equivalent to middle and lower parts of Hell Creek formation (Hell Creek member [1] of Lance formation) in Ekalaka lignite field to east and in part to "sandstone member of Lance formation" in Mizpah coal field to north. Base not exposed.	225+

[1] Name reclassified for use in publications of the U. S. Geological Survey.

DESCRIPTION OF BEDS

HELL CREEK FORMATION

Although all the Hell Creek formation may be present in the eastern part of the Coalwood field, the lower part represented but unrecognized or covered by alluvium in the valley bottoms of Timber Creek (T. 2 S.) and Crow Creek (T. 3 S., R. 54 E.), only the upper 225 feet of the formation was found exposed and is described here. In adjoining parts of the Ekalaka field, where the Hell Creek formation overlies the Fox Hills sandstone, it has a total thickness (excluding the upper hundred feet of beds, which are lignite bearing) of 300 to 450 feet.

Detailed descriptions are given in the measured sections that follow.

Section of upper part of Hell Creek formation in sec. 35, T. 1 S., R. 53 E., Coalwood coal field, Montana

	Feet	Inches
Top of hill.		
Hell Creek formation(?):		
Sandstone, gray-green, brown	30	0
Shale, silty, yellow-gray	7	2
Sandstone, light greenish-gray, cross-bedded, ledge-forming	35	0
Hell Creek formation:		
Shale, greenish-gray	11	0
Shale, chocolate-brown	4	8
Shale, greenish-gray	5	8
Sandstone, buff, cross-bedded, ledge-forming	33	0
Shale, greenish-gray, locally gray	29	0
Shale, chocolate-brown	0	6
Sandstone, buff, ledge-forming	13	0
Shale, light-brown	1	10
Shale, greenish-gray	4	0
Shale, chocolate-brown	1	4
Shale, greenish-gray	4	8
Sandstone, greenish-gray to buff	2	8
Shale, silty, buff	0	10
Sandstone, greenish-gray, buff	10	3
Shale, light chocolate-brown	1	9
Shale, dark chocolate-brown	0	3
Shale, gray	2	7
Siltstone, light-gray, concretionary	2	5
Shale, light gray-brown	1	9
Shale, light-buff; cracks limonite-stained	1	2
Shale, silty, greenish-gray	8	4
	212	10
Alluvium—Powder River valley fill	8+	

Section of upper part of Hell Creek formation and lower part of lower member of Fort Union formation in NE¼ sec. 12, T. 1 S., R. 54 E., Coalwood coal field, Montana

	Feet	Inches	Feet	Inches
Lower member of Fort Union formation:				
Sandstone (thickness estimated in adjacent butte)	60	0		
Sandstone, fine-grained, buff; in places indurated	3	0		
Clay, light chocolate-brown	1	0		
Clay, silty, yellow-gray	6	0		
Sandstone, fine-grained, buff; in part indurated	22	0		
Clay, coaly, chocolate-brown		4		
			92	4
Lower member of Fort Union formation (?):				
Clay, yellow-gray	2	6		
Sandstone, silty, fine-grained, buff	8	0		
Clay, gray	8	0		
Clay, chocolate-brown	2	6		
Clay, silty, yellow-gray	8	0		
Clay, chocolate-brown	5	2		
Clay, yellow-gray	1	0		
Clay, chocolate-brown	1	2		
Clay, gray	5	8		
Clay, bentonitic(?), greenish-gray	2	4		
Clay, yellow-gray	4	6		
Clay, chocolate-brown	2	6		
Clay, gray	13	0		
Clay, chocolate-brown	0	9		
Clay, silty, yellow-gray	4	6		
Clay, chocolate-brown	1	0		
Sandstone, fine-grained, yellow	0	9		
Clay, chocolate-brown; clay, silty	0	6		
Coal, dirty	0	6		
Clay, chocolate-brown	1	2		
			73	6
Hell Creek formation:				
Clay, gray	5	10		
Clay, light chocolate-brown	1	6		
Clay, silty, yellow-gray	4	6		
Clay, yellow-gray	2	0		
Clay, silty, yellow-gray	4	0		
Clay, gray	2	6		
Clay, purple	3	0		
Sandstone, silty, fine-grained, yellow-gray	5	0		
Clay, greenish-gray	5	0		
Sandstone, silty, fine-grained, yellow-gray	2+	0		
			35	4
			201	2

Section of upper part of Hell Creek formation and lower part of lower member of Fort Union formation in NW¼NE¼ sec. 8, T. 2 S., R. 54 E., Coalwood coal field, Montana

	Feet	Inches		
Top of hill.				
Lower member of Fort Union formation:				
Sandstone, thick-bedded, brown	40+	0		
Clay, dark chocolate-brown and gray carbonaceous	5	0		
Sandstone, fine-grained, buff	6	0		
Clay, carbonaceous, gray-brown	19	0		
Clay, coaly	2	0		
			72	0
Hell Creek formation(?):				
Clay, silty, gray-brown	33	0		
Clay, chocolate-brown	1	6		
Hell Creek formation:				
Clay, gray-brown	6	0		
Sandstone, clayey, fine-grained, buff	2	0		
Clay, gray	5	6		
Clay, chocolate-brown	3	0		
Clay, silty, buff	3	0		
Clay, chocolate-brown	2	0		
Clay, gray-brown	4	0		
Sandstone, silty, fine-grained, light-brown	3	0		
Clay, gray	7	0		
Clay, chocolate-brown	3	6		
Clay, gray-brown and brown	14	0		
Clay, chocolate-brown	1	4		
Clay, brown	3	6		
Clay, gray-brown	2	0		
Clay, gray	4	0		
Clay, gray-brown	1	6		
Clay, chocolate-brown	1	6		
Clay, gray	3	0		
			104	4
			176	4

Section of upper part of Hell Creek formation in NE¼ sec. 11, T. 3 S., R. 54 E., Coalwood coal field, Montana

	Feet	Inches
Top of hill.		
Hell Creek formation(?):		
Sandstone, medium-grained, friable, greenish-buff; indurated layers cap numerous surrounding high points; contains tooth and bone chips	60	0
Hell Creek formation:		
Shale, clayey, pale-green; weathers light gray	1	0
Shale, carbonaceous, fissile, dark-gray	0	10
Clay, bentonitic(?), greenish-gray; weathers ash gray	2	6
Sandstone, medium-grained, friable, buff; elongate concretions common near bottom	13	0
Shale, fissile, light-brown; plant fragments	1	3
Shale, clayey, carbonaceous, dark-gray	2	0
Clay and siltstone, pale greenish-gray, purplish-gray, and light-gray	28	0
Sandstone, medium-grained, friable, cross-bedded, buff; indurated layers cap some surrounding high points	15	0
Siltstone and clay, buff; weathers buff to ash gray	29	0
Clay, bentonitic(?), slightly silty, dark brownish-gray; weathers pale purple	13	6
Sandstone, fine-grained, friable, buff; indurated layers cap some nearby high points	6	0
Shale, clayey, carbonaceous, dark-gray; weathers purplish gray	1	1
Clay, bentonitic(?), silty, light-brown; weathers light gray	14	6
Sandstone, medium-grained, friable, light-brown; weathers light buff	2	0
Clay, bentonitic(?), silty, greenish-brown; weathers ash gray; ironstone concretions near top	1	10
Sandstone, medium-grained, friable, buff; weathers light gray	5	6
Shale, clayey, brown; plant fragments; weathers purplish gray	1	6
Clay, bentonitic(?), silty, pale-green; plant fragments; weathers ash gray	8	0
Sandstone, medium-grained, friable, brownish-green; weathers gray	6	0
Clay, bentonitic(?), greenish-gray; weathers ash gray	3	0
Sandstone, medium-grained, friable, drab-green; weathers light gray	15	0
	230	6

Soil and slope wash covered below.

A. VIEW NORTH.

Looking down the west side of the valley of Crow Creek. Buff-weathering sandstone, shale, and thin lignite of the lower member of the Fort Union overlying gray clay, siltstone, and sandstone of the Hell Creek formation in sec. 6, T. 3 S., R. 54 E.

B. VIEW EAST.

Knoll capped by clinker of the Nicholls coal bed, the oldest coal bed in the Coalwood field, overlying beds of the Hell Creek formation in sec. 5, T. 2 S., R. 54 E.

COALWOOD COAL FIELD, POWDER RIVER COUNTY, MONT.

As mapped, the top of the Hell Creek formation (pl. 3)—and the base of the overlying lower member of the Fort Union formation—is defined in this area as the base of the lowest lignite-bearing beds, not necessarily lignite of mappable thickness. Because the lowest lignite bed is very thin in some parts of the field and there may be no coal at this horizon in other parts, it was not possible to establish and map a uniform stratigraphic horizon. In places, the massive or cross-bedded buff to greenish-gray sandstones that locally are included at the top of the Hell Creek formation possibly are equivalent to other, similar sandstones that, because they are known to overlie the lowest observed lignite bed, are elsewhere included in the base of the lower member of the Fort Union formation.

The thick, buff to greenish-gray friable sandstones that have been mentioned crop out prominently along the sides of the valleys of the Powder River and its chief tributaries in the eastern part of the field. In general they are strongly cross-bedded. These sandstones are moderately resistant to erosion; therefore they hold up the steeper slopes and form rounded ridge crests, buttes, and mesas. These sandstones are generally included in the uppermost part of the Hell Creek formation. They overlie and in some places are interbedded with gray to greenish-gray and plum-colored shales and clays and thin brown to black carbonaceous shales. These finer-grained, thin-bedded sediments, locally with bentonitic (?) clays, comprise the bulk of the Hell Creek formation and underlie areas of subdued topography. In recent times these areas have been dissected in part, with the development of arroyos and areas of badland topography. There the soil is thin and the vegetation sparse.

Section of top of Hell Creek formation and lower part of lower member of Fort Union formation in sec. 6, T. 3 S., R. 54 E., Coalwood coal field, Montana (see pl. 3A)

	Feet	Inches	Feet	Inches
Top of hill.				
Lower member of Fort Union formation:				
Sandstone, medium-grained, friable, buff; in part cross-bedded and locally indurated	66	0		
Coal, badly weathered (Nicholls bed?)	1	2		
Sandstone, fine-grained, friable, buff	18	0		
Shale, carbonaceous, fissile, chocolate-brown	0	6		
Coal, weathered	0	7		
Shale, clayey, chocolate-brown; plant fragments	1	0		
Sandstone, fine-grained, friable, buff	6	0		
Shale, clayey, light-gray	0	8		
Coal, weathered	0	4		
			94	3
Lower member of Fort Union formation(?):				
Shale, clayey, chocolate-brown	0	6		
Sandstone, fine-grained, friable, buff	5	6		
Shale, clayey, fissile, light-gray	5	0		
			11	0
Hell Creek formation:				
Clay, bentonitic(?), gray	4	3		
Clay, carbonaceous	2	0		
Clay, silty, greenish-yellow	6	6		
Clay, carbonaceous	1	6		
Sandstone, fine-grained, friable, buff	11+	0		
			25	3
			130	6

Section in upper part of Hell Creek formation and lower part of lower member of Fort Union formation in secs. 6 and 7, T. 2 S., R. 54 E., Coalwood coal field, Montana

	Feet	Inches	Feet	Inches
Top of hill.				
Lower member of Fort Union formation:				
Clay, silty, buff; sandstone, silty, fine-grained	14	0		
Clay, gray	0	6		
Clay, chocolate-brown	2	0		
Coal, dirty	1	6		
Clay, chocolate-brown, with thin coal stringers	3	9		
			21	9
Lower member of Fort Union formation(?):				
Concealed (gray clay at top)	43	0		
Sandstone, dark-buff, thickly bedded, in places cross-bedded and locally indurated	44	0		
			87	0
Hell Creek formation(?):				
Clay, gray-brown	15	0		
Sandstone, silty, fine-grained, buff	15	0		
Hell Creek formation:				
Clay, brown	13	0		
Clay, dark gray-brown	12	0		
Clay, silty, yellow-buff; sandstone, silty, fine-grained	9	0		
Clay, dark gray-brown	18	0		
Clay, light greenish-yellow	1	6		
Clay, dark-gray	2	8		
Sandstone, silty, fine-grained, brownish-buff	3	0		
Clay, brown	1	6		
Concealed (vertebrate-fossil horizon fv–15 at base)	15	0		
			105	8
			214	5

The boundary between the Cretaceous and Tertiary rocks coincides, so far as could be determined from the paleontologic data that were available at the time of the mapping, with the top of the Hell Creek formation as mapped. However, whenever sufficiently detailed stratigraphic and paleontologic work is done to establish this boundary more precisely, it may prove to be lower (by a few tens of feet at the most) where lighter, brownish-gray shales, clays, and the like overlie darker, greenish-gray, less fissile shales, swelling (bentonitic?) clays, and similar beds. This is probably so in sec. 6, T. 3 S., R. 54 E., where the stratigraphic section on page 44 was measured.

LOWER MEMBER OF THE FORT UNION FORMATION

In the central part of the field are approximately 375 feet of strata between the top of the Hell Creek formation and the base of the Tongue River member of the Fort Union formation. These beds, comprising the lower member of the Fort Union formation, consist of somber brownish-gray to gray thin-bedded sandstones, calcareous siltstones, shales, and clays, with smaller amounts of buff sandstones and shales, brown to black carbonaceous shales, and thin lenticular coal beds.

West of the Mizpah Creek-Powder River drainage divide, where the land forms are rounded and the relief subdued, the upper part of the member is poorly exposed. However, all but the uppermost beds are well exposed in the breaks east of the divide. The somewhat resistant calcareous siltstones and sandstones, weathering yellow gray to buff, that crop out along several parts of the divide are regarded as being in the upper part of the member, a few tens of feet below the mapped base of the overlying Tongue River member. The thick, buff to greenish-gray friable sandstones that are locally indurated and as a rule strongly cross-bedded, cropping out prominently along the sides of the valleys of the Powder River and its chief tributaries in much of the east-central part of the field, overlie one or more lignite beds and are therefore included in the basal part of the member. In general the upper beds of the member are grayer and the lower ones more brownish gray to buff. Lateral variation in lithology within short distances is marked, as can be seen by comparing the detailed descriptions in the measured sections that follow.

Section of part of lower member of Fort Union formation in sec. 5, T. 1 S., R. 53 E., Coalwood coal field, Montana

		Feet	Inches
Top of hill (15 feet plus; concealed by soil cover).			
Lower member of Fort Union formation:			
Siltstone, buff		28	0
Coal, sooty		0	3
Shale, chocolate-brown		1	0
Siltstone, light-gray		10	0
Shale, dark-brown and gray		17	0
Siltstone, ledge-forming		22	0
Shale, chocolate-brown		2	0
Siltstone, buff		14	0
Shale, chocolate-brown		2	0
Siltstone, buff		6	0
Shale, chocolate-brown		1	2
Siltstone, gray, cliff-forming		38	0
Shale, chocolate-brown (equivalent of Carter coal bed)		1	0
Siltstone, gray		8	0
Shale, gray to chocolate-brown		13	0
Siltstone, buff		5	6
Shale, chocolate-brown		2	4
Siltstone, gray to buff		7	0
Coal, good	Snedecker coal bed	1	0
Shale, chocolate-brown		0	3
Coal, good		3	0
Shale, gray		1	2
Coal, shaly		0	3
Shale, gray		1	5
Coal, good		0	5
Lower member of Fort Union formation(?):			
Shale, gray		1	0
		186	9
Alluvium—valley fill		2+	

Section of lower part of lower member of Fort Union formation in sec. 31, T. 3 S., R. 54 E., Coalwood coal field, Montana

	Feet	Inches		
Top of hill.				
Lower member of Fort Union formation:				
Sandstone, fine-grained, friable, buff	22+	0		
Shale, clayey, fissile, chocolate-brown; plant fragments	4	0		
Shale, clayey, gray	2	0		
Shale, fissile, chocolate-brown; plant fragments	5	0		
Sandstone, fine-grained, friable, buff	2	0		
Shale, very fissile, chocolate-brown; coal streaks	4	0		
Sandstone, fine-grained, friable, greenish-yellow	10	0		
Shale, clayey, light-gray	5	0		
Coal, dirty, slacked	1	10		
Shale, fissile, chocolate-brown	0	6		
Sandstone, fine-grained, friable, buff	28	0		
Shale, clayey, light-gray	1	4		
Coal, shaly	1	3		
Shale, clayey, chocolate-brown	0	9		
Coal, shaly	1	0		
Silty clay and siltstone, buff	14	0		
Shale, fissile, chocolate-brown	0	7		
Shale and shaly coal	0	6		
			103	9
Lower member of Fort Union formation(?):				
Shale, clayey, dark-gray	14	0		
Shale, fissile, chocolate-brown; plant fragments	3	9		
Sandstone, silty, medium-grained, greenish-brown	28	0		
			45	9
			149	6

Section of lower part of lower member of Fort Union formation in sec. 12, T. 3 S., R. 53 E., Coalwood coal field, Montana

	Feet	Inches		
Top of hill.				
Lower member of Fort Union formation:				
Sandstone, fine-grained; siltstone, buff	24	0		
Clay, silty, ash-gray	11	0		
Coal, shaly (Snedecker bed?)	0	11		
Shale, carbonaceous, fissile, chocolate-brown	4	6		
Sandstone, fine-grained, buff	18	0		
Shale, clayey, carbonaceous, dark-brown	0	8		
Clay, silty, gray; contains gypsum	9	6		
Shale, fissile, chocolate-brown	0	8		
Coal, shaly	0	11		
Shale, carbonaceous, dark-brown	0	6		
Sandstone, fine-grained, buff	29	0		
Shale, fissile, chocolate-brown	1	8		
Coal, dirty (local bed below Snedecker bed)	5	8		
Shale, carbonaceous, light-brown	0	6		
Clay, silty, gray	13	0		
Siltstone and silty clay, buff	42	0		
Shale, clayey, ash-gray	1	0		
Coal (local bed above Nicholls bed)	3	7		
Siltstone, yellow and buff; shale, chocolate-brown	24	0		
Shale, carbonaceous, fissile, chocolate-brown and brownish-black	1	4		
Shale, clayey, gray; darker toward top	0	11		
Coal, shaly	0	8		
Shale, clayey, brownish-gray	11	0		
Coal, good (Nicholls bed)	4	8		
			209	8
Lower member of Fort Union formation(?):				
Siltstone, gray	1	6		
Sandstone, fine-grained, buff	13	0		
Sandstone, brown to buff	60	0		
			74	6
			284	2

Bentonitic clay, which is a common rock type in the underlying Cretaceous strata, was not found in the lower member of the Fort Union formation except for a few thin impure beds of small extent, 125 to 150 feet above the base of the member, in the southeastern part of the field. One of these beds is thicker locally and was mapped in the western part of T. 3 S., R. 53 E. (pl. 1). In section 7, about 200 feet south of the bench mark, 18 feet 9 inches of bentonite or bentonitic clay, or both, was measured and sampled. (See heading "Economic geology.") However, this bed thins within a very short distance and was traced along its outcrop for only a few hundred feet. In the bentonite at this locality, about a foot above the base, is an abundance of roughly spherical masses, up to 5 or 6 inches in diameter, of radiating blades of a carbonate mineral described by Jewell J. Glass in a personal communication as having a small biaxial optical axial angle like that of aragonite but with the indices and X-ray powder pattern of calcite.

Section of lower part of lower member of Fort Union formation in SW¼ sec. 14, T. 3 S., R. 53 E., Coalwood coal field, Montana

	Feet	Inches
Top of hill.		
Lower member of Fort Union formation:		
Sandstone, fine-grained, friable, buff	45	0
Clay, light-gray	12	0
Shale, fissile, chocolate-brown	2	0
Coal (Snedecker bed?)	0	8
Shale, fissile, chocolate-brown	1	6
Clay, gray; sandstone, fine-grained, friable	39	0
Shale, compact, light-brown	4	8
Siltstone, brownish-yellow	2	4
Shale, fissile, chocolate-brown	5	0
Clay, silty, yellowish-gray	4	6
Clay, bentonitic, ash-gray	6	0
Siltstone, yellow	6	0
Clay, light-gray	7	0
Sandstone, fine-grained, friable, buff	6	0
Clay, gray (top concealed)	0	6
Coal (local bed below Snedecker bed?)	0	7
Clay, silty, carbonaceous, brown	0	7+
	143	4

Section of upper part of lower member of Fort Union formation in sec. 35, T. 3 S., R. 52 E., Coalwood coal field, Montana

Top of hill.

Lower member of Fort Union formation:	Feet	Inches
Siltstone, buff, resistant	1	0
Siltstone, shaly, buff	4	0
Shale, chocolate-brown; coal stringer	1	3
Shale, gray	1	4
Shale, carbonaceous; coal stringer	0	6
Shale, chocolate-brown	1	4
Shale, gray	2	1
Coal, very shaly	0	7
Coal, black, shiny } Upper "M"? bed	1	7
Shale, chocolate-brown	0	7
Siltstone, light-gray to buff	11	2
Shale, chocolate-brown	0	1
Coal, very good, shiny, blocky (lower "M"? bed)	0	3
Shale, chocolate-brown	4	0
Siltstone, shaly, buff	5	0
Shale, chocolate-brown	0	8
Siltstone, buff	6	0
Shale, light-gray	3	2
Shale, light-buff	2	4
Shale, chocolate-brown; coal stringer	1	9
Shale, purple	0	9
Siltstone, buff	14	0
Coal; irregular roof	0	10
Shale, chocolate-brown	0	6
Coal, good } "L" bed	0	7
Shale, chocolate-brown	0	4
Coal, good	0	5
Shale, chocolate-brown	0	8
Siltstone, light-gray	5	0
Shale, dark-gray	3	6
Shale, light-gray to light gray-green, with ironstone concretions locally abundant	13	0
Siltstone, buff, with ironstone concretions	35+	0
	123	3

Valley fill.

Section of upper part of lower member of Fort Union formation in NE¼ sec. 25, T. 3 S., R. 51 E., Coalwood coal field, Montana

		Feet	Inches
Top of hill.			
Lower member of Fort Union formation:			
Siltstone		16	6
Shale, carbonaceous		1	0
Siltstone, buff		21	0
Siltstone, buff, hard		0	6
Siltstone, light-buff		16	2
Coal, shaly (upper "M" bed)		2	0
Shale, chocolate-brown		0	4
Siltstone		20	0
Shale, chocolate-brown		0	9
Coal, shaly (lower "M" bed)		2	0
Shale, chocolate-brown		0	3
Siltstone, light-buff		30	6
Coal	"L" bed zone	0	11
Shale, chocolate-brown		0	2
Shale, gray		4	5
Shale, chocolate-brown		0	6
Coal, shaly		0	3
Shale, chocolate-brown		0	3
Coal, shaly		0	9
Shale, chocolate-brown		0	2
Shale, gray		5+	0
		123	5

TONGUE RIVER MEMBER OF THE FORT UNION FORMATION

The uppermost 750 feet of strata mapped have been eroded from all but the west third of the field. These beds are approximately equivalent to the lower half of the Tongue River member of the Fort Union formation (Paleocene) as it has been mapped and described in reports of fields nearby to the northwest, west, and south. The base of the member as mapped in the Coalwood field is defined as the base of the lowermost locally persistent buff-weathering sandstone or siltstone (pl. 5*A*). This sandstone, however, does not everywhere represent a uniform time division. A similar situation was reported (Parker and Andrews, 1939, pp. 100–101) in the Ashland, Rosebud, and Mizpah fields, where the base of the Tongue River member was found to be progressively higher stratigraphically at localities farther and farther east.

Section of uppermost part of lower member and lower part of Tongue River member of Fort Union formation in SW¼NW¼ sec. 19, T. 2 S., R. 51 E., Coalwood coal field, Montana

	Feet	Inches	Feet	Inches
Top of hill.				
Tongue River member of Fort Union formation:				
Clinker and ash (formed by burning of Broadus coal bed)	20	0		
Clay, silty clay, and fine-grained sandstone, gray and greenish-gray, yellow-weathering; sandstone dominates upper third	60	6		
Sandstone, silty, fine-grained, yellow; slightly coarser than sandstone below; slightly more indurated than beds above or below	5	9		
Clay, silty, gray weathering to light yellow or white; indurated layers form yellow ledges; 2-foot bed of chocolate-brown shaly clay near center	28	6		
Sandstone, silty, fine-grained, yellow; clayey in lower few inches; finer-grained and grayer in upper part	11	0		
			125	9
Lower member of Fort Union formation:				
Clay, chocolate-brown; lignite	0	3		
Clay, gray	6	0		
Clay, carbonaceous, dark-brown to black	2	9		
Clay, light-gray to chocolate-brown	8	1		
Clay, dark-gray to black	1	5		
Clay, shaly, gray, with abundant small carbonaceous streaks and flakes	1	4+		
			19	10
			145	7

Section of lower part of Tongue River member of Fort Union formation in sec. 8, T. 3 S., R. 51 E., Coalwood coal field, Montana

	Feet	Inches
Top of hill.		
Tongue River member of Fort Union formation:		
Clinker and ash (formed by burning of Broadus coal bed)	44	0
Shale, gray	11	0
Siltstone, gray, with thin beds of carbonaceous shale	5	6
Siltstone, buff	35	0
Shale, chocolate-brown	1	0
Shale, gray	3	8
Siltstone, light-buff; in part cross-bedded	82	6
Shale, gray	1	5
Siltstone, buff, with ironstone concretions	5	6
Shale, gray	1	0
Siltstone, light-gray, with ironstone concretions	2	9
Shale, gray	3	2
Siltstone, white or light-buff	1	8
Shale, gray and chocolate-brown	0	4
Coal, sooty	0	8
Shale, chocolate-brown	2	10
Shale, gray	1	8
Coal, sooty — Contact bed	1	2
	204	10
Lower member of Fort Union formation: Shale, carbonaceous, chocolate-brown	0	3+

The Tongue River member is characterized by prominent light-gray, buff-weathering sandstones and siltstones and also by persistent thick coal beds. The coal beds commonly have burned along their outcrops and for some distance back from them, thus producing thick, jagged deposits of reddish scoria and baked clay. These deposits, referred to as clinker, cap prominent ridges, mesas, and buttes, dominating the landscape (pl. 4*A*). As a whole, the member may be described as comprising conspicuous light-yellow to light-gray, buff-weathering, thick-bedded and in part cross-bedded calcareous sandstones and siltstones, interbedded with light-buff to light-gray shales, brown to black carbonaceous shales, and persistent coal beds. However, in the vicinity of the Coalwood Post Office and for several miles to the northwest and to the southeast, the Knoblock and Broadus coal beds are much reduced in thickness or entirely absent, and in their place beds of sandstone are uncommonly abundant. Consequently, correlation of these coal beds necessarily is tentative. Gray shales dominate that part of the member between the Mackin-Walker coal bed and the Stump coal bed.

Section of highest beds in Coalwood coal field, Montana, including Stump coal bed and "X" coal bed clinker, which are in lower part of Tongue River member of Fort Union formation, in sec. 33, T. 2 S., R. 49 E.

	Feet	Inches
Top of hill.		
Clinker	20	0
Ash (formed by burning of "X" coal bed)	0	2
Concealed	15	0
Siltstone; locally quartz crystals line joint cracks	3	0
Concealed	7	0
Coal, weathered; shale, dark-brown	2	6
Shale, sandy, calcareous, light-gray to light yellow-brown	2	2
Sandstone, shaly, calcareous, light-gray, friable	7	5
Gypsum; needlelike crystals normal to bedding	0	2
Shale, clayey, light brownish-gray	0	6
Shale, noncalcareous, light yellow-green; gypsum crystals along bedding planes; plant impressions	0	5
Shale, very light brown; gypsum crystals along bedding planes; plant impressions. Eighth-inch gypsum bed at base	0	5
Shale, dark-brown to black; thin lenses of coal; plant impressions; gypsum crystals	2	1
Sandstone, noncalcareous, fine-grained, light yellow-brown to light gray-brown, friable	2	11
Shale, dark-brown; gypsum crystals; few plant-stem impressions	5	2
Shale, blue-gray to light yellow-brown; lower part more calcareous and more sandy than upper part; interbedded thin siltstone (less than 1 inch thick) in lower part	19	2
Shale, brownish-black; very thin lenses of coal	0	1
Sandstone, very calcareous, fine-grained, light-gray to gray-white, friable to indurated and ledge-forming. Upper 5 inches sandy clay	4	7
Shale, greenish-brown, grading downward into bluish gray; weathers very light brown	4	7
Coal (Stump bed); characterized by tree stumps that are partly carbonized and partly silicified, brown to black, and weather bluish white. Small quartz crystals in cavities in stumps	2	8
	100	0

Section of beds, including Mackin-Walker coal bed and Stump coal bed, in lower part of Tongue River member of Fort Union formation in sec. 4, T. 3 S., R. 49 E., Coalwood coal field, Montana

	Feet	Inches
Top of hill.		
Shale, light-gray; some thin, rusty-brown siltstone beds less than 1 inch thick	13	0
Coal (Stump bed); silicified tree stumps	3	6
Shale, carbonaceous, brown, thinly laminated; silicified stumps that spread at base to diameter of as much as 11 feet; gypsum crystals up to 3 inches long; thin beds (less than 1 inch thick) of rusty-brown siltstone	1	8
Shale, sandy, calcareous, light yellow-brown to light yellow-gray	5	6
Shale, somber, gray-brown, soft, grading upward into paper-thin carbonaceous shales with thin lenses (less than 1 inch thick) of coal and of gypsum crystals; plant impressions	13	1
Shale, sandy, somber, gray; weathers grayish yellow brown; thin beds (1 inch thick) of calcareous siltstone	15	7
Siltstone, calcareous, light yellow-brown to light-gray; weathers hackly	1	0
Shale, thin-bedded, gray-brown; weathers yellow brown; contains fresh-water gastropods and unios	3	11
Shale, carbonaceous, brown; minute gypsum crystals	2	7
Sandstone, noncalcareous, light-gray to light yellow-brown, friable	0	7
Shale, carbonaceous, brown, thinly laminated; thin lenses (less than 1 inch thick) of coal	3	5
Sandstone, calcareous, very light yellow-brown to light-gray, grading upward into shaly sandstone; contains fresh-water gastropods and unios near base	13	11
Siltstone, light yellow-brown	0	2
Sandstone, calcareous, very light yellow-brown, friable; plant impressions	3	10
Shale, calcareous, gray to yellow-brown; contains a very few fresh-water gastropods and unios	10	0
Shale, dark-gray to dark yellow-brown, thinly laminated; some gypsum crystals	5	2
Shale, dark-gray to yellow-brown, thinly laminated; weathers gray brown and hackly; contains unios at base	4	8
Sandstone, calcareous, light gray-brown, friable; weathers gray white; very thin shale partings and plant remains	3	5
Siltstone, calcareous, dark blue-gray; weathers light yellow brown and hackly; contains numerous fresh-water gastropods and unios	0	8
Shale, calcareous, gray to greenish-brown; gypsum crystals	10	5

	Feet	Inches
Siltstone, calcareous, blue-gray; weathers light yellow brown and hackly	1	2
Concealed (gastropod-shell fragments on surface)	19	7
Partly concealed (sandstone, calcareous, light yellow-brown to light-gray, friable)	3	6
Partly concealed (shale, light-gray to yellow-brown, very thinly laminated)	6	1
Shale, dark-brown to black, grading upward to dark brown and dark gray; very thinly laminated; gypsum crystals	1	8
Shale, light-gray to light-yellow, containing poorly preserved plant impressions; 1-inch bed of gypsum crystals at top	3	0
Shale, light gray-brown; weathers white; thin beds of chocolate-brown shale and coal lenses; gypsum crystals; fresh-water fossils	3	0
Partly concealed (shale, light yellow-brown)	5	2
Siltstone, calcareous, light-brown, thin-bedded and finely cross-bedded	0	10
Sandstone, calcareous, light-gray to light yellow-brown, friable	4	11
Siltstone, calcareous, light-gray to light yellow-brown, thin-bedded; weathers hackly	1	1
Shale, sandy, calcareous, dark gray-brown; weathers very light yellow brown; contains a few fresh-water gastropods and unios; grades upward into overlying siltstone	6	0
Shale, gray, soft; contains minute gypsum crystals	3	0
Sandstone, calcareous, light-gray; weathers light yellow brown, friable; shaly toward top	10	5
Coal; roof uneven (Mackin-Walker bed)	3	0
Shale, very dark brown, thin-bedded; thin coal lenses in upper part	2	5
Shale, sandy, noncalcareous, gray to light-yellow, thin-bedded	7	7
	198	6

Section of beds, including Sawyer coal bed and Mackin-Walker coal bed, in lower part of Tongue River member of Fort Union formation in sec. 13, T. 3 S., R. 49 E., Coalwood coal field, Montana

	Feet	Inches
Siltstone, calcareous; weathers rusty brown and hackly; contains a few fresh-water gastropod shells	1	6
Shale, gray to light-brown	8	0
Coal, with thin partings of brown carbonaceous shale containing plant remains and gypsum crystals (Mackin-Walker coal bed)	4	5
Sandstone, calcareous, light yellow-brown to gray-brown	4	0
Shale, carbonaceous, brown, very thin bedded; contains abundant gypsum crystals up to 2 inches long	4	2
Concealed (some sandstone and brown shale)	6	2
Siltstone, rusty-brown	0	1
Sandstone, calcareous, gray, friable	5	2
Shale, light-gray to light yellow-brown	2	0
Shale, noncalcareous, dark-gray	3	7
Shale, light-gray to light yellow-brown	3	6
Sandstone, calcareous, friable; contains fresh-water gastropods and unios	2	6
Shale, light-gray to light gray-brown; contains thin beds (less than 1 inch thick) of rusty-brown siltstone between 5 feet 2 inches and 5 feet 10 inches above base	13	1
Sandstone, calcareous, light-gray, friable	1	1
Shale, calcareous, light gray-brown to light yellow-brown, very thin bedded	2	0
Sandstone, light-gray; weathers rusty brown	2	7
Concealed	15	7
Siltstone, slightly calcareous; weathers rusty brown	0	5
Sandstone, calcareous, light gray-brown to very light yellow-brown, friable	3	7
Concealed	7	10
Shale, noncalcareous, dark-gray	5	2
Coal; base concealed; possible maximum thickness of 13 feet (Sawyer coal bed)	9+	0
	105	5

Section of beds, including Knoblock(?) coal bed and Sawyer coal bed, in lower part of Tongue River member of Fort Union formation in secs. 19 and 20, T. 3 S., R. 50 E., Coalwood coal field, Montana

	Feet	Inches
Top of hill.		
Clinker and ash (formed by burning of Sawyer coal bed)	18	0
Poorly exposed (sandstone, blue-gray, very fine grained, friable; few thin beds, less than 1 foot thick, of rusty-brown siltstone; exposures better in lower 20 feet of unit)	63	5
Sandstone, calcareous, fine-grained, light gray-brown; weathers dark or rusty brown; cross-bedded, forming ledge that persists throughout area	3	1
Sandstone, very fine grained, light yellow-brown to gray-brown, friable	4	2
Shale, clayey to sandy, light yellow-brown to bluish-gray; thin lenticular beds (less than 2 inches thick) of indurated, fine-grained, cross-bedded, calcareous sandstone and siltstone. Two-inch bed of black coaly clay shale 11 feet above base of unit	20	10
Siltstone, calcareous, light-brown to rusty-brown, thin-bedded and cross-bedded; weathers to hackly and platy pieces	1	2
Shale, clayey to sandy, light yellow-brown to bluish-gray; thin lenticular beds (less than 2 inches thick) of indurated, fine grained, cross-bedded, calcareous sandstone	21	0
Siltstone, very calcareous, blue-gray; weathers light rusty brown and to hackly pieces; ledge forming; plant impressions; fresh-water gastropods and pelecypods	2	7
Shale, light yellow-brown to blue-gray, in large part very sandy; thin beds of rusty-brown silty and sandy shale in lower 2 feet of unit	10	4
Sandstone, calcareous, fine-grained, cross-bedded, friable	7	4
Shale, sandy to clayey, light yellow-brown to blue-gray; thin beds (less than 4 inches thick) of thin-bedded rusty-brown siltstone	10	5
Shale, blue- to greenish-gray; contains fresh-water gastropods and pelecypods (not unios), also ostracods and plant impressions	0	8
Shale, brownish-gray	1	4
Shale, blue- to greenish-gray, grading into shale above	2	2
Coal (Knoblock? coal bed)	4	0
	170	6

Section of beds, including Broadus coal bed clinker and Knoblock(?) coal bed, in lower part of Tongue River member of Fort Union formation in sec. 20, T. 3 S., R. 50 E., Coalwood coal field, Montana

	Feet	Inches
Clay shale, light-gray; weathers white	3	8
Coal (Knoblock? bed)	3	10
Clay, light-brown to light-gray; weathers very light gray and yellow	9	10
Shale, carbonaceous, brown	0	10
Coal	0	10
Clay shale, gray; weathers white	12	0
Clinker and ash (formed by burning of Broadus coal bed); thickness very approximate	30	0
	61	0

Silicified, partly carbonized tree stumps, which commonly remain in growing position with roots extending into beds of coal or carbonaceous shale, are found abundantly in the Stump bed and in beds as much as 20 feet below it. Such stumps were seen at no other stratigraphic position within the Coalwood field, although they have been found at several others in adjoining fields to the south and southwest and elsewhere. The silicification and resulting preservation of the stumps may be attributed to a locally favorable environment during burial, such as might exist at the margin of a pond area, rather than to a regionally favorable environment such as might result from climatic control. Consequently, the occurrence of the stumps may be regarded as a reliable basis for local correlation but not for regional correlation.

Thin beds of dense, very fine grained gray quartzite with very abundant plant-rootlet impressions, found at three separate localities, are of especial interest in view of their stratigraphic position and possible correlation with beds of similar quartzite described elsewhere in the region. At two of these localities, in and adjoining parts of secs. 11 and 24, T. 2 S., R. 50 E., the quartzite is in a bed 1 to 2 feet thick at or a few feet below the base of the Broadus coal bed, which is 100 to 125 feet above the base of the Tongue River member. At the third locality, in the SE¼ sec. 13, T. 2 S., R. 53 E., the quartzite is in a bed of comparable thickness roughly 100 feet above the Nicholls coal bed, which is in the lower part of the lower member of the Fort Union formation. In the report on the Marmarth field (Hares, 1928, pp. 34–37), attention is called to the widespread occurrence there, and in other fields, of quartzite in thin beds that for the most part have been determined to be in the lower 100 to 200 feet of the Tongue River member.

Strata equivalent to the upper part of the Tongue River member of the Fort Union formation (Paleocene), including the Sentinel Butte shale of southwestern North Dakota (Brown, 1948), and to the Wasatch formation (Eocene) probably were deposited, and strata equivalent to the White River formation (Oligocene) possibly were deposited, within the Coalwood coal field area, but subsequently they were removed by erosion.

TERRACE DEPOSITS

Fluviatile deposits of sand and gravel, found at various elevations of a few tens of feet to about 600 feet above the main valley bottoms, are widely distributed but small in extent and are not correlated, except locally along the west side of the valley of Pumpkin Creek. No fossils are reported to have been found in any of them other than at localities shown in table 3.

Possibly the oldest are the deposits that extend northward from a point about 4 miles north of the Coalwood Post Office, at an altitude of about 3,400 feet, from the head of the valley of Sand Creek along its west side into the Mizpah coal field. Conspicuously present in this deposit, in addition to pebbles and cobbles composed of clinker and other locally derived rock materials, are pebbles and cobbles of crystalline rocks, both igneous and metamorphic, that do not crop out as bedrock within the drainage areas of Mizpah or Pumpkin Creeks or their tributaries. Pebbles and cobbles of similar composition forming deposits too thin and small to map also were found in fair abundance a few miles to the west, 50 or 75 feet lower, on some of the higher parts of the ridge between Essell and Pumpkin Creeks. As has been suggested (Bass, 1932, p. 43; Parker and Andrews, 1939, p. 103) for similar deposits in the adjoining Ashland and Mizpah coal fields, these deposits possibly may be correlated with the Flaxville gravel (upper Miocene or Pliocene) of northern Montana. At about the same altitude, a small gravel deposit that may be of about the same age but is composed chiefly of locally derived rock materials was found several miles to the east, capping a ridge on the Mizpah Creek-Powder River drainage divide, about 600 feet above the Powder River. Rock materials represented in the gravel include fine-grained limestone and calcareous sandstone and fragments of ironstone concretions, together with some quartzite pebbles (half an inch to 3 inches in diameter). Terrace deposits of similar composition are abundant in parts of the Ekalaka field farther east.

Of the younger terrace deposits, which are believed to be Pleistocene in age, those in the valley of the Powder River perhaps are of the

broadest interest in view of the likely possibility that they can be correlated with other terrace deposits, as yet mapped only in part, in the valleys of the Powder River and its tributaries and in other major valleys in the region, thereby providing data bearing on its structural as well as its geomorphic history. Their base elevations above the river in the Coalwood field, some of which were determined by aneroid, range from about 175 feet for the 8- to 15-foot deposit of sand and gravel that caps a low ridge in sec. 18, T. 2 S., R. 53 E., south of H. D. Brown's ranch house, to about 360 feet for the 15- to 20-foot deposit that caps several high points on the ridge in sec. 3, east of the Brown house. In these deposits pebbles, cobbles, and boulders of clinker and of various crystalline rocks are abundant and others of sandstone and silicified wood are common. Remnants of formerly extensive terrace deposits also were observed, but not mapped, along the west side of the valley of the Powder River in T. 2 S., R. 52 E.

Terrace deposits at various elevations have been partly preserved on the west side of the valley of Mizpah Creek. There the gravels are composed dominantly of locally derived sandstone, clinker, and ironstone, but in addition they contain some well-rounded pebbles and cobbles of quartzite and chert. In these deposits gastropod shells of fresh-water species, also known to be present in outcrops of the Tongue River member a few miles to the west, are common at several localities. At fossil locality fi–6, about 110 feet above the creek, where the shells were found cemented in a pebble gravel composed chiefly of slightly rounded clinker fragments, they show clearly the effects of abrasion during transportation, but at fossil locality fi–5, where they are loose on the surface of the ground, they are exceedingly well preserved and must have been derived from a source in the very near vicinity.

Along the west side of the valley of Pumpkin Creek the terrace deposits have been eroded less than elsewhere in the field, forming a discontinuous series that in T. 1 S., R. 49 E., have been separated roughly on the basis of approximate elevations of 40, 65, and 100 feet above the creek. The highest of these deposits apparently corresponds to one mapped in the adjoining township in the Ashland coal field, where it is designated "Qtp–3," and to one mapped in the adjoining townships in the Mizpah coal field that is designated "Qtp–C." Pebbles and cobbles in the gravel are composed of locally derived rock materials, subangular to subrounded clinker fragments dominating and giving a distinctive pink color to the deposits when viewed from a distance. Pebbles and cobbles of sandstone are common; silicified wood and well-rounded fragments of quartzite and chert occur

in lesser amounts. The maximum thickness of these deposits ranges from less than 6 to more than 10 feet.

Other terrace deposits, preserved in valleys tributary to Mizpah and Pumpkin Creeks, are composed almost entirely of locally derived rock materials. Clinker is an abundant constituent, in some deposits as blocks several feet in diameter. Correlation of these deposits with others in the larger valleys was not attempted.

ALLUVIUM

Fluviatile deposits, which form low benches and cover the bottoms of the valleys of the Powder River and the larger creeks to depths of as much as 30 feet, are exposed in steeply cut banks. These deposits are composed largely of fine sand and silt, together with some clay, coarse sand, and gravel containing boulders up to a foot or more in diameter. In addition, slope wash and rock waste from the valley sides form aprons where they merge with, and spread out upon, the alluvium of the valley floors. The base of the alluvium and the underlying bedrock commonly are exposed—or are concealed by only a thin cover of alluvium—in the bottoms of the streams, which flow in entrenched channels cut through the fluviatile deposits.

These deposits are believed to be Recent in age, even though skeletal parts—including large tusk and skull fragments and a single tooth—of the mammoth *Elephas* cf. *columbi?* (Pleistocene) were seen that reportedly were found near the bank of the Powder River at fossil localities fv–10 and fv–11, which are 2 to 3 miles above Powderville. The source of this fossil material can only be conjectured, but it seems probable that it has been reworked from an unidentified remnant of a Pleistocene terrace deposit nearby.

STRUCTURE

Detailed study and mapping of structure were not included in the present investigations. In the absence of precise stratigraphic horizon markers only general observations were made, based upon recognizable approximate marker beds, of which the most prominent are the outcrops of clinker that mark the base of each of the thicker coal beds of the Tongue River member.

Over most of the Coalwood field the strata exposed at the surface are very nearly horizontal, dipping a degree or less in a general northwesterly direction. Steeper dips, shown on plate 1, were observed locally. Anticlinal axes also are shown, marking northwestward-trending undulations whose amplitudes commonly are less than a hundred feet.

Regional geologic relationships suggest that the crest of the Black Hills uplift extends northwestward in a gentle arc from the vicinity of the Wolf Creek anticline toward Porcupine Dome and passes across the Coalwood field in the vicinity of Powderville, with most of the field lying on the crest and the west flank of the gently northwestward-plunging anticlinal uplift. General observations of surface structure within the field support this suggestion.

The Hell Creek formation and the lower and Tongue River members of the Fort Union formation are composed of materials that were derived from sources to the west and southwest and were deposited with an initial dip presumably to the east. Broad and very gentle folding of the strata began contemporaneously with their deposition and continued thereafter until the present gentle northwesterly dips found in the Coalwood field were attained. Much of this folding may have preceded the deposition of the White River formation (Oligocene), which, to the east (Bauer, 1924, p. 244), rests unconformably upon strata of the Tongue River member.

ECONOMIC GEOLOGY

OIL AND GAS

Recent interest and activity centering in the Powder River Basin have extended northward into the Coalwood coal field. To date, the oil and gas possibilities of the rocks that underlie the masking blanket of late Cretaceous and early Tertiary rocks have been tested by only one exploratory hole, the Stanolind Oil & Gas Co.-Northern Pacific No. 1, in sec. 27, T. 2 S., R. 50 E., Powder River County. This hole was drilled to a depth of 8,991 feet and abandoned in August 1945. Somewhat farther north the Pure Oil Co.-State No. 1 well in sec. 36, T. 2 N., R. 51 E., Custer County, was drilled to a depth of 10,018 feet and abandoned in September 1946. For these two holes the "tops" are reported in the files of the Conservation Division, U. S. Geological Survey, as follows:

Stanolind-Northern Pacific No. 1
[Surface elevation, 3,314 feet]

	Depth, in feet
Fox Hills sandstone	1,120
Muddy sand	5,212
Dakota sandstone	5,541
Lakota sandstone	5,748
Spearfish formation	6,480
Charles formation [1]	7,410
Madison limestone	7,880
Englewood limestone	8,425?
Bighorn dolomite	8,560?
Total depth	8,991

Pure Oil-State No. 1
[Surface elevation, 3,007 feet]

	Depth, in feet
Muddy sand	4,800
Dakota sandstone	5,144
Sundance formation	5,935
Spearfish formation	6,055
Minnelusa sandstone	6,612
Charles formation [1]	6,998
Madison limestone	7,605
Englewood limestone	8,175?
Ordovician	8,305
Cambrian	9,057
Total depth	10,018

[1] Name not accepted by U. S. Geological Survey.

With continuing activities and discoveries farther south in the Powder River Basin, additional drilling in Powder County—possibly within the limits of the Coalwood coal field—is to be expected.

BENTONITIC CLAY

Thin beds of bentonite and bentonitic clay were found in the lower member of the Fort Union formation in parts of T. 3 S., R. 53 E. (See p. 50.) They are of little economic significance because they occur in thin lenticular beds of small extent and therefore of limited tonnage. One of these beds is thicker locally and was mapped in the western part of the township. At a locality in section 7, about 200 feet south of the bench mark, 18 feet 9 inches of bentonite and bentonitic clay was measured and sampled by boring with a post-hole auger. Here follows a description of the samples, given by M. M. Knechtel in a personal communication:

	Feet	Inches
Shale, silty.		
Bentonite (nonswelling type)	0	8
Bentonite (nonswelling type), dark olive-green; acid-activable oil-bleaching clay	2	4
Bentonite (nonswelling type), olive-green	2	11
Bentonite (nonswelling type), olive-green; contains fossil leaf; both natural and acid-activable bleaching clay	2	10
Bentonite (nonswelling type), olive-green, in alternating hard and soft layers; both natural and acid-activable bleaching clay	2	11
Bentonite (swelling type), olive-green, in alternating hard and soft layers	4	0
Bentonite (swelling type), olive-green, in alternating hard and soft layers	2	0
Bentonite (swelling type), light olive-green	1	1
	18	9
Shale, siliceous, hard.		

CLINKER

In the western part of the field, clinker, particularly that formed by burning of the Broadus, Knoblock, and Sawyer coal beds, is abundant (pl. 1) and is a suitable source of road metal for highway construction in places where gravel is not available. Where it formed under favorable conditions, a vesicular clinker of low density (some of which is light enough to float) is available as a potential source of light-weight aggregate. At a few localities fragments were seen of brightly varicolored (yellow to reddish-brown to gray), banded clinker that is dense and takes a fairly good polish, suggesting its use as a raw material in the novelty trade of the region. However, only

local use of any of the clinker can be foreseen in view of the enormous amounts of similar material widely distributed in Powder River and adjoining counties.

COAL

PHYSICAL AND CHEMICAL PROPERTIES

The coal in the Coalwood field is lignite. In common with lignite elsewhere, it is dark brown to nearly black and where scratched or crushed gives a brown streak or powder. It tends to be fairly tough rather than brittle. In much of it the original woody texture is well preserved. Dirty coal, shale, and clay partings are found in the coal beds in the western part of the field but are more common in the eastern part. Near the surface of the ground the coal is strongly jointed. When freshly exposed to the air it dries quickly, cracks into small fragments, and within a few weeks slacks to a fine powder. As might be expected, weathered exposures or blossom to a depth of several feet consists of powdered coal mixed with debris and soil from nearby shales and sandstones—which scarcely can be called good "exposures" for sampling and measuring.

The composition of the coal and some pertinent geologic data on its occurrence in the Coalwood field, together with similar information on coal in nearby areas, are given in table 4 for reference and comparison. These data support the classification of all the coal in this field as lignite. In the western part of the field, however, the lignite closely approaches subbituminous C coal in composition. It is likely that analyses, if any were available, would show slightly higher ash and moisture contents and a correspondingly lower B. t. u. heat value for the coal in the eastern part of the field.

In table 4 the analyses are represented in four different ways, designated A, B, C, and D. Form A gives the composition of the sample as it was received in the laboratory—just as it came from the mine. Form B gives its composition after it had been dried at a temperature a little above normal until its weight had become constant. Form C gives its calculated composition after all moisture had been removed. Form D gives its calculated composition after all moisture and all ash had been removed.

The chemical composition of the coal samples from the North Star and Ash Creek mines (A and B) is given in table 5.

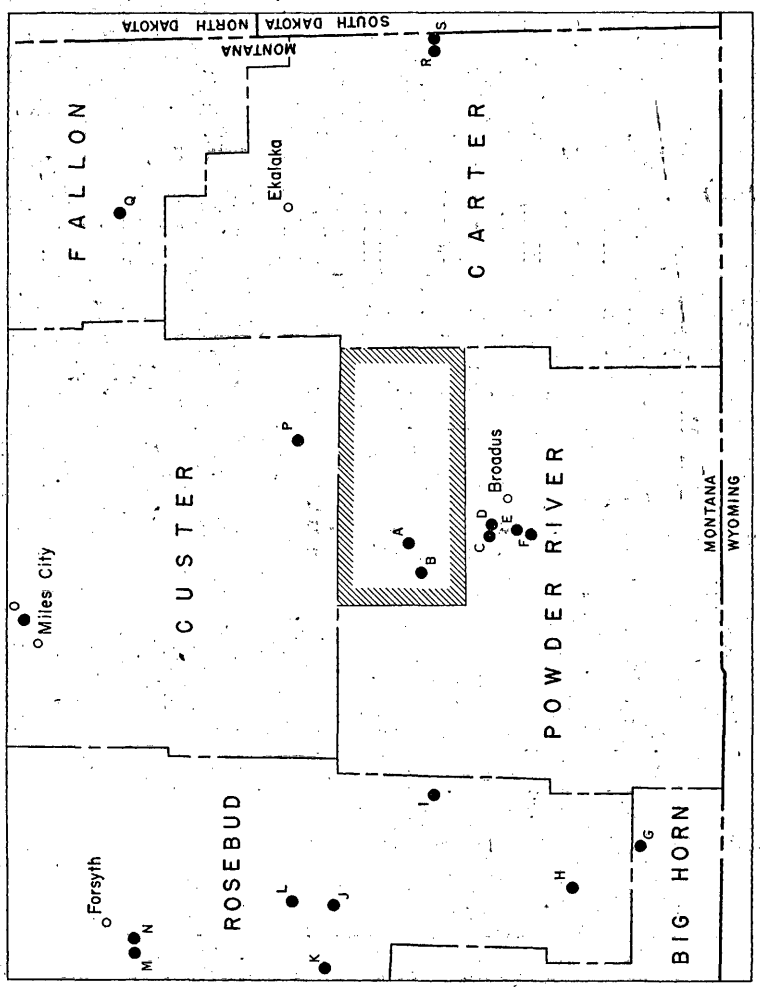


FIGURE 5.—Sketch map of part of southeastern Montana, showing localities in the Coalwood coal field and in areas nearby for which analyses of coal are listed in table 4.

TABLE 4.—*Analyses of coal from Coalwood coal field and selected analyses from some other fields in southeastern Montana*

Reference letter on accompanying sketch map (fig. 5)	Name and location of mine or prospect	Name and approximate stratigraphic position of coal bed	Classification of coal by rank [1] and calculated moist, mineral-free heating value in B. t. u.	Bureau of Mines laboratory sample number and date of analysis	Loss on air drying	Form of analysis [2]	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Heating value in British thermal units (B. t. u.)
A	North Star mine; sec. 21, T. 2 S., R. 50 E., Powder River County.	Broadus bed; lower part of Tongue River member.	Lignite (7,810)	C-75924 (1947)	21.7	A	33.9	28.5	31.5	6.1	0.3	7,300
						B	15.6	36.4	40.2	7.8	.4	9,320
						C		43.1	47.7	9.2	.4	11,040
						D		47.5	52.5		.5	12,160
B	Ash Creek mine; sec. 35, T. 2 S., R. 49 E., Powder River County.	Sawyer bed; lower part of Tongue River member.	Lignite (7,240)	C-75916 (1947)	23.1	A	35.2	30.6	30.2	4.0	.3	6,930
						B	15.7	39.8	39.3	5.2	.4	9,020
						C		47.2	46.6	6.2	.5	10,700
						D		50.3	49.7		.5	11,410
C	Peerless mine; sec. 23, T. 4 S., R. 50 E., Powder River County.	Broadus bed; lower part of Tongue River member.	Lignite (7,770)	B-29378 to B-29381 (1938).	25.7	A	33.9	26.6	33.1	6.4	.2	7,240
						B	10.9	35.8	44.6	8.7	.3	9,750
						C		40.2	50.1	9.7	.3	10,650
						D		44.5	55.5		.4	12,130
D	Victor Stabio prospect; sec. 24, T. 4 S., R. 50 E., Powder River County.	do	Lignite (7,000)	B-56504 (1940) [3]	19.2	A	29.0	31.6	31.3	8.1	.3	6,390
						B	12.1	39.1	38.8	10.0	.4	7,910
						C		44.5	44.1	11.4	.5	9,010
						D		50.2	49.8		.5	10,160
E	Black Diamond mine; sec. 11, T. 5 S., R. 50 E., Powder River County.	do	Lignite (7,940)	C-75726 (1947)	21.0	A	32.3	29.8	31.4	6.5	.3	7,380
						B	14.3	37.8	39.7	8.2	.3	9,340
						C		44.0	46.4	9.6	.4	10,900
						D		48.7	51.3		.4	12,050
F	Superior mine; sec. 14, T. 5 S., R. 50 E., Powder River County.	do	Lignite (7,790)	C-75920 (1947)	20.2	A	33.5	28.3	32.2	6.0	.4	7,290
						B	16.6	35.4	40.5	7.5	.5	9,140
						C		42.5	48.5	9.0	.6	10,970
						D		46.7	53.3		.6	12,050
G	Stroud Creek (Kendrick) mine; sec. 2, T. 8 S., R. 43 E., Big Horn County.	Dietz No. 1 bed; upper part of Tongue River member.	Subbituminous C (8,530).	5403 (prior to 1913)	12.8	A	28.8	29.5	38.4	3.3	.3	8,230
						B	18.4	33.8	44.0	3.8	.4	9,430
						C		41.5	53.9	4.6	.5	11,570
						D		43.5	56.5		.5	12,130
H	Brewster-Arnold mine; sec. 23, T. 6 S., R. 42 E., Rosebud County.	Brewster-Arnold bed; lower part of Tongue River member.	Subbituminous C (9,320).	95879 (1923)	9.7	A	27.3	28.9	39.2	4.6	.6	8,850
						B	19.5	32.0	43.4	5.1	.7	9,790
						C		39.8	53.9	6.3	.8	12,170
						D		42.5	57.5		.9	12,990
I	Holt mine; sec. 10, T. 3 S., R. 44 E., Rosebud County.	Terret bed; lower part of Tongue River member.	Subbituminous C (9,420).	A-42289 (1928) [3]	6.8	A	27.3	27.5	41.3	3.9	.4	9,020
						B	22.0	29.5	44.3	4.2	.4	9,680
						C		37.8	56.8	5.4	.6	12,400
						D		40.0	60.0		.6	13,110

J	McKay mine; sec. 34, T. 1 N., R. 41 E., Rosebud County.	Lee bed; lower part of Tongue River member.	Subbituminous B (9,920).	96583 (1923)[2]	8.4	A	23.9	28.7	40.3	7.1	.6	9,160
						B	16.9	31.3	44.0	7.8	.6	9,990
						C		37.7	52.9	9.4	.8	12,030
						D		41.6	58.4		.8	13,270
K	Brinkerd prospect; sec. 30, T. 1 N., R. 40 E., Rosebud County.	Sawyer. bed; lower part of Tongue River member.	Subbituminous C (8,720)	96587 (1923)	8.1	A	26.6	28.9	37.7	6.8	1.8	8,080
						B	20.1	31.5	41.0	7.4	2.0	8,800
						C		39.4	51.4	9.2	2.5	11,010
						D		43.4	56.6		2.7	12,130
L	Colstrip mine; sec. 34, T. 2 N., R. 41 E., Rosebud County.	Rosebud bed; lower part of Tongue River member.	Subbituminous B (9,870).	A-19659 (1928)	6.6	A	24.1	28.4	40.2	7.3	.7	9,090
						B	18.7	30.4	43.1	7.8	.8	9,730
						C		37.4	53.0	9.6	1.0	11,960
						D		41.4	58.6		1.1	13,230
M	Wright mine; sec. 7, T. 5 N., R. 40 E., Rosebud County.	Wright bed; lower part of Tullock member.	Subbituminous C (9,280).	96584 (1923)[3]	6.5	A	23.7	28.6	35.7	12.0	.6	8,080
						B	18.4	30.6	38.2	12.8	.7	8,640
						C		37.5	46.8	15.7	.8	10,590
						D		44.5	55.5		1.0	12,560
N	Hamre mine; sec. 9, T. 5 N., R. 40 E., Rosebud County.	Hamre bed; upper part of Tullock member.	Subbituminous C (8,910).	96585 (1923)[3]	5.1	A	16.6	21.8	25.2	36.4	.6	5,430
						B	12.1	23.0	26.5	38.4	.6	5,720
						C		26.2	30.2	43.6	.7	6,510
						D		46.4	53.6		1.2	11,540
O	Kircher mine; sec. 19, T. 8 N., R. 48 E., Custer County.	Kircher bed; lower part of Tullock member.	Lignite (8,380)	5964 (prior to 1913)	18.1	A	29.6	27.4	33.0	10.0	.7	7,480
						B	14.0	33.5	40.3	12.2	.8	9,130
						C		38.9	46.8	14.3	1.0	10,630
						D		45.4	54.6		1.1	12,390
P	Kruntzfeldt mine; sec. 3, T. 1 N., R. 52 E., Custer County.	Moths bed; upper part of Tullock member.	Lignite (7,680)	A-84104 (1932)[3]	26.3	A	34.3	25.3	31.9	8.5	.5	6,980
						B	10.9	34.4	43.1	11.6	.7	9,480
						C		38.6	48.4	13.0	.8	10,640
						D		44.3	55.7		1.0	12,220
Q	Coal Bank Spring prospect; sec. 34, T. 6 N., R. 57 E., Fallon County.	Unnamed bed; Tullock (?) member.	Lignite (6,680)	10910 (1910)[3]	26.2	A	38.7	27.0	25.1	9.2	.3	6,020
						B	16.9	36.6	34.0	12.5	.4	8,160
						C		44.1	40.9	15.0	.5	9,820
						D		51.8	48.2		.6	11,550
R	Kerr mine; sec. 11, T. 3 S., R. 62 E., Carter County.	McKenzie bed; lower part of Tullock member.	Lignite (6,700)	20372 (1914)	33.5	A	39.0	22.6	23.9	14.5	1.6	5,600
						B	8.4	34.0	35.9	21.7	2.4	8,420
						C		37.1	39.2	23.7	2.6	9,190
						D		48.7	51.3		3.4	12,050
S	Horner mine; sec. 12, T. 3 S., R. 62 E., Carter County.	Horner bed; lower part of Tullock member.	Lignite (7,320)	20370 (1914)	34.3	A	41.3	24.6	26.9	7.2	.6	6,190
						B	10.6	37.5	40.9	11.0	1.0	9,430
						C		42.0	45.8	12.2	1.1	10,550
						D		47.8	52.2		1.2	12,020

[1] In accordance with American Society for Testing Materials, Standard specifications for classification of coals by rank (A. S. T. M. Designation: D388-38, A. S. A. M20.1-1938): 1939 Book of A. S. T. M. Standards, pt. 3, pp. 1-6.

[2] A, As received; B, air-dried; C, moisture-free; D, moisture- and ash-free.

[3] Sample of slightly weathered coal.

TABLE 5.—*Ultimate analyses of coal from Coalwood coal field*

Reference letter (fig. 5)	Mine and coal bed	Bureau of Mines laboratory sample no.	Form of analysis	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen
A	North Star mine (Broadus bed).	C-75924	A	6.1	0.3	6.7	43.2	0.7	43.0
			B	7.8	.4	5.5	55.2	.9	30.2
			C	9.2	.4	4.4	65.4	1.1	19.5
			D	----	.5	4.9	72.1	1.2	21.3
B	Ash Creek mine (Sawyer bed).	C-75916	A	4.0	.3	6.7	42.1	.7	46.2
			B	5.2	.4	5.4	54.7	.9	33.4
			C	6.2	.5	4.3	64.9	1.1	23.0
			D	----	.5	4.6	69.2	1.2	24.5

UTILIZATION

The lignite has served adequately for many years as domestic fuel for ranchers in the area, who, individually or in small groups, each year mine enough from a nearby bed for their own use. The distance to a market, rather than the quality of the fuel, has discouraged its more extensive development to date. The North Star mine, which produced and sold for local consumption about 1,500 tons in 1946, is the only commercial mine that was operating in the Coalwood field at the time of the field investigations for this report.

BURNING OF THE BEDS

Along their lines of outcrop and for some distance back from them the thicker coal beds almost everywhere have burned (pls. 4*B*, 5), probably as the result of spontaneous combustion at localities where weathering had produced a blanket of coal dust over the outcrop and conditions were otherwise favorable. Lightning and human agencies doubtless have been contributing causes.

Heat from the burning coal affected the overlying rocks, commonly baking or fusing them, or both (pl. 5*B*), through a vertical distance that varied but in many places over the Broadus and Sawyer beds exceeded 75 feet. The nature of the clinker depends as much on the nature of the rock that overlay the coal as it does on the amount of heat to which the rock was subjected (Rogers, 1917). Oxidation of iron in the heated rocks gave them the characteristic brick-red color of clinkered areas.

Back from the outcrop burning continued as long as collapse of the overlying rock failed to cut off the circulation of air, with its essential supply of oxygen. Coal underlying vast areas was destroyed where a coal bed was thick and the overburden either was thin or, if thick, was sufficiently indurated to collapse each time in such a way that new spaces for air circulation were formed. This was so in the western

part of the Coalwood field, where mesa and ridge caps of clinker bear witness to the former existence there of more extensive deposits of coal in the Broadus and the Sawyer beds.

A coal bed was found burning at the Mackin-Walker mine when the locality was visited in the fall of 1946—a year after the fire is reported to have been started by a hired hand who was trying, by burning it, to dispose of the carcass of a noticeably dead cow. Attempts to extinguish the fire by flooding had failed. In adjoining fields other examples of coal beds now burning are common. However, the burning of coal beds is by no means of recent occurrence only. In the Coalwood field, fragments of clinker are common in the oldest terrace deposits, which may be of Miocene or Pliocene age; and south of Forsyth fragments were found (Dobbin, 1929, p. 21) in a terrace gravel deposit of Oligocene or Miocene(?) age, more than a thousand feet above the present channel of the Yellowstone River. These evidences of ancient burning support the inference that the coal already had reached the stage where it was susceptible to spontaneous combustion—a characteristic of lignite and subbituminous coal.

STRATIGRAPHIC POSITION AND CHARACTERISTICS OF THE BEDS

In the Coalwood field coal beds occur in the lower part of the Tongue River member and in the underlying lower member of the Fort Union formation. The areal distribution of each coal bed is shown on the geologic map (pl. 1); suggested correlations with coal beds in other coal fields nearby are illustrated (pl. 2 and fig. 4); intervals between coal beds by township are represented diagrammatically (pl. 6); and thicknesses of measured sections of the coal beds at selected localities are plotted (pls. 7–12; figs. 6–13). As the strata are very nearly horizontal, the outcrop of an individual bed lies at a very nearly uniform elevation and on the map has very much the appearance of a contour line. Coal-outcrop lines are different, however, in that they are not everywhere continuous and the intervals between them are not everywhere identical.

Significant differences in the occurrence of coal in the Tongue River member of the Fort Union formation and in the underlying strata long have been recognized (Smith and others, 1913, p. 102). In general, the coal beds in the Tongue River member are thicker and more nearly continuous and those in the lower member thinner and less nearly continuous—and consequently less reliable as a basis for estimating hidden reserves and for making stratigraphic correlations. These two groups of coal beds generally are associated with strata that differ in composition, the coals of the Tongue River member with thick coarse sandstone and shale units and those of the lower

member with thin shale, silty shale, and sandstone units. Where strata typical of the Tongue River member are found in the lower member, the associated coals commonly are more nearly continuous; where strata typical of the lower member are found in the Tongue River member, the associated coals commonly are less nearly continuous.

For those coal beds that could be traced into an adjoining field in which they had been mapped and named, the same names are used in this report. The same names are used, also, for beds found to be in a similar stratigraphic position with respect to a traced bed. Within the Coalwood field, evidence is inconclusive for correlating (*a*) the coal beds in the areas that center in T. 3 S., R. 51 E., and in T. 3 S., R. 53 E., with (*b*) those west of Powderville Post Office that extend into the Mizpah field—as is also the basis for correlating (*a*) the beds in the northern part of T. 2 S., R. 50 E., with (*b*) those beds north of Coalwood Post Office that extend into the Mizpah field.

Brief descriptions of the individual coal beds follow, beginning with the oldest. For detailed data, see "Township descriptions" on pages 82–103.

Local bed below Nicholls.—The lowermost coal bed that crops out in the field is a local one, 3 feet 2 inches thick where measured at locality 253 in T. 3 S., R. 53 E., about 35 feet below the bed that there is correlated with the Nicholls bed.

Nicholls bed.—This bed is in approximately the same stratigraphic position as a bed of the same name in the southeastern part of the Mizpah field. The Nicholls bed, or one or more local beds of approximately the same age, crop out locally in the eastern part of the Coalwood field, where they were found to contain small reserves of coal in beds 2½ feet or more thick, but commonly they are absent or are less than 2 feet thick and were not mapped. Where mapped, they range in thickness from 2 feet of coal or shaly coal, or both, to a maximum measured thickness of 5 feet 8 inches at locality 238 in T. 3 S., R. 53 E. At scattered localities the Nicholls bed has burned at the outcrop, which there is marked by clinker. In T. 1 S., Rs. 52–54 E., and in part of T. 2 S., R. 54 E., the base of the Nicholls bed was mapped as the base of the lower member of the Fort Union formation.

Local beds above Nicholls.—Above the Nicholls bed but below the overlying Snedecker bed in parts of several townships in the southeastern part of the field, lenticular beds of coal and shaly coal between 2 feet and 2 feet 6 inches thick were found and mapped. In the northeast quarter of T. 3 S., R. 53 E., one of these beds—about 100 feet above the one there correlated with the Nicholls bed—ranges in

thickness, at localities where it was measured, from 2 feet 1 inch of shaly coal to a maximum of 6 feet of moderately clean coal and contains a small amount of coal that is included in the estimate of reserves. This local bed is correlated tentatively with the local bed found 50 feet below the Snedecker bed in some townships farther north.

Snedecker, Moths, and "L" beds.—The Snedecker bed, mapped and named in the southeastern part of the Mizpah field, extends along the west side of the valley of the Powder River southwestward through T. 1 S., R. 53 E., with a thickness of 4 to 6 feet, commonly including one or more shale partings; into T. 1 S., R. 52 E., where shale partings become thicker and more numerous and the bed thins; and on into T. 2 S., R. 52 E., where it decreases to less than 2 feet and finally disappears. In T. 1 S., Rs. 52 and 53 E., this bed contains the only significant reserves found in a coal bed below the base of the Tongue River member in the Coalwood field.

In approximately the same stratigraphic position in the northern part of T. 1 S., R. 51 E., the Moths bed, also mapped and named in the Mizpah field, extends for about 2 miles southward up the east bank of Mizpah Creek, thickening in the same direction from 2 feet 4 inches at locality 152 to 3 feet 7 inches at locality 155. The Moths bed and the Snedecker bed may be a single continuous bed beneath the ridge dividing Mizpah Creek and the Powder River in T. 1. S., R. 52 E.

Farther south, in the eastern part of T. 3 S., R. 51 E., the "L" bed, in approximately the same stratigraphic position, was found to have a thickness of less than 2 feet except at one locality where 2 feet 2 inches of shaly coal is exposed.

Carter and Lower "M" beds.—A thin coal bed about 55 feet above the Snedecker bed in T. 1 S., R. 53 E., is correlated with the Carter bed in adjoining parts of the Mizpah field. It ranges in thickness from less than 2 feet to a maximum measured thickness of about 3 feet, including shale partings.

Farther south a thin lenticular bed of coal, here referred to as the Lower "M" bed, was mapped in the vicinity of locality 195 in T. 2 S., R. 52 E., and also in the vicinity of locality 171 in T. 3 S., R. 51 E. In each township the bed, which is lenticular, has a maximum measured thickness of slightly more than 2 feet of coal and shaly coal.

Local beds above Carter and Lower "M".—Above the Carter and Lower "M" beds, but below the overlying Contact bed in parts of several townships in the central part of the Coalwood field, small lenticular beds of coal and shaly coal were found and mapped for short distances. The Upper "M" bed in the eastern part of T. 3 S.,

R. 51 E., has a maximum measured thickness of 2 feet 4 inches of coal. In about the same stratigraphic position in T. 1 S., R. 51 E., lenses of coal at scattered localities have thicknesses of 2 feet or more but less than 3 feet.

A local bed, approximately 80 feet below the base of the Tongue River member, where present commonly is less than 2 feet thick but in two small areas in the east half of T. 1 S., R. 51 E., attains a thickness of 3 feet or more. Maximum thicknesses of 3 feet 9 inches and 3 feet were measured.

Contact and Patton beds.—Locally a thin bed of coal or shaly coal, commonly less than 2 feet thick, was found in the western part of the field and was mapped as the base of the Tongue River member. This bed is correlated with the Contact bed in the Mizpah field. In T. 1 S., R. 50 E., a thin bed in about the same stratigraphic position has maximum measured thicknesses of 2 feet 3 inches of coal and 3 feet of shaly coal and is correlated with the Contact bed, but it may be somewhat higher and approximately equivalent to the overlying Volborg bed in the Mizpah field. Elsewhere to the east and south, in Tps. 1–3 S., R. 51 E., three small lenses have measured maximum thicknesses of 2 feet 2 inches, 5 feet 2 inches, and 2 feet 3 inches. Reserves in all these lenses are small.

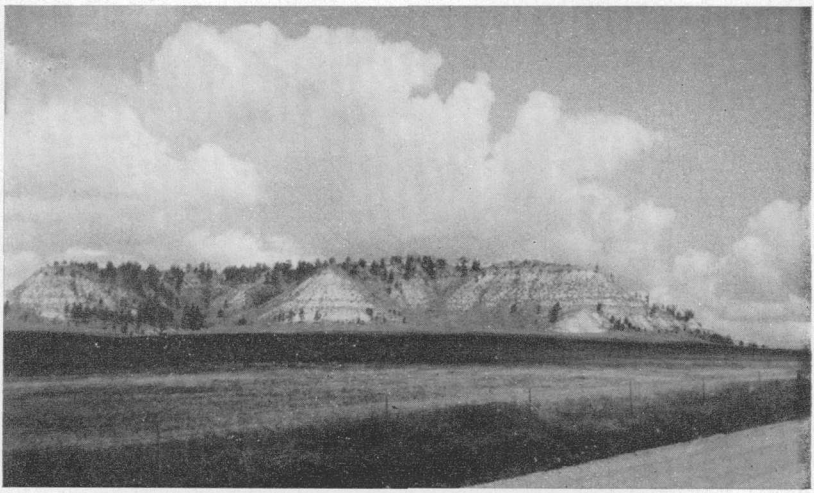
The Patton bed in the valley of Spring Creek, in T. 1 S., R. 49 E., commonly is less than 2 feet thick but attains a maximum measured thickness of 3 feet 4 inches. This bed is about 125 feet below the Flowers-Goodale bed and for this reason is believed to be approximately equivalent to the Contact bed.

Terret[1] *and Allen beds.*—In the northern part of T 1 S., R. 49 E., is a bed that is in about the same stratigraphic position as the Terret bed, which was named in the Ashland field and was mapped in adjoining parts of both the Ashland and the Mizpah fields. At measured localities its thickness does not exceed 2 feet 10 inches. Locally in T. 2 S., R. 50 E., a lenticular bed approximately in the same stratigraphic position has a thickness of 3 feet 1 inch and contains a small amount of coal that is included in the estimate of reserves.

In the eastern part of T. 1 S., R. 49 E., the Allen bed, which may be equivalent to the Terret bed, ranges in thickness from 2 feet to 5 feet 2 inches of good coal.

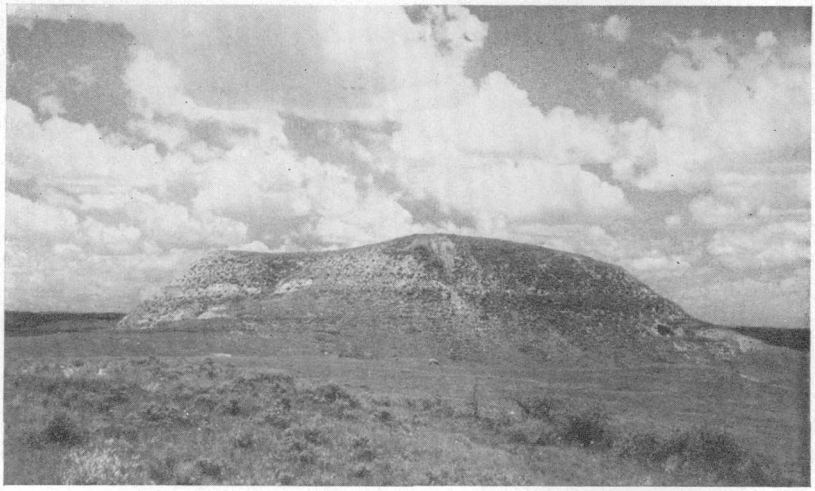
Local bed above Terret(?).—About 15 feet above the Terret(?) bed in T. 2 S., R. 50 E., is a second bed which was mapped in a small area there and in adjoining parts of the next township to the north. Thicknesses measured range from less than 2 feet to a maximum of 4 feet 1 inch.

[1] Spelled "Terrett" in previous reports.



A. VIEW NORTHWEST.

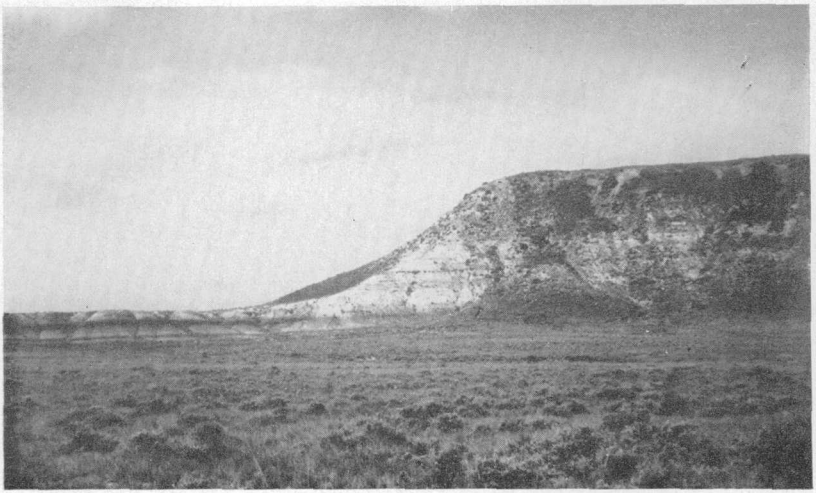
Ridge capped by clinker of the Sawyer coal bed, overlying buff-weathering sandstone and shale of the Tongue River member of the Fort Union formation in sec. 4, T. 2 S., R. 50 E.



B. VIEW NORTHWEST.

Knoll capped by clinker of the "X" coal bed, the youngest coal bed (all burned here) in the Coalwood field, in the NW. corner sec. 34, T. 2 S., R. 49 E.

COALWOOD COAL FIELD, POWDER RIVER COUNTY, MONT.



A. VIEW SOUTHWEST.

Ridge capped by clinker of the Broadus coal bed, with buff-weathering beds of the Tongue River member overlying dark beds of the lower member at its base in the SW¼ sec. 19, T. 2 S., R. 51 E.

B. VIEW NORTH.

Along U. S. Highway 212. Shown in the road cut are clinker and ash, formed by burning of the Broadus coal bed, resting on gray shale and carbonaceous shale in the NW¼ sec. 3, T. 3 S., R. 50 E.

COALWOOD COAL FIELD, POWDER RIVER COUNTY, MONT.

Flowers-Goodale bed.—The Flowers-Goodale bed was named and mapped in the Ashland field, where it is thick and extensive. It extends eastward into the northern part of T. 2 S., R. 49 E., and crosses into the southern part of the next township to the north. However, in the Coalwood field it is a thin bed, ranging in thickness at measured localities from less than 2 feet to a maximum of 3 feet 9 inches. This bed is correlated with the Broadus bed to the east and south, where the latter contains large coal reserves. The Flowers-Goodale and Broadus beds may be a single continuous bed beneath the ridge dividing Pumpkin Creek and Mizpah Creek.

Broadus bed.—This bed, mapped and named in the Birney-Broadus field (Warren and Olive, in preparation) to the south, extends as a thick bed northward across the southwestern part of the Coalwood field. Its line of outcrop, about 135 feet above the base of the Tongue River member, is marked almost everywhere by massive clinker, which commonly extends far back from the line of outcrop. The Broadus bed appears to thin abruptly in the northern part of T. 2 S., R. 50 E. There measurements at several localities show a range in thickness, increasing southward, from 5 feet 8 inches to 6 feet 11 inches and, at the North Star mine, 15 feet 5 inches. Farther south it is not exposed within the Coalwood field, but at the Peerless mine in an adjoining township in the Birney-Broadus field it has a thickness of about 22 feet.

Knoblock bed.—The Knoblock bed was mapped throughout the Ashland field and also in the southwestern part of the Mizpah field. Two benches of the bed, 45 to 60 feet apart, extend from the Mizpah field into the northern part of T. 1 S., Rs. 49 and 50 E., where they are well exposed at several localities. The upper bench is the thicker. However, each bench thins to the southeast, the upper bench from a maximum measured thickness of 13 feet 2 inches and the lower bench from a maximum measured thickness of 7 feet 7 inches, to less than 2 feet in the middle of T. 1 S., R. 50 E. Farther south the Knoblock is thin in most places, although locally in the northwest quarter of T. 2 S., R. 49 E., it is 7 to 8 feet thick. Elsewhere in adjoining townships small lenses in approximately the same stratigraphic position have maximum measured thicknesses of 2½ to 5 feet.

Sawyer and "A" beds.—In the Ashland field the interval between the Knoblock bed and the Sawyer bed was found to decrease eastward from about 300 feet in the middle of the field to about 150 feet in the valley of Pumpkin Creek (Bass, 1932, p. 55). East of Pumpkin Creek the line of outcrop of a bed there identified as the Sawyer bed crosses repeatedly from the Ashland field into Tps. 2 and 3 S., R. 49 E., of the Coalwood field, where the interval is only about 120 feet. In these

two townships the bed contains exceedingly large reserves of coal. However, almost everywhere along its outcrop it has burned, producing a thick and extensive clinker. Measurements at three localities in the northern township show that it is more than 10 feet thick, and at the Ash Creek mine it is more nearly 28 feet thick. In the southern township measurements at several localities indicate that the bed thins to the south or southeast and is less than 10 feet thick at the south border of the township. A thin local bed near the northwest corner of T. 1 S., R. 50 E., because of its stratigraphic interval above the upper bench of the Knoblock, tentatively is correlated with the Sawyer bed.

Where mapped east of Pumpkin Creek in the Ashland field, the "A" bed, about 40 feet below the Sawyer bed, could not be differentiated from it because the clinker formed by burning of these two beds merged. Although possibly it is thick and extensive enough in the western part of Tps. 2 and 3 S., R. 49 E., to constitute a substantial reserve of coal, at no place there was the bed found exposed, and its thickness and extent are uncertain.

Mackin-Walker bed.—The coal bed at the Mackin-Walker mine, in T. 2 S., R. 49 E., underlies the ridge dividing Pumpkin and Mizpah Creeks in the southern part of that township and in the northern part of the township adjoining on the south. Measurements at numerous localities indicate that the bed thins southward gradually from 5 feet or more in the middle of T. 2 S. to about 2 feet in the middle of T. 3 S., beyond which it continues to thin but was not mapped. A coal outcrop reported in sec. 20, T. 3 S., R. 49 E., may be a locally thicker part of the Mackin-Walker bed or a part of the underlying Sawyer bed. Locally in the SW¼ sec. 22, about a mile east of the Mackin-Walker mine, the coal bed is missing, and sandstone appears in place of it.

Stump bed.—The Stump bed, where it underlies small areas at several high points along the ridge between Pumpkin and Mizpah Creeks in the southern part of T. 2 S., R. 49 E., and also in the township adjoining on the south, is about 250 feet above the Sawyer bed. It is tentatively correlated with the "C" bed in the Ashland field, although in the valley of Little Pumpkin Creek the interval between the "C" bed and the Sawyer bed is only about 100 feet. The Stump bed is characterized by the presence in it, and in the beds below, of silicified, partly carbonized tree stumps. It ranges in thickness from 2 feet to slightly more than 3 feet of coal and shaly coal.

"X" bed.—This bed—the highest in the Coalwood field—is represented by clinker 20 feet thick, which caps the highest part of the divide (pl. 4*B*) between Pumpkin and Mizpah Creeks in sec. 34, T. 2 S.,

R. 49 E. As it is about 80 feet above the Stump bed, which is correlated with the "C" bed, it is tentatively correlated with the "X" bed in the Ashland field.

ESTIMATE OF RESERVES

The total reserves of lignite in the Coalwood field are approximately 1,500,000,000 tons. These reserves are in beds 2.5 or more feet thick and are within about 500 feet of the surface. In table 6, the reserves are reported by township, by bed, and by thickness range. In view of the very limited development work in the field, measured reserves are small and are not reported separately from indicated reserves. Reserves more than 2 miles from the line of outcrop of the bed are reported as inferred reserves. Coal in beds within the 2- to 2.5-foot thickness range, which equals in amount only about 2½ percent of the total reserves of the field, is tabulated but is not included in the totals of coal reserves. It will be noted that more than four-fifths of the reserves are contained in two beds—the Sawyer and the Broadus—in four townships in the southwest corner of the field (Tps. 2 and 3 S., Rs. 49 and 50 E.), where more than nine-tenths of all the reserves are located.

The areal distribution of parts of a bed having specified thickness limits was estimated by interpolation of thickness gradients from known points wherever possible. Elsewhere it arbitrarily was assumed that a bed is symmetrically lens-shaped, that the line of outcrop is approximately a diameter of the lens, and that in consequence the bed extends in a semicircle back from the general line of outcrop for a distance roughly equal to half the distance between the two ends of the outcrop. Each area so constructed was measured by planimeter, the average thickness was estimated, and the tonnage was calculated by assuming that the weight of 1 acre-foot of lignite is 1,770 short tons (Combo and others, 1949, p. 17). No allowance was made for additional coal reserves in beds that doubtless are present in the area back of the outcrop but that are nowhere exposed.

TABLE 6.—*Estimated reserves of coal in Coalwood coal field*

Township (south)	Range (east)	Coal bed	Average thickness (feet)	Area (acres)	Reserves (millions of short tons)						
					Measured and indicated				Inferred		
					In beds 2 to 2.5 feet thick [1]	In beds 2.5 to 5 feet thick	In beds 5 to 10 feet thick	In beds more than 10 feet thick	In beds 2.5 to 5 feet thick	In beds 5 to 10 feet thick	In beds more than 10 feet thick
1	49	Sawyer or "A" (?)	8.0	1			0.01				
		Upper Knoblock	8.0	330			4.67				
		Lower Knoblock	4.6	950		7.74					
		Flowers-Goodale	2.3	80	0.33						
		Do	2.9	45		.23					
		Allen	2.3	100	.41						
		Do	3.4	530		3.19					
		Terret	2.2	890	3.47						
		Do	2.6	85		.39					
		Patton	2.2	190	.74						
		Do	2.8	700		3.47					
		Total			4.95	15.02	4.68				
2	49	Stump	3.4	25		0.15					
		Mackin-Walker	4.0	2,110		14.94					
		Do	5.5	2,720			26.48				
		Sawyer	13.0	7,700				177.18			
		Knoblock	2.2	1,080	4.21						
		Do	3.4	6,030		36.29					
		Do	6.2	1,300			14.27				
		Broadus	14.0	7,930							196.51
		Flowers-Goodale	2.2	450	1.75						
		Do	3.0	2,020		10.73					
		Total			5.96	62.11	40.75	177.18			196.51
3	49	Stump	2.0	25	0.09						
		Mackin-Walker	2.3	270	1.10						
		Do	3.3	4,850		18.33					
		Sawyer	8.5	2,340			35.21				
		Do	12.0	13,700				290.99			
		Broadus	14.0	3,790				93.91			
		Do	8.0	14,500						205.32	
		Total			1.19	18.33	35.21	384.90		205.32	

1	50	Sawyer or "A" (?)	2.2	15	0.06						
		Do	8.0	280			3.96				
		Upper Knoblock	3.7	20		0.13					
		Do	7.9	780			10.91				
		Lower Knoblock	2.2	140	.55						
		Do	3.5	1,400		8.67					
		Do	5.9	2,100			21.93				
		Broadus	2.2	160	.62						
		Do	3.3	45		.26					
		Local above Terret (?)	2.2	740	2.88						
		Do	2.6	95		.44					
		Contact	2.3	70	.28						
		Total			4.39	9.50	36.80				
2	50	Mackin-Walker	8.0	55			0.78				
		Sawyer and "A" (?)	6.5	200			2.30				
		Do	10.0	85				1.50			
		Knoblock	2.2	250	0.97						
		Do	2.9	200		1.03					
		Broadus	3.5	15		.09					
		Do	5.5	15			.15				
		Do	14.0	6,530				161.81			
		Do	14.0	300							7.43
		Local above Terret (?)	2.2	25	.10						
		Do	2.9	85		.43					
		Terret (?)	2.4	270	1.15						
		Do	2.7	340		1.63					
		Total			2.22	3.18	3.23	163.31			7.43
3	50	Knoblock	2.2	10	0.04						
		Do	2.7	670		3.20					
		Broadus	14.0	5,870				145.46			
		Total			0.04	3.20		145.46			
1	51	Contact	2.0	20	0.07						
		Local below Contact	2.2	120	.47						
		Do	3.0	75		0.40					
		Local above Carter	2.1	300	1.12						
		Moths	2.2	260	1.01						
		Do	3.0	510		2.71					
		Total			2.67	3.11					
2	51	Contact	4.0	15		0.11					
		Local below Contact	2.0	15	0.05						
		Total			0.05	0.11					

TABLE 6.—*Estimated reserves of coal in Coalwood coal field*—Continued

Township (south)	Range (east)	Coal bed	Average thickness (feet)	Area (acres)	Reserves (millions of short tons)						
					Measured and indicated				Inferred		
					In beds 2 to 2.5 feet thick [1]	In beds 2.5 to 5 feet thick	In beds 5 to 10 feet thick	In beds more than 10 feet thick	In beds 2.5 to 5 feet thick	In beds 5 to 10 feet thick	In beds more than 10 feet thick
3	51	Contact	2.1	5	0.02						
		Upper "M"	2.1	40	.15						
		Lower "M"	2.0	10	.03						
		"L"	2.1	50	.19						
		Total			0.39						
1	52	Snedecker	2.3	110	0.45						
		Do	3.0	5,700		30.27					
		Do	3.0	1,670					8.87		
		Do	5.2	470			4.33				
		Local below Snedecker	2.1	50	.19						
		Local above Nicholls	2.1	100	.37						
		Total			1.01	30.27	4.33		8.87		
2	52	Lower "M"	2.1	5	0.02						
		Snedecker	2.4	300	1.27						
		Local above Nicholls	2.3	150	.61						
		Do	2.1	190	.71						
		Nicholls	2.1	30	.11						
		Total			2.72						
3	52	"L"	2.0	15	0.05						
1	53	Carter	2.0	470	1.66						
		Snedecker	4.0	2,280		16.14					
		Local below Snedecker	2.0	90	.32						
		Nicholls	2.2	670	2.61						
		Total			4.59	16.14					
2	53	Local above Nicholls	2.5	10	0.04						
		Nicholls	2.1	130	.48						
		Do	3.0	90		0.48					
		Total			0.52	0.48					

3	53	Local below Snedecker	2.2	45	0.18						
		Do	2.9	370		1.90					
		Do	5.2	55			0.51				
		Local above Nicholls	2.3	1,580	6.44						
		Nicholls	2.2	280	1.09						
		Do	4.0	740		5.24					
		Local below Nicholls	2.4	85	.36						
		Total			8.07	7.14	0.51				
1	54										
2	54	Nicholls	4.3	20		0.15					
3	54	Do	3.0	40		0.21					
		Total reserves, each thickness range			[1] 38.82	168.95	125.51	870.85	8.87	205.32	203.94
		Total measured and indicated reserves and total inferred reserves						1,165.31			418.13
		Total reserves									1,583.44

[1] Tabulated with, but not classified as, coal reserves.

TOWNSHIP DESCRIPTIONS

T. 1 S., R. 49 E.

[Plate 7]

This township is drained by northward-flowing Pumpkin Creek and its northwestward-flowing intermittent tributaries, of which the principal ones are Spring and Essell Creeks. The alluvial bottom land in the valley of Pumpkin Creek is roughly half a mile wide; above it low, rolling, grass- and brush-covered hills rise gradually to the bases of the steeper, more rugged, pine-covered ridges of the drainage divides in the southern and eastern parts of the township. The maximum relief is about 500 feet.

The rocks exposed at the surface comprise about 400 feet of sandstone, siltstone, shale, and coal beds, all of which are included in the lower part of the Tongue River member of the Fort Union formation (Paleocene) except for perhaps 20 feet of strata—locally sandstone and carbonaceous shale—exposed in the east bank of Pumpkin Creek in section 5, which are included in the lower member of the Fort Union and probably are equivalent to the uppermost "Somber beds" mapped in the Mizpah coal field immediately to the north. On the basis of stratigraphic intervals it appears possible that the buff sandstone, siltstone, and gray shale that underlie the Patton bed in the valley of Spring Creek also are equivalent to the uppermost "Somber beds." Locally the bedrocks are overlain by terrace deposits of sand and gravel of Pleistocene and probably in part of Tertiary age.

In the lower part of the Tongue River member in this township, thick lenticular beds of cross-bedded sandstone are much more abundant than they are in the same part of this member in the townships that adjoin on the east and the southeast. Because of the irregular extent of these lenticular beds and of the coal beds themselves, correlation of coal beds in some parts of the township is only tentative. Burning of the thicker coal beds where they lie near the surface has produced an abundance of clinker on the higher ridges, especially in the southern and eastern parts of the township.

Patton bed.—The lowermost coal bed that crops out in the township is the Patton bed, which is regarded as possibly equivalent to the Contact bed in adjoining parts of the Mizpah and the Ashland coal fields. This bed was found to be less than 2 feet thick wherever it is exposed in the valley of Spring Creek except at localities 23 and 24, where thicknesses of 2 feet 2 inches and 3 feet 4 inches, respectively, were measured. The base of the Patton bed is about 125 feet below the Flowers-Goodale bed to the south and about 65 feet below the Allen bed to the east.

Allen bed.—The Allen bed crops out at several localities in the eastern part of the township, between Spring Creek and Essell Creek, but is less than 2 feet thick except at localities 11, 12, 14, and 17, where it ranges in thickness from 2 feet up to 5 feet 2 inches of good coal. The base of the Allen bed is about 125 feet below the Knoblock bed in the southeastern part of the township. It may be equivalent to the Terret bed in the northern part of the township.

Terret bed.—The lowermost coal bed in the northern part of the township is one that is correlated with the Terret bed in adjoining parts of the Mizpah and the Ashland coal fields to the north and west. It is less than 2 feet thick except at localities 1, 2, 3, 7, and 8, where its thickness does not exceed 2 feet 10 inches. The base of this bed is about 120 feet below the lower Knoblock bed.

Flowers-Goodale bed.—The Flowers-Goodale bed, which crops out near the south edge of the township, is correlated with the bed of the same name in ad-

joining parts of the Ashland coal field to the west and with the Broadus bed in the Birney-Broadus coal field to the south. Where it crops out near the south edge of the township, it is about 125 feet above the base of the Allen bed and its base is about 60 feet below the Knoblock bed. It was found to be less than 2 feet thick except at localities 22 and 27, where its maximum thickness is 3 feet 7 inches of good coal. In adjoining townships to the south and southeast the Broadus bed is much thicker and is an important reserve source of coal.

Knoblock bed.—The Knoblock bed in the northern part of the township comprises two benches about 35 feet apart, of which the lower is about 125 feet above the base of the Terret bed. These benches are correlated with two benches of the same bed in adjoining parts of the Mizpah coal field to the north and also in the township adjoining on the east. Both benches are present in the northeast corner of the township, mainly in section 1, where the lower bench was measured at localities 9 and 10, but almost invariably they are burned at the outcrop. On the divide between Essell Creek and Pumpkin Creek, in sections 3, 4, and 10, remnants of these beds have been burned almost everywhere, leaving thick beds of clinker capping the ridge. However, the upper Knoblock bench is 4 feet 9 inches thick at locality 5, and the lower bench is 2 feet thick at locality 4 and 3 feet 8 inches thick, with an additional 1 foot 2 inches lying 6 inches below it, at locality 6. In the southern part of the township only one bench (lower bench?) was found. Where measured at localities 13, 16, 18, 19, 21, and 25, it has a maximum thickness of 4 feet 1 inch.

Sawyer and "A"? beds.—The next higher coal bed, in the southern part of the township, is about 100 feet above the base of the Knoblock bed. It is tentatively correlated with the "A" bed in adjoining parts of the Ashland coal field to the west. Commonly, clinker of this bed merges with that of the overlying Sawyer bed, 50 feet or more higher, and is mapped with it. On the few ridge tops in the southern and eastern parts of the township where it had not been removed by erosion, this bed burned and now is represented by a thick bed of clinker except in parts of the east half of section 36, where, at locality 20, eight feet of good-quality coal was found. Thin beds of coal, probably splits of a main bed, were measured at localities 15 and 26.

Local bed (equivalent to Sawyer?).—The uppermost coal bed in the township is one that may be equivalent to the Sawyer bed in adjoining parts of the Ashland coal field. On a few ridge tops in section 36, the only part of the township from which it had not been removed by erosion, this bed burned completely and now is represented by a thick bed of clinker. This clinker is about 50 feet above the base of the underlying "A" bed or clinker.

Where exposed in townships to the north and to the east, the rocks that underlie the Patton or Contact bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

T. 2 S., R. 49 E.

[Plate 8]

Except for its east edge, this township is drained by northwestward-flowing intermittent tributaries of Pumpkin Creek. The east edge of the township is drained by headwaters of southeastward-flowing tributaries of Mizpah Creek. Much of the surface is gently rolling, with large pine-covered areas where the surface rock is clinker and, particularly in the south third of the township, somewhat higher grass- and brush-covered slopes that rise to the drainage divide. This surface is dissected by the larger valleys, whose sides rise as much as 200 feet above the creek beds. The maximum relief is approximately 700 feet.

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The rocks exposed at the surface comprise about 600 feet of sandstone, siltstone, shale, and coal beds, all of which are included in the lower part of the Tongue River member of the Fort Union formation (Paleocene). It is estimated that an additional 75 feet of the Tongue River member lies beneath the surface. Locally, near the north edge of the township, in the valleys of both Pumpkin Creek and Spring Creek, the bedrocks are overlain by terrace deposits of sand and gravel of Pleistocene and probably in part of Tertiary age. Burning of coal beds, particularly the Sawyer bed but probably the Sawyer and the "A" bed together, over wide areas has produced an abundance of clinker that covers much of the central part of the township.

Flowers-Goodale bed.—The lowermost coal bed that crops out in the township is the Flowers-Goodale bed, which is an important coal bed in the Ashland coal field to the west and is correlated with the Broadus bed in the Birney-Broadus coal field to the south. In this township it was mapped and its thickness was measured where it is exposed in sections 3, 4, 5, and 6. At localities 29, 30, 32, 34, and 42 it ranges in thickness from 2 feet 4 inches to 3 feet 9 inches of good coal. East of section 3 the bed either is absent or is very thin.

Knoblock bed.—In the northern part of the township and in the southern part of the next township to the north, a bed of coal whose base is about 55 feet above the Flowers-Goodale bed was examined at numerous localities. This bed is correlated with the Knoblock bed (lower bench?) in adjoining parts of the Mizpah and Ashland coal fields. In this township it was measured at localities 28, 31, 33, 35, 36, 37, 38, 39, 40, 41, 43, 44, 45, and 46 and was found to have a maximum thickness of 8 feet 2 inches of good coal at locality 38 in section 4. Farther south, along the east edge of the township, this bed was examined at several localities, at all of which it was found to be less than 2 feet thick.

"A" bed.—The next higher coal bed, about 95 feet above the base of the Knoblock bed, is tentatively correlated with the "A" bed in adjoining parts of the Ashland coal field to the west. At no place was the bed found unburned. Commonly clinker of this bed merges with that of the overlying Sawyer bed and is mapped with it. Locally, concealed under moderately thick cover, it may be thick enough to constitute an important reserve source of coal.

Sawyer bed.—The extensive clinker outcrops in the township were produced by burning of the "A" bed together with an important coal bed, about 135 feet above the base of the Knoblock bed, that is correlated with the Sawyer bed in adjoining parts of the Ashland coal field. Because it has burned so extensively along the outcrop, there are few localities where it can be examined and measured. At locality 65 in section 30, a total of 12 feet of weathered coal was measured, although the base of the coal was not exposed, in a small unburned area surrounded by clinker outcrops. At locality 66 in section 31, as much as 9½ feet of weathered coal was measured. At locality 50 in section 26, Harry Dinzl has opened a pit mine in which 10 feet 7 inches of coal is exposed, with an undetermined additional thickness remaining in the floor. In the vicinity of the Ash Creek (Jim Smith) mine, at locality 54 in section 35, the coal is reported by Wyatt Surgeon to be 28 feet thick, with a clay parting, commonly 3 to 6 inches thick but locally as much as 8 inches thick, 8 to 10 feet below the top of the bed. The Sawyer is a thick and important coal bed where it underlies several square miles in the southern part of the township.

Mackin-Walker bed.—In the southern part of the township, and in the northern part of the next township to the south, the Sawyer bed is overlain about 95 feet above its base by a moderately thick coal bed that has been mined at the Mackin-Walker mine in section 28 and is called the Mackin-Walker bed. This bed appears to become progressively thicker from southwest to northeast across

the township. It was measured at localities 47, 48, 49, 51, 52, 53, 57, 58, 59, 60, 61, 63, 64, and 67, where it ranges in thickness from 2 feet 7 inches at locality 64 to 7 feet 2 inches at locality 47. A local bed noted in the Ashland coal field, in sections 16, 21, and 29 of the adjoining township to the west, may be correlated with the Mackin-Walker bed.

Stump bed.—At several high points along the divide in the southern part of the township, and in the next township to the south, is a coal bed about 170 feet above the base of the Mackin-Walker bed. This bed is characterized by the presence in it, and in beds as much as 20 feet below it, of silicified, partly carbonized tree stumps, which commonly remain in growing position with roots extending into beds of coal or carbonaceous shale. The "C" bed, 20 to 30 feet below the "D" bed in the Ashland coal field to the west, is characterized by similar silicified wood. On the basis of these associations, correlation of the Stump bed with the "C" bed or the "D" bed in the Ashland coal field is tentatively suggested. The Stump bed was examined and measured at localities 55, 56, and 62, where it ranges in thickness from 2 feet 11 inches to 3 feet 8 inches.

"X" bed.—The highest part of the divide, centering in the northwest corner of section 34, is capped by 20 feet of clinker (pl. 4B). The base of this clinker is about 80 feet above the base of the Stump bed. On the basis of this interval the clinker is tentatively correlated with the "X" bed in the Ashland coal field.

Where exposed in surrounding townships, the rocks that underlie the Flowers-Goodale bed do not contain coal beds sufficiently thick to indicate that important coal reserves are contained in these rocks beneath the surface of this township.

T. 3 S., R. 49 E.

[Plate 9]

The drainage divide between intermittent northwestward-flowing tributaries of Pumpkin Creek and southeastward-flowing tributaries of Mizpah Creek crosses the township diagonally from southwest to northeast. In the central part of the township the ground surface, which is brush-covered and partly grass-covered but almost completely devoid of trees, slopes gently, becoming moderately dissected at the east and northwest edges of the township. The maximum relief in the township is about 400 feet.

The rocks exposed at the surface comprise about 375 feet of sandstone, siltstone, shale, and coal beds, all of which are included in the Tongue River member of the Fort Union formation (Paleocene). It is estimated that an additional 235 feet of the Tongue River member lies beneath the surface. Burning of the Sawyer bed along its outcrop has produced a prominent belt of clinker in the eastern and northwestern parts of the township.

Sawyer bed.—The lowest coal bed that crops out in the township is the Sawyer bed, which has been burned almost everywhere along its outcrop in the northwestern part and on the east side of the township. This bed is correlated with the Sawyer bed in the Ashland coal field, in the township that adjoins on the west. It was measured at localities 80, 85, 86, and 87, where it ranges in thickness from 7 feet at locality 85 to more than 10 feet (possibly as much as 13 feet) at locality 80. It is believed that in back of its clinkered outcrops the Sawyer bed underlies most of the township, constituting an important reserve source of coal.

Mackin-Walker bed.—In the northern part of the township the Sawyer bed is overlain, about 100 feet above its base, by the Mackin-Walker bed. At localities 68, 69, 70, 71, 72, 73, 74, 76, 77, 78, 79, 81, 82, 83, and 84, where the bed was examined and measured, it ranges in thickness from 3 feet 11 inches at

locality 83 to 2 feet 3 inches at locality 69. Southwest of the middle of the township it is less than 2 feet thick and is too thin to map. A coal outcrop reported in sec. 20, T. 3 S., R. 49 E., may be a locally thicker part of the Mackin-Walker bed or a part of the underlying Sawyer bed.

Stump bed.—In sections 4, 30, and 31 and elsewhere at high points along the divide, about 170 feet above the base of the Mackin-Walker bed, is a thin bed of poor-quality coal that is characterized by the presence in it, and in beds as much as 20 feet below it, of silicified, partly carbonized tree stumps. At locality 75 it is 2 feet 10 inches thick but contains a parting of carbonaceous shale near the middle. At locality 88 it is barely 2 feet thick, and elsewhere along the divide it measures even less.

Although the possibility cannot be excluded that other significant coal beds underlie those that crop out, only one bed is deserving of special mention. That is the Broadus, which is a thick and important bed in the township that adjoins on the east, where it is about 195 feet below the Sawyer bed. It is likely that the Broadus bed also underlies much or all of this township and constitutes an important reserve.

T. 1 S., R. 50 E.

[Plate 10]

Most of the township is drained by intermittent tributaries of Mizpah Creek, of which the principal ones are eastward-flowing Hay Creek and Dick Creek and northward-flowing Sand Creek. The west edge of the township is drained by intermittent tributaries of Essell Creek, which flows northwestward into Pumpkin Creek. Except for Sand Creek, these creeks head in broad, open, grass- and brush-covered valleys at the bases of slopes that rise rather steeply in the southwest corner of the township to clinkered, pine-covered ridge crests about 300 feet above and, somewhat less steeply, in the northwest quarter of the township, to a clinkered, pine-fringed mesa, about 200 feet above, which is drained by the perched headwaters of Sand Creek. In the east third of the township the brush- and grass-covered surface is moderately dissected. The maximum relief is about 475 feet.

The rocks exposed at the surface comprise about 440 feet of sandstone, siltstone, shale, and coal beds, all of which are included in the lower part of the Tongue River member of the Fort Union formation (Paleocene) except for about 65 feet of strata, dominantly somber carbonaceous and silty shales and sandstones, in the valley bottoms in the eastern part of the township. These beds, included in the lower member of the Fort Union formation, are separated from the overlying Tongue member because they commonly are softer and more somber; they have been correlated with the "Somber beds" in the adjoining Mizpah coal field.

A residual veneer of coarse to fine gravel and sand covers broad areas in the higher parts of the mesa that is drained by Sand Creek; probably these areas are remnants of an extensive terrace gravel (Flaxville?).

Contact bed.—The lowermost coal bed that crops out in the township is one commonly less than 2 feet thick, at or very near the base of the Tongue River member. This bed is correlated with the Contact bed in the adjoining Mizpah coal field but possibly is equivalent to the Volborg. At locality 115 in section 13, where it is 23 feet above the base of the member, it comprises 2 feet 3 inches of coal; at locality 116 in section 1, where it is mapped as the base of the member, it is 3 feet thick but shaly.

Local bed (equivalent to Terret?).—In sections 34 and 35 a local bed, which may be equivalent to the Terret bed in the Mizpah coal field, was observed and

was found at two localities to exceed 2 feet in thickness. At locality 125 the bed is 2 feet 1 inch thick; at locality 128, it is 2 feet 8 inches thick. At the latter locality the bed is about 40 feet above the mapped base of the Tongue River member.

Broadus bed.—A thin bed, correlated with the Broadus bed in townships to the south, was measured at localities 113 and 114 near the center of the township and at localities 126 and 127 near the south edge. It was found to range in thickness from less than 2 feet to a maximum of 3 feet 5 inches. At locality 126 the bed is 60 feet above the base of the local bed measured at locality 125.

Knoblock bed.—In the northwest quarter of the township the Knoblock bed comprises two benches that are 45 to 60 feet apart and are approximately equivalent to similar beds in the Mizpah coal field. The lower of the two is about 50 feet above the base of the Broadus bed at locality 113. The upper bench is the thicker. It was measured at localities 90, 92, 95, 98, 101, 102, 103, 105, 107, 109, and 111 and was found to decrease in thickness in a general southeasterly direction from 13 feet at locality 90 and 13 feet 6 inches at locality 92 to a minimum thickness of 3 feet 2 inches at locality 111. The lower bench was measured at localities 91, 93, 94, 96, 97, 99, 100, 104, 106, 108, 110, and 112 and was found to decrease in thickness in the same direction from 7 feet 7 inches at locality 91 to 3 feet 5 inches (including an 8-inch carbonaceous shale parting) at locality 112, beyond which it decreases in thickness to less than 2 feet. In the southwest corner of the township a bed that is correlated with the lower bench of the Knoblock was measured at localities 117, 118, 121, and 122 and was found to decrease in thickness in the same direction from 3 feet 6 inches at locality 117 to less than 2 feet in the southwest corner of section 29.

Sawyer and "A" (?) beds.—The next higher coal bed, which is in the southwestern part of the township, is about 100 feet above the base of the Knoblock bed (lower bench). Tentatively it is correlated with the "A" bed in the Ashland coal field. Commonly the clinker of this bed merges, and is mapped, with that of the overlying Sawyer bed, 50 feet or more higher, which in this township is burned almost everywhere. Where measured at localities 119, 120, 123, and 124, the "A" bed appears to decrease in thickness in a northeasterly direction from more than 6 feet at locality 123 to 4 feet 5 inches at locality 120.

Local bed (equivalent to Sawyer?).—The uppermost coal bed in the southwestern part of the township is about 50 feet above the base of the "A" bed and may be equivalent to the Sawyer bed in the Ashland coal field. On a few ridge tops in sections 30, 31, and 32 this bed is represented by a very thick bed of clinker—70 feet thick on the ridge above locality 119. In the northern part of the township a local bed, which at locality 89 in section 7 was found to comprise 2 feet 2 inches of weathered coal, occurs about 105 feet above the upper bench of the Knoblock. For that reason, it also is correlated tentatively with the Sawyer bed.

Where exposed in townships to the north and to the east, the rocks that underlie the Contact bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

T. 2 S., R. 50 E.

[Figure 6]

This township is drained by intermittent eastward-flowing tributaries of Mizpah Creek, of which the principal ones include Mud Spring, Double Corral, Flat, and Lake Creeks. The bottoms of the valleys are broad and open, covered with grass and brush. They are bordered by steeper slopes that rise 150 to 300 feet to the sparsely pine-covered ridges of the drainage divides, which are capped by resistant beds of clinker or indurated sandstone (pl. 4*A*). In parts of the

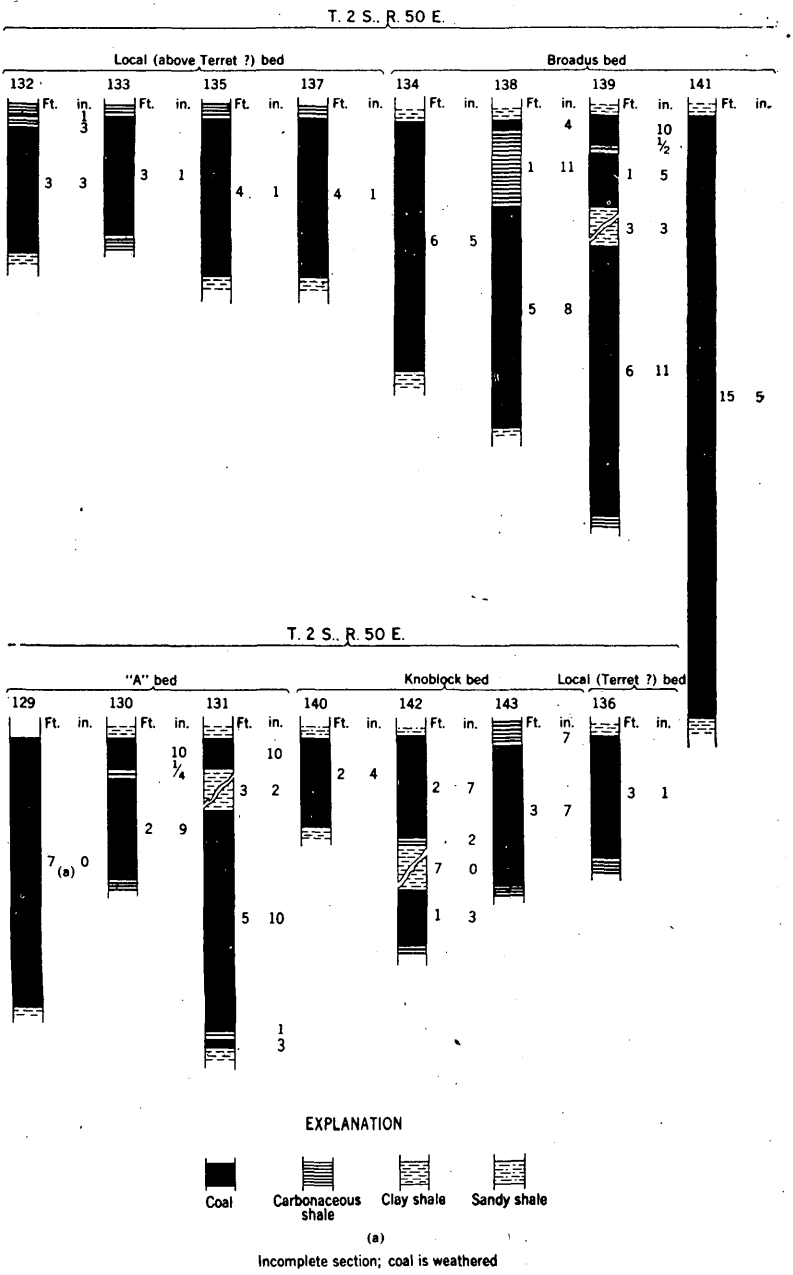

FIGURE 6.—Sections of coal beds in T. 2 S., R. 50 E., Montana.

township the ridges are broken into grouped or isolated red-capped buttes and small mesas. The maximum relief is about 400 feet.

The rocks exposed at the surface comprise about 440 feet of sandstone, siltstone, shale, and coal beds. The upper 375 feet are included in the lower part of the Tongue River member of the Fort Union formation (Paleocene). The

lower 65 feet, which are dominantly softer, more somber carbonaceous and silty shales and sandstones, are grouped separately and included in the lower member of the Fort Union formation. These latter beds are correlated with the "Somber beds," in the Mizpah coal field. Burning of coal beds of the Tongue River member, particularly the Broadus bed, over wide areas has produced an abundance of clinker, which caps most of the high parts of the township.

Contact bed.—The lowermost coal bed that crops out in the township is one that is at or very near the base of the Tongue River member. It is present only locally and everywhere examined is less than 2 feet thick.

Local beds (equivalent to Terret?).—In sections 2, 3, and 11 a local bed was found at localities 132, 133, 135, and 137 to range in thickness from 3 feet 1 inch to 4 feet 1 inch of good coal. A second bed, 15 feet lower and about 65 feet above the base of the Tongue River member, was found to be 3 feet 1 inch thick at locality 136 and to extend southward about 2 miles along a line marked by clinkered outcrops. These beds may be approximately equivalent to the Terret bed in the Mizpah coal field.

Broadus bed.—The Broadus bed, about 125 feet above the base of the Tongue River member, was measured at localities 134, 138, and 139 in the northern part of the township, where it ranges in thickness, increasing southward, from 5 feet 8 inches to 6 feet 11 inches. In the North Star mine, at locality 141 in section 21, coal is mined from an 8-foot face, above which 4 to 7 feet of coal is left in the roof and below which as much as 3 feet may be left in the floor. At this locality the Broadus bed is 15 feet 5 inches thick. Almost everywhere along its outcrop it has burned, and the resulting clinker caps all the ridges in the southeast quarter of the township. Back of its clinkered outcrop the bed remains unburned and constitutes an important reserve underlying almost all the west half of the township. Consequently the Broadus bed is the most important coal bed in the township.

Knoblock bed.—A bed about 55 feet above the base of the Broadus bed in sections 21, 28, and 32 was measured at localities 140, 142, and 143, where it ranges in thickness from 2 feet 4 inches to 3 feet 7 inches, although at many other places along its line of outcrop it is less than 2 feet thick. This bed is correlated tentatively with the Knoblock bed in the townships to the west and north.

Sawyer and "A" (?) beds.—The next higher bed, about 110 feet above the base of the Knoblock bed, is the "A" bed. Commonly the clinker of this bed merges with that of the overlying Sawyer bed, 35 or more feet higher, and is mapped with it. Because these beds have burned so extensively along the outcrop, localities where they can be examined are uncommon. This is particularly true of the Sawyer bed. At localities 129 and 131 the "A" bed ranges in thickness from 5 feet 10 inches to 7 feet, and at locality 130 a lower split contains about 3 feet 6 inches of coal. The Sawyer bed is partly exposed at the Ash Creek (Jim Smith) mine and elsewhere in the township adjoining on the west and is known to be a thick and important bed there. In the township discussed, it has been removed by erosion or burned everywhere except in parts of sections 5, 6, and 19.

Where exposed in townships to the east, the rocks that underlie the Broadus bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

Between 1922 and 1924 three shallow holes were drilled in the township and abandoned: Anna May Oil Co. No. 1 in section 20 (total depth, 500 feet); Anna May Oil Co. No. 2 in section 21 (total depth, 802 feet); and Butler Oil & Gas Co. No. 1 in section 22 (total depth, 1,300 feet). The first test hole drilled in the area in more than 20 years, and the only deep test hole to date,

is the Stanolind-Northern Pacific No. 1 in the SE¼SW¼NW¼ sec. 27, which was drilled between April 7 and August 7, 1945, to a total depth of 8,991 feet and abandoned after penetrating Cretaceous and Paleozoic formations. (See "Economic geology," p. 64.)

T. 3 S., R. 50 E.

[Figure 7]

This township is drained by Mizpah Creek, which flows northeastward across the southeastern part of the township, and by its intermittent tributaries, of which the principal ones are southeastward-flowing Ash, Y. K., and Second Creeks. The main valleys, which are broad and open, rise gently to the base of steeper-sloped, even-topped ridges (pl. 5). The valleys are covered with grass and brush, and the ridges, which are clinker-capped, with pines. The maximum relief, in the western part of the township, is about 375 feet.

The rocks exposed at the surface comprise about 380 feet of sandstone, siltstone, shale, and coal beds, of which all but the lower 10 or 20 feet, poorly exposed, are included in the Tongue River member of the Fort Union formation (Paleocene). Burning of coal beds of the Tongue River member—particularly the Broadus bed but also, in the western part of the township, the Sawyer bed—over wide areas has produced an abundance of clinker, which caps most of the high parts of the township.

Contact bed.—The lowermost coal bed that crops out in the township is one that is at or very near the base of the Tongue River member. It is present only locally and everywhere examined is less than 2 feet thick.

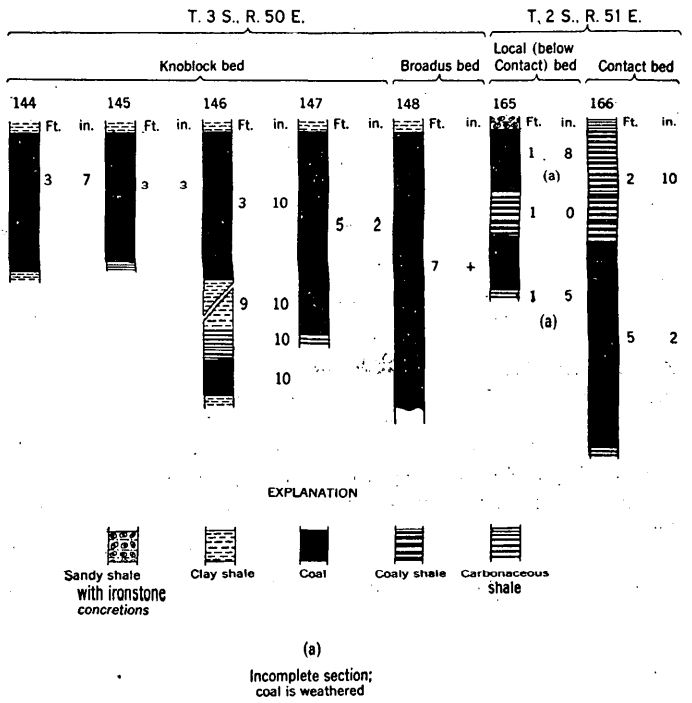

FIGURE 7.—Sections of coal beds in T. 3 S., R. 50 E., and in T. 2 S., R. 51 E., Montana.

Broadus bed.—The Broadus bed, about 145 feet above the base of the Tongue River member, has burned almost everywhere along its outcrop in the east two-thirds of the township, producing abundant clinker (pl. 5*B*) that conceals the bed, doubtless thick and important, and prevents its direct examination and measurement except at locality 148, where 7 feet of the bed is exposed in a small unburned area. At the North Star mine in the township adjoining on the north, the bed is 15 feet 5 inches thick; at the Peerless mine in the next township to the south, it is about 22 feet thick. From these known thicknesses and from the abundance of clinker where the bed has burned, it is inferred that where the bed has not burned, in the west third of the township, it contains at least 15 feet of coal.

Knoblock bed.—A bed, locally more than 2 feet thick, was found about 60 feet above the base of the Broadus bed and is correlated tentatively with the Knoblock bed in the townships to the north and northwest. Where measured at localities 144, 145, 146, and 147, it ranges in thickness from 3 feet 3 inches to 5 feet 2 inches.

Sawyer bed.—The uppermost bed in the township, about 195 feet above the base of the Broadus bed, is correlated with the Sawyer bed in adjoining townships and in the Ashland and Birney-Broadus coal fields. In this township it has burned completely, forming the clinker cap for many parts of the ridges in the western part of the township.

Where exposed in townships to the east, the rocks that underlie the Broadus bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

T. 1 S., R. 51 E.

[Figure 8]

This township is drained by Mizpah Creek, which flows northward across the middle of the township, and its intermittent tributaries, of which the principal ones are Cross-S, Hay, and Dick Creeks. The alluvial bottom land in the valley of Mizpah Creek is roughly half a mile wide; above it low, rolling, grass- and brush-covered hills rise gradually to the tributary drainage divides. The maximum relief is about 235 feet.

The rocks exposed at the surface comprise about 235 feet of soft, somber to buff sandstone, siltstone, shale and thin coal beds, all of which are included in the lower member of the Fort Union formation and probably are equivalent to the "Somber beds" mapped in the Mizpah coal field immediately to the north except for about 20 feet of gray to buff calcareous claystone and sandstone, found capping isolated high points on ridges, which are tentatively correlated with beds above the base of the Contact coal bed and are included in the basal part of the Tongue River member of the Fort Union formation (Paleocene).

Moths bed.—The lowermost coal bed that crops out in the township lies about 205 feet below the base of the Tongue River member and is correlated with the Moths bed in adjoining parts of the Mizpah coal field and with the Snedecker bed farther east. It was examined and measured at localities 152, 154, and 155, where it crops out in the east bank of Mizpah Creek, and found to range in thickness from 2 feet 4 inches to 3 feet 7 inches.

Local beds above base of Moths.—A thin bed, in many places less than 2 feet thick, was found approximately 80 feet above the base of the Moths bed. This bed ranges in thickness from 2 feet 2 inches to 2 feet 10 inches at localities 150, 151, 153, and 163.

Another thin bed, in many places less than 2 feet thick, was found approximately 125 feet above the base of the Moths bed. At localities 156, 157, 158, 159,

160, 161, and 162 in sections 11, 14, 23, and 26, east of Mizpah Creek, and at locality 164 in section 32, west of the creek, the bed is more than 2 feet but less than 3 feet thick. This local bed is approximately 80 feet below the base of the Tongue River member.

Contact bed.—The uppermost coal bed in the township is one at or near the base of the Tongue River member. In this township it commonly is less than 2 feet thick, but at locality 149 in section 8 it contains 2 feet 2 inches of coal.

Where exposed in townships to the north and to the east, the rocks that underlie the Moths bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

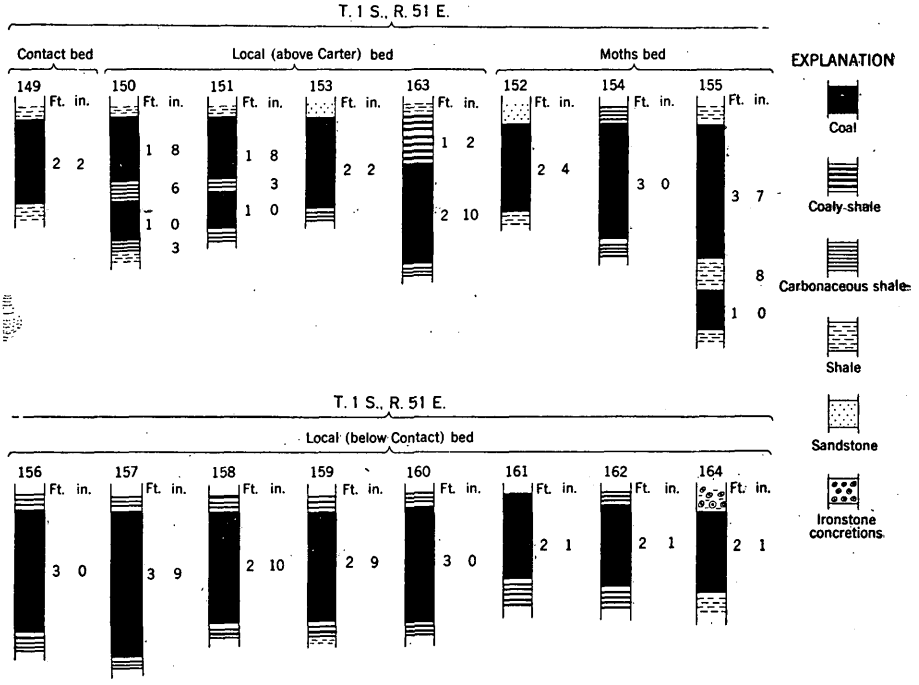

FIGURE 8.—Sections of coal beds in T. 1 S., R. 51 E., Montana.

T. 2 S., R. 51 E.

[Figure 7]

This township is drained by Mizpah Creek, which flows northeastward and northward through the center of the township, and its intermittent tributaries, of which the principal ones are Sheep, Hudson, and Double Corral Creeks. The alluvial bottom land in the valley of Mizpah Creek is roughly half a mile wide; above it low, rolling, grass- and brush-covered hills rise gently to the tributary drainage divides, with relief commonly less than 150 feet. In the western part of the township some valley slopes rise to the bases of steeper, clinker-capped buttes and mesas. Here the maximum relief is about 325 feet.

The rocks exposed at the surface comprise about 335 feet of somber to buff sandstone, siltstone, shale, and thin coal beds. The lower half, dominantly somber, of this 335 feet is included in the lower member of the Fort Union formation and probably is equivalent to the "Somber beds" mapped in the Mizpah

coal field. The upper half, dominantly buff, is included in the basal part of the Tongue River member of the Fort Union formation (Paleocene).

Local bed below Contact bed.—The lowermost coal bed that crops out in the township is a thin bed that at locality 165 in section 18 contains about 4 feet of weathered coal and coaly shale. This bed is about 70 feet below the mapped base of the Tongue River member and is in turn underlain by approximately 100 feet, exposed but barren of mappable coal, of the lower member of the Fort Union formation.

Contact bed.—Where present locally, a thin coal bed marks the base of the Tongue River member. This bed is absent or less than 2 feet thick except at locality 166, where 5 feet 2 inches of coal was measured. The bed at this locality, mapped as the Contact bed, actually may be a lower local bed instead.

Broadus bed.—Clinker as much as 40 feet thick, formed by burning of the Broadus bed, caps several buttes and small mesas at the west edge of the township. The base of this clinker is about 130 feet above the base of the Tongue River member (pl. 5*A*).

Where exposed in townships to the north and the east, the rocks that underlie the Broadus bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

T. 3 S., R. 51 E.

[Figure 9]

This township is crossed diagonally by the Mizpah Creek-Powder River divide. From this divide intermittent tributaries drain northwestward toward Mizpah Creek, which itself crosses the northwest corner of the township, and southeastward toward the Powder River. Northwest of the divide the alluvial bottom land in the valley of Mizpah Creek is roughly half a mile wide; above it low, rolling, grass- and brush-covered hills rise very gently to the tributary divides or to the bases of steep-sloped, clinker-capped buttes and small mesas, sparsely covered with pines. Here the maximum relief is about 200 feet. Southeast of the divide the maximum relief is about 400 feet, as the streams and ridges slope more steeply toward the valley of Powder River, forming the breaks west of the river.

The rocks exposed at the surface comprise about 400 feet of somber to buff sandstone, siltstone, shale, and thin coal beds. The lower 215 feet, dominantly somber, are included in the lower member of the Fort Union formation and probably are equivalent to the "Somber beds" mapped in the Mizpah coal field. The upper 185 feet, dominantly buff, are included in the basal part of the Tongue River member of the Fort Union formation (Paleocene).

"L" bed.—The lowest coal bed that crops out in the township is one, about 185 feet below the base of the Tongue River member, that is correlated tentatively with the Moths bed, which crops out to the north in the valley of Mizpah Creek, and with the Snedecker bed in the valley of Powder River. This bed is less than 2 feet thick where exposed, southeast of the divide, except at locality 168 in section 24, where 2 feet 2 inches of shaly coal is exposed.

Lower "M" bed.—About 130 feet below the base of the Tongue River member is a thin bed of shaly coal and coal, less than 2 feet thick where measured except at localities 170 and 171. This bed is correlated tentatively with the Carter bed to the north in the valley of the Powder River.

Upper "M" bed.—About 25 feet above the Lower "M" bed, at localities 169 and 172, is a thin bed that contains 2 feet to 2 feet 4 inches of shaly coal and coal.

Contact bed.—Where present locally, a thin coal bed marks the base of the

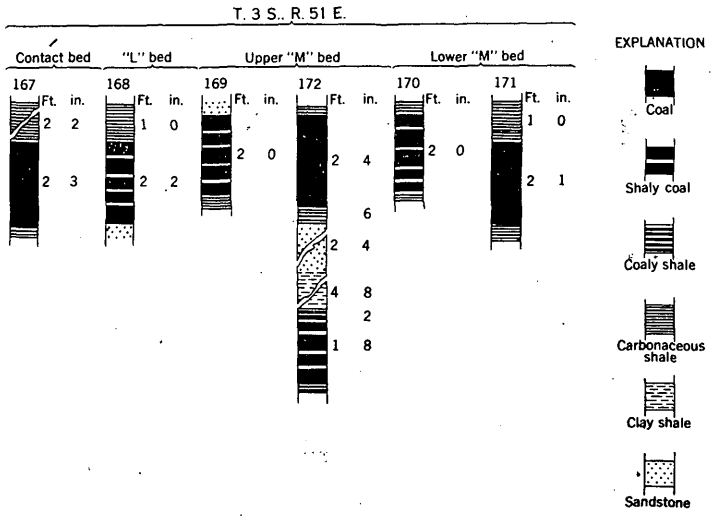

FIGURE 9.—Sections of coal beds in T. 3 S., R. 51 E., Montana.

Tongue River member. This bed is absent or less than 2 feet thick except at locality 167 in section 19, where 2 feet 3 inch of coal was measured.

Broadus bed.—Clinker as much as 40 feet thick, formed by burning of the Broadus bed, caps many buttes and small mesas west of the divide. The base of this clinker is about 145 feet above the base of the Tongue River member.

None of these beds contains significant reserves of coal. Where exposed in the townships to the north and the east, the rocks that underlie the Broadus bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

T. 1 S., R. 52 E.

[Figure 10]

This township is crossed diagonally, southeast of its center, by the Mizpah Creek-Powder River divide, from which intermittent tributaries (Corral, Horse, Cross-S, and East Cross-S Creeks) drain northwestward toward Mizpah Creek in adjoining townships and other tributaries drain southeastward toward the Powder River. Northwest of the divide the valleys of the principal tributaries are broad, with grass- and brush-covered slopes that rise gently to low, rounded tributary divides. Here the relief is approximately 150 feet. Southeast of the divide the maximum relief is nearly 400 feet, as the tributary streams and ridges slope more steeply toward the valley of the Powder River, forming the breaks west of the river.

The rocks exposed at the surface comprise about 410 feet of somber to buff sandstone, siltstone, shale, and thin coal beds. The lower 15 feet or more, poorly exposed, is believed to be of Cretaceous age; the upper 20 feet, approximately, of gray to buff calcareous claystone and sandstone, found capping isolated high points on ridges, is included in the basal part of the Tongue River member; and the intervening 375 feet, dominantly somber in the upper part, is included in the lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field immediately to the north.

Nicholls bed.—The lowermost coal bed, which should crop out in the valley bottoms in section 36, either is too thin to map or is covered, although it crops

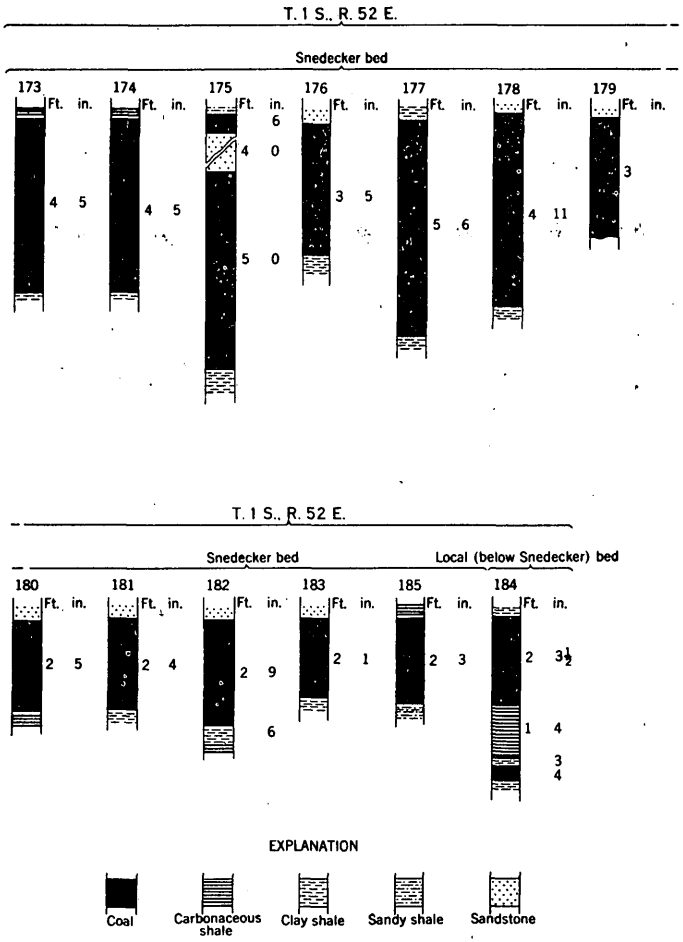

FIGURE 10.—Sections of coal beds in T. 1 S., R. 52 E., Montana.

out and was mapped in nearby parts of adjoining townships. This bed, which is correlated with the Nicholls bed in the Mizpah coal field to the north, in the absence of other stratigraphic criteria locally is mapped as the base of the lower member of the Fort Union formation.

Local bed below Snedecker.—A local bed 45 feet below the Snedecker bed was found in section 35 but is less than 2 feet thick except in locality 184, where the bed contains 2 feet 3 inches of coal. This locality is approximately 125 feet above the Nicholls bed.

Snedecker bed.—The uppermost and also the most important coal bed that crops out in the township is one about 170 feet above the Nicholls bed that is correlated with the Moths bed farther west and with the Snedecker bed in the Mizpah coal field to the north. In general, this bed thins southward along the line of outcrop. At localities 173 to 179, where it is overlain by a shale roof, it ranges in thickness from 5 feet 6 inches to 4 feet 5 inches except at locality 176, where 3 feet 5 inches of coal is overlain by a sandstone roof. At localities 180 to 183 the coal is overlain by sandstone and ranges in thickness from 2 feet 9 inches to 2 feet 1 inch. Farther south it is less than 2 feet thick almost to

the south edge of the township, where, at locality 185, a thickness of 2 feet 3 inches of coal was found beneath a shale roof. The Snedecker bed is overlain by about 225 feet of strata that are barren of mappable coal beds.

Where exposed in the townships to the east and the south, the rocks that underlie the Snedecker bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

T. 2 S., R. 52 E.

[Figure 11]

The western part of the township is crossed diagonally by the Mizpah Creek-Powder River divide, from which intermittent tributaries (Sheep Creek and its tributaries and Cross-S Creek) drain northwestward toward Mizpah Creek and southeastward to the Powder River. Northwest of the divide the valleys of the principal tributaries are broad, with grass- and brush-covered slopes that rise gently to low, rounded tributary divides. Here the relief is approximately 100 feet. Southeast of the divide the maximum relief is about 400 feet, as the tributary streams and ridges slope more steeply toward the valley of the Powder River in the eastern part of the township, forming the breaks west of the river. The Powder River follows a meandering course, marked by cottonwood trees and brush, in an open, flat-bottomed, grass-covered, alluviated valley, roughly 1½ miles wide, that is used for growing hay and for stock pasture.

The rocks exposed at the surface comprise about 425 feet of somber to buff or green sandstone, siltstone, shale, and thin coal beds. The upper 20 feet, approximately, of gray to buff calcareous sandstone and claystone found in section 31 capping an isolated high point on the divide, is included in the basal part of the Tongue River member. The remaining 400 feet, dominantly somber in the upper part and buff to green in the lower part, is included in the lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field to the north. Lenticular beds of cross-bedded green sandstone grouped with the lower member here may be equivalent to part of the underlying sandstone member of the Lance formation mapped in the Mizpah coal field.

Nicholls bed.—The lowermost coal bed, which has burned at its outcrop in the northeast corner of section 1, is correlated with the Nicholls bed in the Mizpah coal field. This bed is present only locally and was found to be less than 2 feet thick except at locality 194, where 2 feet 3 inches of dirty coal was found in a bed that is correlated with the Nicholls.

Local beds above Nicholls.—In sections 1 and 2 a thin bed about 25 feet above the base of the Nicholls bed was found at localities 188 and 189 to contain 2 feet 3 inches of coal, and at localities 187 and 190 in section 2 a local bed about 45 feet above the base of the Nicholls bed was found to contain 2 feet to 3 feet 3 inches of coal.

Snedecker bed.—In sections 3, 9, and 10 a thin coal bed about 170 feet above the base of the Nicholls bed was found to be less than 2 feet thick except at localities 186, 191, 192, and 193, where it ranges in thickness from 2 feet to 3 feet 2 inches. At locality 189 small amounts of coal were mined as late as 1934 for domestic use at nearby ranches. This bed is correlated with the Snedecker bed in the Mizpah coal field. Farther south the bed is too thin to map or is absent.

Lower "M".—At locality 195 in section 34 a thin coal bed was found locally to be slightly more than 2 feet thick. This bed is approximately 235 feet above

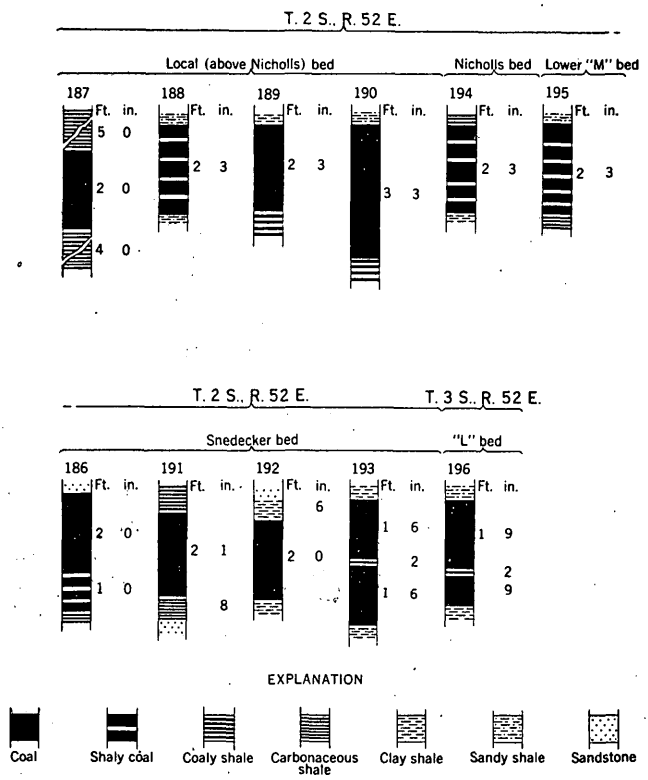

FIGURE 11.—Sections of coal beds in T. 2 S., R. 52 E., and in T. 3 S., R. 52 E., Montana.

the horizon of the Nicholls bed and is correlated tentatively with the Carter bed in the Mizpah coal field.

Where exposed in the townships to the east and the south, the rocks that underlie the Snedecker bed do not contain coal beds sufficiently thick to indicate that important reserves are contained in these rocks beneath the surface of this township.

T. 3 S., R. 52. E

[Figure 11]

This township is drained by intermittent tributaries of the Powder River, which itself follows a meandering northeasterly course, marked by cottonwood trees, willows, and brush, in an open, flat-bottomed, grass-covered, alluviated valley roughly 1½ miles wide. Only the extreme northwest corner of the township is beyond the Mizpah Creek-Powder River divide, from which southeastward-flowing tributary streams and ridges slope steeply toward the valley of the Powder River, forming the breaks northwest of the river. The maximum relief is about 400 feet. The larger tributary streams southeast of the river, of which the principal one is Poker Jim Creek, follow entrenched meander channels in the alluviated bottoms of open valleys. Ridges between these valleys, near the river, rise sharply to steep divides, with the maximum relief about 250 feet.

The rocks exposed at the surface comprise about 385 feet of somber to buff or green sandstone, siltstone, shale, and thin coal beds, which is included in the

lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field to the north. Lenticular beds of cross-bedded buff to green sandstone in the lower part here are grouped with the lower member of the Fort Union but may be equivalent to part of the underlying sandstone member of the Lance formation mapped in the Mizpah coal field.

"L" bed.—Several thin coal beds were examined, but they were found to be less than 2 feet thick everywhere in the township except at locality 196 in section 9, where a bed 2 feet 8 inches thick (including a 2-inch shale parting) was measured. This bed is correlated tentatively with the Snedecker bed in townships to the north and in the Mizpah coal field.

Where exposed in townships to the east and northeast, the rocks that underlie those exposed in this township do not contain coal beds sufficiently thick to indicate that any coal reserves are contained in these rocks beneath the surface of this township.

T. 1 S., R. 53 E.

[Plate 11]

This township is drained by intermittent tributaries of the Powder River, which itself follows a northeasterly course across the southeast quarter of the township, marked by cottonwood trees and brush, in an open, flat-bottomed, grass-covered, alluviated valley roughly 1½ miles wide. Only the northeast corner of the township, in sections 6 and 7 at the head of Corral Creek, is beyond the Mizpah Creek-Powder River divide in a brush- and grass-covered area of low relief. From the divide, tributary streams and ridges slope steeply southeastward toward the valley of the Powder River, forming the breaks northwest of the river. The maximum relief is about 450 feet. Southeast of the river, particularly in sections 34 and 35, the ground rises very steeply to the top of a bluff about 250 feet above the river. Eastward from the edge of the bluff the ground slopes more gently to Crow Creek, a tributary of the Powder River at the east edge of the township, in sections 25 and 36.

The rocks exposed at the surface comprise about 575 feet of somber to buff or green sandstone, siltstone, shale, clay, and thin coal beds, of which the upper 375 feet, overlying the Nicholls bed or an equivalent horizon, is included in the lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field immediately to the north. These beds are dominantly somber in the upper part and dominantly buff or green in the lower part, where thick, cross-bedded sandstone lenses are common, interbedded with gray and brown carbonaceous shale beds. The remaining 200 feet, approximately, below the lower member of the Fort Union comprises gray, brown, and green clay, shale, siltstone, and buff or green cross-bedded sandstone, which is correlated in part with the sandstone member of the Lance formation mapped in the Mizpah coal field.

Nicholls bed.—The lowermost coal bed that crops out in the township is one that ranges in thickness from less than 2 feet to about 3 feet of coal or shaly coal. This bed is correlated with the Nicholls bed in the Mizpah coal field immediately to the north. It was mapped as the basal bed of the lower member and is between 2 and 3 feet thick at localities 198, 205, 206, 214, 215, 216, and 217.

Local bed below Snedecker.—At localities 197 and 199 in section 4 a local bed about 50 feet below the Snedecker bed was found to contain 2 feet 6 inches of weathered coal and 2 feet 1 inch of coal, respectively. This bed may be equivalent to a local bed found about 45 feet below the Snedecker bed in the township adjoining on the west.

Snedecker bed.—The Snedecker bed, about 170 feet above the base of the Nicholls bed, extends southward from the Mizpah coal field. At localities 200, 201, 202, 203, 208, 209, 211, 212, and 213 it was found to range in thickness from less than 2 feet to a maximum of 6 feet. Locally the coal in this bed is good, but commonly it contains one or several shale partings. This bed may be equivalent to the Moths bed in a township farther west.

Carter bed.—A thin bed about 55 feet above the base of the Snedecker bed is correlated with the Carter bed in adjoining parts of the Mizpah coal field. This bed ranges in thickness from less than 2 feet to a maximum of about 3 feet, including shale partings, at localities 204, 207, and 210. There is no higher coal bed between the Carter bed and the top of the ridge.

It is probable that there are no significant coal beds below the Nicholls bed.

T. 2 S., R. 53 E.

[Figure 12]

This township is drained by intermittent tributaries of the Powder River, which itself follows a northerly course just east of the west edge and then crosses diagonally the northwest quarter of the township. The course of the Powder River is marked by cottonwood trees and brush in an open, flat-bottomed, grass-covered, alluviated valley roughly 1½ miles wide. Crow Creek, the largest tributary, flows northward near the east edge and drains the east third of the

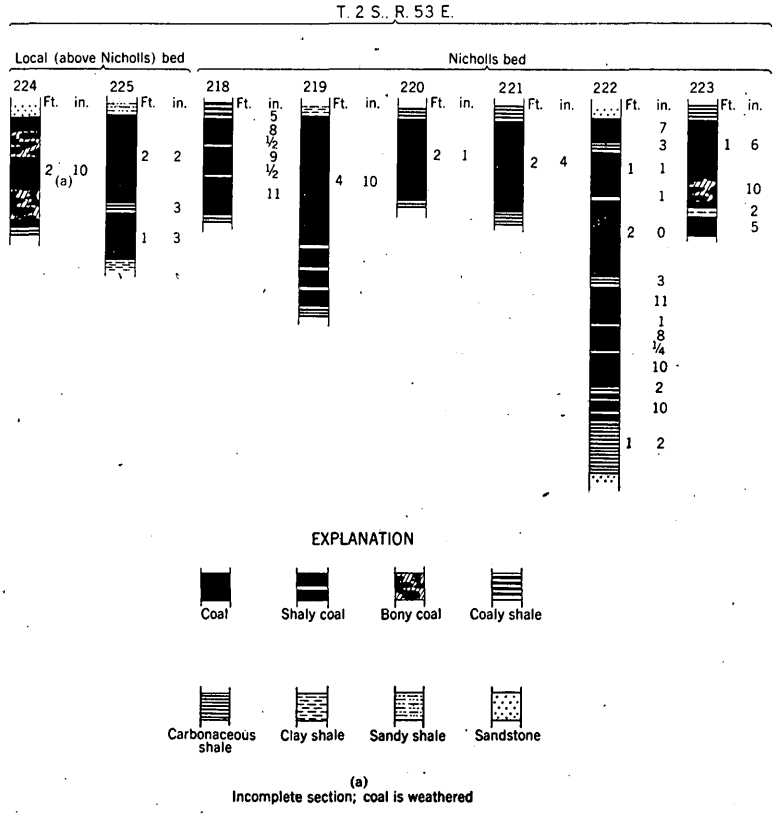

FIGURE 12.—Sections of coal beds in T. 2 S., R. 53 E., Montana.

township. The principal tributary streams follow entrenched meander channels in the alluviated bottoms of open valleys. Slopes are brush- and grass-covered and are gentle except in the smaller tributary stream valleys. The maximum relief is about 450 feet.

The rocks exposed at the surface comprise about 390 feet of somber to buff or green sandstone, siltstone, shale, clay, and thin coal beds, of which the upper 225 feet, with the Nicholls bed or an equivalent horizon near the base, is included in the lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field. The lower 165 feet, approximately, contains no coal beds and relatively few thin carbonaceous shale beds, but it does contain some green shale and green to buff cross-bedded sandstone beds and is correlated with the sandstone member of the Lance formation mapped in the Mizpah coal field.

Nicholls bed.—The lowermost coal bed that crops out in the township is one that is correlated with the Nicholls bed in the Mizpah coal field. It lies near the base of the lower member, and, where the base could not be determined from other stratigraphic data, it was mapped as the basal bed. It is entirely absent in many places and is not uniform in quality or thickness along the line of outcrop. It was found to exceed 2 feet at localities 218, 219, 220, 221, 222, and 223, with a maximum thickness (including partings) of nearly 8 feet of coal and shaly coal at locality 222.

Local bed above Nicholls.—In section 34 a thin coal bed, locally more than 2 feet thick, at localities 224 and 225 contains 2 feet 10 inches of weathered coal and 3 feet 8 inches (including a 3-inch shale parting) of coal, respectively. This bed is approximately 40 feet above the Nicholls bed and is the only other bed in the township found to be as much as 2 feet thick.

It is probable that there are no significant coal beds below the Nicholls bed.

T. 3 S., R. 53 E.

[Plate 12]

This township is drained by northwestward-flowing intermittent tributaries of the Powder River, of which the principal ones are Poker Jim Creek and the south and north forks of Horse Creek. The divide separating the heads of these creeks from eastward-flowing intermittent tributaries of Crow Creek is close to the east edge of the township. The larger tributaries follow entrenched meander channels in the partly alluviated bottoms of open valleys whose sides rise in gentle, grass- and brush-covered slopes to divides that are generally rounded but in some places are sharp. The stream gradients of the tributaries of Crow Creek are steep, and the terrain at the heads of their valleys, especially in sections 1 and 12, is very rough. The maximum relief is about 350 feet.

The rocks exposed at the surface comprise about 370 feet of somber to buff or green sandstone, siltstone, shale, clay, and thin coal beds, of which the upper 245 feet, with the Nicholls beds or an equivalent horizon near the base, is included in the lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field. The remaining 125 feet, approximately, contains no coal beds and relatively few thin carbonaceous shale beds, but it does contain some green shale and green to buff cross-bedded sandstone beds and is correlated with the sandstone member of the Lance formation mapped in the Mizpah coal field.

Local bed below Nicholls.—The lowermost coal bed that crops out in the township is a local one, 3 feet 2 inches thick where measured at locality 253 in section 14, about 35 feet below the bed that here is correlated with the Nicholls bed.

Nicholls bed.—The lowermost coal bed—other than the local bed just referred to—is one that is correlated with the Nicholls bed in the Mizpah coal field. It lies near the base of the lower member of the Fort Union formation but is entirely absent in many places and is not uniform in quality or thickness along the line of outcrop. It was found to exceed 2 feet in the northeast quarter of the township at localities 228, 235, 238, 241, 249, and 252, where it ranges in thickness from nearly 6 feet of good coal at locality 238 to about 2 feet 5 inches of shaly coal at locality 252.

Local beds above Nicholls.—In the northeast quarter of the township a thin bed of coal and shaly coal was found about 40 feet above the one that here is correlated with the Nicholls bed. In many outcrops it is less than 2 feet thick, but at localities 227, 229, 230, 233, 234, 237, 240, 243, 246, 247, 248, 254, 255, 256, and 257 it ranges in thickness from 5 feet of coal and shaly coal at locality 227 to a minimum of 2 feet of shaly coal. The coal in this bed is shaly except in parts of sections 1, 11, 12, and 15.

In the northeast quarter of the township a thin bed of coal and shaly coal, the highest mappable bed in the township, was found about 100 feet above the one that here is correlated with the Nicholls bed. This bed may be equivalent to the local bed found about 50 feet below the Snedecker bed in some townships farther north. In many outcrops it is less than 2 feet thick, but at localities 226, 231, 232, 236, 240, 242, 245, 250, 251, 258, and 259 it ranges in thickness from 6 feet of coal at locality 231 to a minimum of 2 feet 1 inch of shaly coal at locality 251. The coal is thin and shaly except in small parts of sections 11 and 12. The bed exposed at locality 259 in section 31 thins within a short distance along the line of outcrop.

It is probable that there are no significant coal beds below the Nicholls bed.

A small lenticular bed of bentonitic clay or bentonite is exposed in section 7, on a ridge southeast of the Broadus-Powderville road, at an elevation of approximately 250 feet above the river. It has a maximum measured thickness here of 18 feet 9 inches. This bentonitic clay bed is about 150 feet above the base of the lower member. Farther southeast along the ridge, in sections 7, 17, 18, and 20, a thinner, poorer bed was found at approximately the same horizon.

T. 1 S., R. 54 (AND 54½) E.

This township (together with the fractional township) is drained by intermittent tributaries of the Powder River, which itself follows a northeasterly course across the northwest quarter of the township, marked by cottonwood trees and brush, in an open, flat-bottomed, grass-covered, alluviated valley roughly 1½ miles wide. In addition to Crow Creek, which joins the Powder River near the west edge of the township, the principal tributaries are Timber Creek and Stump Creek. These tributary creeks follow entrenched meander channels in the alluviated bottoms of broad, open valleys sparsely covered with brush and grass. Smaller tributaries drain slopes that in general are gentle but upon which small buttes and ridges, formed of resistant sandstone beds, stand out prominently. The ridge northeast of Stump Creek, in the northeast corner of the township, rises with steep slopes well above the surrounding terrain. The maximum relief is about 325 feet.

The rocks exposed at the surface comprise more than 350 feet of somber to buff or green sandstone, siltstone, shale, clay, and thin coal beds, of which the upper 120 feet, approximately, containing thin coal beds, is included in the lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field. The remaining rocks, which contain no coal

beds and relatively few thin carbonaceous shale beds but do contain some green shale and green to buff cross-bedded sandstone beds, are correlated with the sandstone member of the Lance formation mapped in the Mizpah coal field. Rocks of the lower member of the Fort Union formation are present only in the upper part of the high ridge northeast of Stump Creek, in the northeast corner of the township.

No coal beds as much as 2 feet thick are exposed in this township, and it is probable that there are no significant coal beds in the strata that underlie those exposed at the surface.

T. 2 S., R. 54 E.

[Figure 13]

This township is drained by intermittent northwestward-flowing Crow Creek, Timber Creek, and their tributaries. The principal streams follow entrenched meander channels in the alluviated bottoms of broad, open valleys sparsely covered with brush and grass. Smaller tributaries drain slopes that are moderately dissected and upon which small buttes and ridges, formed of resistant sandstone beds, stand out prominently. Scattered pine trees grow on the tops of some of these prominences. The maximum relief is about 275 feet.

The rocks exposed at the surface comprise more than 275 feet of somber to buff or green sandstone, siltstone, shale, clay, and thin coal beds, of which the upper 100 feet, approximately containing one or more thin coal beds, is included in the lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field. The remaining rocks, which contain no coal beds and relatively few thin carbonaceous shale beds but do contain some green shale and green to buff cross-bedded sandstone beds, are correlated with the sandstone member of the Lance formation mapped in the Mizpah coal field. Rocks of the lower member of the Fort Union are present, capping buttes or ridges, only in small areas centering in sections 7, 8, 13, 28, and 31.

Nicholls bed.—The lowermost coal bed, which is the only one that crops out in the township, is correlated with the Nicholls bed in the Mizpah coal field. It lies near the base of the lower member of the Fort Union formation, but is absent in

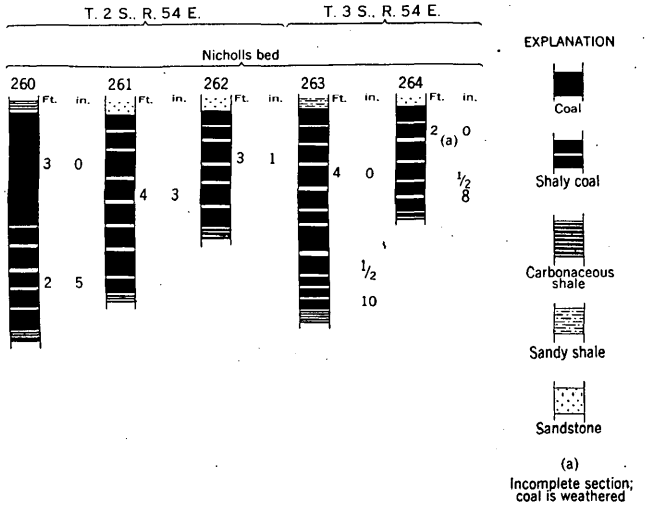

FIGURE 13.—Sections of coal bed in T. 2 S., R. 54 E., and in T. 3 S., R. 54 E., Montana

some places and is not uniform in quality or thickness along the line of outcrop. It was found to exceed 2 feet at locality 260, where it is exposed on a steep flank of a prominent butte in section 8, and at localities 261 and 262, where it is exposed on the sides of smaller buttes in section 31. At these localities it ranges in thickness from 3 feet 1 inch of shaly coal to 5 feet 5 inches of shaly coal and coal. Locally the bed has burned, producing clinker that can be seen from a distance (pl. 3B). Clinker also caps a small butte in the southwest corner of section 28.

It is probable that there are no significant coal beds below the Nicholls bed.

T. 3 S., R. 54 E.

[Figure 13]

Almost the entire township is drained by intermittent tributaries of Crow Creek, which follows a northwesterly course diagonally across the township in a meander channel entrenched in the alluviated bottom of a broad, open valley sparsely covered with grass and brush. Tributaries drain slopes that in general are gentle but upon which small buttes and ridges, formed of resistant sandstone beds, stand out prominently (pl. 3A). Northeast of the drainage divide, the heads of tributaries of Timber Creek have steep gradients, and the surface they drain, in sections 1, 2, 11, and 12, is sharply dissected. Similarly, gradients are steep and the surface sharply dissected in the southern part of the west edge of the townships in sections 18, 19, 30, and 31. The maximum relief is about 375 feet.

The rocks exposed at the surface comprise more than 275 feet of somber to buff or green sandstone, siltstone, shale, clay, and thin coal beds, of which the upper 160 feet, approximately, containing several thin coal beds, is included in the lower member of the Fort Union formation and correlated with the "Somber beds" mapped in the Mizpah coal field. The remaining rocks, which contain no coal beds and relatively few thin carbonaceous shale beds but do contain some green shale and green to buff cross-bedded sandstone beds, are correlated with the sandstone member of the Lance formation mapped in the Mizpah coal field. Rocks of the lower member are present only in the western part of the township.

Nicholls bed.—The lowermost and only mappable coal bed that crops out in the township is one in the western part of the township that is correlated with the Nicholls bed in the Mizpah coal field. It lies near the base of the lower member of the Fort Union formation, but it is absent in some places and is not uniform in quality or thickness along the line of outcrop. In section 18 it was found to exceed 2 feet at localities 263 and 264, where it contains 4 feet 10 inches and 2 feet 8 inches, respectively, of shaly coal.

It is probable that there are no significant coal beds below the Nicholls bed.

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