Economic Geology, v. 3, pp. 77-99

SOUTHERN EXTENSION OF THE KOOTENAI AND MONTANA COAL-BEARING FORMATIONS IN NORTHERN MONTANA.[1]

CASSIUS A. FISHER.

CONTENTS.

INTRODUCTION.

The object of this paper is to set forth the result of recent observations made on certain coal-bearing formations in southern Montana and northern Wyoming, and their correlation with formations in northern Montana which have been studied in a detailed way by Stanton, Hatcher, Newberry, the writer and others. In previous investigations of the geology of southern Montana and northern Wyoming no attempt has been made to fix stratigraphically the line between the Lower and Upper Cretaceous rocks, the term Cloverly being applied to all sediments lying between the top of the Morrison and the base of the Colo-

[1] Published by permission of the Director of the U. S. Geological Survey.

rado formations. Similarly, no subdivisions of the Montana had been recognized in this region, the entire group having been included in the so-called Pierre, Fox Hills and Laramie formations.

During the summer of 1906, while engaged in a detailed survey of the coal deposits of the Great Falls region for the purpose of the classification of the coal lands, under the general supervision of Mr. M. R. Campbell, a special study was made of the Kootenai formation, which contains the only workable coal bed in the field. Fossils were collected from a number of different horizons which not only verified the Kootenai age of these rocks, but proved that the Kootenai formation is thicker in this region than previously supposed. During the past season more extensive surveys of coal deposits in central Montana and northern Wyoming by parties of the United States Geological Survey, with which the writer was associated, afforded an excellent opportunity for a regional study, not only of the Kootenai, but also of the Upper Cretaceous, especially the subdivisions of the Montana group, in the lower part of which valuable coal deposits are found. In this regional study, which extended across southern Montana and northern Wyoming, a number of detailed sections were measured of the Kootenai formation, fossils collected, and a careful study made of the sequence of the beds. By this means it was possible to trace the formation southeastward from the Great Falls region to the southern part of the Bighorn basin in Wyoming. In a similar manner the subdivisions of the Montana group, the Eagle, Claggett, Judith River, and Bearpaw formations, as worked out by Stanton and Hatcher[1] in the Missouri River region of central Montana, were definitely recognized as far south as the Montana-Wyoming line.

DESCRIPTION OF FORMATIONS.

KOOTENAI FORMATION.

General Statements.—The name Kootenai, after a tribe of Indians who hunted in the southern Canadian Rockies, was first proposed in 1885 by Dr. George M. Dawson, to apply to beds

[1] Stanton, T. W., and Hatcher, J. B., Bull. No. 257, U. S. Geol. Survey, 1905.

consisting of sandstones, shales, and shaly sandstones in which there are occasional layers of conglomerate, also a zone of workable coal beds. The area originally described was located along the Rocky Mountain front range in Alberta, between the forty-ninth parallel and Medicine Bow River, including an area about 140 miles long and 40 miles wide. Plants collected from this locality were reported on by Sir William Dawson, who gave twenty-two forms, including new species in four different genera. In the first publication in which the formation receives its name, and where a list of fossils from the beds is given, the following statements concerning the age of the beds are made by Sir William Dawson: "The Kootenai series should probably be placed at the base of the table as a representative of the Urgonian or Neocomian, or at the very least should be held as not newer than the Shasta group of the United States geologists and the lower sandstones and shales of the Queen Charlotte Islands. It would seem to correspond in the character of its fossil plants with the oldest Cretaceous floras recognized in Europe and Asia, and with that of the Kome formation in Greenland, as described by Heer."

In 1887, two years after the formation was described by Sir William Dawson in the Canadian regions, Dr. J. S. Newberry found fossil plants in the coal-bearing rocks of the Great Falls region, which enabled him to make the definite statement that these rocks were of the same age as those north of the International Boundary Line, described by Dr. George M. Dawson, and designated the Kootenai series. Following this first discovery by Dr. Newberry, additional fossil plant collections were made from these coal-bearing rocks of the Great Falls region by Messrs. Peale, Knowlton, Weed, Ward, and others, which materially increased the number of species from this locality. Prior to the investigation of this region by Weed,[1] no attempt had been made to give a stratigraphic limit to the beds of Kootenai age in this locality, the chief interest being centered on the descriptions of the flora and the correlation of the rocks in which it was found with other localities, although fossil plants had been collected

[1] Weed, W. H., Geologic Atlas, U. S. Geol. Survey, folio 55, 1899.

from more than one geologic horizon. In Weed's report, about 300 feet of beds, constituting, what he called, the Cascade formation, were regarded as of Kootenai, or Lower Cretaceous age. During the field season of 1906 large collections of fossil plants were made by the writer at various horizons, which demonstrated that the Kootenai rocks of the Great Falls region are not only thicker than previously supposed, but that they probably constitute all the sediments between the Morrison formation and Colorado shale in the vicinity of Great Falls, and that the Dakota, or lowest member of the Upper Cretaceous, is probably absent from this district.

Great Falls Region.—In the Great Falls region the Kootenai formation consists of alternating layers of gray, medium to coarse-grained pebbly sandstone and red, sandy shale and clay, with the sandstone predominating, especially in the lower half. Limestones, generally concretionary, occur at different horizons throughout the formation. The sandstones vary in thickness from 10 to 90 feet, and are more or less massive in character. In the upper part the red shale predominates and is interbedded with thin layers of impure sandstone. The succession of beds in the Kootenai formation, compiled from exposures on both the east and west sides of Belt Creek at Belt, is given below:

SECTION OF KOOTENAI FORMATION AT BELT, MONT.

	Feet.
Shale, red, somewhat arenaceous, with thin-bedded sandstone members in lower portion	190
Limestone, light, brown, compact, fossiliferous	5
Shale, reddish, arenaceous, and sandstone, red, laminated; shale predominating	29
Sandstone, gray, weathering light brown; coarse-grained, massive,	13
Concealed	19
Sandstone, gray, pebbly, massive	5
Partly concealed; grayish clay in lower portion	4
Sandstone, lilac-colored	6
Concealed	7
Shale, red and purple	11
Sandstone and shale, red, in alternating layers	11
Sandstone, gray, iron-stained, massive	19
Partly concealed; probably red shale	55
Limestone, gray	2½

	Feet.
Shale, green, sandy, containing layers of impure sandstone	3
Sandstone, gray, massive, cross-bedded	21
Clay and carbonaceous shale in alternating layers	6
Coal	6½
Concealed	60
Total	473

On the north side of Skull Butte, a small laccolithic uplift about 6 miles south of Stanford, Montana, which is located about 35 miles southeast of Belt, the following section of the Kootenai formation was measured:

SECTION OF KOOTENAI FORMATION ON NORTH SIDE OF SKULL BUTTE, MONT.

	Feet.	Inches.
Shale, reddish, sandy		
Sandstone, gray, thin-bedded	1	6
Shale, reddish, sandy, with layers of sandstone in lower part	21	
Sandstone, greenish-gray, weathering dark, thin-bedded above, clay-ball conglomerate below	4	
Shale, reddish, sandy, with layers of sandstone in lower part	27	
Sandstone, gray, cross-bedded, clay-ball conglomerate in lower part	5	6
Shale, reddish, sandy	30	
Sandstone, soft, thin-bedded	20	
Sandstone, gray, massive, clay-ball conglomerate	3	6
Shale, red, sandy	38	
Sandstone, gray, massive, clay-ball conglomerate	5	
Shale, red, sandy	24	
Sandstone, calcareous, alternating with sandy shale	20	
Sandstone, light and dark gray, massive, fine-grained	86	
Coal	6	(Est.)
Sandstone, gray, massive, soft	62	
Total	353	6

Judith Basin Region.—The Kootenai formation in Judith basin, which lies about one hundred miles southeast of the Great Falls coal field, is composed of alternating light-colored massive sandstones and reddish shales with occasional calcareous concretionary members. As a rule the sandstones are not persistent, and often thin materially within a short distance. Where coal occurs in the Kootenai it is usually found in close association

with and immediately underlying the lowermost sandstone, which is the most persistent member of the formation. In thickness the Kootenai is fairly uniform throughout the Judith Basin, being approximately 550 feet. Plant remains of the Kootenai formation in the Judith Basin region have only been obtained in a few localities, but the collections contain a sufficient number of well-chosen species to establish the age of the formation in this region. The succession of the beds in the Kootenai formation at two different localities in the Judith Basin region, namely, at the head of Muddy Creek, west of Garneill, and on the east slope of the South Moccasin Mountains, are given in the following sections, measured by W. R. Calvert and the writer:

SECTION OF KOOTENAI FORMATION AT THE HEAD OF MUDDY CREEK, 7 MILES WEST OF GARNEILL, MONT.

	Feet.
Shale, maroon, sandy, with an occasional thin sandstone layer	200
Sandstone, gray, weathering tan, coarse-grained	8
Shale, maroon, sandy	60
Sandstone, gray, coarse-grained, weathering irregularly, and containing woody fragments	25
Shale, maroon, sandy	72
Sandstone, gray, massive, pebbly	50
Partly concealed; consisting of sandstone members in upper part	42
Shale, grayish-brown, compact	6
Coal	3
Concealed; probably greenish sandy shale	87
Total	553

SECTION OF KOOTENAI FORMATION ON EAST SLOPE OF SOUTH MOCCASIN MOUNTAINS, MONTANA.

	Feet.
Partly concealed, red soil	50
Sandstone, light-colored, coarse-grained, clay-ball conglomeratic	10
Shale, maroon, argillaceous	16
Sandstone, white, soft, cross-bedded	12
Concealed	10
Sandstone	3
Shale, maroon, argillaceous	6
Sandstone	2
Shale, maroon argillaceous	30
Sandstone, light-colored, medium-grained, cross-bedded	18

	Feet.
Shale, maroon, argillaceous	20
Sandstone, light-colored; lower 3 ft. contains small clay-balls	15
Shale, maroon, argillaceous	26
Sandstone, thinly bedded	10
Shale, maroon, containing yellowish clay concretions	15
Sandstone, light-gray, fine-grained, massive, calcareous at top	6
Shale, maroon, with several calcareous members containing clay pebbles	23
Sandstone, white, soft, medium-grained	3
Shale, maroon and light-colored; sandy	6
Sandstone, coarse-grained to pebbly; pebbles chiefly feldspathic with a few dark limestones up to 1 inch	1
Shale, gray sandy	4
Sandstone, gray, coarse-grained to pebbly; cross-bedded	60
Shale; dark, carbonaceous, with thin coal beds	10
Concealed	80
Shale, dark gray	1
Sandstone, iron-stained, calcareous	1
Limestone, argillaceous to sandy, without bedding, and weathering into concretionary forms	2
Shale, light-gray, sandy, upper 2 ft. dark-bluish	8
Total	448

Musselshell River Region. — Along Musselshell River the only locality where rocks occupying the position of the Kootenai were examined was on the south side of a small uplift which is structurally a spur of the Little Belt Mountains, located about six miles west of Martinsdale, Mont. Here exposures were not sufficiently good for a detailed measurement of the formation, but the salient stratigraphic features could be recognized, viz., reddish sandy shale above, alternating with thin sandstone members and massive coarse-grained pebbly and conglomeratic sandstones below, followed in descending order by sandy shale and finally highly colored variegated shale and sandstone, presumably Morrison. The coal bed which might be expected below the pebbly conglomeratic sandstone was not observed in this section, probably owing to poor exposures. Farther east on the south side of Musselshell River near Widdicombe's ranch, there is a small dome-shaped uplift which exposes a part of the supposed Kootenai formation, but no fossil plants were found at this locality, and as only a part of the formation is exposed, no section is here introduced. The rocks consist of red sandy shale

with many iron concretions and highly ferruginous sandstone layers. Lithologically the beds exposed resemble the red shaly members of the Kootenai formation farther north.

Bighorn Basin Region.—In the Bighorn Mountain district of northern Wyoming, about 125 miles south of the Musselshell River, rocks of similar lithologic character and holding the same stratigraphic position, have been designated the Cloverly formation by Darton[1] and later used in the same sense by the writer.[2]

The Cloverly formation in the Bighorn Basin region presents considerable variation in stratigraphy and thickness. In many places a portion of the formation is absent, owing to an erosional unconformity which exists between the Cloverly and overlying Colorado. In certain places, however, for example, on Gypsum Creek and near Thermopolis, the greater part of the formation appears to be present. Wherever the Cloverly formation is typically developed it consists of a massive coarse-grained, cross-bedded, often pebbly sandstone, overlain by maroon sandy shale in which occur bands of chert and sandy material. Above the maroon shale there is another massive cross-bedded tan-colored sandstone which is not so coarse-grained as the basal member of the formation. This sandstone in places is overlain by a few feet of dark-red sandy shale, followed by alternating layers of rust-colored sandstone and sandy shale, the lower part of which should probably be included in the Cloverly formation.

On the south side of No Wood Creek, about 30 miles above its mouth, and 2 miles south of Bell's ranch, there is an exposure of the Cloverly formation which is of unusual interest in the present discussion. The dips are low at this locality and the conditions not favorable for a careful measurement of the thickness of the beds. It is therefore impossible to state just how much of the formation is present, but it is reasonably certain that a part of it is absent, having been removed by erosion. About 100 to 125 feet above the contact of the Cloverly and Colorado formations at this place there occurs a bed of dull colored luster-

[1] Darton, N. H., Prof. Paper No. 51, U. S. Geol. Survey, 1906.
[2] Fisher, C. A., Prof. Paper No. 53, U. S. Geol. Survey, 1906.

less coal of workable thickness which is said to continue for several miles to the south, although it has only been observed by the writer at this locality. In dark-colored shale immediately above this coal bed a small collection of fossil plants was obtained by the writer, which have been studied by Dr. F. H. Knowlton, who pronounces them as of undoubted Kootenai age. About 75 miles farther south, in the southern end of Bighorn Basin near Thermopolis, E. G. Woodruff measured a section of the Cloverly formation, which consists of a heavy basal sandstone member overlain by reddish sandy shale which is followed by another sandstone of slightly less prominence. Sections of the Cloverly formation which were measured on Gypsum Creek and near Thermopolis, points in the extreme north and south ends of the Bighorn Basin, are given below:

SECTION OF CLOVERLY (KOOTENAI) FORMATION ON GYPSUM CREEK, 15 MILES EAST OF FRANNIE, WYO.

	Feet.
Sandstone, rust-colored, alternating with dark shales, containing fresh-water shells	—
Shale, dark purplish	15
Sandstone, gray, massive containing a layer of chert pebbles	70
Concealed; probably shale	25
Shale, bluish, with many limestone concretions containing chert in the lower part of shale	70
Shale, deep maroon	12
Sandstone, pure white, sugary	2
Shale, red, sandy, with gypsum	23
Sandstone, thin-bedded, containing many small pebbles of chert about ¼-inch in diameter	40
Sandstone, strong, hard, bluish-gray, weathering pink and brown; stained red in places; leaf-bearing	50
Total	307

SECTION OF CLOVERLY FORMATION, 3½ MILES NORTH OF THERMOPOLIS, WYO.

	Feet.
Sandstone, gray, massive, weathering tan	9
Shale, blue and drab	9
Sandstone, thin-bedded	5
Shale, variegated	40

	Feet.
Sandstone, light-colored, massive, cross-bedded, with lenses of conglomerate throughout; conglomeratic at base; varies in thickness locally	38
Shale, greenish brown	59
Sandstone, yellowish gray; massive at base; argillaceous in upper portion	130
Total	290

Summary.—The salient stratigraphic features of the Kootenai formation of the Great Falls region are two more or less prominent sandstone members, separated by a red sandy shale in the lower part of the formation, and red shale containing a few thin sandstone beds above. Beneath the lowest prominent sandstone, the workable coal bed occurs underlain by soft sandy shale. The tripartite arrangement of sandstone, red shale, and sandstone in the lower half of the Kootenai formation is a very characteristic stratigraphic feature in the Great Falls and Judith basin region; also farther south in the Cloverly formation of the Bighorn Basin region, as is shown by the accompanying geologic sections of these different localities. The red shale, alternating with thin beds of sandstone, which make up the upper part of the Kootenai in the Great Falls region, appear not to be present in the Bighorn Basin. The absence of this upper member may possibly be accounted for by an erosional unconformity which exists between the Cloverly and overlying Colorado formations, and which in places is believed to have removed a considerable part of the Cloverly.

In the Great Falls region a workable coal bed is found in the lower part of the formation with which is associated plant-bearing, carbonaceous shale of Kootenai age. The same is true of the Cloverly in certain parts of the Bighorn Basin region, as demonstrated by the exposures south of No Wood Creek, where plants of Kootenai age are found in shale immediately above the coal. The presence of these plants establishes the correlation of that part of the Cloverly with the Kootenai formation farther north.

The coal-bearing zone of the Kootenai formation on the west side of the Rocky Mountains, in Alberta, has a thickness of

2,800 feet and contains fourteen possibly workable coal beds. On the east side of the range, where the measures of the Kootenai are very much thinner, they still carry a number of workable coals. In the Great Falls region farther south on the same side of the Rocky Mountain uplift, only one workable coal bed occurs, which in places is separated into two members with a few feet of shale between. In two localities in the Great Falls field a coal bed, a few inches thick has been observed near the top of the Kootenai formation. Coal of workable thickness is not continuous at the main coal horizon in this region, but thins out in places, causing the deposits to occur in certain areas with barren measures between. Farther east in the Judith basin the coal bed is thinner and of poor quality, and the coal areas are more separated. To the southward the coal bed of the lower part of the Kootenai diminishes and in the Musselshell River region, wherever the formation was observed, the coal appears to be absent. Still farther south in the northern part of the Bighorn Basin region, the Cloverly is not coal-bearing in its lower part, but to the southeast, in the exposures near No Wood Creek, coal reappears in the lower part of the formation in a bed of workable thickness. The coal of the Great Falls, Judith Basin, and southern Bighorn Basin regions is believed to be at the same horizon, and it possibly occupies about the same position as the Cambria and Hay Creek coals of the Black Hills district, which occur in rocks of Lower Cretaceous age.

MONTANA GROUP.

General Statements.—The name Montana was first used as a group term by the late George H. Eldridge[1] to include the Fort Pierre and Fox Hills formations in the vicinity of Denver, Colorado. Later it was discussed by Stanton[2] and applied in a similar sense by Cross[3] in the same general region, and still

[1] Eldridge, George H., *Am. Jour. Sci.*, 3d ser., vol. 38, 1889, p. 313.
[2] Stanton, T. W., Bull. 106 U. S. Geol. Survey, 1893, pp. 18, 47–52.
[3] Cross, Whitman, Geologic Atlas U. S., folio No. 7, U. S. Geol. Survey, 1894.

later by Eldridge,[1] Iddings and Weed,[2] Weed and Pirsson,[3] Hague,[4] and others, farther north in Wyoming and Montana. In 1903, as above stated, a detailed study was made by Stanton and Hatcher[5] of the Upper Cretaceous rocks along Missouri and Milk rivers in north-central Montana. The object of this investigation was primarily to determine the position and stratigraphic limits of the Judith River beds in this region. It led, however, to a regional study of the stratigraphy of the Upper Cretaceous in northern Montana, and the recognition of four well-defined subdivisions of the Montana group, namely, the Eagle, Claggett, Judith River and Bearpaw formations. The first two and last are mostly marine, while the Judith River is a fresh-water formation with thin brackish-water beds.

Judith River Region.—Along the Missouri near the mouth of Judith River, where Stanton and Hatcher made a careful study of the Judith River beds, local uplifts occur which expose within a radius of a few miles the entire Montana group. Here the Eagle formation, as described by the above authors, "consists of laminated sandstones and shales, grading down through 30 or 40 feet into the underlying formation, but its most conspicuous member is a heavy bedded or massive, very light yellowish or white cross-bedded sandstone, 100 feet or more in thickness," which weathers into cliffs or steep slopes. "Above the massive white sandstone occur softer beds consisting of sandstone, shales, and many beds and seams of lignites."[6] The total thickness, including the softer beds above, which are here assigned to the formation, is 300 feet. Above the Eagle there are about 400

[1] Eldridge, George H., Bull. 119, U. S. Geol. Survey, 1894, pp. 23–24.

[2] Iddings, J. P., and Weed, W. H., Geologic Atlas U. S., folio 1, U. S. Geol. Survey, 1894.

[3] Weed, W. H., and Pirsson, L. V., Bull. 139, U. S. Geol. Survey, 1896, pp. 47–48.

[4] Hague, Arnold, Geologic Atlas U. S., folio No. 30, U. S. Geol. Survey, 1896.

[5] Stanton, T. W., and Hatcher, J. B., Bull. 257 U. S. Geol. Survey, 1905, pp. 1–174.

[6] The original description by Weed gives about the same limits to the formation at the type locality near the mouth of Eagle Creek on the Missouri about 25 miles above Judith. Geologic Atlas, U. S. Geol. Survey Folio 55, 1899.

feet of beds "consisting largely of dark clay shales with variable intercalated bands and beds of sandstone, especially in the upper half," to which Stanton and Hatcher have applied the name Claggett, after old Fort Claggett, where the formation is well exposed. Marine fossils occur at several horizons, especially in calcareous concretions which abound in dark shales of the lower part of the formation, also the yellow sandstones higher up are often locally very fossiliferous.

Overlying the Claggett formation is the Judith River beds which is composed of "light ash-colored sandstones alternating with usually darker colored and more friable shales and clays, mingled with frequent seams of lignite." The lignite beds, especially those near the top of the formation, in places attain considerable thickness. The most persistent one of these lignite beds occurs very near the top of the formation, and is frequently overlain by a shell breccia consisting mainly of *Ostrea subtrigonalis*. The formation has an average thickness of about 500 feet.

The next formation in ascending order is the Bearpaw shale, so named from the Bearpaw Mountains, around which it is well exposed. It consists of uniformly dark clay and shale, which weather into rounded slopes. Calcareous concretions occur throughout the formation, most of which are fossiliferous, yielding a varied marine invertebrate fauna. The thickness of the Bearpaw in this region is estimated at about 650 feet. On the east side of Cow Creek, a tributary of the Missouri, Stanton and Hatcher obtained a section of Judith River, Claggett and Eagle formations, to which is added a section of the Bearpaw shale obtained from exposures farther west.

The following section shows the succession and general characteristics of the beds in the Montana group as observed in the vicinity of Cow Creek by Stanton and Hatcher:

SECTION OF MONTANA GROUP ON EAST SIDE OF COW CREEK, MONT.

	Feet.
Bearpaw Shale (Marine).	
Clay, dark, weathering into rounded slopes; includes light-colored sand and shale at base	560

	Feet.
Judith River Formation (Fresh-water with some brackish-water beds).	
Sandstone, light ash-colored, alternating with usually darker colored and more friable shale and clay mingled with frequent beds of lignite	490
Claggett Formation (Marine with some brackish-water beds).	
Shale, light-colored, or sandy clay with band of brown sandstone containing Tancredia americana in middle. Top of marine	50
Sandstone, yellowish brown, generally soft, but with harder layers and lenses; fossiliferous	20
Shale, dark, weathering with a reddish tinge; beds are lighter toward the top and the upper 50 feet contains two beds of thin brown sandstone, each 2 to 3 feet thick.	300–400
Eagle Sandstone (Mostly marine).	
No fossils; sand cross-bedded, finely laminated with thin seams of lignite	125
Sandstone; very light-colored, fine, heavy-bedded; thickness variable	40
Sandstone, buff-colored, heavy-bedded, soft at base, but harder above, with indurated lenses and numerous large concretions weathering brown at top; thickness variable	50
Sandstone, buff-colored, heavy-bedded, with lenses of lignite and shale sometimes exhibiting cross-bedding	30
Sandstone, buff-colored, regularly bedded, with several thin seams of dark shale	20

Musselshell River Region.—Along either side of the Musselshell River, which lies about one hundred miles south of the Missouri, the formations constituting the Montana group are well exposed. This region was visited by Stanton and Hatcher at the close of their investigation of the Judith River district, and sufficient paleontologic and stratigraphic evidence obtained to enable them to recognize all subdivisions of the Montana group worked out in the region to the north. During the field season of 1907 detailed surveys were made of the coal deposits of the Eagle and higher Cretaceous formations in the area lying south of Musselshell River by L. H. Woolsey and R. W. Stone, of the United States Geological Survey, with whom the writer was associated. This work afforded an excellent opportunity for a more extensive examination of the Montana group than had previously been made. Detailed sections were measured of the Eagle, Claggett, Judith River and Bearpaw formations, and fossils collected at a number of different localities. Some of these

sections were examined jointly by Drs. Stanton, Knowlton and the writer.

On a tributary of Big Elk Creek which enters that stream from the south, about one and one half miles above Big Elk post office, a careful section of the formations of the Montana group was measured and fossils collected at a number of horizons by Dr. T. W. Stanton and the writer. The Eagle sandstone at this locality consists of sandstone, sandy shale, and clay, with a coaly zone about 7 feet thick in the upper part and a 6-inch seam of coal 18 feet higher in the section. The coal in the 7-foot zone is not workable, owing to the presence of numerous shaly partings. The entire thickness of the Eagle sandstone at this place is about 370 feet, and it contains the usual prominent basal sandstone member. It is overlain by sandstone and sandy shale of the Claggett formation, occurring in alternate succession, which are not materially unlike those of the underlying formation. Marine fossils were collected from the sandstones in the lower part of the Claggett formation, which here has a total thickness of about 830 feet. Overlying the Claggett formation occur the soft sandstones and greenish-gray sandy shales of the Judith River beds. They have a thickness at this place of about 730 feet and contain fresh- and brackish-water fossils. The formation is followed in ascending order by uniformly dark shale of the Bearpaw formation, which contains iron concretions at many different horizons. Some of these contain marine fossils. A complete section of the beds measured at this place is as follows:

SECTION OF MONTANA GROUP ALONG TRIBUTARY OF BIG ELK NEAR LEBO CREEK, MONT.

	Feet.	Inches.
Bearpaw Shale (Marine).		
Partly concealed, but consisting of dark-colored shale in which marine fossils were found near middle; gives rise to pronounced valley	985	
Judith River Formation (Fresh-water with some brackish-water beds).		
Sandstone, gray and green, alternating with olive green shale	42	
Shale, greenish gray, alternating with sandstone	100	

	Feet.	Inches.
Sandstone, dark gray, alternating with shale, dull green, sandstone predominating, and weathering into strike ridges	116	
Shale, dull green, containing an occasional sandstone layer, dark colored and ferruginous	133	
Sandstone, gray, thin-bedded, soft, with an occasional shale layer; fossiliferous at base	98	
Concealed; probably consisting of soft, sandy shale with an occasional sandstone layer	194	
Sandstone, gray, iron-stained at top; thin-bedded, soft; brackish water fossils at base	50	
Claggett Formation (Marine with some brackish-water beds).		
Shale, greenish, sandy; partly concealed	28	
Sandstone, gray, thin-bedded	5	
Shale, green, alternating with thin sandstone layers	34	
Sandstone, gray, massive	10	
Shale, dark green, partly concealed	38	
Sandstone, gray, massive, shaly in lower part	228	
Shale, dull green, sandy, with an occasional sandstone layer	123	
Sandstone, gray, weathering brown, concretionary; alternating with shale, green, sandy	30	
Shale, green sandy	50	
Sandstone, gray, thin-bedded, alternating with shale, dark gray, sandy	67	
Concealed; probably soft sandy shales	84	
Sandstone, gray, weathering brown; thin-bedded, alternating with shale, gray, fossiliferous	28	
Concealed; probably soft gray sandy shale	34	
Sandstone, gray, thin-bedded, producing low strike ridge	6	
Concealed; probably consisting of soft sandy shale	47	
Sandstone, gray, thin-bedded	16	
Eagle Sandstone (Mostly marine).		
Partly concealed, mainly of dark concretionary shale with an occasional sandstone layer	37	
Shale, dark colored		5
Coal		6
Shale, dark colored		6
Sandstone, gray, soft, alternating with shale, greenish, sandy	18	
Coat, impure	7	
Clay, green		3
Sandstone, greenish gray, soft, containing an abundance of plant fragments		7
Concealed	13	
Sandstone, dull gray, soft, partly concealed	294	

Pryor Mountain Region.—Around the west and north sides of Pryor Mountain uplift, at a considerable distance from the base of the mountains, the various formations constituting the Montana group are well developed. The Eagle sandstone, which is exposed as prominent bluffs on either side of the Yellowstone River at Billings, is overlain in successive order by the Claggett, Judith River and Bearpaw formations. No section of the beds has been measured at this place, but the different formations were examined by Drs. Stanton, Knowlton, the writer and others, and sufficient fossils obtained to establish the identity of the formations. From the exposures on the south side of Yellowstone River at Billings, the writer traced the Eagle sandstone to the southeast as far as Coburn where it crosses Pryor Creek, and can be seen extending southeastward as a prominent cliff-making sandstone for a distance of 5 or 6 miles. While no attempt was made to trace this formation farther, it is believed from observations made by the writer north of Parkman and northeast of Saint Xavier Mission, that the Eagle sandstone encircles the northern end of the Bighorn uplift, and extends down the east side of that range. In traveling up the Yellowstone River Valley, west of Billings, prominent bluffs of the Eagle sandstone can be seen at some distance to the north. These can be traced as far west as Park City, where the direction of the strike changes and the sandstones cross the Yellowstone River; extend southeastward past Joliet, Fromberg and Bridger, and continue in the same direction, passing over the low divide between Pryor and Heart mountains into the Bighorn Basin. A detailed section was measured and fossils collected of the Eagle, Claggett, Judith River and Bearpaw formations at Bridger, Montana, by Drs. Stanton, Knowlton and the writer, and later another section was measured by C. W. Washburne and the writer at the north end of Elk Basin, a small anticline on the Montana-Wyoming line 35 miles southeast of Bridger. In both of these localities fossil evidence was obtained sufficient to establish the identity of all four members of the Montana group.

In the Pryor Mountain region the Eagle sandstone as exposed

in the Bridger and Elk Basin sections, consists of massive gray sandstones and sandy shales with coal beds and coaly shale in the upper part. The most prominent feature of the formation here, as elsewhere, is a basal sandstone member which weathers into a prominent cliff with two and in some places three less prominent sandstones above. The second sandstone from the bottom is slightly less massive than the basal sandstone, and between it and the one capping the formation the coaly shales and workable coal bed of the Eagle formation are found. The formation has a total thickness of about 215 feet, and contains marine fossils, especially in the lower part. It is overlain by dark sandy shale, which is here regarded as the basal member of the Claggett. Above this shale massive sandstones, alternating with dark sandy shales, continue to the top of the formation, the individual beds ranging from 25 to 75 feet in thickness. The formation has an average thickness of 435 feet, and its upper limit is marked by the discontinuance of sandstone and the occurrence of soft variegated shale and clay of the Judith River formation. In regions of low dips the latter weathers into badland forms, but when dipping steeply produces sharp ridges. Its average thickness is 370 feet, and it contains a fresh-water fauna. Immediately above the soft variegated beds of the Judith River occurs the uniformly dark colored shale of the Bearpaw formation, which here has a thickness of about 125 feet. The shale contains numerous small iron concretions and thin layers of dark ferruginous sandstone. The concretions are locally fossiliferous, bearing marine forms.

SECTION OF THE MONTANA GROUP NEAR BRIDGER, MONT.

	Feet.
Bearpaw Shale (Marine).	
Shale, dark colored, containing iron concretions and thin layers of sandstone. Both concretions and shale contain marine fossils	123
Judith River Formation (Fresh-water with some brackish-water beds).	
Sandstone, gray, soft; shale, sandy, and lignitic beds in alternating layers, the whole member being capped by 3 feet of thin-bedded brown concretionary sandstone (lig-	

	Feet.
nitic member)	45
Shale, gray, sandy, capped by 5 feet of sandstone, brown, lenticular	25
Sandstone, gray, soft, containing large iron concretions 4 to 6 inches in diameter, with lower portion overlain by greenish brown sandy shale with lignite beds, and capped by thin-bedded brown sandstone which is sometimes concretionary	24
Shale, gray, soft, sandy, capped by thin-bedded sandstone, brown	18
Concealed; probably consisting of light-colored sandy shale.	180
Shales, greenish, brownish, and bluish (sandy) in alternating layers, with lignitic beds capped by sandstone, gray, which is apparently lenticular	96
Claggett Formation (Partly marine).	
Sandstone, gray, massive, weathering into a bold cliff	40
Shale, greenish, sandy, dark at base, containing few sandstone layers	60
Sandstone, gray, massive, weathering to smooth cliffs; fossiliferous	40
Base concealed; probably soft sandstone	38½
Sandstone, gray, massive, fossiliferous at top. Typical Claggett fossils	26
Shale, dark, sandy, and sandstone, weak (in streaks 3 to 4 inches thick) in alternating layers	37
Shale, soft gray, sandy	103
Eagle Sandstone (Partly marine).	
Sandstone, gray, soft at base, hard and massive above, weathering into rounded blocks	21
Clay, light buff-colored, sandy, capped by 1 foot of thin-bedded sandstone	15
Shale, dark, coaly, and coal (with thin streaks of sandstone) in alternating layers. Beds poorly exposed. The Bridger coal probably included in this member	19
Shale, dark-gray, with deep rust-colored iron concretions	7½
COAL	2
Shale, coaly	1½
Sandstone, tan-colored	4
Sandstone, and shale, drab, sandy, in alternating layers	3
Sandstone, greenish brown	1
Shale, dark, lignitic, overlain by shale, dull-green, sandy, with deep-brown iron concretions	32
Sandstone, gray, and shale, lignitic, in alternating layers	16
Shale, gray, sandy	42
Sandstone, gray, massive, weathering into smooth, rounded ledges containing Baculites	50

SECTION OF MONTANA GROUP IN ELK BASIN NEAR CHANCE, WYO.

	Feet.	Inches.
Bearpaw Shale (Marine).		
Shale, dark	25	
Sandstone, strong, thin-bedded	30	
Shale, dark	40	
Shale, sandy, with calcareous concretions, containing marine fossils	5	
Shale, dark	30	
Judith River Formation (Mostly fresh-water).		
Shales and clays, variegated, soft, sandy, bright colors prevailing, especially light green and red; sandstone usually white. Contains Unios	350	
Claggett Formation (Partly marine).		
Sandstone, yellow, massive	40	
Sandstone, thin-bedded, and shale, sandy throughout; sandstone generally weak with few thin strong beds, some clayey shale with coal	120	
Sandstone, yellow, massive, strong	45	
Sandstone, thin-bedded, weak	75	
Sandstone, massive strong	50	
Sandstone, thin-bedded, weak	35	
Sandstone, massive, strong	25	
Shale, sandy, with thin layers of sandstone	70	
Sandstone, thin-bedded	20	
Shale, with persistent white streak 10 feet thick at the base	50	
Eagle Sandstone (Partly marine).		
Sandstone	4	
Sandstone, shaly	10	
Shale, bituminous	3	
Shale, gray	20	
Sandstone, thin-bedded	11	
Sandstone, shaly	1	9
Shale, bituminous	2	8
Shale, bituminous	7	
Coal with thin bone partings	5	6
Sandstone, shaly	3	9
Coal with shale parting near top	2	7
Shale, brown	3	8
Coal, poor, bony	3	11
Shale		6
Sandstone, thin-bedded	31	
Shale, gray, upper 20 feet are yellowish and sandy	55	
Sandstone	50	

Summary.—The stratigraphy of the Montana group in north-

ern Montana presents a number of features which aided materially in tracing out and recognizing its subdivisions farther south along the Montana-Wyoming state line, and into the Bighorn Basin. Briefly, these may be stated as follows: The prominent basal sandstone of the Eagle, usually appearing as a bold bluff above the soft Colorado shale; the presence of sandstones of similar character, although less prominent, in the overlying Claggett formation; the soft gray badlands-making sandstone and sandy shale banded with lignitic beds of the Judith River formation, and the uniformly dark valley-making clays of the Bearpaw formation. South of the state line, in the Bighorn Basin, the paleontologic evidence is as yet insufficient to establish the subdivisions of the Montana group. The most marked variation which has been observed in the various formations of this group from northern Montana to the southward, is a thinning of the Bearpaw shale from about 750 to 130 feet. While the formation is much thinner in the southern region, it still retains its lithologic characteristics of uniformly dark shale with thin sandstone layers. The other formations of the Montana group decrease slightly in thickness to the southward.

The Eagle, Claggett and Judith River formations of Montana and northern Wyoming are believed by Dr. T. W. Stanton to be the approximate stratigraphic equivalents of the Mesaverde formation farther south, while the top member or Bearpaw shale may possibly be the northern representative of the Lewis shale.

The correlation of the coal-bearing formations of the Montana group in northern Montana, with their equivalents farther south, furnishes a valuable clue to the distribution and extent of certain well-known coal-bearing zones. The Eagle formation at Joliet, Fromberg and Bridger, in southern Montana, contains a 4-foot coal bed in the upper part, which has been mined for many years, and farther south along the western side of the Bighorn Basin the Eagle is a very important coal-bearing formation, in places containing two or more workable coal beds. Farther north, in the Musselshell River region, the Eagle contains one coal bed in the upper part which, although persistent, rarely reaches a workable thickness; while still farther north, in the

Great Falls and Judith basin regions, it is not coal-bearing. Throughout the region studied, the Claggett formation contains a few thin coal beds, but they rarely attain a thickness sufficient to be of commercial importance. The Judith River formation in northern Montana contains workable coal beds and also many lignitic shales, but to the south in the Musselshell River region no coals of commercial importance have been observed, although many lignitic shales are present. Farther south, in the Bighorn Basin near Cody and Meeteetse, Wyoming, coals of workable thickness reappear in this formation, but the deposits are usually very local in extent.

RÉSUMÉ.

The most important points in this paper may be summarized as follows:

1. The Kootenai formation, which is well developed in the Great Falls region, has been followed southward through Montana into the southern part of Bighorn Basin, Wyoming, a distance of about 350 miles, where it is correlated with the Cloverly formation in which fossil plants of Kootenai age have been found.

2. Workable coals, which are so abundant in the Kootenai formation of Alberta, are found at but one horizon in the Great Falls region. Coal at this horizon thins slightly to the eastward in the Judith basin region, and disappears entirely on the Musselshell River about fifty miles farther south. It reappears, however, in workable thickness in the southern part of the Bighorn Basin.

3. The subdivisions of the Montana group as recognized by Stanton and Hatcher in northern Montana have been definitely recognized as far south as the Montana-Wyoming state line, and they possibly continue farther south into the Bighorn Basin; also around the east side of the Bighorn Mountains. The principal variations noted in these subdivisions of the Montana was the decrease in thickness of the Bearpaw shale from about 750 to 130 feet.

4. Of the subdivisions constituting the Montana group, the Eagle and Judith River are the most important coal-bearing for-

mations, the former containing valuable coal deposits throughout the Bighorn basin, and northward as far as Joliet, Montana. Farther north on the Musselshell River coals are present in the Eagle formation, but too thin to work; while in the Judith basin region, still farther north, they appear to be absent. The Judith River formation contains valuable coal deposits, also lignitic shales throughout northern Montana, but in the southern part of the State only lignitic shales have been observed. Farther south in the Bighorn Basin, however, workable coals are found in beds of local extent.