PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF LANDS

HON. T. D. PATTULLO, Minister of Lands

SUMMARY REPORT

ON

EXPLORATION FOR OIL AND GAS

IN THE

PEACE RIVER DISTRICT

BY

JOHN A. DRESSER

PRINTED BY

AUTHORITY OF THE LEGISLATIVE ASSEMBLY.

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1922.

To the Honourable JAMES ALEXANDER MACDONALD,

Administrator of the Province of British Columbia.

MAY IT PLEASE YOUR HONOUR:

I have the honour to present herewith a Summary Report on Exploration for Oil and Gas in the Peace River District of British Columbia, by John A. Dresser.

T. D. PATTULLO,

Minister of Lands.

Victoria, B.C., November, 1922.

Summary Report on Exploration for Oil and Gas in the Peace River District, British Columbia.

Review.

An inquiry into the resources of the Peace River District, with especial reference to the possibilities of finding oil and gas, has been in progress since the spring of 1919. In the first summer season a general reconnaissance was made by the late Professor J. C. Gwillim, who in conclusion recommended certain areas for more detailed examination. In the field season of 1920 such examination was carried out by E. Spieker, of John Hopkins University, Baltimore, U.S.A., in an area south of the Peace River, and in another area on the north side of the same river by the writer, assisted by Professor Alexander MacLean, of the University of Toronto. These examinations showed that in view of the heavy covering of soil conclusive results could be most economically and, in fact, could only be obtained by exploratory drilling. Consequently field exploration was suspended during the two following seasons, and exploratory drilling was carried on from June, 1921, to June, 1922, in the area north of the Peace River and just west of the Peace River Block.

Method of Drilling.

The drilling was done under contract by Lynch Bros., of Seattle and Vancouver, who have been both efficient and considerate in the performance of the work. J. C. Wilson was employed to keep the records of the operations during the progress of the work.

Diamond-drills were used, power being obtained from a wood-burning sectional boiler which could be carried in parts by a pack-train. The cores range from 2 to 1⅛ inches in diameter and the recovery was excellent—in some holes practically complete. Consequently nearly complete sections of the formations peneterated have been obtained and preserved. In all, some 9,800 feet of the solid formations have been drilled, in six holes, which range in depth from 1,027 to 2,525 feet.

The major part of the cores is stored at Hudson Hope, properly boxed and labelled for future reference by your own or other geologists working in the region. Already Dr. F. H. McLearn, officer of the Geological Survey of Canada in charge of the Peace River District, has begun a critical study of the cores for use in interpreting the geology of the possible oil- and coal-bearing horizons on the west and south of this locality.

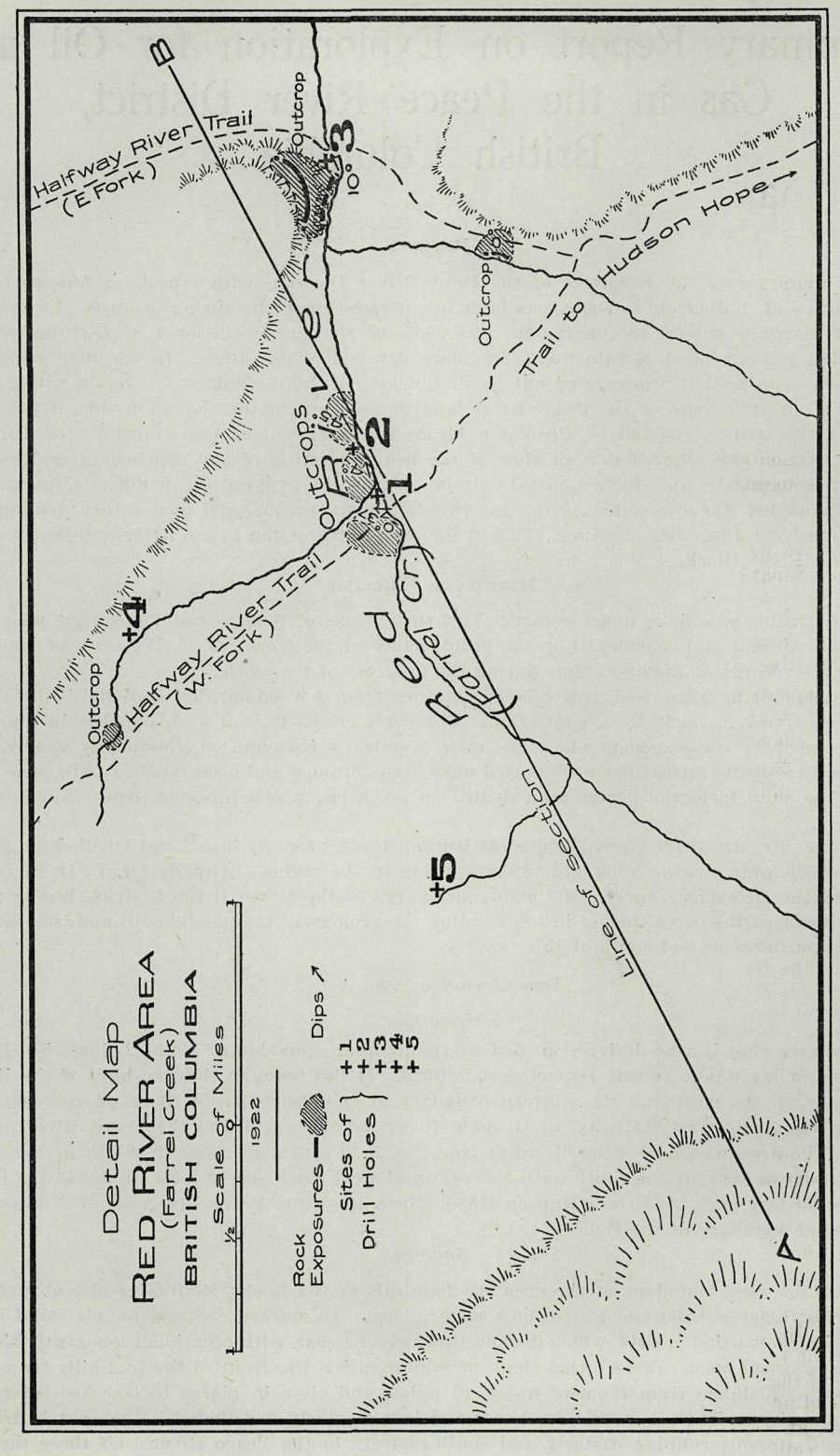
Description of the Area.

Location.

The area that it was designed to test by the drilling campaign of 1921–22, just closed, was described in my report to this Department in 1920. It lies between the foot-hills of the Rocky Mountains on the west and the western boundary of the Peace River Block on the east, and between the South-west Halfway, or Graham River, on the north and the Peace River on the south. The area measures some 40 miles from north to south, 10 miles in width at the north and narrowing towards the south until the east and west sides nearly meet at the Peace River. It is reached by pack-trail from Hudson Hope, which is on the Peace River, about 2 miles east of the west boundary of the Block.

Surface.

Near the west boundary of the area the foot-hills of the Rocky Mountains rise abruptly to a height of 1,200 to 1,800 feet above their eastern base. In marked contrast to this relief is the surface of the wooded prairie, which declines towards the east, with occasional low gently sloping swells and broad open valleys. One chain of hills parallels the front of the foot-hills for nearly 20 miles, at distance from them of about 10 miles, and rises in places to 300 feet above the adjacent valleys. The other hills are lower and less regularly distributed. The area is drained by several streams running easterly and south-easterly to the Peace River. Of these the Red


Detail Map
RED RIVER AREA
(Farrel Creek)
BRITISH COLUMBIA
Scale of Miles
1922
Rock Exposures
Dips
Sites of Drill Holes
+1 +2 +3 +4 +5
Line of Section
Farrel Cr.
Red River
Outcrops
Outcrop
Outcrop
Outcrop
Halfway River Trail (W. Fork)
Halfway River Trail (E Fork)
Trail to Hudson Hope
A
B

River in three branches and Lynx Creek in two are the principal streams. They have cut channels in places as much as 100 feet below prairie-level. There are no waterfalls in their courses, but the gradient is steep, in places amounting to 40 or 50 feet in a mile.

GEOLOGY.

In the Peace River District of British Columbia there are three principal formations. In descending order they are as follows:—

Formation.	Character.	General Origin.
Dunvegan	Sandstone	Land deposits.
St. John	Shale and sandstone; conglomerate	Marine deposits.
Bullhead	Sandstone and shale	Land deposits.

All are of Cretaceous age. The Dunvegan and St. John are referred by Dr. F. H. McLearn, who has made the latest report of the region for the Geological Survey (Summary Report, Geological Survey of Canada, Ottawa, 1917) to the upper or Colorado divisions of the Cretaceous, and the Bullhead to the Lower Cretaceous, probably equivalent to the Kootenay formation of Southern Alberta. It is probably from the upper part of this formation that oil is obtained in the Black Diamond field near Calgary.

The Dunvegan is a land formation. It consists principally of a friable sandstone and contains an occasional small seam of coal. It occupies only a small area in this district and is not important to the present investigation beyond marking the upper limit of the St. John.

The St. John formation consists mainly of soft shale with beds of clayey sandstone near the middle and in the lower part of the formation. It is nearly 2,000 feet thick in one drill-hole and this apparently is considerably less than the total thickness. It is of marine origin and so potentially oil-bearing. Since it occurs over a large part of British Columbia east of the Rocky Mountains and occupies a large area in Alberta its thorough investigation is important. In structure the rocks lie nearly flat, varied only by low local folds.

The Bullhead is essentially a land formation in its upper part at least. As such it would not be an original source of oil, but its upper sand measures are better suited for collecting and retaining oil which may have migrated from other formations than the rather clayey sandstones of the St. John. A few hundred feet from the top, however, the Bullhead becomes dense and compact and there offers less prospect of being either easily permeable or of forming a good reservoir.

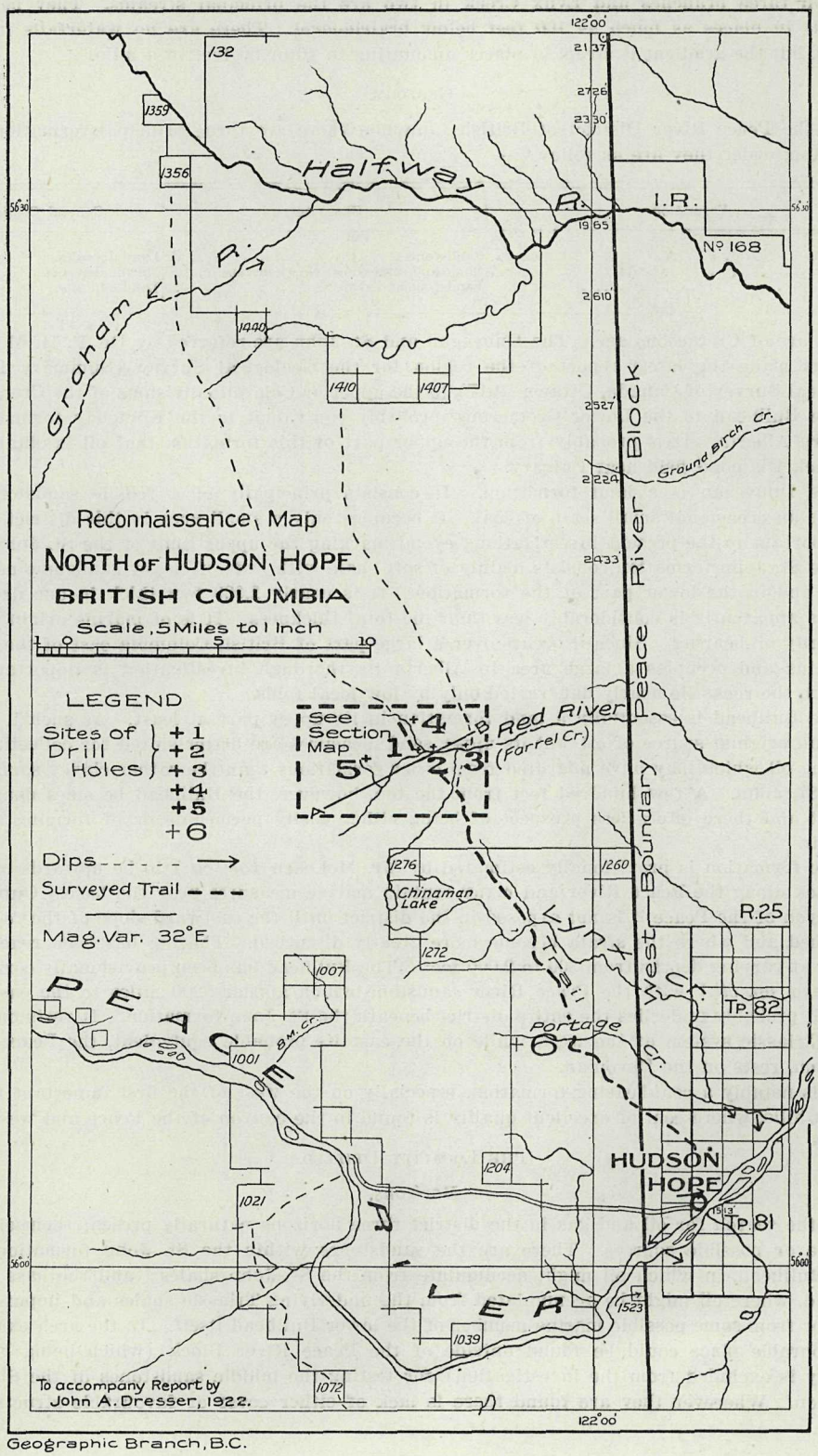
The formation is provisionally estimated by Mr. McLearn (*op. cit.*) to be upwards of 4,000 feet thick along the Peace River and many contain marine measures near the base. Outside of the canyon of the Peace it is not exposed in the district until the eastward slope of the foot-hills is reached and where the strata become more greatly disturbed. The top has been reached in drilling at varying depths from 800 to 2,000 feet. The Bullhead has been provisionally correlated (McLearn, *op. cit.*) with the Peace River sandstone which appears 200 miles to the eastward, and so it probably underlies the entire district beneath the St. John formation. It rests on rocks of the Triassic system at the west, while on the east its probable equivalent, the Peace River formation, rests on the Devonian.

It is notably a coal-bearing formation, especially on the west of the first important fold of the foot-hills, where coal of excellent quality is found in the canyon of the Peace and westward.

THE LOCALITY DRILLED.

Horizons.

In the search for oil and gas in the district three horizons naturally present themselves as probable or possible sources. There are the sandstones within the St. John formation; the upper Bullhead, in which oil might accumulate from the St. John shales; and the base of the Bullhead, where oil might be accumulated from the underlying Triassic shales and impure limestones or from some possible marine member of the lower Bullhead itself. In the area examined no favourable place could be found outside of the Peace River Block (which being Federal territory is excluded from the investigation) for testing the middle sandstones of the St. John formation. Wherever they are found there is lack of either cover or favourable structure, or of both.



Geographic Branch, B.C.

Also the last-mentioned horizon, the Bullhead-Triassic contact, is either too near the mountains or is too deep to be reached by the drill in any part of the district which has transportation facilities which are at all favourable. Consequently attention was given to the remaining horizon only in selecting an area for trial drilling.

Red River.

The area chosen for the first drilling was that shown in the report for 1920, on the Red River and its branches. Five holes were drilled at this locality, as shown in the accompanying plan. In the drill-cores the major divisions can generally be clearly distinguished—namely, St. John shales and sandstones, the conglomerate at the base of the St. John, and the underlying Bullhead sandstones and shales. There are no dominant beds within these formations that can be safely correlated with one another in different holes in greater detail. But for the purpose of the investigation these are perhaps sufficient.

In general the St. John consists of shales with less amounts of sandstone. The materials of both rocks are not well separated. The shale is sandy in places and the sandstones are generally friable and carry a considerable proportion of clayey matter, which makes them less favourable as oil reservoirs than would at first appear.

The conglomerate is made up of well-worn, hard, dark-coloured pebbles, commonly from ⅛ to ¼ inch in diameter, cemented together by a gray siliceous matrix. Not many of the pebbles seem to have been derived from the underlying Bullhead. The source of the matrix is even more doubtful. While it may ultimately prove to be a separate formation, for present purposes at least it may be regarded as marking the base of the St. John.

The Bullhead consists of sandstone with subordinate amounts of shale. The sandstone is harder and rather coarser than that of the St. John formation and in the upper parts might be described as gritty. At greater depth it becomes very compact and hard. The shale, too, is finely compacted. Small coal-seams occur in places and occasional plant-remains. The upper sandstones of the Bullhead for the first few hundred feet offer better reservoirs for containing oil than the sandstones of the St. John formation.

Drilling Results.

Summary of Logs reported by Mr. Wilson.

In all holes 2-inch cores were recovered from the first 800 feet and cores of 1⅛-inch diameter below that depth.

Hole No. 1 (Post 3)—

0–771 feet: Shale and sandstone of St. John formation.
771–826 feet: Conglomerate.
826–1,027 feet: Sandstone and shale, Bullhead formation.

At 191 feet saline water estimated at 300 to 400 gallons per hour appeared. It contained a little non-inflammable gas. From 798 to 950 feet fresh water and inflammable gas appeared. Total flow of water estimated at 2,000 gallons per hour. No means were available for measuring the flow of either water or gas. Gas-bubbles occupied about half the space in the pipe. Gas was piped to the camp and was used for heating and cooking from autumn until the camp was closed in the following March.

A few inches of coal were found at three places near 1,000 feet. About 913 feet a few nodules of pyrites were noted. In places the shale was found to be crushed and cleavage showing slickensided faces was developed. False bedding is a prevalent feature of all the cores. In this one the structure is practically horizontal.

Hole No. 2 (Post 1)—

Location, 60° N.E. from hole No. 1, 1,600 feet; elevation, 23 feet below No. 1.

0–1,081 feet: Shale and sandstone, St. John formation.
1,081–1,141 feet: Conglomerate.
1,141–1,154 feet: Sandstone, Bullhead formation.

A smaller flow of water, estimated in all at 200 gallons an hour, accumulated from different levels down to 647 feet. Between 290 and 325 feet and at 647 feet inflammable gas appeared, also in smaller quantity than in No. 1.

On the hole being cased to a depth of 850 feet it remained dry to the bottom, which is at 1,154 feet. After the withdrawal of the casing after drilling ceased a slight film, apparently of oil, became visible on the water flowing from the hole and still continues, but too small in amount to give a sample.

Broken strata with slickensided faces were detected in the core. The dip of bedding indicated by the core changed from 42° near the surface to 20° or less at depth. No survey of the hole was made.

Hole No. 3 (Post 2)—

Location, N. 80° E. from hole No. 2, 5,800 feet; elevation, 76 feet below No. 2.

0–1,990 feet: Shale and standstone, St. John formation.

1,990–2,035 feet: Mainly sandstone. (Probably Bullhead formation.—J. A. D.)

A small flow of water issued from this hole. A very faint film of oil was reported after reaching 760 feet. A little inflammable gas issued from the hole. Structure indicated by core, a dip ranging from 10° near surface to apparently flat. Much false bedding.

Hole No. 4.—

Location, N. 30° W. from hole No. 1, approximately 4,700 feet; elevation, 92 feet above No. 1.

0–1,100 feet: Shale and sandstone, St. John formation.

1,100–1,106 feet: Conglomerate.

A very slight film of oil was reported to be visible on the water near 65 feet. No gas was encountered and little water. A dip of 4° was noted.

(This hole was unfortunately abandoned before the conglomerate was pierced, through a misinterpretation of instructions.—J. A. D.)

Hole No. 5—

Location, S. 74° W. from hole No. 1, 6,800 feet; elevation, about 200 feet above No. 1.

0–1,118 feet: Shale and sandstone, St. John formation.

1,118–1,154 feet: Conglomerate.

1,154–2,025 feet: Sandstone and shale, Bullhead formation.

A small flow of water. At 1,390 feet a pocket of inflammable gas and a little dark oil were reported. Cores on being drawn from below this level frequently showed a film of oil. Coal in small amount occurs in upper Bullhead. A dip as high as 5° was reported from the upper part of this hole.

REVIEW OF THE FIELD.

In view of the results outlined above a review of the field and of the cores obtained was made by the writer in the month of August, 1922, in company with Dr. F. H. McLearn, of the Geological Survey, Ottawa, whose work in the region has been already cited. Dr. McLearn's wide knowledge of the geology of the Peace River District made this co-operation extremely valuable.

CONDITIONS AT THE DRILL-HOLES.

Drill-holes Nos. 1, 2, 3, and 5 emit gas, but principally at No. 1. Here, however, the flow appears to be slightly less than was found a year earlier. A slight film, apparently of oil, appears on the water as it emerges from No. 2. It is in too small an amount to be sampled. This probably enters the hole above 850 feet from the surface, as it was not observed until the casing, which extended to that depth, had been withdrawn. No oil was detected in the flow or by bailing from any of the other holes.

The water at No. 1 and No. 5 is distinctly salty to the taste.

STRUCTURE.

The structure of the locality as shown in the St. John formation where exposed at the surface is that of a general monocline, the strike being north-west and the dip north-east at a low angle of 2° to 4°. Near hole No. 2 a narrow sharp fold gives a local dip north-east of 45°, and a dip of 10° can be seen near No. 3. Hence this site was selected as probably in the arch of a broad roll.

The bedding as displayed in the cores is too inexact to furnish reliable data as to the attitude of formations. The material of the different beds is poorly assorted and shale and sand are often found irregularly mixed. False bedding, too, is prevalent, and in places a cleavage, apparently

induced by lateral pressure, helps to conceal the bedding. But a controlling feature of the structure is shown by the attitude of the conglomerate, which is plainly indicated by the logs.

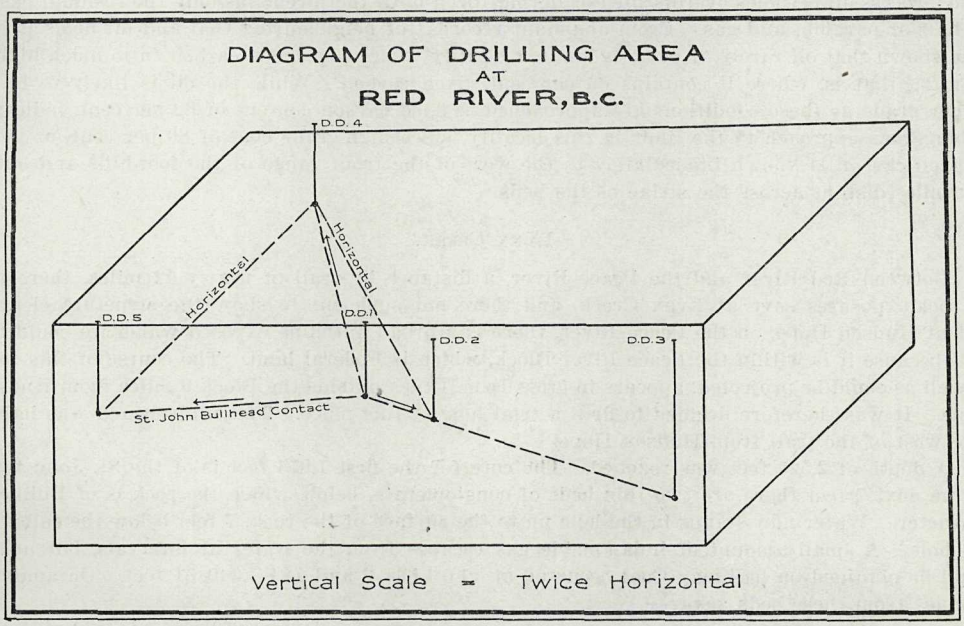
Hole No. 1 (Post 3, Report 1920) : Altitude, 0 feet; depth to conglomerate, 770 feet.

Hole No. 2, 1,600 feet N. 60° E.: Altitude, —23 feet; depth to conglomerate, 1,080 feet.

Hole No. 4, 4,700 feet N. 30° W.: Altitude, +92 feet; depth to conglomerate, 1,100 feet.

Hole No. 5, 6,800 feet S. 74° W.: Altitude, +200 feet; depth to conglomerate, 1,118 feet.

These four holes thus indicate a dome structure in which the strata dip north-east, north-west, and south-west away from hole No. 1, where the structure is practically horizontal as is shown at the surface. (*See* diagram.)



Hole No. 3 was drilled more than a mile east of No. 2 in order to test the St. John formation at a higher horizon, and also to try the ground beneath the prominent chain of hills already mentioned which parallels the foot-hills for some 20 miles in this district. A depth of 2,035 feet was reached. The core is almost entirely dark shale of the St. John type and rarely shows a dip of 3°. No conglomerate was found. But near the bottom, especially below 1,990 feet, the sandstone takes on the general character of the Bullhead, and possibly, if not probably, marks the top of that formation. In any event no upward folding of the Bullhead in this direction is indicated by this core, and a gradual thickening of the St. John still continues towards the east. The hills, therefore, no not appear to offer favourable structure at this point, or the St. John to carry oil in useful quantity.

Chemical Tests.

Eight samples of rock taken from different parts of the cores where traces of oil were reported were submitted to J. T. Donald & Co., Chemists, Montreal, for distillation tests. No oil was found.

The character of the coal was next considered. The proportion of carbon in the coal of a district, in the absence of oil, affords the best available indication as to whether or not oil may exist in the locality. This had been previously tried with two samples of coal from the first hole and a neighbouring locality. But the samples were not representative and the results were conflicting and in a measure misleading. Accordingly two samples were taken from the fifth

core. On analysis they proved within, but dangerously near—within 4 or 5 per cent. of—the limit of carbon that could be expected to occur where oil also exists. The following are the analyses:—

	(3.) Hole No. 5, Depth 1,750 Ft., 4-in. Seam.	(5.) Hole No. 5, Depth 1,720 Ft., 4-in. Seam.
Volatile and combustible	31.40	27.80
Fixed carbon	62.10	61.08
Ash	6.50	11.12

The proportion of fixed carbon in coal, as is well known, increases on approaching the mountains, or where the great stresses developed the rocks by mountain-building forces have compressed the coal, excluded the volatile products, and produced even chemical changes. By the same process oil becomes overdistilled or devolatilized until there remains only the residual bases, asphalt or paraffin, and gas. From abundant records* of neighbouring coal and oil fields it has been shown that oil rarely, if ever, exists in a locality where coal has a carbon ratio much higher than 2; that is, where it contains 66 per cent. fixed carbon. While the oil is likely to be of higher grade as these conditions are approached, a fixed carbon content of 62 per cent. indicates a dangerous approach to the limit in this locality, since high-grade coal of 80 per cent. or more in fixed carbon is known immediately to the west of the front range of the foot-hills and but a few miles distant across the strike of the beds.

LYNX CREEK.

Between Red River and the Peace River, a distance by trail of nearly 12 miles, there are no rock-exposures save at Lynx Creek, and there not sufficient to show the structure clearly. But at Hudson Hope, on the Peace River, there is a broad anticline exposed which we could not drill because it is within the Peace River Block, which is Federal land. The course of this fold, as well as could be projected, appears to cross Lynx Creek outside the Block 9 miles from Hudson Hope. It was therefore decided to drill a trial hole at this place. The site selected was half a mile west of the trail from Hudson Hope.

A depth of 2,525 feet was reached. The core for the first 1,875 feet is of the St. John type. In the next 7 feet there are two thin beds of conglomerate, below which the rock is of Bullhead character. Water now stands in the hole up to the surface of the rock, 7 feet below the collar of the hole. A small amount of inflammable gas escapes from the water at intervals, but no oil could be obtained on bailing. Coal occurred at (1) 1,894–6 and (2) 1,949–51 feet. On analysis samples from these beds gave:—

	(1.)	(2.)
Volatile	25.25	33.30
Fixed carbon	63.26	39.25
Ash	11.49	27.45

No. 1 especially indicates that carbonization is high for the retention of oil in this locality. In other words, this site is still too near the mountains. There remains only 1½ miles between this site and the boundary of the Peace River Block and exposures along Lynx Creek do not show a favourable structure.

Another significant feature, however, was found at 2,273–5 feet in depth. Here a bed reported to be 2 feet thick was encountered, of which only a small part could be recovered by the drill. In appearance the substance is soft, sticky, and nearly black, somewhat resembling the tar-sands of Athabaska region. On analysis, J. T. Donald & Co., Chemists, Montreal, define it as tar-clay, and find it contains 34.50 per cent. of oil which had a paraffin base, and that there are no asphaltic compounds present. In another specimen from this horizon, but not a duplicate, Dr. K. A. Clark, of the Industrial Research Laboratory, Edmonton, obtained 40 per cent. bitumen and found half the residue to be combustible.

Compared with the tar-sands of the valley of the Athabaska and other parts of Northern Alberta, this material differs in several respects. The containing material is carbonaceous clay rather than sand, and the contained oil has a paraffin instead of an asphalt base. The proportion of oil in this sample, about 80 gallons per ton, is also several times greater than in the average of the tar-sands. The small sample obtained did not admit of determination of other than its petroleum content.

* Dr. David White, Chief Geologist of the U.S. Geol. Survey, Tran. A.I.M. & M.E. 1920, Vol. 65 *et al.*

The small thickness of the bed and the depth at which it occurs of course make its use quite impossible, notwithstanding the favourable quality and relative quantity of oil indicated. It is, however, a feature that may be found of use elsewhere in the region, as in the valley of the Peace (within the Block), where drilling can be begun on a much lower horizon. But its chief interest is in the fact that it establishes the existence of oil of high grade in the district and so adds to the likelihood of finding it in useful form and quantity in places where physical conditions are favourable.

Like the coal, the character of this tar-clay indicates that such conditions are more likely to be found where there has been less compression or other metamorphism of the rocks; that is, generally speaking, farther from the mountains, or at least beyond the influence of the forces that produced them.

Summary and Conclusions.

The area of British Columbia east of the Rocky Mountains is approximately 40,000 square miles. Nearly one-third of this territory, or 12,000 square miles, is in the basin of the Peace River. But of this some 5,000 square miles are in the Peace River Block, a tract of Federal lands which occupies the eastern central part of the latter area. There remains therefore about 7,000 square miles of the Peace River District east of the mountains with which this investigation is concerned. Quite half of this area, however, lies north of the Block and is not yet accessible for conclusive examination.

The geological field surveys made in 1919 and 1920 covered rather more than 1,000 square miles, including practically all of the accessible territory between the foot of the mountains and the Peace River Block. The locality then selected for drilling was chosen for a preliminary test in the area thus surveyed, and especially of the section of about 400 square miles north of the Peace. The drilling showed the structure of the locality chosen to be even more favourable than it was previously known to be. It also proved the existence of oil of favourable quality—paraffin series—in the district. But it gave no producing well; and, moreover, the mode of occurrence of the oil and the character of the coal indicate that the territory may be too near the mountains, or, more precisely, too far within the influence of the disturbances that caused them, to be likely to yield an oil production. The common occurrence of small amounts of gas, if at all significant, rather goes to confirm this view.

This feature, of course, applies to the area both north and south of the Peace; that is, within similar relation to the mountains. But the area that is unfavourably affected by nearness to the mountains need not be a belt of uniform width. It may vary in breadth according to the intensity of the stresses developed in mountain-building at different places along a range. Consequently conditions in other localities at equal distance from the mountains may be either more or less favourable than those found at Red River and Lynx Creek. But this can only be proved by drilling.

In general embayments in the front of a range, or intervals where the mountains recede from the plain, are likely to show less alteration of their rocks than other places along the range. In this respect such a locality as Miller Creek (*see* Spieker's map, 1920) seems to be a favourable one. Even the bank of the Peace River just west of the Block or Portage Creek near Rocky Mountain Portage are quite as favourably situated in regard to the mountains as any site west of the area already drilled at Red River.

As to other parts of the territory west of the Block, it would be easily possible to drill on either the First or the Second Lynx Creek 3 or 4 miles farther from the mountains. But what can now be seen of the structure is not particularly favourable and suggests that the thickness of the St. John formation there would be even greater than at hole No. 6. In view of the depth of the St. John and of the results obtained at hole No. 3, it does not seem advisable to go farther east on the Red River.

Any work farther to the west—that is, nearer the mountains—would, as stated above, be better directed to the vicinity of the Peace River or southwards.

One promising structure found by Mr. Spieker in 1920 is the Boulder Creek dome near the south-west corner of the Block. This is important as being the only place yet known where horizon of the Bullhead-Triassic contact may be reached. But it is as yet difficult of access for a drilling outfit and is near the mountains and also to the boundary of the Block.

The natural mode of investigation of the district would be by trial drilling on structures exposed along the banks of the Peace, where drilling could begin 800 feet or more below prairie-

level, and the distance from the mountains could be graduated according to results obtained. When this is done it is not at all unlikely that favourable fields will be developed which may extend north-west or south-east beyond the border of the Block into territory covered and now unknown, but which it would be uneconomical to search for without preliminary trials along the Peace.

But since the Block practically cuts the territory for investigation into two parts there are then two fields of operation, but which do not necessarily exclude each other. One is to drill more closely west of the Block in such localities as have been mentioned. Here the information already gained can be more immediately used, the continuity of the investigation preserved, and greater thoroughness ensured. On the other hand, the entire field west of the Block is limited.

The other course is to direct efforts to the part of the Province south of the Block and near the eastern boundary of the Province. This area is at a safe distance from the mountains, a larger field is open for investigation, and the work would be less restricted by political boundaries. It would seem advisable in any event that this district should be geologically examined.

JOHN A. DRESSER.

Montreal, September 12th, 1922.

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