PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF LANDS

HON. T. D. PATTULLO
Minister of Lands

Lands Branch

REPORT OF OIL SURVEY

IN THE

PEACE RIVER DISTRICT

1919

BY J. C. GWILLIM

PRINTED BY
AUTHORITY OF THE LEGISLATIVE ASSEMBLY.

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VICTORIA, B.C., February 27th, 1920.

To Colonel the Honourable EDWARD GAWLER PRIOR,

A Member of the King's Privy Council for Canada,

Lieutenant-Governor of the Province of British Columbia.

MAY IT PLEASE YOUR HONOUR:

Herewith I beg respectfully to submit the Report of an Oil Survey in the Peace River District of British Columbia in 1919 by J. C. Gwillim.

T. D. PATTULLO,

Minister of Lands.

OIL SURVEY
IN THE PEACE RIVER DISTRICT.

In that portion of British Columbia which lies east of the Rocky Mountains, known as the Peace River District, there is a great area of country similar in geology and topography to the foot-hill country of Alberta. The Alberta foot-hills have in them coal of good quality and large extent, also a few oil-wells, numerous gas-seepages, and some oil-seepages and residues.

It seems not unlikely that these conditions of coal and oil occurrence may be found in the British Columbia portion of the Peace River District, where the Lower Cretaceous strata, which bear these minerals in Southern Alberta, occur under the same conditions. Hence it was considered advisable to place a reservation on these minerals for such a time as may be needed to make some examination of these lands.

For many years there has been an expectation that commercial bodies of oil will be found at some places along the belt of foot-hills which stretches from the boundary of Southern Alberta north-north-westward to and beyond Peace River, or in the plains which lie some distance to the east of the foot-hills.

The occurrence of oil-seepages in Southern Alberta and at places along the basin of Mackenzie River, besides the great outcropping of tar-sands on Athabaska River and tar-springs on Lower Peace River, gave evidence that this great stretch of country was, at least potentially, oil-bearing if suitable structure of the rocks would permit it to accumulate in commercial quantities; such conditions induced the Imperial Oil Company to employ twenty geologists during the season of 1919 and spend half a million dollars on it.

The recent activity in 1913-14 in oil lands in Southern Alberta was caused by finding a light oil, almost a gasoline, in the Dingman well near Black Diamond, thirty miles south of Calgary, in 1913. This Black Diamond field has five wells producing in all fifty barrels a day during the year 1918. A great extent of country was then more or less examined, and holes were put down to depths of 1,000 to 4,000 feet.

The lack of good results is due chiefly to misplaced drilling, often in broken ground, often on wrong structure of the strata, and at places where the oil-bearing strata were beyond the reach of a drill.

Later some activity was shown in the districts east and north of Edmonton, where the assumed oil-bearing strata are within drilling distance, as on Lower Athabaska and Lower Peace River. The results at these places are small amounts of a thick viscous oil from Lower Cretaceous strata which are almost flat-lying.

Within the past year some great oil corporations have interested themselves in this Western and Northern Alberta field; one of which corporations sought concessions in order to examine and develop; the other carried on an investigation of it at great expense during the past summer, and is now drilling and preparing to drill at places as far apart as Southern Alberta and in the Mackenzie River basin.

Such being the conditions to the south, the east, and the north of the Peace River District in British Columbia, it appeared worth while to at least make a reconnaissance of it, similar to such work as was being done along the same foot-hill belt by the Imperial Oil Company.

Before describing the work done within the British Columbia boundaries, north and south of Upper Peace River, it is necessary to give an outline of the general geology in relation to oil-bearing possibilities, also to understand the conditions which are favourable to the origin and retention of oil.

The geological conditions and structure of Western Alberta and the Peace River District are very similar, all the way from the Montana boundary to the Liard River, a distance of over 800 miles, 400 of which are in British Columbia.

There is the same upthrust and overthrust of the Palæozoic rocks of the Rocky Mountains front ranges, which crumpled up the overlying Cretaceous formations and caused the foot-hills,

a belt of faulted and sharply folded rocks, known as the "Disturbed Belt"; east of this belt the rock folding has been less intense—it dies away in gentler undulations until the strata dip eastwards to form a long parallel syncline or trough, which underlies Calgary, Edmonton, and Dunvegan, on Peace River; still farther east the strata incline upwards toward the great plains and then flatten out.

It is on the two sides of this great syncline or trough that the most likely horizons for oil and gas occur, also the most favourable structure within reach of drilling operations, for the most hopeful Lower Cretaceous strata are too deeply buried beneath the syncline.

Deep boreholes put down along the eastern margin of the great syncline have met *gas* at Bow Island, Medicine Hat, east of Edmonton, on Athabaska River, and other places. Some thick *oil* and *tar* have been found in boreholes east of Edmonton and on Lower Athabaska and Lower Peace Rivers, but neither the quality nor quantity have so far been encouraging.

Passing over to the western margin of the great syncline and between it and the "Disturbed Belt" of the eastern face of the Rocky Mountains, a lighter, more valuable oil has been found at places northwards from the Montana boundary to Bow River. It is in this strip that the Black Diamond field occurs; its total daily output is small, not over 50 to 100 barrels a day.

It is possible that somewhere along this foot-hill zone oil in greater quantities may be met with; it is a high-priced oil and likely to occur in narrow fields which are not to be found without close work and many trials by rather deep holes.

Concerning the formations found in the foot-hill belt, it is believed that these were, when laid down as sediments, not far from the ancient western shore of the Cretaceous Sea; hence they are likely to consist of coarser material, such as sandstones and conglomerates; they are also likely to be thicker than their contemporaneous equivalents deposited as silt or mud farther eastwards on a marine floor. Thus the Bullhead sandstones of Hudson Hope are coarse material laid down in brakish water, while their probable equivalent, the Peace River sandstones and Loon River shales, are of much finer material and less thickness. So that, although the geological horizon is believed to be the same, the constituent material is quite different, and it may be that they differ widely in oil-bearing qualities.

We know very little of the origin of any oil so far found; broadly, it must be derived from the strata in which it occurs or from below them, for where water is present oil is unlikely to sink or descend, for water displaces it or forces it up against an impervious roof. If the origin of this oil is credited to buried organic material, it may have its source in any bed or stratum, such as limestones or shales, containing this material.

The Devonian limestones underlie Lower Peace River and Athabaska, and as they carry oil-seepages themselves may be the source of oil in these districts. In the foot-hills belt the underlying sediments are Jurassic and Triassic.

There is no certitude in the matter of oil origin. We can only look for suitable geology, structure, and depth. Conditions which favour it are a porous stratum, usually sandstones, but sometimes shale or limestone. This porous stratum should be arched up as an anticline or dome and sealed by overlying shales or mud. Sometimes the arch is not necessary, as the oil may be caught against a sealed fault or other capping.

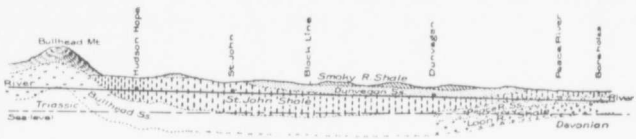
The oil of Black Diamond field in Southern Alberta, the tar-sands of Athabaska, and the heavy oil of Lower Peace River occur in the lowest Cretaceous strata; these have different names in different localities, but are believed to be of much the same geological horizon, and they rest upon the rocks of an earlier period, Jurassic, Triassic, and Devonian, in these different localities.

The Kootenay formation, in which the Black Diamond oilfield probably occurs in Southern Alberta, has its counterpart in Upper Peace River in the Bullhead sandstones; both are coal-bearing in their upper portions, and both are brought up to the surface in violent folds along the line of the "Disturbed Belt," just east of the Limestone or Palæozoic Mountains; they do not show much evidence of oil residues or leakage along this line of outcrop, but this may have no great significance, as such are often absent in known oil-bearing strata.

Above the Kootenay and Bullhead sandstones lie the impervious shales called Benton in Southern Alberta and St. John on Peace River.

The geological sequence on Peace River itself may be tabulated as follows:—

Upper Peace River.	Dunvegan.	Peace River Crossing.
Remnants	Smoky River shales	Absent.
Dunvegan sands	Dunvegan sands	Absent.
St. John shales	Buried in syncline	St. John shales.
Bullhead sands	Buried in syncline	{ Peace River sands. { Loon River shale.
Devonian		Triassic.



Generalized Cross Section

The Peace River sandstones and Loon River shales are considered to be the eastern, seaward, equivalent of the Bullhead western shore deposits; both are Lower Cretaceous, the one lying on Devonian rocks, the other on Triassic sandstones and shales. Between these two is the great syncline or trough which buries them so deeply at Dunvegan that the upper formations alone rise to the river and prairie levels.

Within the area covered by our traverse on Upper Peace River the Upper Cretaceous formations, Smoky River and Dunvegan, occupy the mountain masses and do not offer a good structure for the retention of oil. The main valleys, however, have been cut quite deeply in some places into the underlying St. John shales. These shales in turn overlie the Bullhead sandstones.

Assuming the Bullhead standstones, or the Triassic below it, to be the most likely oil-bearers, our work then was to find suitable structure and reasonable depths to reach desired strata. Hence the chief objects of our survey were to get a general knowledge of the localities where the St. John shales were most deeply eroded or cut into, so that the drilling distance might be shortened; also to find such conditions of folding or arching in them as are usually considered requisite for forming oil-reservoirs beneath an impervious shale such as the St. John formation.

On June 20th I received instructions to proceed to Peace River and conduct such examination as was possible during the summer. Three other men were engaged, all of whom were, or had been, Peace River men and knew the country. L. M. Bower, a returned soldier from Finlay Forks, went with me from Vancouver; H. C. Garbitt, packer, and his outfit, and E. Ouelette, cook, were engaged at Hudson Pope. We arrived at Hudson Pope on June 7th, and left it on the 10th for a trip up the Peace River to 12-Mile Creek and to the South Fork of Halfway River, forty-four miles north of Hudson Hope.

On July 23rd, in company with Dr. J. S. Stewart, of the Dominion Geological Survey, we left for a traverse of the country south and south-west of Peace River Block. We returned to Hudson Hope on September 3rd; then came down the Peace River 240 miles in an open boat to the town of Peace River; thence to Victoria on September 18th.

In such work a geologist does not usually *find* oil; his work is to trace out oil-bearing horizons and favourable structures of the overlying strata, also to examine any seepages, residues, or other evidences. I saw none, and only heard of one occurrence of bitumen or tarry residue which appears to be true.

I do not think that the Imperial Oil geologists doing similar work in adjacent areas, and on some of the same area as myself, found or certified such seepages or residues, excepting in the Dunvegan sandstones on Pouce Coupe River within the Peace River Block.

Hence our work was spent on tracing out formations and structures. Assuming that some portion of the Lower Cretaceous sandstones, or the underlying Triassic shales and sandstones, may be an oil horizon, we tried to locate places where these would be within reach of a drill

and of a structure suitable for retaining oil. The Upper Cretaceous St. John shales and Dunvegan sandstones might also carry oil, but in the area examined they are not structurally hopeful.

We were on the trail fifty-six days; mostly Indian hunting-trails, brushy and often wet. During this time we averaged eleven miles a day pack-train travel and could only examine the country in a reconnaissance way. The trails usually follow valleys which are here deeply cut down into the strata and give good exposures of them. When crossing the mountain masses or uplands between these valleys there was little to see but thick woods, unless it was a general view from some high point, such as Tuskoola Mountain, 5,000 feet, or Salt Hill, 4,000 feet altitude.

In doing this rough or preliminary survey of the geological conditions I was accompanied for most of the season by Dr. Stewart, whose former work in Southern Alberta and experience of the Middle West and Southern United States oilfields made our work much more certain than it would otherwise have been, for no geologists have preceded us in many places. The packer also contributed greatly in knowing the trails and country; we lost no time by mistakes, inefficiency, or casualty.

PHYSIOGRAPHY.

Compared with similar areas of Southern Alberta foot-hills, this Peace River District shows a greater magnitude in several ways. The streams are larger, the mountain masses between them are less cut up or dissected by tributaries, and the geological horizons are not so often repeated by block faulting or folding. The strata, after passing eastwards from the upthrust and crumpling of the Rocky Mountains proper, roll gently or undulate until they flatten out and decline at low angles beneath the great trough or syncline which crosses Peace River near Dunvegan. The general altitude of the deeply cut major valleys is from 1,750 to 2,800 feet, and of the mountain masses between them 3,000 to 5,000 feet above sea-level.

The line of abrupt or disturbed geology adjacent to the Rocky Mountains limited our field-work in that direction; such places are not favourable; they are marked on an accompanying map, so also is the line of gentle dip towards the great syncline. This strip of country between these two lines is the portion worth investigation.

In this strip of country traversed by us from the South Branch of Halfway River, forty-four miles north of Hudson Hope, to Flat Creek, ninety miles south-east of it, these formations are met with in descending order:—

(1.) Smoky River shales as remnants on hill-tops.
(2.) Dunvegan sandstones, 530 feet according to McLearn.
(3.) St. John shale, 2,100 feet according to McLearn.
(4.) Bullhead sandstone, 2,000 feet according to McLearn.
(5.) Triassic shales and sandstones, presumably below.

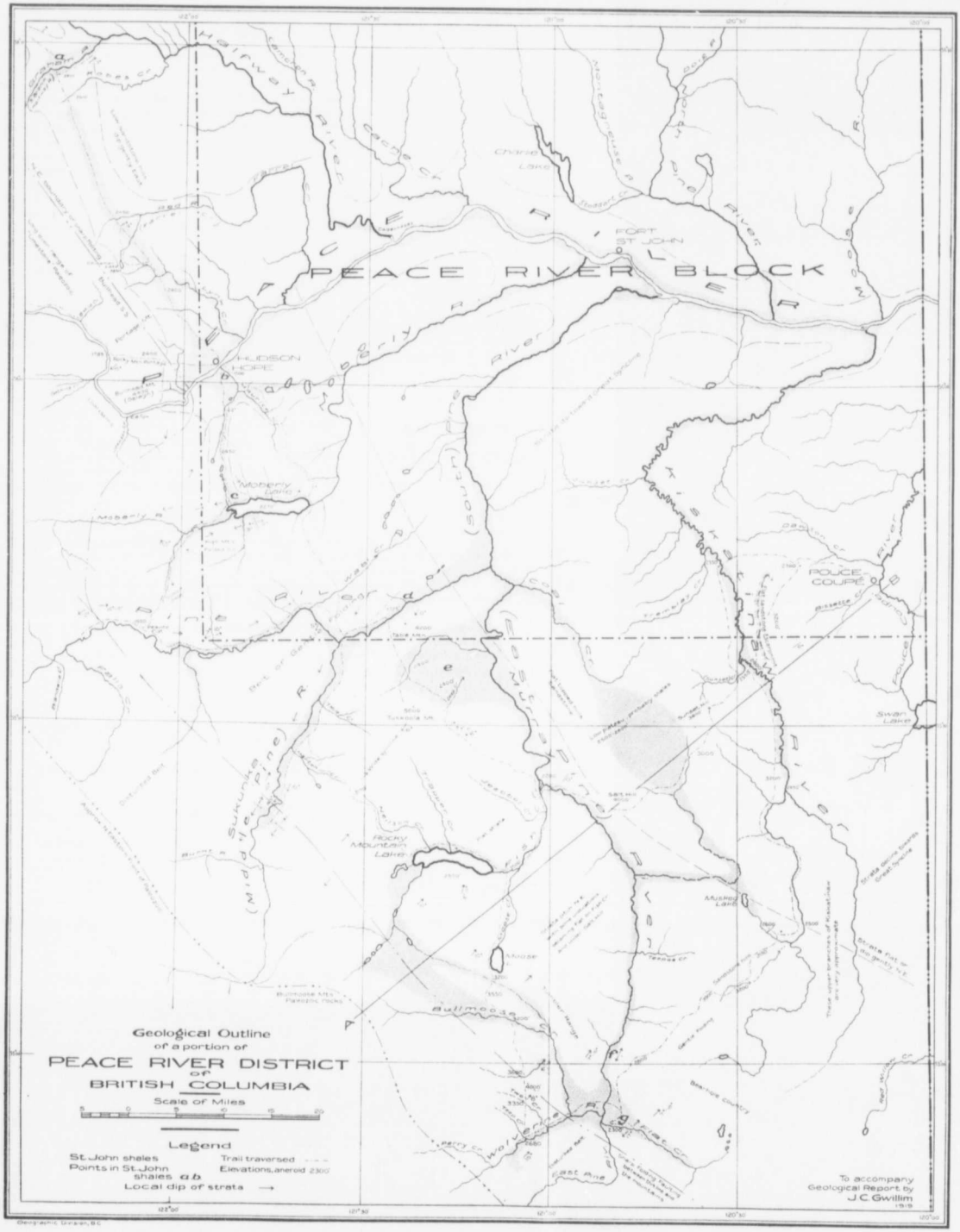
These thicknesses of strata are as estimated by F. H. McLearn, of the Dominion Geological Survey, during his examination of the Peace River section from the Parle Pas Rapids to Vermilion Chutes in 1917. (Summary Report, 1917, Part C.) These estimates may not apply to the country south of Peace River, but are a guide.

Within the strip under consideration the Smoky River shales occur as remnants high up in the hills, the Dunvegan sandstones form the upper hillsides, and the St. John shale is more or less deeply cut into by the main valleys and depressions.

The Bullhead sandstone is everywhere covered, and only appears along the eastern edge of the more severe folding within the "Disturbed Belt," as at Hudson Hope Canyon, and on the upper branches of the Moberly and Pine Rivers.

These Bullhead sandstones are considered by McLearn to be the shoreward equivalent of the Peace River sandstones and Loon River shales. It is near the base of the latter that oil is found on the Lower Peace River at about 1,100 feet below the river-level. These are the lowest Cretaceous rocks of the western plains; the Kootenay formation of Southern Alberta, also oil-bearing at Black Diamond field, is probably their southern representative; it is also a shoreward coarse sediment, similarly coal-bearing, in its upper portion, as Bullhead is.

In this connection it should be understood that the shore of the Early Cretaceous sea lay more or less where the present upthrust Rocky Mountains now are; the sediments deposited in brackish water along this shore were gravel and sand; farther east and northwards the sediments of the same period were more muddy or fine, and were laid down on a marine or sea


PEACE RIVER BLOCK
FORT ST JOHN
HUDSON HOPE
POUCE COUPÉ
Geological Outline
of a portion of
PEACE RIVER DISTRICT
of
BRITISH COLUMBIA
Scale of Miles
Legend
St. John shales
Points in St. John shales a, b
Local dip of strata
Trail traversed
Elevations, aneroid
To accompany Geological Report by J.C. Gwillim 1919

floor; thus, while Bullhead sands were accumulating along the shore-line, Loon River silts and shales, with some thin beds of fine sands, were accumulating on the sea-floor 200 miles eastwards and north-eastwards where Lower Peace River now is.

The chief factors, then, in favour of the Bullhead sandstones as an oil horizon are:—

(1.) Its geological equivalency to the oil- or tar-bearing strata of Lower Peace River, Athabaska River, and of the Black Diamond light oils in Southern Alberta.

(2.) These Bullhead sandstones are structurally favourable; that is, there are rolls, saddles, or anticlines, covered by St. John shale, which seems quite impervious enough to hold down any oil beneath them.

The chief factors against the Bullhead subaerial sandstones as a receptacle of oil are:—

(1.) McLearn thinks them "too massive to serve as a suitable reservoir, and in such strata the presence of oil is improbable."

(2.) We have no proof that oil exists in them or below them, even if they are porous enough to receive it.

However, possibilities are in them sufficient to justify the extensive reconnaissance of the Imperial Oil Company in adjacent areas and of the work done in the British Columbia area last summer. This applies especially to the first down-warp, roll, or sealed fault between the uprising strata of the great syncline trough and the edge of the broken or "Disturbed Belt" farther west. Thus any gas or oil within the syncline might be pushed up westwards by water-pressure to lodge at the first suitable structure approaching the foot-hills. To drill and prove them requires careful choice of location and much time and money, for unless oil is met within the upper portion of Bullhead sandstones, great depths, up to 4,000 feet, may be needed to reach the base.

At several places within the area traversed the upper Bullhead sandstones are within 1,000 feet of the valley's surface. These places are indicated on the maps. Special attention and more detailed work might be given to the following localities:—

(1.) In the vicinity of the trail crossing of the South Branch of Halfway River, forty-four miles north of Hudson Hope, and points north-east and east of it.

(2.) At Hudson Hope itself, and the Gates, a few miles below it, on Peace River. (This is within the Peace River Block.)

(3.) Near the west end of Moberly Lake at greater depth (also within the Peace River Block).

(4.) On Peace River beside the northern base of Table Mountain (Peace River Block).

(5.) On Lone Prairie and East Pine River.

(6.) On East Pine River, five or six miles below Flat River.

(7.) On Flat River, an eastern branch of East Pine, sixty-five miles south of its junction with Pine River proper.

The St. John shales appear to be more or less anticlinal at these places. They are most deeply cut into at (2), (4), and (7), where the depth to Bullhead sandstones is probably less than 1,000 feet.

It must be remembered that all these places are somewhat remote; Hudson Hope is the only place to which drilling-rigs could be brought without first making roads. Also it may be found, after detailed geological work is done on them, that faults or breaks occur along or beside them, which may be unfavourable by reason of allowing the oil or gas to escape.

SUMMARY.

Regarding the area covered by our traverse and shown on the attached map:—

(1.) No oil has yet been found and no residues or gas-leaks of much importance.

(2.) There is a possibility of oil existing below some of the favourable structures which occur.

(3.) The most likely strata are beneath the St. John shales, which are impervious enough to hold oil down.

(4.) The Bullhead sandstones, a shore, brackish water, or subaerial deposit, lie below the St. John shales; these are geologically more or less contemporaneous with or equivalent to the oil-bearing Loon River strata and the Athabaska tar-sands. They also resemble the Kootenay of Southern Alberta of much the same horizon, which is believed to be the oil-carrier at Black Diamond field.

(5.) Assuming the Bullhead sandstones or some underlying formation to produce or carry oil, the necessary work then is to find places where it is structurally favourable and within reach of a drill.

(6.) The thickness or depths to reach any given horizon are very uncertain, but some places offer less vertical depth than others.

(7.) The map shows where these places are and where the structure is most favourable. Such places are in valleys or depressions which have been cut deeply into the St. John shales.

(8.) It is possible, considering the activity of the Imperial Oil Company, that somewhere within the great extent of these Alberta and British Columbia foot-hills an oil discovery of commercial value may be made, and so revive the interest, and perhaps the wild and foolish speculation, of five years ago.

Under these conditions, as above designated, it seems advisable to have at Victoria some more definite knowledge of the geology and structure of the British Columbia area, for up to this time little work has been done on it by the Dominion Geological Survey, excepting on Peace River itself, which portion is mostly within the Federal "Peace River Block" and the Province of Alberta.

Neither is the British Columbia area accurately mapped, because it is outside of the operations of the Dominion Lands Survey.

APPENDICES.

APPENDIX A.

CLIMATE AND AGRICULTURE.

Peace River is generally credited with an early spring, at least as early as the wheat-growing areas of Manitoba and Saskatchewan. The late Dr. G. M. Dawson, at one time Director of the Geological Survey of Canada, gives an average date for the opening and closing of the river by floating ice. These dates are April 21st and November 7th, between the years 1806 and 1875. It is unlikely that these events have undergone much change in the matter of time or that the climate has changed; there are, however, apparently considerable variations in the warmth and rainfall of the summer seasons.

Last year (1919) had a late spring all over Canada. The growth of vegetation at Hudson Hope early in July did not indicate an early spring, and I am inclined to think, from information, that spring, though early, does not bring summer and growth as soon as in the wheat districts of Manitoba and Saskatchewan.

Within the area north and south of Hudson Hope the growth after July 10th was very rapid and reached astonishing developments in the way of weeds, such as wild parsnips 10 feet high, fireweed 7 feet, and peavine as much or more. This was a tribute not only to the weather, showers, and very heavy dews, but to the soil of some of the valleys. The rainfall for July was 3¼ inches; for August, 3⅜ inches; and on September 4th to 5th, 1.42 inches, as recorded at Hudson Hope. It seems to be usual that July and August have much rain, while early summer is dry. The whole country, mostly wooded, bears tribute to a sufficiency of precipitation or such a conservation of it as keeps vegetation abundant.

Concerning summer frosts, these occur at irregular times, but do not appear to affect the crops as much as in the early days of Manitoba. Wheat ripens yearly in the main valley of the Peace. None was seen on the uplands or upper valley-levels, excepting a late-sown patch on Lone Prairie, which is about 1,000 feet higher than Hudson Hope.

The first severe fall frost occurred on the night of August 31st-September 1st. This frost from experience in Manitoba was not, I think, severe enough to injure nearly ripe wheat. The potato-tops at Middle Pine, 1,750 feet altitude, and at Hudson Hope, 1,500 feet, were only partly cut down. Below Hudson Hope, in the Peace Valley, for the 240 miles to Peace River Crossing, there had been no dangerous frost up to September 12th.

Tomato-plants were untouched at Harmer's ranch, Flat River, on August 26th. This place is 2,300 feet above sea-level; nor were tomatoes injured at Cadenhead's ranch at Halfway River, on the Peace River, on September 7th. On the line of the Dunvegan and Peace River Railway there was more evidence of severe frost a little north of Edmonton on September 12th than at any point seen on Upper Peace River up to September 7th.

Concerning agricultural land, there are within the limits of British Columbia, north and south of Hudson Hope, a few partly wooded prairies and some steep, grassy hillsides on the north banks of the rivers. The main country is thickly wooded with small timber, chiefly spruce, jack-pine, and poplar.

The most desirable flats or wintering-places for stock and feed are already partly taken up by squatters, as at Halfway River, Hudson Hope, Moberly Lake, Pine River and its South and East Branches, Lone Prairie between the latter, and Flat Creek, farthest south of all.

These places are all valley lands or deep depressions, mostly less than 2,000 feet above sea-level. Lone Prairie, one of the most elevated (2,400 feet), is a considerable tract of partly wooded flats nearly surrounded by mountains, an area of about thirty square miles, in which are half a dozen settlers. There are also extensive tracts of easily cleared land on the South Branch of Halfway River, forty-four miles north of Hudson Hope, and on the western side of Kiskatinaw or Cutbank River, south-west of Pouce Coupe.

The greater part of this country, if cleared of its forest-growth, which is useless as timber, would afford good grazing land, while the valley-flats would furnish hay and wintering-places, especially those which are visited by Chinook winds.

On Lone Prairie, Mr. Wartenby, one of the settlers, told me he fed his cattle for only ten days during the winter of 1918-19. This place used to be a favourite wintering-place for Indian horses.

The present situation of this area as regards agriculture now is: Some stockmen on Halfway River; settlers who produce little or nothing about Hudson Hope, having little market; and a few trapper settlers, squatters, and absentees on Peace River above Hudson Hope, near Moberly Lake, and at Middle Fork of the Pine, East Fork of the Pine, on Lone Prairie, at Flat Creek, and along the western side of Kiskatinaw River. These people cannot sell produce, nor have they much stock, excepting one case on Halfway River. The country has only Indian trails; hence those who hold the land must risk a living by trapping or other occupations.

The main highway of the country is the Peace River. This avenue of approach from the eastern railway connections and from the west by way of Fort George and the Parsnip River has a considerable traffic of a frontier character, placer-miners, prospectors, trappers, and other adventurers, or exploration parties. Some money should be spent upon the improvement of the one long portage road at Hudson Hope of fourteen miles, and in making a conspicuous landing-place above the canyon at its upper end, for it is a dangerous approach.

APPENDIX B.

ALBERTA OIL PRODUCTION.

The producing wells are, with one exception, all in a small area on the Turner fold or anticline near Black Diamond; here there are five small producers within an area of about two miles by one mile. The exception is the old "Discovery" or Lineham well, which is near Waterton Lakes, in the south-western corner of Alberta. It is within the Palæozoic or Limestone Mountains and has produced a little oil of a heavier quality than the Black Diamond field.

The Black Diamond field produces oils of a paraffin base which vary from 38 to 62 Beaumé, or 0.831 to 0.729 specific gravity, compared with water which is 1.00.

There are here five producers and on semi-official authority their output has been given as follows:—

Year.	Gallons.	Barrels.
1914	7,640	218.3
1915	7,560	216.0
1916	83,680	2,390.3
1917	274,472	7,842.0
1918	592,712	16,934.5
Totals	966,064	27,601.1

A total of 27,601.1 barrels of 35 imperial gallons of a high-priced light oil suitable for gasolene and for motor-driving.

The oil so far found on the eastern side of the great trough or syncline at points east of Edmonton, Lower Athabaska and Lower Peace Rivers is a heavy oil of asphaltum base—15.5 to 25 Beaumé, or 0.96 to 0.903 specific gravity.

The Athabaska tar-sands have been estimated to contain several thousand million barrels of oil, but the problem is to extract it from gummy sands which contain 10 to 15 per cent. bitumen. The oil which seeps into the wells is in small quantity and too viscous to pump readily; such is also the case on Lower Peace River.

Concerning future developments, it is believed that the Imperial Oil Company, after careful investigation of a large portion of the Province, will soon be drilling at points south of Pincher Creek, south of the Black Diamond field, east of Edmonton, near the western end of the Great Slave Lake, and on the Mackenzie River below Fort Norman.

The two former places are within the foot-hill belt of sharper folding and light oils; the well east of Edmonton is in the nearly flat gas-bearing field which lies east of the great trough or syncline; and the two last are in the vicinity of oil-seepages which are presumed to come from a dolomitic portion of the Devonian strata.

Other wells are here and there also being put down in the Southern Alberta foot-hills, in the area east of Edmonton, at High Prairie near Lesser Slave Lake, and on Lower Peace River.

APPENDIX C.

THE MAP.

In order to show the country traversed and give some illustration of the geology it has been necessary to compile a map or tracing from various sources. The nature of the work did not permit much surveying or map-making, but some corrections have been made and some additions.

The Pre-emptors' Map, No. 3E, 1918, of the Peace River Sheet was used as a base for the tracing and some additions made south of its termination on Rocky Mountain Lake.

None of the maps are correct in places, especially of the country between the East Branch of Pine River and the Kiskatinaw River. Also Flat Creek and Moose Lake are placed too far south on current maps.

Using the Pre-emptor's Map No. 3E, after shifting its latitude lines (which were wrong) and expanding it southwards on the same scale of 4 miles to the inch, I have put on it as many details as seem needed at present.

The St. John shales, which seem to be a vital factor in working out the geology, are shown along the lines of traverse and in the deep valleys by a yellow colour, which will show up on blue-prints.

The cross-section illustrates the undulating character of the strata and the way that the deep valleys have been cut through the crust of the Dunvegan sandstones into the underlying St. John shales; these shales probably cover wider areas than marked on the map, but the uncoloured spaces between them are mountain or upland masses of Dunvegan sandstone, with remnants of Smoky River strata here and there.

The Bullhead sandstones do not appear eastwards of the double-dotted line which passes Hudson Hope. They underlie the St. John shales.

Elevations are given from readings of a more than usually reliable aneroid barometer. Moberly Lake is accepted as it is on the maps. Very little precise levelling has been done west of Dunvegan or St. John, and the elevations given on the tracing may be accepted as more exact than any heretofore. Such elevations are valuable in working out a structure where the strata are gently inclined or undulate.

Geological maps can best be made when there is a fairly accurate and detailed topographical survey of the district to put the geology on, and this must be remembered if the tracing is found somewhat sketchy.

VICTORIA, B.C.:
Printed by WILLIAM H. CULLIN, Printer to the King's Most Excellent Majesty.
1920.