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CANADA

DEPARTMENT OF MINES

HON. LOUIS CODERRE, MINISTER; R. W. BROCK, DEPUTY MINISTER.

GEOLOGICAL SURVEY

MEMOIR 61

No. 45, GEOLOGICAL SERIES

Moose Mountain District, Southern Alberta

(Second Edition)

BY

D. D. Cairnes

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OTTAWA
GOVERNMENT PRINTING BUREAU
1914

No. 1410.

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Fig. 1. Sketch section through Forgetmenot ridge 42

Moose Mountain District, Southern Alberta.[1]

Introduction.

This report and the map which accompanies it cover an area lying south of and adjoining the Bow river and extending from the main Rocky Mountain escarpment on the west, to include part of range III, west of the 5th initial meridian, on the east, and extending south to township 18, i.e., to a short distance south of the south branch of Sheep river.

Coal had been found in several places within this district and natural gas had been found to the north, south, and east of this area in the same formations as those within it; it was decided, therefore, to study these coal and gas horizons in sufficient detail to permit of indicating their positions upon the map and to be able to give geological sections at any desirable points. In this way the work of those looking for gas and coal is very much simplified and considerable definite information is afforded.

It had previously been supposed that the Kootenay formation, within the mountains, did not extend east of the main Rocky Mountain escarpment; but this season it has been found here, and as this is the formation which carries the high grade coals of the Crowsnest pass and of the Cascade trough, at Banff and Canmore, the finding of it in this area will prove of interest to many, especially as the measures, although much thinner than to the west, still carry several workable seams of good quality in nearly every place found, and extend the entire length of the map.

The coal measures in the Belly River and Edmonton are not nearly so easily followed as those of the Kootenay formation, which is somewhat thin and occurs in narrow areas and is capped

[1]The field work in connexion with this report was performed in 1905. The first edition of the report was issued in 1908. This, the second edition, is virtually a reprint of the first edition. Certain verbal changes have been made, and the term Belly River substituted for Judith River.

by a very prominent conglomerate, forming, usually, the summits of the points and ridges of the district in which it outcrops, and in the 300 to 400 feet below which the coal seams are always to be found. As this conglomerate can be traced, quite easily, from one end of the district to the other, prospecting for this coal is comparatively easy. On the map accompanying this report, the Kootenay coal seams are not indicated, but a section made at any point across the formation will show several coal seams. The observed coal outcrops of the Edmonton and Belly River are indicated; many more may be found, however, than those shown.

The coals of the Belly River are of a slightly higher grade than those of the Edmonton, and the quality, in both formations, rises as the mountains are approached. This has resulted from the pressure due to the folding and twisting of the rocks, which in places, cause a considerable variation in the same seam within a few feet. The Kootenay coals occur as anthracitic coals, semi-anthracites, or bituminous coals, according to the amount of local pressure. At one place on the south branch of Sheep river, one of these seams, in a tight fold, has been altered to an impure graphite. The Edmonton coals are all lignites or lignitic coals. A few samples collected give evidence by analyses of being the latter.

Coals.

Kootenay Coals.

Distribution.

The Kootenay coal measures outcrop all around the Moose Mountain ridge: from Gleasons Meadow, along the east side of the ridge, through Gleason and Lower Camp; along the northwestern and eastern slopes of Coxcomb mountain, near its summit, and thence to the north end of Forgetmenot ridge; on Jumpingpound creek, north of Coxcomb mountain; on the south branch of Sheep river north of Hoffmann mountain; and in a few other places, as shown on the map accompanying this report. There is no reason to suppose that the places where the coal was measured are richer in coal than others. They were simply convenient places where the seams could be measured without much digging being necessary. There was

no point along the Kootenay outcrop where any considerable portion of the formation was exposed that coal was not seen if search was made.

Bragg Creek near Thorne Mine.

At the head of Bragg creek, near the old Thorne mine, which is situated on the N.E. $\frac{1}{4}$ of sec. 8, tp. 23, R. VI, west of the 5th meridian, a section was measured from the conglomerate at the bottom of the Dakota to the Palæozoic. The Thorne mine was worked for the disseminated iron pyrites in the Fernie shales. The iron occurs here in blossoms quite thickly distributed, but of no present economic value. These black shales are quite calcareous in places, and on one of the weathered dumps of the old mine workings were found a great number of specimens of guards of *Belemnites*, which were very helpful in determining the horizon of this formation. This mine has long since been abandoned, but the remains of an old road still exist, corduroyed in places, and leading up to the old cabins just below the mine workings. The coal measures are very plainly seen on the north side of the creek opposite the mine, but, although deeply covered by wash, the seams appear less disturbed just above it, where the following section was measured:—

	Feet.	Inches.
Dark brown shale	1	0
Coal	1	6
Brown shale	42	0
Sandstone	7	3
Brown shale	3	6
Dark coarse sandstone	22	0
Sandstone and shale	15	6
Coal	1	6
Grey sandy shales	2	3
Coal	3	7
Dark grey shales	8	3
Coal	1	10
Dark brown sandstones and shales	21	0
Coal	2	3
Dark sandstones and shales	73	0
Coal	8	2
Brown coarse sandstones	24	0
Coal	6	10
Dark coarse shales	4	3
Dark blue shales	9	0
Shales and sandstones	23	0
Brown prominent sandstone bed	63	0
Total thickness of Kootenay	344	8
Total thickness of coal	25	8
Dark Fernie shales	195	0

An average outcrop sample of the eighteen-inch seam in the above section, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
1·86%	19·23%	76·07%	2·84%

An average outcrop sample of the seven-foot, six-inch seam, north of the creek, opposite the mine, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
1·17%	13·54%	69·77%	15·52%

An average outcrop sample of the six-foot, ten-inch seam in the above section, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
2·74%	18·62%	75·52%	3·12%

These analyses were made by Dr. Hoffmann, of this Department. Concerning the last sample, he also says—

"Structure, somewhat coarse lamellar, made up of irregularly alternating layers of greyish-black, somewhat bright and dense, jet-black coal of brilliant lustre, with an occasional interposed film of mineral charcoal, contorted, shows slickensides in an eminent degree—compact; firm; fracture, irregular; powder, brownish-black; it communicates a pale brownish-yellow colour to a boiling solution of caustic potash."

As the above measures cross the creek bottom the coal could be advantageously mined by tunnels run in on seams at convenient levels above the creek.

Elbow River.

Near the top of Forgetmenot ridge, half a mile north of the Elbow river, the following seams were measured, but others may be there as the section was rapidly made. Considerable work would be here required to get a perfectly accurate and complete section.

	Feet.	Inches.
1 coal seam	5	4
1 "	2	6
1 "	4	0
2 coal seams, each	2	0
1 coal seam	1	2
1 "	0	11
1 "	0	10
1 "	0	9
2 coal seams, each	0	8
1 coal seam	0	7
1 "	0	6
Total	21	11

An average outcrop sample of very badly weathered coal was taken from the 5-foot, 4-inch seam in the above section, and gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
6·68%	20·68%	64·71%	7·93%

The measures outcrop equally well on both the north and south sides of the Elbow, and the outcrop could easily be traced to the river level where it could be definitely located with a small amount of work, thus affording favourable points for mining by driving in on the coal at convenient levels above the river.

South Branch of Sheep River.

The Kootenay formation outcropping along the eastern side of Lower Camp on the south branch of Sheep river, is somewhat thinner, and the coal is of less importance than at many other localities visited. This is due, to some extent, to the extensive fault running north and south, just east of the measures, and which, in all probability, cuts off part of the original thickness of the formation. A slope, with a very low angle of dip, has been run for a considerable distance, on a three-foot seam in these measures, the entrance to which is just above the wagon road running up the river. This is the best seam noticed here. An average outcrop sample analysed by Dr. Hoffmann, yielded:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
0·69%	19·98%	73·12%	6·21%

The sample was taken from the surface, as the slope was filled with water.

The same measures also outcrop farther up the river, on the north side of Hoffmann mountain and in the river banks. At one place here the coal was so much squeezed and the seams so irregular that they vary in thickness from a few inches to several feet, in almost the same horizontal distance. The coal of one seam has been so altered that in a tight part of a fold it has been changed to an impure graphite.

Farther up the river, about a fourth of a mile, where the coal again appears, one seam about three feet six inches thick

was noticed, which, for some distance at least, is quite regular. An average outcrop sample was analysed by Dr. Hoffmann, giving:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
0·53%	14·99%	64·55%	19·93%

"It yields by fast coking, a compact, firm, coherent coke."

Places could likely be found here where this coal could be profitably worked if there was a demand for it.

Coxcomb Mountain.

Near the top of Coxcomb mountain the Kootenay coal measures outcrop for some distance, but a complete section was not seen. There appear to be, however, at least four or five seams, and some may be of workable width, but those seen were only thirty-six, twenty-three, and nineteen inches, respectively.

An average outcrop sample of the thirty-six inch seam, analysed by Dr. Hoffmann, shows it to be an anthracitic coal and gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
1·64%	14·26%	82·01%	2·09%

Since the measures outcrop in so many places, at all elevations from the level of Jumpingpound creek, below, to the mountain summits on both sides, and also along the creek for about four miles and south of Jumpingpound mountain, there is a likelihood of finding quite accessible points at which the seams are of sufficient width and regular enough to be economically worked, and the quality of the coal itself is good. Where the measures outcrop along Jumpingpound creek to the north of Coxcomb mountain, no seams were noticed over a few inches in width. Several feet of carbonaceous shale outcrop, however, in one place.

Lusk Creek.

Where the Kootenay formation outcrops, on a westward flowing branch of Lusk creek, only the upper part of the formation is exposed, and as the strata here are almost flat, whatever coal exists is below the surface.

P. Burns' Coal Basin.

Just inside the first limestone range, at the head of the south branch of Sheep river, is a Cretaceous trough containing a considerable amount of coal. This was not followed far south of Sheep river, although it appears to run some distance in this direction toward Highwood river. The Kootenay rocks which carry the coal here are very similar to those outside the mountains, but are very much thicker. The P. Burns' coal property includes the southern part of that portion of this basin shown on the accompanying map. Here the Cretaceous strata form a very rugged line of hills, almost as rugged, in places, as the bordering mountains of Palæozoic measures.

Lying immediately on the limestones are 200 to 300 feet of fine-grained quartzites varying in colour from almost pure white to a light grey. Next above these are some very dark, almost black, shales. Above these again are the Kootenay rocks, which extend from near the river level to the summits of the mountains. These hills extend along the valley in a north-westerly direction for about four miles from the main workings, when they rapidly begin to disappear, and from there to the northern end of the trough only the lower rocks still exist, the upper coal-bearing strata having been eroded away.

A section was made up one of the gulches where work has been done on the coal, but as it was hurriedly made there may be more seams than those noticed, as parts of the section were covered by drift. But all the seams that were exposed, or have been opened up at all, are included in the following statement, except three thin seams from one foot to three feet in thickness, which were seen a few hundred feet above the section measured and some considerable distance apart. This section, as in the case of all others in this report, is given in descending order:—

	Feet.	Inches.
Sandstone	9	0
Coal	0	10
Sandstones	39	0
Coal	1	4
Sandstones and shales	322	0
Coal	1	2
Brown sandstones and shales	106	0
Coal	2	0
Dark coarse sandstones and dark shales	45	0
Coal, very clean	1	8
Brown sandstones with very little shale	193	0

	Feet.	Inches.
Coal, dirty seam	2	10
Dark coarse sandstone, with few feet of shale	310	0
Coal, good	2	0
Sandstones and shales	80	0
Coal, very good clean regular seam	10	4
Brown sandstones and shales	427	0
Coal, with two feet of shale, two feet from hanging wall	9	6
Brown sandstones and shales	76	6
Coal, good clean seam	8	8
Brown sandstones	0	0
Total of coal	38	4

Edmonton and Belly River Coals and Lignites.

Bow River.

A seam of good lignite outcrops on the Bow river opposite the mouth of Grand Valley (Coal) creek (S.E. ¼, sec. 13, tp. 26, R. V), but as the mine workings are now all caved in a section could not be seen. The seam appears, however, to be quite regular and of sufficient width to work near the river, but up the creek becomes very irregular and broken. The horizon is probably near the base of the Edmonton. The seam is well exposed on the north bank of the river, just at the mouth of Grand Valley creek, and at several points within a mile from the river. At the last point seen farthest from the river (S.W. ¼, sec. 24, tp. 26, R. V), the seam is only three feet wide with ten inches of clayey parting near the middle. Considerable work has also been done here on what locally is known as the Cochrane property. The workings on the south side of the river are known as the "Vaughan coal," "Mitford coal," or "Merritt coal."

Mr. J. B. Tyrrell has published in the Annual Report of this Department, in 1886, the following section of the "Vaughan coal" property, furnished to Dr. G. M. Dawson by Mr. Vaughan; also the coal analyses given below, furnished by Dr. Hoffmann, of this Department:—

	Feet.	Inches.
Coal	1	0
Black shale	2	9
Coal	1	6
Clay	0	4
Coal	2	6
Clay	0	2
Coal	2	7

From the north side of the Bow river:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
4·93%	27·22%	52·54%	15·3%

From the south side of the Bow river:—

4·41%	40·32%	48·27%	7·00%

A one-foot seam outcrops on the north bank of the Bow midway between the railway bridge at Mitford and the mouth of Grand Valley creek.

On Mr. McPherson's place are several narrow seams of good, firm lignite from six to eight inches wide. (S.W. ¼, sec. 16, tp. 26, R. V; S.W. ¼, sec. 15, tp. 26, R. V.)

An eighteen-inch seam of somewhat powdered lignite outcrops on the south bank of the Bow river opposite Radnor; also a seam, possibly the same one, of soft shaly coal is exposed on the east bank of Ghost river (S.W. ¼, sec. 24, tp. 26, R. V.)

A good, clean-appearing seam of coal, six feet six inches thick, and which has been worked to some slight extent by the Indians, outcrops on the Stony reserve, about three and a half miles northeast of the eastern end of Chiniki lake. The coal dips to the west at about 30°, and has sandstone walls. There is very heavy wash and drift here on all sides, so that little of the formation is exposed, but from what little can be seen the indications are very favourable for the economic working of this coal.

Dr. Hoffmann, of this Department, gives the following description of a sample from this locality, received from Mr. W. Pearce:—

"It has a crumpled, laminated structure, shows slickensides; is moderately firm; colour, greyish-black to black; lustre, resinous to vitreous; fracture, irregular; powder, black with a faint brownish tinge; it communicates a faint brownish-yellow colour to a boiling solution of caustic potash."

An analysis by fast coking gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
1·26%	41·30%	48·60%	8·84%

"This is a true coal and yields, by fast coking, 57.44 per cent of compact, firm coherent coke."

Another two and a half foot seam of very similar appearing coal was seen about half a mile southeast of the above. No work had been done here and it is quite possible that other seams may exist in this vicinity.

Jumpingpound Creek.

On F. H. Towers' place (N.W. ¼, sec. 19, tp. 25, R. IV) are several seams of very good lignite. One is four feet, six inches thick; another is fourteen inches, and there are a number from six inches to one foot in thickness. The two best seams make a very good domestic fuel and have been used locally to quite an extent. Difficulty in obtaining competent miners has interfered materially in the development of this property.

An average outcrop sample of this coal gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
5·0%	52·1%	35·2%	7·7%

This seam is, in all probability, of the same horizon as the seam at Grand Valley creek, farther north.

A coal horizon was also recognized on Jumpingpound creek about one and three-quarter miles east of the mouth of Sibbald creek; this horizon may be the same as that northeast of Chiniki lake on the Stony Indian reserve. Only two very narrow seams, two to three inches thick, were noticed here; but coal was mined at this point a few years ago, so that it appears that the seams which were worked have either pinched out or are covered over by a considerable amount of clay and dirt which has recently slid down the river bank.

Elbow River.

A seam of coal, two feet six inches wide, outcrops in the north bank of the Elbow river (sec. 19, tp. 23, R. IV), but the formation is nearly all somewhat deeply covered for a considerable distance and very little bed-rock is to be seen.

Another seam, approximately two feet six inches wide, outcrops on sec. 33, tp. 22, R. V, in the south bank of the Elbow river. This is, probably, at the same horizon as the seams on Bragg creek to the north.

Bragg Creek.

Two seams of coal outcrop in the south bank of Bragg creek, sec. 7, tp. 23, R. V. Considerable work was done here a number of years ago, but all the works are now completely caved in. The following section was measured in the bank of the creek, but as there is very little outcrop either above or below this for some distance there may exist more coal than was seen.

Shales—	Feet.	Inches.
Coal	2	6
Bituminous shales	2	6
Sandstone	6	0
Coal	1	6
Sandstone	0	0

An average outcrop sample, analysed by Dr. Hoffmann, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
9·31%	35·59%	41·72%	13·38%

South Branch of Fish Creek.

On the northwest ¼, sec. 7, tp. 22, R. III, are several seams of lignite known as "Shaw's coal." One tunnel was run over 180 feet on a seam here averaging about two feet in thickness; but this seam is very irregular and pinches down to a few inches in several places. An analysis of an average outcrop sample of this, made by Dr. Hoffmann, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
3·76%	33·91%	56·37%	5·96%

There are other narrower seams here—one is eighteen inches, and several vary from two to six inches.

On the northeast ¼, sec. 4, tp. 22, R. III, is a seam of lignite having a varying thickness of from two inches to three or four feet. The general dip is about flat, but the formation is somewhat irregular and undulating. There is an old caved-in tunnel on the north bank of the creek, showing that coal was mined here at one time. On the south side of, and up the creek 200 to 300 feet, is a seam, probably the same one. This property is known as "Patterson's coal."

North Branch of Fish Creek.

On the south bank of this creek and 400 or 500 feet from it, on S.W. ¼, sec. 21, tp. 22, R. III, are a number of old mine workings, all now caved in or full of water.

The following section was obtained in one place near an old shaft:—

	Feet.	Inches.
Coal	2	0
Shale	0	6
Coal	3½ to 4	8
Shale	4 to 5	0
Coal	1	6

The dips are here about perpendicular.

This is known as "Gansby's coal" and is the most valuable of the Fish Creek coal properties, which are all at the same horizon and should prove of considerable importance. These coals seem to be at the same horizon as those at Lineham post-office, on the south branch of Sheep river and at Mr. Towers' place on Jumpingpound creek.

South Branch of Sheep River.

On the S.E. ¼, sec. 30, tp. 19, R. IV, is a seam over seven feet in thickness of very good appearing coal. An average outcrop sample, analysed by Dr. Hoffmann, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
2·50%	35·88%	56·64%	4·98%

There are also several narrower seams here of only a few inches in thickness.

On the S.W. ¼, sec. 29, tp. 19, R. IV, occur several seams of coal a few feet apart. Two were noticed from five to six feet in thickness, and five from two to four feet. There are also two old tunnels that are entirely caved in, preventing an examination of the seams they have opened up. Below this point and within a distance of about three miles, a number of seams from a few inches to three feet outcrop, and there are probably others which were not seen. These measures are somewhat irregular in places, but regular points may be found. On account of the steep, high banks, and the high hills to the south, good facilities are offered for prospecting and mining.

An average outcrop sample of the five-foot seam above, analysed by Dr. Hoffmann, gives:—

Water.	Vol. comb. matter.	Fixed carbon.	Ash.
2·16%	34·65%	56·42%	6·77%

The Sheep Creek coals noted are in the Belly River formation, and the analyses show them to be true coals and of a better and higher grade than the Edmonton lignites and some of the Belly River coals. There is also a good wagon road along the river, making them quite accessible, and they should prove of considerable value in the near future.

Natural Gas and Oil.

There are several possible gas horizons in this district, any or all of which may be gas-producing at favourable points. Medicine Hat gas comes from about the middle of the Belly River formation; Langevin gas comes from the same horizon; the Cassils gas is from a higher horizon, just at the bottom of the Pierre. There is also a possible horizon at the bottom of the Edmonton, and one higher in the same formation. Gas or even oil may be found also in the lower Dakota and even in the Kootenay as well—the tar sands, found along the Athabaska river, probably correspond to the Dakota.

Though these are the probable horizons at which gas may be found, it can only exist in quantities of economic value in favourable places. As gas and oil are very light they tend to rise until stopped by some impervious strata. It is only where the rocks are arched up in anticlinal form that gas can accumulate; if the rocks are flat, broken, or have a tendency to synclinal form, the gas escapes. In boring, other things being equal, it is, of course, desirable to operate in some valley or other low point so as to be as near to the gas horizon as possible before commencing drilling. The most suitable places are generally along river valleys.

In the western part of the area studied this season, the formations are very liable to be too much broken to hold any great accumulations of oil or gas, but along the eastern part of the district conditions for boring are favourable in many places.

From the map, sections, and descriptions of the area, the anticlinals can be very closely located and approximate depths calculated to any of the horizons at almost any point on the map.

General Description of the District.

East of the area described in this report, the country is quite open in most places, and suitable for ranching purposes, but to the west it rapidly becomes more and more rugged and heavily timbered until the main Rocky Mountain escarpment is reached, near the western edge of the sheet. These limestone mountains and their outliers, the Moose and Forgetmenot ridges, have very little timber at all, being much too rugged, except in the valley bottoms and for a short distance above them, to support a growth of trees of any kind.

The valley of the Bow river, to the north of this district, is wide, low, and open to the mountains and resembles the country to the east. But immediately to the south of this prairie-like valley, the country commences to be more or less timbered, the timber continuing to increase towards the south as it does towards the west, until at the southwest corner of this area, along the south branch of Sheep river, east of the mountains, the country is so densely covered with both standing and fallen trees that travelling is very difficult. There are wagon roads up some of the main rivers for a distance, but it is the Indian hunting trails that are chiefly used by persons wishing to travel through this district.

The Indian trail running just east of Chiniki lake was followed from Morley to Sibbald creek. In dry or frosty seasons this is a very fair pack trail, but at other times there are a number of somewhat bad muskegs to be encountered. The hills to the south of Chiniki lake and around Sibbald creek are about three-fourths covered with small trees, chiefly jack pine, spruce, poplar, and aspen, but they are not thick enough anywhere to make walking difficult.

There is a very fair wagon road from Sibbald's cabins on Sibbald creek down Jumpingpound creek to Jumpingpound post-office. On account of a few muskegs, however, loaded wagons would not be able to travel parts of this road in wet seasons.

The low hills to the south of this road and along its western portion, are mostly covered with small evergreens, the growth in places being quite thick, but, to the north and east, for a short distance, the trees are chiefly poplar and willow. East and north of this again is the open, rolling, grazing country, which is almost prairie. The hills just north of Springbank reservoir site are covered with a thick growth of poplar and willow, and the muskegs to the south of it are the most dangerous in the district.

All the valleys here contain considerable areas of muskeg which are generally covered only by grass or underbrush, making it dangerous for stock except in dry or frosty seasons. Generally these muskegs are over the soft, dark shale formations, but sometimes they merely indicate flat dips or low synclinal folds. One such muskeg valley exists about two miles east of Pine Top and North Bragg.

The trail up Jumpingpound to the head of the creek is well travelled and continues along the creek bottom most of the way to its head, where a few more small muskegs are encountered. The valley is rather narrow most of the way and the hills on both sides are fairly high and somewhat rugged, and are over half timbered with green timber—jack pine and spruce chiefly, with some poplar and aspen. There is also a considerable amount of small dead timber, both down and standing.

Within a mile or so of the head of the creek there are two or three miles of thick, dead, standing timber along the trail, but from here to Canyon creek, the country on both sides is densely covered with evergreens. There are no big trees in this part of the country.

The Moose Mountain ridge, as seen in the distance, consists of bare, rugged, limestone mountains. Coxcomb mountain and the high ridge running thence south to Forgetmenot ridge are also bare and somewhat rugged. The tops of the high hills north of Coxcomb mountain and across Jumpingpound creek from it are bare of timber in most places. Most of the hills to the north and south of Canyon creek, west of the Moose Mountain ridge, are densely wooded with chiefly jack pine, fir, and

spruce. Most of this country was burnt over a number of years ago, and the timber, which was very thick, has all fallen, and the new growth is very thick and is now quite a size, so that between the fallen and standing trees it is almost impossible to get over some of the hills at all.

The valley of Canyon creek is wide, and consists, to a great extent, of gravel bars, showing that the creek is subject to great floods. It flows through a deep canyon, through the limestone of the Moose mountains, and from there it continues in somewhat of a canyon to its mouth. This creek is very peculiar in that, although a large creek at all times, there is no water to be seen, except at flood times, in its bed for about three miles from its mouth—the water all running under the gravel for this distance. The trout which go up in high water are, therefore, kept in the deep holes in the canyon above, which afford the best trout fishing discovered in the whole country.

The Indian hunting trail from the head of Jumpingpound creek to the Elbow river, for about half the distance passes over muskegs. The country on both sides is nearly all covered with evergreens of medium size—with the exception of the summit of the ridge, continuing along east of the trail, which is rugged and free from trees of any kind. A line of small round green hills continues all the way from Canyon creek to the Elbow river, the trail being on the west of the first two, but to the east of the rest.

The river bottom of the Elbow is wide in places, being a quarter of a mile, and is nearly altogether gravel bars, at low water, showing that the river is particularly subject to seasons of heavy floods.

The trail continues south and west up the river, following the river bottom, and crossing and recrossing a number of times, until the limestone mountains are reached. The low hills between this part of the river and the mountains are mostly covered by evergreens; the ridge to the east, however, is high and timbered to near the summit, which is open. The part of the trail going up the Elbow river through the first limestone range to the Kootenay trough to the west, is very rough and steep in many places, and passes through considerable timber, which, however, does not extend very high up on the sides of the mountains.

On reaching this trough the trail turns southeast to the head of the south branch of Sheep river and follows down it five or six miles, then crosses the ridges to the west and continues south to the Highwood river. This part of the trail south of the Elbow river has not been used much of late. The valley is quite open, except for a few shrubs and some underbrush. The northern part of this Kootenay basin consists of low rolling hills for about two miles south of the Elbow, but south of this it rapidly becomes more mountainous and for several miles is a very high and rugged ridge, almost as much so as the Palæozoic ranges on each side.

A trail also goes up the Fisher branch and turns south to the Elbow again, as shown on the acocmpanying map. It is somewhat rough but horses may be taken over it without much trouble. The river bed is wide, flat, and gravelly most of the way, as it is farther east. There is, however, a deep narrow canyon about a mile long situated about four miles from the mouth of this branch of the Elbow, which has a good, well-blazed trail cut around it, to the south of the river—both ends of the cutting being well blazed on the river. As the timber is very heavy here a great deal of work would be necessary to get around the canyon if this trail was not available. For the rest of the way, as far as this trail is marked on the map, horses can travel along the gravel bars at low water, The timber is heavy on both sides most of the way and some cutting has been done in several places, which is a considerable help to travelling. After leaving the Fisher branch the trail turns south and is well marked and easily followed to the Elbow river again.

Another trail continues down the Elbow to the mouth of Bragg creek, but as this follows the river bars and low benches for a great part of the distance, and crosses the river a number of times, it can only be used at seasons of very low water.

The Forgetmenot ridge, as seen from the Elbow river, is very prominent, the eastern part being limestone, the top of which is quite wide and open, particularly to the south of the river for a few miles. The summit of the ridge is along its western side and is a somewhat narrow ridge formed by the conglomerate which overlies the Kootenay coal measures. Between the Forgetmenot and Moose Mountain ridges, the

country to the south of the river is low and quite open for three or four miles, but to the north it is somewhat more rolling and is thickly timbered with evergreens.

The Moose Mountain ridge, which is also composed of Palæozoic limestones and quartzites, is quite rugged and its hills tower above those of the surrounding country, making them a very prominent feature of the landscape. Just along the Elbow, however, it is not so high and wide as farther north along Canyon creek, where its hills are about as high and rugged as those of the main Rockies.

Prairie Chicken creek flows through a canyon several hundred feet deep for over two miles from the river, and other smaller creeks in the vicinity are somewhat similar, so that this, combined with the heavy timber both fallen and standing wherever the hills are not too rough for its growth, makes work here somewhat difficult. East of the Moose Mountain ridge the country on both sides of the river is low and rolling, becoming more so towards the east. For four or five miles the hills are all densely covered with small green timber, but farther east the spruce and pine gradually give place to poplar, aspen, and willow, and the country becomes more open, especially to the north of the river. For about two miles west of the mouth of Bragg creek the trail practically follows the gravel bars of the river bottom, so that it would be difficult for unshod horses to travel over this trail.

There are some quite extensive hay meadows for two or three miles along the north bank of the Elbow near the western side of range V. These are not used by anyone, are not too wet, and would be valuable if easier to reach. However, during the dry months a wagon could easily drive to them by following the wagon road from Robinson's cow camp on the north branch of Fish creek, up to about a mile west of the Sarcee fence, then going north to the Elbow river over a level, open piece of country and from there following up the wide level river flats. Along this part of the river the water is low enough in the summer months to allow a person to drive across it safely and easily at almost any point. It would be difficult, however, to take a wagon up the Elbow by following the river from the mouth of Bragg creek.

There are also valuable hay meadows north of Bigmeadow, to which the wagon road up the north branch of Fish creek is built, but the hay is cut here every year.

There was formerly a wagon road also up Bragg creek to the Thorne mine at its head, but now, with the exception of about the first two miles, it is only a trail and hard to find in most places. There is a particularly bad muskeg about three miles from the mouth of the creek, but this is avoided by following the creek bottom for a short distance. It is quite open on both sides of Bragg creek for about four miles from the Elbow, except for a few patches of poplar, willow, etc., here and there. Long grass grows everywhere and it is particularly suitable for ranching here, except for the muskegs; however, cattle seem to avoid them fairly well, as a rule. The only safe times for rounding up the stock, though, are in the early spring and late autumn when the ground is frozen. This is the western edge of the ranching country here.

North Bragg is quite open as is also South Bragg opposite it; but most of the country to the west of this is densely wooded with pines, spruce, etc. There is very little poplar or willow in this vicinity. For about two or three miles east of the Thorne mine there is some fairly valuable timber, the growth being very thick and the trees being larger than seen in most places this season.

Another trail from Morley crosses Jumpingpound creek near the Springbank reservoir site. This far it is good; but from here the Indians generally travel south through the muskeg valley west of James Greyson's to Bragg creek. To persons not perfectly familiar with the trail it is much better to take the wagon road shown on the map, passing through Mr. Greyson's place to the Elbow river and thence south as shown. The Sarcee reserve was fenced on all sides with barbed wire fencing this summer and, as there are gates only on the main wagon roads, the trails now go around the outside of the fence. From the Elbow river to the south branch of Sheep river this is a good, well travelled trail can be easily followed.

The hills for three or four miles east of Bigmeadow are about two-thirds covered with a thick growth of poplars, aspens,

and willows. Robinson and to the east are somewhat more open. Topknot and Bigmeadow are only partially covered with trees, these, however, being nearly all evergreens. The hills to the north of this portion of Fish creek are low and rolling; but to the south of the creek the country is much rougher and the hills much higher and more rugged and much more heavily timbered. Practically all the trees are evergreens to the south of the portion of this creek shown on the map. Rock point, and the hills for four or five miles to the east, rise quite abruptly from the south bank of the creek, forming quite a contrast to the low, flat country to the north. The valley of the south branch of Fish creek west of the end of the wagon road, continues to be wide, low, and flat in many places, but is often covered with trees and underbrush and there are a few muskegs, making it difficult to travel with horses. Portions of it, however, are quite open, and with the wide open valley running up to the Elbow, just west of Topknot, might be valuable for ranching purposes.

From the mouth of Fisher creek good wagon roads (see map) run up to John Quirk's place, which is the farthest ranch up the river. This valley is particularly adapted to ranching, having extensive hay meadows, and the valley itself being somewhat wide and the surrounding hills low and only partially covered with poplars, aspens, etc. But what is most noticeable is that no muskegs were seen; the valley appears to be free from them. A wagon road also runs up Ware creek, locally known as Sinnot creek. The valley of this creek to the end of the road is wide and open; but above this it becomes narrow and heavily timbered, chiefly with evergreens. The hills to the south of this creek up to Gleason creek are thickly covered with timber, chiefly spruce and pine, there being no open places except some patches on Gleason, which are too rocky for plant growth. The upper parts of Sinnot 1 and Sinnot 2 are sparsely covered with poplar, the surrounding valleys being completely covered with poplar interspersed with fallen spruce and pine. From here along Death's Head ridge, the pine and spruce growth increases, though it has nearly all been recently burned over and much of the timber is down. Death's Head itself is quite open. Along the south side of Ware creek there is also considerable

poplar and aspen. The south side of the ridge running from Death's Head to Volcano, and Gleason Meadow ridge has been burned over, and a young growth of pine now covers it here and there. Nearly the whole country west of Gleason and Missing Link to the Rocky Mountain escarpment is completely and generally thickly and heavily covered with evergreens. The top of Ware Head, however, is a high rocky summit several hundred feet above any timber.

The trail running up Ware creek and down Gorge creek to the south branch of Sheep river is a very fair one except in wet seasons, when the muskegs at the head of Ware creek might give some trouble. The greater part of the hills to the south of that portion of the north branch of Sheep river from the mouth of Ware creek to south of Mesa Hill is heavily wooded, there being more evergreens than poplar and aspen. The northern side is only sparsely covered here and there with, chiefly, poplar. Mesa hill, Lowndes, and the hills to the east and north, and the valleys in between them, are covered with a dense growth of spruce, pine, and poplar, except the summits of the hills, which are quite open. From about a mile west of Mesa hill following along the south side of Barwell ridge and west to Nichi, the country is mostly heavily covered with spruce and pine; towards the east, however, are some poplar and willows close to the river. The top of Nichi is burned over and is quite open. On the south side of the river the hills have a comparatively thin growth of pine, beginning about two miles east of Allsmoke, but that portion west of Mesa hill has been partially cleared by fires. The northern slope of Allsmoke and the country from there to the limestone is thickly timbered, chiefly with pines. The greater part of the valleys of Threepoint and Volcano creeks is densely wooded, but the muskeg, and the country west of the head of Threepoint creek west to the Elbow river, are quite open.

The trail from John Quirk's place up the river to the mouth of Muskeg creek is very good, but above this there were no signs of any one having travelled this way for years. In a place or so, parts of an old trail could be seen, but the great amount of fallen trees would have necessitated five or six miles of heavy cutting to have got horses over to the Elbow river this way. North of Death's Head the river valley narrows up

considerably, and at the mouth of Muskeg creek it becomes a gorge with almost perpendicular walls and remains so up to the falls—just below which the gorge is 390 feet deep and is about the same in several other places. Above the falls for about a mile the banks of Threepoint creek are steep, grassy slopes, partly covered with timber. West of Nichi the valley again closes in and deepens and a canyon with sides chiefly of limestone talus extends through the Forgetmenot ridge.

A good wagon road, except in very wet seasons, goes up the south branch of Sheep river to the logging camp north of Hoffmann mountain. From here a good pack trail continues up the river to connect with the trail running south from the Elbow river, west of the first limestone range of the Rockies. Going through this most easterly range of the mountains proper the trail is very rough, crossing the river a number of times.

Sheep river flows through what is practically a canyon 50 to 300 feet deep nearly the entire distance from the mouth of Macabee creek west to the logging camp, above mentioned, and as nearly all the creeks running into it have formed canyons near the river as well, travelling becomes somewhat difficult along the river, and the wagon road up it for this reason follows up Macabee creek for several miles.

To the north of the mouth of Macabee creek the hills are quite open, but towards the west the country becomes gradually covered for three or four miles with poplars and aspen, which are then gradually replaced by a more or less heavy growth of pines to Lower Camp. West of this on both sides of the river to the Rocky Mountain escarpment the country is densely wooded. Darkie and the hills to the east are only partially covered with timber, chiefly pine, but west of this there is a very heavy growth of evergreens everywhere.

Along the river, for about four or five miles north of Greenslope, the river flows through a dark shale canyon with almost perpendicular walls 100 to 200 feet high. Up Gorge creek this canyon continues for about three miles, with an average depth of over 200 feet.

The tops of Junction and Hoffmann are the only open points practically in this part of the country, except some open flats along the north of the river, close to the top of the canyon and just west of Lower Camp.

General Geology.

In the portion of the foothills examined this season the following formations were studied:—

Edmonton formation.	Cretaceous.
Bearpaw shales.	
Belly River beds.	
Claggett shales.	
Niobrara-Benton.	
Dakota beds.	
Kootenay formation.	
Fernie shales.	Jurassic.
Devonian and Carboniferous limestones and quartzites.	

Edmonton Formation.

The *Edmonton* formation consists of light-coloured, soft sandstones, shales, and clays, usually fairly well bedded and frequently alternating. The sandstones predominate, are often thinly bedded, occasionally quite hard, and at times weather to a yellow colour; grey or brown shades are, however, rather more common. The shales and clays are grey, yellow, greyish-brown, bluish-grey, or even quite blue or pale green in colour. Molluscs are quite plentiful. There are at least two coal horizons in the Edmonton, one near the base and the other somewhat higher up. This formation corresponds to the lower beds of Dr. Dawson's St. Mary River beds which he placed at the bottom of the Laramie. The term Laramie, however, has become so indefinite and unsatisfactory that in this classification it is omitted. The Edmonton is here considered to form the top of the Cretaceous and the beds above this are placed in the Tertiary. In the area worked this season we were unable to find a complete section of the Edmonton which could be satisfactorily measured, so that its thickness was not determined for this district. It is a fresh-water formation, becoming brackish towards the base.

Bearpaw or Pierre-Foxhill Beds.

As Foxhill fossils are found at different horizons in the Pierre, and, in fact, seem to be distributed throughout it, and as the Pierre and Foxhill rocks are in most places so intermingled as to cause the latter term in this locality to be too indefinite to be of value, in this report no attempt has been made to draw a line between them or to separate the Foxhill rocks, and both these and the Pierre are included under the name Pierre or Pierre-Foxhill shales. These consist of dark grey to brown, or even, in places, nearly black shales or shaly clays of a very uniform appearance. Somewhat coarser and lighter coloured sandy shales and sandstone bands occur at uncertain intervals throughout the formation. At times these are quite prominent, but often they are hardly noticeable unless the formation is closely examined. The more prominent sandstone beds are usually near the middle. At the top and bottom the dark shales grade into the overlying and underlying light coloured sandstone fresh-water series. These shales are essentially marine. A great many ironstone bands and nodules occur throughout them.

These shales are somewhat difficult to measure except in places where the formation is quite regular, because when there is any disturbance at all these soft, pliable rocks become much more easily folded and broken than the sandstones above and below them; also on account of their very uniform appearance, with few or no horizon markers, irregularities are difficult to solve. This formation was, however, measured in a few places and the thickness in each case was nearly 650 feet, which was the average.

A carbonaceous horizon exists near the base of these shales, but in this area no coals of economic value were noticed here.

Considerable difficulty has been experienced by geologists both in western Canada and in the western States by finding Pierre shales both above and below the Belly River beds. This has caused the latter to be assigned to different horizons. Recent study has shown that marine and fresh-water conditions have so alternated as to cause the Belly River formation to exist somewhat in the form of a wedge in the Pierre. Variations

in the thickness and characteristics of the Belly River beds and in those of the Pierre and in the relative portions of the latter above and below the former, have added considerably to the difficulties in the study of this part of the Cretaceous section.

Belly River Beds.

The formation designated as Belly River was, in 1875, correlated by Dr. G. M. Dawson with the Judith River series of Missouri. These are the same beds which, in 1874, he had called Lignite Tertiary. Recent investigation has proved this correlation of the Judith River with the Belly River beds. Attempts have also been made to correlate these with the Dunvegan sandstones of the Peace River country.

This series underlies the Bearpaw and consists of light coloured sandstones, shales, and clays—very similar in some respects to those of the Edmonton. However, in this area the molluscs which are quite plentiful in the Edmonton are almost entirely missing in the Belly River beds, especially the *Ostrea glabra*—not one specimen of which was found in the latter beds, but were very plentiful in the former. Also remains of plants, leaves, tree-trunks, etc., are quite plentiful in the Belly River beds. One thick, white, rather massive sandstone bed, in particular, was noticed in several localities which afforded numerous specimens of tree trunks, often up to eighteen or twenty inches in diameter. These white sandstone strata, often cross-bedded, are very characteristic of this formation. Yellowish, grey, blue, and greenish-grey shales and clays are common, often becoming quite hard. A few brownish shale beds were occasionally seen. Brown, grey, and yellow weathering sandstones predominate.

This is essentially a fresh-water formation, but it becomes brackish towards the top and bottom. Even marine beds have been detected in some localities in this horizon. The maximum thickness of these beds, where measured, was 1,025 feet, measured along the Bow river. Farther south a good section was obtained, but the formation here was only 850 feet thick.

Claggett Formation.

These shales correspond to Dr. Dawson's Lower Dark shales and are really a lower portion of the Pierre; but for convenience this name Claggett has been adopted for those dark Pierre-like shales immediately underlying the Belly River beds. They contain a fauna formerly considered as being chiefly Pierre or Foxhill. In the western States where the Niobrara limestones are easily identified these Claggett shales are easily distinguished from the Bearpaw and Benton, but when the Niobrara is absent or not sufficiently prominent to be identified, the distinctions between Bearpaw and Claggett can be made only when their position relative to the Belly River beds can be definitely ascertained. The fossils help to some extent, but being so similar they are only of value in this instance when extensive collections can be made.

Below the Belly River beds in this portion of the Foothills, are 150 to 300 feet of dark shales followed by a sandstone series 50 to 150 feet thick, which overlies, again, 500 to 800 feet more of dark shales lithologically similar to the Pierre and Claggett. The upper 150 to 300 feet stratigraphically and lithologically can be correlated with the Claggett. Also the few fossils found bear out this correlation, such types as *Baculites compressus* being somewhat common. At the bottom of this upper group of black shales are several calcareous bands from a few inches to one foot in width and the shales here become somewhat calcareous as well. The sandstone series which immediately underlies these is most prominent on the Bow river and consists of three sandstone bands separated by, and somewhat intermixed with, the dark shales. One or each of these sandstone bands is sometimes capped by conglomerate, which has at times been mistaken for the conglomerate overlying the Kootenay coal measures. Since portions of this sandstone series, as well as the upper part of the shales below, are quite calcareous, and since Colorado fossils are quite plentiful in both the sandstones and the shales, it appears practically certain that the calcareous rocks correspond to the Niobrara and the shales below to the Benton, so in this report the sandstone series with the dark shales below are included under the name Niobrara-Benton.

In the work this season the Claggett could be only distinguished in the field from the Benton shales where fossils were found, or where the sandstone series between them was of sufficient prominence to be identified; and the Claggett could only be distinguished from the Bearpaw when their positions relative to the other horizons—such as Belly River or the sandstones series between the Claggett and Benton—could be determined.

Specimens of *Cardium pauperculum* are so plentiful in this sandstone series that Dr. Hector, in 1858, called the whole shale series along the Bow river, including the Claggett and Niobrara-Benton, the *Cardium* shales. Farther south this sandstone series, which for convenience is here called the Cardium sandstones, is not so prominent, being only about fifty feet thick, and the characteristic associated conglomerates are only occasionally seen, so that what is such a good and reliable horizon marker along the Bow river ceases to be of much value as such along the south branch of Sheep river. As, for these reasons, it would require considerable detailed work to accurately map the Claggett and the Benton separately, except in a few localities, on the map to accompany this report the Claggett shales, the Cardium sandstones, and Benton shales are grouped together.

The following is a generalized section of the Cardium sandstones as measured along the Bow river, near Old Bow fort:—

	Feet.
Claggett shales; dark Pierre-like.	
Cardium sandstones.	
Upper sandstone bed. Greyish and greyish green, fine-grained sandstones, weathering to a reddish colour. The intercalated shales are nearly black, somewhat calcareous throughout.....	70
Dark Pierre-like shales with a few calcareous sandstone beds, 6 inches to 1 foot thick, near the top and which are very regular, persistent, and noticeable.....	60
Middle sandstone bed. At top; 18 inches of conglomerate. Very hard, quartzitic, massive sandstone bed, presents a somewhat blue colour	30

	Feet.
Dark Pierre-like shales.....	20
Lower sandstone bed. Conglomerate at top. Weathers to a reddish colour. Considerable amount of intercalated dark shales. Fine-grained, rather hard, greyish sandstone.....	40
Benton shales; dark, Pierre-like.	

The *Eagle* formation, which is so well developed along the Missouri river, has not been identified as yet in western Canada. Messrs. Stanton and Hatcher are of the opinion, however, that certain rocks referred by Dr. Dawson to the Belly River belong to this series. In Bulletin 257 of the U. S. Geological Survey, they say: "The castellated sandstones along Milk river between Verdigris coulee and Dead Horse coulee, as described on page [1] 40 C and as figured [2] in an earlier report, resemble the Eagle sandstone much more closely than any part of the Judith River or any other horizon in the general region. This same sandstone horizon was recognized in Rocky Spring ridge and on the west flank of West butte (Sweetgrass hills) resting on dark shales, which, at the last named locality, have an estimated thickness of 800 feet. Now this thickness is much too great for the shales of the Claggett formation, which underlies the Judith River and is the same as that of the Fort Benton shales beneath the Eagle."

In this portion of the foothills covered by this report the Cardium sandstones correspond stratigraphically to the Eagle formation and one or more of these beds might be correlated with it, but sufficient evidence was not obtained this season for so doing.

Benton Shales.

These are the dark marine shales which occur below the Cardium sandstones and have a thickness of from 500 to 800 feet. They correspond lithologically with the Bearpaw and Claggett, and, except where the Cardium sandstones are to be seen, no line can be drawn between them and the Claggett.

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[1] Geol. Surv. Canada, Rept. Prog. for 1882-1884.

[2] Rept. Progress for 1880-1882, frontispiece of Dr. Dawson's report.

These shales, being somewhat soft and pliable, are easily folded and distorted, and it would, therefore, require a great amount of detailed work to map the Benton and Claggett shales separately, so, as explained above, in the accompanying map they are grouped together. As these dark shales weather very easily their outcrop tends to become a valley, and on this account their exposures would often be very difficult to find if it were not for the Cardium sandstones which are very hard and whose outcrops very often form the summits of hills and ridges, so that the shales are then known to be on each side.

Dakota Formation.

The Niobrara-Benton formation rests on a sandstone formation which, taken as a whole, presents a greenish-blue appearance. The upper beds consist of light coloured sandstones, shales, and clays, somewhat similar in a few respects to a portion of the Belly River beds—but they are harder and finer grained and present a greater variety of colour, and are somewhat darker. Greens, blues, and greys are the most noticeable colours, but there are also a few very persistent red bands about two feet wide, which occur near the top of the Dakota and form good horizon markers in certain localities. The rocks of this formation are well bedded and are chiefly fresh-water, particularly the upper light coloured beds.

Below these upper beds are some which are darker and harder, which in turn overlie some coarser, lighter-coloured, and somewhat more massive, beds of sandstone. These again are followed by 300 or 400 feet of thinner, harder, darker strata. The sandstones, which are very hard and often quartzitic, frequently are seen projecting in ridge-like form beyond the shales on each side, which, being softer, weather much more rapidly. This is particularly noticeable near the logging camp on the south branch of Sheep river. The shales here are very dark and occasionally quite black. The sandstones as a rule present the general appearance of a dark green or greenish-blue colour. Below these again are a few thicker beds of sandstone which are very fine grained, quartzitic, and grey in colour; the

lowest one being very noticeable and almost white in colour, and averaging from ten to fifty feet in thickness. This latter bed is very persistent and was traced for over thirty miles, nearly the entire distance from the Bow river to the south branch of Sheep river. Below this is the conglomerate forming the base of the Dakota. This gives a total thickness to this formation in this area of from 900 to 1,700 feet. This conglomerate is the best horizon marker in the whole area covered this season, extending from about five miles south of the Bow river to past the southern edge of this district, and maintaining its characteristics throughout. It is generally from ten to thirty feet in thickness and consists chiefly of cherty and milky pebbles, generally not very large, averaging from the size of marbles up to hens' eggs. Occasionally it is somewhat iron stained, but usually presents a somewhat milky-blue appearance. The pebbles are held together by a hard siliceous cement.

This represents a shore line running just east of the Rockies for this distance, and it probably extends for many miles to the south. As this conglomerate is so hard its outcrop forms the summits of most of the hills and ridges whre it is found, and as the Kootenay coal measures lie immediately underneath, it is very valuable to persons looking for coal, and is, therefore, often referred to in this report as the *coal conglomerate.*

The Dakota formation also seems to correspond very closely with the Flathead beds as observed farther south and inside the mountains. However, from the evidence furnished by quite an extensive collection of plant remains gathered this season, it would seem quite possible that the dark lower beds of this series might be Kootenay. This would make the Dakota thinner and the Kootenay thicker, and so nearer the relative thicknesses shown within the mountains. The conglomerate, however, has been taken as the dividing line between the two formations, not only because it is a good horizon marker, and so a convenient dividing line, but also because from a close study of the rocks there is readily seen to be a decided difference lithologically in the formations above and below it.

Kootenay Formation.

Mr. McEvoy, in the Summary Report of this Department for 1900, gives a section on the Elk river, of the Crowsnest coal fields proper, of which 3,290 feet are likely Kootenay rocks. These contain 216 feet, 2 inches of coal. Of this thickness of coal, however, 198 feet occur in 1,847 feet of measures. In the Summary Report for 1902, Mr. W. W. Leach gives sections of the Blairmore-Frank coal fields, which are east of the above coal fields and separated from them by the main range of the Rocky mountains. On Cat mountain, on the western flank of the Livingstone range, the coal measures beneath the nine feet, six inches of conglomerate are only 732 feet, 6 inches thick, with a total of 125 feet, 3 inches of coal. Just inside the first limestone range, at the head of the south branch of Sheep creek, on P. Burns' coal property, about forty-four feet of coal was all that could be found. East of the Rockies in this portion of the foothills, the average thickness of the Kootenay coal measures found was about 340 feet, containing from twenty-one to twenty-six feet of coal. This shows that the Kootenay coal measures are rapidly thinning out towards the east, and do not likely extend past the edge of the disturbed foothills region. Until this season it was not known that they extended into the foothills at all.

The strata between the conglomerate at the base of the Dakota and the dark shales of the Fernie below, contain all the coal seams discovered below the Belly River beds, and they stratigraphically and lithologically correspond to the Kootenay formation as found inside the mountains. At the top is usually a coarse, dark sandstone bed, ten to thirty feet thick. Below these are chiefly dark shales and sandstones, presenting a general brownish appearance. Interbedded with these are the coal seams. Below these is a very prominent and persistent hard sandstone bed, thirty to seventy-five feet in thickness. This weathers to a peculiar yellow colour, similar to that often seen on limestone. The faces of its bedding planes are also always pitted in a peculiar manner; but it is not at all calcareous. A fractured surface always presents a brown to an almost black, fine-grained appearance.

The fossils, chiefly plants, found in this formation in different localities, point very strongly to the possibility of its being Jurassic and not Cretaceous, as has been previously supposed. The Fernie shales, which lie immediately beneath, have been proved by Mr. T. W. Stanton, and others, to be Jurassic; and in this region in the foothills no evidence of an unconformity or any lapse of time exists between the Kootenay and the Fernie shales (in fact they gradually change into one another); and it would seem possible that the conglomerate at the top of the Kootenay might mark a slight time hiatus, particularly as the rocks above and below are so entirely different in character—both in colour and in the character of their components. So for these reasons it is considered very probable that the coal measures, as well as the Fernie shales, are Jurassic, and that the Dakota, in this region, forms the bottom of the Cretaceous.

Fernie Shales.

Immediately below the brown sandstone bed at the bottom of the coal measures, are thin-bedded, brown sandstones and dark shales, grading down within a few feet to black, fine-grained, finely bedded clay shales, which are rather hard and slaty in most places. Fossils are somewhat scarce in these shales, but in one place Belemnites are very plentiful. These dark shales in this district are from 100 to 250 feet thick, having, like the Kootenay rocks above them, become much thinner towards the east than inside the mountains.

Descriptive Geology.

General Outline of the District.

The contact between the Palæozoic and Cretaceous is a faulted one—the former having been pushed over the latter for several miles, in most places the fault plane dipping west, usually at low angles. It is these Palæozoic limestones and quartzites, next the Cretaceous, which form the eastern escarpment of the Rocky mountains, immediately east of which is the disturbed foothill region, that portion of which lying between the Bow river and the south branch of Sheep river is dealt with in this report.

Enormous and long continued pressure from the southwest has caused the structure of this district to be often very irregular, the rocks being all more or less folded and the folds usually pushed over and often faulted. The high, rugged, Palæozoic ridges—the Moose and Forgetmenot, somewhat to the west of the centre of this area—are the most marked results of this pressure, and form not only the most prominent topographical features of this district, but are also the most interesting geologically. They are immense folds. The mountains of the Moose Mountain ridge form an anticlinal ridge, or rather a quaquaversal of limestones and quartzites, having the Fernie shales overlain by the Kootenay rocks lying on them and dipping away on all sides. Just west and south of this limestone ridge is another—the Forgetmenot ridge—narrower and less prominent than the first and formerly mapped as being connected with it, but at their closest points they are separated by about one and a half miles of Cretaceous and Jurassic rocks. This latter ridge is not as regular as the more easterly one, being faulted nearly its entire length along its eastern side; but along the western edge and at the north and south ends the Lower Cretaceous strata are exposed.

It was by working around these ridges that our expectations of finding the Lower Cretaceous, and thus having a section in

the foothills of Alberta from the Carboniferous to the Tertiary, were realized. The overlying Cretaceous strata were upraised with the Palæozoic rocks of these ridges, and now, after long periods of erosion, the Lower Cretaceous rocks appear with upturned edges high up on the sides of these limestone mountains, entirely encircling them, with the exception that along the eastern side of Forgetmenot ridge the pressure was too great and the fold was broken, causing the limestones to be pushed over the Cretaceous rocks, in a similar manner to that along the contact east of the main Rocky Mountain escarpment. Thus, these two ridges afford an excellent opportunity for studying the Cretaceous, a complete section being exposed commencing with the Kootenay and passing up, within a few miles, into the Edmonton. The thicknesses of these beds were measured in several places, about an average section being obtained just south of the Forgetmenot ridge, on the north branch of Sheep river. The following statement gives the average thicknesses of the various geological formations in this locality.

	Feet.
Edmonton (not measured).	
Bearpaw (Pierre-Foxhill)	650
Belly River	850
Claggett (Lower Dark Shales)	250
Cardium sandstone	50
Niobrara-Benton	725
Dakota	950
Kootenay	375
Fernie	225
Palæozoic (not measured).	

Bow River Section.

On the map accompanying this report is shown a structural section along the Bow river from the mountains to a short distance east of the mouth of Jumpingpound creek. This section is measured true east and west, the outcrops being those observed chiefly along the banks of the river and projected on this east and west line; therefore, the distances between points

along this section are the distances the points are east and west from one another and consequently somewhat less than the actual distances as measured along the river.

The disturbed area of the Foothills extends along the Bow river from the mountains east to the mouth of Grand Valley creek. East of this the strata are quite regular but the hills are somewhat rolling for a distance, forming what may be regarded as the northern extension of the Porcupine hills.

At the mouth of Jumpingpound creek characteristic sandstones and shales have a slight easterly dip of 5° to 10°. East of this, to the end of the section, the formation has a lower dip-becoming almost flat south of Cochrane station, where the rocks are upper Laramie, or what Dr. Dawson called the Porcupine Hills series.

West of Jumpingpound to the mouth of Grand Valley creek, the Edmonton rocks continue to dip quite regularly, increasing the angle of dip to about 28°—just east of the mouth of the creek. These rocks are light coloured, soft sandstones, clays, and shales, usually of very pale brownish or yellowish shades; some light grey sandstones, however, outcrop as well. The shales and clays at the mouth of Grand Valley creek are pale yellows, blues, and greens. Molluscs are of frequent occurrence in these sandstones, *Ostrea glabra* being very plentifully found at several places. At the mouth of Grand Valley creek are also the coal seam and old mine workings described above. For about a mile west of here the rocks show considerable disturbance, exhibiting a series of folds accompanied, to some extent, by faulting. Thence to about two miles west of Morley bridge —a distance of approximately fifteen and a half miles along the river—the dips, as seen on the river banks, are with only few exceptions, all to the west; as the horizons are becoming lower this may, at first, appear strange, but the change is caused by reversed folding. Some faults were noticed west of Grand Valley creek, but they are only of minor importance and are thrusts with eastern downthrow of only a few feet.

Between Grand Valley creek and the mouth of Ghost river two dark shale, Bearpaw belts are seen. The more easterly one shows only the top of an anticlinal fold, rising only a few feet above the water and having the Edmonton sandstones overlying the dark shales composing it.

For about three miles west of Ghost river the rocks are considerably disturbed and those of the Pierre-Foxhill, Edmonton, and Belly River formations are very much interbanded and so intermixed in places that they are exceedingly difficult to distinguish from one another. The fossils found were all those of Pierre-Foxhill types. Three dark shale, Pierre bands were recognized in this distance, between which are chiefly Belly River strata. In places are narrow sandstone beds, often about ten to thirty feet thick, interbedded with portions of these Pierre shales of about the same thickness, showing that these formations are very considerably squeezed together. The section shown is somewhat diagrammatic here, being too small to show this close interbanding, and showing only the main folds.

At a bend in the river about four and a quarter miles above the mouth of Ghost river, the first Niobrara-Benton rocks are seen. Here the Cardium sandstones are quite prominent and each of the three sandstones is capped by conglomerate beds varying from a few inches in thickness to ten or twelve feet. On the hills just north of the river two bands of the conglomerates from ten to twelve feet wide were observed. Specimens of *Cardium pauperculum* are very plentiful in these sandstones. From here up the river for about two and a half miles, to a few hundred feet above Morley bridge, these dark shales with the Cardium sandstones outcrop continuously, either on the river banks or in the hills to the north. The sandstones and conglomerates cross the river twice above the bend in the river above referred to, the second crossing being just at the Morley agency. Pierre fossils, such as *Baculites compressus*, occur in several places in the Claggett shales, and Benton types, as *Inoceramus problematicus* and *Scaphites ventricosus*, occur in the shales below.

Up the river, from the most westerly point above described, for about half a mile the Belly River rocks outcrop, overlying the Claggett, and are here noticeably white in colour. A thrust fault, with small throw, again brings the dark shales to the surface for a few feet and then for two miles there is a low flat syncline of Belly River beds, from the western edge of which, to within a mile of the Palæozoic contact, the Claggett, Benton, and Cardium sandstone formations occupy the river bed, the

outcrop in the banks being almost continuous. Here the upper and lower series of dark shales can readily be distinguished from each other by stratigraphy on account of the prominence of the intercalated sandstones. The shale formations are lithologically almost identical, the lower being, however, considerably the thicker. For this distance these formations are in the form of a very flat syncline, similar to that observed in the country to the south of the river, the whole central portion of the fold being approximately flat and undulating. East of Old Bow fort the Cardium sandstones outcrop for over two miles along the river and are practically flat for nearly the whole distance.

The Kananaskis falls, at the mouth of the Kananaskis river, are caused by these sandstones. The upper bed is above the falls proper and gives rise to a rapid. The other two outcrop below the mouth of the river and cause the greater part of the falls. These sandstone beds dip to the west at about 20° and the water falls over their hard projecting edges. The lowest bed is a very hard sandstone weathering to a reddish colour, and is fairly well bedded. The sandstone next above is grey in colour on a freshly fractured surface, is very massive, thick, hard, and even quartzitic. There is a conglomerate bed about one foot thick on top of each of these two lower sandstones. The upper sandstone is here also quite hard, and weathers to a reddish colour. The Belly River beds, overlying the upper shale series, *i.e.*, the Claggett, to the west of here, can be seen reaching high up on the eastern side of the mountains which form the eastern escarpment of the Rockies; and they continue so for about twenty miles to the south of the Bow river.

The formations north from the north end of the Moose mountains are in the form of a wide east and west anticline, pitching to the north, to such an extent that by the time the Bow river is reached, just west of the Kananaskis, the Benton shales are the lowest rocks outcropping even at this relatively low elevation, whereas, only eight or nine miles to the south-east, Kootenay rocks and Fernie shales, over 1,000 feet lower down, outcrop on Coxcomb mountain at an elevation of about 7,000 feet. This shows the structure of this whole area to the northwest of the Moose mountains to be in the form of a toe pointing down to the north and bending over on each side to

the east and west. This same thing also occurs, although not quite so noticeably, on all sides of the Moose Mountain ridge, which in this way influences both the geology and topography of almost the entire area described.

Jumpingpound Creek.

Going up Jumpingpound creek from the mouth of Little Jumpingpound, the two dark shale belts running north from the Elbow river are seen to outcrop, as shown on the map. On account of scarcity of outcrops—the hills being low and deeply covered with wash and drift—these belts were not traced past the points shown, although they may extend farther north than is shown and may be somewhat wider at their northern ends. West of these is the low flat syncline of Belly River beds which is here about eight miles wide and composed of light coloured sandstones, shales, and clays, the sandstones often almost white and generally soft and easily weathered. Ironstone nodules are quite plentiful in many places. For the whole central portion of this belt the formation is somewhat wavy, but is, on the whole, practically flat. A section from its western edge east to the edge of the map-area would be very similar to the one shown along the Elbow river, except that the western sandstone belt is so much wider.

To the west of this syncline come the dark shales again, which are here about two and a half miles wide on account of considerable folding and disturbance, but have their main dip to the east. The folds can here be traced fairly well as the Cardium sandstones are rather prominent and make good horizon markers. These shales were originally folded over the anticline of Dakota rocks to the west, but the upper portion of the fold is entirely eroded away. The Dakota formation here is composed of brown, red, and grey sandstones, and bluish, yellow, green, brown, red, and black shales and clay; in fact, this is a very highly coloured, though somewhat dark series. The sandstones are mostly coarse, but are generally rather hard, and, at times, both these and the shales are very fine-grained and extremely hard and quartzitic—almost as much so as the Cardium sandstones. The upper rocks are very character-

istically green and blue with a few red bands. The beds of this anticline dip rather abruptly to the east and west, but the central portion of the fold is almost flat in an east and west direction, being only slightly undulating. To the west of these Dakota rocks the dark shales again appear, overlying them, but are here somewhat narrow, being quite regular, and have a regular dip to the west. The Cardium sandstones are well defined along the creeks cutting this formation and specimens of *Cardium pauperculum* are here very plentiful in them, as to the north. West of this belt the Belly River beds overlie the dark shales of the Claggett and dip to the west also with decreasing angle of dip until next the fault line between them and the Palæozoic; their angle of dip nearly coincides with that of the fault plane, which is here about 23°.

The hills to the north and south of Jumpingpound creek, where it is passing through the anticline of Dakota rocks, are high and somewhat rugged with dips to the north and south down to the creek from the south and north sides respectively, so that the creek is flowing in a natural channel, somewhat deepened, of course, by erosion and glaciation. The Kootenay rocks near the top of Coxcomb mountain dip to the north down over the face of the hills so rapidly that they outcrop in the creek bottom, nearly 2,000 feet below and only about a mile distant. Those seen in the creek, however, are upper Kootenay and no coal of importance outcrops.

Along the upper part of Sibbald creek, and also along a small creek flowing into Lusk creek from the east and heading at about the same place as Sibbald creek, a splendid section of the Dakota is exposed, the hills rising quite abruptly for nearly 1,000 feet in places, both to the north and south of the heads of these creeks. A somewhat thick, red, coarse sandstone bed about fifty feet thick is noticeable here. Many of the shales and sandstones are very hard, being very different from those seen east of the mouth of Sibbald creek.

The shale belt to the west of here is represented topographically, for the greater part of the thirty-five miles in length of its outcrop, by a valley, or more often by low hills— the soft shales weathering easily— the Cardium sandstones being harder and forming the axis of a ridge or line of hills. These sand-

stones are very helpful in tracing and locating the shales as their outcrop is easy to find, and the dark shales are then found on each side of them.

Following up Jumpingpound creek to its head and continuing in a southerly direction to Canyon creek, up Trail creek and down Ford creek to the Elbow river, the formations remain very constant in strike, dip, and general appearance. The dark shale belt (Claggett and Niobrara-Benton) continues with strike parallel to the mountains to the west, has a very constant width, and maintains a westerly dip of about 35°. Between Canyon creek and the Elbow river a very regular line of low, rounded hills is very noticeable. The Cardium sandstones which form their axes, and hence their summits, have resisted weathering to a much greater extent than the shales on each side. Creeks coming down in an easterly direction from the mountains have worn out valleys and caused the separate hills; otherwise there would be a long ridge for this distance. West of this the Belly River sandstone series dips to the west under the Palæozoic rocks; to the east is a long high ridge running from the west of Coxcomb mountain to the Forgetmenot ridge, and composed chiefly of Dakota rocks, the summit being usually the conglomerate which overlies the coal measures. Canyon creek has cut a wide valley in this ridge, but otherwise it is quite continuous. Thus this outcrop of the coal measures, except along Canyon creek and the Elbow river, is high up on the hills, in fact, near the summit of this ridge. Along the west side of Forgetmenot ridge the conglomerate outcrop forms a ridge higher in most places than the limestones and quartzites.

Elbow River.

The mouth of Bragg creek is somewhat to the west of the centre of a belt of Belly River beds about a mile wide. Only the lower members of this series outcrop here, the formation being in the form of a synclinal fold and the upper beds being eroded away, so that the same strata are easily recognized on both sides of the belt. Dark shale series occur on each side, the ones to the west, particularly, being considerably disturbed, folded, and broken, causing the Cardium sandstones, intercalated

in them, to appear in a number of places. West of this again is the wide low flat syncline of Belly River rocks, which is about three miles wide along the Elbow. This series presents an almost continuous grey appearance and the beds are for the most part soft and coarse-grained, but there are a few, however, which are somewhat harder. The sandstones are chiefly grey and light yellow in colour, the shales being bluish, grey, or light yellow.

From the contact as seen along the river, between this last-mentioned series and the dark shales to the west again, it would be difficult to say which series was the older; but the exposures along the hills to the north and south leave no doubts as to this; the contact being well defined and the strata all having regular, low dips to the east for a considerable distance on each side of the contact. This Claggett and Niobrara-Benton belt is about two and a half miles wide here and the dips are chiefly low, 10° to 15°, to the east. However, here as elsewhere, these rocks have been considerably more disturbed than the sandstone series on each side and are repeated by folding and faulting, so that they are not nearly so thick as would be supposed from this wide outcrop. The Cardium sandstones were only noticed in one place. When once below the surface the irregularities were not sufficient to bring them up this high again.

West of these shales is a sandstone belt of Dakota about two miles wide. In contrast to the Pierre, Claggett, Benton, and Fernie shales, the Edmonton, Belly River, Dakota, and Kootenay formations are frequently in this report referred to as sandstone series. This does not mean that they are all sandstones, but merely that they have so much more sandstone that they relatively appear to be sandstone horizons in contrast to the shale formations. The rocks of this Dakota series above mentioned are very different from those of the Belly River being much harder and on the whole much darker coloured. Here the whole series dips to the east and is somewhat folded, as shown on the section along this river.

Where the Kootenay formation crosses the Elbow at the mouth of Canyon creek the upper parts of the coal measures are exposed and show considerable disturbance. One fairly

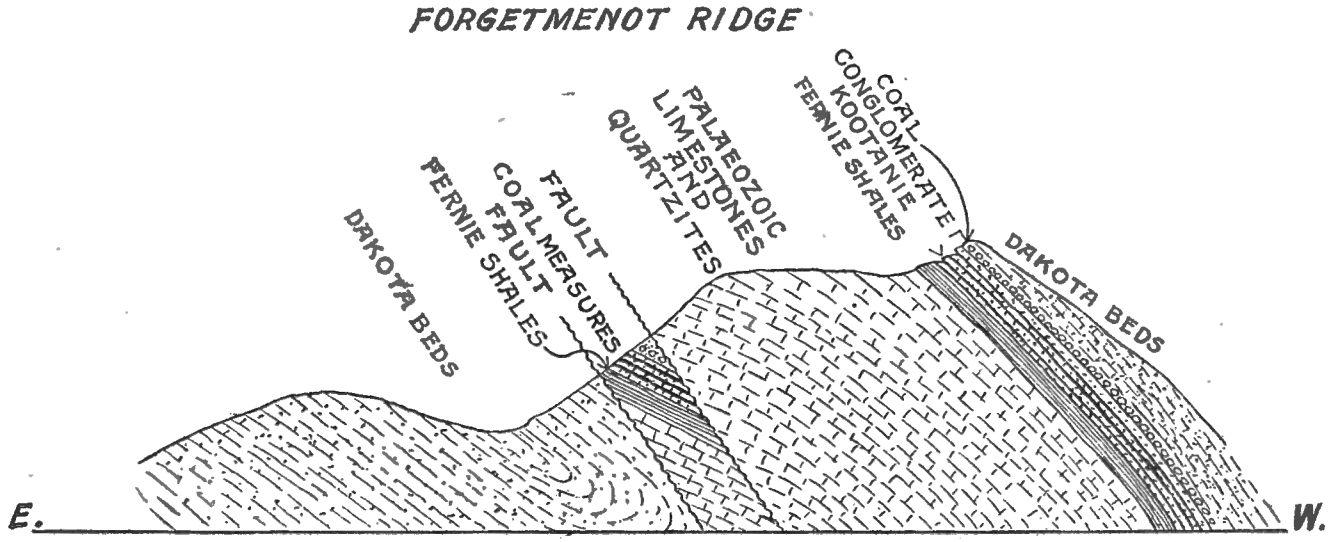

FIG. 1. Sketch section through Forgetmenot ridge.

good regular seam six feet, six inches wide outcrops and others twelve inches and less were seen; the greater part of the measures, however, are under cover. The Fernie shales are well exposed up Canyon creek a short distance from the river, blossoms of iron pyrites being quite plentiful in them, similar to the occurrence at the Thorne mine.

The Kootenay coal measures also outcrop on the west side of this Moose Mountain ridge, all along the western side of Forgetmenot ridge, and were noticed for a short distance along its eastern side; this is owing to a double fold, the Palæozoic rocks here having been pushed over the Cretaceous and the great pressure causing the Cretaceous also to break and a portion to slide over itself again. The sketch, Figure 1, shows a section through the Forgetmenot ridge, just south of the Elbow river, where the double faulting occurred.

West of this Forgetmenot ridge, along the Elbow river and the Fisher branch to the mountains, the prevailing dip is to the west. The Dakota rocks dip quite regularly so, but the dark, softer shale series are considerably folded and broken, much more so than farther north, where they are still overlaid by the Belly River beds.

The section *A* - *B* shown on the map to accompany this report is approximately along the Elbow river and shows the chief folds, faults, etc., of the different formations.

South Branch of Fish Creek.

The Belly River beds along the west side of Robinson dip to the east, overlying the dark shales to the west. These shales, Claggett and Niobrara-Benton, are in the form of a double fold, and the Cardium sandstones outcrop along the summits of the two north and south ridges north of this branch of Fish creek. In this part of the country outcrops are very scarce, and these hard Cardium sandstones are often the only outcrops to be seen over considerable areas. Even the very summits of some of these ridges are heavily covered with wash and drift. A Belly River belt lies just west of these shales, becoming narrower towards the south and disappearing entirely about three miles

south of the creeks. Another belt commences just east and about half a mile north of Bert, and continues to the south branch of Sheep river.

The top of Bert is formed of the Cardium sandstones, the middle sandstone bed forming the summit on which is placed the triangulation station. These sandstone beds here, as elsewhere, are often capped by conglomerate, generally only a few inches to about two feet in thickness, but sometimes considerably more; about one and a half miles southeast of Bert, and just west of the Indian trail, is a nine foot bed of it.

The section through the synclinal, containing Big Meadow and Topknot along this creek (south branch of Fish creek) and the shale belt to the east, is very similar to that along the Elbow river, to the north. The contacts on each side of the Belly River belt here are well exposed, and well defined regular dips were seen on its east and west sides dipping to the west and east respectively—placing these sandstones decidedly above the Claggett and Niobrara-Benton shales on each side. These shales to the west of this Belly River belt, and north of the creek, are very much the same as to the north, but south of the creek there is a very noticeable change.

Erosion has been greatest on the steep, high sides of the Moose Mountain Palæozoic ridge, which extends south to just about the head of the south branch of Fish creek. The formations outcropping to the south of this ridge, however, are more easily weathered, and the hills, which were lower, originally, are much more so now, and, on this account, the erosion to the east has been very much less. So great has the effect of this been that the hills to the south of this south branch of Fish creek near its head rise quite abruptly for 1,000 to 1,500 feet from the valley. North of the creek the Belly River formation has been entirely eroded away and only low rolling hills of shales are left, which would be still lower and practically down to base-level only for the resistance offered by the harder intercalated Cardium sandstones.

So these causes account for the high ridge to the south of this creek, which is almost continuous from Rock point to Bert. Rock point, and the two hills just to the east forming the northern end of Barwell ridge, are in the form of a flat

syncline, about two miles wide. The Belly River beds on the tops of these hills can be distinctly seen overlying the dark shales on the north and west sides. Along their west side, along the east side of Long Muskeg, and south to the north branch of Sheep river, the contact is a considerable distance up the hill sides, causing the Belly River formation to appear like a wide flat cake overlying the dark shales.

East of Robinson, to the edge of the map-area, the outcrops are very scarce. Even the tops of the hills and ridges are often only wash gravel and glacial drift. However, Edmonton sandstones and shales were recognized about two miles east of Robinson, and the Pierre belt was searched for—which should lie in between these and the Belly River beds,—but could not be found. A low, prominent strike valley, however, lies about a mile east of Robinson and Fish butte, and is noticeably continuous for a considerable distance north and south of Fish creek, and in all probability connects with the Pierre belt just west of the mouth of Ghost river to the north, and with the one about a mile west of the mouth of Fisher creek.

Very little time was spent along this eastern portion of the map-area on account of the heavy covering everywhere. When the Edmonton and Belly River outcrops become so scarce it is almost impossible to follow the Pierre belts except by finding some point where they cross a stream or river, and probably outcrop, and then following the valleys caused by their presence.

The coal seams east of Evans and along both the north and south branches of Fish creek are probably of the same horizon as the seam at Grand Valley creek on the Bow river.

From Robinson to Evans the dips are somewhat undulating dipping both to the east and west, but chiefly to the east. Otherwise the formations seem quite regular until in the vicinity of the coal, half a mile east of Evans. Here the rocks are much disturbed and folded, and twisted considerably; the area being very similar to the correspondingly narrow and irregular belt along Grand Valley creek to the north. This line may be regarded as the eastern edge of the disturbed region of the foothills.

North Branch of Sheep River.

Within about one mile up Sheep river from the mouth of Fisher creek are two narrow belts of Pierre shales. These could not be traced far to the north of the river on account of the scarcity of outcrops of any kind. However, the more westerly belt probably continues north as described above. West of this for nine or ten miles, to the fault line running north and east of Allsmoke, and east of Gleasons Meadow and Gleason, the formations are folded into a series of quite regular wave-like folds, with the crests of the waves pushed over, so that the dips are all to the west. Belts of Belly River beds alternate with those of the dark shales for this distance.

The Belly River formation has been entirely eroded off the wide belt of shales just east of Nigger John, owing to the rather flat dip here; just as much or even more erosion has taken place for six or seven miles to the west, but the angles of dip are higher and consequently the Belly River beds dip lower; so that this wide shale belt is an indication of less disturbance than farther west, and of the approach of the eastern edge of the disturbed belt. The Cardium sandstones are here, as elsewhere, very valuable in locating and tracing these Claggett and Niobrara-Benton dark shale outcrops. The top of Mesa hill is formed of these sandstones, which also outcrop prominently in the shale belt just west of Nigger John.

Light brown, grey, and white sandstones are common in these Belly River belts; also some greenish sandstones and shales appear; a good outcrop of which was seen on Lowndes. On Sinnot 2 brown weathering, light grey, and brown sandstones outcrop for some distance On the east side of Sinnot 1 are the white and light grey sandstones so typical of these Belly River beds. An outcrop of this same formation on Ware creek, about half a mile below Gleason creek, shows a great variety of shales and sandstones. All are light coloured, but all shades of shales from light, bright yellows, to blues and green were seen, as well as light brown, grey, white, and yellow sandstones.

From Nigger John to Death's Head the dips are all to the west and at rather high angles, in most places, but a somewhat abrupt fold has brought the dark shales and Cardium sandstones

to the surface just west of Death's Head. The high part of the hill around the station consists of a rather flat layer of very white sandstone overlying the Claggett shales. About a quarter of a mile south of here the formation dips to the south at 28°.

West of Death's Head about two miles is the fault line above referred to. Between it and the dark shales just west of Death's Head the Belly River beds dip to the west in most places, but the formation is very much folded and distorted, much more so than is shown on the section, which, owing to the scale on which it and the other section are necessarily drawn, is in very irregular places, somewhat diagrammatic. West and south of this fault line, i.e., south of the north branch of Sheep river, south of the Palæozoics of the Forgetmenot ridge, and north of Gleasons Meadow and Volcano, is a very irregular block of country. The displacement of the thrust fault east of the Forgetmenot ridge has been quite extensive and to the south of it this fault has given place to a great fold, so that on the top of Allsmoke is the coal conglomerate, overlaid by some of the Kootenay rocks; and on the north side of the hill an almost complete section is shown from the Kootenay down the hill through the Dakota to the Niobrara-Benton and Claggett. So that here these formations are exactly upside down, whereas on Volcano, Gleasons Meadow, and Gleason identically the same section appears but right side up. The rocks at Allsmoke have been pushed over each other so as to form a complete double fold and then the top has been eroded off. This is shown in the two sections on the map, through Allsmoke—*C. D.* being east and west and *E. F.* being north and south. The *C. D.* section also shows the structure, approximately, along the north branch of Sheep river east of Allsmoke.

The great fold, above mentioned, also accounts for the great variation in the strike of the rocks in this locality. The dips from the north of Volcano and Allsmoke south for several miles are, in a general way, all to the south at low angles, the horizons becoming higher and the hills lower in this direction. Also this displacement of the fault by the fold accounts for the low wide valley north of Allsmoke and west of Long Muskeg, and for the rapid rise of 1,500 feet to 18,000 feet of the hills along the

Volcano-Allsmoke ridge from the river on their north side. The rocks of these latter hills have been folded and pushed high up in the air, whereas those of the valley to the north, which are in the form of a low wide anticline, have had the Palæozoics thrust over them.

Quite a wide flat cake of the conglomerate which overlies the Kootenay coal measures forms the top of Gleasons Meadow.

The limestones of Forgetmenot ridge in places appear to be in the form of a complete anticline, especially east of Forgetmenot and Old Forgetmenot, as the western part of the ridge is arched and the arching continues to the eastern edge, which in most places between Threepoint creek and the Elbow river is an abrupt escarpment of from 700 feet to 1,000 feet. This arching causes the dips on the top of the hills to be almost flat, but dipping at low angles to the west, and as the west is approached they become higher until next the Cretaceous they are, in places, 60° to 65°. This shows that here there was considerable folding before the break occurred, which exists all along the eastern edge of this ridge.

South Branch of Sheep River.

For seven or eight miles up the south branch of Sheep river from the mouth of Macabee creek, the geology is very similar to that along Ware creek to the north, the noticeable feature being the succession of somewhat wavy, regular folds, causing the Belly River beds and the dark shale series to appear in alternate narrow strips or belts, presenting on the map a ribbon-like appearance. The cause of this folding is the same as to the north along Ware creek, the displacement of the fault east of Forgetmenot ridge is much greater than east of Lower Camp and Gleason and this folding takes up the surplus of lateral area.

The dips from the mouth of Macabee creek to Gorge creek are all to the west, showing that pressure from the west has caused the crests of the folds to be all pushed over. The Cardium sandstones have become much less prominent here than to the north; there being no conglomerates noticed at all, and their thickness west of Lower Camp being only about fifty feet. They still, however, possess the same characteristics as to the north and the total thickness of the Claggett and Niobrara-Benton has increased to 1,200 feet to 1,300 feet.

The Belly River beds east of Lower Camp contain coal seams in several places as described above, and on account of the accessibility and favourable opportunities for working and prospecting, these coals ought to prove of considerable value in the near future. The Belly River belts east of the mouth of Dyson creek are noticeable for their rapid alternations of sandstones and shales, for the general softness of the rocks, and for the great amount of light coloured clay shales, chiefly grey, blue, green, and very light brown. The sandstones, in which are abundant remains of tree-trunks often of large size, are usually coarse and white or grey, being occasionally a very light brown.

In the river banks just above Lower Camp is probably the best section of the Dakota seen this season. It is here all exposed and there is a continuous outcrop from the top to the bottom. The dips are all quite regularly to the west. In the river banks farther up the river, just south and east of Hoffmann, is also a very good section. The description given above of the Dakota formation describes the rocks of these sections quite closely.

The top of the mountain on which are North Greenslope and West Greenslope stations is composed practically of a flat cake of Belly River beds, which can be distinctly seen overlying the dark shale series on all sides, the contact being rather high up on the sides of the mountain. The same thing also exists on the north side of the river in the case of the mountains containing Forks and Missing Link stations. Here, however, the contact is very nearly at the tops of the hills in places.

Just east of Gorge creek is the axis of a wide synclinal fold and from here west for some distance the dips are low and to the east.

The ridge just south of the river and east of North Greenslope is composed of a row of small summits, each one caused by the Cardium sandstones. This is the same thing happening as was seen in the northern part of this district so often, the softer shales weathering rapidly away from each side of these harder sandstones and causing the summits of the hills and ridges.

The wide Dakota area just west of the mountains and south of Threepoint creek, and containing Volcano, Ware Head, Hoffmann, and Junction, is in the form of a high, flat anticline,

very similar in structure, and in the rocks composing it to the area north of the Moose mountains. The contact on the eastern edge with the Benton shales is well exposed in the river and in the hills to the south; and the shales are in every case overlying the Dakota beds with low dips to the east. Toward the western side the dips are to the west, and along the river the angle of dip nearly coincides with the angle of the fault plane between it and the Palæozoic rocks. The central portion of the fold is undulating somewhat, but taken as a whole is practically flat. Ware Head is the axis of an irregular anticlinal fold. The coal measures outcrop in places to the north of Hoffmann, but the outcrops are in most places covered by drift gravels and wash, so that a section of the measures was not obtained here. On the north face of Hoffmann, about half way up it, the conglomerate which overlies the coal measures appears in the form of an arch, the whole hill being a minor anticline somewhat pushed over to the east. The measures are here also mostly covered, but a partial section is to be seen along the river.

P. Burns' Coal Basin.

Just inside the first range of mountains and along the headwaters of the south branch of Sheep river is a Cretaceous trough carrying valuable coal measures of Kootenay age, of which a considerable area is owned by P. Burns, of Calgary. The coal seams which have been described in another part of this report have been opened up to some extent in a couple of small creeks, running into Sheep river from the west, just about where the Indian trail crosses the divide from the Highwood river.

This Cretaceous basin terminates to the north about two and a half miles north of the Elbow river; the southern end was not explored as it extends far to the south of the area covered by this report.

The Cretaceous measures in some places, especially to the south, appear to be faulted along their western edge. Toward the north, however, a secondary fold is developed as the Elbow river is approached, that causes the trough to become somewhat narrower. Here it appears quite certain that the Palæozoic rocks to the west have been pushed over themselves and now overlie the Cretaceous.

Immediately on top of the limestones are some very hard, fine-grained, almost white quartzites, from 200 to 300 feet thick, and varying in colour from pure white to a light grey. The shales and sandstones which overlie these are much thicker than to the east around the Moose mountains, although they are otherwise very similar. The conglomerate which overlies the coal measures to the east was not seen here in place, but considerable of the float was found on the hillsides, so that it very probably outcrops on some of the higher points or ridges; but as our work was done late in the autumn, with considerable snow on the ground, we did not find it.

The formation here consists chiefly of sandstones, characteristically brown in appearance. In fact from the river up to the tops of the high rugged Cretaceous ridge here, the whole series is strikingly brown in colour. The sandstones are, for the greater part, quite uniform in texture as well as in colour, being rather fine-grained and not very hard. About halfway up the hill a few coarser and greyer beds were seen and also some darker ones. Above this again are a number of black shale beds generally only a few feet in thickness, and often carbonaceous, being at times composed almost wholly of the remains of ferns, etc. Near the top of the hills are a few coarser grey and greenish sandstones. Quite a number of plant remains were collected from this series, all being very characteristic Kootenay types.

The lowest beds of this series were only seen in a few places, but there they correspond very closely with the rocks underlying the coal measures just outside the mountains and even very noticeably have the same peculiar yellowish weathering which so much resembles limestone weathering, although these shales and sandstones in most places contain very little lime.

The high hills of this Cretaceous trough extend in a northwesterly direction along the west side of Sheep river to within about three miles of the Elbow river. From here they rapidly disappear and the Cretaceous and Jurassic instead of being a high rugged ridge become a narrow valley in between the limestone hills on each side. The formation, as it were, goes up in the air; so that about three miles north of the Elbow

river it has tapered out entirely. The coal also disappears with the high hills, having been all eroded away in the northern part of the basin.

At the northern end of this trough the same quartzites appear as were seen farther south and they outcrop similarly on both sides, proving that this part of the trough is in the form of a synclinal fold. Along the river the folding of the limestones, also, gives ample evidence of this.

The western contact is high up on the face of the escarpment at the Elbow river, but as the trough is traced northward it descends, and finally, at the point of thinning out entirely, reaches nearly the level of the valley.

Some hundreds of feet of dark shales were seen next the Palæozoic quartzites here, resembling very closely those around the Moose mountains, and they are undoubtedly of the same horizon. Intercalated in these dark Fernie shales are thin beds of yellowish brown weathering sandstones of medium hardness and texture and reddish-grey in colour. The shales themselves are quite soft and free from coarse sand and often present in their bedding planes quite a soot-like appearance.

Fossils.

No vertebrate remains were found.

Specimens of the following invertebrate remains were obtained.

From the Edmonton formation—
Ostrea glabra.

From the Bearpaw shales—
Lingula subspatulata.
Pteria nebrascana.
Baculites compressus.

From the Claggett shales—
Lingula subspatulata.
Pteria nebrascana.
Baculites compressus.

From the Cardium sandstones—
Cardium pauperculum, Stanton.

From the Benton shales—

Inoceramus problematicus.
Scaphites ventricosus.
Mould of an ammonitoid, likely—
Prionscyclus woolgari.

From the Dakota formation—

Sphærium, sp.
Viviparus, sp.
Goniobasus, sp.
Campeloma, sp.

From the Fernie shales—

Guards of *Belemnites*, sp.

The above specimens were examined and named by Dr. Whiteaves of this Department.

The plant remains found this season were examined and named by Dr. D. P. Penhallow, of McGill University. The following were obtained:—

From the Edmonton formation—

Sequoia reichenbachi, Heer.
Viburnum, sp.
Platanus newberryana, Heer.

From the Bearpaw shales—

Sequoia reichenbachi, Heer.
Cyadites unjiga, Dn.

From the Belly River formation—

Populus elliptica, Newb.
Betulites, sp.
Dioonites, sp.
Asplenium niobrara, Dn.
Athrotaxopsis tenuicaulis, Font.
Asplenium dicksonianum, Heer.
Thyrsopteris pecopteroides, Font.
Sequoia smittiana, Heer.
Protophyllum haydenii, Lecsq.
Cissites, sp.
Sequoia cuneata, Newb.
Ginkgo baynesiana, Dn.

Paliurus cretaceus, Lecsq.
Salix, sp.
Quercus rhamnoides, Lecsq.
Juglans crassipes, (?) Heer.
Paliurus ovalis, Dn.
Angiopteridium strictinerve. (?)
Ginkgo sibirica, Heer.
Sequoia reichenbachi, Heer.
Sphenopteris johnstrupi, Heer.
Sequoia ambigua, Heer.
Alnites grandifolia, Newb.

From the Claggett shales—
Cycadites unjiga, Dn.

From the Dakota formation—
Carpolithus ternatus, Font.
Fruits, probably of *Ginkgo*.
Sphenolepidium sternbergianum densiflorum, Heer.
Ginkgo lepida, Heer.
Ginkgo sibirica, Heer.
Ginkgo, sp., male inflorescence.
Athrotaxopsis tenuicaulis, Font.
Nilsonia californica, Font.
Ginkgo huttoni, Heer.
Thyrsopteris brevipennris, Font.

From the Kootenay formation—
Dryopteris fredericksburgensis (Font.), Knowlt.
Cycadites longifolius, Font.
Sagenopteris mantelli (Dunk.), Schenk.
Athrotaxopsis tenuicaulis, Font.
Sagenopteris n. sp.
Thyrsopteris meekiana, Font.
Sequoia heterophylla, Vel.
Sequoia smittiana, Heer.
Sagenopteris elliptica, Font.
Baieropsis pluripartita, Font.
Podozamites longifolius, Emmons.
Podozamites lanceolatus (L. and H.), Schimp.
Thyrsopteris insignis, Font.

Thyrsopteris pecopteroides, Font.
Cladophlebis falcata, Font.
Zamites arcticus, Gopp.
Ginkgo huttoni magnifolia, Font.
Cladophlebis constricta, Font.
Nilsonia, n. sp.
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Some of the types found in the Belly River formation have by some authorities been considered as belonging to the Dakota.

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LIST OF RECENT REPORTS OF GEOLOGICAL SURVEY

Since 1910, reports issued by the Geological Survey have been called memoirs and have been numbered Memoir 1, Memoir 2, etc. Owing to delays incidental to the publishing of reports and their accompanying maps, not all of the reports have been called memoirs, and the memoirs have not been issued in the order of their assigned numbers, and, therefore, the following list has been prepared to prevent any misconceptions arising on this account. The titles of all other important publications of the Geological Survey are incorporated in this list.

Memoirs and Reports Published During 1910.

REPORTS.

Report on a geological reconnaissnace of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont.—by W. H. Collins. No. 1059.

Report on the geological position and characteristics of the oil-shale deposits of Canada—by R. W. Ells. No. 1107.

A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories—by Joseph Keele. No. 1097.

Summary Report for the calendar year 1909. No. 1120.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 1. *No. 1, Geological Series.* Geology of the Nipigon basin, Ontario—by Alfred W. G. Wilson.

MEMOIR 2. *No. 2, Geological Series.* Geology and ore deposits of Hedley Mining district, British Columbia—by Charles Camsell.

MEMOIR 3. *No. 3, Geological Series.* Palæoniscoid fishes from the Alberta shales of New Brunswick—by Lawrence M. Lambe.

MEMOIR 5. *No. 4, Geological Series.* Preliminary memoir on the Lewes and Nordenskiold Rivers coal district, Yukon Territory—by D. D. Cairnes.

MEMOIR 6. *No. 5, Geological Series.* Geology of the Haliburton and Bancroft areas, Province of Ontario—by Frank D. Adams and Alfred E. Barlow.

MEMOIR 7. *No. 6, Geological series.* Geology of St. Bruno Mountain, Province of Quebec—by John A. Dresser.

MEMOIRS—TOPOGRAPHICAL SERIES.

MEMOIR 11. *No. 1, Topographical series.* Triangulation and spirit levelling of Vancouver island, B.C., 1909—by R. H. Chapman.

Memoirs and Reports Published During 1911.

REPORTS.

Report on a traverse through the southern part of the North West Territories, from Lac Seul to Cat lake, in 1902—by Alfred W. G. Wlison. No. 1006.

Report on a part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers—by W. McInnes. No. 1080.

Report on the geology of an area adjoining the east side of Lake Timiskaming—by Morley E. Wilson. No. 1064.

Summary Report for the calendar year 1910. No. 1170.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 4. *No. 7, Geological Series.* Geological reconnaissance along the line of the National Transcontinental railway in western Quebec—by W. J. Wilson.

MEMOIR 8. *No. 8, Geological Series.* The Edmonton coal field, Alberta—by D. B. Dowling.

MEMOIR 9. *No. 9, Geological Series.* Bighorn coal basin, Alberta—by G. S. Malloch.

MEMOIR 10. *No. 10, Geological Series.* An instrumental survey of the shore-lines of the extinct lakes Algonquin and Nipissing in southwestern Ontario—by J. W. Goldthwait.

MEMOIR 12. *No. 11, Geological Series.* Insects from the Tertiary lake deposits of the southern interior of British Columbia, collected by Mr. Lawrence M. Lambe, in 1906—by Anton Handlirsch.

MEMOIR 15. *No. 12, Geological Series.* On a Trenton Echinoderm fauna at Kirkfield, Ontario—by Frank Springer.

MEMOIR 16. *No. 13, Geological Series.* The clay and shale deposits of Nova Scotia and portions of New Brunswick—by Heinrich Ries, assisted by Joseph Keele.

MEMOIRS—BIOLOGICAL SERIES.

MEMOIR 14. *No. 1, Biological Series.* New species of shells collected by Mr. John Macoun at Barkley sound, Vancouver island, British Columbia—by William H. Dall and Paul Bartsch.

Memoirs and Reports Published During 1912.

REPORTS.

Summary Report for the calendar year 1911. No. 1218.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 13. *No. 14, Geological Series.* Southern Vancouver island—by Charles H. Clapp.

MEMOIR 21. *No. 15, Geological Series.* The geology and ore deposits of Phoenix, Boundary district, British Columbia—by O. E. LeRoy.

MEMOIR 24. *No. 16, Geological Series.* Preliminary report on the clay and shale deposits of the western provinces—by Heinrich Ries and Joseph Keele.

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