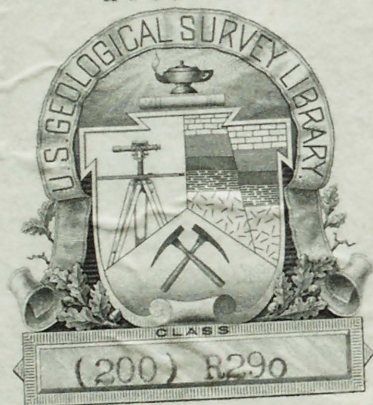


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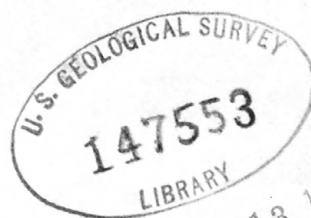


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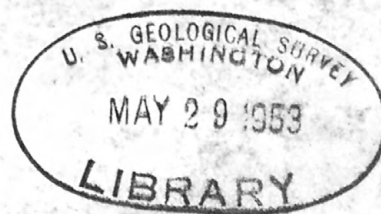
UNITED STATES DEPARTMENT OF INTERIOR

GEOLOGICAL SURVEY

THE SPOTTED HORSE COAL FIELD, SHERIDAN AND CAMPBELL COUNTIES

WYOMING

OPEN FILE



U. S. Geological Survey
OPEN FILE REPORT

This report ~~(or plate)~~ is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.

by
Wilde Williamson Olive
June, 1953

From **FUELS BRANCH**
1314 Interior (Zeigen)

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ACKNOWLEDGMENT

The writer wishes to express his appreciation for the help given by many people in many ways. W. C. Pierce and L. S. Gardner of the U. S. Geological Survey directed the work, and R. P. Bryson of the U. S. Geological Survey organized the party at the start of the 1948 field season. Dr. Grover E. Murray, Chairman of the Department of Geology and professor of stratigraphy at Louisiana State University, made many suggestions which were helpful in the preparation of the report. The ranchers, farmers, and merchants of the Spotted Horse area were very helpful and cooperative in providing camp sites, information, and other valuable assistance to the writer and his associates.

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ABSTRACT

The Spotted Horse coal field comprises about 720 square miles of rugged terrain in Sheridan and Campbell Counties, northeastern Wyoming. Two dissected erosion surfaces, which are held up by resistant strata, are present in the area. The higher surface is preserved at altitudes of 4,450 to 4,660 feet; and the lower surface, at altitudes of 4,000 to 4,250 feet.

The rocks exposed in the area are of continental origin and range in age from Paleocene to Recent. The coal-bearing rocks belong to the Tongue River member of the Fort Union formation (Paleocene) and to the Wasatch formation (Eocene). The propriety of the term Wasatch as used in northern Powder River Basin has been questioned by some geologists, but as used in the Spotted Horse field the term is clarified and is retained to conform with widespread and long accepted usage.

The Tongue River member, which consists of sandstone, shale, and coal beds, surfaces about two-thirds of the area and comprises about 900 feet of the exposed stratigraphic section. The member is conformably overlain by the Wasatch formation in the northern part of the field, but elsewhere the upper beds of the Tongue River member were probably removed by pre-Wasatch erosion. The thickness of removed rocks increases southward from the vicinity of Spotted Horse.

The Wasatch formation, which is similar in lithology to the Tongue River member, covers large areas in the western and southern parts of the field and caps many divides in the north-central part. Although

the formation is thickest, about 700 feet, in the western part of the area, the youngest beds occur in the southern part where the Wasatch is 410 to 600 feet thick.

Pleistocene? deposits of sand and gravel cover small areas at different levels above the Powder River and Clear Creek. Recent deposits surface the floors of the main valleys.

The prevalent dip of the strata is less than 3 degrees southwestward. A belt of southwesterly plunging folds trends about N 25° E across the northern part of the coal field. In other parts smaller folds trend parallel to this belt of low flexures, and other small folds trend about N 45° W.

Faults are concentrated in three main areas-- (1) the southern part of the main belt of folds, (2) the northern end of this same belt where it merges into a syncline across the northern row of townships, and (3) in parts of Tps. 54 N., Rs. 74 and 75 W. All are normal except one which is reverse. Displacements range from about 20 to 300 feet. Most of the faults trend either northeastward or eastward and are as much as 3½ miles long.

Two deep wells drilled in the area failed to encounter commercial quantities of oil. Coal beds ranging in thickness from 2½ to about 40 feet contain an estimated 12,060,200,000 short tons of subbituminous and lignite coal. Construction material consisting of clinker, sandstone, shale, gravel, and sand occur in many parts of the coal field.

INTRODUCTION

Purpose and scope of the report.--The investigation of the Spotted Horse coal field was undertaken by the U. S. Geological Survey as a part of the Department of the Interior program for the development of the Missouri River Basin. The site of the proposed Moorhead dam on the Powder River is three miles from the north boundary of the Spotted Horse field, and the proposed reservoir will extend several miles southward up the Powder River and tributary valleys. The objectives of the investigation were to map the geology and structure of the proposed reservoir area, and to determine the mineral resources and geologic features of the adjacent area for use in the classification and administration of public lands. The area contains many important coal beds, and much of the field work consisted of mapping their outcrops and measuring their thicknesses in order to determine the reserves of coal.

Location of the area.--The Spotted Horse coal field comprises about 720 square miles of Sheridan and Campbell Counties in northeastern Wyoming adjacent to the Montana-Wyoming state line. The field is named from Spotted Horse, a post office and general store, near the head of Spotted Horse Creek. The boundaries of the coal field are the limits of previously mapped adjacent fields. The Moorhead coal field¹ is to the north, the Sheridan and Powder River to the west, the Powder River to the south, and the Little Powder River to the east. Figure 1 shows the areas included in each of these fields as well as other coal fields in northeastern Wyoming, eastern Montana, and western South Dakota and North Dakota.

¹Geologic map in the files of the U. S. Geological Survey.

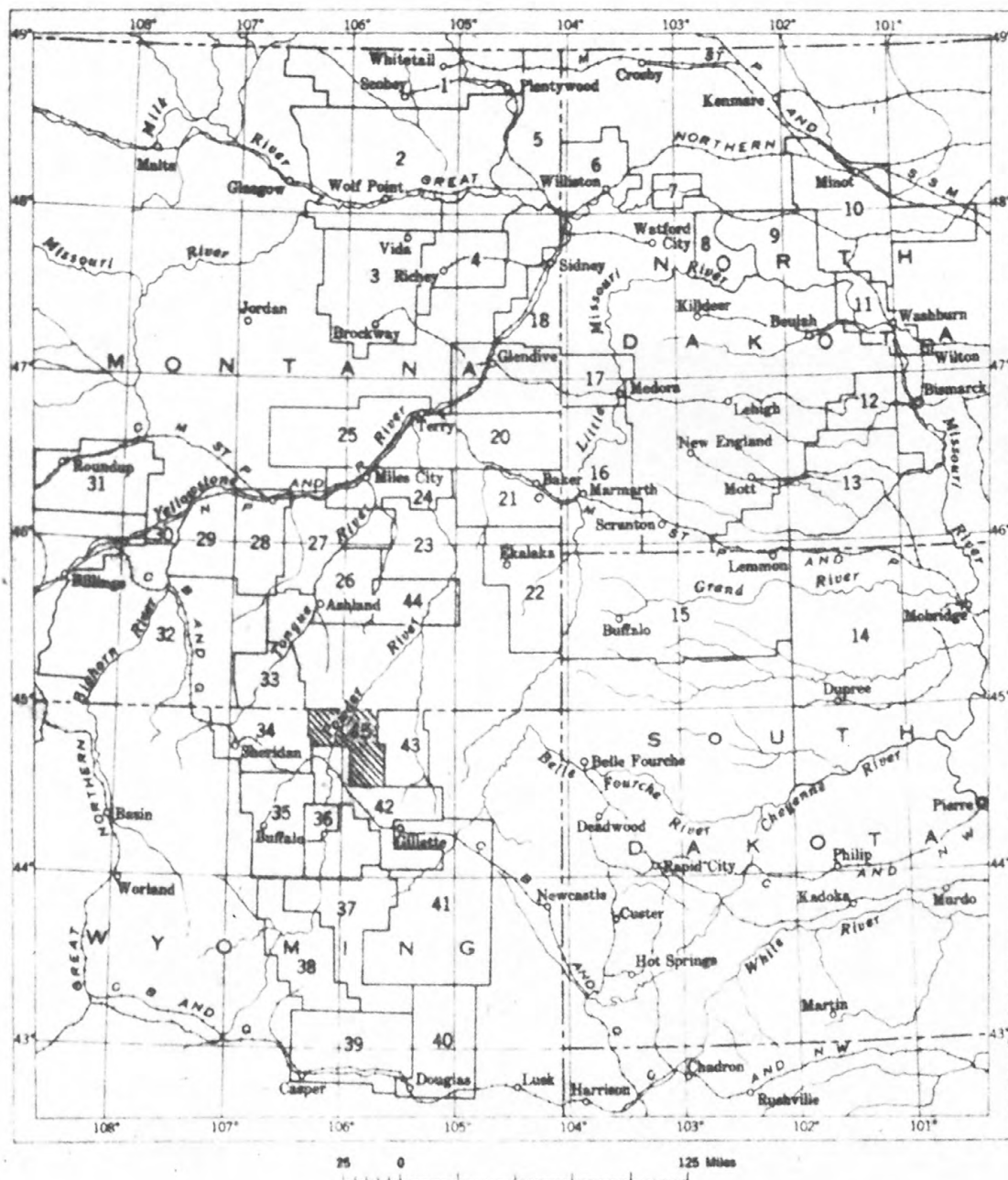


Figure 1.--Index map showing the location of the Spotted Horse coal field, Montana, and of other coal fields in northeastern Wyoming and adjacent parts of Montana, South Dakota, and North Dakota described in bulletins of the U. S. Geological Survey.

No.	Field or area	U. S. Geol. Survey Bull.	Author	Date of Publication
1.	Scobey	751-E	Collier, A. J.	1924
2.	Fort Peck	381-A	Smith, C. D.	1910
3.	McCone County	905	Collier, A. J. and M. H. Knechtel	1939
4.	Richey-Lambert	847-C	Parker, F. S.	1936
5.	Culbertson	471-D	Beekly, A. L.	1912
6.	Williston	531-E	Herald, F. A.	1913
7.	Messon Anticline	691-G	Collier, A. J.	1918
8.	Fort Berthold	726-D	Bauer, C. M. and F. A. Herald	1922
9.	Fort Berthold	381-A 471-C	Smith, C. D. Pishel, H. A.	1910 1912
10.	Minot	906-B	Andrews, D. A.	1939
11.	Washburn	381-A	Smith, D. C.	1910
12.	New Salem	726-A	Hancock, E. T.	1921
13.	Cannonball River	541-G	Lloyd, L. R.	1914
14.	Standing Rock and Cheyenne Reservations	575	Calvert, W. R., and others	1914
15.	Northwestern South Dakota	627	Winchester, D. E., and others	1916
16.	Marmarth	775	Hares, C. J.	1928
17.	Sentinel Butte	341-A	Leonard, A. G. and C. D. Smith	1909
18.	Sidney	471-D	Stebinger, Eugene	1912
19.	Glendive	471-D	Hance, J. H.	1912
20.	Terry	471-D	Herald, F. A.	1912
21.	Baker	471-D	Bowen, C. F.	1912
22.	Ekalaka	751-F	Bauer, C. M.	1924
23.	Hizpah	906-C	Parker, F. S., and D. A. Andrews	1939
24.	Miles City	341-A	Collier, A. J. and C. D. Smith	1909
25.	Little Sheep Mountain	531-F	Rogers, G. S.	1913
26.	Ashland	831-B	Bass, N. W.	1932
27.	Rosebud	847-B	Pierce, W. G.	1936
28.	Forsyth	812-A	Dobbin, C. E.	1930
29.	Tullock Creek	749	Rogers, G. S., and Wallace Lee	1923
30.	Southwest of Custer	541-H	Rogers, G. S.	1914
31.	Bull Mountain	647	Woolsey, L. R., and others	1917
32.	Big Horn County	856	Thom, W. T., Jr., and others	1935

*Compiled and edited by E. R. Lloyd

No.	Field or area	U. S. Geol. Survey Bull.	Author	Date of Publication
33.	Northward extension of Sheridan	806-B	Baker, A. A.	1929
34.	Sheridan	341-B	Taff, J. A.	1909
35.	Buffalo	381-B	Gale, H. S. and C. H. Wegemann	1910
36.	Barber	531-I	Wegemann, C. H.	1913
37.	Pumpkin Buttes	806-A	Wegemann, C. H., and others	1928
38.	Sussex	471-F	Wegemann, C. H.	1912
39.	Glenrock	341-B	Shaw, E. W.	1909
40.	Lost Spring	471-F	Winchester, D. E.	1912
41.	Gillette	796-A*	Dobbin, C. E., and V. H. Barnett	1927
42.	Powder River	381-B	Stone, R. W., and C. T. Lupton	1910
43.	Little Powder River	471-A	Davis, J. A.	1912
44.	Coalwood	973-B	Bryson, R. P.	1952
45.	Spotted Horse	(This Report)	Olive, W. W.	(in press)

* With a chapter on the Minturn district and the northwestern part of the Gillette field by W. T. Thom, Jr.

Field work.--Field work for this report was done during the summers of 1948 and 1949. The writer was assisted by J. F. Cronin, W. D. Johnson, Jr., J. C. McLachlan, and C. E. Person in 1948; and by W. J. Hail and A. A. Meyerhoff in 1949. Johnson aided in compiling information and data during the winter of 1948-1949.

Each member of the field party was assigned a township to map, and upon completing one township he was assigned another until all were mapped. Transportation to most parts of the area was by means of automobiles with two- and four-wheel drive. Access to several, small, rugged areas was gained on foot. Geologic contacts, outcrops of coal beds with thicknesses of two feet or more, clinker, drainage, and culture were drawn on aerial photographs with a scale of approximately 1:29,000. The outcrops of the coal beds were cleared or dug out by shoveling (Fig. 2), at 1,572 localities spaced at intervals of one-half to one mile, and the thickness and lithologic composition of the beds determined. Information recorded on the photographs was transferred by means of a sketchmaster to a base map, compiled from General Land Office township plates, on a scale of 1:31,680. The small number of section corners located in townships which were surveyed in 1883 were inadequate for control, and the base and geologic map for these townships was compiled by means of a radial line method.²

²T. P. Pendleton, "Map Compilation From Aerial Photographs," U. S. Geol. Survey Bull. 788-F (1928), pp. 409-416.



Figure 2. METHOD OF CLEARING POORLY EXPOSED COAL BED

Anderson coal bed at locality 762 in sec. 29, T. 57 N., R. 7 $\frac{1}{2}$ W.



Figure 3. VIEW OF HORSE CREEK BUTTE FROM U. S. HIGHWAY 14 AND 16
IN SEC. 14, T. 54 N., R. 7 $\frac{1}{2}$ W.

The butte is capped with clinker formed by the burning of the Ulm No. 2 coal bed. The Felix coal bed crops out near the base of the butte.

Land Surveys.--All of the land within the Spotted Horse coal field has been subdivided by surveys of the United States General Land Office (now part of the Bureau of Land Management). About 45 percent of the area was surveyed in 1883, and few of the stone markers could be found. The township and section lines for these old surveys are shown on the accompanying geologic maps (Plates I and II) by dashed lines to indicate that their location is uncertain. The remainder of the area was surveyed after 1912, and iron pins capped with bronze plates mark the section corners.

Previous geologic work.--No detailed geologic study of the area has been made previous to this investigation, but the general geologic features have been known from early reconnaissance work in the region, and from studies in adjoining coal fields. As early as 1804 and 1806 members of the Lewis and Clark Expedition³ observed coal beds in the bluffs of the Yellowstone River near the mouth of the Tongue River, and further downstream they noted "burnt hills" (clinker formed by the burning of coal beds). In 1859 and 1860 Dr. F. V. Hayden, a member of Captain W. F. Reynolds' expedition to explore the Yellowstone River and its tributaries for the United States War Department, described the geology of

³Paul Allen, History of The Expedition Under The Command of Captains Lewis and Clark to The Sources of The Missouri, Thence Across The Rocky Mountains and Down The River Columbia to The Pacific Ocean; Performed During The Years 1804, 1805, and 1806 by Order of The Government of The United States (Philadelphia, Bradford and Inskeep, 1814), II, pp. 391-393.

the country covered.⁴ A report by W. H. Darton⁵ on the geology and underground water resources of the general region was published in 1902. A map by W. G. Pierce and R. M. Girard⁶ published in 1945 shows the broad structural features of the region. R. W. Brown⁷ presented a map in 1949 showing Paleocene deposits of the Rocky Mountains and plains which includes the area discussed in this report. A geologic map of the Powder River Basin, compiled by J. D. Love and J. L. Weitz⁸ is useful in depicting the regional geology. The Wasatch-Fort Union contact in the Spotted Horse field as shown on this map was determined from the present investigation; however, the location of the contact is revised in this report.

⁴F. V. Hayden, Geological Report of The Exploration of The Yellowstone and Missouri Rivers, Under The Direction of W. F. Reynolds, 1859-1860 (U. S. Engineer Dept., 1869), pp. 1-174.

⁵W. H. Darton, "Preliminary Report on The Geology and Underground Water Resources of The Central Great Plains," U. S. Geol. Survey Prof. Paper 32 (1905), pp. 21-413.

⁶W. G. Pierce and R. M. Girard, "Structure Contour Map of The Powder River Basin, Wyoming and Montana," U. S. Geol. Survey Oil and Gas Investigation Preliminary Map No. 33 (1945).

⁷R. W. Brown, "Map Showing Paleocene Deposits of The Rocky Mountains and Plains," U. S. Geol. Survey Preliminary Map (1949).

⁸J. D. Love and J. L. Weitz, "Geologic Map of The Powder River Basin and Adjacent Areas, Wyoming," U. S. Geol. Survey Oil and Gas Investigation Map OM 122 (1951).

GEOGRAPHY

Land features.--The Spotted Horse coal field is in the Great Plains physiographic province, midway between the Black Hills and the Big Horn Mountains. The topography is characterized by flat-topped buttes, long narrow flat-topped divides, and steep valley walls that rise 100 to 600 feet above valley bottoms. Thick sandstone units and clinker cap most of the high surfaces. The highest altitudes, ranging from about 4,625 to 4,660 feet above sea level, were noted along the Powder River-Little Powder River Divide in the southwestern part of T. 53 N., R. 74 W. (Plate I) and at the top of Horse Creek Butte (Figure 3), sec. 23, T. 54 N., R. 74 W., which is one of the most prominent features in the coal field. The lowest elevation is 3,395 feet where the Powder River crosses the state line into Montana (Plate II).

The flood plain of the Powder River, which has an average width of about one-half mile, follows a sinuous, northeasterly trending course across the north-central part of the coal field. Steep slopes generally rise 100 to 600 feet above the valley floor, although north of Big Remington Creek and Gray Cabin Draw the slopes are interrupted by a series of benches which have been formed on resistant clinker. A picturesque description of this part of the area is given by Captain W. F. Reynolds,⁹ who in 1859 explored the Powder River as far north as Clear

⁹W. F. Reynolds, "The Report of Brevet Brigadier Colonel W. F. Reynolds, U.S.A. Corps of Engineers, on the exploration of The Yellowstone and The Country Drained by That River, 1859-1860," U. S. 40th Cong., 2d Sess., S. Ex. Doc. 77 (1869), p. 36.

Creek (then known as Clear Fork). In describing his observations near the point of juncture of the two streams he wrote:

"Tuesday, July 26 (1859).---The landscape before us was wide in extent, but characterized by forbidding desolation. The valleys of the Powder and its branch were marked by narrow and sinuous belts of green, but these, with here and there a solitary pine of stunted growth, constituted all the verdure that relieved the monotony of barrenness. Naked brown hills rose up on all sides, broken into irregular peaks, and with their sides torn into deep and impassable gullies by the mountain torrents--a petrified representation of an angry sea in all the fury of a storm."

Badland topography occurs south and west of U. S. Highway 14 and 16 (Plate II) where the maximum local relief is about 450 feet. Streams and gulches have steep, barren walls to within a few hundred feet of their heads. Sinuous lines of cottonwoods grow along valley bottoms; sparse stands of pine grow on a few clinker-covered hills; and an occasional, lone straggling juniper grows near the top of a butte or divide. The rugged topography, the barren terrain, and drab-brown soil combine to give this area an appearance of desolation.

The flood plain of Clear Creek, about three-eighths of a mile wide, trends northeasterly across T. 56 N., R. 77 W. to join the Powder River flood plain in sec. 31, T. 57 N., R. 76 W. (Plate II). Except for its smaller size Clear Creek Valley closely resembles the valley of the Powder River for it is bordered by slopes of comparable height and steepness. The divide between the two streams is high and narrow in the southern part of T. 56 N., R. 77 W., but northeastward from sec. 23 it descends gradually to merge into the flood plains in sec. 31, T. 57 N., R. 76 W.

Most tributaries to the Powder River and Clear Creek occupy straight, narrow, deep valleys. The valleys east of the Powder River

are generally longer than those to the west. The valley of Spotted Horse Creek, east of the river, is about 25 miles long, the longest tributary completely contained within the area. From the Powder River to about one mile northwest of Spotted Horse the valley is bordered by steep slopes rising 300 to 600 feet above the bottom. South of Spotted Horse the valley forks into several narrow channels which head on the higher slopes to the east and south and extend for short distances across a gently undulating surface. Buffalo Creek, which is the largest tributary to Powder River from the west, flows across about 15 miles of the area and joins Clear Creek in sec. 21, T. 56 N., R. 77 W.

Most of the tributary valleys trend northwesterly, roughly at right angles to the Powder River and Clear Creek. The valleys of Buffalo and Fence Creeks trend easterly and are notable exceptions to this directional alignment.

Two well-defined erosion surfaces, held up by resistant strata, and much dissected by stream erosion of the present cycle, are present in the area. Owing to the prevailing southwesterly dip of the strata the surfaces bevel younger rocks southwestward. The higher surface, which ranges in altitude from 4,450 to 4,660 feet occurs on high buttes and divides in the area south and west of U. S. Highway 14 and 16 (Plate I). Large areas are preserved on the Powder River-Little Powder River Divide in T. 53 N., R. 74 W., and in the southern part of T. 53 N., R. 75 W.; and smaller areas remain on a few high clinker-capped buttes in Tps. 54 N., Rs. 74 and 75 W. Much of this surface is underlain by the resistant clinker formed from the burning of the Ulm No. 2 coal bed, but in the southwestern part of T. 53 N., R. 75 W. it is underlain by

a thick bed of sandstone that overlies the Ulm No. 2 bed.

The lower erosion surface is a gently rolling plain at elevations of 4,000 to 4,250 feet, preserved on high stream divides and flat-topped buttes in the area north and east of U. S. Highway 14 and 16. The largest remnants are on the Tongue River-Powder River Divide in the westernmost row of townships (Plate I), and on the Powder River-Little Powder River Divide in Tps. 55 N., Rs. 73 and 74 W. (Figures 4 and 5). Several sandstone-capped buttes rise 200 to 300 feet above the general level of the surface in Tps. 56 and 57 N., R. 78 W. (Plate I), and several clinker-capped buttes rise 180 to 220 feet above it in T. 55 N., R. 74 W. (Plate II), southwest of Recluse. In the north-central part of the area the surface has been destroyed by erosion except on some of the high stream divides. The lower surface is developed on clinker of the Anderson bed in Tps. 58 N., Rs. 74 and 75 W., and on beds as much as 400 feet stratigraphically higher in Tps. 56 and 57 N., R. 78 W. (Plate I). At levels above the Anderson clinker, the surface is generally held up by sandstone.

Drainage and water supply.--About three-fourths of the Spotted Horse field is in the Powder River drainage basin. Tributaries of the Little Powder River drain about 145 square miles in the southeastern part of the area, and tributaries of the Tongue River drain about 35 square miles in the northwestern corner.

The Powder River heads south of the Big Horn Mountains near the town of Powder River, Wyoming, and flows northward to join the Yellowstone River near Terry, Montana. In the area described in this report it has a meandering channel with a gradient of about 5 feet per



Figure 4. LOWER EROSION SURFACE IN THE VICINITY OF RECLUSE, WYOMING
(VIEW NORTHWARD FROM SE $\frac{1}{4}$ SEC. 13, T. 55 N., R. 7 $\frac{1}{4}$ W.)



Figure 5. LOWER EROSION SURFACE ALONG THE TONGUE RIVER-POWDER RIVER
DIVIDE (VIEW SOUTHEASTWARD FROM NW $\frac{1}{4}$ SEC. 2, T. 57 N.,
R. 78 W.)

mile. Normally it is a wide, shallow, muddy river, which at times has no surface flow. On the accompanying geologic map (Plate I) it is shown as a perennial stream north of Clear Creek, but at times the flow of Clear Creek is not sufficient to maintain a surface flow for more than a few miles below the junction of these two streams. The Powder River Valley is subject to flooding during periods of heavy rainfall, generally in spring and autumn. On September 29, 1923 a flood, remembered by older settlers as the most destructive in the history of the region, swept away homes, equipment, fences, and crops; and destroyed much livestock. This flood was estimated at 95,000 second-feet near Arvada, Wyoming.¹⁰ As the waters receded the river assumed a channel quite different from that of its earlier course.

Clear Creek heads to the west in the Big Horn Mountains and empties into the Powder River in sec. 31, T. 57 N., R. 76 W. In contrast to the turbid water of the Powder River the flow of Clear Creek is clean water which in unusually dry summers or during prolonged drouths may diminish to a mere trickle. A government gauging station near the mouth of Clear Creek recorded a minimum flow of .2 second-feet on August 16 and 17, 1940; and a maximum flow of 9,000 second-feet on June 26, 1942.¹¹ The gradient of the stream is about 6½ feet per mile.

Other streams in the area of this report flow only for short periods

¹⁰ Robert Follansbee and P. V. Hodges, "Some Floods in the Rocky Mountain Region," U. S. Geol. Survey Water Supply Paper 520-G (1925), pp. 119-120.

¹¹ C. G. Paulsen and others, "Surface Water Supply of The United States, 1947, Part 6. Missouri River Basin," U. S. Geol. Survey Water Supply Paper 1086 (1950), p. 246.

after summer rains and during wet seasons. Seepage beneath small, earth, reservoir dams along stream channels usually is sufficient to flow for short distances below the dams. Torrential downpours of summer thunder storms sometimes produce local floods in tributary valleys; however, as the valleys are small and the population sparse, the damage generally is not great.

Springs in many of the valleys flow from beds of carbonaceous shale beneath the coal beds, but high alkali content renders most of their waters unfit for domestic use. Potable water generally comes from wells, cisterns and from drilled wells which range in depth from 100 to 600 feet. A few artesian wells are located along the Powder River and east of the Powder River-Little Powder River Divide south of Recluse. The artesian flows generally are accompanied by natural gas. Most of the drilled wells are pumped by windmills, but several are pumped by gasoline motors. The cisterns are filled with snow during the winter, and melt water from the snow is pumped up as needed.

A few hand-dug wells in the area, generally less than 50 feet deep, commonly have water, relatively free from alkali but with an unpleasant odor.

A concrete dam across Clear Creek in sec. 14, T. 56 N., R. 77 W. stores water for livestock and for irrigating hay meadows at the K Ranch of the Kendrick Cattle Company. An attempt has been made to use the silt-laden water of the Powder River to irrigate the hay meadows of the L X Bar Ranch but abrasive action of the silt soon ruined the power pump that lifted the river water into the irrigation ditches.

Climate.--The Spotted Horse area has a semi-arid climate with large annual ranges in temperature. In 1948 the low was -27 degrees on February 11, and the high was 104 degrees on August 11, as reported by the United States Weather Bureau station three miles north of Arvada, Wyoming. There were 144 days between the last frost of spring and the first frost of fall during that year. Average annual precipitation was 13.32 inches for a ten year period ending January 1, 1949. About three-fourths of the water fell during spring and autumn storms, many of which lasted for several days. Summer rainfall is characterized by local heavy thunder showers.

Timber.--Scattered stands of western pine and cottonwood comprise almost the entire timber resources of the area. North of the valleys of Seventy Six, Squaw, and Ivy Creeks most of the pine trees grow on weathered outcrops of clinker and thick beds of sandstone in the Tongue River member of the Fort Union formation; whereas, the outcrops of the overlying Wasatch formation support only a few widely spaced stands. South of these three valleys the Wasatch formation is more widespread, and pines are much less abundant.

Along the Powder River and Clear Creek flood plains, where the land has not been cleared for cultivation, fairly thick stands of cottonwood grow with interspersed small clumps of box elder, ash, and willow, and undergrowths of small shrubs and brambles. Elsewhere in the area cottonwood trees generally grow in narrow bands, rarely more than 150 feet wide, along stream channels. Junipers grow in widely spaced coppices or as lone trees on and near the tops of stream divides.

Population and routes of travel.--The Spotted Horse coal field area is sparsely populated and contains no incorporated towns. Recluse, with a

population of about 25, is the largest settlement in the area. U. S. Post Offices are located at Recluse, Spotted Horse, and Wild Cat. A saloon and a general store with post office, are the only buildings at Moorhead, Montana on the west bank of Powder River three miles north of the state line. Moorhead Dam campsite of the United States Bureau of Reclamation is about halfway between the state line and Moorhead. Arvada, population about 100, is on the banks of Powder River about 9 miles south of the area. Sheridan, about 40 miles west of the Spotted Horse field, with a population of 11,402 in 1950, and Gillette, about 17 miles to the southeast, with a population of 2,196, are the nearest commercial centers.

U. S. Highway 14 and 16, an all-weather paved road between Sheridan and Gillette, crosses the southern part of the Spotted Horse area. Several graded and clinker-surfaced county roads traverse the area, generally following the main valleys and divides. A county road, locally known as the "highline road," follows the Tongue River-Powder River Divide across the western part of the area. County roads in other parts of the area that have been named for stream valleys which they follow are the "river road," the "Bitter Creek road," and the "S A road." Unimproved and locally maintained, dirt roads from the highway and county roads follow many of the divides and valleys. The unimproved roads are usually rough and tortuous, and progress along them by automobile is very slow and difficult. Several cross Powder River and Clear Creek at fords which are passable by automobile only during low water or when the streams are frozen.

The Chicago, Burlington & Quincy Railroad follows the main valleys

of Wild Horse and Clear Creeks about three-fourths to 15 miles south of the Spotted Horse area. Croton, a small railroad maintenance station, is three-fourths of a mile southwest of T. 53 N., R. 75 E.; and Dieter, a flag stop, is $3\frac{1}{2}$ miles south of T. 56 N., R. 78 W. Good rail loading facilities are available at Arvada.

Land utilization.--Stock raising, mainly cattle, is the chief industry of the region. A few herds of sheep are grazed in the higher parts of the area. The number of cattle that can be grazed on a section of land ranges from about 20 to 35 head, depending in some cases on the amount of forage, in others, on the amount of water available. Marketable stock generally are shipped in autumn to eastern markets. A few horses are raised, mostly for local use.

Dry farming of wheat, barley, oats, and hay is practiced on the high flatlands along the major divides, and in the bottomlands bordering Powder River and Clear Creek. Grain is the chief crop in the flatlands along the divides, particularly those in the vicinity of Becluse, Wildcat, and Spotted Horse; and hay, which is used for winter feeding of livestock, is the chief crop in the valleys.

All of the industries are subject to the devastating effects of extremely dry years, and of hordes of grasshoppers which frequently plague the area. Agencies of the federal and state governments in cooperation with the landowners have instituted a program to control the spread of grasshoppers by spraying infested areas with poison.

GEOLOGY

STRATIGRAPHY

General Discussion

The rocks that crop out in the Spotted Horse coal field range in age from early Tertiary to Recent. The coal-bearing rocks are of early Tertiary age and were laid down on a broad, level plain that stood close to sea level. Sands and sandy clays were deposited in and near the channels of the many streams that meandered over this surface, and sandy clays, clays, and coal beds accumulated in the backswamp areas. This process of orderly deposition was commonly interrupted by flooding and by shifting of stream channels. Some thick layers of sand, at times, were deposited uniformly over large areas by swift currents, at other times muds were deposited. The result was a heterogenous sequence of sedimentary units which vary greatly from place to place.

Quaternary rocks consist of terrace deposits and alluvium. Small patches of Pleistocene(?) gravel at various levels above the Powder River and Clear Creek probably were deposited by streams when the valleys stood at higher levels. Alluvium of Recent age surfaces the flood plains of the main streams.

Sequence of Stratigraphic Units

The coal-bearing rocks of the Spotted Horse coal field belong to the Tongue River member of the Fort Union formation and to the Wasatch formation. The Tongue River member is defined by Thom and Dobbin¹² as consisting "of yellow or light-colored strata containing massive sandstones and numerous thick coal beds. * * * The top of the member as here defined is placed beneath bed K of the Sidney field, bed F of the Sentinel Butte field, and the Roland coal bed of the Sheridan field. The base of the member is placed beneath the light-colored, coal-bearing rocks which characteristically form a marked clinker-capped escarpment rising above lowlands or badlands developed from the somber Lobo shale."

The use of the term Wasatch formation as applied to continental deposits of Eocene age in the northern Powder River Basin has been the subject of considerable discussion. The Wasatch formation was named by Hayden¹³ for exposures of variegated sands, clays, and conglomerates of continental origin in Echo and Weber Canyons in the Wasatch Mountains of Utah, which are about 450 miles from the Spotted Horse field. The name was first used in northeastern Wyoming by Wegemann¹⁴ who assigned 2,400 feet of rocks of freshwater origin, exposed between Pumpkin Buttes

¹²W. T. Thom, Jr. and C. E. Dobbin, "Stratigraphy of Cretaceous Eocene Transition Beds in Eastern Montana and The Dakotas," Geol. Soc. America Bull., XXXV (1924), 495.

¹³M. G. Wilmarth, "Lexicon of Geologic Names of The United States (Including Alaska)," U. S. Geol. Survey Bull. 895 (1938), pp. 2277-2278.

¹⁴C. H. Wegemann, "Wasatch Fossils in So-called Fort Union Beds of The Powder River Basin, Wyoming, and Their Bearing on The Stratigraphy of The Region," U. S. Geol. Survey Prof. Paper 108-D (1918), pp. 57-60.

and Great Pine Ridge, about 50 miles south of the Spotted Horse area, to the Wasatch. This assignment was based principally on the occurrence of the fossil Coryphodon in these rocks. Wegemann¹⁵ also expressed the "opinion that the Kingsbury conglomerate (exposed on the east flank of the Big Horn Mountains, about 50 miles west of the Spotted Horse area) is equivalent to part of the Wasatch, and that the unconformity at its base separates that formation, in the Kingsbury region at least, from all older rocks."

As with most continental deposits of this type it is difficult to correlate deposits of one basin of deposition with those of another. Regarding Wegemann's use of the name, Wasatch, for rocks in the Pumpkin Buttes area Nace¹⁶ writes:

"In the present writer's opinion, the paleontologic evidence proffered by Wegemann does not justify use of the name, Wasatch, in the Pumpkin Buttes area. The nearest equivalents of the Pumpkin Buttes "Wasatch" appear to be the Clark Fork and lower Greybull horizons, both of which are definitely older than the only known mammal-bearing horizon (Knight member) of the typical Wasatch in southwest Wyoming. The Clark Fork and Greybull have been included in the so-called Big Horn Wasatch by some writers, but the legitimacy of this usage is questioned, since the Clark Fork horizon has no known equivalent in any part of the typical Wasatch."

In the Sheridan coal field, which joins the Spotted Horse field on the west, Taff¹⁷ divided the coal bearing rocks, including correlatives to those exposed in the Spotted Horse area, into a lower and an upper member, and subdivided the upper member, from bottom to top, into the

¹⁵Ibid., p. 60.

¹⁶R. L. Nace, "Summary of The Late Cretaceous and Early Tertiary Stratigraphy of Wyoming," The Geological Survey of Wyoming Bull. 26 (1936), p. 131.

¹⁷J. A. Taff, "The Sheridan Coal Field, Wyoming," U. S. Geol. Survey Bull. 311-B (1909), pp. 127-131.

Tongue River, Intermediate, and Ulm coal groups. Thom and Dobbin¹⁸ raised the Tongue River coal group to the rank of member of the Fort Union formation, and correlated the Intermediate coal group with the Sentinel Butte shale of western North Dakota, which they assigned to the Wasatch instead of the Fort Union. They also placed the Ulm coal group in the Wasatch. Nace¹⁹ later proposed that the Intermediate group be designated Sentinel Butte shale and the Ulm group be raised to the rank of formation. These proposals now appear untenable inasmuch as Brown²⁰ has found fossils which indicate that the Sentinel Butte shale is Paleocene in age (upper Fort Union). Fossils of Eocene age (listed on p. 48) have been collected in the Spotted Horse field from beds correlated with the Intermediate coal group of the Sheridan field.

Although Nace²¹ and Wood²² question the propriety of the term, Wasatch, as used in northern Powder River Basin, it is retained in this report to conform with long accepted and widespread usage in the Powder River Basin.

The Wasatch formation of the Spotted Horse field is correlated with

¹⁸Thom and Dobbin, op. cit., pp. 494-496.

¹⁹Nace, op. cit., pp. 104-106, and 131.

²⁰R. W. Brown, "Correlation of Sentinel Butte Shale in Western North Dakota," Am. Assoc. Petroleum Geologists Bull., XXXII (1948), 1265-1274.

²¹Nace, op. cit., p. 131.

²²H. E. Wood, 2nd and others, "Nomenclature and Correlation of The North American Continental Tertiary," Geol. Soc. America Bull., LII (1941), 35-36.

the Intermediate and Ulm coal groups of the Sheridan,²³ Barber,²⁴ and Powder River²⁵ coal fields. The formation also has been mapped in the Gillette coal field,²⁶ the northward extension of the Sheridan coal field²⁷ (see Plate IV), and the Pumpkin Buttes coal field.²⁸

²³Taff, op. cit., pp. 123-150.

²⁴C. H. Wegemann, "The Barber Coal Field, Johnson County, Wyoming," U. S. Geol. Survey Bull. 531-I (1913), pp. 1-24.

²⁵R. W. Stone and C. T. Lupton, "The Powder River Coal Field, Wyoming, Adjacent to The Burlington Railroad," U. S. Geol. Survey Bull. 381 (1910), pp. 115-136.

²⁶C. E. Dobbin and V. H. Barnett, "The Gillette Coal Field, Northeastern Wyoming," with a chapter on "The Minurn District and The Northwestern Part of The Gillette Field" by V. T. Thom, Jr., U. S. Geol. Survey Bull. 796-A (1927), pp. 1-64.

²⁷A. A. Baker, "The Northward Extension of The Sheridan Coal Field, Big Horn and Rosebud Counties, Montana," U. S. Geol. Survey Bull. 606-B (1929), pp. 15-68.

²⁸C. H. Wegemann and others, "The Pumpkin Buttes Coal Field, Wyoming," U. S. Geol. Survey Bull. 806-A (1929), pp. 1-14.

Tertiary System

Tongue River Member of The Fort Union Formation (Paleocene)

Lithology.--Rocks of the Tongue River member in the Spotted Horse coal field are about 900 feet thick. They are of continental origin, and consist mainly of friable yellowish-gray sandstone, and waxy medium-gray shale, and lesser amounts of coal and dusky-brown shale. An additional 300 to 400 feet of sediments in the lower part of the member is not exposed. Tongue River rocks surface about two-thirds of the area. They are best exposed in the north-central and north-eastern parts on steep valley walls of Powder River and its tributaries. Westward and southwestward the top of the member passes beneath younger rocks.

The prevailing color of rocks in the Tongue River member is yellowish-gray. At many places, however, the sediments have been baked by burning of underlying coal beds to form brittle hard "clinker" which is conspicuous in various shades of red, purple, and violet. These baked sediments are resistant to erosion and cap many high surfaces on the divides and prominent benches along the valley walls. The zones of clinker and outcrops of sandstone generally support stands of pine trees. Figure 6 is a view of a typical landscape on Tongue River sediments.

In the north-central part of the Powder River Basin the top of the Tongue River member, as defined by Thom and Dobbin²⁹ and accepted by the Geological Survey,³⁰ is the top of the Roland coal bed, which was named in the Sheridan coal field, Wyoming. Inasmuch as the Roland bed

²⁹Thom and Dobbin, op. cit., p. 495.

³⁰Wilmarth, op. cit., p. 2163.



Figure 6. OUTCROP OF THE TONGUE RIVER MEMBER OF THE FORT UNION FORMATION (VIEW WEST ACROSS BITTER CREEK FROM NW $\frac{1}{4}$ SEC. 23, T. 57 N., R. 7 $\frac{1}{4}$ W.)

Characteristic topography and vegetation on outcrop of the Tongue River member. The even-topped ridges in the background are held up by clinker of the Anderson bed.



Figure 7. OUTCROP OF THE WASATCH FORMATION (VIEW SOUTHWEST ACROSS MIDDLE PRONG OF WILD HORSE CREEK FROM NW $\frac{1}{4}$ SEC. 11, T. 5 $\frac{1}{4}$ N., R. 75 W.)

Characteristic topography on outcrop of the Wasatch formation. The Felix coal bed crops out near the base of the steep slopes that border the valley.

is not continuous in the Spotted Horse field and is therefore not a convenient mappable horizon, the top of the member was mapped on a persistent, highly fossiliferous zone of shale, sandstone, and limestone from 5 to 65 feet above the Roland bed. The fossiliferous horizon is in the upper part of a transition zone, 150 to 200 feet thick, within which the light-colored sediments of the Tongue River member grade into the lithologically similar, but darker-colored sediments of the Wasatch formation.

The persistent fossiliferous zone could not be traced eastward beyond the NW $\frac{1}{4}$ sec. 12, T. 55 N., R. 74 W. (Plate II). Eastward and southeastward from this locality the Smith coal bed of Tongue River age converges with basal Wasatch sediments. East of the Powder River-Little Powder River divide the interval between the Smith coal bed and the Felix coal bed, of Wasatch age, is occupied by 160 feet of cross-bedded, coarse-grained sandstone; in areas to the west the interval between these two beds is occupied by 670 feet of interbedded sandstone, shale, and coal--225 feet belonging to the Tongue River member and 445 feet to the Wasatch formation. This relationship suggests that the southern part of the area was uplifted slightly at the close of the Paleocene, with a resulting change of conditions from depositional to non-depositional or erosional. The sandstone between the Smith and Felix coal beds is assigned to the Wasatch and is interpreted as an aeolian deposit which accumulated above the eroded Tongue River sediments near the eastern margin of the Wasatch basin of deposition. While the sandstone was being laid down, shales, sandstones, and coals, indicative of swampy conditions, were accumulating in other parts of the

Wasatch basin. As the basin filled, swamp conditions encroached eastward with the subsequent deposition of the Felix coal bed immediately overlying the sandstone. Owing to a transgressing of time horizons the Felix bed occurs about 100 feet higher above the base of the Wasatch formation near the eastern margin of the basin than in areas westward. The stratigraphic position of the Felix coal bed is treated in more detail in the discussion of the Wasatch formation and coals of the Wasatch formation. Composite sections showing stratigraphic changes in rocks exposed in the Spotted Horse coal field are presented in Plate III.

Throughout the southern part of the field the Wasatch-Fort Union boundary is nearly everywhere covered by soil and slope wash derived from the basal Wasatch sandstone and could be located only approximately.

In the Gillette coal field Dobbin and Barnett³¹ place the upper boundary of the Tongue River member at the top of the D coal bed, which they believe to be the Roland bed. The D bed is correlated with the Anderson coal bed of the Spotted Horse field and is about 350 feet stratigraphically below the fossiliferous zone marking the top of the Tongue River member. Tongue River rocks above the D coal bed probably have been removed by pre-Wasatch erosion. Wegemann³² places the top of the Fort Union formation at the top of the H coal bed in the Pumpkin Buttes coal field southwest of Gillette; however, in this same area Brown³³ shows the top of

³¹C. E. Dobbin and V. H. Barnett, op. cit., p. 10.

³²C. H. Wegemann and others, op. cit., p. 4.

³³R. W. Brown, "Map Showing Paleocene Deposits of The Rocky Mountains and Plains," U. S. Geol. Survey Preliminary Map (1949)

the Fort Union formation at a somewhat higher level.

A complete section of the Tongue River member in the Spotted Horse field was not measured as the base of the member is not exposed. In the Sheridan coal field the Tongue River "coal group," correlated with the Tongue River member, is about 800 feet thick.³⁴ In the northward extension of the Sheridan coal field Baker³⁵ estimated it to be 1,626 to 1,780 feet thick. According to Bass³⁶ it is 1,150 to 1,600 feet thick in the Ashland field although the upper 200 to 300 feet is missing due to erosion. In the Gillette coal field 250 to 400 feet of Tongue River rocks³⁷ remain after an estimated 350 feet of rocks was removed by pre-Wasatch erosion. On Plate IV a fence diagram shows the relationship of Tongue River rocks to the overlying Wasatch formation and to the underlying Lebo shale member of the Fort Union formation in parts of northeastern Wyoming and southeastern Montana.

Seds of massive, cross-bedded, friable sandstone, ranging in thickness from a few inches to as much as 100 feet, hold up many high surfsces in the eastern part of the area and are exposed in valley walls where they form almost vertical slopes broken at intervals by ledges developed on thin indurated beds, lenses, and concretionary zones of sandstone.

³⁴Taff, op. cit., p. 129.

³⁵Baker, op. cit., p. 27.

³⁶N. W. Bass, "The Ashland Coal Field, Rosebud, Powder River, and Custer Counties, Mont.," U. S. Geol. Survey Bull. 831-B (1932), p. 35.

³⁷Dobbin and Barnett, op. cit., pp. 9-10.

Sandstone is more abundant in the upper part of the section than in the lower. The transition from shale to sandstone is rather sharp, about 350 feet below the top of the member, which is approximately the horizon of the Anderson coal bed. Beds of sandstone above the Anderson are more persistent than those in the lower part of the section although they vary considerably in thickness. Sandstone and shale are in about equal proportion below the Anderson bed, and both show considerable lateral change. In a short distance a bed of sandstone may grade into shale or shaly sandstone, or it may lense out and have no correlative lithologic unit. Such lensing causes a convergence of overlying and underlying strata.

Many thick coal beds of the Tongue River member crop out in the Spotted Horse field. Some underlie hundreds of square miles of the area and extend into nearby coal fields (See Plate V). These persistent beds of coal maintain a relatively constant stratigraphic position in the section, although pronounced changes in interval between two persistent coal beds may occur due to thickening and thinning of the intervening strata. Many local coal beds occur in the intervening strata.

Beds of dusky brown carbonaceous shale ranging in thickness from a fraction of an inch to 30 feet commonly contain abundant plant impressions and coalified plant material. The surface of many weathered outcrops is littered with well-formed crystals of gypsum (selenite) derived from the shale. The carbonaceous shale makes up only a small proportion of the sediments but is important because it grades into coal beds, overlies and underlies coal beds, and forms partings in the coal.

Several beds of yellowish-gray sandstone, light gray shale, and

light brown limestone which contain an abundance of gastropod and pelecypod shells and shell fragments commonly occur near the top of the Tongue River member. These fossiliferous beds, together with interbedded non-fossiliferous sediments, make up a zone as much as 30 feet thick that is mappable over much of the north-central and western parts of the coal field. The zone was traced into T. 58 N., R. 77 W. from the Moorhead coal field where it is believed by Bryson³⁸ to be the same fossiliferous zone that occurs above the Roland bed in the northward extension of the Sheridan coal field.³⁹ It also correlates with a fossiliferous zone below the Arvada coal bed in Powder River coal field.⁴⁰

At most places the fossiliferous units are easily recognized because of numerous mollusk shells that litter their outcrops. The most conspicuous units are the beds of coquina limestone which weather into grayish-white blocks and form small ledges (see figures 8 and 9). In T. 58 N., R. 78 W. (Plate I) the zone reaches the maximum observed thickness, about 30 feet. In sec. 29 of this township the lower 3 feet contain abundant gastropod and a few pelecypod shells. The next overlying 9 feet are composed of non-fossiliferous shale and sandstone above which is about 3 feet of highly fossiliferous shale and sandy shale, differing from the lower beds in that the majority of fossils are pelecypod shells. The proportion of pelecypod to gastropod shells

³⁸R. P. Bryson, Personal communication (1948)

³⁹A. A. Baker, op. cit., p. 34.

⁴⁰E. W. Stone and C. T. Lupton, op. cit., p. 122.



Figure 8. OUTCROP OF A THIN, LEDGE-FORMING, COQUINAL LIMESTONE IN THE FOSSILIFEROUS ZONE NEAR THE TOP OF THE TONGUE RIVER MEMBER IN NE $\frac{1}{4}$ SEC. 6, T. 57 N., R. 77 W.

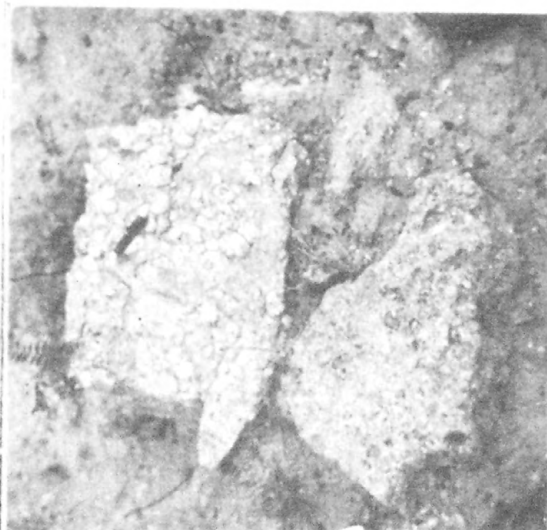


Figure 9. WEATHERED BLOCKS OF COQUINAL LIMESTONE FROM THE FOSSILIFEROUS ZONE NEAR THE TOP OF THE TONGUE RIVER MEMBER IN NE $\frac{1}{4}$ SEC. 6, T. 57 N., R. 77 W.

varies from place to place.

The zone thins southward to about 5 to 10 feet in Tps. 56 N., Rs. 77 and 78 W. and eastward to 1 or 2 feet in Tps. 56 and 57 N., R. 76 W., and T. 56 N., R. 75 W. (Plate I). Here it is a ledge-forming, fossiliferous limestone, generally underlain by a few inches of fossiliferous shale. The zone lenses out in the northwestern part of T. 55 N., R. 75 W. (Plate II). Fossils collected from the zone are listed on page 39.

The following detailed sections are representative of that part of the Tongue River member which crops out in the Spotted Horse field.

Section of upper part of Tongue River member of Fort Union formation and lower part of Wasatch formation in sec. 25, T. 57 N., R. 77 W., Wyoming

Top of hill.	Feet Inches	
Wasatch formation:		
Sandstone, medium-grained, friable, yellowish-gray; contains log-shaped concretions 15 to 20 feet long - -	96	0
		96 0
Tongue River member of Fort Union formation:		
Shale, dusky brown - - - - -	0	5
Coal (Roland bed) - - - - -	2	4
Sandstone, medium-grained, friable, yellowish-gray - - - - -	15	8
Sandstone, well-indurated, platy, ledge-forming, yellowish-gray - - - - -	2	0
Sandstone, medium-grained, friable, yellowish-gray - - - - -	26	0
Coal (local bed) - - - - -	1	8
Shale, dusky brown - - - - -	0	8
Shale, gray; interbedded with fine-grained yellowish-gray sandstone - - - - -	3	9
Shale, dusky brown and black - - - - -	2	8
Sandstone, friable, yellowish-gray - - - - -	42	0
Coal (local bed)		
Coal - - - - -	0	3
Shale, dusky brown - - - - -	1	0
Coal - - - - -	2	6
Sandstone, fine- to medium-grained, friable, yellowish-gray - - - - -	24	0
Shale, dusky brown - - - - -	3	6
Coal (local bed) - - - - -	5	7
Shale, dusky brown - - - - -	3	1
Sandstone, medium-grained, friable, yellowish-gray - - - - -	28	0
Coal (local bed)		
Coal - - - - -	0	4
Shale, dusky brown - - - - -	0	10
Coal - - - - -	0	6
Shale, dusky brown - - - - -	0	1
Coal - - - - -	1	1
Shale, dusky brown - - - - -	4	4
Sandstone, yellowish-gray, interbedded with light gray shale - - - - -	28	0
Shale, dusky brown - - - - -	7	0
Coal (Smith bed), contains fossilized wood - - - - -	7	10
Sandstone and shale, interbedded, gray and yellowish-gray, fragments of pelecypod shells occur from 30 to 36 feet above base of unit - - - - -	58	0

	Feet Inches	
Sandstone, fine-grained, well-indurated, orange - - - - -	1	6
Sandstone, fine-grained, friable, light gray; contains fragments of pelecypod shells - - - - -	15	0
Sandstone, fine-grained, well-indurated, orange - - - - -	2	7
Sandstone, friable, yellowish-gray and gray - - - - -	29	0
Shale, dusky brown and black - - - - -	6	0
Coal (local bed) contains fossilized wood - - - - -	1	7
Shale, dusky brown and black - - - - -	6	6
Sandstone, friable, yellowish-gray, con- tains indurated sandstone lenses - - - -	22	0
Coal (Anderson bed)		
Coal - - - - -	4	6
Shale, black - - - - -	2	6
Coal - - - - -	10	1
Shale, dusky brown - - - - -	9	6
Sandstone, fine-grained, friable, yellowish-gray, contains thin layers of dusky brown shale - - - - -	42	0
Coal (local bed) - - - - -	0	9
Shale, dusky brown - - - - -	0	2
Sandstone, fine-grained, friable, yellowish-gray; contains ironstone concretions - - - - -	6	3
Shale, dusky brown - - - - -	2	10
Coal (Dietz No. 1 bed) - - - - -	2	9
Shale, dusky brown - - - - -	0	9
Sandstone, fine-grained, gray - - - - -	4	8
Sandstone, well-indurated, light brown; ledge-forming - - - - -	2	10
Sandstone, fine-grained, gray - - - - -	3	2
Sandstone, fine-grained, well-indurated, yellowish-brown - - - - -	1	9
Sandstone, fine-grained, gray; contains ironstone concretions - - - - -	28	0
	480	0
Alluvium - - - - -	14	0
Level of Powder River		
		576 0

Section of upper part of Tongue River member of Fort Union formation in
sec. 4, T. 57 N., R. 78 W., Wyoming.

Wasatch formation:	Feet	Inches
Tongue River member of Fort Union formation:		
Limestone, light gray to yellowish-gray, contains many pelecypod and gastropod shells and fragments - - - - -	6	1
Shale, dusky brown- - - - -	10	4
Limestone, light gray to yellowish-gray, contains many pelecypod and gastropod shells and fragments - - - - -	1	11
Shale, dark gray and dusky brown- - - - -	9	5
Sandstone, yellowish-gray, well-indurated - - -	9	0
Shale, dark gray; grades upward into black carbonaceous shale- - - - -	5	9
Sandstone, fine-grained, friable, yellowish-gray- - - - -	3	7
Shale, gray - - - - -	2	0
Sandstone, friable, yellowish-gray; contains thin lenses of bright orange well-indurated sandstone - - - - -	25	0
Shale, gray, carbonaceous - - - - -	6	0
Coal (local bed, elsewhere 50 feet below Roland bed), slumped and slightly oxidized- - - - -	2	0
Shale, dark gray, waxy, carbonaceous- - - - -	0	3
Sandstone, massive, well-indurated, yellowish-gray; base is covered - - - - -	31	0
	119	4
Valley fill		

Section of Tongue River member of Fort Union formation measured in W.,
sec. 31, T. 58 N., R. 76 W., Wyoming.

	Feet	Inches
Top of hill.		
Clinker, including ash of burned Canyon bed at		
base - - - - -	50	0
Shale, sandy, gray - - - - -	33	0
Sandstone, well-indurated, ledge-forming,		
yellowish-gray - - - - -	4	7
Shale, dusky brown - - - - -	2	0
Sandstone, weathers gray - - - - -	4	0
Sandstone, friable, yellowish-gray - - - - -	19	6
Shale, dusky brown - - - - -	0	5
Coal (local bed)		
Coal - - - - -	0	8
Shale, dusky brown - - - - -	9	0
Coal - - - - -	3	5
Sandstone, fine-grained, shaly, dark brown - - - - -	2	8
Shale, dusky brown - - - - -	7	0
Shale, sandy, weathers brown - - - - -	3	2
Shale, dusky brown with minor amounts of black		
and gray shale; contains gypsum crystals - - - - -	24	7
Shale, sandy, yellowish-gray - - - - -	0	5
Sandstone, light gray to yellowish-gray; grades		
upward into shale - - - - -	11	0
Shale, black to dusky brown - - - - -	2	3
Coal (local bed), thickens westward - - - - -	1	6
Shale, dusky brown - - - - -	2	0
Sandstone, fine-grained, gray to yellowish-gray - - - - -	8	0
Sandstone, shaly, yellowish-gray - - - - -	17	0
Shale, sandy, gray - - - - -	20	0
Sandstone, friable, massive, white to yellowish-		
gray - - - - -	15	0
	241	2
Valley fill .		

Section of Tongue River member of Fort Union formation in NW₁, sec. 25,
T. 58 N., R. 75 W., Wyoming.

	Feet.	Inches
Top of hill.		
Clinker, caps highest ridges and buttes - - - - -	48	0
Ash of burned Anderson coal bed - - - - -	1	6
Shale, medium gray- - - - -	58	0
Shale, yellowish-gray - - - - -	28	0
Clinker, upper 53 feet composed dominantly of baked shale; lower 20 feet, of baked sandstone-	73	0
Ash of burned Canyon coal bed, consists of 2 feet 6 inches of ash at top and 9 inches of ash at base, separated by 1 foot 1 inch of clinker - - - - -	4	4
Shale, indurated, yellowish-gray- - - - -	1	6
Shale, gray and yellowish-gray- - - - -	11	6
Sandstone, yellowish-gray, concretionary; and medium-grained, friable, grayish-brown sandstone - - - - -	10	6
Shale, gray and yellowish-gray- - - - -	6	7
Sandstone, indurated, yellowish-gray- - - - -	9	6
Sandstone, fine-grained, friable, gray- - - - -	11	3
	<u>263</u>	<u>8</u>

Paleontology.--Plant fossils are abundant in the Tongue River member; and invertebrate fossils, chiefly pelecypod and gastropod shells, occur in thin beds, widely spaced throughout the stratigraphic section. The plant fossils consist of impressions, coalified and carbonized leaves, twigs and stems, and fossil wood. Plant impressions occur chiefly in the medium gray shales and yellowish-gray sandstone and are best preserved in rocks that have been somewhat hardened by burning of underlying coal beds. Coalified plant material commonly occurs in dusky brown, carbonaceous shale associated with the coal beds, but generally in such small pieces that identification is difficult. Silicified and "ocherized" stumps and pieces of wood are abundant in some coal beds. No plant fossils were collected in the Spotted Horse area; however, the following lists of fossil leaves, identified by Knowlton and Brown were collected from the Tongue River member of the Little Powder River coal field⁴¹ and from the lower part of the member in the Coalwood coal field.⁴²

List of Fossil Leaves Collected From The Tongue River Member of The Little Powder River Coal Field--Identified by F. H. Knowlton and Revised by R. W. Brown

Onoclea sp.
Glyptostrobus dakotensis Brown
Metasequoia occidentalis (Newberry) Chaney
Corylus sp.
Cercidiphyllum arcticum (Beer) Brown
Celastrus ferruginea Ward
Sapindus grandifoliolus Ward
Viburnum sp.

⁴¹J. A. Davis, "The Little Powder River Coal Field, Campbell County, Wyoming," U. S. Geol. Survey Bull. 471 (1912), p. 426.

⁴²R. P. Bryson, "The Coalwood Coal Field, Powder River County, Montana," U. S. Geol. Survey Bull. 973-B (1952), pp. 34-36.

List of Fossil Leaves From the Lower Part of The Tongue River Member of The Coalwood Coal Field, Powder River County, Montana--Collected by R. P. Bryson and Identified by Roland W. Brown

<u>Platanus raynoldsi</u> Newberry	<u>Sapindus grandifoliolus</u> Ward
<u>Betula</u> sp.	<u>Corylus fosteri</u> Ward
<u>Onoclea sensibilis fossilis</u> Newberry	<u>Equisetum</u> sp.
<u>Cabomba inermis</u> (Newberry) Hollick	<u>Viburnum asperum</u> Newberry
<u>Quercus</u> sp.	<u>Laurus</u> sp.
<u>Viburnum antiquum</u> (Newberry) Hollick	

Two collections of pelecypod and gastropod shells from the fossiliferous zone near the top of the Tongue River member have been identified by T. C. Yen of the U. S. Geological Survey as follows:

Locality: NW $\frac{1}{4}$ sec. 24, T. 58 N., R. 75 W.

Elliptio cf. E. priscus (Meek and Hayden)
Viviparus raynoldianus (Meek and Hayden)
Lioplacodes mariana Yen
Lioplacodes? limnaeiformis (Meek and Hayden)

Locality: NW $\frac{1}{4}$ sec. 32, T. 58 N., R. 78 W.

Elliptio cf. E. priscus (Meek and Hayden)
Viviparus trochiformis (Meek and Hayden)
Lioplacodes tenuicarinata (Meek and Hayden)
Lioplacodes mariana Yen
Lioplacodes? limnaeiformis (Meek and Hayden)
Pleurocera? warrenianum (Meek and Hayden)
Gyraulus parvulus (Meek and Hayden)
Carinulorbis planospiralis Yen

Yen⁴³ regards these assemblages as indicating an upper Paleocene age--probably the same as the age of the Roland coal beds. Yen⁴⁴ has described other collections of fossils from this and other zones in the Tongue River member of southern Montana.

⁴³T. C. Yen, Personal communication (1952)

⁴⁴T. C. Yen, "Paleocene Fresh-water Mollusks From Southern Montana", U. S. Geol. Survey Prof. Paper 214-C (1948), pp. 35-47.

Wasatch Formation (Pocene)

Lithology.--The Wasatch formation covers large areas in the western and southern parts of the Spotted Horse field and caps many divides in the north-central part. North of Tps. 55 N., Rs. 74 and 75 W. it conformably overlies the Tongue River member of the Fort Union formation, but in the southern part of the field it lies on an erosional surface which bevels successively older Tongue River rocks southward. Wide-spread erosion has destroyed the upper part of the formation in northern Powder River Basin and its complete thickness could not be determined. In the Spotted Horse area it has a maximum thickness of about 700 feet in the western part of the field.

The Wasatch formation and the underlying Tongue River member show no marked difference in lithology. The Wasatch, like the Tongue River, consists of continental deposits with similar percentages of sandstone, shale, and coal. The drab moderate yellowish-brown color and scarcity of timber that characterize the outcrop (see Figure 7) are in strong contrast to the lighter colors and fair stands of timber that characterize the outcrops of the Tongue River.

Although the Wasatch formation is thickest in the western part of the area the section here is not complete, and stratigraphically higher beds occur in the southern part (see Plate III). In the southwestern part of T. 57 N., R. 76 W. a coal bed tentatively correlated with the Felix coal bed is about 430 feet above the base of the Wasatch. The intervening rocks are shale, sandstone, and a few thin coal beds which thin eastward and grade laterally into sandstone, until in the west-central part of T. 54 N., R. 74 W. they have become about 100 feet of

yellowish-gray friable cross-bedded coarse-grained sandstone containing many ironstone concretions.

The easterly decrease in interval between the Felix and the Uln No. 2 coal bed, is due largely to thinning and pinching out of intervening strata. The interval decreases from about 330 feet in the northeastern corner of T. 54 N., R. 74 W. (Plate II) to about 250 feet in the northwest corner of the eastern adjoining township.

The following detailed sections measured in various parts of the coal field give some idea as to the composition, character, and distribution of rocks in the Wasatch formation.

Section of Wasatch formation in sec. 28, T. 57 N., R. 73 W., Wyoming.

Top of hill.	Feet	Inches
Sandstone, slightly indurated, yellowish-gray - - -	8	0
Shale, dusky brown - - - - -	1	2
Sandstone, fine-grained, friable, yellowish-gray -	9	0
Shale, mottled gray and dusky brown - - - - -	20	0
Shale, dusky brown - - - - -	9	0
Sandstone, well-indurated, yellowish-gray; caps ridges - - - - -	10	0
Shale, dusky brown - - - - -	29	0
Coal (local bed) - - - - -	2	6
Shale, dusky brown - - - - -	0	6
Sandstone, well-indurated, gray; caps ridges - - -	18	6
Shale, gray to orange - - - - -	12	0
Sandstone, slightly indurated, gray; contains gastropod and pelecypod shells and fragments - -	1	0
Shale, gray - - - - -	7	6
Shale, dusky brown - - - - -	6	6
Coal (local bed)		
Coal - - - - -	1	3
Shale, dusky brown - - - - -	0	9
Coal - - - - -	1	5
Shale, dusky brown to black - - - - -	13	6
Shale, dusky brown and gray - - - - -	20	0
Sandstone, friable, dark grayish-green - - - - -	2	5
Shale, dusky brown - - - - -	0	7
Coal (local bed)		
Coal, shaly - - - - -	2	0
Shale, dusky brown - - - - -	5	3
Shale, gray - - - - -	1	3
Shale, dusky brown - - - - -	0	5
Coal - - - - -	2	5
Shale, gray - - - - -	3	8
Sandstone, friable, yellowish-gray - - - - -	4	4
Shale, dusky brown - - - - -	6	0
Sandstone, friable, yellowish-gray; interbedded with gray shale - - - - -	5	8
Shale, dusky brown - - - - -	9	8
Sandstone, friable, yellowish-gray - - - - -	5	3
Shale, dusky brown - - - - -	4	5
Coal (Felix? bed) - - - - -	1	9
Shale, gray; interbedded with fine-grained, friable sandstone containing lenses of hard orange sandstone - - - - -	54	0
Shale, dusky brown - - - - -	1	10
Shale, gray - - - - -	1	0
Sandstone, friable, yellowish-gray; contains lenses of well-indurated orange sandstone - - -	2	8
Shale, dusky brown - - - - -	0	4

	Feet	Inches
Coal (local bed), contains fossil wood - - - - -	0	6
Shale, dusky brown - - - - -	0	10
Shale, gray- - - - -	4	2
Sandstone, yellowish-gray; contains lenses of well-indurated sandstone - - - - -	4	8
Shale, dusky brown - - - - -	5	7
Shale, mottled gray and orange - - - - -	2	0
Shale, purplish-gray - - - - -	1	0
Shale, greenish-gray; contains well-indurated lenses of orange sandstone - - - - -	3	1
Shale, dusky brown - - - - -	0	6
Shale, light gray- - - - -	37	0
Shale, dark gray and black - - - - -	0	4
Shale, dusky brown - - - - -	3	6
Shale, gray; grades upward into yellowish-gray shale- - - - -	29	0
Sandstone, fine-grained, friable, yellowish-gray; becomes harder in upper part - - - - -	6	0
	<u>385</u>	<u>1</u>
Soil cover		

Section of Wasatch formation in S₂ sec. 14, T. 53 N., R. 75 W., Wyoming.

	Feet	Inches
Top of hill.		
Sandstone, yellowish-gray - - - - -	1	6
Shale, pale brown - - - - -	8	0
Shale, dusky brown - - - - -	1	1
Coal (Ulm No. 1 bed) - - - - -	10	10
Shale, dusky brown - - - - -	2	4
Sandstone, fine-grained, friable, yellowish-gray; contains lenses of well-indurated sandstone - - -	7	3
Shale, dusky brown - - - - -	1	0
Shale, pale brown to pale olive; contains many gypsum needles - - - - -	9	5
Shale, dusky brown - - - - -	1	8
Sandstone, friable, yellowish-gray - - - - -	3	10
Shale, dark yellowish-brown - - - - -	0	5
Coal (local bed) - - - - -	2	4
Shale, dusky brown - - - - -	1	2
Shale, silty, yellowish-gray; becomes darker near top - - - - -	9	0
Sandstone, medium-grained, friable, cross- bedded, yellowish-gray - - - - -	8	7
Sandstone, medium-grained, friable, cross- bedded, white - - - - -	25	0
Unconformity		
Coal (Ulm No. 2 bed)		
Coal, contains fossil tree stumps - - - - -	3	0
Sandstone, fine-grained, light olive gray - - - -	0	1
Coal - - - - -	0	5
Shale, light olive gray - - - - -	1	8
Coal - - - - -	1	4
Sandstone, friable, yellowish-gray to dusky brown - - - - -	12	0
Shale, light medium gray - - - - -	3	0
Coal (local bed)		
Coal - - - - -	0	10
Shale, dark yellowish-brown - - - - -	0	7
Coal - - - - -	0	6
Shale, dark yellowish-brown - - - - -	0	6
Covered - - - - -	5	4
Sandstone, medium-grained, well-indurated, yellowish-gray; ledge-forming - - - - -	2	5
Sandstone, friable, pale yellowish-brown - - - -	13	0
Shale, light medium gray - - - - -	2	4
Sandstone, shaly, pale yellow; and fine-grained friable sandstone - - - - -	10	0
Shale, light medium gray - - - - -	1	4
Sandstone, fine-grained, friable, pale yellowish-gray - - - - -	4	0
Shale, medium light gray - - - - -	7	3

	feet	Inches
Sandstone, coarse-grained, pale yellowish-gray; contains oval concretions, 6 to 10 feet in diameter, or indurated sandstone - - - - -	36	0
Shale, light medium gray - - - - -	1	0
Sandstone, medium- to coarse-grained, friable, pale yellowish-gray- - - - -	1	9
Unconformity		
Coal (local bed) - - - - -	2	10
Shale, pale brown to dusky brown - - - - -	0	7
Shale, light medium gray - - - - -	0	6
Sandstone, friable, pale yellowish-gray; contains lenses of well-indurated sandstone- - - -	14	6
Shale, pale yellowish-brown- - - - -	3	6
Shale, dusky brown - - - - -	1	9
Coal (local bed) - - - - -	2	6
Shale, dusky brown - - - - -	0	5
Shale, light olive gray- - - - -	1	3
Shale, dusky yellow- - - - -	0	6
Sandstone, friable, pale yellowish-gray- - - - -	8	5
Shale, medium light gray - - - - -	5	0
Sandstone, medium-grained, well-indurated, pale yellowish-gray - - - - -	1	6
Sandstone, friable, moderate yellow- - - - -	10	5
Shale, medium light gray - - - - -	1	2
Shale, yellowish-brown - - - - -	0	4
Coal (local bed); contains lenses of well- indurated sandstone- - - - -	2	10
Shale, dusky brown - - - - -	5	0
Sandstone, friable, pale yellowish-gray- - - - -	10	0
Shale and silty shale, light moderate gray - - - -	2	8
Shale, dusky brown and pale yellowish-brown- - - -	1	11
Sandstone, friable, pale yellowish-gray; with dark yellowish-orange stains - - - - -	13	7
Shale, olive gray- - - - -	0	2
Coal (local bed)		
Coal - - - - -	4	2
Shale, dusky brown - - - - -	2	4
Coal - - - - -	0	5
Shale, dusky brown - - - - -	0	5
Sandstone, friable, pale yellowish-gray- - - - -	5	6
Shale, olive gray- - - - -	0	6
Coal (local bed), shaly- - - - -	0	6
Shale, olive gray- - - - -	0	8
Cover- - - - -	1	8
Sandstone, shaly, fine-grained, light olive gray - -	6	0
Sandstone, well-indurated, ledge-forming, pale gray; weathers yellowish-orange- - - - -	16	0
Shale, dark yellowish-brown- - - - -	0	1
Coal (local bed) - - - - -	1	11
Shale, dusky brown - - - - -	0	2

	Feet	Inches
Shale, olive gray - - - - -	1	6
Cover - - - - -	29	0
Sandstone, fine-grained, friable, grayish-yellow; contains lenses of well-indurated sandstone - - - - -	30	0
Sandstone, fine-grained, shaly, light olive gray; with moderate yellow stains along bedding planes - - - - -	2	8
Coal (Felix bed) - - - - -	2	6
Coal - - - - -	1	3
Sandstone, fine-grained, shaly, medium gray - - - - -	2	1
Coal - - - - -	0	11
Sandstone, medium-grained, very friable, pinkish-gray, lenticular - - - - -	11	8
Coal - - - - -	0	10
Sandstone, fine-grained, shaly, medium gray - - - - -	17	6
Coal - - - - -	0	8
Shale, dusky brown - - - - -	3	1
Shale, slightly silty, light olive gray; contains moderate yellow vein-like stains - - -	112	11

Bottom of draw

Section of Wasatch formation at Horse Creek Butte, sec. 23, T. 54 N.,
R. 74 E., Wyoming.

Top of butte.	Feet	Inches
Clinker - - - - -	36	0
Ash of burned Elm No. 2 coal bed- - - - -	2	0
Sandstone, friable, yellowish-gray- - - - -	18	0
Shale, light brown and grayish-brown- - - - -	0	5
Coal (local bed)- - - - -	0	5
Shale, dusky brown; silty in lower part - - - - -	1	8
Sandstone, friable, yellowish-gray- - - - -	32	0
Shale, sandy, light brown; grades upward into grayish-brown shale - - - - -	6	0
Coal (Scott bed)		
Coal- - - - -	2	3
Shale, dusky brown- - - - -	0	4
Coal- - - - -	0	9
Shale, silty, light brown - - - - -	2	0
Sandstone, friable, yellowish-gray- - - - -	12	6
Sandstone, indurated, yellow; ledge-forming - - - - -	4	0
Sandstone, silty, friable; interbedded with silty shale - - - - -	27	0
Shale, light brown and medium brown - - - - -	0	9
Sandstone, friable, yellowish-gray- - - - -	14	7
Shale, light brown and brownish-gray- - - - -	4	0
Coal (local bed)- - - - -	3	2
Sandstone, shaly, light brown - - - - -	6	6
Shale, dusky brown- - - - -	1	5
Shale, sandy, light gray and brown- - - - -	8	0
Shale, light brown- - - - -	1	4
Shale, sandy, gray; interbedded with yellowish- gray sandstone- - - - -	5	0
Shale, dark brown and black - - - - -	1	4
Coal (local bed)- - - - -	2	2
Shale, light yellowish-brown and gray - - - - -	5	3
Shale - - - - -	0	5
Sandstone, fine-grained, shaly, light grayish- brown - - - - -	47	0
Shale, light gray to brownish-yellow- - - - -	6	0
Shale, light brown- - - - -	6	0
Coal (Felix bed)		
Coal- - - - -	0	10
Sandstone, fine-grained, light brown- - - - -	0	8
Coal- - - - -	0	7
Sandstone, fine-grained, light brown- - - - -	0	1
Coal- - - - -	6	2
Shale, dark brown - - - - -	0	4
Coal, shaly - - - - -	8	6
	273	10
Soil cover		

Paleontology.--Fossil plants and mollusk shells are abundant in some beds of the Wasatch formation. Roland W. Brown visited the Spotted Horse field during the field seasons of 1948 and 1949 and collected the plant fossil Salvinia preauriculata Berry from beds above and below a coal in the western part of the area, tentatively correlated with the Felix bed; and from strata overlying the Felix bed in the southern part. Brown⁴⁵ considers this species to be definitely of early Eocene age, but as regards other plant fossils he states: "It is plain that many, perhaps most, of the Fort Union species continued into the Wasatch."

Mollusk shells collected by W. J. Mapel, of the U. S. Geological Survey, during the 1950 field season from Wasatch beds near the U. S. Coast and Geodetic Survey triangulation station in the northern part of sec. 5, T. 55 N., R. 78 W., listed below, were identified by T. C. Yen who considers them to be lower Eocene in age.

Unio sp. undet.
Valvata sp. undet.
Viviparus paludinaeformis (Hall)
Goniobasis cf. G. tenera (Hall)
Goniobasis sp. undet

⁴⁵R. W. Brown, Personal communication (1951)

Quaternary System

Terrace Deposits (Pleistocene?)

Deposits of sand and gravel of Pleistocene? age cover small areas at various heights above the valley floors of the Powder River and Clear Creek. The gravel is composed dominantly of rounded to sub-angular pebbles and cobbles of quartzite, sandstone, and chert and come from outside the Spotted Horse area. Disc-shaped pebbles of limestone, which closely resemble the Madison limestone (Mississippian) that crops out in the Big Horn Mountains, and rounded pebbles of igneous rocks are present in minor quantities. Clinker derived from local sources is present in the lowest gravel deposits bordering the Powder River and Clear Creek; however, none was observed in deposits which are more than 100 feet above the levels of these streams. Presumably most of the clinker in this region was formed subsequent to the deposition of the terrace gravels.

The highest terrace in the Spotted Horse field occurs at elevations of 3,300 to 3,960 feet, or 400 to 425 feet above the Powder River and is best represented by beds of sand and gravel in sec. 1, T. 57 N., R. 76 W., and near the level of the Powder River-Clear Creek Divide in T. 56 N., R. 77 W. Smaller deposits occur on the noses of divides between Big Remington and Little Remington Creeks, between Short and Fence Creeks, and along the Montana-Wyoming state line in sec. 24, T. 58 N., R. 75 W.

Other gravel deposits of the Spotted Horse field are at lower elevations and occur along the sides of the valleys above the level of the alluvium which borders Clear Creek and the Powder River.

Watson Basin in sec. 10, T. 57 N., R. 75 W. was formed by a meander of the Powder River when the valley bottom was about 150 feet higher than at present. Gravel deposits near the center of the basin are 10 to 20 feet higher than surrounding levels and represent a lens in the alluvial deposits of the old river bed.

Recent Deposits

Sand, silt, and clay, with lenses of gravel and rubble, surface the floor of the main valleys in the Spotted Horse area. The gravels come mainly from the terrace gravels, but some were carried from the Big Horn Mountains by the Powder River and Clear Creek during floods. Blocks of angular sandstone and clinker fragments from nearby outcrops comprise the rubble deposits.

Well borings along a line across the Powder River valley at the proposed Moorhead dam site, where the valley bottom is about 1,700 feet wide, penetrated from 12 to 21 feet of alluvium. During floods this shallow cover probably moves downstream, and the river erodes the underlying bedrock. Such recent downcutting is shown by banks of alluvium that stand 10 to 20 feet above the level of present flood plains. The county road in secs. 5 and 8, T. 57 N., R. 75 W. (Plate I) lies at the foot of such a bank which rises about 15 feet above the road level.

STRUCTURE

Relations and Character

The Spotted Horse coal field is in the north-central part of the Powder River Basin, the major structural depression between the Big Horn Mountains on the west and the Black Hills on the east. The sedimentary rocks dip gently southwestward, but slight variations and reversals of the dips indicate shallow synclines and anticlines in the surface rocks. Dips generally are less than 3 degrees; but locally, are as high as 11 degrees where the strata are faulted.

The structure of surface rocks in the area is shown on Plates VI and VII (in pocket) by contours drawn on the bases of the Smith and Ulm No. 2 coal beds, and the attitudes and stratigraphic positions of the main coal beds is shown by cross sections in Plate VIII (in pocket). Most of the elevations used in drawing the contours were determined on coal beds, the most persistent and easily recognized rock units for the purpose of structure determinations. Some elevations were determined on the bases of persistent beds of sandstone and on the bases of fossiliferous limestone beds near the top of the Tongue River member of the Fort Union formation. Numerous intervals between coal beds were measured by hand-levelling, and these were used in reducing the elevations to a common horizon. For most of the field the contour lines are shown on the base of the Smith coal bed, and on its inferred base in those parts of the field where the Smith bed has been removed by erosion. The base of the Ulm No. 2 coal bed, inferred where absent, represents the reference plane in the southern part of the field where the Wasatch formation unconformably overlies the Tongue River member. Contour

lines were not drawn for parts of Tps. 56 and 57 N., R. 76 W. (Plate VI) owing to a lack of correlatable horizons.

Folds

The dominant structural feature in the area is a series of gentle southwesterly plunging folds trending about N 25° E in a belt about 8 miles wide across Tps. 56 and 57 N., R. 76 W. and Tps. 56 and 57 N., R. 77 W. (Plate VI). The folds merge into a shallow syncline which trends eastward across the northern tier of townships. Elsewhere in the area less pronounced folds trend parallel to this belt of low flexures. Other small low folds trend about N 45° W.

Faults

Faults in the Spotted Horse field are concentrated in three main areas. Six faults were mapped near the southern end of the belt of low folds, and five were mapped near the northern end of the belt where it merges into the shallow syncline extending across the northern tier of townships (Plate VI). The third concentration of faults is in Tps. 54 N., Rs. 74 and 75 W. (Plate VI). Scattered faults occur at widely spaced localities in various parts of the field. With the exception of one reverse fault, all are normal. Displacement ranges from about 20 to 300 feet, and traces range in length from a fraction of a mile to about 3½ miles. Most of the faults trend either northeastward or eastward.

Rocks on the upthrown side of many faults are undisturbed; whereas, strata on the downthrown side dip steeply near the fault trace, but flatten out a short distance from the fault at elevations accordant with those of equivalent horizons on the upthrown side. Thus, the displacement seemingly is due to movement of the downthrown block possibly

caused by differential compaction of underlying sediments. This type of faulting occurs near the central parts of T. 58 N., R. 77 W. and T. 56 N., R. 77 W., in the northeastern corner of T. 58 N., R. 76 W., in the south-central part of T. 56 N., R. 76 W. (Plate VI), and in the area south of U. S. Highway 14 and 16 (Plate VII). Strata along opposite sides of other faults in the area have relatively steep dips.

A northeasterly trending fault, in the north-central part of T. 58 N., R. 76 W. (Plate VI), with north side dropped, has a displacement of 100 to 150 feet in Black Canyon Prong and Red Prong valleys, but on the divide between the two valleys the displacement is only one or two feet.

The Scott coal bed dips southward at 11 degrees in the eastern part of sec. 35, T. 53 N., R. 75 W. (Plate VII) and here, is about 100 feet higher than in the western part of the section. The local high dip and the differences in elevation of the Scott bed probably are due to a fault trending northeastward from sec. 35 into the southeastern part of sec. 26.

A graben in the south-central part of T. 58 N., R. 76 W. (Plate VI) is bounded on the southeast by a reverse fault and on the northwest by a normal fault. The reverse fault dips 62° E, trends northeastward, and has a throw of 150 feet. The normal fault, which is parallel to and one-half mile northwest of the reverse fault, has a displacement of 100 feet. Another graben, about 1-1/3 miles wide, which occurs near the northeastern corner of T. 56 N., R. 76 W. (Plate VI) is bounded by two northeasterly trending normal faults, each of which has a displacement of about 200 feet.

ECONOMIC GEOLOGY

OIL AND GAS

Interest in the oil possibilities of the Spotted Horse field was stimulated by the discovery of oil in the Texas Company's Adon well in Sec. 2, T. 52 N., R. 72 W., Campbell County. The well, which is about $7\frac{1}{2}$ miles from the southeastern corner of the Spotted Horse field, was completed in March 1948 with initial production of 204 barrels per day. Production is from the Misselusa sandstone (Pennsylvanian) at a depth of 9,345 feet.⁴⁶

Following completion of the Adon well two wildcat wells were drilled in the Spotted Horse area. The first deep test in the north-central Powder River Basin, the Shell Oil Company's Clear Creek No. 1 well (Severy and McLarty refer to this well as Shell Oil Company's Unit No. 1), was located in sec. 11, T. 57 N., R. 78 W., Sheridan County on the basis of surface and seismic information. The well, completed June 28, 1949, bottomed in Cambrian rocks at a depth of 12,215 feet below the surface. A slight show of oil was reported from Mississippian strata.⁴⁷ The Spotted Horse Syndicate's Fringle No. 1 well in sec. 21, T. 55 N., R. 74 W., Campbell County was abandoned April 6, 1950 in the

⁴⁶C. L. Dorn, "Developments in Rocky Mountain Region in 1948," Am. Assoc. Petroleum Geologists Bull., XXXIII (1949), 630.

⁴⁷C. L. Severy and D. M. E. McLarty, "Developments in Rocky Mountain Region in 1949," Am. Assoc. Petroleum Geologists Bull., XXXIV (1950), 1039.

Sundance (Jurassic) at a depth of c. 503 feet below the surface. No shows of oil or gas were reported.⁴⁸

According to a trade journal the first commercial production of oil reported in Sheridan County is from the No. 1 Elsie Barry well, drilled in early 1952 by J. Ray McDermott and Company in the SW $\frac{1}{4}$ sec. 24, T. 58 N., R. 85 W. The well encountered two producing zones in the Shannon sandstone member of the Steele shale (Upper Cretaceous). The upper zone, 4,715 to 4,721 feet below the surface, yielded 160 barrels of 31.5 gravity oil and 40 barrels of water during 36 hours of swabbing; and the lower zone, 4,746 to 4,750 feet below the surface, yielded 240 barrels of 31.5 gravity oil and 60 barrels of water during 48 hours of swabbing.

⁴⁸C. L. Severy and D. M. E. McLerty, "Developments in Rocky Mountain Region in 1950," Am. Assoc. Petroleum Geologists Bull., XXXV (1951), 1171.

Natural gas, probably derived from coal, has been encountered by several shallow wells drilled in the southeastern part of the coal field and in areas adjacent to the Powder River and Clear Creek. The gas occurs in beds of sandstone at various stratigraphic levels of the Tongue River member of the Fort Union formation. Three shallow wells in Tps. 54 N., Rs. 73 and 74 W. (Plate II) encountered large flows of gas. Statistics on these wells are presented in the following table.⁴⁹

Table 1.--Statistics on three gas wells in the southeastern part of the Spotted Horse coal field, Wyoming

Name of Well and Location	Total Depth (feet)	Depth of Gas Sand (feet)	Initial Production (cubic feet)
Hay Creek Well SW $\frac{1}{4}$ sec. 8, T. 54 N., R. 73 W.	245	223-229	1,000,000
Hay Creek Well SW $\frac{1}{4}$ sec. 20, T. 54 N., R. 73 W.	415	395-415	1,000,000
NW $\frac{1}{4}$ sec. 12, T. 54 N., R. 74 W.	?	263- ?	500,000

Gas from some wells is captured in water-sealed tanks and used for domestic purposes. Gas from a well in the SE $\frac{1}{4}$ sec. 30, T. 58 N., R. 75 W. (Plate I) has been used at the W. F. Dobrenz ranch since 1916. The gas pressure in this well is reported by the owner to be sufficient to lift a weight of 600 pounds.

⁴⁹From unpublished information in the files of the U. S. Geol. Survey (Fuels Branch, Washington, D. C.).

THE COAL BEDS

Coal beds in the Spotted Horse field occur in the Tongue River member of the Fort Union formation and in the overlying Wasatch formation. The oldest beds in the area are exposed in the Powder River Valley near the Montana-Wyoming state line, and the youngest crop out near the tops of the highest buttes and divides in the southern part of the field. Beds containing 2 feet or more of coal were examined and mapped, and their outcrops are shown on Plates I and II. Numbered localities along the outcrops indicate points where sections were measured.

The coal beds, carbonaceous shale, and carbonaceous sandstone occur in zones. Within a zone the coal may show intricate gradations with the sediments. A coal bed near the middle of a zone at one locality may elsewhere be in the upper or lower part of the zone. Thin shale partings in a coal bed may intergrade or thicken to split the coal into several stringers which may eventually pinch out. Owing to variations in the position of coal beds in the zones and to thickness changes in rocks between carbonaceous zones, intervals between coal beds are not constant.

Identification of Tongue River coal beds in this report is by correlations with beds in the nearby northward extension of the Sheridan coal field, Montana; and Wasatch coal beds are identified by correlations with beds in the Powder River coal field, Wyoming, which adjoins the Spotted Horse field on the west and south. Plate V is a correlation chart of the principal coal beds of the Spotted Horse and nearby coal fields.

The following generalized section shows the most important coal beds in the Spotted Horse field. Some of the beds are important because of the large reserves they contain; others, because they are correlated with coal beds of nearby fields and therefore are valuable for regional studies. Many coal beds of local extent, associated with these beds, are less important because they are thin and discontinuous and represent only a small part of the total coal reserves in the area. The crop lines of the coal beds are shown on Plates I and II; however, only the most extensive beds will be discussed in this report.

Generalized section showing the most important coal beds in the
Spotted Horse coal field

Coals of the Wasatch formation: Feet

Ulm No. 1 bed	
Interval- - - - -	75
Ulm No. 2 bed	
Interval- - - - -	65
Scott bed	
Interval- - - - -	190-280
Kelix bed	
Interval* - - - - -	425
Arvada bed	
Interval* (to Roland bed) - - - - -	65

Coals of the Tongue River member of the Fort Union formation:

Roland bed	
Interval* - - - - -	180
Smith bed	
Interval- - - - -	160
Anderson bed	
Interval- - - - -	75
Dietz No. 1 bed	
Interval- - - - -	85
Canyon bed	
Interval- - - - -	290
Wall bed (lowest exposed in Spotted Horse field)	

*Intervals apply only to northern part of coal field
as Arvada and Roland beds are absent in southern
part.

Coal

Physical Properties

The coal of the Spotted Horse field is classified as lignite and subbituminous in rank. It generally has a woody texture, conchoidal fracture, and dark brown streak. Freshly exposed coal is shiny black and hard. On exposed surfaces the coal rapidly loses moisture, and in a relatively short time it slakes to fine black dust and irregularly shaped granules. Long-distance shipping therefore is not feasible. Coal stored by ranchers for domestic use is kept in closed bins where it may be stored for several months without disintegrating.

Silicified and "ocherized" pieces of wood were noted in the coal at many outcrops, and silicified tree stumps with roots extending into the underlying sediments were found in many thin coal beds and near the base of thick beds. The stumps seldom extend more than 1½ feet upward from the floor of a coal bed.

Chemical Properties

No analyses of the coal in the area of this report were available at the time the area was examined, and it was not considered practicable to take samples for analyses because there were no mines operating within the area from which un-weathered samples of coal could be collected; however, the general quality of the coal is suggested by the following table of analyses from nearby areas.

Form A is the approximate composition of the coal as it is mined, B is the composition with moisture excluded, and C is the composition with moisture and ash excluded.

TABLE 11. SELECTED ANALYSES OF COAL FROM SOME COAL FIELDS IN NORTHEASTERN WYOMING AND SOUTHEASTERN MONTANA

SOURCE	LABORATORY NUMBER FOR SAMPLE	AIR DRYING LOSS	FORM OF ANALYSIS	PROXIMATE				ULTIMATE					HEATING VALUE		CLASSIFICATION BY RANK ACCORDING TO AMERICAN SOCIETY FOR TESTING MATERIALS
				MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULPHUR	HYDROGEN	CARBON	NITROGEN	OXYGEN	CALORIES	BRITISH THERMAL UNITS	
WILDHORSE MINE, SEC. 24, T.54N., R.77W.; ARVADA (?) COAL BED	D-20225	13.3	A	28.6	29.9	33.1	8.4	1.6	6.5	46.0	.9	36.6	4,439	7,990	LIGNITE OR SUBBITUMINOUS C COAL (54-87) ^{2/}
			B		41.9	46.3	11.8	2.2	4.6	64.3	1.3	15.8	6,217	11,190	
			C		47.5	52.5		2.5	5.2	73.0	1.5	17.8	7,044	12,680	
PEERLESS MINE, CAMPBELL COUNTY, WYO.; ROLAND COAL BED	A-2640	18.0	A	33.3	29.0	31.8	5.9	.5	6.8	45.7	.6	40.5	4,317	7,770	LIGNITE (53-83) ^{2/}
			B		43.4	47.7	8.9	.8	4.7	68.5	1.0	16.1	6,472	11,650	
			C		47.7	52.3		.8	5.2	75.2	1.1	17.7	7,100	12,780	
MONARCH MINE, MONARCH, WYO.; MONARCH COAL BED	C-11137- C-11139	13.2	A	21.5	32.1	35.2	11.3	1.3	6.1	49.8	1.1	30.3	7,100	8,740	SUBBITUMINOUS B COAL (54-110) ^{2/}
			B		40.9	44.7	14.4	1.9	4.7	63.3	1.6	14.3	6,183	11,130	
			C		47.7	52.3		2.5	5.5	74.0	1.6	16.8	6,944	12,500	
MOORHEAD DAM PROJECT (DRILL CORE HOLE C-3) BROADUS (?) BED	C-92753- 92754	15.1	A	27.9	30.3	35.8	6.7	.9	6.5	49.2	.9	36.6	4,711	8,480	SUBBITUMINOUS C COAL (55-91) ^{2/}
			B		42.0	49.7	8.2	1.1	4.6	68.2	1.2	16.5	6,533	11,760	
			C		45.8	54.1		1.2	5.1	74.4	1.4	17.9	7,122	12,820	
LAKE DESMET PROJECT, BUFFALO, WYO. (BUREAU OF RECLAMATION DRILL CORE HOLE NO. 7)	C-97450	6.7	A	23.6	31.9	34.8	9.7	1.0	6.1	48.3	.7	34.2	4,594	8,270	SUBBITUMINOUS C COAL (53-92) ^{2/}
			B		41.7	45.6	12.7	1.3	4.6	63.2	1.0	17.2	6,017	10,830	
			C		47.8	52.2		1.5	5.2	72.4	1.1	19.8	6,889	12,400	
NORTH STAR MINE, COALWOOD, MONTANA. BROADUS BED	C-75924	21.7	A	33.9	28.5	31.5	6.1	.3	6.7	43.2	.7	43.0	4,056	7,300	LIGNITE (53-78) ^{2/}
			B		43.1	47.7	9.2	.4	4.4	65.4	1.1	19.5	5,778	11,040	
			C		47.5	52.5		.5	4.9	72.1	1.2	21.3	6,756	12,160	
SWEAT AND SMITH MINE, NE.1/4 SEC. 13, T.55N., R.78W. ARVADA BED.	6798 ^{1/}	8.7	A	18.3	34.6	40.7	6.4	1.2	5.7	53.9	1.1	31.8	5,115	9,207	SUBBITUMINOUS B COAL (55-99) ^{2/}
			B		42.4	49.8	7.8	1.4	4.4	66.0	1.3	19.1	6,261	11,270	
			C		46.0	54.0		1.5	4.8	71.6	1.4	20.7	6,791	12,224	

^{1/} SAMPLE FROM SLIGHTLY WEATHERED COAL.^{2/} PARENTHESIS SIGNIFIES THAT THE CONTAINED NUMBERS ARE ON THE MINERAL-MATTER-FREE BASIS. THE FIRST NUMBER REPRESENTS FIXED CARBON ON THE DRY BASIS, REPORTED TO THE NEAREST WHOLE PER CENT. THE SECOND NUMBER REPRESENTS BTU. (TO THE NEAREST HUNDRED).

Burning of Coal Beds

In many parts of the Spotted Horse area coal beds have burned at the outcrop and beneath shallow cover. The extent of burning depends on the quality and thickness of the coal, the presence or absence of water in the coal bed, and the porosity and thickness of the cover. As a result of the burning, overlying rocks were baked or even fused to produce clinker. The clinker generally is red, but locally, it may be violet or purple. Because of its appearance it is called "porcelanite," "scoria," "red shale," "lava rock," and "slag." The formation of clinker and the physical and mineralogical changes accompanying the process have been described by Rogers.⁵⁰

Extensive burning of coal beds has produced abundant clinker that now surfaces the high, even-crested divides and buttes in the north-eastern and south-central parts of the field. The clinker generally forms patches and discontinuous bands along the burnt outcrops of coal beds. Most of the burning of the coal beds probably occurred during the Recent. At localities in secs. 15 and 16, T. 57 N., R. 76 W.; sec. 6, T. 56 N., R. 76 W.; and sec. 19, T. 57 N., R. 74 W. (Plate I) the coal is still burning. Clinker eroded from local sources is present in the low terrace deposits bordering Powder River and Clear Creek; but none was observed in deposits more than 100 feet above the levels of these streams. If clinker were present in the higher terrace deposits at the time of deposition it has since been weathered beyond recognition.

⁵⁰G. S. Rogers, "Baked Shale and Slag Formed by The Burning of Coal Beds," U. S. Geol. Survey Prof. Paper 108-A (1918), pp. 1-10.

Coals of The Tongue River Member of The Fort Union Formation

Wall bed.--The Wall bed, the oldest coal bed exposed in the Spotted Horse field, occurs about 300 feet below the top of the Tongue River member just as it does in the nearby northward extension of the Sheridan coal field. It crops out for a short distance in the north-central part of the area (Plate I) low in the valley of the Powder River. The gentle southward dip of the rocks and the northward slope of the valley floor bring the Wall bed below river level in sec. 30, T. 58 N., R. 75 W.

The thickness of the coal could be measured at only two localities. A partially exposed section at locality 315 in sec. 19, T. 58 N., R. 75 W. shows 12 feet 5 inches of coal with a 2-inch parting near the top.

Eastward the bed splits into two relatively thin benches of coal which, at locality 319 in sec. 18, T. 58 N., R. 75 W., are about 12 feet apart.

Canyon bed.--The Canyon coal bed, about 290 feet above the Wall bed, is best exposed in the north-central and northeastern parts of the field. The coal has burned along much of its outcrop to produce thick clinker which now forms a bench on the sides of the Powder River, Fence, Bitter, and S A Creek valleys and caps small flat-topped buttes that overlook these streams. The Canyon bed passes below the floor of the Powder River Valley in sec. 30, T. 57 N., R. 76 W. (Plate I) but is lifted and exposed for a short distance about a mile further southward by a small normal fault. Coal of the Canyon bed is very lenticular and at many places is not mappable. Thickest sections were measured at locality 375 in the NE $\frac{1}{4}$ sec. 29, T. 57 N., R. 76 W. (Plate I), where the bed is 23 feet 1 inch thick with a 5-inch shale parting near the middle, and at locality 336 in the SE $\frac{1}{4}$ sec. 28, T. 58 N., R. 75 W.

(Plate I) where the bed contains 22 feet 3 inches of coal, free of partings. The Canyon bed is excellently exposed for several hundred yards along the west bank of the Powder River in the $\frac{1}{2}$ sec. 20, T. 57 N., R. 76 W. (Figure 10). Here, at locality 376, an incomplete section, overlain unconformably by alluvium, shows 18 feet 3 inches of coal with an 8-inch parting in the upper $1\frac{1}{2}$ feet.

Dietz No. 1 bed.--Coal of the Dietz No. 1 bed forms several lenses about half-way between the Canyon and Anderson beds in the north-central and northeastern parts of the area. Small patches and bands of clinker have been produced by the burning of the thickest parts of the coal. The bed rarely exceeds 10 feet in thickness, and at many places it contains partings. The thickest and most persistent coal at this horizon was mapped in the area bordering Buffalo (T. 58 N., R. 74 W.), Fence, and Bitter Creeks andutte Prong of Bitter Creek in the northeastern part of the coal field.

Anderson bed.--The Anderson bed occurs about 160 feet above the Canyon and 75 feet above the Dietz No. 1 beds. Coal and clinker mark the outcrop of the Anderson coal over much of the north-central and northeastern parts of the Spotted Horse area and in the valleys of Spring, Squaw, Hay, and Horse Creeks near the southeastern border. Anderson clinker, as much as 100 feet thick, caps high buttes and even-topped ridges that rise above the Powder River near the state line, and overlook Buffalo (T. 58 N., R. 74 W.), Dry, and Bitter Creeks. Elsewhere in the area the coal is protected from extensive burning by a thick cover of sediments, and clinker occurs only in a narrow band, rarely more than 200 yards wide. The Anderson bed is well exposed in

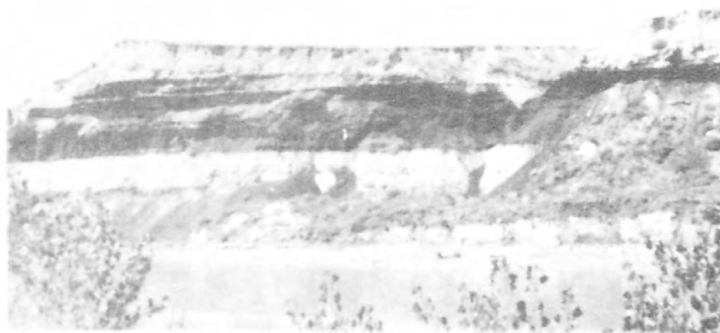


Figure 10. CANYON COAL BED EXPOSED IN THE WEST BANK OF THE POWDER RIVER AT LOCALITY 376 IN SEC. 20, T. 57 N., R. 76 W.

Man standing on the base of the bed near the center of the picture affords a comparative scale for measurement.



Figure 11. ANDERSON COAL BED EXPOSED IN THE EAST BANK OF THE POWDER RIVER AT LOCALITY 710, SEC. 18, T. 56 N., R. 76 W.

the east bank of the Powder River at locality 710 in sec. 18, T. 56 N., R. 76 W. (Figure 11) but passes below the ground in sec. 24, T. 56 N., R. 77 W. (Plate I). Exposures of unburned coal were found in many parts of the area, but at some of the localities the base of the bed was not exposed. The Anderson coal has an average thickness of about 15 feet and contains the largest reserves of coal for any bed in the Spotted Horse field. The thickest section was measured at locality 557 in the west-central part of sec. 2, T. 57 N., R. 75 W. (Plate I) where 26 feet of coal at the top is separated from 6 feet 8 inches of coal at the base by a 12-foot covered interval. At locality 596 in the SW $\frac{1}{4}$ sec. 26 of the same township 31 feet of coal is exposed, but at locality 360, about 1 $\frac{1}{2}$ miles north of locality 557, the bed is only 6 feet 5 inches thick and contains a 10-inch parting near the middle of the section. Along the valley of S A Creek, in secs. 22 and 28, T. 56 N., R. 74 W. (Plate I), the Anderson bed consists of interstratified layers of sandstone and carbonaceous shale, and elsewhere in this general vicinity the coal is abnormally thin. The only outcrop near the southeastern border of the area where the thickness of the coal could be measured is at locality 1424 in the NE $\frac{1}{4}$ sec. 16, T. 54 N., R. 73 W. (Plate II) where 18 $\frac{1}{2}$ feet of coal is split by 3 partings which total 11 inches in thickness.

Smith bed.--The Smith bed, about 160 feet above the Anderson, is one of the most persistent units in the area. It commonly crops out high on the even-topped ridges and buttes in the eastern part of the coal field and at lower elevations on steep valley sides in the central and western parts. Throughout the southern half of T. 56 N., R. 75 W.

(Plate I) the coal averages about 10 feet in thickness, and in a small area embracing parts of Tps. 53 and 54 N., R. 73 W. (Plate II) it is about 12 feet thick. Short distances northward and southward from here, however, the bed thins to less than 5 feet and locally pinches out completely. Partings were noted in the coal at many localities in the southwestern half of T. 56 N., R. 77 W. (Plate I) and at several localities in T. 56 N., R. 76 W. (Plate I) the bed splits into two benches of coal separated by 1 to 25 feet of sediments. The coal thins northwestward and is not mappable in the northern part of T. 57 N., R. 77 W. and T. 58 N., R. 77 W.

Thick, massive, cliff-forming, grayish-yellow beds of sandstone crop out above and below the Smith bed throughout most of its extent. In T. 56 N., R. 76 W. (Plate I) the bed is underlain by a thick, light bluish-gray sandstone which forms steep slopes above the mouth of Spotted Horse Creek. Because of their prominence and color these slopes locally are referred to as "the blue wall." Baker⁵¹ noted the occurrence of a "soft steel-gray sandstone" at about the same stratigraphic position in the southern part of the northward extension of the Sheridan coal field.

(Roland bed.)--The Roland bed, the uppermost coal of the Tongue River member, is about 180 feet above the Smith bed. A fossiliferous zone, as much as 30 feet thick, occurs above the coal at intervals ranging from a fraction of an inch to about 30 feet and affords an excellent criterion in the identification of the bed. Coal of the Roland bed forms several lenses which crop out near the crests of high divides

⁵¹ A. A. Baker, op. cit., p. 35.

and buttes, principally in the area west of the Powder River and Clear Creek. East of the streams Roland coal occurs in only a few small patches, the easternmost of which is in a small knoll high on the S A-L X dar Creek Divide in sec. 30, T. 57 N., R. 75 W. (Plate I). The thickest section of coal, about 6 feet, was found in T. 58 N., R. 77 W. and in the northern part of T. 57 N., R. 77 W. (Plate I). Southward and eastward from this area it thins and grades into shale within a few miles.

A coal bed about $3\frac{1}{2}$ feet thick which crops out along Clear Creek in sec. 31, T. 56 N., R. 77 W. (Plate I) was believed by Stone and Lupton⁵² to be equivalent to the Roland of the Powder River field. However, it probably is the local bed which is exposed at locality 454, about 100 feet below the horizon of the Roland.

Coals of The Wasatch Formation

Arvada bed.--The Arvada coal bed occurs near the base of the Wasatch formation. It is about 65 feet above the Roland bed. With the exception of small patches near the tops of several high buttes and ridges in T. 56 N., R. 76 W., outcrops of the Arvada bed are limited to the high divides west of Powder River (Plate I). In the westernmost tier of townships coal of the Arvada usually is less than 5 feet thick and contains partings. The coal thickens and becomes cleaner to the east, and in the area of the Powder River and Clear Creek it averages about 7 feet thick and rarely contains partings. The maximum observed thickness of 11 feet 11 inches of coal is at locality 478 in the NW₄

⁵² R. W. Stone and C. T. Lupton, op. cit., p. 122.

sec. 35, T. 56 N., R. 76 W.

3) Felix bed.--The Felix bed was traced from the Powder River coal field into the southern part of the Spotted Horse field. South and west of U. S. Highway 14 and 16 the Felix bed crops out near stream levels. In T. 55 N., R. 74 W. (Plate I) coal and clinker of the bed crop out on several small buttes and ridges 180 to 200 feet high. The Felix occurs about 160 to 180 feet above the base of the Wasatch formation in the area east of the Powder River-Little Powder River Divide, but this interval increases to as much as 400 feet westward due to thickening of sediments below the Felix. Throughout most of the area the Felix is overlain by a thick cover of sediments and thus, is protected from burning. The Felix contains the largest coal reserves of any coal bed in the Wasatch formation. It has an average thickness of about 15 feet. At many places the coal contains partings; some of them, persistent. Bony coal occurs near the base of several sections in Tps. 54 N., Rs. 74 and 75 W. (Plate II). The thickest section was measured at locality 1322 in sec. 15, T. 53 N., R. 75 W. (Plate II) where the bed contains 31 feet 5 inches of coal and 4 partings totaling 6 feet 5 inches in thickness. At locality 1162 in sec. 35, T. 54 N., R. 75 W. (Plate II) the coal is 28 feet 4 inches thick with no partings. About 15 feet of Felix coal is well exposed in a narrow ridge at locality 1292 a few feet north of the county road in sec. 2, T. 53 N., R. 75 W. (Figure 12).

A thin coal bed, about 425 feet above the Arvada coal bed, in the southwestern parts of Tps. 56 N. and 57 N., R. 78 W. (Plate I) is tentatively correlated with the Felix bed.



Figure 12. FELIX COAL BED EXPOSED AT LOCALITY 1292 IN SEC. 2,
T. 53 N., R. 75 W.



Figure 13. STONE BUILDINGS AT THE K RANCH IN SEC. 1, T. 56 N.,
R. 77 W.

Sandstone used to construct buildings was taken from outcrops
in secs. 13, 14, and 24, T. 57 N., R. 76 W.

Scott bed.--The Scott coal bed is named from an exposure at locality 1502 in the NE₄ sec. 14, T. 53 N., R. 74 W. (Plate II) about one mile northwest of the Harola v. Scott place. Here it occurs about 190 feet above the Felix; however, the interval increases westward and is about 280 feet in the western parts of Tps. 53 and 54 N., R. 75 W. (Plate II). The bed is limited in extent to the area south and west of U. S. Highway 14 and 16 (Plate II). It is persistent, but generally is less than 4 feet thick. At a few places, however, it is as much as 10 feet thick. The coal commonly contains shale partings, and at some localities fossil wood was found in the bed.

Ulm No. 2 bed.--The Ulm No. 2 coal bed, which is about 65 feet above the Scott bed, crops out near the tops of the divides south and west of U. S. Highway 14 and 16 (Plate II). The coal has burned at many places to form a thick clinker which caps the highest buttes and ridges. The largest areas of unburned coal are in the southern parts of Tps. 53 N., Rs. 74 and 75 W. where the coal is overlain by 30 to 60 feet of cover. The maximum observed thickness of the coal is 21 feet at locality 1517. East of Windmill Draw its average thickness is about 12 feet. The coal thins westward to about 4½ feet in the western part of T. 53 N., R. 75 W. where it commonly contains partings and much fossil wood.

Ulm No. 1 bed.--The Ulm No. 1 coal bed, 75 feet above the Ulm No. 2 bed, has an areal extent of about 1 acre beneath a small, high butte in sec. 14, T. 53 N., R. 75 W. (Plate II). Here, it consists of 10 feet 10 inches of coal which is overlain by 9 feet of cover. Elsewhere in the Spotted Horse field it has been removed by erosion.

Tonnage Estimates of Coal Reserves*

Coal beds thicker than 2½ feet in the Spotted Horse field contain an estimated 12,060,200,000 short tons of coal. About 10,305,400,000 tons occur in the Tongue River member of the Fort Union formation and 1,754,800,000 tons in the Wasatch formation. Of the Tongue River reserves 7,801,880,000 tons, about 76%, are in 3 beds; the Canyon bed with 2,995,560,000 tons, the Anderson bed with 3,861,330,000 tons, and the Smith bed with 1,356,220,000 tons. About 77%, or 1,356,220,000 tons, of the Wasatch reserves are in the Felix coal bed. Local beds of the two formations contain about 1,600,000,000 tons of coal.

*Calculated by H. L. Berryhill and D. A. Taylor, U. S. Geological Survey.

CONSTRUCTION MATERIALS

Construction materials consisting of clinker, sandstone, shale, gravel, and sand occur in many parts of the coal field. Clinker which is abundant in most parts of the area is used as road metal and railroad ballast. Well-indurated sandstone which crops out in secs. 13, 14, and 24, T. 57 N., R. 76 W. was used in the early 1900's in constructing stone buildings at the L X bar and K (Figure 13) ranches. Beds of medium-gray, waxy, silt-free, hackly shale, as much as 4 feet thick, which occur beneath many coal beds in many parts of the area, may be suited for use as fire clay.

An investigation of rocks for use as riprap and concrete aggregate in the construction of the proposed Moorhead dam was conducted in August 1950 by the United States Bureau of Reclamation.⁵⁴ Many rock samples were collected and were examined and tested in order to determine their composition, specific gravity, absorptive capacity, resistance to abrasion, resistance to weathering, and durability under freezing and thawing conditions. Clinker collected along the Powder River and Bitter Creek, short distances south of the state line, has a low density, variable hardness, and low resistance to abrasion. It ranges from poor to fair as riprap and is unsuitable as a concrete aggregate. Samples of sandstone collected in the vicinity of the dam site show little variation in composition but under tests show wide variation in physical qualities. As riprap the sandstone ranges from

⁵⁴Inventory of Sand, Gravel, and Riprap Deposits of The Yellowstone District (unpublished, 1951), in the files of the United States Bureau of Reclamation, Region 6; Billings, Montana.

inferior to fair. Some is suitable for use as concrete aggregate provided it is properly graded and an air-entraining agent is used.

Gravel deposits near the Jackson ranch in sec. 31, T. 56 N., R. 76 W. (Plate I) are unsuitable as concrete aggregate because they contain about 6 to 26 percent of physically unsound material, although the deleteriously reactive portion is insignificant. Other gravel deposits in the Spotted Horse area were not tested by the Bureau. Concrete cylinders made from gravels collected from the bed of the Powder River about 3 miles north of the state line showed poor durability when subjected to freezing and thawing conditions.

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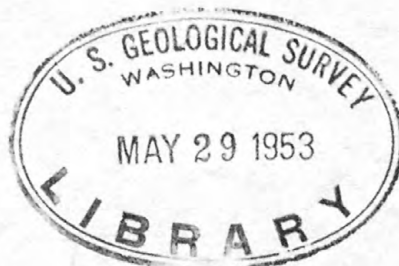
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12. Spotted Horse coal field, Sheridan and Campbell Counties, Wyo., by W. W. Olive, 77 p., 21 illus., 2 tables.

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