

GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, LL.D., F.R.S., DIRECTOR.

PRELIMINARY NOTE

ON THE

GEOLOGY

OF THE

BOW AND BELLY RIVER DISTRICTS,

N. W. TERRITORY,

WITH

SPECIAL REFERENCE TO THE COAL DEPOSITS.

BY

GEORGE M. DAWSON, D.S., F.G.S.,

ASSOCIATE ROYAL SCHOOL OF MINES.

Montreal :

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GEOLOGICAL SURVEY OF CANADA,
7th May, 1882.

THE RIGHT HONORABLE

SIR JOHN A. MACDONALD, K.C.M.G.

Minister of the Interior.

SIR,—I have the honor to transmit, for the information of the Government, the accompanying interesting and important notes by Dr. G. M. Dawson, embodying the results of his exploration, made last summer, of the extensive coal deposits in the North-west Territory. Several seasons' work will be required to obtain the necessary data for a full report, and for the construction of an accurate map of these coal fields. As, however, they are likely to attract considerable attention during the ensuing summer, with a view to their practical development, it has been thought desirable that the publication of the facts that have already been ascertained should not be delayed.

I have the honor to be, Sir,

Your obedient servant,

ALFRED R. C. SELWYN,
Director of the Geological Survey.

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OUTLINE OF THE GEOLOGY OF THE REGION.

In submitting the following preliminary report, I may state that it is intended as an outline of the work done during the past summer (1881). In the prosecution of the exploration I was ably assisted by Mr. R. G. McConnell, B.A.

The region examined forms the south-western angle of the North-West Territory, and is drained chiefly by the Bow and Belly Rivers and their tributaries, though a portion of it lies in the Missouri Basin and is drained by the Milk River.

It is proposed at present to give merely a short preliminary account of the geology of the district, with special reference to the coal beds. After the completion of next summer's work it is intended to construct a geological map on the scale of 8 miles to an inch, corresponding with those already published for British Columbia and the Peace River and Upper Saskatchewan country, and to embody all the necessary details of structure in a general report. The region which has now been partially mapped and examined, extends from the 111th meridian westward to the Rocky Mountains, and is bounded south and north by the 49th and 51st parallels of latitude. The area of this region—drawing the western line at the edge of the Palæozoic rocks—is slightly over 20,000 square miles.

A portion of the Rocky Mountains was also explored and mapped; but as the mountainous district must form the subject of a separate investigation, it will be necessary to state here, merely that the south

Kootanie Pass, the Crow's Nest Pass, and the eastern portion of the Bow River Pass, were the districts particularly examined. The most interesting feature of these explorations was the discovery that in the region of the Crow's Nest Pass, wide valleys based on Cretaceous rocks occur west of the first range formed of the Palæozoic limestones, and that, in these Cretaceous rocks, an important intercalation of volcanic material appears. It is possible that in some of these now isolated troughs of Cretaceous rocks coal beds may yet be found, in the heart of the range. The existence of a seam was indeed reported about twenty miles west of the summit of the Crow's Nest Pass, but I was unable to reach the locality.

The rocks of the foot-hills and plains east of the mountains, are, so far as ascertained, entirely of Cretaceous and Laramie age, overlain by boulder clay and other beds referable to the glacial period, and alluvium. In the eastern portion of the district they are horizontal or very nearly so, being frequently affected by light undulating dips scarcely greater than may be supposed to have characterized the original surface of deposition. On approaching the base of the mountains this uniformity suddenly ceases, and the beds become more or less sharply corrugated, the disturbance being in some instances so great as to result in overturned folds. The belt of country affected by this disturbance constitutes the foot-hills. The exposures of the newer rocks nearest the actual margin of the Palæozoic, very often show comparatively light south-westerly or westerly dips toward the base of the mountains. A series of great faults with downthrow eastward must separate these newer rocks from those of the mountains, and it is by a repetition of similar faulting in the mass of the range, that the isolated areas of Cretaceous rocks already alluded to have been introduced.

On the Bow River Valley, the width of the disturbed belt from the edge of the Palæozoic (which here falls back some miles from its general line) is about twenty-seven miles. On the Highwood River and its tributaries, the limit of the region has not yet been ascertained. On the North Fork of the Oldman it is about twelve miles in width. On the southern branches of the same stream, including Mill and Pincher Creeks, about thirteen miles. On the Waterton (Kootanie), Belly and St. Mary Rivers, about eighteen miles.

The geology of the region in the immediate vicinity of the mountains is also complicated by the fact that the beds there change considerably in lithological character, the change being such as would be expected to occur on the approach to a shore line. Sandstones are much more abundant and coarser in texture, and in a few places conglomerates holding pebbles derived from the mountains, occur.

One of the most abundant materials in these coarser rocks is the chert which is derived from concretions and irregular layers in some parts of the limestone series.

In the Belly River region, east of the belt of disturbed rocks referred to above, the Cretaceous and Laramie beds form a broad, shallow synclinal, the centre of which is occupied by the Porcupine Hills. A series of reddish and purplish clay beds, which may be named provisionally the Willow Creek series, appear to be very persistent in the Laramie of this region, and afford the means of recognizing a definite horizon over a large tract of country. The width of the synclinal just alluded to—measuring from the base of the Willow Creek series on each side—on the Oldman River and its tributaries, is about forty miles. In proceeding eastward from this synclinal to the boundary of the district embraced in the season's work, the series is, with little exception, a descending one. The beds appear to have, as a rule, persistent light westerly or south-westerly dips, while the rivers have a considerable eastward slope; and though, as above stated, many minor undulations affect the nearly horizontal rocks of the plains, these are, as a rule, so light as to interfere little with their uniformity on the large scale. One important exception only has been noticed to this rule, where, a few miles above the mouth of the Belly, on the Oldman River, the estuarine and marine beds characteristic of the base of the Laramie are upturned at angles of from 30° to 45°. Similar abrupt local disturbances are occasionally found in the west—as in several instances on the Missouri River—in connection with the intrusion of volcanic rocks, but there is no evidence here of such cause.

The general arrangement of the rocks may be represented as in the subjoined table, the subdivisions being in descending order. No attempt is at present made to state the thickness of the several subdivisions, as the map work and sections are not yet sufficiently advanced to render it possible to do so with an approximation to accuracy:—

LARAMIE, (including Judith River series.)	}	Beds of the Porcupine Hills. Massive sandstones, with shales, &c.
		Willow Creek beds. Reddish and purplish clays, with grey and yellowish sandstones.
		St. Mary River series. Sandstone shales and clays of general greyish or greyish-green colours.
		Yellowish sandstones and shaly beds, with a mingling of fresh-water and brackish or marine molluscs.
FOX HILLS.	{	Yellowish sandstones, with some shales, apparently irregular in thickness and character. Molluscs all marine.

PIERRE.	{	Blackish and lead-coloured shales, with occasional sandstone intercalations, especially toward the mountains.
NIORARA ?	{	Belly River series. Sandstones, shales and sandy clays. Upper part generally greyish ; lower yellowish, and often banded by rapidly alternating beds. Fresh and brackish water molluscs.

So far, no reason has been found to suppose that any beds newer than the Laramie (including under this general name the Judith River and Fort Union series) have been found in this district, or indeed in any part of the Canadian North-west Territory.

The beds typically developed in the Porcupine Hills have not yet been fully examined, though it is probable that those seen on the upper part of the Bow River, in similar relation to the mountains, are of the same age. It was my intention to run a line of section completely across the Porcupine Hills last autumn, but the unusually stormy weather and early fall of snow prevented this from being done. It is probable that the beds developed in these hills are, alone, several thousand feet in thickness. No coal or lignite seams have yet been found in this part of the series, though its general character is such as to render their discovery not improbable.

The relation of the Willow Creek series to the wide synclinal of the Porcupine Hills has already been referred to. The beds of this series are generally soft, and their outcrop has caused the wide low valley which bounds the Porcupine Hills to the west, and crossing Pincher Creek at the Police Farm, runs south-eastward to the Waterton (Kootanie) River. In the vicinity of the upper part of Milk River, however, they are almost horizontal, and form the higher parts of the plateau. They also stand up prominently in the Belly Butte, near the confluence of the Belly River with the Waterton, and probably form the upper portion of the western part of Milk River Ridge. The characteristic colouring and appearance of these beds constitutes the only reason for giving them a separate provisional name, as they appear to be perfectly conformable with those above and below. Small, irregular, clayey nodules of peculiar appearance abound in some layers. Fossils are remarkably scarce, though a few fresh-water molluscs have been observed ; and on the Oldman River, a few miles below the mouth of Willow Creek, the remains of a large chelonian were met with. These beds were not recognized on the Bow River, and it is probable that they die out or change their character in the region between the localities just mentioned and that stream. In this region exposures are few and poor, owing to the depth of the drift covering. No coals or lignites have been found in the Willow Creek beds.

The rocks which may be provisionally designated the St. Mary River Series cover a large portion of the region under description. They have been carefully examined at many different localities, and extensive collections of fresh-water molluscs have been made from them. These beds are shown in excellent sections for many miles on the Upper Belly River, and the St. Mary, Waterton and Oldman Rivers and Pincher Creek. They are generally characterized by rapid alternations of sandstones and shaly or clayey beds, the stratification, as a rule, being regular. Greyish or greenish- or bluish-grey tints characterize the beds, though some of the sandstones weather to yellowish colours, and ironstone nodules are of frequent occurrence. At the base, these rocks show estuarine and marine conditions, and yellowish colours prevail. These latter beds have been separately designated in the table of formations, but there is probably no distinct character by which they may be separated from those above, except the passage from brackish-water to fresh-water conditions. The close relations of these with the upper beds is further illustrated by a section on Bow River, described below. In these transition beds, in the Belly River region, *Corbicula pyriformis*, *Corbicula occidentalis* and *Ostrea* are found in some layers in great abundance. These fossils were observed in several places on the Upper Belly and St. Mary Rivers, and also on the Oldman River at the point already mentioned as showing a peculiar disturbance of the beds. The same zone runs northward to the Scabby Butte, and here includes large numbers of bones of vertebrates, probably dinosaurian.

The whole of the beds so far described have been included under the general name of Laramie. The total thickness of the formation in this region is very great, several thousand feet at least, and much in excess of that of the Judith River beds as developed on the Missouri. Northward, on the Bow River, the Willow Creek beds have not been identified, and it has been found impossible to carry out the subdivisions which can be defined on the Belly and its tributaries. On the Bow, the Laramie extends continuously from the edge of the disturbed rocks of the vicinity of the mountains to a point about ten miles below the Blackfoot Crossing—a distance of over eighty miles. At the western edge of this region, the beds in their colour and general appearance closely resemble those of the typical St. Mary River subdivision,*but eastward, sandstones predominate over shales and clays, the rapid alternation of beds differing lithologically is less marked, and the bluish and greenish-grey tints before observed are replaced by yellowish-grey and buff. The representatives of the brackish or marine beds described in the Belly River region are first seen near the eastern edge of the formation on the Bow. In a scarped bank about ten miles

above the Blackfoot Crossing, the lowest layers near the river level are full of specimens of *Corbicula occidentalis* and a species of *Ostrea*, while a few feet higher, beds of similar lithological character, and perfectly conformable, are charged with *Unio* and *Vivipara*, and contain no brackish or marine forms.

Near the base, the Laramie is, in the region now reported on, a persistent lignite- or coal-bearing formation. A few miles north of the 49th parallel, on the St. Mary River, a coal bed of excellent quality, eighteen inches in thickness, is found, overlain by a bed holding *Corbicula occidentalis* and *Ostrea*. It is described in my Report on the Geology and Resources of the 49th Parallel (pp. 132, 172.) Another coal outcrop, possibly on the same seam, and about a foot in thickness, is found on the Upper Belly River. The seam at the Indian farm near Pincher Creek is probably again not far from the same horizon, though perhaps a little higher in the series. Coaly streaks occur in the sandstones at the disturbed locality on the Oldman River, which has already been referred to, and a lignite at Scabby Butte may hold the same position. Further north, the seam on the Bow at Coal Creek, between Morleyville and Calgary, and those in the vicinity of the Blackfoot Crossing, appear to occupy nearly the same horizon. The thin seams near the mouth of the Highwood River may possibly be higher in the Laramie, and from the character of the St. Mary River subdivision throughout, it is not improbable that other coal- or lignite-bearing zones may occur locally. The character and surroundings of the more important seams now known are detailed on a subsequent page.

The Fox Hill beds, or their representatives in this district, appear to pass into the base of the Laramie upward, and below to blend with the Pierre, both lithologically and in their fauna. On the lower part of the St. Mary River, a massive sandstone, about fifty feet in thickness, which may be supposed to represent the Fox Hill formation, from its position at the top of the Pierre, is well exposed. On the Milk River, near the crossing of the Benton Trail, and again north of the East Butte, flaggy, yellowish sandstones with truly marine shells occur, and occupy the same position with regard to the Pierre shales.

The Pierre Group, throughout this district, is not so homogeneous in character as further east, and frequently holds sandstone intercalations. Its occurrence at the base of the West Butte has been described in the Report on the Geology and Resources of the 49th Parallel, already referred to. A further examination of this locality has since resulted in the discovery of additional fossils.

The Pierre is again seen with its characteristic fossils on the lower St. Mary River, and its outcrop (at a low angle and occupying consequently a wide belt of country) runs thence north-eastward to the Bow

River, a distance of eighty miles. On the Oldman River the upper part of the Pierre, for a thickness of about fifty feet, ceases to show its usual blackish or dark grey colour, becoming a sombre brown clay shale. On the Bow River the same appearance is found, but the beds so affected are several hundred feet in thickness, and there is also here toward the base of the Pierre a zone characterized by pale sandy clays and sandstones. The Pierre is, however, as a whole, the best marked and most easily recognized formation of the district. The most persistent coal-bearing horizon is included in its base, and has already been utilized in supplying Fort MacLeod, and for shipment to Benton on the Missouri by waggons returning from Fort MacLeod. A second coal seam occurs at the summit of the Pierre on Bow River, at Horse-shoe bend. Details of these are given on a subsequent page.

The beds outcropping on the Bow and Belly Rivers for a distance of over forty miles on each stream above their confluence, are believed throughout to underlie the Pierre. They hold in their upper portion a few fresh-water shells, with occasional fragments of dinosaurian bones, but becomes estuarine and brackish-water toward the base. A more detailed account of these beds is reserved till the examination of the fossils—which seem to show an early appearance of types usually considered as Laramie—has been completed. A seam of lignite, of good quality, but generally of small thickness, occurs on both rivers. It is referred to again where, at one point on the Belly River, it becomes of possible economic importance.

The pale beds underlying the Pierre in this region represent, with little doubt, the Dunvegan sandstones of the Peace River section. (Report of Progress, 1879-80.) They are also evidently identical with those described by Prof. Cope as occupying a similar position on the Missouri (Bulletin U. S. Geol. and Geog. Survey, Vol. III, p. 568.) This subdivision, which appears to occupy the position of the Niobrara in the Nebraska section, is therefore one of great importance in the Cretaceous series.

No description is given in this preliminary report of the Laramie (Judith River) beds of the vicinity of the Three Buttes. These fall within the area of the present exploration, but have already been described at some length in my Boundary Commission Report.

NOTES ON THE MORE IMPORTANT COAL SEAMS OF THE BOW AND BELLY RIVER DISTRICTS.

The fuels contained in the rocks described in the foregoing general notice vary from lignites, but slightly superior in quality to those of the Souris region, to materials containing a very small percentage of water, forming a strong coke on heating, yielding abundance of highly

luminous hydrocarbons, and precisely resembling ordinary bituminous coals, though of Cretaceous or Laramie age. In describing them the general term *coal* will be used, as it is impossible to draw a definite line between the two classes among the numerous intermediate varieties.

The coal seam last referred to as occurring on the lower Bow and Belly Rivers, is seen in the banks for many miles at a varying height above the water, owing to the light undulating dips by which it is affected. It is generally not more than a foot or eighteen inches in thickness though so persistent in extent, but at one point on the Belly River it thickens to three feet, forming a workable seam, which appears to be of good quality throughout. This locality is thirty-two miles in a direct line from "Coal Banks." No analysis has yet been made of this fuel.

The locality just referred to as "Coal Banks" is at the crossing of the Belly River by the trail to Benton. The coal occurring at this place is that which has been described as existing at the base of the Pierre. It is one of the best in the district, and has been worked to a small extent for some years at this point by Mr. N. Sheran. The outcrop of this seam is now known to extend from a point about six miles up the St. Mary River to that part of the Belly near and below Coal Banks, and thence to run northward to the Bow River. South of the point indicated on the St. Mary River, it has not yet been traced, but as it appears remarkably constant in thickness and general character, both here and at the Bow River, sixty-six miles distant, it doubtless extends considerably further in each direction, and may also be assumed to underlie the plains between the Belly and Bow Rivers in workable thickness.

The drift deposits average about one hundred feet in thickness over this part of the plains, and it is consequently, in general, only in the river valleys or in the larger conlées which flow into them that the Cretaceous rocks can be seen. The Belly Valley in this part of its course is about 300 feet deep, and averages nearly a mile in width. It therefore cuts about 200 feet into the Cretaceous rocks, and displays fine sections of these. There are in this vicinity several associated coal seams; one of these, that which has been opened by Mr. Sheran, I may, for the sake of clearness, refer to as the "main coal." It is more or less perfectly exposed at intervals along this part of the Belly for a distance of about twelve miles, or from the workings at Coal Banks to Big Island of the map. Above the Coal Banks the measures are affected by a light anticlinal swell which brings up older rocks, and the outcrop runs round to the west, appearing on the river again at the mouth of the St. Mary. At the furthest point up the St. Mary, where the coal appears (about seven miles from the mouth of the river), it shows the following section, the second column being a continuation of the first at a spot about 100 yards further down stream:—

	ft. in.			ft. in.	
Rusty ironstone layer.....	0	8			
Blackish and rusty shale	5	0			
Coal	0	3			
Blackish shale	6	0			
Coal	0	6			
Soft carbonaceous shale	0	4			
Coal	0	8			
Soft, thin shale, highly carbonaceous in upper part.....	0	6			
Ironstone shale	0	6			
Blackish shale	3	0			
Coal	0	8	Coal	1	0
Carbonaceous shale (some coal).....	1	6	Shaly coal	0	6
Coal (partly below water).....	1	6	Coal	1	3
			Shale	0	2
			Coal	0	9
			Grey shale	4	0
			Coal	1	4
			Grey Shale (to water) ..	4	0

About two miles further down the St. Mary the coals are again seen, with the following development:—

Coal (rather shaly).....	1	0
Coal	1	4
Shale	0	3
Coal	0	9
Shale	10	1
Coal	3	8
Shale (with obscure plant impressions)	6	0

At the mouth of the St. Mary the main seam has a thickness of 3 feet 6 inches, but about 18 inches at the top is rather shaly.

On comparing these sections on the St. Mary with those at Coal Banks and on the Belly River to the north, it will be noticed that the coal at the first-mentioned locality is more divided by shales and less favourably situated for working.

On the part of the Belly River near Coal Banks the measures have, as a whole, a light westerly dip, while that part of the outcrop between Coal Banks and Big Island forms a minor synclinal hollow in its edge, across which the river cuts in a direction nearly coinciding with the main strike of the measures, and gives rise to a great display of coal on this part of the valley. The coal-bearing horizon, as above mentioned, lies at the base of the Pierre, and its position between the dark shales of this formation and the pale sandy beds of that underlying it, renders it easy to define the situation of the coals, even where their actual outcrop is concealed. For a distance of five miles north of the

Coal Banks exposures, the dark shales just referred to occupy the river valley, while the outcrop of the coal is carried eastward to an uncertain distance by the light synclinal undulation above referred to. The gentle inclination of the measures shows that the coal might be reached at a moderate depth by shafts sunk through the dark shales in this part of the valley, from which it might with facility be worked up its slope to the eastward. The undulating character of the dips renders it impossible to estimate the exact depth at which the seam would be found, but it is probably not over 500 feet below the river, midway between its southern and northern outcrops in the valley. It may also be worked on a smaller scale, but with great facility, by levels driven into the actual outcrops in the river banks.

Having thus briefly described the general mode of occurrence of the coal on this part of the Belly River, the following more detailed notes on the outcrops which occur will serve to show the actual character of the seam.

At the Coal Banks, the coal has been extracted chiefly by quarrying along the natural outcrop, though during the past summer a small level has been begun. The outcrop is situated in the front of a steep scarped bank facing the river, and the seam, which at the southern end of the bank is about 30 feet above the water, dips away below the water at the northern. The following section shows the mode of occurrence and association of the coal in the bank, but does not extend upward to the base of the drift deposits:—

		ft.	in.		
	Finely laminated grey shale	8	0		
	Coal (shaly below).....	1	6		
	Grey, thin-bedded shale	12	0		
	Ironstone.....	0	3		
	Grey shale	1	9		
	Coal	0	8		
	Grey shale and nodular sandstone, carbonaceous below ...	7	0		
Main seam.	{	Coal	1	4	} Coal, 5' 4''
		Shaly parting (often almost absent).....	0	4	
		Coal	4	0	
	Carbonaceous shale.....	2	0		
	Grey shale.....	2	0		
	Ironstone.....	0	4		
	Greyish and brownish shale	3	0		
	Carbonaceous shale	3	0		
	Coaly shale	0	8		
	Grey shale.....	2	0		
	Coal	0	4		
	Carbonaceous shale (to water)	1	4		

The dip at this place is about N. 83° W. (mag.), at an angle of 5 to 8 degrees.

On the opposite side of the river, at its next bend, the coal seam is again well shown. It is slightly undulating, and dips gradually away below the water level at the northern end of the bank. The part of the section designated above as the Main Seam is here as follows:—

	ft. in.
<i>Coal</i>	1 6
Shaly parting (1 to 3 inches)	0 2
<i>Coal</i>	3 3
Total coal	<u>4 9</u>

About four inches in thickness at the base of the seam is here laminated in texture, but appears nevertheless to be of good quality. The general dip is about N. 50° W. (mag.), at an angle of less than 5°.

From this point for a distance of five miles down the valley, the dark shales overlying the coal are alone seen. When it again appears, on the west bank of the river, the Main Seam shows the following section:—

	ft. in.
<i>Coal</i>	1 6
Shale	0 3
<i>Coal</i>	4 6
Shale	1 6
<i>Coal</i>	2 9
Total coal	<u>8 9</u>

The lowest division of the seam at this place is apparently not represented in the sections previously described. The coal in it is somewhat laminated, but seems to be of good quality. The dip is here about S. 70° W. (mag.), at an angle of 5°.

About three miles further north, extensive exposures of the coal are again found in the scarped bank or cliff facing the river, at a height of about 100 feet above the water level. The dip is light and undulating, but on the whole westward, or away from the river. The Main Seam is here composed as follows:—

	ft. in.
<i>Coal</i>	2 6
Carbonaceous shale	0 7
<i>Coal</i>	2 2
Carbonaceous shale	1 0
<i>Coal</i>	1 3
Total coal	<u>5 11</u>

The coal here appears to be of good quality throughout. North of this point on the river the Main Seam is not again found well exposed,

though in several places the associated rocks are shown in such a way as to indicate that it outcrops below the drift a short distance east of the river valley.

At the point at which the base of the Pierre should cross the Little Bow River, a seam of coal a few inches thick was observed by Mr. McConnell, but the exposures did not bring the main seam into view.

This coal-bearing horizon appears again on the Bow River at Grassy Island, about thirty-three miles in a direct line below the Blackfoot Crossing, in lat. 50° 25' 15". In their general appearance, arrangement and thickness, the seams here exposed closely correspond with those on the Belly River. The subjoined section exhibits the relations of the coal at this place :

	ft.	in.
Lead grey shale.....	25	0
Coal.....	1	6
Soft grey and yellowish-grey shaly sandstone.....	13	0
Carbonaceous shale, coaly streaks.....	2	3
Coal (good and sound throughout).....	4	6
Dark grey shale and shaly clay.....	7	0
Coal.....	1	0
Carbonaceous shale.....	1	0
Coal.....	0	8
Soft shale and clay.....	8	0
Coal and carbonaceous shale (to water).....	1	6

The seams dip westward at a very light and constant angle. The seam 4 feet 6 inches in thickness probably represents the Main Seam of the Belly River.

Some general facts regarding the composition of the coal of this horizon in the Cretaceous may be given. The analysis by Prof. Haanel quoted in my report on the Geology and Resources of the 49th Parallel (p. 179, No. III, in table) is of coal from this seam, but probably from that part of the outcrop near the mouth of the St. Mary River. The same remark applies to a specimen which was analysed by Dr. Harrington. (Report of Progress, 1877-78, p. 49 C.) Prof. Haanel's analysis shows 6.69 per cent. of moisture and 6.36 per cent. ash. Dr. Harrington's specimen contained 5.79 per cent. water and 2.05 ash. A specimen from Mr. Sheran's mine, collected and examined by myself, yielded the following result:

Water.....	6.52
Volatile combustible matter.....	31.03
Fixed carbon.....	56.54
Ash.....	5.91
	100.00

The coal is compact, does not easily break up by handling or exposure, and is in every respect a very excellent fuel, but does not yield a coherent coke.

In correspondence with the increased distance from the mountains of the outcrop of the same seam on the Bow River, and probable inferior degree of alteration to which it has been subjected, the coal is there found to contain more water, approximating in this respect to some of the Souris River lignites. From these, however, it still differs in its more compact texture and resistance to weathering and the regular vertical cleat or jointage planes by which it is traversed, which cause it to assume cuboidal instead of conchoidal forms on fracture. A preliminary examination of an outcrop specimen from this locality gave the following result:—

Water.....	12.37
Volatile combustible matter	32.33
Fixed carbon	46.39
Ash.....	8.91
	100.00

The seam occurring at the summit of the Pierre formation on the Bow River, at the point which I have designated as Horse-shoe bend, has a very light westerly or north-westerly dip, and is not known to be represented on the Belly River, though it is probably its continuation which appears on the Little Bow, near the mouth of the Snake Valley. The outcrop at Horse-shoe Bend is situated about fifteen miles east-north-east of the Blackfoot Crossing. The seam appears at a height of 135 feet above the water in a steep scarped bank on the south-east side of the river, and is exposed for nearly half a mile. It is 4 feet 4 inches in thickness, compact and hard where not long weathered, and in physical character resembles that last described. A preliminary examination of an outcrop specimen showed the following composition:—

Water.....	13.67
Volatile combustible matter	37.16
Fixed carbon.....	40.50
Ash (reddish)	8.67
	100.00

Still following an ascending order in the series, the seam which has been known for some years at Blackfoot Crossing next claims attention. This is several hundred feet higher in the section than the last, and is distinctly included in the Laramie. It is probable that still another seam exists between this and that last described, but no good sections of it were found.

Coal occurs in several places on the Bow River a few miles above the Blackfoot Crossing. The seams are too thin to work, but are probably on the same horizon with that described below. Throughout this region the beds are affected by gentle undulating dips, and though they have besides a very light general inclination westward, they may be considered as practically horizontal.

The outcrop from which a small quantity of coal has been extracted, and which has been referred to by several travellers, is situated six and a half miles eastward from the Blackfoot Agency buildings, on a coulée which runs northward to the Bow. The deposit here consists of two seams, the upper averaging 1 foot 8 inches in thickness, the lower 3 feet. They are separated by about a foot of carbonaceous shale. At this spot the bed may be traced about 500 feet in natural exposures, and is affected by variable dips which do not exceed 5° in amount. The thickness of the seams continues nearly uniform, and they would afford, say, 4 feet 6 inches of clean coal, the whole of which could be worked at once. The immediate banks of the coulée are about 80 feet high at this place, the upper two-thirds being composed of drift deposits, which rest on a worn undulating surface of the rocks below. The general level of the surrounding prairie is about 110 feet above the horizon of the coal, and no exposures of the coal or associated rocks are found except in the river banks or coulées, which cut deeply into the surface of the plain.

In following the coulée northward from the spot just described, the coal is frequently seen on the right or east bank for about a mile, after which the coulée opens into a wider valley with sloping grassy sides, and exposures cease. Owing to the slope of the bottom of the coulée toward the river, the beds are cut into more deeply near its mouth, and at the last exposure the seam is about thirty feet up in the bank. The upper seam is here not well shown, but the lower exhibits a few inches over 4 feet of good coal. In an exposure intermediate between this and the first, the upper seam is 8 inches thick, the shales 1 foot, and the lower seam 4 feet 4 inches. The seams are underlain by at least twenty feet of soft whitish sandstone. The same bed appears near the Agency buildings, where the Indian trail going eastward, leaves the valley, but the coal seams are here wanting or very poor.

Between the Blackfoot Crossing and the coulée above described, the same coal-bearing horizon appears in several places in the banks of Bow River. The seams are here more favourably situated for working, and of greater thickness than in the coulée. The subjoined section shows their mode of occurrence at one point :—

	ft.	in.
<i>Coal</i>	1	8
Black carbonaceous shale	1	4
<i>Coal</i>	1	8
Shale	0	3
<i>Coal</i>	0	9
Shale	0	3
<i>Coal</i>	3	0
Shale	1	0
<i>Coal</i>	1	10
Total	11	10
Total coal	8	11

The coal is here again underlaid by whitish sandstone for about 30 feet, or to the water's edge. Nearly opposite the exposure, on the south side of the river, the seam appears at intervals in the bank, at a height of about 40 feet above the water, for at least a quarter of a mile. It is affected by a series of light undulations.

The natural exposures serve to prove the continuity in good workable thickness of this coal deposit over a tract of country several miles in extent, and its nearly horizontal attitude and moderate depth below the surface of the plains, would enable it to be proved by boring at a small expense over any desired area.

In texture, this coal is not so firm or well adapted for transport as those of the localities previously described, but in composition appears closely to resemble that of Horse-shoe bend.

The following are analyses of the fuel from this place; the first from a specimen obtained by Prof. Macoun, the second from one collected by myself, and probably not subjected to such prolonged desiccation:—

	I*.	II.
Water	10·72	13·20
Volatile combustible matter	29·26	33·80
Fixed carbon	46·09	48·10
Ash	13·93	4·90
	<u>100·00</u>	<u>100·00</u>

Three coal-bearing localities on the head waters of the Oldman River appear to be of sufficient importance to obtain notice at the present time, but as the country toward the base of the mountains becomes more fully known, it is probable that numerous additional outcrops will be discovered.

* By Mr. C. Hoffmann. Report of Progress, 1879-80, p. 12 n.

At the Government Indian Farm, south of Pincher Creek, a seam of coal occurs about one mile from the farm buildings, up the valley of the small stream on which they are situated. The rocks in the lower part of the valley belong to the St. Mary River subdivision of the Laramie, and dip toward the north-north-east (mag.) Their angle gradually increases from about 20° till the beds become nearly vertical where the coal occurs. Beyond this point the rocks are concealed, but the coal probably occupies a position very near the base of the Laramie.

Near the coal seam, the beds have been much disturbed, and the coal itself is slickensided and broken throughout in such a way as to cause it to crumble easily by handling. The seam is two feet in thickness where exposed, but is said to have been considerably thicker where followed into the bank. The opening made on the coal has, however, since been filled in. This seam should reappear on Pincher Creek above the crossing place of the road, but the horizon at which it should occur appears to be covered.

An analysis of the coal from this seam by Mr. Hoffmann is given in the Report of Progress for 1878-79, p. 12 H. It may be quoted here for comparison with those of the other seams, and illustrates the improvement in quality of the coals on their approach to the base of the mountains:—

Water	6.26
Volatile combustible matter.....	29.31
Fixed carbon.....	55.70
Ash	8.73
	<hr/>
	100.00
	<hr/> <hr/>

On the middle fork of the Oldman River, a few miles below the falls, and nearly north of the mill on Mill Creek, two seams of good coal occur in a scarped bank on the north side of the stream. The beds are each about three feet in thickness, and are folded in a very remarkable manner, illustrating the intensity of the force which has acted in crumpling the rocks near the base of the mountains. It is probable that these beds occupy a horizon near the base of the Laramie. They approximate in character to true bituminous coals, and would yield coherent cokes, but no analysis has yet been made of them.

The section in which these coal seams occur is as follows. The order appears to be descending, but the whole may not improbably be overturned:—

	ft.	in.
Grey to black, very fine shale, with occasional small fish scales and bones, becoming sandy and yellowish at base.	6	0
Ferruginous sandstone	0	6
Greyish, soft sandstone or arenaceous clay, with some thin ironstone layers	10	0
Harder greyish and ferruginous sandstone, with some obscure plant fragments.....	6	0
Hard, flaggy, yellowish sandstone.....	2	0
Grey sandy shale and shaly sandstone.....	3	0
Coal	3	0
Soft black carbonaceous shale.....	0	9
Grey sandy shale	3	6
Grey sandy shale and sandstone	4	6
Grey flaggy sandstone, weathering rusty.....	2	6
Grey sandy shale and shaly sandstone.....	5	0
Coal. Imperfectly seen, but at least 3 feet of good quality	3	6
Carbonaceous shale.....	1	0
Grey sandy shale	4	0
Ferruginous sandstone	0	6
Greenish-grey sandstone.....	10	0
Grey and blackish carbonaceous shale	4	0
Greenish-grey, soft sandstone	6	0
Sandstone and arenaceous and carbonaceous shale, with general greenish-grey tints, (about).....	80	0
	<u>155</u>	<u>9</u>

On Mill Creek, about four miles above the mill, a seam of coal outcrops. The measures are somewhat broken, and the seam appears to be rather inconstant in thickness. It was intended last autumn to make a careful examination of this neighbourhood, and to endeavour to follow the coal-bearing horizon southward and northward from Mill Creek to its outcrop on other streams, but this was prevented by the early onset of wintry weather. The coal is of excellent quality, and yields a firm coke. It has been used to a small extent in blacksmith-work at the mill. The following are sections of the seam on opposite sides of a break or fault which traverses the measures at the outcrop:—

	ft.	in.
Coal (rather shaly).....	3	1
Coal	2	0
Shale	1	4
Coal	2	0
Shale	1	4
Coal	2	0
Total coal	<u>9</u>	<u>1</u>

	ft.	in.
Coal (rather shaly).....	2	0
Shale	1	0
Coal (apparently good throughout, with the exception of a few shaly partings, not equalling 4 inches in all)	6	0
Total coal	<u>8</u>	<u>0</u>

The geological horizon of the coal at Mill Creek has not been determined.

GENERAL REMARKS ON THE COALS AND LIGNITES.

Whether from an economic or purely scientific point of view, one of the most interesting results of the exploration of the Bow and Belly River country is the determination of the fact that the coals are not confined to a single horizon or formation, but characterize at least four zones in the geological series of this region. The fuels found in the Laramie represent, at least in a general way, those characterizing the same formation or its representative, the Fort Union Group, eastward on the plains to the Souris River. As far north as the Athabasca and Peace Rivers, fuels are now known to occur in rocks of about the same age. The coal seam which has been referred to as attached to the summit of the Pierre shales, is not known to be represented elsewhere, unless indeed by a very thin seam near the same horizon on the Smoky River. (Report of Progress, 1879-80, p. 125 B.)

The coal at the base of the Pierre, which has been worked at Coal Banks, on the Belly River, has not been recognized in a workable form beyond the limits of the district now described. The dark, highly carbonaceous beds at the base of the Upper Shales of Smoky River are, however, at about this horizon, and in one place a thin seam of lignite coal is locally developed (op. cit. p. 118 B.) A bed of lignite described by Prof. Cope on the Missouri as in some places of possible economic value must also be of nearly the same age. (Bulletin U. S. Geol. & Geog. Survey, Vol. III., p. 566.) It is further worthy of remark that this coal-bearing horizon at the base of the Pierre of the interior continental region is, as nearly as possible, equivalent to that at the base of the Chico Group, which yields the coals of Vancouver Island at Nanaimo and Comox.

The coal in the series below the Pierre on the Bow and Belly River may be taken in a general way as representing those which occur in the Lower or Dunvegan Sandstones of the Pine River, in the Peace River country (op. cit. p. 116 B.)

The occurrence of workable coal seams at several different horizons, and the proved continuity of some of them over great areas, guarantees an abundant supply of fuel in this district, a matter of great import-

ance in a country which over great areas is almost entirely destitute of wood. The quality of some of the fuels is such as to render them suitable for transport to a distance, and it is doubtless on this belt of coal-bearing rocks in the vicinity of the mountains that the railways of the North-west will depend chiefly for their supply.

The quantity of coal already proved to exist is very great. The distances for which the outcrops of certain seams have been traced have been mentioned. Approximate estimates of the quantity of coal underlying a square mile of country in several localities have been made, with the following results :—

Main Seam, in vicinity of Coal Banks, Belly River. Coal underlying one square mile, 5,500,000 tons.

Grassy Island, Bow River. (Continuation of Belly River Main Seam.) Coal underlying one square mile, over 5,000,000 tons.

Horse-shoe Bend, Bow River. Coal underlying one square mile, 4,900,000 tons.

Blackfoot Crossing. Workable coal in seam as exposed on Bow River. Underlying one square mile, 9,000,000 tons.