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The Commercial Value of the Oil-Shales of Eastern
Canada, Based on their Contents by Analysis in Crude
Oil and Ammonium Sulphate.

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The Commercial Value of the Oil-Shales of Eastern Canada,
Based on their Contents by Analysis in Crude Oil and
Ammonium Sulphate.

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Ottawa.

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In a paper read before your society in March last on "Oil shales of the Maritime provinces" but little definite information as to their extent and economic value, especially as regards the deposits which occur in Nova Scotia, could be given beyond certain statements taken largely from the reports of Mr. J. Campbell and contained in How's *Mineralogy of Nova Scotia*, 1868. Even as regards the shales of New Brunswick, where the presence of oil-bearing strata has been known for many years at a number of points, but few reliable analyses were available by which their content in crude oil and ammonia could be ascertained. In New Brunswick our knowledge of the oil-bearing shales was much further advanced, owing to the mining which had been carried on for a quarter of a century on the large vein of albertite, which occurred in connection with the series of black-grey and brown, generally bituminous shales which, in that province, had long been known under the name "Albert shales." The supposed equivalent of this formation as developed in Nova Scotia was, by Sir William Dawson, styled the Horton series. While however in their contained fossils, in certain physical features, and in stratigraphical position, these two series of sediments have been long recognized as contemporaneous formations, the peculiar development of hydrocarbons, so conspicuous in the Albert shales of New Brunswick, has served to distinguish them in certain respects from the shales of the Horton series of Nova Scotia. As to their economic value, the statements made some years ago by Mr. Campbell, as given in the report mentioned, were found to be somewhat vague in several particulars.

Soon after the completion of the experiments made in Scotland in 1908, in connection with the shipment of oil-shales from New Brunswick, which were carried out to a very satisfactory conclusion, under the authority of Dr. Haanel, director of the Mines Branch of the Department of Mines at Ottawa, the results of which have now been somewhat widely circulated, it was decided to make a systematic examination, not only of the other deposits known to occur in New Brunswick, but also of certain other oil-shales which had been reported as occurring in Nova Scotia and in Gaspé, of which some portions were stated to be sufficiently rich in hydrocarbons to warrant the expenditure of capital in development. Shortly after my return from Scotland, therefore, the detailed examination of these various shale areas of New Brunswick was commenced.

These are found principally in the counties of Albert and Westmorland. Samples of ten pounds each were taken in duplicate, one set of which was sent to the laboratory of Dr. Baskerville, of the College of the City of New York, the other being sent to the Department of Mines, Ottawa.

Prior to this date there was no apparatus, either in Canada or the United States, which was suitable for determining the commercial value of these shales. However, Mr. W. A. Hamor, chief assistant chemist to Dr. Baskerville, in New York, who had accompanied me to Scotland to witness and report on the distillation of the New Brunswick shale shipment, on his return to New York designed and erected a small laboratory plant similar in most respects to that in use in the Pumpherston works in Mid Calder, Scotland. By means of this apparatus the samples selected in New Brunswick were tested by Mr. Hamor, for the Albertite, Oilite and Cannel-coal Company of New York and New Brunswick. Owing to the lack of facilities for doing this kind of work in Canada, the Mines Branch of the Mines Department, acting under the advice of the director, Dr. Haanel, also designed a laboratory plant or retort which was set up in the winter of 1908-09 at Ottawa. This on being carefully tested was found to give excellent

results, and in this respect it agreed very closely with the new apparatus installed in New York. The Ottawa plant was operated under the personal management of Mr. H. A. Leverin, one of the chemists of the department.

In the meantime some ten or twelve samples of the oil-shales collected in Albert and Westmorland counties had been tested by Dr. Baskerville's assistant, a portion of the results being forwarded to this office, and on the commencement of field-work in 1909, the examination of the New Brunswick areas was continued. Subsequently this work was extended to include all the known shales of Nova Scotia, and later, those of Gaspé. The results of all these analyses from the various areas in the three eastern provinces are of great practical value, and are now being published by the Department of Mines. Details of a number of these tests are given in this paper, including not only certain analyses of the shales made in New York laboratory, but also those made in the Ottawa laboratory, which are given for purposes of comparison. It may be here stated that the results obtained in the two laboratories at New York and Ottawa agree fairly well, and quite as closely as could be expected from samples taken at different times, making due allowances for possible variations in the nature of the material selected for analysis.

Prior to the recent work of Mr. Leverin, conducted in the laboratory of the department, no regular series of the analyses of these rocks was available. A few partial tests had been made by various chemists, but the location even of many of the samples so treated was very uncertain. In a majority of cases the percentage of ammonium sulphate was not ascertained, and even as regards the percentages of crude oil much uncertainty existed. In these respects it can now be confidently stated that owing to the work of the last few months we have available an exact statement in so far as concerns the economic value of a great number of samples of shales. These include shales rich in hydrocarbons from several provinces, as well as those lacking in this constituent but full of carbonaceous matter, and much less

valuable for purposes of distillation. They comprise practically all the known deposits found in New Brunswick, Nova Scotia and Gaspé. Their analyses have furnished us with a large amount of valuable information, and have shown us conclusively that in these eastern provinces, Canada has an immense area of oil-shales abounding in hydrocarbons, which on distillation yield far better results, as regards crude oil and sulphate of ammonia, than the celebrated shales of Scotland, and are unsurpassed in these respects by any deposit of a similar nature in any part of the world, in so far at least as the development of this industry is known.

Of the samples obtained during the past year, no less than 24 have been collected from different points in New Brunswick, mostly from places in Albert and Westmorland counties. From Nova Scotia twenty samples were obtained, principally from the counties of Pictou and Antigonish, where shale abounding in hydrocarbons and others of the type known as carbonaceous are found at a number of places; while from the so-called oil-shales of Gaspé peninsula, four samples were selected as probably fairly representative of the area as a whole. It may be here remarked that the material from Gaspé differs in character from the oil-shales of Nova Scotia and New Brunswick. The Gaspé oil-bearing beds are all sandy. The bituminous matter is evidently derived from remains of plant stems and is present mostly in the form of resinous material, which lies along the planes of sedimentation, and is associated with the organic matter which occurs in the thin bedded, sometimes shaly parts of the sandstone formation. These plant-bearing beds sometimes form zones of considerable thickness in the mass of the grey Devonian sandstone of this area. It was held that these various samples would fairly illustrate the greater part of the oil-bearing sediments of eastern Canada, in so far as these are yet known.

As for the deposits which occur in other parts of the Dominion, as the shales in the northern part of Manitoba, the shales and sandstones of the Athabasca and the Mac-

kezi e rivers in the west and north, these have in a number of cases been compared with those from points in the maritime provinces. Comparative tests have also been made of samples of different kinds of hydrocarbon shales from far distant points, including islands within the Arctic circle.

There are, however, large areas of shales in Nova Scotia which, owing to the absence of any reliable apparatus for determining their value in crude oil and ammonium sulphate, were early regarded as true oil-shales. They were so described in the paper by Mr. Campbell already referred to in How's *Mineralogy*, and were quoted to some extent in the paper read before this society last March.

A number of the localities referred to by Mr. Campbell were examined during the past year, some merely by field methods, others in the laboratory. A number of these were found on preliminary test to be too poor in hydrocarbons to warrant detailed analysis as regards either crude oil or ammonium sulphate. In this category are great thicknesses of black and greyish shales which occur along the south coast of Minas basin, between Split rock at the mouth of the Avon and the villages of Walton and Noel some miles to the east. On the west side of the Avon similar dark shales are well exposed at Horton bluff, Lochartville, and the vicinity of Hantsport. They have long been regarded as belonging practically to the same horizon as the bituminous shales of New Brunswick.

These deposits about the Avon are as a rule very deficient in hydrocarbons, the shales, while often black, being carbonaceous rather than bituminous. In the field tests applied to many of them the greater portion shewed but slight tendency to ignite even in a strong flame. At Hantsport where considerable boring has been done in a search for coal, the statement was made by several residents of the district that in some portions of the area shales occur which kindle readily on the application of flame. Several days' careful investigation of these shale areas reported to contain hydrocarbons, failed to reveal any traces of such sediments. In some places metamorphism of certain of

the shales had been such that all the bituminous matter which may formerly have been present had practically been destroyed. The black colour of many of these shales seemed to be due to contained carbon only.

Along the north side of Minas basin, similar black and carbonaceous shales were examined at a number of points from Parrsborough eastward. This belt of shaly rocks follows along the south side of the Cobequid mountains for about sixty miles. They are well exposed along the Harrington and Moose rivers and along the north river of Onslow, near Truro, as also along several of the streams which flow south from the mountain range into Minas basin. Black carbonaceous shales are well exposed at a number of points, and occasionally these are associated with thin beds of dirty coals such as are found in some parts of Onslow and Debert. Similar coals in similar rocks, shales and sandstone occur in Antigonish county. The analysis of the latter shews so high a percentage of ash, ranging from 29 to 46%, as to render the deposit unfit for ordinary fuel purposes.

It will be seen by the accompanying analyses that a great part of these shales are too poor in hydrocarbons to give satisfactory results in the laboratory tests; while in certain other areas the analyses shew the percentages of crude oil and ammonium sulphate to be fairly satisfactory.

The shales in Pictou county occur principally in connection with the productive coal measures. They are best developed in the vicinity of Stellarton and along McLellan's brook south of New Glasgow. From the geological standpoint they are higher in the series than those already described, which are usually regarded as either of Lower Carboniferous or possibly of Upper Devonian age.

While a number of beds of these black shales have recently been tested by analysis to ascertain their actual content in crude oil and sulphate of ammonia, it will be observed that, in the case of the greater part, they are too poor in hydrocarbons to be of much economic value. On the other hand, both at Stellarton and on McLellan's

brook certain bands of oil-shale are found which very closely resemble the celebrated mineral at one time mined and used in the production of crude oil in Scotland, under the name of Torbane hill mineral, the use of which was practically the beginning of the oil industry of that country. Upon the exhaustion of that mineral in 1862 the ordinary oil shales were utilized.

In comparing the Scotch torbanite with the Pictou stellarite it may be said that the two minerals are almost precisely similar, not only in general aspect, but also in the content of crude oil and sulphate of ammonia. The yield of both is practically the same, ranging in crude oil from 45 to 130 gallons to the ton. In Scotland the mining of the Torbane hill mineral was continued until the thickness of the workable bed was reduced to about three inches. In Pictou county the thickness of the bed of stellarite and associated strata is sixty inches, of which 16 inches is bituminous coal, 22 inches of stellarite, with 22 inches of black oil-shale.

In Pictou the results of the tests made on the stellarite fifty years ago were quite equal to any obtained from the similar shales in Scotland. The deposit was first opened at Stellarton in 1859. It was mined for some three years, the output being partly used for admixture with ordinary coal in the manufacture of illuminating gas, and partly shipped to the shale works then in operation at Boston, Mass., and at Portland, Maine, probably at Downer's. It is stated in Logan's report for 1866-69, that in mining this stellarite the shale from the eastern part of the area was much richer in crude oil than that from the west end, the shale yielding 130 gallons per ton coming from this part of the field.

In a recent visit to the place samples were taken from an old dump in rear of Stellarton. These gave on analysis by the Mines Department at Ottawa, 44.8 gallons crude oil per ton, and sulphate of ammonia 14.5 pounds. The same conditions were found to affect the torbanite of Scot-

* land. Where the yield of crude amounted to 130 gallons the yield of ammonium sulphate was only a few pounds.

In the examination of McLellan's brook a bed of almost precisely the same material as regards appearance was opened up a fourth of a mile below the old fulling mill, by what was known as Patrick's slope, and samples picked out of an old dump made nearly 50 years ago gave on analysis by the Mines Branch, crude oil 42 gallons and ammonium sulphate 41 pounds per ton. The width of this bed at one time was reported as eight feet, but on being worked was found to be affected by a fault by which its thickness was much reduced. Analyses of a number of samples taken from the black carbonaceous shales of this brook were also made, and for the sake of comparison of the samples from different localities these analyses may here be inserted. It may also be here stated, that in so far as our examinations have extended, no deposits of shale rich in hydrocarbons, other than those two just described from Stellarton and McLellan's brook, have been found in this part of the province. As the result of the tests recently made in the laboratory of the Mines Branch at Ottawa, we are now in a position to pronounce definitely on the actual economic value of most of these deposits, something that we were unable to do last year.

The deposits found in eastern Gaspé, are of much interest, and should the area upon further examination be found to be as large as anticipated, this field, as a source of supply for raw material for distillation, should be an important one. These oil-bearing deposits of Gaspé differ in character from those already described as occurring in New Brunswick and Nova Scotia. It is therefore for future exploration to determine whether deposits of sufficient extent to be of economic importance exist in this part of Gaspé peninsula.

As for the shales to which attention was directed last year as occurring in Newfoundland, beyond the fact that explorations in that area have been going forward for several months at various points, nothing of importance

has apparently yet been ascertained, either as regards the extent of the several reported areas or the true nature and value of the shales there found. Several persons are now engaged in investigating the actual conditions and the character of these deposits. They report that enormous quantities of very high-grade hydrocarbons, convenient of access, easy to mine, with exceptional facilities for shipment exist, but samples supposed to have been forwarded for examination to this department have not yet come to hand. Apparently the deposits most convenient of access are said to be on the north-east part of the island near Cape Rouge. But in the absence of samples for analysis nothing further can be said than was stated in last year's paper. It may be said, however, that during an examination of certain portions of the shores about Port-au-Port bay some years ago, deposits of shales, identical in character with those of the Albert shales of New Brunswick, were found. These had been bored for oil quite extensively, with but small success.

As indicating the somewhat wide distribution of oil-shales it may here be mentioned that Capt. Bernier, on his return from his recent voyage in the steamer Arctic, brought back with him from his wintering place on Melville island, about lat. 75° N., a number of samples of a thin-bedded shale, black and very rich in hydrocarbons, the quality as far as yet tested being equal to any yet found in Canada. The final results of the test or analyses, have not yet come to hand, but if the deposits were readily accessible they should be of great value as a source of supply for material for oil distillation. Large quantities of somewhat similar oil-shales have been reported as occurring along the lower part of the Mackenzie river. The presence of these oil-shales of Melville island is of special interest from the fact that many years ago, the occurrence of similar shales was noted in the vicinity of the island of Spitzbergen. These have been correlated, from the fossil evidence, with the Horton series of Nova Scotia. Owing however to the general inaccessibility of these deposits

inside the Arctic circle, the presence of these oil-shales should have but little influence upon the question of oil-production in Canada.

With the exception of the shales found in Pictou county, all these deposits belong to the same general geological horizon. They are also similar in age and character, in so far as yet determined, to the oil-shales of Scotland. For the sake of comparing the oil-shales of Scotland with those of eastern Canada, the following brief notes taken from the statistics of the Scotch industry may here be given.

The annual output of the Scotch shales from the seven principal works of that country is about $2\frac{3}{4}$ million tons. This on distillation produces not far from 65 million gallons of crude oil, or 23.6 gallons per ton of shale mined. In addition there are produced about 50,000 tons of ammonium sulphate, and about 20,000 tons of paraffin, with various other by-products. Of late years the sulphate is worth in the Scotch market about £12 or \$60 per ton, the paraffin varying from three pence to four pence per pound, or say £28 per ton. The yield of crude oil per ton from shale used in the Scotch industry at several of the principal works, ranges from 15 to 40 gallons, with a corresponding yield of sulphate of ammonia, ranging from 20 to 60 pounds per ton; the yield of the latter substance being as a rule in inverse ratio to the yield of crude oil. A sample of Scotch shale yielding from 20 to 25 gallons of crude oil, with 30 to 50 pounds of sulphate of ammonia, is now regarded as of high grade, and the market value would probably be as large, if not larger, than a shale giving say 40 gallons crude and only 20 pounds of sulphate of ammonia. This would be due probably to the present high price of sulphate. It may be inferred therefore that with a shale yielding 40-45 gallons of crude and from 75 to 100 pounds of sulphate of ammonia per ton, as is the case with much of the shale of New Brunswick, the percentage of profit on manufacture may be fairly estimated as equal at least to that obtained in Scotland, especially when the cost of mining in Canada does not exceed that in Scotland.

The theory that the yields of crude oil and ammonium sulphate are often in inverse ratio as regards the Scotch shales, does not seem to be supported by the results of the analyses of a large number of samples of the Canadian shales, made in the laboratory at Ottawa, as will be seen by the published figures. If we compare then the yields of crude oil and ammonium sulphate as obtained from the shales of Scotland with those obtained from the shales of the maritime provinces during the recent series of analyses, the following results may be presented, and the Canadian shales shewn to be of much higher grade as regards their economic values than those of Scotland.

Shales of Taylorville, Westmoreland county, N. B.

The black and massive bands of oil-shale, including both the plain and curly varieties which occur at Taylorville, Westmoreland county, were mined and shipped to points in the eastern States in 1862, apparently to be used in oil-distillation. It is reported that the shipments at that date amounted to some 4000 tons. In 1909, the area was again opened up and a number of samples were taken from four of the principal beds thus exposed in the vicinity, on what are known as the Taylor and Adams farms. The samples were taken in duplicate, one set being sent to the laboratory of Dr. Baskerville, of the College of the City of New York, while the duplicates went to the laboratory of the Mines Department at Ottawa. The total thickness of the four beds opened and sampled was twelve feet, the several thicknesses being two beds of 22 inches each, one bed of three feet, and one bed of five feet. The result of the analyses of these beds, which are interstratified with thin banded shales, also rich in hydrocarbons, was as follows:—

Two samples from the Adams farm gave in the Ottawa laboratory:

No. 1. Crude oil, 42.3 imp. gals.; sulph. amm. 96.5 pounds per ton.

No. 2. Crude oil, 47.3 imp. gals.; sulph amm., 88.7 pounds per ton.

From the Taylor farm, adjacent:

No. 1. Crude oil, 46.8 imp. gals.; sulph. amm., 85 pounds per ton.

No. 2. Crude oil, 45 imp. gals; sulph. amm., 101 pounds per ton.

Samples of shale from the same place, collected in the previous year and analyzed in New York, by Dr. Baskerville:

Adams farm, No. 1. Crude oil, 43 imp. gals.; sulph. amm., 93 pounds.

Taylor farm, No. 1. Crude oil, 48 imp. gals.; sulph. amm., 98 pounds.

Taylor farm, No. 2. Crude oil, 37 imp. gals.; sulph. amm., 110 pounds.

Further north, on the north side of the main syncline at Downing's creek near Upper Dover, the shales are mostly of the thin variety, the massive bands not being readily recognized. Four samples were collected from different points along the outcrops on the creek, and an average sample of the four was analyzed with the following result:

Downing's creek, Westmorland county, near Upper Dover:

Crude oil, 27.2 imp. gals; ammon. sulph., 29.5 pounds per ton.

Shales of the Albert Mines Area, N. B.

Proceeding to the Albert Mines, Albert county, a number of samples were collected, representing both the curly and plain varieties, and the thin-bedded or paper shales, of which there is an immense thickness. The total thickness of the interstratified massive oil-shales, exposed in a distance of about a fourth of a mile along Frederick brook, is about 30 feet, in six beds. The thickness of these ranges from $3\frac{1}{2}$ feet to 7 feet. They are interstratified with

thin papery shales, of which the measured thickness is several hundred feet. The analyses of these shales is as follows:

Shale from Bed No. 1, thickness $6\frac{1}{2}$ feet:	
Crude oil, imp. gals. per ton.....	48 $\frac{1}{2}$
Sulp. amm., pounds per ton.....	82.8
Shale from Bed No. 2, thickness $3\frac{1}{2}$ feet:	
Crude oil, imp. gals.....	45 $\frac{1}{2}$
Sulp. amm., pounds per ton.....	48
Shale from Bed. No. 3, thickness 5 feet:	
Crude oil, imp. gals.....	38.8
Sulp. amm., pounds per ton.....	60.3
Shale from Bed No. 4, thickness $4\frac{1}{2}$ feet:	
Crude oil, imp. gals. per ton.....	43.5
Sulp. amm., pounds.....	56.8
Shale from Bed No. 5, mixed thin and massive, thickness several hundred feet:	
Analysis of this band omitted, apparently very like that of No. 7. below.	
Shale from Bed No. 6, thickness 6 feet:	
Crude oil, imp. gals. per ton.....	27
Sulp. amm., pounds.....	56.8
Paper shale, sample No. 7, thickness several hundred feet:	
Crude oil, imp. gals. per ton.....	40.8
Sulp. amm., pounds per ton.....	41
Paper shale, sample No. 8:	
Crude oil, imp. gals. per ton.....	33.5
Sulp. amm., pounds.....	47
Paper shale, sample No. 9:	
Crude oil, imp. gals.....	18
Sulp. amm., pounds.....	40.8
Tunnel south of Frederick brook, above No. 6, driven 350 feet. Apparently average sample:	
Crude oil, imp. gals. per ton.....	32.5
Sulp. amm., pounds.....	33

It will be seen that these yields, both from Taylorville and the Albert mines, are largely in excess of those obtained from the Scotch shales which have been worked for half a century. As to the thickness of the variety known as paper shale at the Albert mines where they are highly developed, at the date of the first survey in 1876 this was estimated at about 1000 feet, but some allowance must be made for faults and folds. The thickness of the whole series is however several hundreds of feet, all of which is of sufficiently good quality to put through the retort for the manufacture of crude oil and sulphate of ammonia.

Shales of Baltimore, N. B.

Going west, the next large area of these shales is found at Baltimore, some six miles distant. Here is a large development of shale, including both the thin papery variety, interstratified with the massive beds known usually as the black oil-shale. At least five or six well defined bands of this variety are known in this area in beds ranging from four to seven feet, the total thickness of the massive bands, as measured where uncovered, being about 30 feet or practically the same as that at the Albert mines. Other bands probably exist but have not yet been uncovered, as is also the case at the Albert mines. A number of samples from the massive shales of Baltimore have been analyzed both at New York and at Ottawa and the percentage of crude oil and sulphate of ammonia is very high. The results obtained from the analyses of several of the principal beds are as follows:

From the Irving seam which was tested on the large scale in Scotland, the yield of crude oil was 40 gallons imperial, and of sulphate of ammonia 77 pounds. From the Baizley bed which was opened and worked locally to some extent in 1862-3, the percentage of crude oil by recent test in the Ottawa laboratory was 54 gallons and of sulphate of ammonia 110 pounds, which is certainly a wonderful yield; and from the Stevens bed, with a thickness of

about seven feet, the yield of crude oil was 49 imp. gallons and 67 pounds of sulphate of ammonia. At the time of the shale distillation at this place in retorts, the yield of crude oil was stated as 63 gallons per ton.

At Turtle creek, a couple of miles further west, a variety of oil-shale known as "grey shale" is exposed, and has been opened up to a slight extent, the thickness of certain bands ranging from $3\frac{1}{2}$ feet to about 15 feet. The thinner bands, on being tested in the laboratory, gave 56.8 gallons imp., equal to 68 gallons (U. S.), with 30.5 pounds sulphate of ammonia. These two areas, therefore, viz., the Baltimore and Albert mines, would appear to be specially rich in both crude oil and ammonia, and from the extent of the deposits should be specially valuable.

Following the belt of shales westward across Albert county, in about six miles from Baltimore the shale outcrops of Hayward brook or Prosser brook are reached. Here several bands from four to five feet thick are exposed, and have been opened to a slight extent. Samples were collected from one of the exposed beds only, as the general character of the other outcrops seemed to be similar, as far as could be determined in the field. The result of the analysis, both in New York and in Ottawa, gave crude oil 30 imp. gallons and ammonium sulphate from $53\frac{1}{2}$ to 75 pounds per ton of shale. This shale may therefore be classed as high grade, and as well worthy of being properly opened up. It is a much softer shale than that already described, being a chocolate brown in colour, easily cut with a knife, and closely resembling certain of the oil shales of Scotland.

Further west the belt of shales extends through the valley of the Coverdale river, Mapleton and Elgin. In portions of this area the shales seem to lose much of their hydrocarbons, the percentage of crude decreasing near Elgin to 14 gallons, and in one outcrop near Prosser brook to only four gallons. Some five miles west of Elgin or two miles west of Goshen corner, an apparent continuation of this belt is found. Samples of shales from this place shew a marked increase in value, yielding by analysis $27\frac{1}{2}$ gallons crude,

with 36 pounds of ammonium sulphate. This point is about 36 miles in a direct line west from the most easterly outcrop in Taylorville, Westmorland county. The shale belt is apparently continuous throughout, though probably concealed in places by the overlap of newer formations, and may be affected to some extent by faulting.

Shales of Pictou county, Nova Scotia.

If we compare in the next place the oil-shales of Nova Scotia with those of New Brunswick, just described, it will be seen that the shales from the two provinces are on the whole of different types. Those from Nova Scotia are on the whole much more carbonaceous, and by no means so rich in hydrocarbons as those of Albert and Westmorland counties. A somewhat full description of the shale areas of Pictou county was given by Sir W. E. Logan and Edward Hartley in the Geological Survey report for 1866-9, which more especially relates to the oil-shales of Stellarton and McLellan's brook. The Stellarton deposits were worked quite extensively in 1860, shortly after their discovery in the previous year, and the output was partly shipped to distillation works in Boston and Portland, and in part was used for mixing with bituminous coals in the manufacture of illuminating gas. For the same reasons, apparently, that so disastrously affected the mining of the shale deposits of New Brunswick and the Utica shales of western Ontario, viz. the discovery of the native oils in that province and in the United States, the mining of stellarite was soon after suspended, and has never been resumed.

The description of the deposits in the vicinity of Stellarton is such as to shew that in the present stage of enquiry for oil-shales these are of sufficient importance to be again investigated and more thoroughly than before. In connection with this it may be said that a couple of years ago, samples of the stellarite mined in 1860 were collected after being exposed on the dumps for nearly half a century. They were analyzed in the department at Ottawa, the

result being a yield of 44.8 gallons crude oil with $14\frac{1}{2}$ pounds ammon. sulphate per ton. Samples taken from Patrick's old dump near the old fulling mill on McLellan's brook, mined about the same date, gave by similar test in Ottawa, crude oil 42 gallons, and ammonium sulphate 41 pounds per ton. This analysis indicates a shale of sufficient value to be worthy of further examination, especially in view of the statement made by Sir W. Logan in his description of the section given of this part of McLellan's brook, that the seam originally opened by Mr. Patrick had in places a thickness of eight feet, and that the measures at this place were affected by faulting, by which the original thickness was so reduced as to render the further working impossible at that time. The thickness of the deposit at Stellarton as given by Logan and which was quoted in the paper of last year, is in one place five feet, of which the upper part of 16 inches is bituminous coal, the middle portion of 22 inches is stellarite, and the bottom bench, also of 22 inches, is oil-shale.

In a section given by Logan along Marsh brook mention is made of a bed of oil-shale, the thickness of which is not clearly defined but is said to be four feet. A small pit was sunk on this seam by a Mr. Haliburton. During our examination of this area last year this pit could not be definitely located, but several tests were made of shales along Marsh brook, though no deposits as rich as those found on McLellan's brook were seen. The analyses of three samples of the shales from this area will be found in the list given of analyses made from samples taken along McLellan's brook.

On a map issued by the Geological Survey, of the Pictou coal-field, 1904, which is largely the work of Dr. H. S. Poole, the locations of several outcrops of oil-shale are given. It was however found somewhat difficult to locate these outcrops on the ground so as to secure specimens for analysis. A number of locations were however selected at various points along McLellan's brook and in the vicinity, including Marsh and Shale brooks, and samples were taken from what were regarded as the most promising outcrops. These have been analyzed by the Department of Mines at Ottawa, to determine the content in crude oil and ammonium sulphate.

In all eight samples were selected for this analysis, the results of which are as follows:

McLellan's brook, New Glasgow, a branch of East river of Pictou; from Patrick's old slope, 27 chains below the old fulling mill:

Crude oil, imp. gallons, 42; sulph. amm., pounds 41, per ton.

McLellan's brook, Black's old mill site:

Crude oil, imp.gals., 14½; amm. sulph., 35 pounds.

Marsh brook, the lower end at the forks with McLellan's brook:

Crude oil, imp gals. 8; amm. sulph., undetermined.

Marsh brook, 150 feet above McKay's house:

Crude oil, imp.gals. 3; sulph. amm., undetermined.

Marsh brook, 300 feet above McKay's house, from area blasted:

Crude oil, imp. gals 14; sulph. amm., undetermined.

Shale brook, upper end:

Crude oil, imp.gals. 4; sulph. amm., undt.

Shale brook, near forks with McLellan's brook:

Crude oil, 9; sulph. amm., undt.

From bed of black shale, one mile west of Woodburn station, in small brook 500 feet north of railroad track, from bed 10 feet thick:

Crude oil, imp.gals. 14.3; sulph. amm., undt.

It will be seen from the above list of analyses that most of the samples selected are not sufficiently rich in hydrocarbons to repay any attempt at development, but that in the case of the stellarite found at Stellarton and at Patrick's slope on McLellan's brook, the results of the several analyses made would appear to warrant further investigation, sufficient at least to prove conclusively the extent and thickness of the oil-shale deposits at these places.

Antigonish county, Nova Scotia.

Of the shale deposits of Antigonish county, it may be said that several of the tests recently made shewed a sufficiently high percentage of crude oil and sulphate of ammonia

to warrant the expenditure of capital in the development or further testing of certain portions. This remark applies more particularly to outcrops seen in Hallowell Grant along Sawmill brook, which is about ten miles north of the town of Antigonish. Other areas in the vicinity do not seem, from the tests recently made in Ottawa, to contain sufficient hydrocarbons to warrant much expenditure in development work. The shales, while black and highly carbonaceous, resemble much of those seen along the lower part of the Avon river, and are too poor in hydrocarbons to render the extraction of the crude oil or sulphate of ammonia profitable under the most favorable circumstances.

Hallowell Grant or Big Marsh, includes a number of outcrops of shale. They are alluded to in the report of Mr. J. Campbell already referred to, in How's *Mineralogy of Nova Scotia*, 1868. From the description there given, it was at one time hoped that large and valuable deposits of hydrocarbons would be found. Black carbonaceous shales outcrop along the post-road, extending north from the town of Antigonish to Big Marsh post-office. They cross the road in several well defined bands, have a general east and west strike, and near the post-office contain irregular beds of a dirty bituminous coal, associated with black and grey shales and greyish sandstone. These have been opened up to some extent in search of a fuel supply. The analyses of the coal was made by the Mines Branch, Ottawa, several years ago, but the results, as then published, were such as to discourage further development at the time. The percentage of ash in the coal ranged from 27% to 46%, being such as to render the coal practically valueless as a fuel. The volatile combustible ranged from 21½% to 29%. A careful examination of a number of outcrops of shale, supposed to be of the oil-bearing series, was made during the past season.

Attempts were made in the field to test the value of several of these outcrops by ignition in stoves, forges, and even by the blowpipe, but in some cases even the last named test failed to produced a flame. As a last resort a number of samples carefully selected from the most promising looking

beds, were sent to the laboratory of the Mines Department to ascertain the exact value of these in crude oil and ammonium sulphate.

In all, samples from eight localities were chosen, in order to give the shales as fair a test as possible over a considerable area. It was found that the black matter of the shales themselves was almost entirely carbonaceous and not due to the presence of hydrocarbons. In fact as regards the shales of New Brunswick, it has been observed that the shales richest in hydrocarbons, were grey rather than black, as can be seen in the case of the grey shales of Turtle creek, Albert county.

The first test of the Antigonish shales was made from a deposit of black shales, including both the plain and curly varieties, located on a farm of Mr. Dan. McDonald, near the forks of the road going east a short distance north of the Big Marsh post-office. Here a pit had been sunk many years ago, referred to in Campbell's paper, 1868, to a depth of 60 feet, of which the upper 40 feet seemed to be a plain black carbonaceous shale. This appeared to be almost incapable of ignition by ordinary test. The lower 20 feet was of the curly variety, and when tested in the forge kindled with difficulty. In the laboratory at Ottawa, the test by Mr. Leverin gave of crude oil 4.8 imp.gals. and of ammonium sulphate 8.7 pounds per ton, the yields in both cases being insufficient to render the mineral of value for economic use.

A short distance east of the forks of this road a small brook, known as McLellan's, crosses the road to the south. On this both varieties of shale, the curly and plain, occur. Samples selected and analyzed at Ottawa gave for the curly variety six gallons crude oil, but the ammonium sulphate was undetermined. The samples of plain black shale gave neither oil nor ammonia. The next brook, going east, crosses this road a short distance beyond the house of John Boyd. From the presence of a sawmill at the road crossing near Boyd's house the stream was named Saw-mill brook for convenience of reference. The banks are frequently steep and in many

places are composed of black and grey shales, some of which is of the curly variety, other parts are plain, as stated by Mr. Campbell in 1868.

A number of these shale beds were tested in the field by the application of heat. Some portions kindled fairly readily and burned quite freely. Several outcrops of both varieties, both black and brown, are seen; and at one place, known locally as "the Banks," the shale forms cliffs of 100 feet or more in height. Much of this is quite bare of vegetation, the forest growth having been destroyed some years ago by fires, which in places burned to a considerable depth in the shale itself. This fire is reported as having burned in the shale for some months before it could be extinguished. The shale deposits at this place appear to possess considerable value. A number of samples were taken, representing the several varieties, and were analyzed in Ottawa with fairly satisfactory results, as follows:—

Samples of shale from the surface at the Banks, gave:

Curly variety; crude oil, 11 gals; amm. sulph., 22 pounds

From bed of Sawmill brook near by, gave:

Curly shale; crude oil, 10 gals; amm. sulph., 38 pounds.

Plain shales; crude oil, 10 gals; amm. sulph., 34 pounds.

From branch of Sawmill brook, adjacent:

Sample of freshly mined shale; crude oil, 10 gals;
amm. sulph., 17 pounds.

It would appear from these tests, which include the shales over a considerable area, that much of the material so tested is not sufficiently rich in hydrocarbons to give profitable returns either in crude oil or in sulphate of ammonia, though the percentage of the latter is fairly high in several cases.

Possibly the fact that parts of the area had to some extent been burned over may have reduced the percentage of crude oil. This place on Sawmill brook, in so far as our examinations in Hallowell Grant extended, seems to be well worthy of further investigation.

Further east near the shore of George bay, at a place known as the Beaver settlement, several holes have been

sunk on bands of black shales regarded as oil bearing. One of these areas was examined and the rocks found to be a very black carbonaceous shale which contains the remains of plant stems and fish scales. Parts of these black shales kindled in the forge quite readily, and the deposit at this place seemed to be quite extensive, exposed from east to west for several miles. The samples collected were from the farm of Hugh McInnis, near the shore of the bay, and on analysis at Ottawa, the black shale gave 7.45 gals. crude oil, but the percentage of ammonium sulphate was not determined.

On the commencement of the examination of the black and grey shales of the formation just described, which is known as the Horton series, and is widely distributed over Nova Scotia, it was hoped that the deposits of Cheverie, Hantsport, and other districts in that vicinity, including Newport, Truro, etc., might on careful examination shew well defined areas, sufficiently rich in hydrocarbons to be utilized in the distillation of crude oil and the manufacture of ammonium sulphate on the large scale. More especially was this hoped for from the fact that all geological determinations on these rocks had shewed conclusively that these shales of the Horton series were the equivalents, as regards horizon, of the shales of New Brunswick, so rich in hydrocarbons. In this examination I may say I was greatly aided by the late Mr. Hugh Fletcher, whose intimate knowledge of the geology of the province was of the greatest assistance in work of this kind. In so far, however, as our field-work on these shales was concerned, the absence of hydrocarbons seemed to be so general that in many cases it was deemed unnecessary to submit samples of them to detailed examination by analysis in the laboratory at Ottawa.

Gaspé Peninsula, Quebec.

The presence of oil-shales of supposed high grade, already referred to as occurring in the eastern part of Gaspé peninsula, was reported first in 1843-4 by Sir W. E. Logan, the first director of the Geological Survey. This belt of oil-

bearing rocks shews the presence of oil-springs at a number of points, and the shales themselves are thrown into several well defined anticlines. They are faulted at a number of places and the springs are apparently connected with certain of these faults. Many thousands of dollars have been expended by several companies in boring operations for oil, but the value of the shales as regards the content in crude oil and sulphate of ammonia was only ascertained last year.

It may be here remarked that in the last thirty years over sixty wells have been bored in this part of Quebec, some of which reached depths of more than 3500 feet. In several of these deep holes no trace of oil was found, and in none was crude oil obtained in quantity of economic importance. In a recent exploration of this district (1909) an area of about 300 square miles was traversed, and a number of shale or oil-bearing sandstone bands were found and carefully examined, samples being selected for analysis in the laboratory at Ottawa. These samples were taken principally from outcrops along the St. John and the York rivers, including the areas which had recently been bored so extensively for oil.

The shales of this district, while practically of the same general horizon as the bituminous or oil-bearing strata of New Brunswick and Nova Scotia, differ in a marked degree in physical character.

The oil-bearing strata in this area are usually thin bedded grey sandstones with interstratified bands or layers which are strongly charged with plant remains, mostly of the species known as *Psilophyton*, a characteristic plant of the Devonian formation. These fossil-bearing strata have usually a local development only. They are traceable from 100 to 200 feet along the strike of the beds, and vary in thickness from a few inches only to 15 or 16 inches. In places a number of these fossil bands or layers unite and form a mineralized zone which with the associated sandy layers may reach a thickness of 8 to 10 feet. The oil-bearing portions seem to be strongly charged with a

substance, sometimes black and sometimes an amber brown, resembling a resin. This mineral when black resembles albertite and is distributed through the beds of fossil plants.

A number of specimens were obtained from different points in this district, extending from east to west for about 30 miles, with a breadth across the measures of 8 to 10 miles. Of the numerous samples collected, four were chosen for analysis, as fairly representing the mineral, and the results of these tests were as follows:

Two samples from the St. John river, gave of crude oil, 30 and $31\frac{1}{2}$ gallons; and sulphate of ammonia 40 and 42.2 pounds per ton.

Two samples from the York river gave in one case 20 gallons crude oil and 22 pounds of sulphate of ammonia, and in another case 36 gallons crude and $59\frac{1}{2}$ pounds of sulphate ammonia. In so far as these figures apply, this shale should be rich enough in these two substances to warrant further exploration to ascertain the probable extent of these oil-bearing bands, since with a few exceptions the yield in both oil and ammonia is equal to that found in New Brunswick and Nova Scotia.

Commercial Value of the Oil-shales of Canada.

The utilization of the oil-shales of Canada depends upon several things, such as percentage of crude oil and sulphate of ammonia, contained in the crude material; the cost of mining and of the manufacture of the oil and sulphate, with that of other by-products; the actual market value of the manufactured articles; and the accessibility of the markets themselves.

For the purposes of comparison it may be assumed that the yield of crude oil from the Scotch shales, as now worked, will average about 24 imp. gallons, and of sulphate of ammonia about fifty pounds per ton put through the retorts. At the present prices of these substances the crude oil may be placed at .025 cents per gallon, and the ammon-

ium sulphate at .029 cents per pound. The value of these two materials from the Scotch shales should be at present prices about \$2.075 per ton of shale.

Taking now the values of several samples of the New Brunswick shales as obtained by actual analyses, we can readily see that the average returns of these shales as a whole is much greater than that of the Scotch output. Thus, the yield of the shale from the Irving seam, which was tested on the large scale in Scotland in 1908, was 40 gallons crude oil and 77 pounds sulphate of ammonia. At the figures quoted as the present market values of these two substances, the value of the Irving shale would be, for the oil content, \$1.20, and for the ammonium sulphate \$2.23, a total of \$3.43, to which must be added the government bonus of $1\frac{1}{2}$ cents per gallon on all crude oil manufactured, or in this case 60 cents per ton, and there is a total valuation of \$4.03 for the shale from the Irving seam. If we can ascertain the actual cost of the manufacture of the Scotch product, which it may be assumed to be well under the two dollar mark, there will be evidently a considerable balance to the good when the Canadian industry becomes established.

Or taking the richer shale of the Albert mines, with 48.5 gallons, crude, and 83 pounds sulphate of ammonia, the value including the bonus would be \$4.37 or a value of \$2.23 over the Scotch shale. With the still richer shales from the Baizley property at Baltimore, which yield crude oil 57 gallons, equal to 65 U. S. gallons per ton, and 110 pounds of ammonium sulphate, the value of this shale on the figures already assumed would be \$4.81 or \$2.76 per ton more than the Scotch shale, to which must be added the bonus of $1\frac{1}{2}$ cents per gal. manufactured and there would be a total gain over the value of the Scotch shale of \$3.73. The profits on the Scotch shale on which large dividends are paid, were stated to me to be about three shillings per ton.

It will be readily seen therefore that if an adequate market is secured the immense quantity of these shales in the maritime provinces, so rich in hydrocarbons, makes their proper utilization well worthy serious consideration.

Extent and cost of plants.

While in Scotland, estimates were obtained from several of the managers of the leading oil-shale works as to the cost of plants, etc. Thus in 1908, the number of retorts in operation in Scotland by five of the seven companies engaged in the industry, was 1502, with a number of others under construction for the coming year. These five plants include the Pumpherston, Tarbrax, Dalmeny, Oakbank and Broxburn. Two companies, belonging to the Youngs and to James Ross Co., declined to furnish us returns. Of these the Broxburn alone puts through the retorts about 1600 tons of shale every day of 24 hours. For this they use three benches of 64 retorts each or 192 in all, with a reserve half bench of 32 retorts in case of needed extension.

A bench of retorts consists usually of 64, and each retort is designed to put through about four tons of shale per day. Hence 6000 tons per day are retorted daily in the retorts of the five companies which furnished us the information. The total amount of shale retorted annually by all the works, seven in number, is not far from 2½ million tons. It may be remarked that the acreage of the Scotch shales areas is less than that of the shale areas found in Albert county, N. B., alone, at the Albert mines and Baltimore.

As regards the cost of the necessary plants for manufacture of crude oil and sulphate of ammonia, it may be said, from information obtained from several of the managers of the principal works, including Mr. Norman Henderson of the Broxburn and Mr. James Bryson of the Pumpherston, and from Messrs A. F. Craig & Co. of Paisley, one of the largest manufacturing firms of such plants in Britain, that the following figures may fairly be quoted. Thus, for a Henderson retort for experimental purposes, such as was used in the test of the shale shipment sent from New Brunswick, the cost would be from £350 to £500 complete. But if a number of these units were erected to form a complete plant for oil manufacture, the cost would be from £60 to £70 per ton of shale put through daily. Such figures refer to the cost of a

retort plant erected only on a large scale in Scotland, and using such basis of calculation only, an approximate cost of a full retort plant would be obtained.

Mr. J. Bryson, manager of the Pumpherston works, stated that a Pumpherston retort would cost £350, when only one retort would be erected for experimental purposes. This figure would include a condenser, ammonia scrubber, and receiving tank, but not the scaffold for charging the top of the retort. As an illustration of the cost of a plant at present in operation, Mr. Norman Henderson stated that a crude oil plant, like that at Tarbrax, with three benches of 64 retorts each or 192 in all with a daily capacity of 700 to 800 tons would cost about £100,000, or \$500,000. These figures would include condensers, engines, pumps, shale breakers, tanks, boilers, sheds, all connections for these, a naptha recovery plant, an ammonia sulphate plant and all necessary brickwork.

The nominal figure of £65 per ton capacity, as usually quoted, serves merely as a basis of calculating the cost of the benches of retorts, and does not refer to a complete oil-plant. The retorting plant is arranged in groups of four, and the complete cost of a retorting plant containing 180 Pumpherston retorts would be about £80,000.

From Messrs A. F. Craig & Co. of Paisley, it was learned that the cost of three benches of 64 retorts each or 192 retorts, with all condensers, engines, pumps, tanks, boilers, sheds and connections would be about £43,700; a naptha recovery plant for the same would be £4,320, and all brickwork necessary for the erection of these plants would be £16,200. These figures are intended to apply only to plants erected in Scotland, and to those portions of a plant necessary at the crude oil stage. They do not include costs of erection and delivery. In Canada the costs would be increased somewhat by freight, duties, extra charges for labour, etc.

These figures as stated are for plants making crude oil, sulphate of ammonia and paraffin. In addition, if it is required to manufacture illuminating, lubricating and other oils, and by-products, the expenses of plant building will be

greatly increased. Thus the cost of a sulphate house with a capacity of 1200 tons of shale per day would be about £5000.

The cost of a refinery plant would be about £11,000 per million gallons capacity.

The cost of a candle house for such a refinery would be from £5000 to £7000 complete in Scotland.

As to the cost of mining and retorting the shales, the expense in Canada should not be excessive. In Scotland the cost per ton for mining and delivery to the retort mouth ranges from 3/6 to 6/ per ton, the workings in some of the mines now being 200 fathoms deep. The cost is said to average about 4/ or \$1.00 per ton. Retorting will be about 40 cents, and sulphate manufacture about 46 cents. These figures would certainly not be exceeded in Canada, where immense bodies of the richest shale occur at or near the surface. In addition, in Scotland, the royalty or lordship on the shale mined is from three pence to ten pence per ton, while in Canada, according to the present agreement, the shales mined are exempt from tax for ten years.

DISCUSSION.

A general discussion on the subject of Dr. Ells's paper then ensued and was taken part in by Hon. R. Drummond, T. Cantley, A. Dick, G. E. Corbett, the author and others. It bore upon the extent and character of the various deposits of oil-bearing shales of Nova Scotia and New Brunswick, their suitability for producing commercially oil and ammonium sulphate, and their relative values compared with the Scotch shales. Attention was drawn to the excessively larger profits made by the manufacturers in Scotland, which indicated that oil-shales of the richness of some of the deposits in the Maritime Provinces, as shown by Dr. Ells's paper, should prove to be a most enticing field for the investment of capital. It was thought that considering the heavy yield of oil and ammonium sulphate of some of our shales, that an effort should be made to give the greatest

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publicity to a paper such as the present, which showed the opportunities we possess for the establishment of an industry which bids fair to be a most lucrative one.

The speakers all referred in the highest terms to the great value of Dr. Ells's paper, and a hearty vote of thanks was presented to the author.