

GEOLOGICAL SURVEY OF CANADA
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON A PORTION OF THE

DISTRICT OF ATHABASCA

COMPRISING THE COUNTRY BETWEEN

PEACE RIVER AND ATHABASCA RIVER

NORTH OF LESSER SLAVE LAKE

BY

R. G. McCONNELL, B.A.



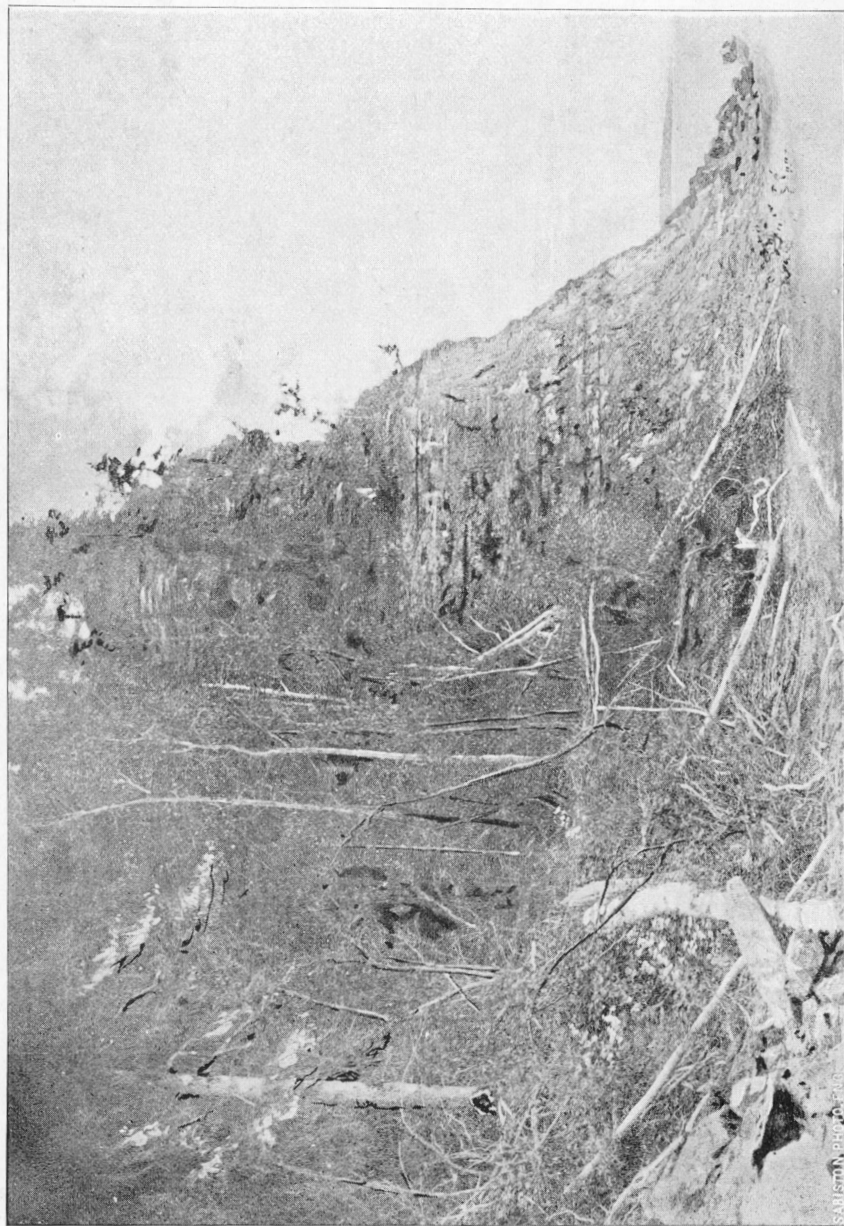
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R. G. McConnell, Photo., August, 1890.

CLIFF OF TAR SANDS, ATHABASCA RIVER.

TO ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., &c.,
Director and Deputy Head,
Geological Survey of Canada.

SIR,—I beg to submit herewith a report on the geology and the general characters of the country in the vicinity of the Peace and Athabasca rivers. An index map of the region and two geological sections accompany the report. A map on a scale of eight miles to the inch has been completed, but is not yet published.

I have the honour to be, sir,

Your obedient servant,

R. G. McCONNELL.

GEOLOGICAL SURVEY OFFICE,
OTTAWA, December, 1892.

INTRODUCTORY.

PREVIOUS EXPLORATIONS, GENERAL PHYSICAL FEATURES AND AGRICULTURAL CAPABILITIES.

The history of the Peace and Athabasca country commences in 1778 when Peter Pond, subsequently a partner in the North-west Company, pushing north-westward in search of new fur districts, reached the Athabasca by way of Methy Portage and the Clearwater River, and descending it, founded a fort known as the "Old Establishment," about thirty miles above its mouth. In 1788, this post was abandoned and a new one built on the south shore of Lake Athabasca, on what is now known as "Old Fort Point." Still later, this site was also deserted and a better one selected on the north shore, near the outlet of the lake. A general map of the North-west was published by Peter Pond in 1785. Peter Pond's travels.

Peter Pond's venture proved extremely remunerative, and he was followed by other traders who gradually spread themselves over the then unknown country to the north and west. A complete survey of the Athabasca appears to have been made by David Thomson.* This energetic but little known traveller made a track survey in 1799 of Lesser Slave River, and of the Athabasca from the mouth of the Pembina to Clearwater Forks. In 1803, he filled in the gap between the Forks and Lake Athabasca, and in 1810 ascended the river and crossed the Rockies by the Athabasca Pass, thus completing his traverse. Peace River was ascended and surveyed by Sir Alexander Mackenzie in 1792, from its mouth to a point about six miles above the Smoky River Forks, but a post had been established some years before, near the present site of Fort Vermilion. In 1793 he completed his journey and explored the river to its source. David Thomson's surveys.

The portion of the Athabasca between the Clearwater Forks and the lake was examined and briefly described by Franklin in 1819 and 1825, and by Richardson in 1848, and as it formed part of the principal inland route to the Arctic Ocean, it was also travelled by Back, Simpson and other Arctic explorers. In 1843, LeRoy descended the Clearwater and the Athabasca River, and in 1844 ascended Peace River to Dunvegan, and then leaving the river travelled eastwards to Mackenzie's journey.

*Brief narrative of the journeys of David Thomson in North-western America, by J. B. Tyrrell, M.A., Proc. Can. Ins., 1887-88, vol. VI., p. 135.

Edmonton by Lesser Slave Lake. Lefroy observed for latitude and longitude and established the magnetic variation at a number of points along his route. In 1875, Dr. Selwyn, Director of the Geological Survey, mapped and reported on the upper part of Peace River, as far down as the mouth of Smoky River, and in the same year Professor Macoun, who accompanied him proceeded down the river to Lake Athabasca, and returned east by the usual Athabasca-Clearwater route, while Dr. Selwyn reascended Peace River, and returned by British Columbia.* In 1879, Dr. Dawson examined Pine River, Smoky River and other branches of Peace river. In 1883, W. T. Thompson, D.L.S., extended the regular instrumental surveys of the Dominion Lands Branch, Department of the Interior, into the Peace River country. In 1882, a track survey and geological examination of the Athabasca, below the mouth of Lake La Biche River, was made by Dr. R. Bell†, and finally, in 1884, a micrometer survey of the lower parts of both the Peace and Athabasca rivers, was made by Wm. Ogilvie, D.L.S.

Area of country.

The country between the Peace and Athabasca rivers north of Lesser Slave Lake, comprising an area of about 44,000 square miles, was not entered by any of the travellers referred to and remained entirely unknown until the present exploration was undertaken.

General description.

The greater part of this district may be described as a gently undulating wooded plain, diversified with numerous shallow lakes, muskegs and marshes. Small prairie patches, manifestly due to forest fires, occur north of the west end of Lesser Slave Lake, at several points along the Loon and Wabiscaw rivers, also on Peace River around Fort Vermilion and at other places, but their total area is relatively insignificant. The principal forest trees are the white and black spruces, *Picea alba* and *nigra*, the balsam-fir, *Abies balsamea*, the Banksian pine, *Pinus Banksiana*, the larch, *Larix Americana*, the aspen, *Populus remuloides*, the balsam-poplar, *Populus balsamifera*, and the canoe birch *Betula papyracea*. The species of spruce occur along many of the river flats, and on the uplands they are found nearly everywhere except on the drier hills. The white spruce attains, in favourable localities, a diameter of two feet or more, but it is usually much smaller. It is the most valuable tree in the district. The Banksian pine grows thickly on the sandy and gravelly ridges, while the aspen prefers a loamy soil and characterizes the best agricultural parts of the country. The larch, balsam, balsam-poplar and birch, although found in every part of the district, are more scattered and

Trees.

*Geological Survey of Canada, Report of Progress, 1875-76.

†Geological Survey of Canada, Report of Progress, 1882-3-4.

do not form continuous forests like the spruce, Banksian pine and aspen. On the lower part of the Wabiscaw and Loon rivers a large irregular branched, rough barked cottonwood was noticed, which is probably *Populus monilifera*.

The rolling plains between Peace River and the Athabasca are Elevations. relieved by several high ridges or plateaus, all of which owe their origin to a differential denudation of the soft rocks on which the plains are based. Of these Marten Mountain is situated north-east of Lesser Slave Lake, above which it rises to a height of about 1,000 feet. The Buffalo Head Hills commence abruptly about fifty miles above the mouth of the Loon River, with an elevation of about 2,500 feet above the sea, and running in a south-south-westerly direction die away opposite the mouth of Battle River, while Birch Mountain extends for nearly ninety miles along the lower part of the Athabasca, from which it is separated by a plain fifteen to twenty miles wide. Among the smaller elevations are Trout Mountain, which is situated north of the Wabiscaw River, and the Thickwood Hills, which lie south of Birch Mountain. The uplands of the district, like the lowlands, are all wooded, and are dotted everywhere with lakes and marshes.

The principal watercourse of the district is the Wabiscaw-Loon Rivers. River. This stream, with its numerous tributaries, drains nearly half the region. Among the other rivers are the Pelican, Red, Moose and Tar rivers, flowing into the Athabasca; Birch River draining into Lake Claire; and the Red, Wolverine and Cadotte's rivers are tributaries of Peace River. The main rivers branch in the interior of the district into a multitude of small winding streams, few of which have valleys of any size, and they usually flow in a sluggish manner, often expanding into lakes in the flat districts, but break over the steeper slopes of the country in a series of strong rapids. With the exception of the lower part of Loon River, none of these rivers are navigable by steamers.

A noticeable feature of the district reported on is the multitude of Lakes. lakes which occur everywhere, scattered over plains, plateaus and ridges. The lakes range in size from broad sheets of water twelve to fifteen miles in length, to small ponds a few feet across. They are usually shallow and weedy, and in many cases are being gradually filled up with *Sphagnum*. Many of the smaller lakes of former times have been completely filled up and are now represented by muskegs. The origin of most of the lakes is due to the numerous shallow depressions in the boulder-clay floor of the district, becoming filled with water; but in some instances they appear to have been caused by the damming up of some of the smaller streams by beavers.

Lake Claire, Lake Mammawee, and a number of other smaller lakes in the north-eastern part of the district, differ in origin from those just described, as they occupy part of the common delta-plain of the Peace and Athabasca rivers, which stretches from the west end of Lake Athabasca up both these streams for many miles. They represent portions of Lake Athabasca separated from the main basin by accumulations of stream detritus. These lakes are everywhere very shallow, their ordinary depth seldom exceeding nine feet, even in their deepest parts. In seasons of exceptionally high water, the low marshy plain separating them from the main lake, and from one another, is flooded, and they become re-united. Lake Claire is the largest of the group, being from ten to fifteen miles wide, and from twenty-five to thirty miles in length. The northern part of this lake has not yet been surveyed.

Agriculture.

The agricultural capabilities of portions of the Peace-Athabasca district are promising, but have not yet been thoroughly tested. Vegetables of various kinds are grown yearly without difficulty, at Fort Vermilion, Lesser Slave Lake, Whitefish Lake and Trout Lake, while potatoes are grown by Indians even on the summit of Birch Mountain, at a height of 2,300 feet above the sea. Wheat and other cereals have been fairly successful at Lesser Slave Lake and at Fort Vermilion, the only places where they have been tried. The prairie country around Fort Vermilion equals in fertility the famous Edmonton district and appears to enjoy an equally good climate, its higher latitude being compensated for by its more western situation, and by its lower elevation. This district is about 1,000 feet above the sea. In the interior, narrow strips of aspen-covered, but excellent land are usually found along the main rivers, and surrounding many of the lakes; and numerous areas, often equal in size to eastern counties, might be selected, which appear well adapted for cultivation, but the numerous swamps, muskegs and marshes, which separate these areas, detract greatly from their value. The western, and especially the north-western, portion of this district contains the most promising agricultural lands.

DESCRIPTION OF ROUTES.

Canoe traverse from the Athabasca River to Peace River by way of the Pelican, Wabiscaw and Loon Rivers.

Canoe traverse
from the Atha-
basca to the
Peace.

The field season of 1888 was commenced by making a canoe traverse across the unexplored country lying between Peace River and the Athabasca, by way of the Pelican, Wabiscaw and Loon rivers. The

length of this traverse from the mouth of the Pelican to the mouth of the Loon, is about 200 miles, measured in a straight line, but the distance actually travelled, following the winding courses of the various streams, amounted to nearly 400 miles, and occupied altogether about three weeks. Two portages, one of three miles and the other of two miles, occur on the route, and great care had to be exercised in descending the unknown Wabiscaw River with its numerous rapids, but with these exceptions, no especial difficulties were encountered. Portages.

The Pelican River empties into the Athabasca about 102 miles below Athabasca Landing. Its length, from its source in Pelican Lake to the Athabasca, is about twenty-seven miles, measured in a straight line, but fully twice this distance following the numerous windings of the stream. It has a total fall of 544 feet, the greater part of this descent occurring in the last five miles, where it breaks through the plateau down to the level of the Athabasca. The lower portion of the stream in which this rapid descent takes place is unnavigable, and the traverse began by making a disagreeable portage of three miles out of the valley of the Athabasca—which is here 350 feet deep—through aspen and spruce forests and across muskegs to a point on Pelican River above the rapids. Pelican River.

From the east end of the portage to Pelican Lake, Pelican River maintains a general westerly direction, it has an average width of fifty to sixty feet, its current, as a rule, is sluggish, but boulder bars forming short rapids occur frequently for the first ten miles, and occasionally all the way up.

It is exceedingly crooked, and in one place a portage of less than a mile, saved a detour reported to be ten or twelve miles.

The principal tributaries of Pelican River are: Muskeg River, which enters it from the north, and is fully equal in size to the main stream; and Crooked Neck River and Long Lake Creek, which join it from the south. The country adjoining the Pelican River is low and generally wooded, chiefly with spruce and aspen, but in places the river winds through wide marshy flats covered with wild hay. The flat country extends southward to Pelican Mountain, a wooded ridge which can be seen from several points along the river, and which is said to extend westward to Marten Mountain, at the east end of Lesser Slave Lake.

The channel of Pelican River above the portage is only a few feet deep, and affords no geological sections, seldom even cutting down to the boulder clay. The small amount of erosion

performed by this stream evidences an origin subsequent to the Glacial period.

Pelican Lake. Pelican Lake, the head of Pelican River, is a small lake about four miles in length and one to two miles in width, it is very shallow, and its water has the usual brownish colour of water issuing from muskegs. Its shores are low, and it is surrounded by shelving sandy and gravelly beaches.

Pelican Lake, like the majority of lakes in this district, occupies a shallow depression in the boulder clay and associated drift deposits, and has no connection in any way with the pre-glacial features of the country.

After crossing Pelican Lake, the traverse led up Beaver Creek, a small stream, in places, scarcely large enough to turn the canoe.

Beaver Creek. Beaver Creek was followed in a westerly direction for two miles, and as the stream then turned to the south, we left it, and made a portage of two miles across the watershed, between the Athabasca and Peace rivers, to Sandy Lake, one of the sources of Loon River.

Sandy Lake. Sandy Lake is rounded in outline, with a diameter of four to five miles, it is deeper than Pelican Lake, and its waters are clearer. Its height above the sea is 1,910 feet. Its shores are low, and like Pelican Lake, it occupies a hollow in the drift. Sandy Lake drains westward by Sandy Lake Creek into Wabiscaw Lake. Sandy Lake Creek is a stream of from fifty to seventy feet wide, and its length, measured in a straight line, is eleven miles. About half way down, it expands into a small lake, and two miles further on falls over the Devil's Rapids, where it makes a descent of about fifty feet. A portage of about a mile in length leads past the rapids, but they are not dangerous. The country bordering Sandy Lake Creek is generally wooded, but opposite the rapids a large space has been cleared by fires, originating from the camping places at the ends of the portage, and now forms a typical prairie. At the Devil's Rapids, Sandy Lake Creek develops a small valley, but no rocks are exposed. In the greater part of its course its bed is only a few feet below the general surface of the country.

Wabiscaw lakes.

At the head of the Wabiscaw River, are the two Wabiscaw lakes. The upper lake is about six miles long, and from two to three wide; its water is shallow and is filled with small algæ, probably belonging to the genus *Aphanizomenon*. South of the lake, the flat or slightly rolling plain, wooded with aspen and spruce, which characterize the region, is terminated at a distance of twelve to fifteen miles by a range of low hills, connecting Pelican and Marten mountains. In other directions no high land is visible.

The stream connecting the two Wabiscaw lakes is about three miles in length and winds sluggishly through a marshy flat covered with wild hay.

The lower Wabiscaw Lake is about eight miles long with an average width of three miles. It is deeper than the upper lake, and its water is clearer. Boulder clay is exposed in two places along its eastern shores, but no outcrops of the older rocks were seen. Numerous boulders occur along the beach in places. These consist principally of Archæan gneisses, but others of sandstone and limestone are not uncommon. Boulder clay outcrops.

The Wabiscaw lakes are drained by the Wabiscaw River, which, with its continuation, Loon River, is the most important stream in the district examined; it has a course of 290 miles and drains an area of about 14,200 square miles. The principal tributaries are Bear, Trout, House and Loon rivers, which join it from the west, and Wood Buffalo, Pine and Panny rivers, which enter it from the east. Most of these streams have their sources in lakes, but they have not yet been explored. Tributaries of Loon River.

The Wabiscaw River, after leaving Wabiscaw Lake, runs in a south-easterly direction to Pine River, a distance of about forty-seven miles, in a straight line; its width varies from 75 to 120 yards; for some miles from its head the current is sluggish and the channel of the stream is encumbered by numerous gneissic boulders, through which we had some difficulty in finding a passage. Twelve miles from the lake, Bear River joins the Wabiscaw from the west, and is almost equal to the latter in size. It heads in Bear Lake, but is continued under the name of Whitefish River to Whitefish Lake, and has only been partially explored. Above the junction of Bear River with the Wabiscaw, the latter is interrupted by a series of short rapids, but after passing these it is easily navigable for many miles. At the rapids the river cuts through a small ridge, and a valley about fifty feet deep is developed, while above and below the banks disappear, and the bed of the river is only a few feet below the general level. The adjacent country is all well wooded, chiefly with aspen, interspersed with groves of spruce. Five miles below Bear River, Trout River comes in from the same side. This stream is about sixty feet wide and originates from the Trout lakes. Below Trout River the Wabiscaw is easily navigable, the current averaging about two miles an hour, and is uniform in appearance until near Wood Buffalo River; at this point the slope of the stream increases and rapids occur at the extremities of all the bends. Wabiscaw River.
Character of adjacent country.

Current of
rivers.

Channel
changed.

Navigation.

Valley
deepens.

Grand Rapids

Loon River.

From Wood Buffalo, to House River the current of the Wabiscaw is generally rapid, and stretches of rough water occur frequently. Two miles above House River a recent change in the course of the stream was noticed. Here the river, apparently within the last few years, has broken through the tongue of land separating two of the bends, and rushes with great velocity between the high boulder-clay banks of the narrow gap thus formed. The old channel is now quite dry for about two miles. Below House River the Wabiscaw winds for some miles through a flat, swampy region; further on it straightens out and runs with a swifter current through a somewhat higher region. Here a valley from fifty to sixty feet deep is gradually developed, but disappears again before reaching Pine River. From Pine River the Wabiscaw bends more to the west and runs in a general north-westerly direction towards the Buffalo Head Hills. Between Pine River and Two Lakes Creek, canoe navigation is comparatively easy, although a few small rapids occur about half way down. The average width of the stream is about 100 yards, and the current runs at a rate of from two to four miles an hour.

Two large tributaries come in from the north, the names of which I could not learn. Descending the Wabiscaw, its valley gradually deepens and at the mouth of Two Lakes Creek, it is 350 feet deep. The banks are generally wooded, chiefly with aspen, mingled in places with spruce. Twelve miles below Two Lakes Creek the Wabiscaw falls over the Grand Rapids, so-called, although they are not very formidable. These rapids are about a mile in length and consist of three distinct rapids; the upper two were run without trouble by keeping close to the left bank, but the lower one is shallower and crowded with boulders, and we were obliged to cross to the right hand and let the canoe down with a rope; at high water no trouble would be experienced in shooting the whole rapid. Nine miles below the Grand Rapids, Panny River, one of the largest tributaries of the Wabiscaw comes in from the east. This stream is about 100 feet wide, and is reported to head in Chippewyan Lake, but it has not been explored. A few miles lower down, Loon River joins it from the west and thence gives its name to the main stream. Loon River heads in Loon Lake, which is described on a succeeding page. Loon River is much smaller than the Wabiscaw, enters the latter at right angles, and has no geographical right whatever to give its name to the common stream. From the junction of the Wabiscaw and the Loon rivers, to Muddy River, a distance of about thirty miles in a straight line, Loon River has a current of about three miles an hour and is almost free from rapids. The valley is about 250 feet deep, and with its steep grassy and wooded banks often presents a very picturesque appearance.

Muddy River is about sixty feet wide ; it drains part of the Buffalo Head Hills, and its waters are usually discoloured by sediment, derived from the waste of the shales of which these hills are composed. Muddy River.

Below Muddy River, Loon River skirts the base of the Buffalo Head Hills for some miles, and appears to cut through their lower slopes, as the valley acquires an increased depth and assumes for some distance the appearance of a cañon. In this reach, steep banks often exceeding 400 feet in height, cut out of the dark Cretaceous shales, narrowly inclose the river. The current of the river is also swifter than usual, and strong, but easily-run rapids are numerous. The valley of the Loon River maintains its narrow gorge-like character for about fifteen miles, but before reaching Bat River the elevation of the country through which it cuts is suddenly lowered, the valley becomes shallower and wider, and the naked scarps are replaced to a large extent by woody and grassy slopes. Below Bat River the Loon River becomes very tortuous and continues so all the way to Peace River. The river flats become large and are occasionally partly open, in some cases giving evidence of having been cleared by ice. A few miles above its junction with Peace River the current of Loon River decreases to two miles an hour, the valley disappears, and the width of the stream increases to about 150 yards. Two miles above its mouth it receives Bear River, a small muddy stream coming from the direction of the Buffalo Head Hills. Narrow valley
Current lessens.

The Loon-Wabiscaw River might possibly be navigated, by powerful steamers, as far as the Grand Rapids, during the season of high water, and by using the line occasionally, but with the exception of a few miles of still water above its mouth, it can hardly be considered a navigable stream.

Peace River.

Peace River is formed by the junction of the Finlay and Parsnip rivers, two transmontane streams, and is the largest and longest of the tributaries of the Mackenzie. It rises in, and drains a large district west of the Rocky Mountains, and then continuing eastwards, intersects the axis of that range, and drains the country lying along its eastern slopes, through four degrees of latitude. Its length, from the confluence of the Finlay and Parsnip rivers, to the point at which it unites with the waters flowing from Lake Athabasca to form Slave River is 757 miles, but measuring from Summit Lake, the source of its principal branch, it is approximately 905 miles. Peace River.
Length of Peace River.

Peace River forms the eastern boundary of the region embraced in this report, and was examined from the Smoky River Forks to the mouth of Red River, a distance of 311 miles.

Between Smoky River Forks and the mouth of Battle River, a distance of 108 miles, the general course of Peace River is northerly. Its average width in this distance is about 400 yards, but it occasionally expands to nearly twice this size. The current has a uniform rate of about four miles an hour. The valley is deep, and in places presents a very picturesque appearance. It is about two miles wide, and at the mouth of Smoky River the water is not less than 700 feet below the level of the plateau. Going northward the valley becomes gradually shallower, and at Battle River its bottom is only 600 feet below the plateau. The banks are often scarped, and where composed of sandstone are precipitous.

Valley of
Peace River.

Traverse to
Wabiscaw
River.

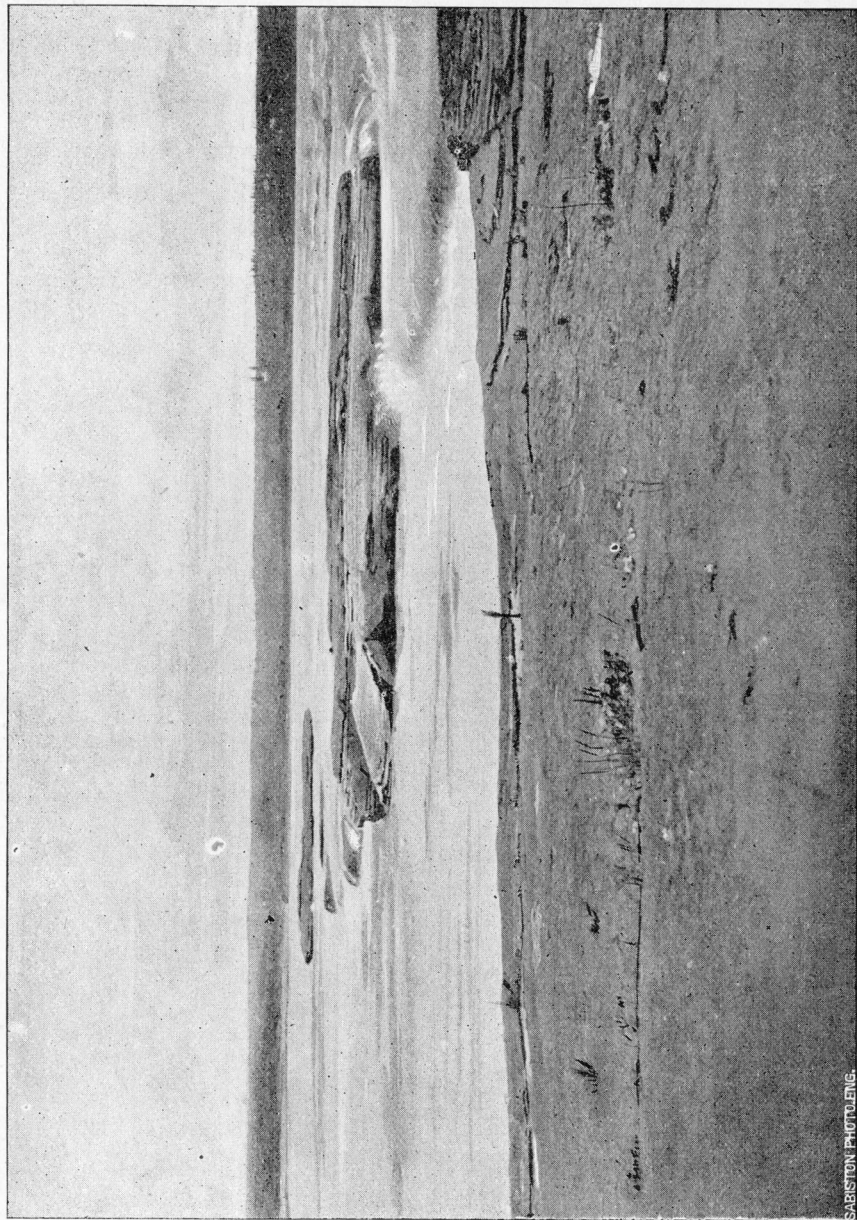
A short traverse was made on foot from a point about three miles above Battle River eastward to Wolverine River, and up that stream for some distance. After climbing out of the valley of Peace River, which is here 600 feet deep, we passed through a spruce, aspen, and Banksian pine forest, about a mile wide, and then entered a rolling country partially cleared by forest fires. Beyond this, all the way to Wolverine River, the trail crosses a succession of wide muskegs, sandy ridges, covered with Banksian pine, and loamy ridges, covered with aspen. Wolverine River, where we reached it, is a small sluggish stream about thirty feet wide. Its valley is about fifty feet wide, but the banks are not scarped, and no exposures were seen. We followed it up for about ten miles through small prairies, aspen woods and muskegs, and then, finding that it afforded no geological information, or prospect of any, we returned.

Uniform ap-
pearance of
river.

Below Battle River, to the Vermilion Falls and rapids, a distance of nearly 200 miles, Peace River is rather monotonous and the current is less rapid, having a uniform rate of about three miles an hour. The valley decreases in depth to about 100 feet, and the sandstone cliffs, which lend variety to the upper stretches of the river, disappear, and are replaced by grassy and wooded slopes, or by the sombre clay shales of the Cretaceous. Islands become more numerous, and the bars gradually change from gravel to sand.

Traverse to
Buffalo Head
Hills.

From Fort Vermilion, one of the establishments of the Hudson's Bay Company, 152 miles below Battle River, a traverse of about forty miles was made inland to the Buffalo Head Hills. For the first ten or twelve miles the trail led across a partially wooded and fertile prairie, and then through marshes, alternating with wooded ridges to Buffalo Lake, a small sheet of water from two to three miles long, and about



SABISTON PHOTOENG.

R. G. McConnell, Photo., July, 1889.

VERMILION FALLS, PEACE RIVER.

a mile wide. Buffalo Lake is bordered by extensive meadow lands, covered with luxuriant grass. After leaving it, we passed through an aspen wood, crossed two small streams flowing into Bear River, and then for some miles, travelled through a belt of partly wooded, partly open country, which lies at the foot of the Buffalo Head Hills. The greater part of the land just described, is well fitted for settlement.

The Buffalo Head Hills are about fifty miles long, and from twenty-five to thirty miles wide, with a height of 2,500 feet above the sea. The northern and north-eastern escarpments are the boldest, and rise to a height of 1,000 feet above the plains at their base. To the southward, the relative elevation gradually decreases, and the hills appear to die away opposite Black River. The summit, so far as observed, is a level, slightly-rolling plain densely wooded with aspen and spruce.

Below Fort Vermilion, Peace River runs in an easterly direction for forty-six miles to the Vermilion Falls and Rapids. Vermilion Falls, like the Cascade Rapids on the Athabasca, are caused by the river falling over a low limestone ledge. The height of the falls varies according to the volume of water. At low water they are from fifteen to twenty feet high, while at high water, they become greatly reduced, and on one occasion were descended in safety by a York boat. Peace River at this point is nearly a mile wide; the falls are not continuous all the way across, but are interrupted at several points by the higher portions of the limestone ledge. A mile above the falls a strong rapid occurs, a third of a mile in length, and these two obstructions constitute the only serious break in the navigation of Peace River for hundreds of miles.

Peace River was not examined below Vermilion Falls. In its lower stretches the river averages nearly a mile in width, the current is gentle and uniform and the valley almost disappears. A small rapid occurs at one point, but does not obstruct navigation except during low water.

Red River.

In the district reported on there are two Red rivers, one draining into Peace River and the other into the Athabasca. Both head in lakes situated within a few miles of each other on the Birch Mountains, and the Indians frequently carry their canoes from one stream to the other. The westward-flowing Red River empties into Peace River five miles below the Vermilion Falls. It is about 240 miles long, and averages about 200 to 250 feet in width. Its name is derived

Buffalo Head
Hills.

Vermilion
Falls.

Peace River
below Ver-
milion Falls.

Two Red
rivers head-
ing in Birch
Mountains.

from the reddish-brown colour of its waters. It was ascended for about 100 miles, measuring in three stretches along the river, but for fully 160 miles following the tortuous course of the stream.

Description of
Red River.

From its mouth, to Owl River (Oho sipi), a distance of fifty miles, measured in a straight line, Red River follows a general direction a little west of south. For some miles above its mouth it is confined by low limestone cliffs, and the current is swift, with occasional rapids. Further up, the limestone banks disappear, and the river winds for many miles between low boulder-clay, and mud banks, through a flat, wooded and monotonous country. Thirty miles above its mouth, rapids commence again, and extend for several miles, and a valley about 100 feet deep is developed. The plateau adjoining the river has been burnt over in places, and small prairie patches appear occasionally. Near the head of the rapids, the river has recently broken through the neck of one of the bends, and the water, pouring with great velocity through the new and much shortened channel, strikes the opposite bank with great force; a part of it is deflected up the old channel, and passing completely round the bend, a distance of about a mile, falls into the river again above the break. The curious feature is here presented of

Course of
river reversed.

a river reversing its course for a considerable distance. This, of course, only happens when the river is flooded. Above the rapids the current gradually diminishes, the valley disappears, and the river continues to be easily navigable as far as Owl River; above Owl River, a small stream, fifteen to twenty feet wide, enters Red River from the left. At Owl River, Red River approaches to within a few miles of the Wabiscaw, and, the Buffalo Head Hills, which are situated on the further side of the latter stream, are plainly visible at an estimated distance of ten to fifteen miles. Above Owl River, Red River bends almost at right angles to its former course and runs in a direction a little south of east to the Birch Mountains. A few miles above Owl River, rapids commence again, and short stretches of rough water occur frequently for fifteen or twenty miles, above which they disappear and the current remains uniform as far as Burnt River. Burnt River is a stream about forty feet wide and is the first large tributary of the Red River. Its water is dark and is evidently derived from the numerous muskegs of the region. Above Burnt River, small rapids reappear and increase in frequency until the river becomes one continuous and wild rapid; and, as a walk of eight or ten miles up the valley showed the rapids to continue for that distance at least, it was decided to return, as our supplies were almost exhausted. In these rapids Red River has a fall of fully 250 feet over the western face of a gradual rise in the general elevation of the region. A view

Burnt River.

Long rapids.

from the summit showed a range of hills in a direction which I took to be the Birch Mountains. From the foot of the long rapids, we descended to Peace River, easily in four days, although the ascent had cost us ten long days of hard labour.

Red River is not a navigable stream and can only be ascended, even in canoes, during high water. It is, however, quickly affected by rains, and the showery weather which we experienced while on it, kept it in a fairly high stage and enabled us to proceed. Like most of the streams in the district its valley is insignificant and affords little geological information.

Navigation of
Red River.

Lesser Slave Lake.

Lesser Slave Lake is a long and comparatively narrow sheet of water, extending in an east and west direction along the southern border of the region already described. It is sixty-one miles long, has an average width of eight miles, a maximum width of twelve miles, and covers altogether an area of 484 square miles. Lesser Slave Lake, notwithstanding its size, is very shallow, seldom exceeding ten feet in depth in low water, and over a large part of its area is much less. The deepest part of the lake lies to the east of the narrows, south-west of Marten Mountain. The north shore of the lake is fairly regular in outline, with stony and sandy beaches, while low bluffs of boulder clay and Cretaceous shales occur occasionally. The southern shore is nearly everywhere marshy, and affords no exposures. A series of plateaus from 800 to 1,000 feet high, of Laramie sandstone and shale, runs parallel with the southern shore at a distance of eight to ten miles, but decreases in height westward, and terminates in a low ridge running round the bay, which forms the western end of the lake. Along the northern side, the land slopes up from the shore to a height of 150 feet, but after passing Marten Mountain going eastward, it suddenly rises to a height of about 1,000 feet, forming the elevation known as Marten Mountain. This range of hills follows the north-eastern shore of the lake for some distance, and then stretches eastward to Pelican Mountain. No exposures were found on it, but it is evidently a continuation northward of the Laramie plateaus south of the lake.

Description of
Lesser Slave
Lake.

Marshes covered with wild hay occur along the southern and western shores of Lesser Slave Lake, and a small prairie has been cleared by forest fires, north of the west end of the lake, but the country generally is covered with the same monotonous spruce and aspen forest which characterizes the whole northern region.

Forests.

The principal streams flowing into Lesser Slave Lake, are, from the west, Heart River; from the north, Salt Creek, the Narrows River

and Marten River ; and from the south, Swan River and two smaller streams, the names of which I did not ascertain. The outlet is from the eastern end, by Little Slave Lake River into the Athabasca. All of the streams emptying into Lesser Slave Lake are insignificant in size and can only be navigated in high water with small canoes. An attempt was made in September to ascend Marten River, which skirts the western base of Marten Mountain for some distance, but this was found to be impossible owing to the numerous piles of driftwood which blocked the river every few hundred yards. Heart River is reported to be navigable for a considerable distance, and by ascending it, and portaging for two miles, to a chain of lakes, canoes can be taken to Whitefish Lake.

Traverse from Lesser Slave Lake to the Wabiscaw River by Whitefish Lake, Bear Lake and Trout Lake.

Country between Lesser Slave Lake and Whitefish Lake.

The trail to Whitefish Lake leaves Lesser Slave Lake at the crossing of Salt Creek near its mouth, and runs in a general north-easterly direction. The distance in a straight line is twenty-eight miles. After leaving Lesser Slave Lake the trail leads across a hay-covered flat, only slightly raised above the lake, and then following up Salt Creek mounts the plateau which is here about 200 feet high and passes for some miles through a rolling well-grassed prairie, the evident product of forest fires. Ten miles from the lake, the limit of the open country is reached, and the trail enters the forest, and then winds along the dry wooded ridges which separate the numerous muskegs and beaver meadows with which the country abounds. Horse Creek, a small stream probably tributary to Heart River, is bordered by two miles of open country, after passing which the trail leads through an aspen forest nearly all the way to Whitefish Lake.

Whitefish Lake.

Whitefish Lake is from ten to twelve miles long, and four to six miles wide. Its shores are low and featureless, and it is surrounded on all sides by an aspen-covered country, which, if cleared would afford excellent farming land. It drains northwards by Whitefish River into Bear Lake, and thence into the Wabiscaw. It is 2,075 feet above the sea level. At its western end it is connected with a smaller lake by a sluggish stream two miles in length, on which is situated a small trading post belonging to the Hudson's Bay Company. A small clearing has been made in the vicinity of the post, and some potatoes and other garden produce are annually grown, but the inhabitants depend for their subsistence, principally on the whitefish with which the lake abounds, and from which it has taken its name.

From Whitefish Lake the trail to Trout Lake leads for some miles through an aspen forest, where the travelling is fairly good, and then crosses a succession of sphagnum-filled hollows, alternating with wooded ridges to Swampberry Creek (Wi-si-ki-ni-mi-ni Si-pi). This stream is about twenty feet wide and flows through a wide valley with sloping wooded banks. It afforded no exposures. It was crossed shortly after reaching it and we followed down its left side through numerous muskegs and marshes until it emptied into a lake of the same name. Swampberry Creek.

At Swampberry Lake the writer separated from the pack train, which was sent on to Trout Lake, and made a canoe traverse to Bear Lake. Canoe traverse to Bear Lake. Swampberry Lake is a shallow sheet of water about four miles long and one mile wide, and is surrounded by low marshy shores and spruce-covered flats. Its outlet, a small weedy stream from fifteen to thirty feet wide, empties, after a short course, into Whitefish River, the outlet of Whitefish Lake. This stream is about thirty feet wide. It has low banks overhung on both sides by willows, and flows at the rate of two to three miles an hour. No rapids were found on it, but it is occasionally blocked with piles of drift wood making portages necessary. It is extremely crooked, and at one point, a great bend, said to take nearly a day to go round, was avoided by making a short portage to a small lake. This was crossed, and its shallow and weedy outlet descended to Whitefish River, the whole traverse occupying about an hour. Below the portage, Whitefish River is from fifty to sixty feet wide, and winds for a number of miles through wide marshy meadows, in the middle of which it receives Shoal River, a small stream about twenty feet wide. Below Shoal River a ridge is crossed, the banks become higher, and the tamarack and willow are replaced by an aspen forest. A second wide marsh then appears, followed by a ridge, through which the banks are thirty feet high and show boulder clay in one or two places, but nothing older was seen. Beyond the ridge the bordering flats again become marshy and continue so until Bear Lake is reached.

Bear Lake receives two other small streams, besides Whitefish River Bear Lake. which we descended. It empties into Bear River which flows into the Wabiscaw twelve miles below Lake Wabiscaw. It is four to five miles long and about two miles wide, and, like the other lakes of the district, occupies a shallow basin in the drift. A low ridge skirts its eastern shores and a second ridge running south-eastward terminates in a rounded wooded hill near its outlet, and may afford exposures where cut by the river, but I was unable to visit it.

Trail from
Bear Lake to
Trout Lake.

From the mouth of Whitefish River we crossed to the northern end of the lake, then *caching* the canoe, set out on foot for Trout Lake. The trail led almost due north, through an aspen forest, with occasional swamps and muskegs. Nine miles from the lake we came to a small stream flowing eastward, and shortly afterwards to Trout River, which we followed up for two miles, and then crossed. Trout River empties the waters of Trout Lake into the Wabiscaw. It is a shallow but rapid stream about seventy feet wide, and has much clearer water than other rivers of the district. It skirts for some distance, and partly cuts through, the elevation known as Trout Mountain. Its valley showed no sections, and the loose rocks in its bed were exclusively Archæan, and afforded no indications of exposures in its upper part. After crossing Trout River, the trail led to the summit of a ridge about 300 feet high, forming part of Trout Mountain, and then continued parallel with Trout River, to Mudpout Lake (Ni-ye Sâ-ga-hâ-gan), passing through deep muskegs and over sandy ridges covered with Banksian pine the greater part of the distance.

Mudpout
Lake.

Mudpout Lake is an expansion of Trout River, and is about three miles long by a mile wide. It is connected with Trout Lake by a short stream, two miles long, on which is situated a small trading post of the Hudson's Bay Company.

Trout Lake.

From the Hudson Bay post at Trout Lake, an exploratory trip was made northward to the Wabiscaw River, in order to connect with the traverse down that stream. A guide and canoes were obtained at the fort, as the way led through a chain of lakes connected with Trout Lake. Trout Lake is divided into two parts, by narrows half a mile in length. The lower lake is five to six miles long, and four to five miles wide at its widest part. The comparatively clear condition of the water, is due to the latter passing through a chain of lakes, and on the way, depositing its sediment; and is illustrated by the fact, that trout are obtained there in abundance. A wooded ridge follows the north-eastern shore of Trout Lake, and our guide stated that Manitou Lake lies behind this ridge. Strange tales are told of this lake by the Indians. Drums beaten by invisible hands have been heard by the awe-struck Indians; fires have been seen at night dancing over the surface of the water, and Indians have mysteriously disappeared, their canoes being afterwards found right side up and uninjured.

Manitou
Lake.

The upper Trout Lake is ten miles long, and at its upper end widens into a bay six to seven miles wide. It is connected by a small winding stream with Good Fish Lake, a small body of water about two miles long. After leaving Good Fish Lake we crossed Rush Lake, and followed a short stream a mile and a half long into

Long Lake, and thence into Round Lake, the head of the series. The stream connecting Long Lake and Round Lake is two miles in length, and is interrupted by a series of rapids, necessitating a portage of half a mile.

From Round Lake a portage of nearly a mile is made to Kidney Lake across the watershed separating Two Lakes Creek from Trout River. Kidney Lake is situated on nearly the highest point of Trout Mountain, and has an approximate elevation above the sea of 2,320 feet, or nearly the same as Birch Mountain. Two miles from Kidney Lake the trail reaches the edge of Trout Mountain, and a gradual descent of 320 feet is made. At the foot of this escarpment is Two Lakes, the source of Two Lakes Creek. Camped on the shore of this lake, I found a solitary Iroquois Indian the only representative of his tribe in the whole district. From Two Lakes a good trail led northward through alternating forest and muskeg to the Wabiscaw River, meeting the latter about a quarter of a mile below Two Lakes Creek. The valley of the Wabiscaw at this point is 350 feet deep, and the total descent from the top of Trout Mountain to the river is 820 feet. No sections of any kind were seen along the route examined.

After returning to Trout Lake, I accompanied the pack-train on the return journey to Lesser Slave Lake. For some miles from the Post at Trout Lake the country is of the most worthless description, wide muskegs alternating with sandy ridges covered with Banksian pine, and with occasional aspen-covered ridges. Five miles from Trout Lake we crossed a tributary of Trout River about thirty feet wide, winding between marshy flats in a valley about 100 feet deep, and seven miles further on came to Shoal River. From this point a side trip was made on foot to Loon Lake, the source of Loon River. An old trail, impassable for horses, owing to the numerous muskegs and marshes, but practicable on foot, was followed for a distance of about twenty-two miles, as far as Red Earth Creek, a tributary of Loon River. From Red Earth Creek we struck westward until we reached the Loon River, and then followed it up to the lake. Between the crossing of Shoal River and Loon Lake, muskeg and marsh alternate monotonously with pine and aspen ridges, and, with the exception of an aspen-covered strip along Loon River, very little country suitable for any purpose was seen.

Loon Lake proved to be much smaller than expected. It is about seven miles long, with an average breadth of about two miles. It is shallow, with low banks, and is situated in the midst of a low wooded and marshy district. The eastern shore is bordered by a wide marsh, the home of innumerable flocks of wild fowl. Loon Lake is much lower than Trout Lake, being only about 1,660 feet above the sea.

After rejoining the pack-train, we continued south-westward along the Trout Lake trail, wading for most of the distance through muskegs and marshes to Swampberry Lake, where I separated from the pack-train on the way north. From Swampberry Lake back to Lesser Slave Lake the same trail was followed as on the way out.

General description of country north of Lesser Slave Lake.

The country north of Lesser Slave Lake, bordering the Trout Lake trail, may be described, generally, as a lightly rolling plain, elevated about 2,000 feet above the sea, the surface of which consists of a network of low ridges, wooded with aspen, spruce and Banksian pine, separated by muskegs, marshes, beaver meadows and shallow lakes, some of which are ten or twelve miles long. The streams are small and have little excavating power, seldom cutting through the drift to the rocks beneath, and consequently affording little geological information.

Athabasca River.

Athabasca River.

The Athabasca is the most southerly of the three great tributaries of the Mackenzie. It rises in the summit ranges of the Rocky Mountains between latitude 52° N. and longitude 54° N., and after a northeasterly and northerly course of 776 miles empties into Lake Athabasca. From thence, its waters are conveyed by Slave River to Great Slave Lake, and thence by the Mackenzie to the sea.

Portion examined.

The Athabasca was examined in the course of the present exploration, from its junction with Little Slave River to its mouth, a distance of 456 miles. Between Little Slave River and Athabasca Landing, a distance of 66 miles, the course of the Athabasca River is at first easterly and then southerly. Its width averages about 250 yards, and it occupies a valley 350 feet deep and about two miles wide. The current has a fairly uniform rate of three to four miles an hour, and the river is easily navigable.

At Athabasca Landing, which is the terminus of the cart trail from Edmonton, the goods required in the fur trade are shipped northward and westward by steamers and York boats, to the Peace, Athabasca, and Mackenzie River districts.

Rapids.

From Athabasca Landing to the Grand Rapids, a distance of 153 miles, the general course of the river is northerly, its width varies from 250 yards to 400 yards, and the current, except for occasional accelerations, is fairly steady at three to four miles an hour as far as the mouth of the Pelican River. Between Pelican River and the Grand Rapids, three rapids occur, viz., Pelican and Stony Rapids, and the Rapide du Joli Fou, so called on account of an unskilful steersman running his boat against the most conspicuous rock in the channel.

These rapids obstruct the navigation of the river in low water, but at medium or high water they are easily ascended and descended by the steamer plying between Athabasca Landing and the Grand Rapids. The river valley in this stretch is 300 to 400 feet deep, and the banks consist of a succession of slides due to the plastic character of the clay shales through which it is cut. The grade of the Athabasca River between the mouth of Little Slave River and the head of the Grand Rapids amounts to 2.72 feet per mile, the total fall being 596 feet. Valley.

At the Grand Rapids, the character of the Athabasca River entirely changes, its grade becomes greatly increased, and for the next seventy-six miles, or as far as its junction with Clearwater River, there are swift and dangerous rapids every few miles. At the Grand Rapids the river falls between fifty and sixty feet in about half a mile. Change at Grand Rapids.

The rapids are caused by the river meeting and cutting through a soft sandstone terrane of the Cretaceous. This sandstone is filled with hard spherical concretions which become gradually liberated as the matrix is slowly worn away. The concretions, some of which are six to eight feet or more in diameter, now pave the channel of the river, and the water in its swift descent, breaks over them in a tumult of waves and foam. The Grand Rapids are unnavigable by craft of any kind. There is a small island about a quarter of a mile long opposite the worst part of the rapids; boats are brought down to the head of the island and their contents portaged across by means of a short tramway which has been built by the Hudson's Bay Company. Grand Rapids.

From the foot of the island, the river is again navigable, but it continues rough for two or three miles. After passing the Grand Rapids, and the rough water below them, the Athabasca runs smoothly for over twenty miles, and then rushes down the Burnt Rapids. In this stretch the valley is deep and gorge-like. The banks are from 500 to 600 feet high and are often terraced by differential denudation. At the Burnt Rapids the river is shallow and filled with boulders, but the fall is not so great as at the Grand Rapids, and we had no difficulty in descending them. Deep valley.

The canoe channel follows the left bank. The Burnt Rapids are followed by sixteen miles of smooth water, below which the river falls in quick succession over the Boiler, Middle and Long Rapids, all of which occur within a stretch of seven miles. These three rapids are similar in character to the Burnt Rapids, and owe their existence to a steeper declination than usual, combined with an accumulation of boulders in the channel of the river. They are all navigable at ordinary stages of the water, both with canoes and York boats. Burnt Rapids.

Five miles below Long Rapids the river makes a sharp bend, at

the extremity of which is Crooked Rapid, where two ledges of limestone project into the stream from the right side, but no trouble was experienced in running down close to the left bank. Below Crooked Rapid the river falls over several limestone ledges, forming Rock Rapids and the Little and Big Cascades. Small falls extending partly across the river occur at these points, but the ledges are broken down in places enabling boats to get through. Below the Cascades the river is unobstructed for eight or nine miles to Mountain Rapid. This rapid, like the Cascades, is formed by the river flowing over a low limestone ledge. A short portage was made here, but at certain stages of the water, a channel navigable by small boats exists near the centre of the river where the ledge has been worn down. Mountain Rapid is the last dangerous rapid on the river. Two miles above the Forks, Moberly Rapid was passed, but the fall there is slight.

Crooked
Rapid and
Cascades.

Grade of river.

The fall of the Athabasca, between the head of the Grand Rapids and the Clearwater confluence, a distance of seventy-six miles, amounts to 360 feet, an average of 4.7 feet per mile.

Athabasca
River below
the Clear-
water.

Below the confluence of the Clearwater River the character of the Athabasca entirely changes, the rapids disappear, and the river, enlarged to a third of a mile in width, flows smoothly at an average rate of three miles an hour. The valley increases in width and the banks gradually decrease from an elevation of about 400 feet at the Forks to the level of the delta. In passing through the delta the channel divides in several branches, and new channels are constantly being opened and old ones closed by the spring floods. From the Forks to the head of the delta, a distance of 130 miles, and thence to Athabasca Lake, a further distance of thirty-one miles, the Athabasca offers no obstruction to navigation. The steamer "Grahame," owned by the Hudson's Bay Company, has been plying on this portion of the river for some years.

*Traverse from the Athabasca to Moose Lake, Birch Mountains, and
return by Moose River.*

Trail to Moose
Lake.

The trail to Moose Lake leaves the Athabasca River about a mile below the mouth of Red River, and follows the valley of the latter for about five miles. At this point Red River bends away to the south, and the trail continues a little north of west across a wide muskeg to Moose River, which it crosses. At the crossing, Moose River is a rapid stream 100 feet wide, in a valley about eighty feet deep, the banks of which are formed of tar sands capped with dark shales.

From Moose River the direction of the trail is a few degrees north of west to the foot of Birch Mountain, a distance of about twelve miles. This district is slightly undulating, with a number of muskegs and marshes in the depressions, and is wooded chiefly with small aspen, spruce and Banksian pine.

The eastern escarpment of Birch Mountain, where the Moose Lake trail crosses it, is about 500 feet high, the ascent is easy, and is made in about two miles. From the brow of the escarpment the surface slopes gradually upward towards the centre of the plateau, where it is about 2,300 feet above the sea, or about 1,500 above the level of the Athabasca. The surface of the Birch Mountain uplands is rolling and drift covered, and near the Moose Lake trail, is indented by a number of old valleys holding small streams and lakes, which are evidently pre-glacial in origin.

Birch Mountain.

The forest is similar in character to that covering the plains beneath, but has been largely destroyed by fires.

Moose Lake, the objective point of the traverse, is situated about twenty miles from the edge of the mountain, and occupies a wide depression about 300 feet below the level of the plateau. It is a shallow lake, about two miles long, and is separated into two parts by narrows, on the right side of which are two small huts, used at times by the Hudson's Bay Company as a trading post. It receives from the south, by a short stream, the waters of Buffalo Lake, which is seven to eight miles long and two to three miles wide, and northward is said to be connected by a series of small streams with a chain of five lakes.

Moose Lake.

The return journey from Moose Lake was made by water, in two small bark canoes, which we were fortunate enough to find on the lake.

Moose River, the outlet of Moose Lake, is sixty-five miles long, measured in two-mile stretches along its course, but following the bends it is fully 100 miles long. It has a total fall of 1,200 feet, or about twelve feet to the mile. Its grade is irregular, and its course is interrupted by several long and wild rapids.

Moose River.

After leaving Moose Lake, Moose River is wide and sluggish for two miles, and then its course is intercepted by a high ridge, in crossing which it contracts, and forms a rapid about a mile long.

Below the ridge it expands into a long shallow sheet of water known as Willow Lake, beyond which rapids continue until the river leaves the mountains. The fall in these rapids amounts to about 250 feet. From the foot of the mountains, the river winds gently along for fifteen or twenty miles, between low wooded banks. Between this reach and

Rapids.

the crossing of Moose River, three strong rapids, separated by short stretches of smooth water, were encountered. The rapids occur where the river cuts through the ridges which cross its course, and are always accompanied by a deepened valley. At the lower, or Big Rapids, the banks of the valley show the same nodular sandstone which outcrops at the Grand Rapids on the Athabasca, and the channel of the stream is encumbered by a multitude of nodules derived from this formation.

Canoes
abandoned.

Both canoes were repeatedly broken in descending the numerous rapids. One was abandoned at the foot of the mountain, while the other was left at Big Rapid, which is situated only a few miles from the trail crossing, and we returned to the Athabasca on foot over the same trail used in beginning the traverse.

Between the trail crossing and the Athabasca, Moose River is said to be full of rapids and to be unnavigable.

Muskeg River.

Muskeg
River.

Muskeg River enters the Athabasca from the east about thirty-one miles below the Forks. It was ascended for a distance of thirty miles. Like most of the other streams in the district, its lower part is unnavigable, and it is reached by making a portage from the Athabasca to a point on it, about three miles above its mouth. The portage track begins nearly opposite the mouth of Red River and is about a mile long. The general direction of the stream is north-easterly. For some miles above the head of the portage occasional exposures of limestone, capped in places with tar sands, occur in the banks, but further up, the valley disappears and the river winds through a low, marshy and worthless region. The stream here is about fifty feet wide and is blocked every few hundred yards with piles of drift wood and beaver dams. Before returning, a low wooded ridge running in a north and south direction between Muskeg River and the Athabasca was visited, but no exposures were found.

List of Elevations.

Elevations.

The following elevations were obtained by comparing the readings of two aneroids with the readings of the Standard mercurial barometers at Edmonton and Lake Athabasca. Heights obtained in this manner are necessarily only approximate :—

	Feet.
Athabasca River (at "Landing").....	1,650
" " (head of Grand Rapids).....	1,200
" " (at Clearwater Forks).....	840
" " (at mouth).....	690

	Feet.
Peace River (mouth of Smoky River).....	1,225
“ (mouth of Battle River).....	1,090
“ (Fort Vermilion).....	950
“ (mouth of Red River).....	870
Athabasca Lake.....	690
Lesser Slave Lake.....	1,890
Whitefish Lake.....	2,075
Trout Lake.....	2,130
Loon Lake.....	1,680
Lake Claire.....	700
Long Lake.....	2,269
Kidney Lake.....	2,320
Pelican Lake.....	1,910
Buffalo Lake (Birch Mountains).....	2,000
Wabiscaw Lake (Upper).....	1,720
“ “ (Lower).....	1,705
Wabiscaw River (mouth of Trout River)....	1,643
“ “ (mouth of Two Lakes Creek)....	1,484
“ “ (at junction with Peace River).....	920
Birch Mountains.....	2,300
Buffalo Head Hills.....	2,500
Marten Mountain.....	2,890
Trout Mountain.....	2,350
Plateau south of east end of Lesser Slave Lake..	3,090

The general elevation of the region decreases going northwards from 2,200 feet, the height of the plains south of Lesser Slave Lake, to 700 feet, the height of the lower part of the Peace-Athabasca delta. The rate of decrease averages 6·9 feet per mile.

Decrease in elevation to the north.

GEOLOGICAL SECTIONS.

Section on the Athabasca from the mouth of Little Slave River to Lake Athabasca.

From the mouth of Little Slave River to Pelican River the valley of the Athabasca is cut out of soft dark grayish or brownish shales (La Biche shales). These shales are usually rather coarsely laminated, are very plastic and when unsupported are easily affected by land-slips. They contain, besides the argillaceous material, nodules and small lenticular beds of limestone, numerous calcareous nodules, and occasionally thin beds of grayish and yellowish sandstone. Iron pyrites occurs in crystals and spherical crystalline aggregates scattered through the shales, and to its decomposition is doubtless in a large measure due the salts in the numerous mineral and chalybeate stream-lets which trickle down the faces of many of the escarpments and often

La Biche shales.

Iron pyrites.

Burnt shales. form small red pools at their bases. At one point, about twenty-four miles below the mouth of Lake la Biche River, the La Biche shales have been baked and reddened for about 100 yards along their strike by the combustion of the carbonaceous matter which they contain, but the fires are now extinct.

Exposures of La Biche shales. Exposures of the La Biche shales are infrequent in the valley of the Athabasca above the mouth of Lake La Biche River, but below that point the sections are often continuous for miles. Approaching Pelican River the banks again become wooded and the shales are only occasionally seen. The attitude of the shales is horizontal so far as observed, but owing to the concealment of the bedding by slides, and the washing down of the soft material from above, with the lack of any definite horizon traceable from point to point, small dips, if present, would be unrecognizable.

Fossils. Fossils although carefully searched for, proved to be extremely scarce. The following forms, all typical Pierre and Foxhill species, were found in an exposure about twenty-five miles above the "Athabasca Landing:"

Tancredia Americana, Meek and Hayden.

Pteria Nebrascana, Evans and Shumard.

Modiola, sp.

Lunatia concinna, Hall and Meek.

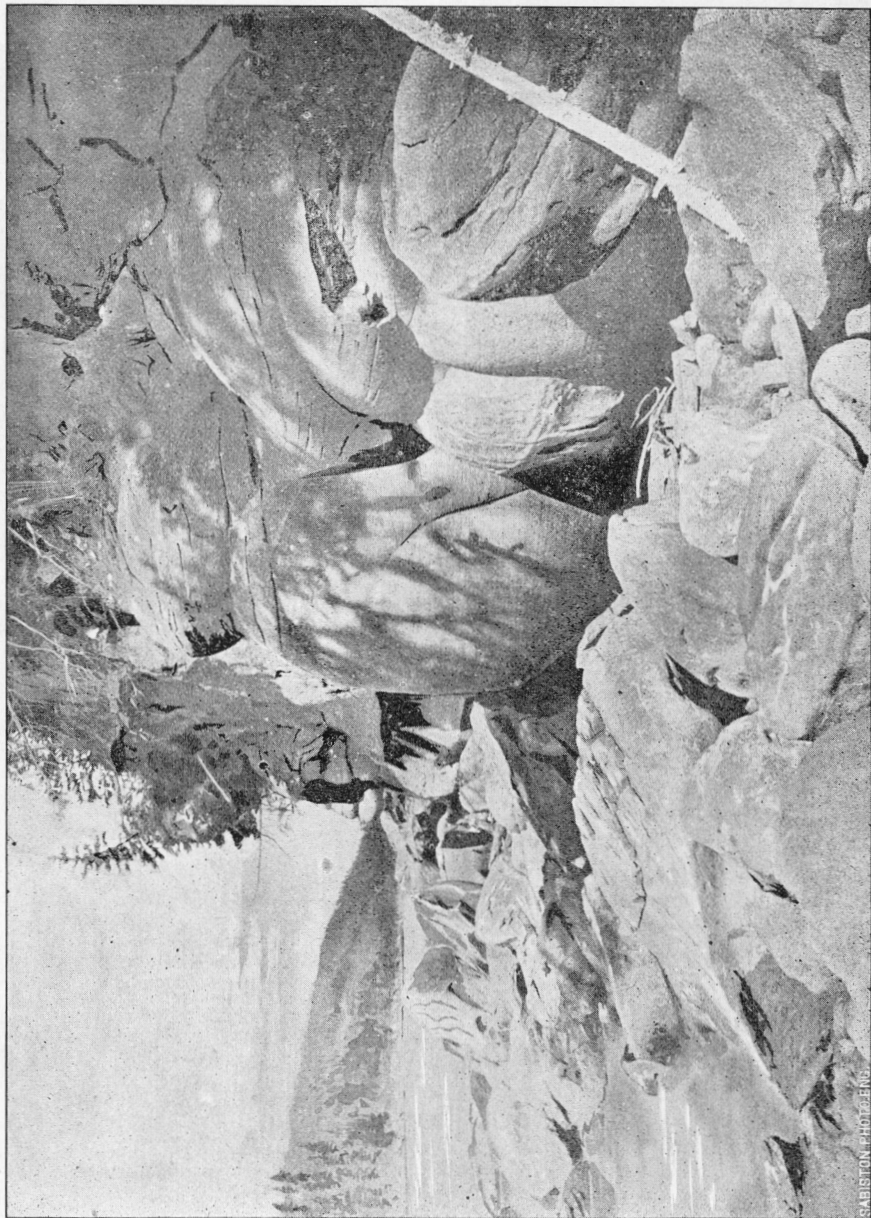
Baculites compressus.

Below the mouth of Lake La Biche River, fragments of *Baculites compressus* and *ovatus* and specimens of *Ostrea congesta*(?) were found in a number of places, and at Stony Rapids, a few miles below the mouth of the Pelican River, I was fortunate enough to find some large well-preserved specimens of *Acanthoceras Woolgari*, Mantell, and a large *Desmoceras* since described by Mr. Whiteaves as *D. Athabascense*.*

Age of lower part of La Biche shales. The two latter fossils occur at the base of the shales, and with *Ostrea congesta*, which is usually regarded as a characteristic fossil of the Niobrara, seems to show that the lower part of the La Biche shales are older than Pierre.

Pelican sandstone. At the mouth of Pelican River the shales are underlaid by a band of sandstone which for the sake of distinction may be called the Pelican sandstone. The Pelican sandstone has a slight dip to the south, of a few feet to the mile, and this added to the fall of the river, causes it to rise gradually in the banks of the valley. It is forty feet thick, and is usually conspicuously white, but is also tinged yellowish and brownish in places, by iron oxide. The lower beds as a rule are soft and crumbly, but towards the top, the granular constituents are cemented by iron, into a hard hemitiferous sandstone passing in

*Trans. Roy. Soc. of Can., vol. X., sec. iv.



SABISTON PHOTOGRAPH.

R. G. McConnell, Photo, August, 1890.

NODULES IN GRAND RAPIDS' SANDSTONE.
GRAND RAPIDS, ATHABASCA RIVER.

places into a quartzite. No fossils were obtained from the Pelican sandstone and its exact position in the Cretaceous series is therefore doubtful.

Underlying the Pelican sandstone is a shale formation, which, from its intimate relations with the former, may be called the Pelican shale. It makes its appearance a short distance below the mouth of the Pelican River, and is a conspicuous feature in the valley of the Athabasca for many miles. The Pelican shale varies in thickness from ninety to 100 feet, and is very uniform in composition throughout. It is slightly darker and harder than the Pierre shales, and weathers down into a *talus* of small flaky particles. No fossils were obtained from it.

The Pelican shale is underlaid, about half-way between Pelican River and House River, by a second sandstone formation, for which I propose the name of the Grand Rapids sandstone, as it is well developed at that point. The Grand Rapids sandstone is characteristically yellowish, but is also occasionally whitish, and is coarser-grained than the Pelican sandstone. It is remarkable for the large number of spherical siliceous concretions which it contains, and which range in size up to ten feet or more in diameter. It weathers into steep slopes and cliffs, the faces of which are often studded with the concretionary masses. Lignite seams, varying from a few inches to five feet in thickness occur at intervals through this formation. The following section was measured about ten miles above the mouth of House River. It is in descending order :—

Dark soft shales.....	100' +	La Biche shales.
Whitish and yellowish sandstone becoming ferruginous above.....	20'00'	Pelican sandstone.
Shales and sands.....	10'00'	
Sands and shaly partings.....	10'00'	
Dark shales.....	90'00'	Pelican shale.
Soft sandstone.....	4'00'	Upper portion of Grand Rapids sandstone.
Lignite	0'50'	
Soft grayish and yellowish sandstone..	15'00'	

249'50'

Twenty feet of Grand Rapids sandstone exposed at this point has been grooved horizontally by river ice. At the mouth of House River 150 feet of the Grand Rapids sandstone is exposed, about half its total thickness, above which comes the Pelican shale and sandstone, and about 130 feet of the La Biche shales. At the head of the Grand Rapids, about 200 feet of the Grand Rapids sandstone is exposed. The lower portion near here consists of about fifty feet of a soft yellowish almost homogeneous sandstone, packed thickly with nodules, and weathering into almost vertical cliffs. Resting on this is about 100 feet of alternating sandstone and shales, then

Section at House River.

Concretions.

Grand Rapids sandstone.

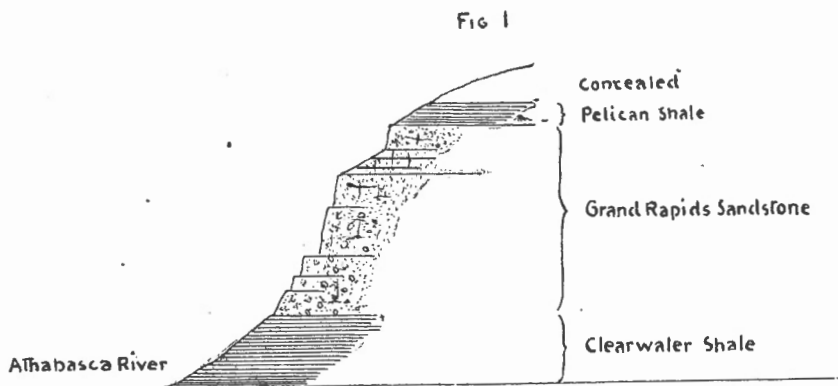
fifty feet of greyish and yellowish sandstone overlaid by a seam of lignite four to five feet thick, above which comes the flaky Pelican shale. Below the Grand Rapids, the Grand Rapids sandstone is exposed for several miles in continuous and almost vertical cliffs, on both sides of the river. Nodules occur throughout the formation, but are more abundant in the lower part, and seams of inferior lignite were noticed at several points. Some of the beds by the addition of small quartz pebbles pass occasionally into a grit or fine-grained conglomerate.

Clearwater
shale.

Eight miles below the Grand Rapids at Pte. la Biche the Grand Rapids sandstone is underlaid by an argillaceous formation which will be referred to as the Clearwater shale, as it is well developed on that river. The full thickness of the Grand Rapids sandstone, (300 feet) is exposed at this point. It is overlaid by fifty feet of the Pelican shale. At the junction of the two formations, a small bed of ferruginous conglomerate was noticed. On the west side of the valley, in the Grand Rapids sandstone, there is a seam of lignite about four feet thick. The sandy beds immediately underlying the lignite, have been bleached nearly white.

Rocks at Pte.
Brulée.

At Pte. Brulée, eight miles below Pte. la Biche, the valley is deep and gorge-like and a section is shown over 400 feet thick. The Clearwater shale has gradually risen and at this point has a thickness of 100 feet. It is less homogeneous than the Pelican shale, and holds, besides dark and lead gray shales and clays, a considerable proportion of grayish sandstone, greenish glauconitic sandstone and ironstone.



Section at Pte Brulée

Scale 300 Ft = 1 inch.

Above the Clearwater shale the Grand Rapids sandstone rises by cliffs and terraces to a further height of 300 feet. The lower part of the formation is yellowish and filled with nodular concretions, while further up grayish colours prevail and some of the beds become conglomeritic. Resting on the Grand Rapids sandstone is fifteen feet of flaky shales representing the lower part of the Pelican shale. This formation is apparently concealed by surface deposits near this point, as it was not seen to crop out further down the river.

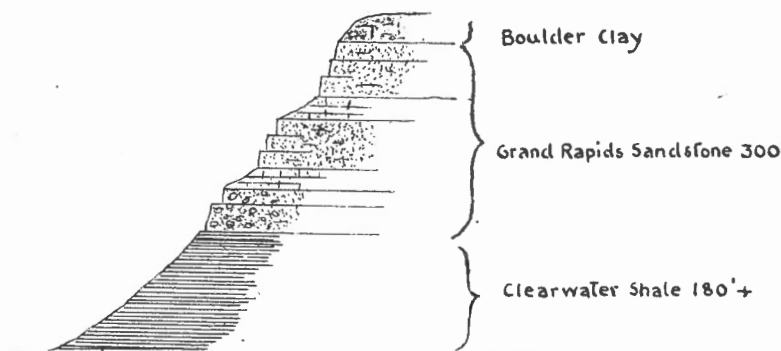
At the Burnt Rapids the Clearwater shale, about forty feet above the surface of the river, holds a bed of greenish glauconitic sandstone about two feet thick, which is highly fossiliferous. The specimens are in a good state of preservation, but most of the species are new and on this account their value in the determination of the horizon in which they were found is greatly lessened. The fauna has, however, a general Benton aspect. Mr. Whiteaves furnished me with the following list of fossils collected at this point as the result of a preliminary examination: *Camptonectes*, a *Modiola* allied to *M. tenuisculpta*, Whiteaves; a *Yoldia*, like *Y. Evansi*, Meek and Hayden; a *Nucula*, a *Protocardium*, *Callista tenuis*, Hall and Meek; a *Macra*, a *Cinulia*, *Desmoceras affine*,* Whiteaves; and *Hoplites McConnelli*,* Whiteaves.

Rocks at
Burnt Rapids.

Fossils at
Burnt Rapids.

Below Burnt Rapids the Clearwater shale overlaid by the terraced Grand Rapids sandstone, is exposed in magnificent sections on both sides of the deep trough-like valley. The following illustration shows the general arrangement of the beds.

FIG 2



Section three miles below Burnt Rapids, Athabasca River.

Scale 300 ft = one inch.

* Trans. Roy. Soc. of Can., vol. X., sec. iv., 1893.

Fossils in
Clearwater
shale.

Ten miles below Burnt Rapids some fossils were collected from a sandstone bed in the Clearwater shale, among which are *Callista tenuis*, Hall and Meek, a *Mactra*, a *Yoldia*, a *Nucula*, and a *Cinulia*.

Tar sands.

Origin of Tar
sands.

At the head of Boiler Rapid, forty miles below the Grand Rapids, and 193 miles below Athabasca Landing, the base of the Clearwater shale rises above the surface of the valley and uncovers the *Tar sands*, the lowest local division of the Cretaceous. The Tar sands must have consisted originally of almost unconsolidated sands and soft sandstone, ranging in texture from a fine silt to a coarse grit, but have been cemented into a coherent tarry mass, 200 feet thick, by the heavy constituents of the oils which have welled up during past ages, in almost inconceivable quantities from the underlying Devonian limestones. At Boiler Rapid, fifteen feet of the Tar sands are exposed, overlaid by 275 feet of the Clearwater shale, which is its ordinary thickness, above which comes the nodular sandstone and the yellowish and grayish sandstone of the Grand Rapids division. The Clearwater shale at this point yielded *Desmoceras affine*, Whiteaves, a *Goniomya*, and a *Thracia* or *Tellina*.

Rocks at
Middle
Rapid.

Thickness of
Tar sands.

At Middle Rapid, three miles below Boiler Rapid, forty feet of the Tar sands are exposed. The sands are heavily saturated with tar at this point. They are overlaid by the Clearwater shale and the Grand Rapids sandstone. Two miles below Long Rapid 100 feet of the Tar sands are exposed, and at the head of Crooked Rapid this is increased to 140 feet, the full thickness of the formation at this point. The Tar Sands at Crooked Rapid are massive and show false bedding below, but are stratified in more regular beds above. The saturation is less than usual, and to this fact is due the brownish colour of the beds. Two miles above Crooked Rapid the base of the Tar sands rises above the surface of the water, and discloses a few feet of grayish crumbly evenly-stratified Devonian limestones. The contact between the two formations is apparently conformable and affords little evidence of the vast interval of time which separates them.

Anticlinal at
Crooked
Rapid.

Crooked Rapid marks the summit of a low anticlinal. Above this point the beds dip in a south-westerly direction at from five to ten feet to the mile, while below, the general dip is to the north, but is very slight, as it averages less than two feet to the mile, and is just about equal to the fall of the river.

Exposure of
limestone.

Between Crooked Rapid and the Forks, the lowest beds exposed consist of a few feet of grayish evenly-stratified Devonian limestone. Ledges of this rock cross the river at several points and form small falls and cascades. The limestone is affected by a number of small folds and in two or three places sinks below the surface of the valley.

It is terminated upwards, for some distance below the Crooked Rapid, by a thin bed of conglomerate, consisting principally of sub-angular Conglomerate limestone pebbles ranging from half an inch to an inch in diameter. Siliceous grains fill up the interstices between the pebbles, and the whole is hardened into a compact rock by a calcareous, and in places ferruginous cement. A second variety of this rock consists largely of small ironstone concretions.

Resting on the limestone and well exposed in high cliffs on both sides of the river, is the black plastic mass of the Tar sands. At the Cascade Rapid, this formation is 150 feet thick and is so saturated that pure tar oozes out of the bank in several places and Tar streams. streams down the slope.

The Tar sands increase in thickness, descending the river, from 140 feet at Crooked Rapid to 200 feet at the Forks. The peculiar cleavage, Cleavage. mentioned by Bell*, which they affect in many places, has no general direction, but is usually nearly parallel to the face of the adjoining cliff. Flat plates, an inch or more in thickness, peel off easily and regularly from the ends of many of the beds, but the tendency to cleave does not appear to penetrate far from the surface.

The Grand Rapids sandstone was not observed below the Crooked Rapid. Between that point and the Forks, the upper part of the valley section consists of about 250 feet of the dark and lead gray shales, clays and sands of the Clearwater shale. The beds of this formation are not bituminous.

Below the Forks, or the confluence of the Athabasca and Clearwater, the valley of the former loses its narrow, gorge-like character and becomes wider and shallower, but still continues to afford good sections of the rocks. Evenly-bedded limestones of Devonian age, Devonian limestones. rising from fifteen to twenty feet above the surface of the river, are almost continuously exposed for a long distance on the right bank. They are horizontal, or nearly so, for some miles below the Forks, but further down, undulate in gentle folds, but seldom show more than the upper fifty feet of the terrane. The limestone is grayish, but often weathers to a light yellow, and is usually more or less argillaceous, in places passing into a calcareous shale. Fossils are numerous, among others, a large *Stromatoporoid* of variable shape is especially noticeable, from its abundance and size, in most of the sections. The following list of fossils collected between the Forks and Red River is furnished by Mr. Whiteaves:—

Chonetes Logani, var. *Aurora*, Hall.

Strophalosia productoides, Murchison.

* Geological Survey, Report of Progress. 1882-83-84, p. 15 C. C.

Productella dissimilis, Hall.

Spirifera subattenuata, Hall.

" *inutilis*, Hall.

" *tullia*, Hall, var.

" *Richardsoni*, Meek.

Atrypa Angelica, var. *occidentalis*, Whiteaves.

" *reticularis*, L.

" *reticularis*, var. *aspera*, Schlotheim.

Actinopteria Boydii, Conrad.

Ptychopteria æquivalvis, Whiteaves.

Leptodesma Demus, Hall.

" *Jason*, Hall.

Conularia Salinensis, Whiteaves.

Aparchites mitis, Jones.

These fossils indicate a horizon in the Upper Devonian probably nearly equivalent to the Cuboides zone.

Disappearance of Clearwater shale.

The Devonian limestones are overlaid for some miles below the Forks by heavy sections of the Tar sands, but on account of the decrease in the height of the valley, the Clearwater shale almost disappears.

FIG. 3



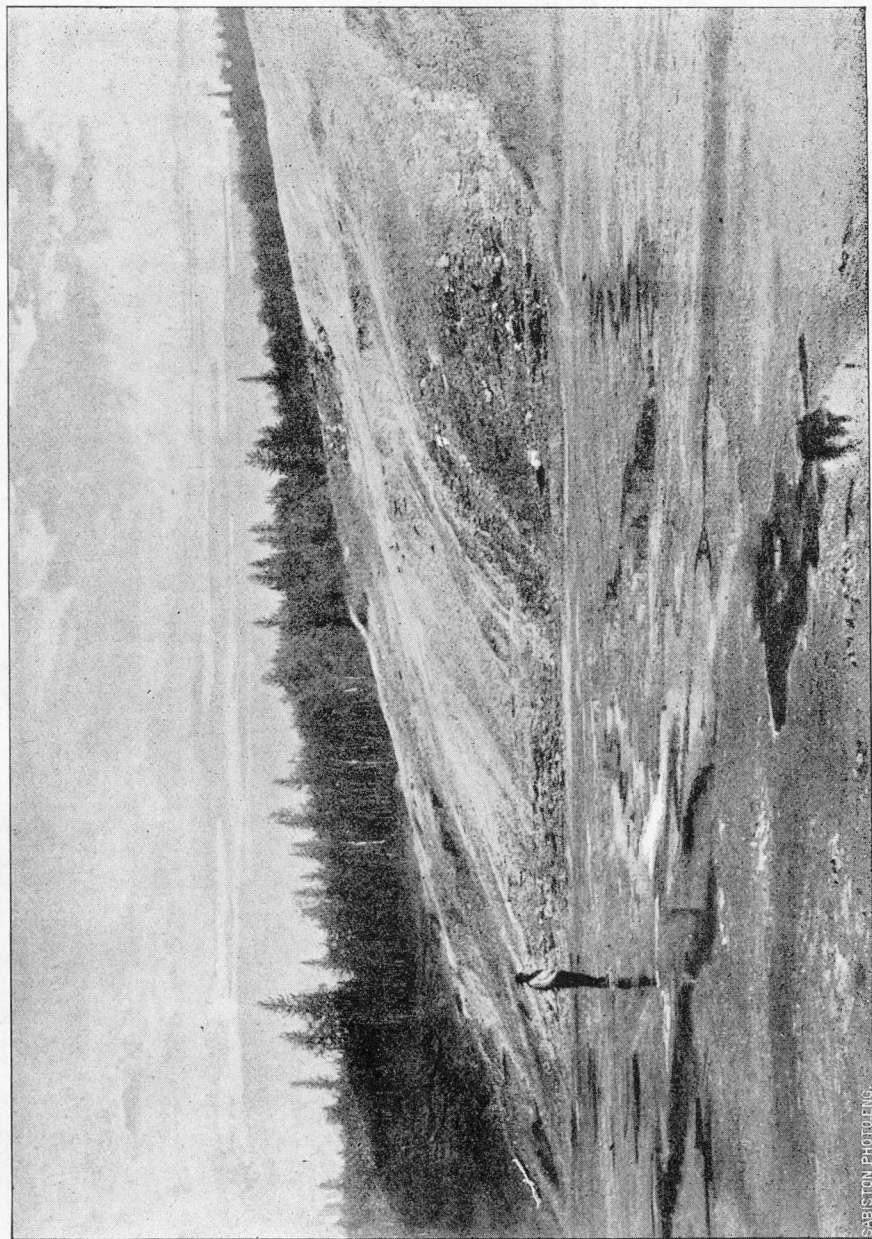
Section Six Miles Below Forks

Scale 300 Ft = 1 inch

Description of Tar sands.

The Tar sands hold in places lenticular beds of limestone, lignite seams two or three feet thick and fragments of fossil wood. They vary in colour according to the quantity of tar they contain, from a gray to a dark brown, and jet black. Where heavily saturated streams of tar issue from the banks during the heat of summer, and form pools at the bases of the escarpments. This appears to be the origin as suggested by Bell* of the "tar springs" which occur in the right bank opposite Tar Island, two miles below the mouth of Red River, and in numerous other places.

* Geological Survey, Report of Progress, 1882-83-84, p. 22 C. C.



SABISTON PHOTOGRAPH.

R. G. McConnell, Photo., July, 1890.

LA SALINE, ATHABASCA RIVER,
SHOWING DEPOSIT FROM MINERAL SPRING.

At La Saline, twenty-eight miles below the Forks, several mineral springs occur about half a mile east of the river on the edge of the valley there sixty feet deep. The deposits from the springs, consisting principally of calcareous tufa, cover the face of the escarpment and have also built up a cone on the top of the bank ten to fifteen feet high and about 200 feet wide. An analysis of the water which is strongly saline, is given in another place. Sulphuretted hydrogen gas escapes from the bank in several places and taints the air for some distance from the springs. Besides the calcareous tufa the cone contains small deposits of common salt, gypsum and native sulphur, while pure tar derived from the Tar sands beneath issues from the bank in two places. The springs feed a shallow lake which is situated at the foot of the escarpment, and is surrounded by a clay flat partly bare and partly covered with coarse grasses.

Devonian limestone is exposed for a couple of miles below the mouth of Red River, but below that point sections seldom occur. There are two small exposures about a mile below Red River, and the limestones are again brought up by a low anticlinal two miles and a half below Calumet River. At this point they are overlaid by fifty feet of light coloured shale. A number of fossils were collected here, from among which Mr. Whiteaves has identified the following species :—

- Cyathophyllum Athabascense*, Whiteaves.
- Spirorbis omphalodes*, Goldfuss.
- Hederella Canadensis*, Nicholson.
- Ascodictyon stellatum*, Nicholson.
- Crania Hamiltonia*, Hall.
- Productella dissimilis*, Hall.
- Orthis striatula*, Schlotheim.
- Strophodonta demissa*, Conrad.
- Spirifera subattenuata*, Hall.
- “ *inutilis*, Hall.
- Cyrtina Hamiltonensis*, Hall.
- Athyris parvula*, Whiteaves.
- Atrypa reticularis*, L.
- “ “ var. *aspera*, Schlotheim.
- Rhynchonella pugnus*, Martin.
- Aparchites mitis*, Jones.

The last exposure observed of Devonian limestone occurs about ten miles below the Calumet River, or sixty-three miles below the Forks. The beds here have a slight southerly dip. They are fossiliferous, but the species collected, with the exception of *Campophyllum ellipticum* and *Cyrtina Billingsi* are the same as those enumerated in the list

given above. A short distance below the limestone outcrop, some sandstone beds dipping in the opposite direction occur, the exact relations of which are obscure. These beds hold vegetable remains and while soft and tar-soaked in some places, in others they pass into a quartzite. They are unfossiliferous.

Tar sands disappear.

A quarter of a mile below the last limestone exposure the Tar sands, sections of which, ranging in thickness from a few feet to 200 feet, are almost continuously exposed below the Forks, also disappear, and from this point on to the mouth of the river only the boulder clays and associated beds were seen.

These Tar sands are well saturated, and are twenty-five feet thick on the east side of the river, and fifteen feet on the west side, where they hold a small bed of lignite. They are overlaid by forty feet of soft reddish sands, belonging to the period of the Saskatchewan gravels, above which comes a few feet of boulder clay.

Saline spring.

Twelve miles below the last exposure of the Tar sands, and about two miles above the mouth of Red Earth Creek, a copious saline spring bubbles up about 100 feet from the west bank of the river and feeds a considerable stream. Large quantities of sulphuretted hydrogen gas escape at the same place and taint the air for half a mile around. An analysis of the water is given in another place.

Superficial beds.

The superficial beds through which the valley of the Athabasca cuts in its lower part are described under the heading of Glacial Geology. They consist of an upper and lower sandy deposit, separated by red and dark boulder clays. The upper sands and gravels are soaked in places near the surface with tar, and contain beds of sandy nodules cemented by the same material.

Sections on Moose River, Muskeg River, Lesser Slave River and other tributaries of the Athabasca.

Moose River.

Moose River affords the best geological section of any of the tributaries examined. A description of this stream is given in a previous chapter. It forms the outlet of Moose Lake situated near the centre of the Birch Hills, and after a course of about 100 miles, during which it describes a great bend to the south, it falls into the Athabasca forty-six miles below the Forks.

Gray shales.

Two miles below Moose Lake at the first rapids encountered, an exposure of grayish shales holding ironstone nodules was observed. No fossils were collected, but from their stratigraphical position there is little doubt that the shales belong to the La Biche series. Five miles lower down a section of boulder clay seventy-five feet thick was observed, and two miles further on an exposure showed several beds of

boulder clays, separated by layers of sand and gravel, the whole overlying the grayish La Biche shales. The following section in descending order was measured at this point :

	Feet.
Sand and gravel	8
Boulder clay	4
Stratified sands	2
Boulder clay	3
Stratified gravels holding large boulders	3
Boulder clay	3
Gray shales with large limestone concretions	40
	<hr/>
	63
	<hr/>

Four miles below the last exposure, Moose River leaves the Birch Mountains, and winds for some miles through the plains at their base. Exposures at foot of Birch Mountain. Boulder clays are exposed along this stretch in a number of places, and dark evenly-bedded shales come to the surface at two points. Ten miles from the foot of the Birch Mountain escarpment, Moose River cuts through a ridge 120 feet high, and for some miles the valley affords good sections. The rocks here exposed consist of forty feet of whitish sands underlaid by twenty feet of dark plastic clays or shale. These beds represent the Pelican sandstone, and shale of the Athabasca section. They are underlaid by a few feet of sandy shales and sandstone, belonging to the Grand Rapids sandstone. A lignite seam two feet thick was observed in two places near the top of the Grand Rapids sandstone.

The Cretaceous rocks are overlaid by a boulder clay band fifty feet thick.

In the next few miles the sandstones of the Grand Rapids division are frequently exposed, and often hold numerous nodules similar to those characterizing the same formation on the Athabasca.

After cutting through the ridge mentioned above, Moose River bends at right angles to its former course and follows a general north-easterly direction to the Athabasca. Two miles below the bend the river cuts through the Grand Rapids sandstone and exposes the upper part of the Clearwater shale. Below this point the banks are low for some miles and exposures are infrequent, but further down, the valley increases in depth and almost continuous sections of the Clearwater shale are exposed. The rocks of this division consist here of plastic clays and shales, alternating with sandy shales and occasional beds of sandstone and ironstone. Some fossils were collected, among which are the same species of *Nucula*, *Yoldia* and *Camptonectes* found in Rocks on Moose River

the Clearwater shale on the Athabasca. The beds have an easterly dip, and at the Big Rapids they are overlaid by the nodular sandstone of the Grand Rapids division. The following section was measured at the latter point:—

	Feet.	
Boulder clays	10	
Sandy shales.....	15	} Grand Rapids sandstone.
Nodular sandstone.	20	
Sandy shales.....	15	} Clearwater shale.
Clays and shales.....	40	
	<hr/> 110 <hr/>	

Moose River was not followed for some miles below the Big Rapids, and at the crossing of the Moose Lake trail, the next point examined, the Clearwater shale comes to the surface and is underlaid by sixty feet of Tar sands.

Comparison of
Moose River
and Athabasca
River sections.

The Moose River section in its general character resembles that on the Athabasca, but differs in some of the details. The Pelican shale has decreased from ninety to twenty feet in thickness, and the Pembina shale appears to have become differentiated into an upper part consisting of sandy shales and sandstones, and a lower and more purely argillaceous division.

Red River.

Red River, which empties into the Athabasca twelve miles above the mouth of Moose River, shows, for some miles above its mouth, thick sections of the Tar sands, overlying the Devonian limestones.

Muskeg River

Muskeg River was examined for thirty miles from its mouth. This stream joins the Athabasca from the east about two miles above Red River. It is reached from the Athabasca by a portage, as the lower two or three miles are unnavigable. Tar sands overlying Devonian limestones are exposed for the first three or four miles above the head of the portage, when the limestones disappear, but Tar sands occasionally outcrop for ten or twelve miles further. In the upper part of the valley no exposures were seen.

Exposures on
Muskeg River

A mile above the head of the portage the Tar sands, here only twenty feet thick, are overlaid by a bed of hard sandstone or quartzite, which has become developed in them, probably by siliceous infiltration. A mile above the last exposure a crevice in the Devonian limestone was noticed, which had become filled up with well-saturated Tar sands, derived from the overlying formation.

The section on Muskeg River shows that the Tar sands extend at least eight miles east of the Athabasca River.* They are much

*Since writing the above Mr. D. B. Dowling has found a small exposure of Tar sands on Firebag River, eighteen miles east of the Athabasca River.

thinner than usual, but this is probably due to the upper part having been removed by denudation.

Steep Bank River, which enters the Athabasca twenty-one miles below the Forks, was ascended for about ten miles on foot. Tar sands, overlaid by the lower part of the Clearwater shale, were exposed all the distance. Steep Bank River.

A trip was made from the Forks up the Clearwater River to the mouth of Pembina River, and thence up the latter stream for some miles, until the water became too shallow to continue the traverse.

The Clearwater, below Pembina River, winds along a great valley two miles wide and from 300 to 400 feet deep, which looks much older than the valley of the main river above the junction. Three miles above the Forks an exposure of Tar sands was observed, and three miles further up, Devonian limestones appear at the surface and recur at intervals all the way up. The limestones are similar in character to those on the Athabasca and hold the same fossils. Clearwater River.

The Pembina was ascended for thirteen miles in a straight line. Its valley is deep and gorge-like and affords many good sections. For some miles above its mouth Devonian limestones holding *Atrypa reticularis*, *Spirifera inutilis* and other fossils, undulate along the edge of the water and are then replaced by the Tar sands, many sections of which, in varying states of saturation, occur at all the bends of the river. Five miles above the mouth of the Pembina a seam of lignite, four feet thick, occurs in an exposure of the Tar sands, and a short distance further on a lenticular bed of quartzite, six feet thick and 100 yards long, was observed, somewhat similar to that found on Muskeg River. Five miles further up the Tar sands are overlaid by the Clearwater shale holding some fossiliferous beds, in which were found species of *Cyprina*, *Nucula*, and a *Yoldia* like *Y. scitula*. Two miles above the last section the Tar sands, overlaid by the Clearwater shales, are again well exposed. In the valley opposite this exposure several springs of saline water, accompanied as usual by sulphuretted hydrogen gas, bubble up close to the left bank of the river. The valley was not examined above this point. Pembina River.
Lignite seam.
Saline springs.

The Pelican River was ascended to its source, but it afforded no exposures above the head of the portage made to overcome the rapids at its mouth. Below the portage, sections of the La Biche shales are present, but do not differ from those on the Athabasca. Pelican River.

Lesser Slave River affords a couple of small sections of La Biche shales, in one of which a specimen of *Baculites compressus* was found, but in its upper part it does not cut through the drift deposits. Lesser Slave River.

Lesser Slave Lake.

Lesser Slave
Lake.

Lesser Slave Lake rests on the La Biche shales but owes its existence to an embankment of drift deposits at its eastern end. Its shores are low and often marshy, and exposures of the older rocks seldom occur. Grayish calcareous shales, holding ironstone, were noticed east of the Narrows River, and sections of dark shales, holding *Baculites compressus*, occur near the eastern end of the lake, opposite Marten Mountain. A high plateau skirts the southern shores of the lake at a distance of eight or ten miles, and a small nameless stream was examined, which flows from it into the south-east corner of the lake. Sections showing beds of hard yellowish sandstone, alternating with sandy clays and sands, occur on the lower part of this stream. Some of the beds are fossiliferous, and the following species, with, others were collected :—

Protocardia borealis, Whiteaves.

Pteria Nebrascana, Meek and Hayden.

Anchura Americana, Meek and Hayden.

Foxhill sand-
stones.

These beds rest on the La Biche shales, and evidently represent the Foxhill sandstone. They were found as high as 160 feet above the lake, and are overlaid by the sands, sandy clays and sandstones of the Laramie, numerous sections of which occur all along the valley and in the scarped face of the plateau. Lignite seams were observed at several horizons, the thickest of which measured three feet, and a conspicuous bed of soft yellowish homogeneous sandstone fifty feet thick occurs at the foot of the plateau. The Laramie beds have a thickness of about 1,200 feet, but appear to be unfossiliferous throughout.

Lignite seams.

Marten
Mountain.

Marten Mountain north of the lake, was examined, but no sections were found on it, although fragments of lignite and sandstone are abundant on its lower slopes. It is 1,000 feet high and must be composed largely of Laramie as the rocks in this region are practically horizontal. A loose fragment of sandstone found at its base afforded specimens of *Limnæa* and other fresh water shells.

Section on the Wabiscaw and Loon Rivers.

Wabiscaw
River.

The Wabiscaw River for many miles below Lake Wabiscaw does not cut through the boulder clay. The first exposure of the older rocks noticed, occurs about nineteen miles below Pine River, nearly in line with the continuation of the Birch Mountains, and consists of light grayish soft shales, holding ironstone and calcareous nodules, similar to those overlying the Pelican sandstone on the Athabasca, and capping the Birch Mountain. Small sections of shale underlying the boulder clay again

occur at the Grand Rapids, eight miles above the mouth of Panny River, after having been concealed for a long interval. The next exposure occurs twenty-six miles further down, or about ten miles below the junctions of the Loon and Athabasca rivers, and consists of fifteen feet of soft falsely-bedded sandstone, passing into a fine conglomerate. The coloration varies from white to red. Two miles further down, the same sandstone outcrops again with an exposed thickness of thirty feet, but is here overlaid with 100 feet of dark shales holding ironstone nodules, which probably represent the Fort St. John shales. The arenaceous band below, so far as the stratigraphical evidence goes, appears to be a continuation of the Peace River sandstones. Approaching the Buffalo Head Hills, the valley of the Loon River deepens and scarped banks are more numerous. A mile above the mouth of Muddy River, a cut bank showed seventy feet of soft, grayish sandy shales, interstratified with a few beds of grayish and greenish sandstone and ironstone. A number of fossils were collected from this section, among which are *Desmoceras affine*, var. *glabrum*, a species first described by Mr. Whiteaves from Peace River, *Hoplites Canadensis*, Whiteaves*, found also in the lower part of the Peace River sandstones on Peace River; casts of a *Trigonia*, a *Mactra*, an *Axinæa*, and a *Lunatia*.

Exposures on
Wabiscaw
River.

Valley
deepens.

Fossils.

Below the mouth of Muddy River, Loon River breaks through the lower slopes of the Buffalo Head Hills, and has cut out for some miles a deep narrow gorge with banks 400 feet high in places, chiefly composed of a succession of land-slips. Dark and grayish shales, usually in a soft and plastic condition, are exposed all along this stretch. The shales are sandy in places and include thin beds of gray and greenish limestone and layers of calcareous and ferruginous nodules. Fossils were found at several points, and the collection, besides those enumerated above, includes a *Yoldia* like *Y. Evansi*, which is indistinguishable from the one obtained from the lower part of the Peace River sandstones on Peace River and from the Clearwater shale on the Athabasca, a *Teredo* boring into fossil wood, a *Lima*, and a *Pecten*.

Narrow gorge.

After passing the Buffalo Head Hills, the valley of the Loon is greatly reduced in depth, and its banks for some miles are composed of boulder clay overlying stratified sands and gravels. In the vicinity of Bat River the shales reappear and are exposed in several places underlying the boulder clay. A mile below Bat River, specimens were found of the large *Desmoceras*, since described by Mr. Whiteaves under the name of *D. affine*. This fossil occurs in the Clearwater shale at Boiler Rapid on the Athabasca, all along Peace River, from the first

Valley
reduced in
depth.

Shales reap-
pear.

* Trans. Roy. Soc. of Can., vol. X., sec. iv., 1893.

appearance of the Cretaceous above Vermilion Falls, up to Cadotte's River, and it was also found on Red River. It characterizes the lower part of the Cretaceous section in the vicinity of Peace River, and on the Athabasca the beds immediately overlying the Tar sands.

Drift-filled
basin.

Three miles below Bat River the Loon enters and traverses for some miles a basin filled with glacial deposits. In this stretch the valley is about 100 feet deep and its banks show sections of boulder clay, often seventy-five feet or more in thickness. This clay is dark and very plastic, and holds numerous concretions, evidently derived like the main part of its substance from the underlying shales. It is usually underlaid and occasionally overlaid by stratified sands and gravels, and in one section was divided into two distinct divisions by a layer of well-rounded boulders.

Seventeen miles in a straight line, below Bat River, the boulder clay rises and the shales appear again above the surface. At this point they are grayish, and very soft, but hold a few hard beds of calcareous sandstone or impure limestone, and numerous variously shaped calcareous ironstone and clay nodules. Fossils were found at two points, among those collected being a *Yoldia*, and several specimens of the same large *Desmoceras* referred to above.

Exposures of
shales.

The shales are exposed along the river for a distance of eight miles, measuring in a straight line. At the end of this stretch, the valley almost disappears, but small sections of boulder clay continue to be exposed almost to the mouth of the river. The boulder clay here is stained red in places, and holds beds of nearly pure red clay similar to those on Peace River, in the vicinity of Fort Vermilion.

Comparisons
with Peace
River section.

The Wabiscaw-Loon Cretaceous section resembles in its general features that on the Peace River, but differs from it in the less importance of the central arenaceous division. On the Loon River, thirty feet of sandstone was observed at one point, but as a rule the sandy beds alternate with much greater thicknesses of shale, and this stream appears to mark in one direction the vanishing point of the great sand bank which stretched with gradually diminishing thickness from the Rocky Mountains into the Cretaceous sea.

Section on Red River.

Valley of Red
River.

The valley of Red River is very shallow, seldom exceeding 100 feet in depth, and the geological section it affords is very imperfect, as it is interrupted by long intervals, in which the river fails to cut through the drift. Limestones of Devonian age occur at its mouth, and extend up the valley for two miles in low cliffs bordering both sides of the stream. The limestone is nodular and crumbly and weathers to a light.

cream colour. It is filled with corals, brachiopods and other fossils belonging to the same species as those previously enumerated as occurring at the Vermilion Falls. Above the limestone exposures, the valley shows only dark and reddish boulder clay for twenty miles. Two large gypsum boulders, probably brought hither from Peace Point on Peace River, were noticed about half-way up this stretch. Above the boulder-clay basin, dark shales representing the lower part of the Cretaceous series appear, and are exposed at intervals for eight or ten miles. The shales include limestone and calcareous nodules, and are similar in appearance and composition to those on the lower part of Loon River, and they also hold numerous specimens, in various stages of growth of the same *Desmoceras* (*D. affine*, Whiteaves).

Exposures in
Red River
valley.

Six miles above the shale occurrences, a small anticlinal brings cream-coloured Devonian limestones to the surface, holding *Atrypa reticularis* and other fossils. The limestones are only shown in one place, and the valley, for many miles above, is destitute of any exposures older than the drift. The shales appear again for a short distance near the mouth of Owl River. At this point Red River approaches within fifteen miles of the Buffalo Head Hills. Above Owl River, the Red River valley, so far as ascended, yielded no exposures of the older rocks.

Devonian
limestone.

Plateaus of the District.

The rocks of the Peace-Athabasca region are everywhere practically horizontal, as the dips seldom exceed a few feet to the mile, and such highlands as exist necessarily owe their origin to differential denudation. The principal highlands are the Buffalo Head Hills, Birch Mountains and Marten Mountain.

Rocks, hori-
zontal.

The Buffalo Head Hills may be described as a plateau of circum-denudation still lingering in the angle between the Loon and Peace rivers, and its geology is very simple. A description of the plateau is given on another page. It is 2,500 feet above the sea, and has a maximum height above the plains at its base of 1,000 feet. The escarpments are generally wooded, but good sections were found at the northern end of the plateau on a small tributary of Bear River, a feeder of the Loon. These sections show the plateau to be entirely composed of shales. The shales are of a dark colour but weather to a light gray and at a distance look almost white. They are soft and plastic and are very uniform in composition throughout. Nodules occur, but are comparatively scarce, and no fossils of any kind were obtained. As in other places, many small streams highly charged with salts of various kinds, furrow the lower slopes of the escarpment.

Buffalo Head
Hills.

Plateau com-
posed of
shales.

Thickness of
Cretaceous
sections.

The exposures in the Buffalo Head Hills, together with those on Loon River, show that the Cretaceous section in this part of the district has an approximate thickness of 1,500 feet, all of which, with the exception of a few sandy beds about 500 feet above the base representing the horizon of the Peace River sandstones, consists essentially of shales, and is probably of Benton age. The beds above the sandstone horizon correspond to the Fort St. John shales, while those below are referred to the Loon River shales of the Peace River section.

Birch Mountain.

Birch Mountain is a name given to a great ridge situated west of the Athabasca, in the south-eastern part of the district reported on, and extending in a northerly and southerly direction nearly parallel with the course of that stream. It is nearly 100 miles long with an average width of about thirty-five miles. Its elevation above the sea is approximately 2,300 feet, and it overlooks the surrounding plains from heights ranging up to about 1,000 feet. The surface is undulating, the depressions being frequently filled with lakes, and except where cleared by forest fires, the whole ridge is densely wooded. The slopes are usually easy, and exposures, except at the southern end, are confined to the valleys of the streams.

Composition
of plateau.

Genetically, Birch Mountain, like the Buffalo Head Hills, is a plateau of circumdenudation, carved out of the horizontal beds of the Cretaceous, but it has been somewhat modified by glacial action. Sections were examined on Moose River, and on Steep Bank Creek, a small stream flowing into Lake Claire. At the former place, the plateau, so far as ascertained, is formed entirely of the grayish and dark shales, which on the Athabasca overlie the Pelican sandstone. No fossils were obtained from these shales on Moose River, but on the Athabasca, they contain a Pierre and Foxhill fauna above, while the lower part of the band is probably Benton.

Rocks on
Steep Bank
Creek.

On Steep Bank Creek, the shales still cover the summit of the plateau, but they are underlaid by a band of yellowish and grayish sands and soft sandstone, exposures of which also crop out at various points round the northern end of the mountain. These beds are destitute of fossils, but on stratigraphical evidence, there is little doubt that they represent the continuation of the Pelican and Grand Rapids sandstones, although the Pelican shale, which separates these two on the Athabasca, is absent here. The sands contain small coaly seams, and some of the beds are blackened with bituminous matter. They have an exposed thickness of 200 feet, but the base is concealed. The Clearwater shale and the Tar sands which underlie the Grand Rapids sandstone on the Athabasca, if present here, are also hidden, as the next rocks seen in descending the river consisted of crumbling Devonian limestones, but these occur some miles from the foot of the plateau.

Swift Current Creek, a tributary of Birch River, was examined up to the foot of the Birch Mountain plateau, but no exposures were found on it, although pebbles of tar-soaked sandy shales were found on a number of the bases, and point to an occurrence of the Tar sands in the north-western part of the ridge. Swift Current Creek.

The plateau south of Lesser Slave Lake was examined only in one place, and a description of the sections obtained is given on page 40. It consists of Laramie sandstones and shales holding lignite seams, overlying 150 feet of Pierre and Foxhill beds. Marten Mountain north of Lesser Slave Lake, is probably built of similar beds, but the section, except at the base where Pierre shales are shown, is concealed. Plateau south of Lesser Slave Lake.

Sections on Peace River.

Peace River was examined from the mouth of Red River up to the Smoky River Forks. The portion of the river below Red River was traversed by Professor Macoun in 1875. Rock exposures in this stretch seldom occur, but grayish limestones interbedded with white gypsum, and holding *Strophodonta demissa* and other Devonian fossils are described as outcropping at Rapid Bouillé or Little Rapid, and extending down the river to Peace Point, a distance of fifteen miles. Below this point, no rock exposures were noticed by Macoun until Quatre Fourches River was reached, where Archæan gneisses outcrop*. Peace River.
Rocks at Peace Point.

Above Red River, Devonian limestones are exposed in low cliffs along the shore to the Vermilion Falls, and for two miles beyond. The limestone is horizontal and occurs in thick evenly-stratified light grayish or cream-coloured beds alternating with softer and more argillaceous bands. The latter are often stained reddish or greenish, and are easily eroded, and the origin of the falls is due to their gradual waste, and the consequent undermining and breaking down of the heavier beds. The limestones in the vicinity of the falls, have an exposed thickness of sixty feet. They do not appear to be bituminous. Some of the beds are very fossiliferous, the following species, among others, being collected here :— Exposures at Vermilion Falls.

Cyathophyllum cespitosum, Goldfuss.

Phillipsastræa Hennahi, Lonsdale.

Pachyphyllum Devonienne, Edwards and Haime.

Pachypora cervicornis, De Blainville.

Alveolites vallorum, Meek.

“ *Rœmeri*, Billings.

Monotrypella Unjiga, Whiteaves.

Strophodonta demissa, Conrad.

“ *perplana*, Conrad.

* Rep. of Prog., Geol. Surv. of Can., 1875-76, pp. 89-90.

Spirifera disjuncta, Sowerby.

Atrypa reticularis, L.

“ “ var. *aspera*, Schlotheim.

Rhynchonella cuboides, Sowerby.

Cryptonella Calvini, Hall.

Pterinea flabellum, Conrad.

This fauna agrees very closely in its general characters with that occurring in the Devonian limestones on the Athabasca, and indicates that the basement rocks on the two rivers, occupy a similar position in the geological scale.

Appearance of
Cretaceous.

Above Vermilion Falls and Rapids, the Devonian limestones disappear, and for some miles only the boulder clays and associated beds are exposed in the banks. Further up the dark shales of the Cretaceous make their appearance, and are shown in frequent exposures all the way to Fort Vermilion. The general horizontality of the Devonian limestones in the region between the Peace and the Athabasca is shown by their disappearing below the surface in ascending these streams, at almost the same height, viz., 930 feet above the sea. The contact between the Devonian and Cretaceous rocks is concealed on Peace River, but there is little doubt that the limestones are directly overlaid by shales, and that the sands soaked with tar, which occupy this position on the Athabasca are absent. The shales seen between Vermilion Falls and Fort Vermilion are of a dark colour, and are only slightly indurated. They contain occasionally, thin beds of limestone, and more frequently layers of ironstone, and calcareous concretions. The latter are often fossiliferous, specimens of *Desmoceras affine*, Whiteaves, being especially abundant although usually in a more or less fragmentary condition.

Contact with
Devonian
concealed.

Rocks be-
tween Fort
Vermilion and
Battle River.

Between Fort Vermilion and Battle River, a distance measured in a straight line of eighty-five miles, but following the course of the river of about 150 miles, there is little change in the geology of the Peace River valley. Dark shales holding large limestone concretions, short lenticular limestone beds, nodular beds of ironstone, and occasionally a bed of sandstone, are exposed at all the bends of the river, and occasionally are shown for miles in continuous sections. The shales are uniform in composition throughout. They are very soft, almost passing into clays in places, and like the shales on the Athabasca and Saskatchewan, break away in frequent slides. Reddish ferruginous streamlets issue from the shales at almost every section, and often feed small pools lying in the hollows caused by the slides. The shales do not appear to be bituminous to any extent, but inspissated bitumen was observed at several points lining cracks in the nodules. Fossil wood is very abundant in some of the sections.

The shales are overlaid nearly everywhere by heavy sections of Boulder clay. boulder clay, usually associated below, here as elsewhere, with stratified sands and gravels. The boulder clay for some distance above and below Fort Vermilion, shows the same red coloration as that noted in the vicinity of Red Earth Creek on the Athabasca.

Three miles below Battle River, the shales are interbedded with a band of bluish, yellow-weathering, soft sandstone and sand, about seventy feet thick, which makes its first appearance in the left bank about 150 feet above the level of the river. The shales above and below the sandstone band are similar in appearance, and are apparently simply a continuation of those exposed lower down the river, but the formation is here divided by the sandy intercalation. The thickness of the shales underlying the sandstone is uncertain, but is probably in the neighbourhood of 500 feet.

Shales divided
by sandstone
band.

Above Battle River the sandstones which may be provisionally named the Peace River sandstones, rapidly increase in thickness and appear to have a slight southerly dip, as the lower shales gradually disappear. At the great bend which Peace River describes, about fifteen miles above the mouth of Battle River, the cut banks show 100 feet of dark shales holding limestone nodules, above which comes fifty feet of bluish and yellow sandstone, followed by 100 feet of alternating sandstones and shales. The valley here is nearly 700 feet deep, but the upper part of the section is concealed. The lower band of sandstone weathers into cliffs and holds some beds resembling the green sand bed of the Clearwater shale on the Athabasca, but they are apparently not glauconitic. A number of fossils were collected from the sandstones, but they are nearly all undescribed species.

Peace River.
sandstones.

Rocks at bend
above Battle
River.

Five miles above the bend just referred to, the Peace River sandstones descend to the surface of the valley and the lower shale division disappears. The Peace River sandstones at this point are 230 feet thick, showing an increase in volume since first observed below Battle River of 210 feet. Part of this increase appears to be due, however, to arenaceous beds replacing the shales in the lower shale division. A section of the sandstone division shows eighty feet of yellowish sands and shales, holding numerous nodules of various kinds, and short beds of yellowish limestone, above which comes forty feet of sands and sandstones, interbedded with small lignite seams, and holding numerous fragments of fossil wood. The upper part consists of about 110 feet of alternating sands and shale, resting on which are 200 feet or more of dark shales, representing the Lower or Fort St. John shales of Dr. G. M. Dawson's Peace River section. A number of fossils were collected from the lower part of the sandstones, among which are *Callista tenuis*, and a *Yoldia* like *Yoldia Evansi*, both of which were found in the Clear-

Increase in
thickness of
Peace River
sandstones.

Fossils.

water shales on the Athabasca. Besides these, the collection includes two species of *Nucula*, a *Panopæa*, n.sp., a *Camptonectes*, a *Macra*, a *Protocardium*, an *Axinea*, a *Lunatia*, an *Inoceramus*, specimens of *Desmoceras affine*, and *D. affine*, var. *glabrum*, Whiteaves, *Hoplites Canadensis*, Whiteaves, and a tooth of *Ptychodus*. The Fort St. John shales hold numerous ironstone nodules, but no fossils were obtained from them. Twenty miles below Cadotte's River, the banks of the valley showed the following section, in descending order : —

	Feet.	
Dark shales (Fort St. John).....	200	
Brownish shales, with yellowish clay.....	10	} Peace River sandstones.
Yellowish sands.....	6	
Alternating sands and shale, with some ironstone.	70	
Yellowish sands.....	20	
Yellowish sandstone.....	8	
Yellowish sands.....	20	
Yellowish striped sands and clays, with ironstone and limestone concretions (fossil- iferous).	60	
	<hr/> 294 <hr/>	

Section at
mouth of
Cadotte's
River.

Opposite the mouth of Cadotte's River, the Peace River sandstones consist of 100 feet of sandy shales, holding ironstone and siliceous nodules, followed by forty feet of yellowish sands studded with large sandy concretions similar to those in the Grand Rapids sandstone on the Athabasca, above which, and underlying the Fort St. John shales, comes ninety feet of yellowish sands and shales, interbedded with numerous layers of ironstone. Between Cadotte's River and Tar Island, the Peace River sandstones are well exposed in cliffs, terraces and sloping banks all along the valley.

FIG. 4



Section near Tar Island

Scale 300 Ft. = 1 inch

Above Cadotte's River the Peace River sandstones become more completely arenaceous, and the lower part is filled with fantastically shaped sandy nodules, some of which are fifteen feet or more in diameter. The general appearance of this formation as developed along this part of the river, is strikingly similar to that of the Grand Rapids sandstone on the Athabasca. It consists of three sandstone divisions, which weather into steep cliffs, separated by shaly bands, forming sloping terraces. The two lower sandstone divisions are of a yellow colour and carry nodules, while the upper one often shows grayish tints, and is occasionally conglomeritic. Fossils are scarce along this part of the river, but fragments of Ammonites and other marine fossils occur in many of the nodules.

Numerous nodules.

Scarcity of fossils.

A saline spring, emitting natural gas and carrying up small quantities of tar, occurs on the boulder beach at the upper end of Tar Island, about thirty miles below the Smoky River Forks, and a short distance further down, cracked nodules, with the fractures filled with inspissated bitumen, were noticed in the right bank. A second spring is reported to occur on an island opposite the mouth of White Mud River, but this was not seen.

Saline spring.

Opposite Tar Island and for some distance above, the Peace River sandstones are shown in high cliffs on both sides of the river, but they become influenced near this point by a slight southward dip, and ascending the river they gradually decrease in height, and at length disappear just below Smoky River Forks. When last seen they consist of a few feet of soft grayish massive sandstone, marked in a peculiar manner by thin curving lines of carbonaceous shale. Two miles below the Forks the sandstones here showing an exposed thickness of twenty feet, have been grooved and fluted horizontally by river ice. At the base of this cliff, are several small springs emitting sulphuretted hydrogen gas. At the Forks the whole valley section, 700 feet in height, consists of the dark ironstone bearing shales of the Fort St. John series, crowned by a varying thickness of boulder clay and associated beds. These shales, which have overlaid the Peace River sandstones since the first appearance of the latter below Battle River, were frequently searched for fossils without result, and its fauna is still represented only by the *Inoceramus* and *Buchiceras*, or *Acanthoceras*, *cornutum* found by Dr. Selwyn, near Fort St. John, in 1875.

High cliff.

Peace River sandstones dip below the surface.

Gas springs.

Fort St. John shales.

Peace River was not examined by the writer above the Smoky River Forks, as the upper part of the river was explored by Dr. Selwyn, in 1875. The shales of the Fort St. John series are described by him, as extending up Peace River, above the Forks, for a distance of about twenty-

Peace River above the Forks.

Thickness of
Dunvegan
beds.

five miles, where they are overlaid by the sandstones and shales of the Dunvegan group. The latter then occupy the valley all the way to the cañon of the Mountain of Rocks, except for some distance above and below Fort St. John, where they rise above the surface and the Fort St. John shales appear. Above the cañon of the Mountain of Rocks, Peace River enters a region of tilted beds, and the sequence of the formations becomes obscure. The Dunvegan beds have a minimum thickness at Dunvegan of 600 feet, but appear to thicken rapidly westward, and probably include the whole 2,000 feet or more of sandstones and shales, shown in the escarpments of Table Mountain. The fossils collected by Dr. Selwyn from this formation, include fresh water, brackish water and marine species, and the general character of the fauna is similar to that of the Belly River series of the Great Plains, and the Bear River beds of Wyoming.

Smoky River
section.

The Smoky River section above the Forks, was examined by Dr. G. M. Dawson, in 1879. Here, as on Peace River, the valley is occupied for about twenty-five miles by the Fort St. John shales. These are succeeded by 100 feet of sandstones, representing the Dunvegan group, above which comes 350 feet of shales, holding numerous fossils, most of which belong to the typical Pierre and Foxhill fauna, but Benton forms were also found. The shales are overlaid by sandstones and shales, belonging, so far as known, to the Laramie, but it is probable that here, as in the plateaus south of Lesser Slave Lake, some of the lower beds may be of Foxhill age.

GENERAL GEOLOGY.

ARCHÆAN.

Archæan
area.

A small area of Archæan gneisses occurs in the north-eastern quarter of the region reported on, but they were only hastily examined. They occupy the northern shore and neighbouring islands of Lake Athabasca, and are also found in the islands of Lake Mammawee, and in the rounded knobs projecting above the delta deposits bordering Quatre Fourches River. The gneisses here have a typical Laurentian appearance. They are usually reddish, but in places are strongly and evenly banded with alternating red and dark tints. The texture varies from medium to fine-grained, and the foliation is usually distinct, the rock passing in one or two places into a mica or chlorite schist. Both hornblendic and micaceous varieties are present, but these minerals in many instances are largely replaced by chlorite. Epidote occurs in large quantities. The gneisses dip at high angles, and the strike varies from ten to twenty degrees west of north.

CAMBRIAN.

An examination of the southern shore of Lake Athabasca was made from the mouth of Athabasca River to near Point William. This shore, as a rule, is low, and is bordered for long distances by low bluffs, composed of recent sands and clays. At Pointe de Roche and at another point seven miles further on, the underlying rocks are exposed and consist of a granular siliceous sandstone, which, from its general character and position, probably belongs to one of the divisions of the Cambrian. For reference it may be called the "Athabasca sandstone." No fossils were found in it, nor was its contact with the overlying or underlying rocks observed. This sandstone is usually coarsely granular in texture, but passes occasionally into a fine-grained conglomerate. Its colour varies from white to dull red. Its bedding planes have been obliterated, but its general horizontal attitude is betrayed by the textural differences. It is cut by two systems of jointage planes, and in weathering, breaks into huge blocks, some of which contain several hundred cubic feet of material.

South shore of
Athabasca
Lake.

Athabasca
sandstone.

Numerous fragments, some of large size, of a mottled red and green fine-grained sandstone, somewhat similar in appearance to that found at Sault Ste. Marie, were noticed strewn along the track, but were not found *in situ*.

The Athabasca sandstone apparently extends all along the southern shore of Lake Athabasca, as specimens brought by Mr. Cochrane, in 1882, from the east end of the lake, cannot be distinguished in appearance from those collected at Pointe de Roche and neighbouring localities. Its extension southwards, has not as yet been approximately determined. On the north its junction with the Archæan is concealed beneath the waters of Lake Athabasca.

DEVONIAN.

Devonian limestones crop out from beneath the Cretaceous, along the northern part of the district. On the Athabasca they rise to the surface at Crooked Rapid, and occupy the bottom of the valley down to a point about ten miles below Calumet River, except in a few places where they are carried below the surface by synclinal folds.

Devonian
limestone.

Below this point they are covered by recent deposits, and their junction with the underlying rocks is concealed. From the Athabasca, the Devonian limestone extends in a broad band round the southern end of Birch Mountains, and across Lake Claire to Peace River, and up the latter stream to a point two miles above Vermilion Falls.

Distribution
of limestone.

Dip of limestone.

Characters of Devonian limestone.

Bituminous beds.

Absence of formations between Devonian and Cretaceous.

Fossils.

Range of Cretaceous.

Difficulty in classification.

The Devonian limestones on the Peace and Athabasca rivers have a general northerly dip of three or four feet to the mile, and are also affected in some places by a series of small, subordinate folds, few of which, however, succeed in bringing into view more than the upper 100 feet of the formation. The limestone is very uniform in character throughout the district. It is grayish or light yellowish in colour, and is evenly stratified, the beds ranging in thickness from two inches to several feet. It is usually more or less argillaceous, and in places passes into a calcareous shale. The purer beds are often nodular and crumbly, but resist denudation more successfully than the shaly varieties, and now frequently form long horizontal lines of relief, running across the faces of the exposures. Some of the beds are bituminous, but seldom to an important degree, and the sources of the oils which have saturated the overlying Cretaceous sands must occur beneath the exposed part of the formation. That the oils have risen from below, is shown by the cracks and fissures lined with bituminous matter which occur in the limestone in various parts of the district, and through which the liquid has evidently escaped.

The Devonian limestone is apparently succeeded conformably by the Cretaceous, and with the possible exception of a thin bed of conglomerate of limited extent, which occurs below Crooked Rapid on the Athabasca, the age of which is doubtful, the vast interval of time which separated the two formations, is, so far as observed, unrepresented, either by deposition or erosion. This can hardly be explained, except on the assumption that the formation during all this period, was buried far from land in the depths of some abyssal ocean, as the only other alternative, viz., that its surface represents a former base level of erosion, is, in view of the remarkable persistency of the upper beds, scarcely credible.

Lists of the Devonian fossils collected are given in the description of the Athabasca and Peace River sections.

CRETACEOUS.

The Cretaceous section in the Peace-Athabasca country includes beds ranging in age from the Laramie to the Dakota, but the lithological succession of the various divisions, differs from that which obtains on the Great Plains, and also varies in different parts of the district. This feature of the formation, together with the further fact that most of the fossils collected are new to science, and therefore useless for the purpose of correlating the beds here with known horizons elsewhere, makes it difficult to classify the different terranes in a satisfactory manner, and also renders necessary the provisional use of some

new names. The following illustration shows the succession of the various divisions of the Cretaceous on the two rivers, and also their ages, so far as the stratigraphical and palæontological evidence at hand admits :

Athabasca River Section.

Peace River Section.

Laramie.	Laramie.	Wapiti River sandstones.
Foxhill sandstone.	} Montana.	{ Foxhill sandstone.
La Biche shales (upper part.)		{ Smoky River shales.
Unrepresented.		Dunvegan sandstone.
La Biche shales (lower part.)	} Colorado.	{ Fort St. John shales.
Pelican sandstone.		{ Peace River sandstones.
Pelican shale.		{ Loon River shales.
Grand Rapids sandstone.		
Clearwater shale.		
Tar sands.	Dakota.	Unrepresented.

Laramie.—The Laramie occurs in the southern part of the district, and is well exposed in the plateaus south of Lesser Slave Lake. The north-eastern boundary of this formation crosses the Saskatchewan in Long. 112° 30' and runs in a north-westerly direction, crossing the Athabasca near the mouth of the Pembina, to the east end of Lesser Slave Lake. From this point it bends to the west, and extends in a sinuous line along the foot of the plateaus south of the lake, and thence in a westerly direction to Smoky River, beyond which its course, as yet, is only a matter of conjecture. An outlier of Laramie forms the upper part of Marten Mountain north of the east end of Lesser Slave Lake, and probably caps the highlands extending eastward from this elevation towards Pelican Mountain. Exposures of Laramie.

In the plateaus south of Lesser Slave Lake, the Laramie has a minimum thickness of 1,000 feet. It is practically horizontal and consists of yellowish and grayish flaggy and massive sandstones, often holding large nodules, alternating with grayish and dark clays and shales. Thin ironstone beds occur frequently throughout the section, and several seams of lignite were seen, the largest of which is three feet thick, but is of inferior quality. Fragments of fossil plants occur in some of the sandstones, but no determinable fossils of any kind were obtained. Character of beds.
No fossils obtained.

Montana.—This formation on the Athabasca and its tributaries is represented by about fifty feet of alternating sandstones and shales, exposures of which occur along the lower slopes of the Laramie plateaus south of Lesser Slave Lake, and by the upper part (about 700 feet) of the La Biche shales of Lesser Slave River and the Athabasca. The exact junction between the Montana and the Colorado was not definitely Beds of Montana age south of Lesser Slave Lake.

ascertained owing to the scarcity of fossils, and to the fact that the La Biche shales pass downwards from the Montana into the Colorado without any structural break or lithological change of any kind.

Fossils.

The fossils collected from the Montana on the Athabasca and on Lesser Slave Lake and River include :—

Pteria Nebrascana, Meek and Hayden.

Tancredia Americana “ “

Protocardia borealis, Whiteaves.

Lunatia concinna, Hall and Meek.

Anchura Americana, Meek and Hayden.

Baculites compressus, Say.

Montana beds
on Peace
River.

In the Peace River section the Montana is represented by the Upper or Smoky River shales, and possibly by the lower part of the Wapiti River sandstones. These occur south of the district now reported on, but were examined and described by Dr. G. M. Dawson in 1879.* The Smoky River shales are the equivalents of the Upper or Pierre portions of the La Biche shales of the Athabasca sections. They are 200 feet thick, and are described as dark grayish or bluish-black, thin-bedded shales, holding beds of ironstone and in some places large ferro-calcareous nodules. The fossils obtained from the Smoky River shales belong chiefly to the typical Pierre and Fox-hill fauna, and includes such well-known fossils as *Pteria linguiformis*, *P. Nebrascana*, *Nucula cancellata*, *Liopistha undata*, &c., but besides these, specimens of *Scaphites ventricosus*, a typical Benton species were also found.

Dunvegan
beds.

Dunvegan Group.—This name has been applied to a series of sandstones and shales, which are extensively developed along the Peace River valley, from about fifteen miles above the Smoky River Forks, up to the Cañon of the Mountain of Rocks. This part of the river was not visited during the present exploration, but was examined by Dr. Selwyn in 1875, and a description of the formation is given in the Report of Progress, Geological Survey of Canada, 1875-76. In 1879 the lower part of Smoky River was examined by Dr. G. M. Dawson, and the Dunvegan beds were found on it, underlying the Smoky River shales (Pierre), but in greatly diminished volume.†

Character of
Dunvegan
beds.

The character and age of the Dunvegan beds are fully discussed by Dr. Dawson in the report just mentioned, and but little additional information has since been obtained. They consist of grayish and yellowish flaggy and massive sandstones, often false-bedded and ripple-

* Report of Progress, Geological Survey of Canada, 1879-80, Part B, page 122.

† Report of Progress, Geological Survey of Canada, 1879-80, Part B, pages 116-122.

marked, alternating with grayish and dark shales, usually more or less arenaceous, and holding small beds of ironstone and thin seams of lignite. The thickness of the formation rapidly increases going westward towards the mountains, from 100 feet on Smoky River to 600 feet or more at Dunvegan, and nearly 2,000 feet at Table Mountain. The Dunvegan beds have not been detected east of Smoky River, and probably die away soon after crossing that stream, and they are not represented, so far as known, on the Athabasca.

Increase in thickness going west.

The fauna of the Dunvegan formation is remarkable for its varied character, as it contains fresh water shells like *Vivipara* and *Corbicula*, brackish water shells like *Corbula* and *Ostraea*, and such a strictly marine genus as *Inoceramus*. This assemblage of fossils, together with the general character of the beds, evidences estuarine conditions and deposition on an oscillating surface.

Fauna of Dunvegan beds.

The Dunvegan formation occupies nearly the same position stratigraphically, as the Belly River series of Assiniboia and Alberta, and may possibly be a continuation of it, but it differs in containing marine fossils, the fauna of the latter so far as known, being confined to fresh and brackish water species. It is also closely allied by its fauna to the Bear River formation of Wyoming, lately described by White and Stanton*. Two of the most characteristic species of the Bear River beds, *Corbula pyriformis* and *Corbicula Durkeii* occur in the Dunvegan formation, and most of the genera are alike. The position of the two formations in the Cretaceous is, however, different, as the Bear River beds are placed by the above writers below the Colorado, while the Dunvegan series overlies that formation.

Position in Cretaceous.

Colorado.—The beds assigned to the Colorado on Peace River are about 1,500 feet thick, and include in descending order, the Fort St. John shales, the Peace River sandstones, and the Loon River shales. The Fort St. John shales are exposed in the Peace River valley for some miles above and below Fort St. John and extend up Pine River nearly to the Forks. They are brought up here by a low anticlinal and disappear in descending Peace River near the mouth of Pine River north, and do not appear again until a point twenty-four miles above the Smoky River Forks is reached. Below this point they are exposed in the banks of the valley all the way to Battle River and beyond, and still further north form the upper part of the Buffalo Head Hills plateau. The Fort St. John shales have a minimum thickness of 700 feet, and consist throughout of brownish and dark grayish to black shales holding calcareous nodules, and in places a notable quantity of ironstone in nodules, lenticular beds and sheets. They are very unfossiliferous,

Colorado beds on Peace River.] 1 M

Character of Fort St. John shales.

* American Journal of Science, vol. XLIII., p. 91.

as with the exception of a few fish scales, no specimens were found in the numerous sections examined, from the Smoky River Forks northwards. In their outcrop near Fort St. John a species of *Inoceramus*, and *Buchiceras cornutum*, which is most probably an *Acanthoceras* allied to *A. Woolgari*, were found by Dr. Selwyn in 1875.

Characters of
Peace River
sandstones.

The Peace River sandstones underlie the Fort St. John shales, and appear from beneath the latter in descending the river, immediately below the Smoky River Forks, and are then exposed in the banks of the valley down to about three or four miles below Battle River. Exposures are confined entirely to the valley, as the slight southerly dip by which they are affected for some miles below the forks, fails to bring them to the surface of the plateau, and further down they become almost horizontal. The Peace River sandstones consist of heavy massive beds of yellowish and grayish soft coarse sandstones, alternating with bands of thin-bedded sandstones and shales. The massive beds have an occasional thickness of fifty feet or more, and weather into a series of steep cliffs separated by sloping terraces cut out of the shaly bands. Lignite seams occur occasionally, and hard sandstone concretions ranging from a few inches to ten or fifteen feet in diameter form a prominent feature of the formation. In descending Peace River, the Peace River sandstones become more argillaceous, decrease gradually in thickness and at length disappear a few miles below the mouth of Battle River. They occur along Loon River for some miles, nearly due east from the mouth of Battle River, but in diminished volume, and the exposures here mark approximately the northern limits of the formation in this longitude.

Fossils.

Fossils were found throughout the Peace River sandstones, but occur most abundantly near the base of the mountain. The fauna differs from that of the Dunvegan group in being strictly marine. (See list pp. 47-48.)

Loon River
shales.

The Loon River shales, the lowest division of the Colorado or Peace River, consist of about 400 feet of dark grayish to nearly black, soft shales, holding calcareous and ironstone nodules, interstratified with occasional beds of sandstone, impure limestone, and ironstone. Fossil wood was found in considerable quantities, scattered through this formation, and a lignite seam is said to exist some miles above Fort Vermilion, but was not seen. The Loon River shales appear in descending Peace River, about twenty miles above Battle River, and are exposed on the banks of the valley nearly all the way down to the Vermilion Falls. They also occur on the lower part of Loon River, and on Red River. They alternate above with Peace River sandstone, and below appear to rest directly on the

Devonian limestones, although the contact was nowhere seen. The fossils collected from the Loon River shales consist of numerous specimens of *Desmoceras affine*, Whiteaves, *D. affine*, var. *glabrum*, Whiteaves, and *Hoplites Canadensis*, Whiteaves.

The Colorado, in the parallel Athabasca section, resembles in its general features that on Peace River, but differs in detail. It includes, according to present evidence, the lower part of the La Biche shales, the Pelican sandstone and shale, the Grand Rapids sandstone, and the Clearwater shale in all about 930 feet of strata.

The lower part of the La Biche shales corresponds in a general way with the Fort St. John shales. They consist of soft dark grayish to black clay shales, differing in no respect lithologically from those forming the upper part of the formation, but have been separated from them on fossil evidence. The upper part of the La Biche shales holds a characteristic Pierre and Foxhill fauna, while in the lower part *Ostræa congesta*, *Desmoceras Athabascense*, Whiteaves, and *Acanthoceras Woolgari*, Mantell, occur. The La Biche shales are succeeded in descending order by the Pelican sandstone and shale, and the Grand Rapids sandstone, the probable equivalents of the Peace River sandstone. The Pelican sandstone is forty feet thick, and consists of a massive bed of soft grayish sandstone, which becomes hemitiferous above in some places. No fossils were obtained from it. The Pelican shale is ninety feet thick, and is argillaceous throughout. It alternates above with the Pelican sandstone, and appears to die out toward the northwest, as the thickness on Moose River is only a few feet, and it was not recognized at all on the north end of the Birch Mountain. The Grand Rapids sandstone is 300 feet thick, and is composed of massive cliff-forming beds of yellowish and grayish sandstone, separated by bands of thinly-bedded sandstones and shales. Lignite seams appear in places, and large, rounded sandstone concretions occur so abundantly in some of the beds, that they form a considerable portion of the substance of the formation. Fragments of Ammonites and other marine shells were found in the Grand Rapids sandstone, but no specimens perfect enough for determination were obtained.

The Clearwater shale, the lowest division of the Colorado on the Athabasca, holds a considerable proportion of sandstone interstratified in thin beds with the shales, and also a green sand bed, which is probably glauconitic. Mr. Ferrier, Lithologist to the Survey, reports on this rock as follows:—"After a careful examination of this section and comparing it with a series of typical glauconitic rocks from the Tertiary of various foreign localities, I can find no difference in character between it and them. The mineral agrees in all its characters

Colorado terranes on the Athabasca.

La Biche shales.

Pelican sandstone and shale.

Grand Rapids sandstone.

Clearwater shale.

Glauconitic bed.

with typical glauconite. Zirkel states* that the mineral, glauconite, is only single refracting. This must be an error, as the glauconite in all the slides examined was decidedly double refracting, but in weak colours. It has a slight resemblance to some varieties of Serpentine." Ironstone in nodules and beds is also present, and fossil wood occurs occasionally. The Clearwater shale has an average thickness of 275 feet, and occupies approximately the same stratigraphical position as the Loon River shale on Peace River, and the lower part of the Peace River sandstone. A number of fossils were collected from it, lists of which are given on pp. 31-32. The following list by Mr. Whiteaves includes all the fossils collected from the various subdivisions of the Colorado. As some of the species are undescribed, only the generic names of these can be given.

Character of
Clearwater
shale.

PELECYPODA.

Lima sp.

Pecten sp.

Camptonectes sp.

Modiola, allied to *M. tenuisculpta*, Whiteaves.

Nucula (*Acila*) sp.

Yoldia, like *Y. Evansi*, Meek and Hayden.

Trigonia sp.

Protocardium sp.

Callista tenuis, Hall and Meek.

Goniomya sp.

Mactra (*Cymbophora*) sp.

Teredo sp.

GASTEROPODA.

Lunatia sp.

Cinulia sp.

CEPHALOPODA.

Desmoceras affine, Whiteaves.

" " var. *glabrum*.

Desmoceras Athabascense, Whiteaves.

Hoplites McConnelli "

Acanthoceras Woolgari, Mantell.

Dakota age of Tar sands. *Dakota*.—The Tar sands underlying the Clearwater shale have been assigned to the Dakota, entirely on lithological and stratigraphical evidence, as no fossils were obtained from them. They rest on the Devonian limestones, and occur in the same position as the sands of undoubted Dakota age, which outcrop along the eastern edge of the

* "Die mikroskopische Beschaffenheit der Mineralien und Gesteine," Leipzig, 1873, p. 487.



R. G. McConnell, Photo, 1890.

VIEW ON ATHABASCA RIVER.
SHOWING TAR SANDS OVERLYING DEVONIAN LIMESTONES.

Cretaceous in Manitoba, and south of the International Boundary in Minnesota. They consist of an almost homogeneous mass of tar-cemented sands, ranging in texture from a coarse silt to a grit, and vary in thickness, where fully exposed, from 140 to 220 feet. They contain occasional thin beds of ironstone, and in two places lenticular beds of quartzite were noticed. Fragments of fossil wood occur throughout the formation. The Tar sands occur along the Athabasca valley from Boiler Rapid to a point about nine miles below the mouth of Calumet River, a distance of about ninety miles. West of the Athabasca they are soon concealed by the overlying divisions of the Cretaceous, but are exposed for some miles along the valleys of the tributary streams. They were not found on Peace River. East of the Athabasca they occur in heavy sections on the Clearwater, Pembina and High-bank rivers, but on Muskeg and Firebag rivers the sections are small, and the greater part of the material in this district has evidently been planed away by glacial action.

Character of
Tar sands.

GLACIAL GEOLOGY.

Boulder clays and the stratified sands and gravels by which they are usually accompanied, mantle the greater part of the region dealt with in the present report, so heavily and universally, as to conceal the older rocks nearly everywhere, except in the deep valleys of the main drainage channels, and along the escarpments of some of the plateaus. The glacial deposits have not been distributed uniformly, as in some of the old pre-glacial depressions they attain a thickness of 200 feet or more, while on the ridges they become greatly attenuated, and in some places the boulder clay disappears and the superficial deposits are represented only by the modified drift. Their influence in levelling the country has, however, been destroyed to some extent by irregularities in their own deposition, resulting in the production of the rolling type of country which prevails throughout a large part of the region. Another feature directly due to the unequal distribution of the glacial deposits is the number of small lakes and ponds inclosed in shallow land-locked basins in the drift, which are met with throughout the district, and which occur so frequently in some localities as to cover a considerable proportion of the surface. The present lakes and ponds represent only a part of those which originally existed, as many of them have become filled up with sphagnum and converted into muskegs and marshes.

Distribution
of glacial
deposits.

The glacial beds are very uniform in character, and will only require a brief description. On the Athabasca, boulder clays of the ordinary type, usually underlaid by stratified sands and gravels

Glacial beds
on the Atha-
basca.

Glacial beds
well repre-
sented below
the Forks.

of the age of the Saskatchewan gravels, are met with, capping most of the sections between the mouth of Lesser Slave River and the Pelican, but from the latter point to the Forks, they were seldom observed, and the glacial deposits are represented chiefly by a thick bed of gravel and boulders of all ages, piled confusedly together, accompanied in some places by sands and clays. Below the Forks the glacial beds increase in importance, and from Calumet River to the delta, they form the principal feature in the geology of the Athabasca valley. They consist in this portion of the valley, of boulder clays, underlaid by stratified sands, and overlaid by a bed of coarse sand and pebbles. The lower sands are never fully exhibited, but show an exposed thickness in different sections of from thirty to 100 feet. They are unconsolidated, and in some places are interstratified with beds of gravel and layers of rolled sandy nodules, cemented by tar. The sands are characterized in many of the sections by a peculiar reddish colour, but in other places yellowish and brownish tints prevail. They are exposed in numerous sections on both sides of the valley, nearly to the head of the delta.

Red boulder
clay.

The boulder clay is divided by a difference in coloration into two parts. The lower division is characterized by a distinct reddish tint, while the colour of the upper part is usually a dark gray. The line between the two boulder clays, while often indistinct, is sometimes clearly drawn, and in one place, a short distance below the mouth of Firebag River, they are separated by stratified sands. The section at this point in ascending order, consists of :—

	Feet.
Soft sands, holding layers of sandy tar nodules....	50
Red boulder clay.....	20
Sands, similar to those below boulder clay.....	20
Dark boulder clay.....	2
Sands and gravels, partly concealed.....	15
	<hr/> 107 <hr/>

Section below
Firebag
River.

A mile below the last section, the glacial deposits consist of sixty feet of yellowish and brownish sands, overlaid by twenty feet of reddish clay, holding scratched and polished boulders, above which comes ten to fifteen feet of coarse sands and gravels, part of which is saturated with tar. The red boulder clay is well exposed in the vicinity of Red Earth Creek, and was traced down the river to a point about ten miles below Pointe aux Trembles.

Beds overlying
boulder
clay.

The boulder clay is overlaid in most places by sands and gravel and pebble beds, a notable feature of which is the amount of tar they con-

tain. The tar in these beds is not distributed uniformly like that in the Tar sands of the Cretaceous, but occurs in irregular patches, from a few feet to 200 feet in length, and from a few inches to five or six feet in thickness. The tarry patches, as a rule, immediately underlie the surface, and are confined to the coarse beds. The tar is in a soft condition, and the percentage is as high as in the most saturated portions of the Tar sands of the Cretaceous. The tar in these beds is mixed with fragments of lignite and shale, and appears to have been derived from the Tar sands of the Cretaceous and transported to its present position in some way not fully understood. It has not ascended from below, as no trace of it was observed in the underlying beds, and the compact boulder clays, when present, would necessarily stop its upward flow. Tarry masses of sand and gravel occur at intervals, underlying the surface down to a point about twelve miles below Pointe aux Trembles. Below this point the cut banks show only stratified sands, interbedded in places with layers of rolled tar nodules.

Tar in glacial beds.

The stratified sands and gravels, both below and above the boulder clay in the lower part of the Athabasca valley, are evidently lacustrine in origin and were doubtless deposited along the southern margin of the greatly extended Lake Athabasca of the Glacial Period. The upper sands extend down to and form largely the present shores of the lake, except when they are covered by the more recent delta deposits.

Origin of stratified beds.

The Athabasca, in the lower thirty miles of its course cuts through its own delta, and beds of this age, although partly the product of Peace River, extend west of the Quatre Fourches River to Peace River and beyond, and underlie the wide plain west of Lake Athabasca, on which are situated the separated portions of the lake known as Lakes Claire and Mammawee, together with numerous other nameless sheets of water.

Delta deposits.

In the plains between the Athabasca River and Birch Mountain, and on the eastern slopes and summit of the latter, the boulder clay, as shown by the Moose River section, attains an exceptional development, in some places being fully seventy-five feet thick. The lower sands and gravels appear to be absent here, but stratified gravels were found in one exposure alternating in thin beds with the boulder clay. West and south-west from the Birch Mountains, the rolling plains stretching towards Lesser Slave Lake and Peace River, are everywhere drift-covered but full sections are seldom seen, except near the mouths of the streams flowing into the two trunk rivers, as owing to the immature condition of the drainage system, the valleys are seldom excavated sufficiently deep to reach the older rocks, and in most cases they are only a few feet deep.

Glacial beds on eastern slopes of Birch Mountain.

Immature drainage system.

Boulder clay
in Peace
Valley.

In the deep valley of Peace River, boulder clays often associated below with stratified beds, are found overlying the older rocks in most of the sections examined. In the upper part of the valley the boulder clay is of the normal type, but for some miles above Fort Vermilion, down to the Vermilion Falls, and up the Red and Loon Rivers for a considerable distance above their mouths, reddish clays are intermixed in patches and bands with the ordinary boulder clay. The reddish clays are occasionally pure, but as a rule they carry boulders, are more or less arenaceous, and are only distinguished from the associated clays by their colour.

Red clays.

Direction of
movement of
Great Glacier.

The red boulder clay affords a means of tracing the general direction of movement of the Great Glacier, superior even to that afforded by glacial striæ, as the latter are apt to be deflected locally by the contours of the country. On the Athabasca these clays are found, from above Red Earth Creek down to a point about ten miles below Pointe aux Trembles, below which the boulder clay is covered by more recent deposits. On Peace River the red boulder clay occurs on the lower parts of the Red and Loon Rivers, and along the Peace River from the mouth of Red River up to Fort Vermilion and beyond. A line running 12° N. of W. from Pointe aux Trembles to the mouth of the Loon on Peace River, would pass through the centre of the red boulder clay belt. The glacier travelling along this line must have moved up the eastern slope and over the summit (1,500 feet) of Birch Mountain. That it did so, is further shown by masses of Tar sands occurring in the drift on the summit of this plateau, which could only have been derived from the exposures in the Athabasca valley, many hundreds of feet lower down. The nearly easterly movement of the glacier west of Athabasca and Great Slave Lakes, taken in connection with the southerly movement south of Lake Athabasca, and its northerly movement on the Mackenzie, shows that the ice must have radiated from a centre situated somewhere between the eastern ends of these two lakes and Hudson Bay.

Distribution
of red boulder
clay.

ECONOMIC GEOLOGY.

Gold on Peace
River.

Gold.—Gold was found in many of the bars along Peace River, and in several places in sufficient quantities to deserve attention. Three miles above the mouth of Battle River, a large bar nearly a mile long, on the left bank, was examined, from which we obtained fifteen to twenty *colours* of fine gold, by washing a few handfuls of the mixed gravel and sand in an ordinary frying pan. We tried the bar at several points, and always with the same result. A small stream descends from the plateau on the opposite side of the river, and by

leading its waters across the river, which is here about 1,000 feet wide, the bar might be easily and inexpensively worked on a large scale. Twelve miles further up the river, another bar was examined, which yielded from twenty to forty *colours*, when washed in the same way. Numerous other bars occur in this portion of the river, which would probably give as good results as those examined.

The presence of fine gold in some quantity in the bars above the mouth of Battle River is probably due to the diminution in the strength of the Peace River current which takes place here, and its consequent loss of transporting power. The same fact is shown in the gradual substitution of sand bars for gravel bars which occur at the same point.

Cause of deposition of gold.

Besides the gold on Peace River, two *colours* were also washed out of a bar on Loon River, an eastern tributary of the Peace.

Iron.—Clay ironstone in nodules and thin beds, is of universal occurrence in the Cretaceous shales of the region, but is especially abundant in some of the outcrops of the Fort St. John shales on Peace River, between Battle River and the mouth of Smoky River. The ironstone here, owing to the rapid erosion of the soft shales has been silted out, and in many places forms thick accumulations at the foot of the cliffs lining the valley, some of which may prove to be of economic value. The Pelican sandstone on the Athabasca is usually capped with a bed of hemitiferous sandstone varying in thickness from a few inches to four or five feet. A specimen of this rock was examined in the laboratory of the Geological Survey, and found to contain 12.4 per cent of metallic iron.

Distribution of clay ironstone.

Hemitiferous sandstone.

Lignite.—Lignite was found in the Peace River sandstones on the Peace River in several places, but in seams too small to be workable. It also occurs in the plateaus south of Lesser Slave Lake. In one section at the latter place, four seams ranging in thickness from one to four feet, besides a number of smaller ones were found, distributed through about 1,000 feet of sandstones and shales. Drift lignite was also found in Marten River near the base of Marten Mountain, but it was not traced to its source. On the Athabasca, the Grand Rapids sandstone is lignitiferous, some of the seams being from four to five feet thick, but the quality is usually inferior. Several small seams also occur imbedded in the Tar sands.

Lignite.

Salt.—Mineral springs holding considerable percentages of sodic-chloride occur on the Athabasca at La Saline, twenty-eight miles below the Forks, and about two miles above the mouth of Red Earth Creek (see p. 36). Samples of the water have been analysed in the Survey laboratory by Mr. Wait, with the following result.

Mineral springs.

Grains of saline constituents in one imperial gallon—at 60° F.

	Red Earth Creek.	La Saline.
Chloride of potassium	4.89	121.87
“ sodium	860.28	4,475.69
“ magnesium		77.25
Sulphate of lime	228.10	394.12
“ magnesia	43.21	85.05
Total	1,136.48	5,153.98

Specific gravity at 60° F. 1.012 1.052

Saline springs of small volume also occur on the Pembina River and at Tar Island on Peace River.

Gypsum at
Peace Point.

Gypsum.—Gypsum is deposited in small quantities by the mineral springs at La Saline, and it also occurs on Peace River between Bouillé Rapid and Peace Point, where beds ten to fifteen feet in thickness are said to exist. Blocks of gypsum several feet in diameter were found on Peace River above its confluence with Loon River, and on Red River, a few miles above its mouth. They have probably been derived from the Peace Point exposures, and carried up the valley of the Peace River by ice during the Glacial Period.

Gas springs
on the Atha-
basca.

Natural Gas.—The most important natural gas spring in the district occurs on the Athabasca at the mouth of Little Buffalo River. The gas here forces its way up from the Tar sands, through 250 feet of the Clearwater shales and issues from the surface in numerous small jets distributed over an area, fifty feet or more in diameter. Some of the jets burn steadily when lighted, until extinguished by heavy rains or strong wind, and afford sufficient heat to cook a camp meal. A second spring was noticed on the left bank of the Athabasca about thirteen miles below the mouth of the Pelican River. The volume of gas escaping here is less than at the mouth of Little Buffalo River, and in order to reach the surface it is obliged to penetrate 570 feet of shales and sandstone which here overlie the Tar sands. Escaping jets of gas were also noted at several points further up the river, but these were mostly small, and may possibly be due to decaying vegetable matter. On Peace River natural gas issues in small quantities from the Tar spring on Tar Island. The natural gas springs have less value in themselves at present, than in the indications they afford of the existence of petroleum beneath.

Gas spring on
Tar Island.

Age of Tar
sands.

Bitumen.—The Tar sands, the principal bitumen bearing formation of the district, are described in a preceding part of the report. This unique formation is of Dakota age, and constitutes in this region

the basal member of the Cretaceous series. It rests unconformably on the Devonian, and is exposed overlying the latter along the valley of the Athabasca for a distance of ninety miles. Lithologically it may be described as a soft sandstone, the cementing material of which is a bitumen or inspissated petroleum derived from the subjacent limestones. The boundaries of the Tar sands were only precisely defined at a few points, but they were estimated to have a minimum distribution of fully 1,000 square miles, where either completely uncovered, or buried beneath a part of the overlying Clearwater shale on the highlands, and exposed in the river valleys. They vary in thickness where the section is complete, from 140 to 225 feet. The bitumen is unequally distributed through the sands, in a few places merely staining the grains, but in most of the sections examined it is present in sufficient quantity to render the whole mass more or less plastic. The following calculation, which is extracted from the Summary Report for 1890, although it can only be regarded as an approximation, yet will serve to give some idea of the enormous outpouring of bituminous substances which has taken place in this region.

Distribution
of Tar sands.

"An analysis by Mr. Hoffmann of a specimen collected some years ago by Dr. Bell, gave by weight :—

Bitumen	12.42
Water (mechanically mixed).....	5.85
Siliceous sands.....	81.73

"A cubic foot of the bituminous sand rock weighs, according to Mr. Hoffmann, 117.5 lbs. This figure multiplied by the percentage of bitumen 12.42 gives 14.59 lbs. as the amount of bitumen present in a cubic foot; or $\frac{14.59}{63.5} = 22.9$ per cent in bulk. Taking the thickness at 150 feet, and assuming the distribution as given above at 1,000 square miles, the bituminous sands in sight amount to 28.40 cubic miles. Of this mass, if the preceding analysis is taken as an average, although it is probably rather high 22.9 per cent in bulk, or 6.50 cubic miles is bitumen. The amount of petroleum which must have issued from the underlying limestones to produce 6.50 cubic miles, or by weight approximately 4,700,000,000 tons of bitumen, cannot now be estimated, as the conditions of oxidation and the original composition of the oil is unknown. It must, however, have been many times greater than the present supply of bitumen."

Amount of
bitumen.

The commercial value of the Tar sands themselves, as exposed at the surface, is at present uncertain, but the abundance of the material, and the high percentage of bitumen which it contains, makes it probable that it may, in the future, be profitably utilized for various purposes, when this region is reached by railways. Among the uses to which

Commercial
value of Tar
sands.

it is adapted, may be mentioned roofing, paving, insulating electric wires, and it might also be mixed with the lignite which occurs in the neighbourhood, and pressed into briquettes for fuel.

Probability of finding oil.

The Tar sands evidence an upwelling of petroleum to the surface unequalled elsewhere in the world, but the more volatile and valuable constituents of the oil have long since disappeared, and the rocks from which it issued are probably exhausted as the flow has ceased. In the extension of the Tar sands under cover the conditions are different, and it is here that oils of economic value should be sought. In ascending the Athabasca, the Tar sands are overlaid at Boiler Rapid by a cover of shales sufficient to prevent the oil from rising to the surface, and in ascending the river, this cover gradually thickens. The geological attitude of the shales is not the most favourable, as the beds dip away from the outcrop at the rate of five to ten feet to the mile, and it is possible that a part, or even the whole of the oil may have flowed northwards and eastwards through the sands, and escaped where these come to the surface. It is unlikely however, that all the oil has escaped in this manner, as small anticlinals in the covering beds are almost certain to exist, and a differential hardening of the beds themselves may serve to inclose reservoirs or inverted basins of large capacity. It is also possible that the sands at their outcrop, may by the deposition of tarry substances be plugged tightly enough to prevent further egress. Favourable indications of the presence of oil in the vicinity of the Athabasca, are also afforded by the existence of the natural gas springs referred to on a previous page.

Drilling desirable.

The question of the continuity of the Tar sands and their petroliferous character under cover, can, however, only be settled in a decided manner by boring, and it is highly desirable that drilling operations should be undertaken for this purpose. At the mouth of Pelican River the Tar sands are probably covered by about 700 feet of strata, and this amount increases as the river is ascended. At the Athabasca Landing, if the formation extends to that point, it probably lies at a depth of from 1,200 to 1,500 feet below the surface, but the distance of the Landing from the outcrop of the Tar sands, and the variability in the thickness of the Cretaceous formations make it impossible to give more than a rough estimate.

Indications of oil on Peace River and other places.

Indications of the presence of oil in the district is not confined to the Tar sands, as on Peace River and Lesser Slave Lake inspissated bitumen was found in a number of places lining cracks in nodules, and at Tar Island in Peace River, small quantities of tar are brought to the surface by a spring. Tar springs are also reported from several

other points, but their existence lacks verification. North of this district tar occurs at intervals in the Devonian limestones exposed along the valleys of Slave River and the Mackenzie, all the way to the Arctic Ocean.

