REPORT

BY

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ON BORING OPERATIONS IN THE

SOURIS RIVER VALLEY.

1880.

Leaving Montreal on the 13th of May, I reached Winnipeg on the 18th at 12.30 a.m. The following four days were employed in procuring the necessary outfit, horses, carts, &c., and engaging men. Left Winnipeg at noon on the 23rd by steamer for West Lynne, arriving there early the following morning. Here we found the contractors, Messrs. McGarvey & Highman, and their party encamped. They were endeavoring to engage teams to transport engine and boring plant, &c., to the proposed site of operations near Roche Percée, in the Souris River valley. I left West Lynne the same day, and proceeded westward partly by the old Missouri, and partly by the Boundary Commission trail. Bad roads and high water in the creeks and rivers caused considerable delay, especially at the two crossings of the Souris River, where neither boat nor raft was found, nor available timber to construct one. The crossings were, however, accomplished without accident, and on the 17th of June we reached the Riviere des Lacs, 229 miles west from the Red River. This curious sheet of water is described by Dr. G. M. Dawson* as follows :—

"The so-called *Rivière des Lacs*, which crosses the Line at the 227 mile point, seems to occupy the bed of a former stream. This sheet of water where it is intersected by the Line, must be nearly three-quarters of a mile wide, and is not fordable. It occupies the bottom of Rivière des Lacs.

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* Report on the Geology and Resources of the Forty-ninth Parallel, 1875.

a valley, and is over fifty feet below the prairie level. Northward it extends about four miles, becoming gradually narrower, and ending in a broad coulée, which shallows and dies away in a strip of boulder-covered ground, which stretches northwestward toward the Souris River five miles distant, and is somewhat lower than the general surface of the plain. Southward it is said to extend about seventy miles, and finally to join the southern bend of the Souris River, where it gives issue to a small running stream."

Fixing sites for bore-holes.

The examination for fixing the sites of the proposed borings commenced at this point. The afternoon of the 17th was spent examining the banks of the Riviere des Lacs, and the prominent hill which rises at its upper end. This Hill is unnamed on the maps, but is known by the traders and half-breeds as the Hill of the Murdered Scout. Though only about 100 feet above the general level of the plain it is, especially from the eastward, a conspicuous object, and affords from its summit a very extended view over the surrounding country. On the 18th an examination was made in a southerly direction from Rivière des Lacs to the Souris River, and for several miles up the valley of the latter, including a number of the adjacent dry coulées. Over considerable areas the surface presents a bed of closely-packed ice-borne boulders of Laurentian rocks, and fossiliferous Silurian white or cream colored limestone, some of the latter being of gigantic size. Three of these boulders gave the following dimensions: 6 x 13 x 14 feet; 4 x 11 x 11 feet, and 6 x 5 x 3,

Large limestone boulders.

The largest would contain 1092 cubic feet and weigh more than 85 tons. These all lay within an half mile radius. There were many others in the vicinity presenting flat surfaces of nine feet by six feet, the thickness of which was not ascertained, as they were more or less imbedded in the soil.

The dry coulées, which are one of the most remarkable features of this part of the Souris River valley, nearly all have courses more or less parallel with that of the main valley, and appear to be the ancient flood channels of the Souris when its main channel was at a much higher level. The intervening ridges must then have formed long boulder-covered reefs or islands in a broad river.

Topographical features of the country.

These peculiar coulées or side valleys were not observed on the right bank of the river west of St. Peter's spring, or on the left bank west of Roche Percée. They appear to be limited to about two miles on either side, and to extend from the vicinity of Roche Percée eastward to where the river makes its great northern bend. In some instances they open into the main valley, gradually rising till they run out on the level of the plain 100 or 150 feet above the river. While the tops and sides of the intervening ridges are a mass of boulders, the bottoms of the coulées are comparatively free, and are often occupied by water-holes

and grassy swamps, in which ducks and other wild fowl abound, and along the margins of which wheeled vehicles can pass from the river valley to the plain.

As the whole of the country traversed on this occasion has been fully described by Dr. Dawson in the volume already referred to, it is proposed to confine these remarks chiefly to a brief statement of the work in connection with the boring operations, which, unfortunately, the limit of the funds available prevented from being carried to a satisfactory conclusion, a sufficient depth not having been reached to decide the question for which the work was undertaken when it had to be suspended.

No outcrops of the lignite formation could be found in the country around the Rivière des Lacs, nor any evidence of the probable thickness of the drift. I therefore on the 21st June proceeded westward 24 miles and camped at Roche Percée to await the arrival of the boring party, of whom no tidings had been received since leaving the Pembina River on the 1st of June.

On the following morning, 22nd June, one of the contractors arrived at Roche Percée, and reported that the teamsters had refused to bring the engine, &c. beyond the second crossing of the Souris, and had left them to return east. This obliged the contractors to bring the boring plant on by instalments, with their own four horses and two wagons. In the meantime the men were employed getting out the timber required for derrick, engine-bed, &c., much hunting up and down the river being required before suitable trees could be found. The next few days till the 30th June we remained encamped at Roche Percée, the time being occupied in making a careful examination of the valleys of the Souris River and of Short Creek, also of the adjacent country southward to the International Boundary. The site for the first bore was fixed, photographs taken, and a section measured from the left bank of the Souris south to where the east bank of Short Creek intersects the Line, a distance of about four and a half miles. On the 30th June we moved camp six miles down the river, close to the site selected for the first bore hole. The next nine days were occupied in further examinations of the small valleys on either side of the river, searching for outcrops of the lignite, in making a plan of the neighborhood of the bore, and in collecting fossils.

Preparations for boring.

It now became necessary to consider the best site for the second boring. Immediately opposite this camp the sandstone with associated lignites appeared to pass beneath the plain. These being the most easterly visible outcrops in the Souris Valley, it was hoped the same strata might be again found cropping out in the valley of Moose Mountain Creek, where it meets the apex of the great northern bend of the Souris, some twenty

miles distant to the north-east, and thus demonstrate the extension of the lignite-bearing formation in this direction. On the 10th of July I proceeded across the plain to Moose Mountain Creek, and struck it at about one and a half miles above its confluence with the Souris. It lies here about 130 feet below the level of the plain, and has a shallow, stony bed with deep pools one quarter to half a mile in length, connected by rapids. Some of the hills have a very steep slope to the creek, but show nothing but gravel and brown silt and clay mixed with boulders. Up some of the side gullies, which are also steep and narrow, rising rapidly to the plain, there are patches of willow and brush indicating moisture, which may be at the bottom of the drift, or only at the outcrop of impermeable beds of clay associated with it. Surface evidence by which the choice of a site for the boring could be determined being wanting, it was decided to fix it on the plain at a point about two miles west of the confluence of the creek and river.

Moose Mountain Creek.

Returning to the site of No. 1 bore on the 12th, we found the work had commenced that afternoon. The details of the boring are given on pages 8 to 11 A.

District examined.

The examination made extended south to the Line, and west to the Wood End depot, and embraced all the principal northern side gullies. These are for the most part short, running steeply up to the plain, which stretches northward as an almost unbroken treeless expanse for more than fifty miles towards the valley of the Qu'Appelle River. The greater part of the area indicated, west of No. 1 bore, and south of the Souris River, except where affected by the denudation of the valleys, may be regarded as a coal-field. There is no evidence to show the extent of the field to the north of the river. It is probably large, but there can be no doubt that the area to the south of it is underlaid by the same seams that are well exposed in the bank of Short Creek, immediately above its confluence with the Souris, and which are also seen at intervals both east and west along the main valley, and in many of the smaller gullies that descend from the plain on either side.

In many places the outcropping edges of the lignite seams are either burnt, and now only indicated by lines of red shale, or they are concealed by land slides, making it exceedingly difficult to connect such outcrops as are still well exposed. Sufficient of these, however, are seen to prove that at least two workable seams occur over an area north of the 49th Parallel, in the Souris Valley, east and west of Roche Percée, which may be safely estimated at about 120 square miles.

Section at the Sutherland Mine.

The section of the strata exposed at the junction of Short Creek and the Souris River measures 145 feet on the angle of the cliff, and is as

follows, in descending sequence. The cliff slopes at 75° to 80°, and is in some parts vertical :—

	Feet	in.
1. Soil and superficial drift	5—6	0
2. Sand rock, or sandy clay	10	0
3. *Lignite*	2	0
4. Clay shales, dark drab plastic	1	6
5. *Lignite*	5	0
6. Whitish soft sand rock	50	0
7. *Lignite*	3	0
8. Soft brown sandstone	17	0
9. Ironstone, nodular and lenticular	6 to 7	0
10. Whitey brown sand rock, with bands and concretions of ironstone	49	6
	145	0

The bands and layers of ironstone here contain fine specimens of fossil leaves, a large collection of which was made. Principal Dawson has kindly examined these, and furnished the notes appended. The specimens are now exhibited in the Geological Museum, Ottawa.

In the 5 feet seam, a level 78 feet in length and 3 feet wide, has been driven by W. D. Sutherland, of Winnipeg, and in the spring of 1880 several tons of the lignite taken out were floated in barges down the Souris and Assiniboine Rivers to Winnipeg, and a large heap still remained on the bank at the time of our visit. On the surface it had all crumbled by the action of the weather, but on digging into the heap large sized solid blocks were found.

In the tunnel the lignite appeared to be solid, and of good quality. The upper seam is only between 15 and 20 feet below the prairie level, and thus slight depressions in the surface would suffice to have caused its removal.

Comparison of the sections.

In the foregoing section Nos. 2 to 5 are clearly the same beds, as Nos. 8 to 11 in Dr. Dawson's section No. 7, which was measured by him in 1873, not a mile distant, on the opposite side of Short Creek (See page 17 A, Appendix II.) East of the Sutherland mine section, and extending for a distance of about seven miles along the valley to the site of No. 1 Bore, there are numerous sections on both sides of the river in which the same seams of lignite are exposed. The most perfect section occurs on the south side, near the mouth of a gully which takes its rise on the plain, below and a little west of St. Peter's spring, and is probably the channel by which its waters reach the Souris River.

St. Peter's Gully section.

St. Peter's Gully Section.

	Feet	in.
1. Soil and sandy clay	10	6
2. *Lignite* 2ft. 6 in.—	3	0
3. Soft drab sand rock	9	0
4. Ironstone band	0	8
5. Soft drab sand rock	8	4
6. *Lignite*	0	8
7. Sandy clay shale	8	0
8. Ironstone with clay shale 1 foot to	1	6
9. Sandy shale	8	4
10. Do. with carbonaceous streaks	2	0
11. Sandstone and concretionary sand rock	0	0
with ferruginous bands and concretions	9	0
12. Clay shales	5	0
13. Carbonaceous streak	0	6
14. Clay shales, sandy	5	0
15. Ironstone and shale	2	0
16. *Lignite* (underlaid by stiff clay shale)	3	0
	76	6

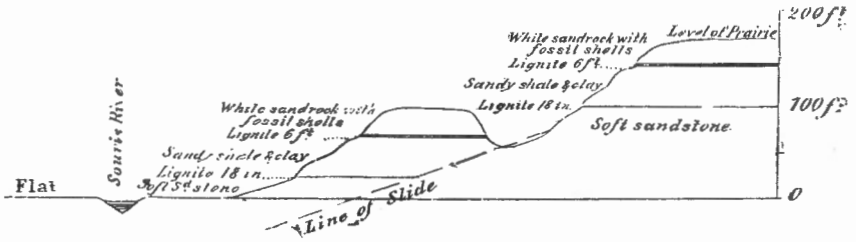
In the above section No. 16 is probably the equivalent of No. 7 in the Sutherland mine section, and No. 2 represents No. 5, notwithstanding that the intervening measures differ considerably in character, and about ten feet in thickness.

Short Creek.

To the south, a few yards north of where the Boundary Line crosses the east branch of Short Creek, a seam is exposed in the bank seven feet thick, with a shaly parting of three inches, at about two feet from the top. It is not more than fifteen feet beneath the surface of the plain, and the drift covering is thin. Eight or ten feet below the seam is the water level of the creek. On the north side of the river, and a little above the St. Peter's gully section, a very interesting exposure occurs, in which the whole cliff has slid down into the valley. At 25 feet below the prairie level, which is here about 140 feet above the river, the six feet seam crops out, and is well exposed, resting on 30 feet of clay shales and sand rock, underlaid by lignite eighteen inches thick. Below this the ground is broken, and the measures concealed in a depression. On passing across this and over the rise there is a cliff about 40 feet in height, rising abruptly from the river flat, in which both seams are again exposed. The six feet seam can be seen here for nearly 200 feet in length, beyond which on either side it appears to have been completely burnt away, the position of it being indicated by irregular

heaps of hardened red shale, the whole surroundings being not unlike those of an old brick yard.

A section across this ground from the prairie level to the river is represented in the figure below:—



The lower 3 feet seam seen on the opposite side of the river in the St. Peter's Gully section was not observed here, its outcrop being probably concealed by the slides.

It may be assumed that there are in this region, above the level of the Souris River, at least eight feet of available lignite coal over an area of not less than 120 square miles. This would give 7,136,864 tons to the square mile, calculating the cubic foot at only 64 lbs. Quantity of lignite per square mile.

From the vicinity of St. Peter's spring eastward there appears to be a gradual fall in the country amounting to about 2½ or 3 feet per mile. The strata are apparently horizontal, but probably have a slight westerly dip which, together with the fall in the ground, would cause them to crop out rapidly beneath the drift-covered plain to the east, and perhaps explains their not being found in the bore-holes at Moose Mt. and South Antler Creeks, the details of which are given on pages 8–9 A. The same cause does not, however, affect the Turtle Mountain bore-hole, as the country there again rises to an elevation, on the Line, six miles to the south, of 2,000 feet, and from the evidence afforded by the creek, which runs through Sections 32, 33 and 34, Township 2, Range 19, West, it seems that, though no lignite was struck in the bore-hole situated six miles to the south, the country here is nevertheless underlaid by the sandstones, clays, and ironstone of the lignite Tertiary formation, and therefore an available seam of lignite may at any time be discovered.

The details of the Turtle Mountain bore-hole are given on page 10 A.

No. 1.

SOURIS RIVER BORE.

IN THE VALLEY OF THE SOURIS, 6¼ MILES BELOW ROCHE PERCÉE.

295 *feet deep;* 1610 *feet above sea level.*

The work here was commenced on the 8th of July, by sinking a pit about ten feet deep, showing :—

Soil	3 ft. 0 in.
Stiff grey clay, like clay below lignite	6 " 6 "

No. 1 bore-hole. On the 12th of July the boring commenced, and reached a depth of seventeen feet, all in stiff, dark clay. At eighteen feet the rock, a soft, friable, brown sandstone which crops out at the river immediately below the bore-hole, and about 77 yards distant, was struck, and continued almost without change to 154 feet, where it rested on a very tenacious blue clay. At 68 feet some small fragments of lignite came up in the sand pump, and from 48 to 73 feet fragments of ironstone and lignite in powder.

On the 15th the water which up to that time had stood in the hole at about five and a half feet from the surface, suddenly sank to within 38 feet from the bottom, and shortly after the rods dropped one foot. This occurred between the 68th and 73rd foot. On the 22nd, when a depth of 273 feet had been reached without change, through 119 feet of clay, a seam of lignite was struck, and the next 23 feet gave a section as under :—

Lignite	6 ft.	1 in.
Clay	1	0
Soft sandstone	1	0
Clay, same as above lignite	15	0

making a total depth of 295 feet from the surface, or about 575 feet below the plain at St. Peter's spring.

No. 2.

MOOSE MOUNTAIN CREEK BORE.

20⅜ MILES FROM No. 1.

155 *feet deep*; 1590 *feet above sea level.*

No. 2 bore-hole. This bore was situated on the level of the plain, about 128 feet above the river, 2⅛ miles west 10° south from the confluence of Moose Moun-

tain Creek and the Souris River; and 20¾ miles distant in a direct line from Bore No. 1.

Boring was commenced here on the 7th August, with a ten-inch auger, from the surface, giving the following section:

	Feet	in.
1. Black loam	1	6
2. Yellow brown sandy loam	3	0
3. Gravel	2	0
4. Stiff sandy clay	8	6
5. Stiff dark blue clay	5	0
6. Quicksand		9
7. Stiff dark blue clay	10	3
8. Gravel, same as 3, but coarser		9
9. Dark blue clay	23	3
10. Cemented gravel, passing down into soft gravel	2	0
11. Loose gravel, mixed with some dark grey clay	4	0
12. Clay mixed with fine gravel and boulders	79	0
13. Dark grey clay	15	0
	155	0

On the 16th August, in a depth of 18 feet, five boulders were passed, supposed to be granite. At 83 feet a small sample of lignite was brought up, apparently a drifted fragment.

From the foregoing record, and from a careful examination of the samples, it would seem that the lignite-bearing Tertiary formation was not reached in this boring, only the superficial deposits and boulder drift having been penetrated.

No. 3.

SOUTH ANTLER CREEK BORE.

37 MILES FROM No. 2.

155 *feet deep;* 1595 *feet above sea level.*

No. 3 bore-hole.

This boring was made at a spot 700 yards east of where the Boundary Commission trail crosses the North Antler Creek. The elevation here, according to the Boundary Survey, is about 1645 feet. The site of the bore would be about 50 feet below this, or 1595 feet, nearly the same elevation as the Moose Mountain Creek bore. This bore, like No. 2, did not penetrate the drift, which consisted of sand, clay and gravel,

with some boulders, chiefly made up of the white or cream colored Palæozoic limestone.

The boring commenced here on the 1st of September, and finished on the 5th, giving the following section:—

	Feet	in.
Dry sand and gravel	3	0
Yellow sandy clay	7	0
Dark blue clay, mixed with fine gravel	15	0
Limestone boulder		
Clay and gravel mixed	2	0
Boulder drilled through	2	0
Grey clay and sandy clay	39	0
Sandy clay and gravel	6	0
Sand, with sandy clay and gravel	9	0
Fine dry sandy clay and sand, with small pieces of white limestone (silt)	20	0
Do., with water coming in slowly	19	0
Do., with clay, passing into the next	18	0
Sand	15	0
	155	0

The absence of water in this bore till a depth of 122 feet was reached is singular. When the work ended the water stood at 95 feet from the surface. Owing to the constant falling in of the sides of the holes, it is impossible from the samples brought up to give a very accurate description of the different strata bored through.

NO 4.

TURTLE MOUNTAIN BORE.

63 Miles East of No. 3. 200 Feet Deep.

No. 4 bore-hole. This bore was made in the south-east corner of Section 6, Township 1, Range 19, West. Commenced on the 20th September, and finished on the 6th October.

No lignite was met with, and as in the case of the other bores, and from the same cause, there is considerable uncertainty as to whether the Tertiary lignite-bearing formation was reached.

At 43 feet, and again at 103 feet, beds of well-rounded gravel were found, but from about 160 to 200 feet, nothing but dark blue or grey clay was met with, which cannot be distinguished from that

passed through both above and below the lignite seam in No. 1 bore.

The elevation of the country at this point is nearly the same as at St. Peter's spring, viz., about 1,900 feet, and inasmuch as the beds are, as already stated, nearly, if not quite horizontal, it was considered not unlikely that they might be found here, even if absent in the intervening lower country. After the boring had commenced it was found that sandstones similar to those associated with the lignite seams of Roche Percée cropped out in ledges for a considerable distance along the creek which traverses the north part of Sections 33 and 34, Township 2, Range 19 West, and are accompanied by ironstone and the peculiar red (burnt) shales, indicative of the combustion of lignite seams. The relative level of this locality and the No. 4 bore hole is not known exactly. It is presumably considerably lower, and it is quite probable that seams of lignite occur here, which might have been discovered had there been funds available to continue the boring to greater depth.

APPENDIX I.

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ON THE

LIGNITE TERTIARY FORMATION

FROM THE SOURIS RIVER TO THE 108TH MERIDIAN,

BY

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

[NOTE.—The introductory pages of the subjoined account of the Tertiary Lignite Group of a portion of the North-West Territory, are based on an article on "The Lignite Formations of the West," (*Canadian Naturalist*, Vol. vii., No. 5). The descriptions of localities and analyses of lignites and ironstones is reprinted, with little alteration, from the "Report on the Geology and Resources of the 49th Parallel," published in connection with the Boundary Commission Expedition. The name *Lignite Tertiary* having been used in the report above referred to, is here retained for this northern extension of the Fort Union Group.]

Carboniferous system in the West, poor in coal.

The true Carboniferous system with which the greater part of the valuable coals of the world are associated, and which is so largely developed in the eastern half of the American continent, from Nova Scotia southward, is not the coal-bearing formation of the western prairie region. Rocks of Carboniferous age are, it is true, found in the eastern part of Nebraska and in Iowa, where the thickly-wooded country of the East has already passed into the prairie land of the West. Here, however, the formation depended on for fuel in so many parts of the world has to a great extent lost its coal-bearing character, and where it is last seen in Nebraska, though now pretty thoroughly explored, both by surface examination and boring, has yielded coal in very sparing quantity. This region, in fact, appears to be upon the western lip or margin of the true coal formation, and the sandstones and mud rocks usually associated with coals are being replaced by limestones, indicating deeper waters and the absence of the terrestrial conditions necessary to the growth of the coal-producing plants.

Poor as these western Carboniferous rocks are in coal, they labour under the additional disadvantage of being in great part covered by a newer formation, the Cretaceous; and where the Carboniferous system again comes to the surface in the Rocky Mountain region of uplift, to the west of the Great Plains, it has not been found to contain so much as a single seam of coal, but it is represented chiefly by massive limestones, implying deposit in deep ocean water, and so far removed from land that it is rare to find in them even a fragment of any of the plants which were growing so luxuriantly in the swamps and deltas of the eastern half of the continent at the same time. Just where the coal of Palæozoic age fails, the luxuriant forest growth of the East also comes to an end, and the country assumes that prairie character which, to the south of the Saskatchewan, persists with scarcely a break to the foot-hills of the Rocky Mountains. The bare rolling plains and grassy hills, though over extensive areas eminently suited for agriculture, seldom yield wood in sufficient quantity to ensure a permanent supply of fuel. Trees in the true plain country are found only fringing the deep river valleys and in steep-edged gullies, where they are protected from the sweep of the prairie fires, and find a permanent suply of moisture.

Treeless country.

In the eastern portion of our North-west Territory, including Manitoba, the Carboniferous system is not found at all, but the Cretaceous rocks already alluded to overlap the limestones of the older Silurian and Devonian periods. The true coal formation can, therefore, in this region, only be supposed to exist below a great thickness of Cretaceous rocks, and even if accessible, the probability of coal of any value being found in it is—from analogy with the portion of the Western States already mentioned—exceedingly small.

No Palæozoic coals in the North-West.

Neither do the Cretaceous rocks (including under that name the beds to the top of Division No. 5 of Meek and Hayden's section) of the eastern portion of the plains yield, so far as known, any fuel of economic value, in their great stretch from the borders of Mexico to the northern part of the North-west Territory. They consist almost entirely of clay rocks and sandstones, with one interesting zone of limestone and marl, which forms part of the Niobrara Division, or No. 3 of the classification above referred to, and which appears to be recognizable in Pembina Mountain and the highlands west of the great lakes of Manitoba.

Eastern Cretaceous rocks without coal.

The lower part of the Cretaceous system, however, in Nebraska and elsewhere on the Missouri River, seems to show an attempt at the production of beds of fuel. Beds of "impure lignite" and "carbonaceous clays" of small thickness are there met with, especially in Hayden's lowest or Dakota Group. Fossil leaves and stems are also

Unimportant deposits of lignite only.

found associated with these beds, and I find one lignite mentioned as occurring in beds believed to be transitional between the Dakota Group and the Benton Group, immediately above it, which is even stated to have been worked to a small extent.

Small and irregular seams of lignite have also been found in western Minnesota in outliers of beds supposed to be of lower Cretaceous age, and it is probably from local deposits of this nature that the pieces of lignite sometimes found in the superficial drift deposits of Minnesota and Manitoba are derived. While there is, therefore, a *possibility* of the occurrence of fuels of some economic importance in the lower Cretaceous of Manitoba, such an event is by no means probable. The outcrop of these lower beds is, however, everywhere concealed by drift deposits and the alluvium of the Red River Valley, and they could be examined only by boring. In the western portion of the plains, in the vicinity of the Rocky Mountains, lignites and coals are now known to occur at several different stages in the Cretaceous rocks, but the series is there different lithologically, and the actual distance between the outcrops of the beds and those of the vicinity of the Red River, here referred to, is so great as probably to imply quite different conditions of deposition. Overlying the Cretaceous proper, however, are the representatives of the Fort Union beds of the United States geologists, and in these the extensive and numerous beds of lignite of the Souris River region occur, and constitute the nearest available source of supply of mineral fuel, so far as known, for the province of Manitoba.

Possible occurrence of lignites in Manitoba.

Lignites and coals in western Cretaceous.

Lignites of the Fort Union Group.

The character and thickness of the different members of the Cretaceous in the Manitoba region have not been worked out in detail, owing to the extent of the drift covering and scarcity of sections. The following tabular arrangement of the sub-divisions on the Missouri, according to Meek and Hayden, probably represents the Manitoba regions also, with some approach to accuracy. An examination of it will render the relations of the Fort Union or "Lignite Tertiary" beds quite clear.

Cretaceous and Tertiary groups on the Missouri.

	Feet.
Fort Union Group.—("Lignite Tertiary.")—Hard and soft sandstones, clays and shales, with lignite coal	2,000*
No. 5.—*Fox Hill Group.*—Grey, ferruginous and yellowish sandstones and arenaceous clays	500
No. 4.—*Fort Pierre Group.*—Dark grey and bluish shales or clays	700
No. 3.—*Niobrara Group.*—Calcareous marls	200
No. 2.—*Fort Benton Group.*—Dark grey laminated clays or shales, with some limestone	800
No. 1.—*Dakota Group.*—Yellowish, reddish and whitish sandstones and clays	400
	4,600

* Or more.

In the flat country of the Red River Valley, no exposures of the Cretaceous rocks are found, and it is below the alluvium of this region that the older sub-divisions probably occur. The western margin of the valley is formed by the escarpment of the second prairie steppe, and here, in the so-called Pembina Mountain, and in its continuation to the north-westward, the Cretaceous beds are first met with. About twenty-five miles north of the forty-ninth parallel, where the Boyne River cuts through the Pembina escarpment, beds clearly referable to the Niobrara Group are known to occur, and precisely resemble both lithologically, and in their included fossils those of the corresponding Nebraska division. The rock is generally a cream-coloured limestone, chiefly composed of shells of *Inoceramus* and *Ostrea congesta*, but in places a white, chalky material, which under the microscope is resolved into a mass of foraminiferal shells, coccoliths, and allied minute organisms. This exposure, though probably small in extent, enables the outcrop of the Niobrara to be defined at a point nearly four hundred miles beyond the furthest northern locality known previous to its discovery. Still further north, along the outcrop of the Cretaceous, at Swan River and Thunder Hill, west of Lake Winnipegosis, limestones and marls containing fossils like those of the last-mentioned locality, and evidently of Niobrara age, are again found, and other outcrops of these, and possibly of older beds, may probably be discovered in this vicinity. Niobrara Group in Manitoba.

With these exceptions, however, the Cretaceous rocks known to occur between the Red River Valley and the Lignite Group of the Souris region belong exclusively to the Pierre Group of the Cretaceous, while the Fox Hill Group, which should intervene between this and the lignite-bearing series, has not in this district been recognized, and is, not improbably, but feebly developed.

The Pierre rocks found in occasional exposures in this district resemble those described in the table above quoted, consisting of dark-colored greyish, bluish or blackish shales, generally homogeneous in character through great thicknesses, and seldom containing fossils of any kind, though frequently charged with selenite crystals and holding nodular layers of poor ironstone. Exposures of these beds are found in the Pembina escarpment, on the Pembina River and its tributaries, and on the Assiniboine, where the thick drift deposits have been cut through. The clays or shales are generally quite characteristic in appearance, and where they are found it may be taken for granted that the lignite-bearing formation has either been removed by denudation or has from the first been wanting. Though usually in appearance quite horizontal, these beds must have a general light westerly dip, which carries them beneath the lignite group of the Souris River. Pierre Group.

Drift-covered country.

In the vicinity of the forty-ninth parallel, the furthest western observed exposures of these Pierre shales occur on Cypress Creek,* about forty miles from the base of the Pembina escarpment. From this point for about 150 miles, the country is so thickly covered by drift deposits that none of the streams cut through to the underlying strata, or if the great valley of the Souris does so, the rocks are concealed by its gently sloping and grassy banks. When the rocks underlying the drift are again seen, near the Roche Percée, they belong to the overlying lignite-bearing series.

North-east edge of Lignite Tertiary.

In my preliminary report on the Lignite Tertiary† it was stated that the north-eastern edge of the Lignite Tertiary formation, probably crossed the Souris about five miles east of the Roche Percée, and was connected with a gentle rise which runs south-eastward across the plains from this point. In 1874, however, a thin seam of lignite was found in clays below the Roche Percée, and on the map accompanying the *Geology and Resources of the 49th Parallel*, the boundary was marked so as to include these furthest east exposures. As stated in Dr. Selwyn's report, however, the result of the late borings has been to show a great depth of rocks of the lignite-bearing series below those seen furthest down the Souris in natural exposures, and the line representing the edge of the formation must, therefore, be moved still further north-eastward, though to an undetermined distance.

North-eastward from its intersection of the Souris, the line indicating the margin of the formation, as shown on the map just referred to, is not founded on direct observation, the country being heavily drift-covered, but is drawn with reference to all known exposures of the rocks—joining with Dr. Bell's observations northward—and is probably not in any part of its course very far from the truth.

Portion of the Souris, showing outcrops.

From the point where the Lignite Tertiary beds are first seen in the valley of the Souris, at a point 250 miles west of the Red River, and about six miles east of the tributary from the south known as Short Creek, exposures occur at frequent intervals in the banks of the Souris Valley, westward, to the position occupied in the summer of 1873 by Wood End Depot Camp, a distance of about twelve miles from east to west and considerably more by the river.

Lowest beds seen.

The hard sandstones of the Roche Percée series fringe the Souris Valley, near the mouth of Short Creek, and give it a picturesque appearance. These are not, however, the very lowest visible beds of the formation, as some miles east of this point, and underlying the sandstones, whitish and purplish clays, and arenaceous clays occur; and in

* Called Long River in my reports in connection with the Boundary Commission Expedition.
† Report on the Tertiary Lignite Formation in the vicinity of the Forty-ninth Parallel. North American Boundary Commission, 1874, p. 12.

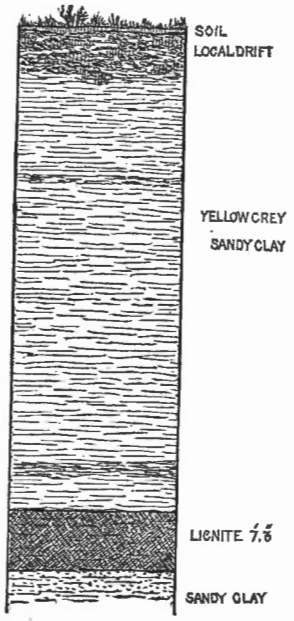

Figure 1—Souris River.

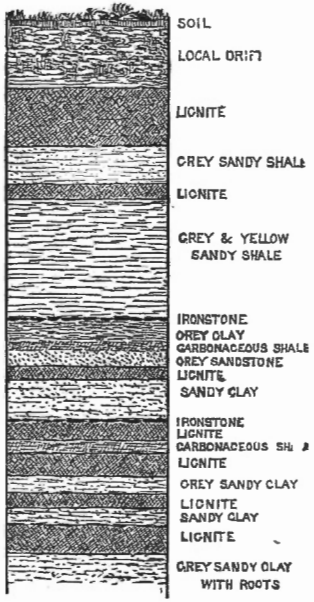

Figure 2—Souris River.

one place, as above stated, a small bed of lignite was found, with specimens of *Viviparus Leai* in the associated strata.

Roche Percée sandstones.

On the south side of the Souris Valley, and a short distance to the east of the valley of Short Creek, the Roche Percée group of rocks is situated. This locality has already been described by Dr. Hector, who made a branch expedition to it from the north, in August, 1857, being induced to do so by the reports of Indians and half-breeds.* These remarkable rocks, which have long been objects of superstition to the Indians inhabiting the surrounding country, owe their curious forms to the weathering away of a soft, grey sandstone from below a bed of similar rock which weathers yellow, and is rendered durable by an abundant calcareous cement. Both the upper and lower sandstones show false-bedded structure in great perfection; though that in the upper hard portion is on a smaller scale, owing to the thinner divisional planes of the rock. The capping sandstone is not hardened in a perfectly uniform manner, but in belts several yards in width, lying parallel in a north-west and south-east direction, and separated by spaces more easy of disintegration. There is also a system of cross-jointing nearly at right angles to this main direction.

This combination of structures has given rise, under the long continued action of the weather, to the remarkably castellated, fantastic and picturesque rock scenery of this part of the Souris Valley. The hard belts form tongues projecting diagonally from the grass-covered bank, and the erosion of the underlying soft sandstone, parallel to the cross joints, has, in several places, produced window-like openings through them. The soft rock bears in many places rude Indian carvings, representing various animals and birds, strings of beads, &c.

Short Creek.

Short Creek, already mentioned as an affluent from the south, shows many sections of the lignite strata. The banks of the stream have assumed the most picturesque forms from successive landslips, and are often quite red in colour from the alteration of the clays by the burning of lignites. One of the most perfect sections is on the left bank, near the crossing place of the Commission Trail, and extends from the level of the prairie almost to tbe water of the stream. (Plate II. A., Fig. 2.)

Section at Short Creek.

*Section 7.**

	Feet	in.
1. Soil	1	6
2. Yellowish coherent sand, grey externally, and holding some much broken *Unio*-like shells at its base.	12	6
3. Grey clay	2	10

* Exploration of British North America, pp. 49 and 225.

* The sections are numbered here as they appeared in the first report on the lignite deposits above referred to. The same numbers are attached to the analysis on a succeeding page.

	Feet	in.
4. Yellowish and greyish thin-bedded sands and sandy clays, with several very thin ironstone layers, weathering orange-red externally	6	0
5. Grey clay	2	4
6. Similar to No. 4, with decayed fragments of gastero-podus shells	12	0
7. Also similar to No. 4, but with a great number of thin ironstone sheets	3	0
8. Hard yellowish sandy clay, a few inches at the top carbonaceous	10	0
9. Good hard lignite	2	2
10. Hard yellowish sandy clay	2	7
11. Good lignite	4	9
12. Greyish sand and sandy clay, showing lines of stratification—in some places soft and incoherent, in others with large concretions, and sometimes forming a nearly solid sandstone	9	0
13. Hard grey clay	2	0
14. Greyish-yellow clay, with many thin layers of orange-weathering ironstone	3	0
15. Lignite	2	6
16. Greyish and yellowish hard sand and sandy clay	11	0
Section concealed by slope of detritus to water level, about	12	0
	99	2

Small spherical ferruginous nodules, resembling bullets, occur in considerable number at the foot of the bank. They have a calcareous cement, and are derived from one or other of the sandy layers. This exposure is remarkable for the very gradual passage of one bed into the next, making it almost impossible to draw lines between them in a measured section.

Souris Valley west of Short Creek.

Sections more or less perfect are exhibited in many places in the Souris Valley, a mile or two west of the entrance into it, from the south, of Short Creek, but more especially on the north side of the valley. They show a great similarity, though not absolutely the same in any two places. One of the most perfect exposures seen (Section 6) was in the face of a bank from sixty to seventy feet high, and consists of sand, sandy clays, and hard, fine clays, very regularly and perfectly stratified, and coloured in various shades of yellow-grey, grey and light drab. At two different levels harder sandstone layers of small thickness were seen, and also three distinct beds of lignite. The lowest is a hard compact lignite, resembling cannel coal in aspect, and two feet three inches thick. A few feet above this a second seam, eighteen inches thick, occurs; and still higher in the series, and about half-way up the

bank, a third, of the same thickness. At the top of the bank, some large nearly spherical sandstone nodules rest, and have evidently been derived from a superior bed which has been removed by denudation. The clays and arenaceous clays at several different levels include remains of mollusca, but these are very fragmentary, having been crushed by the compression of the containing material. A species of *Unio* is abundant, and remains of gasteropoda also occur, though rarely, and in poor preservation.

On the opposite side of the Souris Valley—which is here of considerable width—and not far from the last-mentioned section, soft sandstone beds capped by a harder layer of sandstone, weather into table-like forms. These beds are doubtless the representatives of those which a few miles eastward produce the Roche Percée.

Six miles north from the former position of Wood End Depot, at the bend of the river where Rough Bark Creek enters, the following section occurs :—

Section on Souris at mouth of Rough Bark Creek.

Section 1.

	Feet	in.
1. Fallen bank, no section, (about)	8	0
2. Finely stratified, greyish sandy clay	7	0
3. Lignite	0	7
4. Sandy clay, greyish, laminated, including two "leaf-beds," each a few inches thick	7	7
5. Yellowish fine sandy clay, passing below to grey soft sandstone	11	5
6. Ironstone, a nodular layer	0	3
7. Greyclay	1	0
8. Whitish clay	1	0
9. Carbonaceous shale	3	3
10. Grey clay	3	6
11. Ironstone	0	2
	43	9

The beds appear to be perfectly horizontal. Those of sand and arenaceous clay, though having the appearance of well characterized layers at a little distance, and giving the banks a ribboned aspect, are found, on closer examination, to pass almost imperceptibly into each other. This peculiarity is often to be observed in almost all localities where these rocks are found. The so-called "leaf beds" are of a greyish-purple tint, and contain many impressions of flag-like, parallel-veined leaves, which, though distinct enough when freshly taken from the bank, it is impossible to preserve, on account of the crumbling nature of the matrix. The ironstone, though generally forming extensive sheets, is nodular in structure, and varies much in thickness. It weathers a bright, brownish red, is hard, compact, and very heavy, and on fresh fracture is bluish to yellowish-grey.

Sections between Rough Bark Creek and Wood End.

A short distance south of this locality the bank shows the following section very perfectly (Plate I. A., Fig. 2) :—

Section 2.

	Feet	in.
Prairie sod.		
1. Mixed shale and drift	7	0
2. Lignite	6	6
3. Greyish sandy shale (about)	4	0
4. Lignite	1	6
5. Greyish and yellowish well-stratified fine sandy and shaly clays	14	0
6. Ironstone (nodular)	0	4
7. Greyish and whitish clay	2	0
8. Carbonaceous shale	1	0
9. Grey soft sandstone	1	8
10. Lignite	1	0
11. Grey and yellowish laminated sandy clay	5	0
12. Ironstone (nodular)	0	3
13. Lignite	1	7
14. Carbonaceous shale	1	6
15. Lignite	2	2
16. Grey sandy clay	2	0
17. Lignite	1	5
18. Sandy underclay with large and small roots badly preserved	1	6
19. Lignite	3	2
20. Greyish sandy clay		
	57	7

The lower lignite beds are of excellent quality, firm and compact, and in some places show spots of fossil resin. The structure of the component wood is also in many instances very plainly apparent. The upper lignite, lying immediately below the surface, is soft and decomposed where shown, being in many places penetrated by roots from above. It might, however, prove equally compact with the lower beds where undisturbed. Layer 18 is one of the few instances in which lignite was actually observed to lie on an evident underclay, with roots. The ironstones are specially good and compact in this section. Owing to the wearing away of the softer strata a large quantity of this material strews the surface of the hillside.

This section does not correspond at all with the last, though situated only a few hundred yards from it, and if no fault or break in the strata intervenes—and there is no appearance of any such—the horizontal uncertainty of the deposit must be very great. Fragments of a vesicular material, resembling scoriaceous lava, are abundant in this locality. This substance is produced by the combustion of the lignite beds.

Nearly three miles southward from the last mentioned locality, in following up the valley, another very good section occurs on the east side of the stream, where in one of its many devious windings it has undermined the bank. This section is specially interesting, as affording one of the best localities for the collection of shells of mollusca characteristic of the formation. The section is as below, measurements being estimated :—

Section 3. Section with shell bed.

	Feet	in.
Sand and sandy clay, stratified, and yellowish in general colour	40	0
Lenticular mass of poor clay ironstone, running out rapidly in both directions	2	6
Grey sand	2	0
Shell bed	1	6
Lignite	2	6
Sand and clay	10	0
	58	6

The shell bed is of hard grey sandy clay, and in some places is very full of shells, which are also less crushed, and in a better state of preservation than is usual in this formation. The most common mollusc is *Goniobasis Nebrascensis* M. & H., which occurs in all stages of growth, and several varietal forms. Fragments of *Unio* and *Viviparus ;* and a few examples of *Corbula* (*Azara*) *mactriformis* M. & H. The latter must be considered a brackish-water type, but with this exception no brackish or salt-water forms have been found in these sections of the Souris Valley. The mollusca exactly resemble those of the Fort Union or Great Lignite Group, of the Missouri, and fix with certainty the stratigraphical position of the beds here represented. Fossils.

In the water of the stream, at this place, are several large spheroidal sandstone concretions which have a tendency to split into layers parallel to their flattened surfaces—one of them measuring four or five feet in diameter. These do not appear in the bank, but probably have been washed out of the lower part of the section, which was not so clearly shown.

South of the last section, and about one mile nearly due north of the position occupied by Wood End Depot, is situated an exposure showing the most valuable lignite bed I have seen in the Souris Valley. The beds are arranged thus :— (Plate I. A, Fig. 1.)

Section 4. Section near Wood End.

	Feet	in.
1. Drift material (about)	8	0
2. Yellowish and gray stratified sandy clays, obscured in most places by slips of the bank	52	0
3. Lignite	7	3
4. Grey soft arenaceous clay	1 or more.	

Thick bed of Lignite.

The base of the lignite is about twenty-five feet above the level of the river below, and this part of the section, though apparently consisting of yellowish sandy clays like those overlaying it, is obscure. The lignite is continuously visible for at least two hundred feet along the face of the bank, and seems to preserve uniformity of character and thickness. Externally it is often crumbling, and mixed with clay which has penetrated its joints from above; but where newly exposed, it is hard and compact. It is quite black on freshly fractures surfaces, but has a brown streak, and in many places the structure of the original wood is quite discernable. Some surfaces are strewn with fragments of mineral charcoal like that found in many true coals. Other specimens are apparently structureless, and resemble cannel coal in appearance, though not in composition. The upper beds of arenaceous clay yield a few poorly preserved shells (*Viviparus*).

On the opposite side of the river valley, near this place, the upper part of the bank shows a good section of arenaceous clay, below which, and some fifteen or twenty feet below the prairie level, is a seam of lignite of good quality, four feet in thickness. This lignite bed would seem to occupy a position stratigraphically superior to the last.

Somewhat further up the stream, and on the same side of the valley, about sixty feet below the prairie level, and sixteen feet above the river, a bed of lignite occurs, of which the upper three feet only are visible (Section 5). The bank above it is not well exposed, but appears to consist of sandy clays. The lignite is of good quality, but much weathered at the outcrop. It may very probably represent a continuation of that of the last section.

The whole of these deposits, though in some places showing a dip amounting to a few degrees in one direction or other, appear to have no determinate direction of inclination, but over large areas are as nearly as possible horizontal.

Gap in the Section on the Boundary Line.

Extensive drift-covered region.

West of Wood End, the Souris Valley runs northwestward along the the base of the Coteau, diverging rapidly from the Boundary-line. It loses, at the same time, its abrupt character, and no sections either of Tertiary or Cretrceous rocks occur on it for a long distance. In following the forty-ninth parallel, the escarpment of the third great prairie steppe is first overcome, and it is not until after having passed through the broken Coteau belt, and reached the Great Valley, that exposures of the underlying rocks are again found. This valley is the most eastern great erosion which crosses the Line southward, toward the Missouri, and in it the beds of the Lignite Tertiary are exhibited on a grand scale.

There is thus a space of eighty-two miles from the 263 to the 345 mile point, measured westward along the Boundary-line from the Red River, completely shrouded by drift deposits. There is every reason to believe, however, that the Lignite Tertiary beds stretch uninterruptedly between the two localities, and an exposure of these rocks some distance north of the Line helps to sustain this view.

Small exposure on Traders' Road.

This small exposure was discovered at a locality on the meridian of the 309 mile point, but nearly twenty miles north of the Line; where in going westward by the Trader's Road to Wood Mountain, the Souris is crossed for the second time. Of the rocks at this place a very small section is seen, but sufficient to correlate them with those to the east and west. At the water's edge about eighteen inches of a bed of lignite appears, the bottom of the bed being concealed. It is overlain by several feet of greyish sandy clay, of rather fine texture. The lignite exactly resembles those described as occurring near Wood End, and in some places shows spots of amber.

Country examined on two lines.

Between Wood End and Wood Mountain,—[Long. 103° 10′ to 106° 30′] —the country was examined on two lines; the first nearly coinciding with the Forty-ninth parallel, the second following the Traders' Road above-mentioned, and at its furthest point being thirty-eight miles from the Line. In describing the geology of this region, the general plan of taking localities in succession westward will be in so far departed from as to allow the description of these in the immediate vicinity of the Line before mention of those further to the north.

Lignite Tertiary Rocks of the Great Valley and Pyramid Creek.

Great Valley.

In the gorge already referred to as the Great Valley, the beds exposed are at an elevation of about seven hundred feet greater than that of those last seen on the Souris, near Wood End; and probably at least six hundred feet above those of the northern locality above mentioned. Their exact stratigraphical relation to either of these it is, however, impossible to determine. The lowest beds seen are curiously banded clays and shales. Clay beds charged with plant remains and carbonaceous matter, and having quite a purple tint when viewed from a little distance, alternate with clays nearly white, and yellowish sandstones. Above these is a sandstone layer which though of no great thickness, has in several places produced remarkable conical mounds by acting as a protecting capping for the softer strata below, the latter forming slopes or nearly perpendicular steps, according to their relative hardness, which, taken together with the distinctive colouring of the beds, gives a very striking aspect to the scenery. Above the sandstone capping of this lower part of the section, is a great deposit of sandy clays

Peculiar weathering.

and concretionary sandstones, among which three beds of lignite of various thicknesses are intercalated. The beds are almost horizontal, but undulate at low angles, and the valley of the stream appears to occupy, in the main, the centre of a shallow synclinal fold.

Character of beds.

The upper part of the section in this valley consists of at least 100, and probably 150 feet of clays and argillaceous fine sands of greyish and yellowish-grey colours, well stratified. They contain thin leaf-beds at several different levels, which are prominent from their grey-purple tint, but though containing very many dicotyledonous and flag-like leaves, from their soft and crumbling nature they do not yield determinable specimens.

This part of the section also includes at least three lignite beds. The highest of these is about 140 feet above the base of the section, and three feet or more in thickness. It would appear to be of fair quality, though much decomposed and quite crumbling at the outcrop, from the action of the weather. The next is about 120 feet above the same datum, and can be traced a very considerable distance along the face of the bank. It is five feet in thickness, but includes, where examined, several thin layers of carbonaceous shale; and though of good quality in places, does not appear to have the same uniformity in the various layers that is generally found in the coals of this region. The lowest lignite is some seventy-five feet above the base of the section, and is only a few inches in thickness.

The complete section may be thus represented:—

Section 8.

Section in Great Valley.

	Feet	in.
1. Yellowish sands and clays, lignites, &c	150	0
2. Hard grey and yellowish, somewhat false-bedded sandstone, forming a "capping rock" to beds below (about)	3	0
3. Greenish-yellow, thinly bedded fine sand	15	0
4. Soft yellowish sandy clay	2	4
5. Greyish and yellowish hard-bedded clay	2	6
6. Blackish thin-bedded clay or shale, with plant remains	5	0
7. Greyish thin-bedded clay, becoming darker toward the top (plant remains) graduating into next bed	10	0
8. Hard, pale brown, compact clay, with very few plant remains	1	4
9. Hard, whitish clay, with some plant remains, and a scattered layer of heavy ironstone balls, about a foot from the top	9	0
10. Thin-bedded grayish and blackish hard clay, with leaves, and some small groups of selenite crystals..	7	0

	Feet	in.
11. Fine-bedded clay filled with leaves and plant remains, hard and rusty in the upper portion.....	1	8
12. Grey hard sand, with charcoal-like fragments in some places.....	3	0
13. Ironstone with many plant remains, mostly sedge-like blades.....	0	3
14. Soft grey clay.....		
	210	1

Fossil Shells.

In certain parts of the upper portion of this section, the remains of mollusca occur in some abundance, but in a very bad state of preservation. By dilligent search, however, some specimens of *Goniobasis Nebrascensis*, and large examples of *Viviparus trochiformis* were obtained. No shells, other than those of purely fresh waters, were found.

Plant remains.

The lower part of the section forms a group well distinguished by its colour and the perfection of its stratification from the upper, and often endures, protected by its hard sandstone (No. 2), when the more crumbling upper division has been removed. The plant remains, though occurring more or less throughout the whole section, are best preserved in the lower purplish layers. They consist chiefly of leaves of dicotyledonous trees, which appear to have fallen when mature in the course of nature, and with the change of the seasons, and floated without violence to the great lake in the fine silty deposits of which they have been preserved. *Populus*, *Cinnamomum*, *Quercus*, and other forms, are represented. Leaves and small branches of coniferous trees, referable to *Sequoia Langsdorfii*, and *Glyptostrobus Europeus*, are particularly abundant at this place.

Many of the crumbling hill-tops in this valley have a brick-red colour resembling that seen in parts of the Souris Valley, and due, as there, to the combustion *in situ* of the deposits of lignite. The slag or clinker produced by this action is also found here, though it was not observed actually in place.

Pyramid Creek.

The next stream crosses the Line at the 351 mile point. It also flows through a deep valley of erosion, and may be called Pyramid Creek, from a remarkable pyramidal hill formed of the usual clays and sands, capped by a portion of a layer of hard grey sandstone, the cement of which is calcareous. It has a tendency to break into large quadrangular masses, along intersecting jointage planes, and shows conspicuous false-bedded structure. Below this is a thickness of about fifty feet of rather incoherent fine yellowish sand, sometimes argillaceous. This, producing a sloping bank, is not very well seen, but constitutes about one-third of the thickness of the beds exposed in the valley. The middle third consists of soft crumbling sandstone, or compact sand

without any apparent cementing matter, and of which the constituent particles are rather coarse, and contrast strikingly in this respect with the overlying material. It shows evidence of having been deposited by water in rather rapid motion, through its entire thickness, but the false-bedding is very definitely cut off at many different horizons by perfectly horizontal planes, above which it again commences. The weather acting on these beds causes the hillsides composed of them to assume a well-marked terrraced appearance, on a small scale, each horizontal break producing a terrace level. The sandstone contains here and there a few poorly preserved shells, among which can be recognized two species of *Goniobasis*, fragments of *Viviparus*, and of *Unio*. In one place a layer of ironstone, about three inches thick, is seen to run for some distance, The most notable feature, however, of this part of the section, is the remarkable concretionary character of some layers of the sandstone. The concretions are hard, and of all shapes and sizes. They are generally spherical or spheroidal, and two or more of them are often confluent, forming dumb-bell-like masses, or more or less continuous sheets of a lumpy character. Many are long and root-like, and project in a singular way from the bank.

Fossil Shells.

Concretions.

The lower third of the section in this valley is—as seems often to be the case with the lower layers of these rocks—much more clearly defined, and divided into thinner beds, in which dark colors preponderate. Altogether the section here much resembles that seen in the last great valley. The lower beds of this, probably correspond with the purplish leaf-beds there, and the great thickness of sands and sandstones above, correspond in a general way; though in this place they differ in the absence, so far as could be ascertained, of beds of lignite. The layers of hardened sandstone must also in this case occupy different horizons in the two sections, but this is not to be wondered at, when the extremely local, and often nodular character of the induration is considered, and the fact that it merely depends upon the introduction of a small proportion of calcareous cement among the particles already compacted by pressure.

Section in Pyramid Creek.

The whole section in Pyramid Valley may be represented thus:—

Section 10.

	Feet	in.
1. Hard capping sandstone (several feet)		
2. Soft yellowish sandy beds, forming a sloping bank (about).....	50	0
3. Soft sandstone, grey, false-bedded (about).....	50	0
4. Stratified sandy clay.....	3	0
5. Purplish plant beds with thin layers of lignite and much selenite in thin sheets, isolated crystals and stellar groups.....	3	0

	Feet	in.
6. Lignite, with many spots of amber	1	6
7. Purplish bed, with a few plants	2	0
8. Grey slightly coherent sand, with nodules of arenaceous selenite crystals	4	0
9. Purplish bed, with obscure remains of leaves	1	0
10. Incoherent arenaceous clay and sand	7	0
11. Purplish-grey arenaceous clay, with obscure plant remains and some fossil wood	3	0
12. Brownish clay with ferruginous layers	6	0
13. Lignite	1	0
14. Brown earthy bed	0	6
15. Grey somewhat coherent coarse sand, with argillaceous matter	12	0
About	144	0

The rocks show no well marked dip, but appear to undulate slightly at very low angles.

Association of Selenite.

The occurrence of gypsum, as selenite, was observed here and elsewhere, to be nearly always in association with plant-beds, and generally with those holding many half-obliterated vegetable remains, and of a purplish shade. This association is not accidental, but brought about by the action of the included vegetable matter, which, while still undergoing decomposition, would facilitate the deposition of iron pyrites by the deoxidation of iron compounds in presence of organic sulphur compounds. The porous character of the plant-beds, at a subsequent period, would allow the passage of surface waters containing oxygen; leading to the decomposition of the pyrites, the formation of sulphuric acid, and by its action on the clays, of selenite or calcic sulphate.

A few miles west of Pyramid Creek several hills are capped with heavy and hard sandstone beds, a feature quite exceptional in a country so gently undulating. These do not appear to be perfectly horizontal, but have a slight dip to the west. They may be equivalent to the capping sandstone of the Pyramid Hill, but more probably are yet higher in the series.

Ten miles west of Pyramid Valley, in the upper part of the valley of another stream, yellowish and grey stratified sandy clays are again seen, but are not perfectly exposed.

Concealed interval.

With the exception of this exposure, the underlying rocks are nowhere clearly visible in the vicinity of the Line from Pyramid Valley to Porcupine Creek, a distance of about thirty-five miles. One very considerable stream is crossed about midway, but its valley is wide, and with gently sloping banks. Highlands appear to the north, and may possibly show sections of strata overlying those seen in the

banks of the streams, but I was unable to reach them, the ground, especially in the vicinity of these highlands, being covered with snow, and the time at my disposal limited.

Lignite Tertiary Rocks of Porcupine Creek.

In Porcupine Creek and its tributary valleys, many partial sections occur. Lignite is seen in three places near the forty-ninth parallel, and just above the level of the brook in each instance. The exposures seem to belong to a single bed, and if so, nearly a mile of its horizontal extent can be traced. The lignite and associated beds undulate slightly in all the sections, the former decreasing from four feet in thickness in the most northern bank to one foot in that furthest south. The overlying rocks consist of yellowish and grey sands and clays, well stratified, and much resembling those forming the upper part of the section in the Great Valley.

Section in Porcupine Creek.

The best exhibition of these strata was obtained in a bank about forty feet in height, on removing the decomposed material from the surface. The section was carefully measured as follows:—

Section 11.

	Feet	in.
1. Soil.		
2. Quartzite drift, several feet.		
3. Soft greenish sandy clay, 2 feet or more.		
4. Soft blackish clay	1	6
5. Rusty crumbling sandy clay	0	6
6. Grey clay, with some plant remains	9	0
7. Grey clay, with well preserved dicotyledonous leaves.	1	8
8. Impure ironstone in concretions	0	3
9. Yellowish sand and sandy clay, with obscure plant remains	9	0
10. Greyish and yellowish fine sandy clay	1	3
11. Scattered layer of small ironstone balls		
12. Grey fine sandy clay	1	0
13. Rusty layer, with crumbling plants	0	3
14. Grey sand	0	4
15. Detached masses of lignite, showing the form of flattened tree trunks, about	0	4
16. Yellowish-grey fine sand	0	6
17. Grey clay, with plant remains	0	4
18. Lignite, not of best quality. The grain and form of component wood generally clearly perceptible. Bed undulating slightly. 3 to 4 feet.		
19. Soft grey arenaceous clay, 1 to 2 feet.		
About	31	0

SOURIS VALLEY
LIGNITE BED BURNED AT OUTCROP

Figure 1.

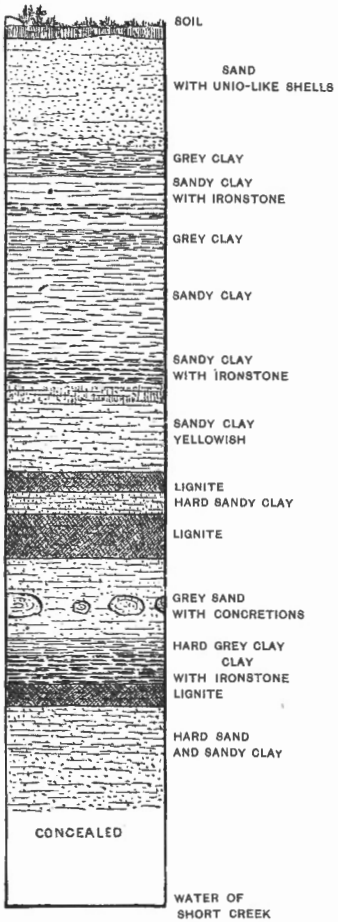

Figure 2—Short Creek.

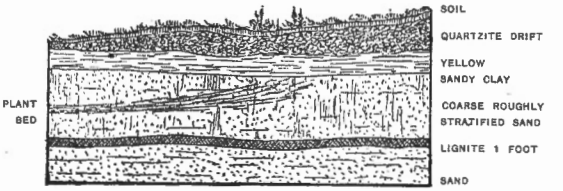

Figure 3—Porcupine Creek.

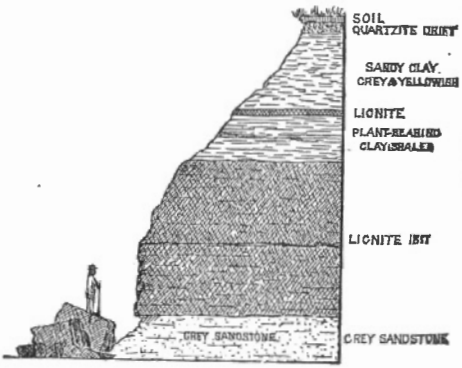

Figure 4—Porcupine Creek.

The vegetatable remains imbedded in the rocks overlying the lignite are mostly those of deciduous trees, and in certain beds are very perfectly preserved. Lignite from this section was used for camp fires, in the absence of wood, but did not burn very freely, as it was taken damp from the bed, and piled on the ground without any provision for draught from below.

Section with 18 foot Lignite.

The most interesting and important section, however, in this region, is that which occurs in a valley joining that of Porcupine Creek from the west, exhibiting a bed of lignite eighteen feet in thickness, and yielding also some of the most perfect and interesting remains of plants. The bank in which this out-crop is situated is over half a mile south of the Line. The beds are arranged thus:— (Plate II. A, Fig. 4.)

Section 12.

	Feet.	in.
1. Surface Soil	1	0
2. Quartzite drift	1	6
3. Yellowish and grey sandy clays, well stratified, but somewhat soft (about)	9	0
4. Lignite	0	9
5. Banded clays, yellowish, grey and purple, with well-preserved remains of plants, and in some layers much crystalline gypsum	5	0
6. Lignite, weathering soft, some layers laminated, others rotten and brownish; forms a steep slope	10	0
7. Lignite, hard, compact, horizontally laminated, but also breaking into large cubical blocks along vertical planes	8	0
8. Soft grey sandstone much jointed, and breaking out in pieees bounded by plane faces, some vertical and others oblique; holds root-like remains and gives issue to springs of water	5	0
	40	3

Though undulating a little, the strata have no true dip, and are as nearly as possible horizontal on the large scale.

Character of Lignite.

The lower part of the lignite bed is very compact and tough under the pick, and holds in some layers many drops of amber. The jointage planes form a conspicuous feature, and were not noticed in anything like the same perfection in other lignite beds examined. They cause the coal to break off in large cubical pieces which lie in the stream at its base. Some of them show thin seams of white gypsum, and in one case a thin film of iron pyrites was detected, being the first appearance of this mineral in connection with these lignite deposits.

Dislocation

This section also exhibits the first instance of dislocation observed to

affect the Lignite Tertiary formation. The eighteen-foot lignite and associated strata, are seen to have been brought to their present position by a downthrow fault, on the other side of which their place is taken by underlying sandy clays.

tion of bed consumed.

The southern side of the valley, opposite this great lignite bed, is broken down, and forms a gentle though irregular slope, which is encumbered by many large, strangely shaped and coloured blocks of stone, much harder than any rocks occurring in the neighbourhood, and in pieces larger than the erratics found in the region. They proved on inspection to consist of masses of beds such as those associated with the lignite, but indurated by its combustion, which has also caused the interruption in the edge of the valley. About a fourth of a mile east on the same valley the great lignite is again exposed, and apparently in much the same development and association.

Plant remains.

The plants in layer 5, are in a beautiful state of preservation, and when the clay is first split open, show every vein-mark in perfection, not only in the larger and coarser leaves but in delicate ferns, which are here unusually common. The matrix is, however, unfortunately soft. It crumbles easily, and tends to crack on drying. A considerable number of specimens of fossil plants from the vicinity of Porcupine Creek have been preserved, though all in a more or less shattered condition. They are in the main identical with those of the Fort Union Group, and include *Glyptostrobus Europeus*, *Sequoia Langsdorffii*, *Thuja interrupta*, *Onoclea sensibilis*, and other species of ferns; and examples of the leaves of many deciduous trees. For the identification of these fossils, and the notes on them which appear in my report on the *Geology and Resources of the Forty-ninth Parallel*, I am indebted to Principal Dawson.

No molluscous remains were found in any of the Porcupine Creek sections.

Lignite Tertiary Rocks on the Traders' Road to Wood Mountain.

Traders' Road.

The furthest west of the sections in the vicinity of Porcupine Creek —that in which the eighteen-foot lignite occurs—is situated near the 393 mile point on the Line, and lies about thirty miles south-east of the trading settlement of half-breeds known as *Montagne de Bois*, Wood, or Woody Mountain. The point above indicated was the terminal one of the geological work of the season of 1873. Reverting now to Wood End, on the Souris River, the exposures of Lignite Tertiary rocks on the Traders' Road to Wood Mountain—which runs nearly parallel with, but to the north of the Boundary line—require a brief notice.

The section first met with is that already described as filling a gap in

the sequence on the Line. Westward for about ninety miles, no beds underlying the drift and surface deposits are seen in the vicinity of the Traders' Road. Beyond this point, however, for the remainder of the way to Wood Mountain—about thirty miles—many more or less perfect exposures of the rocks of the Lignite Tertiary occur.

The road here follows along the northern slope of the water-shed plateau, or occasionally crosses over one of its projecting spurs. The whole region appears to be formed of rocks of Tertiary age, against which the drift deposits of the northern extension of the Coteau, elsewhere more fully described, are found to lie.

General character of rocks.

The north-eastern exposure of this series is found in a steep wooded hill, which forms the salient angle between two of the broad flat-bottomed valleys, so common in this region. The section consists of alternations of sand and arenaceous clay of light-grey and drab colours, the different layers not well defined. No hard sandstone layers crop out, and the whole of the beds are of a very soft and unconsolidated nature. A seam of impure lignite two feet in thickness occurs. It is soft, brown in colour, and holds much sandy matter. Selenite crystals are abundant, and some thin layers of ironstone are also found. The whole appears to be quite horizontal, and the thickness more or less perfectly displayed, must be over 150 feet.

The remainder of the sections from this point to Wood Mountain do not present any features of much interest, and resemble pretty closely that just described. Yellowish-grey, greyish, whitish, and drab, soft arenaceous clays and sandstones, appear with unvarying monotony in all the scarped valleys, which here ramify in every direction. No fossils, except the badly preserved remains of plants, were found, nor were lignites of any importance observed, though some of the men on a hunting excursion, some miles south of the road, brought back samples of a fair quality.

*Rocks near Wood Mountain.**

General character of beds near Wood Mountain.

In the immediate neighbourhood of the half-breed settlement of Wood Mountain, no good exposures were observed. Where rocks are seen they are generally hard greyish sandstones, which protrude here and there in the sides of the hills, and banks of valleys, the softer intervening beds being concealed. These sandstones no doubt belong to the Lignite Tertiary, and probably occur at several different horizons. They have much to do with the definite shape of the watershed plateau, which but for them would probably have been but a diffuse ridge.

* The name Wood, or Woody Mountain, is sometimes used to designate the whole, or an indefinite part, of the Tertiary watershed plateau. It is here restricted to the half-breed settlement and its immediate vicinity.

South-west of Wood Mountain, on the trails used by the half-breeds of that place in going to Fort N. J. Turney—a small trading past south of the Line—ravines cut in the southern edge of the watershed plateau show occasional sections of the Lignite Tertiary rocks. At nineteen miles from Wood Mountain, by odometer, the edge of the plateau is reached, and a few miles further on, the trail crosses the junction of the Tertiary and Cretaceous, and passes out on a lower level plain based on the latter formation. Near this place, an exposure shows several seams of lignite, one of which appeared to be of good quality and considerable thickness, though not sufficiently well exposed for measurement. This bed turns out from the bank in which it occurs, a copious spring of cold water, with a very slight ferruginous taste. The associated beds are thick arenaceous clays of purplish-brown colour; soft, and containing some selenite in crystals.

Sections in the Bad Lands South of Wood Mountain.

The most instructive section, however, in the Wood Mountain region, lies twenty miles south of the settlement of that name, on the forty-ninth parallel near the 425 mile point from Red River. Here beds undoubtedly belonging to the Lignite Tertiary formation—which, east of this locality has covered so great an area of country—are found clearly superposed on indubitable Cretaceous rocks. The exposures are numerous, and are produced by the streams flowing from the southern escarpment of the water-shed plateau above referred to, which has here been gashed by their action into most rugged *Bad Lands.*

Bad Lands.

This term has attached to it in the western regions of America, a peculiar significance, and is applied to the rugged and desolate country formed where the soft, clayey Tertiary formations are undergoing rapid waste. Steep irregular hills of clay, on which scarcely a trace of vegetation exists, are found, separated by deep, nearly perpendicular-sided, and often well nigh impassable valleys; or, when denudation has advanced to a further stage—and especially when some more resisting stratum forms a natural base to the clayey beds—an arid flat, paved with the washed-down clays, almost as hard as stone when dry, is produced, and supports irregular cones and buttes of clay, the remnants of a former high-level plateau. Denudation in these regions, proceeds with extreme rapidity during the short period of each year, in which the soil is saturated with water. The term first and typically applied to the newer White River Tertiaries of Nebraska, has been extended to cover country of similar nature in the Lignite Tertiary regions of the Upper Missouri, and other Tertiary areas of the west. In the Bad Lands south of Wood Mountain, the hills assume the form of broken

Their formation and character.

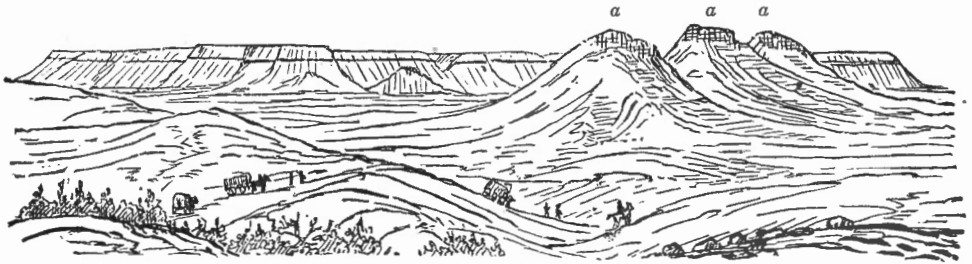

Figure 1—Effects produced by combustion of Lignites—Bad Lands south of Wood Mountain. *a. a. a.*—Buttes capped with altered sandstone and slag. The dark line on the distant escarpment represents the lignite bed where unconsumed.

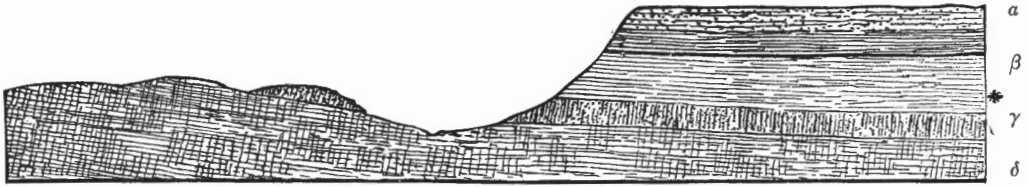

Figure 2—Junction of Cretaceous and Tertiary—Section in Bad Lands south of Wood Mountain. The asterisk indicates the horizon on which vertebrate remains were found.

plateaux, degenerating gradually into conical peaks, when a harder layer of sandstone, or material indurated by the combustion of lignite beds, forms a resistant capping. When no such protection is afforded, rounded *mud-lumps* are produced from the homogeneous arenaceous clays. Waste proceeds entirely by the power of falling rain and the sliding down of the half-liquid clays in the period of the melting snow in spring. The clay hills are consequently furrowed from top to base, by innumerable runnels converging into larger furrows below. The small streams rapidly cutting back among these hills, have formed many narrow steep-walled gullies, while the larger brooks have produced wide flat-bottomed valleys at a lower level, in which the streams pursue very serpentine courses. Denudation is even here, however, still going on, as from the frequent change in the channel of the stream, it is constantly encroaching on the banks of the main valley, undercutting them and causing landslips. The method of the immense denudation of Tertiary beds, which is proved to have taken place over the area of the western plains, is explained by that still in progress in this way along their present borders.

The general section at this place, which though not exposed as a whole at any one spot is remarkably clear, is naturally divided into four parts.

Taking first the highest bed seen, the order is as follows. (Plate III. A., Fig. 2.) General section.

a. Yellowish sand and arenaceous clay, somewhat indurated in certain layers and forming a soft sandstone. It produces the flat plateau-like tops of the highest hills seen. *About* 50 *feet.*

β. Clays and arenaceous-clays. with a general purplish-grey colour when viewed from a distance. *About* 150 *feet.*

γ. Yellowish and rusty sands, in some places approaching arenaceous clays, often nodular. *About* 80 *feet.*

δ. Greyish-black clays, rather hard and very homogeneous, breaking into small angular fragments on weathering, and forming earthy banks. *About* 40 *feet seen.*

The whole of the beds appear to be conformable, and disregarding minor irregularities, are quite horizontal to the eye.

The clays and arenaceous clays of the upper part of Division *β.* are very regularly bedded and include a lignite bearing zone. Three lignite beds, of from one to two feet each in thickness, were observed, but they are separated from each other by rather wide clay partings, and are not pure or of good quality. A bed rich in the remains of plants immediately overlies the upper lignite. It is composed of a very fine and nearly white indurated clay, in which the most delicate structures are perfectly preserved. From its soft and crumbling character, it is Lignite Tertiary.

almost impossible to obtain or keep good specimens; but, in the fragments which were preserved, a few very interesting plants appear. Of these, some are characteristic of the Fort Union Group, and identical with those of Porcupine Creek. The association of remains is that of a fresh-water pond or lake, and a fine new species of *Lemna* occcurs abundantly.

Plant remains.

In the lower portion of this division, the beds are more sombre in tint, and little differentiated by colour, which elsewhere often renders the stratification apparent. They contain some layers of sand and sandstone, which show much false-bedding and current structure, and sometimes terminate suddenly with abrupt undulations. In some places, sufficient calcareous cement has been introduced among the grains to form hard sandstones, but their thickness is never great, nor do they extend far. Much ironstone occurs in thin nodular layers, and some selenite. About one-third from the base of this division a bed was found, in which curious fruits have been preserved, referable to an *Æsculus*. which has been named *E. antiquus*. (Geology & Resources of the Forty-ninth Parallel, p. 330.)

Bones of Vertebrates.

The most interesting feature of this part of the section, however, is the occurrence of the remains of vertebrate animals. These are found exclusively in the lower portion of this division, and most of them below the fruit-bed just mentioned. They are generally closely connected with the ironstone layers, and are often themselves impregnated with that substance. They are also, unfortunately, apt to be attached to the ironstone nodules, or incorporated with them, and traversed by crack-lines, in such a way as to render it difficult to obtain good specimens. A more prolonged search among those hills than I was able to make, would, however, no doubt result in the discovery of localities where the remains are more abundant and in better preservation.

Professor Cope kindly examined the vertebrate fossils obtained in connection with the expedition. Those from this place include fragments of several species of turtles, scales of a gar-pike, and broken bones of dinosaurian reptiles. Of the turtles, two are new species, to which Professor Cope has given the names—*Plastomenus costatus*, and *P. coalescens*—and there are portions of species of *Trionyx* and *Compsemys*. The gar-pike belongs to the genus *Clastes*, and of the dinosaurian remains, though mostly too fragmentary for determination, a caudal vertebra resembles that of *Hadrosaurus*.

Cretaceous No. 5, or Fox Hill Group.

Division γ., the lower series of yellow sands and arenaceous clays, is a much better defined member of the section than division α. It is exposed chiefly in the banks of the smaller ravines, but also in the upper parts of those of the main brooks. The nodules which it contains are large and irregular, but often approach more or less closely to a

spherical form. They are arranged in horizontal lines in the exposures. No fossils were found in this part of the section.

The line of separation between divisions γ. and δ., is quite well-marked by the change in the colour. Division δ shows scarcely a trace of stratification lines. I was very anxious to obtain fossils from it but succeeded in collecting a few small fragments only. They, however, indicate purely marine conditions, and one of them is referable to the genus *Leda* or *Yoldia*. The identification of the horizon of this bed does not, however, depend on such slight grounds as these, as it was afterwards traced westward, and found to be continuous with well-marked fossiliferous Cretaceous rocks.

Portion of Lignite Tertiary represented.

Division α. and β. of this section, clearly belong to the Lignite Tertiary. They probably represent, however, merely the lower layers, and differ somewhat in lithological character and arrangement from those seen at Porcupine Creek, thirty miles east of this place, and at other localities still further eastward. These beds, no doubt, belong to a lower part of the series than is exposed in any of the sections examined between this locality and the Missouri Coteau, and are probably also older than any of those found in the Souris Valley. The beds described as occurring on the trail south of Wood Mountain, belong to about the same horizon, and it is probable that those seen in some places on the Traders' road, may not be much higher up in the series. It would appear that the conditions most favourable to the production of deposits of lignite, did not occur frequently or continue long in the earlier stages of the formation in this locality.

Division δ. being certainly Cretaceous, it only remains to classify division γ., which is so markedly different in character from the beds above and below it. This bed, I believe, represents group No. 5, of the Cretaceous, or the Fox Hill Group of Meek and Hayden. It was frequently observed at other places further west, and its relation will be more fully discussed in the sequel.

Combustion of Lignite beds.

The lignite beds occurring in division β., have been burned away over great areas in this region. Numerous red-topped hills are seen, the capping being composed of indurated clays and sandstones often with much the colour and appearance of red brick. The tops of these hills are nearly on the same plane, and this, if traced back into some of the larger hills and edges of the plateau, exactly coincides with the zone there still containing the lignite. The beds, as there exposed, however, seem hardly of sufficient thickness or importance to cause an alteration of the strata so extensive as has taken place. It is possible, from the irregular nature of these deposits, that over the areas destroyed by combustion, the lignite has been thicker and of better quality, and that the fire may have been unable to extend itself into the thinner por-

tions of the bed, where it is separated by clay partings and covered by such a great thickness of other deposits. The combustion must have taken place ages ago, as only isolated red-topped buttes now remain to mark what must have been the level of the plain at that time. (Plate III. A., Fig. 1.)

Cretaceous and Tertiary Rocks south of Wood Mountain Plateau, and between the Bad Lands and White Mud River.

Rocks south of Wood Mountain Plateau.

On proceeding westward along the Line from the sections above described, one passes over Cretaceous beds, while the southern edge of the Wood Mountain water-shed plateau—which is here coextensive with the edge of the Tertiary—follows a more or less nearly parallel direction at a distance of ten to fifteen miles to the north.

Great spread of Pierre Group.

The sombre Cretaceous clays of division *δ.*, may be traced almost continuously for a distance of about ten miles. Lower beds are, however, exposed, by the general slight easterly dip of the rocks. This is proved by the fact that the sombre clays, though first seen in the bottoms of the valleys, soon form the whole mass of the hills. They attain this position much more rapidly than the slight westward slope of the surface of the country at this place, will account for. About ten miles westward, near the crossing of the forty-ninth parallel and trail to Fort N. J. Turney, where the Wood Mountain Astronomical Station was established, good exposures of these rocks are again found in the banks of the valley of a large brook. On careful examination they were found to contain fossils, and specimens of *Baculites compressus*, *B. ovatus*, and other forms characteristic of Meek and Hayden's 4th, or Fort Pierre Group, were obtained. This horizon is also indicated by their position relatively to the Tertiary and their lithological character.

Lithological character.

The rock is a soft clay-shale, which though fine and regularly stratified, from its homogeneous character hardly shows traces of its bedding. It crumbles down into earthy banks, which, however, in some places, exhibit prominent nodular bands of ironstone, and in connection with these the fossils are, for the most part, preserved. They are usually completely imbedded in the ironstone and filled with it, though the concretions must have been formed some time after the deposit of the clay, as the larger shells are completely crushed. The *Baculites* still retain to a great extent, their original nacreous lustre and play of colour. The ironstone nodules are often septarian, and from the rapid removal of the clays by denudation, the fragments strew the surface in abundance. Selenite is diffused in small quantity through all parts of the beds.

Taking into account the difference of level between this locality and that of the section of the Bad Lands, the clays here seen must be at least 200 feet below the base of division γ. The sombre Cretaceous clays of these localities much resemble in lithological characters the beds of the Pembina Mountain Group, and they also hold the same relation to the overlying Lignite Tertiary series as that assigned to those deposits. They differ chiefly in being less consolidated and darker in colour, and in forming when weathered a crumbling bank of earthy appearance, rather than one of somewhat sharp-angled shaly fragments. The scarcity of fossils in the Pembina Mountain sections, prevents any palæontological comparison of these beds with them. It must be remembered, too, that at least several hundred feet of the upper part of the Pembina Mountain Group, on the eastern margin of the basin, was not seen, and it is this very part of the series which must be represented here. Taking into account, however, the great distance separating the exposures on the eastern and western margins of the region covered by Tertiary, the lithological and structural resemblance of the deposits is quite as close as could be looked for, even in an area characterized by such wide-spread similar conditions, as the interior plateau of the continent.

Comparison with Pembina Mountain series.

Westward from these sections, the continuity of the Cretaceous clays in the vicinity of the Boundary Line, is indicated by occasional small exposures, and at a distance of thirteen miles, a tolerably good exhibition of the rocks again occurs. They are now found to resemble very closely the clay-shales of the upper part of the Pembina Mountain series, and to differ to a corresponding extent from those last described. They are firmer in texture, and lighter in colour, and are traversed in all directions by rusty-faced cracks. The peculiar small rusty fucoidal markings, already more than once referred to, are also abundant, though other fossils are extremely scarce. A few impressions resembling fish-scales, but very obscure, were found; also a single specimen of *Baculites compressus*, being a cast of the interior of the shell in soft ironstone, with the impressions of two gasteropodous shells, which had fallen into its outer chamber. One of the latter is of naticoid type, with a short spire, and few volutions rapidly increasing in size. Not a trace of the calcareous substance of any of these fossils remains; and the clay-shale shows, in many places, obscure impressions, which apparently mark the former positions of other calcareous fossils, as in the shales of the Pembina Mountain series. Taken in connection with the indications just mentioned, the fact that two shells of different species were caught up in the body-chamber of the single *Baculite*, which owed its preservation to an ironstone concretion, would tend to show that organic remains were originally somewhat abundant,

Fossils.

but that they have been removed by chemical action in the way already noticed.

Bleached clays. Selenite in small crystals abounds, and is generally found filling the lines of fissure. Well-marked white bands indicate the stratification lines in some places. They are occasionally several inches in thickness, and have evidently been bleached subsequently to the deposition of the clays, by the percolation of water charged with sulphuric acid, produced by the decomposition of pyrites, along the more permeable layers.

Division γ at White Mud River. Where the Line crosses White Mud River,* or Frenchman's Creek, numerous and very fine exposures of the Cretaceous rocks occur. The stream flows in the bottom of a great trough, cut out of the soft Cretaceous strata, over three hundred feet deep, and in some places fully three miles wide. Many ravines enter this valley from the sides, and numerous land-slips have brought down the upper beds to various levels in its banks, and have produced a rugged mass of conical hills and ridges. The tops of the banks on both sides of the valley are formed of yellowish ferruginous sands, referable to division γ., of the Bad Land section. They are, in many places, hardened into layers of sandstone, and are nowhere very soft. Land-slips have confused the section, but they can be traced in their original position as far up and down the valley as can be seen. I could find no fossils in these beds, though sixty to seventy feet of them must be visible in some places.

Pierre shales. Below these are sombre Cretaceous clays of division δ., and they extend downward to the water level of the river; showing a thickness of 273 feet, the base not being seen. The portion of these clay-shales most closely resembling those last described, and those of the Pembina Mountain series, lies immediately below the yellow sands. Below this, to the bottom of the valley, they show rather the crumbling earthy character and more sombre color of the Bad Lands and Wood Mountain Astronomical Station exposures. This would tend to prove that rocks like those of the upper part of the typical Pembina Mountain series, are not confined to any particular horizon in the western representatives of that group.

Fossils. About 100 feet below the base of the yellow sands, a bed characterized by the great abundance of the remains of a fine species of *Ostrea* occurs. It is referable to *Ostrea patina* of Meek and Hayden; and fragments of a thick *Inoceramus* appear in the same stratum. The ostreas, for the most part, are quite perfect, and have been intombed where they grew, the valves being still attached. They are frequently roughened externally, and crusted with selenite crystals,

* There are probably half-a-dozen streams of this name in different parts of the North-west. The best known is that at the south end of Manitoba Lake, with which this must not be confounded.

produced apparently by the action of acidulous waters on the shell itself.

A short distance below this ostrea bed is a zone containing many large septarian ironstone nodules. In some places a horizontal surface of this bed has been exposed, forming an arid wind-blown expanse of crumbled fragments of the shale, which here and there supports an *Artemisia*, and from which the nodular masses stand up at intervals, as they have been exposed by weathering. The concretions are often as much as twelve or fifteen feet in diameter, and lenticular in form, but are generally broken into fragments by the action of the frost. They hold remains of *Ammonites* and *Baculites*, the former at times two feet in diameter, and referable to *A. placenta*, a form, like *Ostrea patina*, characteristic of the 4th group of the Missouri River section. The fossils are unfortunately intersected by the cracks which traverse the mass of the nodules, in such a way as to render their preservation very difficult. Some of them retain their nacreous lustre in all its original perfection. Bleached bands like those already described, occur in many parts of these clays. Septarian nodules.

The beds here appear to be perfectly horizontal, and the increased elevation of the general surface of the country will more than suffice to account for the reappearance of the yellow sandy deposits last seen in the Bad Lands—without supposing the existence of any gentle anticlinal between the two localities. Our camp, situated a short way down the eastern slope of the White Mud Valley, and consequently somewhat below the general level of the prairie, was 445 feet above the Wood Mountain Astronomical Station, nineteen miles east, by comparison of seven barometric readings at each place. The base of the yellow sands being about 30 feet below the camp, is 409 feet above the Astronomical Station; and as the base of the same stratum (division γ.) in the Bad Land Section was found to be about 170 feet above the Astronomical Station, a difference of 239 feet between the same horizon in the Bad Lands and at White Mud River, would remain in favour of the latter. The distance being about thirty miles, gives an eastward slope of about eight feet in the mile. Dip of the beds.

Cretaceous and Tertiary Rocks—Wood Mountain Settlement to the Crossing Place on White Mud River.

The main trail going west from Wood Mountain settlement, passes for some distance along the northern edge of the water-shed plateau, and then going over it where it turns north-westward, crosses the valley of the White Mud River, sixteen miles north of the forty-ninth parallel, and twenty-three miles north-west of the exposures last Rocks west of Wood Mt.

described. Between Wood Mountain and the White Mud River the water-shed plateau is formed, as before, of the lower beds of the Lignite Tertiary, and projects like the prominent parts of a cameo, while the lower ground, and the deeper portions of the valleys of the streams, are formed of the underlying Cretaceous clays. On the trail, near Wood Mountain, small exposures of the Tertiary rocks frequently appear. About thirty-four miles west of that place, sections of characteristic sombre Cretaceous clay-shale occur, and a deep bay of these lower rocks, penetrates the edge of the Tertiary plateau from the north, in this vicinity. On ascending the plateau forming the west side of this bay, Lignite Tertiary rocks are again seen at intervals, to within about fifteen miles of White Mud River, when the road descends the western edge of the plateau, and again passes over the Cretaceous clays.

Bay of Pierre shales.

In the absence of other information for the district north-west of Wood Mountain, I would have followed Dr. Hector in provisionally indicating the border of the Tertiary as running from the Cypress to the Thunder Breeding Hills. The occurrence of a bay of Cretaceous rocks on the north side of the Tertiary plateau, however, throws doubt on Dr. Hector's supposition of the continuity of the edge of the Tertiary between the two last mentioned localities. Judging from analogy, there is reason to believe that the bay of Cretaceous rocks must extend continuously from the north side of the plateau to the South Saskatchewan River. The strata are as nearly as possible horizontal, and throughout this region it is found that a valley once cut down through the harder Tertiary rocks to the Cretaceous, does not in the lower part of its course again pass over the former. Dr. Hector did not reach the northern edge of the Tertiary between the Cypress and Thunder Breeding Hills, and it is by no means certain that there is even a continuous escarpment uniting them, as shown on the map.

Fossiliferous nodules.

Twelve miles east of the White Mud River, in the banks of a deep coulée tributary to it, good exposures of the Cretaceous rocks occur, and yield in great abundance the characteristic fossils of Meek and Hayden's 4th group. *Baculites compressus* is the most common form, and is associated with several species of *Inoceramus* and other molluscs. Specimens of *Avicula* (*Pteria*) *linguiformis* and *Actæon concinnus*, are included in the collection, and are especially interesting, as having been previously recognised by Prof. Hind, in localities further to the north,—the former at the elbow of the South Saskatchewan, the latter at Two Creeks on the Assiniboine.

The fossils resemble very closely, both in their general appearance and mode of preservation, those brought by Dr. Hayden's expeditions from the Upper Missouri. They are included in nodules of ferruginous

limestone, which, like the enclosing clays, are of dark-grey colour. The concretions occur only in certain beds of the clay, and are generally more or less septarian in character, the cracks being filled with amber-coloured calcite. In other parts of the section, beds with large ironstone concretions occur, and these usually have the same septarian character, but were not observed to contain many fossils. Selenite crystals abound in the clays, and a fibrous mineral, which may best be called a ferro-calcite, occurs in discontinuous layers parallel to the stratification; one of which was observed to be nearly a foot in thickness. This substance was also found in connection with the sombre clays of the Wood Mountain Astronomical Station exposures, and with those of the Bad Lands. It is minutely prismatic, the prisms in some cases, radiating from a centre, but more usually nearly parallel, and at right angles to the beds. It is pearly-grey within, but weathers yellowish-grey, and in that state much resembles, at first sight, silicified wood.

Ferro-calcite.

The valley of the White Mud River, where crossed on this northern route, is very broad, but the banks are much reduced in height, as compared with those on the Line, and are not of the same precipitous character. The bottom of the valley is flat, and the soil being based on the Cretaceous clays without the intermediation of drift material, is barren in the extreme, and supports a scattered growth of *Artemisia*, and some salt-loving plants. The Cretaceous clays are seen in the banks, but are not well exposed.

From the Souris River region to this point near the 108th meridian, the Lignite Tertiary beds exist as a conformable deposit overlying the Cretaceous, properly so-called. They are generally nearly horizontal, and where they are cut away the lowest beds exposed are these of the Pierre Group, or Cretaceous No. 4. A portion of the northern extension of the same lignite-bearing formation is described by Dr. Bell in the Report of progress for 1873–4, p. 66, and analyses of lignites given. West of this point lignite-coals are now known to occur on several horizons in the Cretaceous series, a circumstance not ascertained at the time of publication of my report on the the *Geology and Resources of the Region in the Vicinity of the 49th Parallel.* The structure of this western region will form the subject of a forthcoming report.

Note on western continuation of the rocks.

Composition and Practical value of the Lignites and Ironstones.

The coaly material of the beds above described is, for the most part true lignite, as distinguished from brown coal, being composed of flattened and carbonized tree-trunks. The fossil woods associated with

Composition of lignites.

the plants, and which can be recognized in the mass of the lignites themselves, are all coniferous, and may, from their structure, have belonged to the species of *Thuja* and *Sequioa* represented by the leaves found in the accompanying clays (See Geology and Resources of the 49th Parallel. Appendix A). I have made some assays of the lignites, for the purpose of ascertaining as far as possible their economic value, and in doing so have not thought it necessary to confine my examination to those beds only which are of workable thickness, as a general comparison of the various seams, thick or thin, is of more value in giving an idea of the average quality of the lignites of the formation now known and those which further exploration may bring to light over the same region. The analyses, therefore, include a selection from the various sections, and several beds of good quality and thickness are unrepresented.

Mechanical characters.

The lignites all contain, when in the bed, a very considerable percentage of hygroscopic water, and even those which are very hard and tough under the pick at first, when exposed to the air tend from the loss of water to crack into angular fragments or split up along the layers of deposition, rendering it difficult to transport them to any distance without considerable loss and deterioration. The lignites generally present a rather unpromising appearance in the banks where they crop out, from the fact of their having undergone superficially a certain amount of fissuring and the interstices being filled with clay from above. When followed inward a few feet, however, they usually become quite solid and compact; They vary a good deal in appearance, some beds having a dull lustre almost like that of cannel coal; others, and this is perhaps the most common form, have the same black colour on faces of fracture, but tend rather to split parallel to planes of deposit and show on careful examination distinct traces of the medullary rays and rings of growth of the component wood. Other samples have almost a shaly appearance, caused by numerous layers of mineral charcoal, which is present in small quantities in nearly all the beds. Amber spots are common but generally quite small, The lignites do not soil the fingers like ordinary bituminous coal. Their powder is generally a dark shade of brown but sometimes quite black.

They all yield easily a dark brown solution when treated with caustic potash. The lignites from various beds might be designated by such names as *pitch coal, brown coal, lamellar brown coal*, &c., but it seems better, as they pass by easy gradations from one variety to another, to class them under the generic term lignite.

Water content.

Though giving below the actual amount of hygroscopic and combined water as found by analysis, it must be premised that it depends to a large extent on the conditions to which the lignites have previously

been subjected, and that by prolonged exposure to dry air, it might in many cases have been very considerably reduced. I have, therefore, thought it advisable in another place to reduce the results of all analyses to correspond to a certain percentage of moisture, that they may be better compared with each other and with foreign lignites. The high percentage of volatile combustible matters renders the difference due to slow and rapid coking in some cases very marked.

Souris Valley. Section 6. Lowest lignite, two feet three inches thick. Conchoidal fracture with rather dull surfaces and resembling cannel coal. Ash reddish-white. Analyses.

		By rapid coking.
Water	12.07	
Fixed carbon	45.44	38.90
Volatile matter	39.74	
Ash	2.75	
	100.00	

Souris Valley. Section 2. *Layer* 19. A weathered specimen separating into laminæ horizontally. Clay from overlying bed filling fissures. Ash yellowish-brown.

		By rapid coking.
Water	13.94	
Fixed carbon	45.27	38.35
Volatile matter	35.00	
Ash	5.79	
	100.00	

Souris Valley. Section 2. *Layer* 17. Weathered specimen. Black, compact, with shining faces. Ash yellowish.

		By rapid coking.
Water	12.67	
Fixed carbon	31.39	28.01
Volatile matter	49.52	
Ash	6.42	
	100.00	

Souris Valley. Section 2. *Layer* 10. Lustre dull, separating along horizontal planes. Ash light yellowish.

		By rapid coking.
Water	14.90	
Fixed carbon	36.94	36.68
Volatile matter	42.98	
Ash	5.18	
	100.00	

Souris Valley. Section 2. *Layer* 2. A weathered specimen soft and crumbling. Ash greyish-white.

		By rapid coking.
Water	17.97	
Fixed carbon	32.86	30.10
Volatile matter	44.56	
Ash	4.61	
	100.00	

Souris Valley. Section 5. Black compact lignite with much woody structure apparent. Ash yellow.

		By rapid coking.
Water	14.73	
Fixed carbon	42.48	34.07
Volatile matter	39.99	
Ash	2.80	
	100.000	

Souris Valley. Section 4. *7 feet seam.* Hard compact black lignite, breaking with pseudo-conchoidal fracture, and showing traces of structure of wood. Ash yellowish-white, light.

		By rapid coking.
Water	15.11	
Fixed carbon	47.57	41.67
Volatile matter	32.76	
Ash	4.56	
	100.00	

Section 8. *Lowest Lignite.* Weathered specimen, crumbling. Ash grey.

		By rapid coking.
Water	18.74	
Fixed carbon	35.69	30.04
Volatile matter	40.54	
Ash	5.03	
	100.00	

Section 8. *Middle Lignite.* Weathered specimen. Soft, breaking into layers along deposition surfaces. Largely composed of comminuted charcoal-like fragments.

		By rapid coking.
Water	16.28	
Fixed Carbon	46.25	29.18
Volatile matter	33.19	
Ash	4.28	
	100.00	

Section 8. *Upper Lignite.* Out-crop specimen. Crumbling. Tends to break into layers parallel to deposition planes.

		By rapid coking.
Water	15.20	
Fixed Carbon	34.45	27.61
Volatile matter	44.43	
Ash	5.92	
	100.00	

Section 9. Out-crop specimen. Brownish. Fracture almost conchoidal. Ash yellowish-white.

		By rapid coking.
Water	15.51	
Fixed carbon	37.12	28.44
Volatile matter	42.65	
Ash	4.72	
	100.00	

Section 12. *Lower part of* 18 *feet seam.* Tough, compact lignite, separating into horizontal layers. Much amber in small spots, a good deal of woody structure apparent and some mineral charcoal. Ash light-grey.

		By rapid coking.
Water	12.05	
Fixed carbon	46.18	41.03
Volatile matter	35.12	
Ash	6.65	
	100.00	

Section 12. *Upper part of* 18 *feet seam.* Out-crop specimen. Crumbling. Ash white.

		By rapid coking.
Water	16.87	
Fixed carbon	34.32	24.30
Volatile matter	37.51	
Ash	11.30	
	100.00	

Average composition.

The lignites, it will be observed, are on the whole uniform in composition and contain an average amount of over 40 per cent. fixed carbon, when the water content is estimated at 12 per cent. They are thus inferior to the lignite coals in the vicinity of the Rocky Mountains. The lignites here described, however, gain some advantage in a practical point of view from occurring in a horizontal position and out-cropping in the sides of valleys in such a way that they might be

worked by simple adits, avoiding the expense and trouble necessary when vertical sinking has to be resorted to in the first instance.

Do not yield coke or illuminating gas.

None of the lignites in this region yield a true coke, but merely shrink somewhat in size during the expulsion of the volatile combustible matter, and turn out of the crucible in a dry incoherent powder. The volatile matter is, as might be expected, comparatively poor in luminous gases, and the lignites would, consequently, be of little use in the manufacture of illuminating gas.

Ash.

The ash is generally of pale colours; grey and white, passing into yellowish-white, being the prevailing shades. One or two only yield a deeply-coloured ash, which is then brick-red. It is small in amount in most of the specimens, and does not usually appear of a nature to form troublesome clinker. The lignites when burning yield a peculiar empyreumatic odour but no smell of sulphur, and indeed, as might be foreseen from the nature of the ash, the quantity of sulphur present is very small.

In the table opposite, the analyses of all the lignites are calculated to correspond with a quantity of water, combined or hygroscopic, equal to twelve per cent., which may, I think, be accepted for the samples examined as the practical limit of desiccation in dry air at ordinary temperatures. This will allow of a more accurate comparison of the value of those from different parts of the series.

Deterioration at outcrop.

It should be stated that, with the exception of two or three specimens, all those analysed were mere out-crop samples, and from the facility with which these lignite coals deteriorate under atmospheric influences, show a result much inferior to that which would be obtained from the same beds at some depth. Nos. 1 and 12 with one or two others were obtained from portions of the beds recently exposed by slips of the bank, and probably represent more fairly the quality of the better class of lignites. The total amount of carbon, inclusive of that which passes off with the volatile matters, varies probably between 60 and 70 per cent. The lignites do not appear to be suited for smithy purposes, and the smiths who tried them reported it difficult to obtain a welding heat. The same fault has been found, I believe, with even the best classes of similar fuels found in the vicinity of the Union Pacific Railway, and arises, no doubt, from the great proportion of volatile combustible matter to fixed carbon, and the quantity of hygroscopic and combined water. As the lignites do not coke, they would appear to be unsuited for the smelting of iron in the blast furnace. They are perfectly suited for puddling iron, and the metallurgical treatment of various ores, if burned in gas furnaces. Similar and even inferior lignites are extensively used for steam purposes in various parts of the world, and may even be employed on railways, though locomotives intended

to burn these fuels, in order to give satisfactory results, must have, compared to those worked on bituminous coal, larger grates and fire boxes, and longer boiler-tubes, giving a greater heating surface compared with the horse-power. The value of the lignites of this region lies rather in the abundant supply they offer of fuel of fair quality for local use in a country which, though adapted for stock-raising and agriculture, is practically without wood.

RESULTS OF ASSAYS OF LIGNITES, WATER BEING ESTIMATED AT AN AVERAGE OF 12 PER CENT.

	Locality.	Miles West of Red River.	Thickness of bed.		Fixed Carbon.	Volatile combustible matter.	Ash.	Remarks on Ash.
1	Souris Valley. Sect. 6..	255	2′ 3″	Water estimated at 12 per cent.	45.48	39.77	2.76	Reddish-white.
2	" " " 2..	263	3′ 2″		46.18	35.90	5.92	Yellow-brown.
3	" " " 2..	263	1′ 5″		31.51	50.02	6.47	Yellowish.
4	" " " 2..	263	1′ 0″		38.08	44.57	5.35	Light yellowish.
5	" " " 2..	263	6′ 6″		34.82	48.30	4.88	Greyish-white.
6	" " " 5..	262			43.72	42.40	2.88	Yellow.
7	" " " 4..	263	7′ 3″		49.31	33.98	4.71	Yellowish-white.
8	Great Valley. " 8..	344	a few inches		38.65	43.92	5.43	Grey.
9	" " " 8..	344	5′		48.61	34.90	4.49	Grey.
10	" " " 8..	344	3′		36.92	44.95	6.13	White.
11	" " " 9..	346	4′		38.63	44.48	4.89	Yellowish-white.
12	Porcupine Valley Lower part.... " 12..	390	18′		46.20	35.14	6.66	Light grey.
13	Upper part.... " 12..	390	"		36.33	39.97	11.70	White.
	Average.....				41.10	41.41	5.55	

Ironstones.

The ironstones of this formation, though occurring very frequently in the same sections, and in close proximity to the coals, have not been observed in any place to attain a considerable thickness. They generally run in nodular sheets of only a few inches thick, through the clays and argillaceous sands. Externally they weather to various shades of chocolate brown and reddish brown, but are hard and compact in structure and within preserve their original bluish or yellowish grey colour. They ring beneath the hammer, and break off in conchoidal chips. Considerable quantities of this material might be gathered from the surface in some localities, and it is possible that further search might bring to light localities in which so many layers of ironstone occur in the same section as to render it profitable to work over the entire bank.

Clay Ironstones, Souris Valley. Section 2.

Protoxide of iron	49.00
Water lost at 115° C	1.21
Carbonic acid, lost on ignition	28.57
Siliceous matter insol. in HCl	17.04
Sulphuric acid	0.26
Phosphorus	*Trace*
Metallic iron per cent., in raw ore	38.11
Metallic iron per cent., in calcined ore	54.27

Clay Ironstone, Great Valley. Section 9.

Protoxide of iron	46.72
Water lost at 115° C	3.57
Carbonic Acid lost on ignition	21.23
Siliceous matter insol. in HCl	8.72
Sulphuric acid	0.30
Phosphorus	0.03
Metallic iron per cent., in raw ore	37.53
Metallic iron per cent., in calcined ore	49.90

A small quantity of iron is present as peroxide in each ore, but I have not thought it necessary to make a separate estimation of this.

A third specimen from the Great Valley, Section 8, examined for iron, gave a percentage in the raw ore of only 37.95.

The percentage of iron in the specimens examined is very good for the class of ores to which they belong. The average percentage of iron

of several good English clay-ironstones amounts to 33.84; of several samples of black-band ironstones to 35.39. Where these ironstones are unweathered, the whole of the iron appears to be in combination with carbonic acid. The quantity of sulphur psesent is small, and it is entirely as sulphuric acid and in combination with lime. Phosphorus is also present in very small quantity.

Fire-clays.

The clays and argillaceous sands accompanying the lignites are in many places of the nature of fire-clays, and contain but very small quantities of iron or lime. It is probable that many of them would make very refractory fire bricks. Clay of sufficiently good quality for the manufacture of ordinary bricks and pottery is present everywhere in close connection with the lignites.

APPENDIX II.

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Note by Principal Dawson, C.M.G., LL.D., F.R.S., on Fossil Plants Collected by Dr. Selwyn, in the Lignite Tertiary Formation of Roche Percée, Souris River.

Platanus nobilis.—*Newberry.*

This magnificent leaf, of which several very good specimens have been obtained, was first described by Dr. Newberry in the Annals of the Lyceum of New York for 1868. His specimens were from near Fort Clarke, on the Upper Missouri, and were found in beds then regarded as Miocene Tertiary, though now known to be much older, and which are on the horizon of the Lignite Tertiary Series of the Souris River. A figure of the leaf is given in Dr. Newberry's later work, "Illustrations of Cretaceous and Tertiary Plants," Geological Survey of the Territories, 1878. There can be little doubt that this plant is the same with that named by Lesquereux, *Platanus dubia*, in 1878, and subsequently described in his Report on the Tertiary Flora of the Western Territories, as *Aralia notata*. Fragments of this leaf were obtained by Dr. G. M. Dawson in the region of the Souris River in 1874, but they were too imperfect for description. The present specimens are in some respects the most perfect ever obtained. Some of them are a foot in diameter, and they show some points of structure not before noticed.

I may, before referring to these, quote Newberry's description, which is very full and accurate.

"Leaves large, one and a half feet in length and breadth, petioled, 3 lobed, or sub-5 lobed, lobes acute, margins of lobes and base entire or near the summits of the lobes delicate sinuate-toothed; nervation strongly marked, generally parallel; medial nerve straight, two basilar nerves of nearly equal length and strength diverge from it at an angle of 30°–35°, are straight throughout and terminate in the apices of the principal lateral lobes. Above the basilar nerves about 16 pairs of lateral nerves are given off from the mid-rib at about the same angle; these are nearly straight and parallel, terminating in the teeth of the margin. From each of the basilar nerves diverge about the same number

of pairs of branches as from the mid-rib, and these are also nearly straight and parallel and terminate directly in the margin. Of these the second and third exterior, one on each side, is often much the strongest of the series, and is then prolonged into a small but distinct lateral, triangular acute lobe, giving the leaf a somewhat pentagonal form. From this basilar branch of the lateral nerves, 12 or more short, generally simple branchlets, spring on the lower side, and 4–5 on the upper side, near the summit, all of which terminate in the margins. The tertiary nerves connect the adjacent secondary nerves nearly at right angles. Sometimes they are straight and parallel, but oftener more or less broken and branching where they meet, near the middle of the interspaces. Where the systems of nervation of the lateral and middle lobes come into contact, the tertiary nerves are stronger and form a somewhat irregular network, of which the areolæ are large and sub-quadrate."

The above description corresponds perfectly with Dr. Selwyn's specimens, xcept that only the right basilar nerve sends off a large branch terminating in a lobe; that on the left side having somewhat equal branches.

As to the affinities of the leaf, Newberry remarks that the texture is thicker and the surface smoother than most sycamores, resembling in this some tropical leaves; but as the radical structure is that of a *Platanus*, and the associated plants indicate a temperate climate, he refers the plant to *Platanus*.

Lesquereux, in describing his *Aralia notata*, gives nearly the same characters, except that he characterizes the secondary nerves as camptodrome, or bending before they reach the margin. He admits that he would consider it identical with Newberry's species but for this feature, and further admits that in one of his specimens the outer veins appear to be craspedodrome and terminating in small teeth, and he refers to other cases in which such characters are inconstant. In Dr. Selwyn's specimens, while in the basal part of the leaf the veins bend somewhat toward the margin, which is entire, in the upper part they run straight to the margin, and terminate in short teeth, separated by broad, shallow sinuses. Thus these specimens satisfactorily unite Newberry's and Lesquereux's species.

Dr. Selwyn's specimens, however, exhibit a peculiarity which seems to have been absent from the specimens studied by Newberry and Lesquereux, in the presence of two short basal lobes, extending backward on the petiole. Each of these is about an inch in length, pointed, and with one strong exterior tooth and two delicate nerves, one extending to the point and the other to the tooth. It does not certainly appear whether these basilar lobes are separate or united in the

middle. If the latter, they would present some resemblance in mode of attachment to the Cretaceous leaves known as *Protophyllum*, and to the tertiary species of *Pterospermites*, from which, however, this leaf differs materially in other respects. These peculiar basal lobes are preserved only in one of the specimens, and they have been wanting or concealed in those figured in the United States Reports.

In Dr. Selwyn's specimens the petiole is four inches long in a specimen about a foot in diameter. It is channelled, woody in texture and with an articulating surface at the proximal end. This and its great abundance on certain surfaces, shows that the leaf belonged to a deciduous tree, which, from the localities cited by the authors already named, must have been widely distributed, though as Lesquereux remarks, especially abundant to the northward.

It is to be hoped that further research will disclose the fruit of this remarkable tree, and thus make its affinities more certainly known. In the meantime, I think it well to retain Newberry's name, as having priority, and quite as likely to be correct as any other. If a *Platanus*, the tree must, as Newberry remarks, have borne somewhat the same relation to our sycamores which *Acer Macrophyllum* of the West Coast bears to the other maples. This species would seem to be specially abundant in the *Second Group* (Evanston, Mount Brosse, &c.,) of Lesquereux's arrangement of the Lignite flora.

Sassafras Selwyni, s. n.

Leaf somewhat rough on the under side; three lobed, three ribbed, with the central lobe longest; ribs and nerves strong and woody; margin entire and slightly waved; breadth, 4.5 centimetres; length, 5 centimetres. The two lateral nerves diverge at an angle of 40° from the mid-rib. Each lateral rib gives off three small curved veins at its base, and these six strong curved veins which bend round and become parallel with the margin. Slender parallel veins are given off from the inner sides of the lateral ribs, and join those of the mid-rib up to a height of 1.5 centimetres, when the mid-rib gives off 6 strong slightly curved parallel lateral veins on each side, at angles of about 40°.

This species is represented by only one well-preserved example in Dr. Selwyn's collections. Its form and venation are very peculiar, and I think entitle it to be referred to *Sassafras* with quite as much probability as many of the leaves from the Cretaceous referred to that genus, It is indeed very near to *S. Cretaceum* Newberry, especially the variety *obtusum* of Lesquereux. It is to be observed, however, that this common Cretaceous species has also been referred to *Araliopsis*. If a *Sassafras*, it is of interest as being the first representative of that genus

from the Lignite Tertiary, and as connecting a generic form of the Cretaceous and modern floras of America with the Tertiary as well.

QUERCUS. Sp.

An oak with leaves about 1.5 inch broad, and probably 4 or 5 inches long, having strong mid-rib and numerous straight veins, terminating at the apices of abruptly-pointed teeth pointing upward. This leaf seems different from any I can find figured. Its nearest American ally seems to be *Q. antiqua* of Newberry, from the Cretaceous of Nebraska. It is probably a new species, but the specimens are scarcely sufficiently perfect to warrant its description.

Associated with these leaves are those of a *Populus*, referable to the widely-distributed *P. arctica*, of Heer, another which seems to be *P. cuneata*, Newberry, from the Fort Union group, and one which may be *P. acerifolia*, of Newberry, while a fourth resembles *P. Hookerii*, of Heer, found in the McKenzie River Tertiary beds by Richardson There are also leaves probably of a *Corylus* not unlike our modern species, and a fragmental leaf which may belong to the genus *Pterospermites.*

TAXITES OLRIKI.—*Heer.*

There are some leaves and branchlets of *Coniferæ* and *Taxineæ* on the same slabs with the other leaves. The most abundant and striking of these is a large-leaved *Taxites*, apparently *T. Olrikį* of Heer, a species found in Alaska, Greenland and Spitzbergen. It is the most luxuriant in its foliage of the tertiary species of Taxites, but Dr. Selwyn's specimens are even larger and better developed than those figured by Heer.

TAXITES OCCIDENTALIS.—*Newberry.*

Taxites Occidentalis of Newberry is represented by a few small fragments, and there is a well-preserved leafy branch of a *Sequoia*, apparently *S. Langsdorffii*, though larger and richer in foliage than most of the specimens figured by Heer and others. This species also occurs at Porcupine Creek (G. M. Dawson), at Dirt Hills (R. Bell), at McKenzie River (Richardson), at Atlanta (Heer), and very extensively in the Tertiary of North America and Europe.

The above plants are contained in slabs of a ferruginous sandstone, which retains good impressions of their forms and venation, and is sufficiently hard to allow large specimens to be obtained.

The fossils above noticed would refer the beds containing them to the Eocene or Paleocene group designated, in the Reports of the Canadian Geological Survey and Boundary Commission, the Lignite Tertiary

series, and in Hayden's and other reports of the U. S. Survey of the Territories, the Fort Union, or Lignitic, or Upper Laramie group.

The Flora of the Roche Percée thus proves to be similar to that of the Porcupine Creek Series of Dr. G. M. Dawson's Report on the 49th parallel, to that of the Lignite Series of the Lower Mackenzie River and to that of the Fort Union group and Lesquereux's Carbon gronp, or third and highest sub-division of the Laramie group of the Rocky Mountain Region. It belongs to the great Lignite Tertiary series of the North-West, which rests on well characterized upper Cretaceous rocks; and though undoubtedly similar to that of the Miocene of Europe, really characterizes the beds which in the West constitute the transition from the Cretaceous into the Tertiary, and which form one great continuous series, probably on the horizon of the Eocene of Europe, though with local differences which are liable to be mistaken for differences of age.