1943

CRETACEOUS SHALES OF MANITOBA AS A POSSIBLE SOURCE OF CRUDE PETROLEUM by S. C. ELLS

During recent years attention has been directed to reported occurrences of oil shale in the provinces of Manitoba and Saskatchewan. The snales are exposed along the escarpment of the Pembina, Riding, Duck, and Porcupine mountains, which border the lake plain and Red River valley of Manitoba. They are also found in the escarpment of the Pasquia hills, a northern extension of the same series. These hills, dignified by the name of mountains, constitute the erosion escarpment of the Cretaceous beds which form the first prairie step. The eastern edge is indented by drainage valleys of varying importance, which separate the hill features into groups. The Pasquia hills, and Porcupine, Duck, and Riding mountains, occupy an area which is bounded toward the north and northwest by the Carrot river, and toward the east by waterways, which include Moose lake, Cedar lake, and lake Winnipegosis. Broad, low-lying, slightly undulating, lacustral plains, which formed the bed of glacial Lake Agassiz, stretch away from the various waterways of the lower slopes of the hills. These lower slopes are marked by a series of wold lake beaches, and rise by easy gradients, through some five or six hundred feet, to the more abrupt escarpment of the main ridge.

The whole area is well watered by numerous small streams few of which have a width greater than 60 feet. In descending from the table lands, these streams, for the most part, flow with rapid current along boulder-strewn channels, deeply entrenched in precipitous valleys and ravines, where active erosion and landslides are much in evidence. On reaching the lower slopes of the hills, the current slackens, and many excellent geological sections are exposed in cut banks at concave bends. Through the low-lying alluvial lands, the banks, as a rule, are low, and the channels of the meandering type.

Outcrops of shales examined on Birch river, Eavel river, Sclater river, Pine river, Vermilion river and Ochre river, are all near the Winnipeg-Prince Albert branch of the Canadian National Railways, and may be easily reached by highway roads.

Toward the east and northeast, the slopes of the Pasquia hills are marked by somewhat sharp gradients. In passing westward, however, the slopes become more gentle, and rock exposures along the various streams less frequent. The elevation of the summit has not been accurately determined, but apparently ranges from 2,000 to 2,300 feet above sea level datum. The area throughout is densely wooded. Apart from a number of comparatively limited areas reserved as timber berths, the forest growth consists, principally, of large poplar and birch. Much of the land is of excellent quality, and, when cleared, should prove well adapted to agricultural development.

GLOLOGY

The general geology of the area was worked out many years ago

by Tyrrell, Dowling, and McInnes, and the reports then issued 1 remain authoritative. The general geological features are simple, and may be very briefly summarized as follows

The Pasquia hills, and Porcupine, Duck, and Riding mountains, are built up of Cretaceous sediments, resting unconformably on limestones of Palaeozoic age. Apart from type fossils, which are found at many localities, the principal subdivisions of the Cretaceous, within the area under consideration, may frequently be recognized by lithological characteristics.

A marker band of impure limestone, averaging some four feet thick, and containing typical fossils, occurs near the top of the Niobrara, and apparently extends over a wide area. Other marker cands are of local significance only. In the following general section, estimated thicknesses are given, out, pending the collection of further data, these must be considered as approximations.

	(Montana (Pierre (upper) Odanah snales 400 feet (lower) Millwood shales 650 feet
Cretaceous	(Colorado ((Boyne Shale) (Niobrara (Morden shale) 130-240 feet (Assiniboia shale)
	(Benton shale
Devonsen		The component days

Devonian Unconformity.

The detailed geological structure has not been accurately worked out, although numerous exposed sections, together with correlated elevations, indicate that the general dip of strata of Cretaceous age is almost horizontal. Between Winnipegosis and the well drilled by the Manitoba Oil Company, il miles southwest of Dauphin, the dip of Upper Palaeozoic limestones is apparently about four feet to the mile, in a southwesterly direction. South of Swan River valley, Cretaceous sediments also dip at a very low angle toward the southwest. North of this point, the strata flatten out, and finally dip toward the north. The same general horizontal structure apparently typifies strata underlying the Pasquia hills. Minor local folding was observed, but this in itself can scarcely be considered as of economic importance. The general physical characteristics of members of the Cretaceous system may be briefly summarized as follows

Pierre. Odanah series. Dark fissile shales, usually poor in fossils, and weathering to light grey fissile flakes. Often rusty along joint planes.

Canada, Mem. 30. 1913.

Report on Northwestern Manitoba with portions of the adjacent districts of Assiniboia and Saskatchewan, J. B. Tyrrell and D. B. Dowling. Geol. Survey of Canada, 1892.

The Basins of Nelson and Churchill Rivers, Wm.McInnes, Geol. Surv.of

Millwood series. Soft grey shales, sometimes almost black in colour. Weathers to light grey flaky particles, which eventually disintegrate to dark plastic clay. Slopes adjacent to cut banks exhibit marked evidence of instability. Ironstone nodules are common, particularly near contact with Niobrara.

Niobrara. — Dark grey clay shales, frequently mottled, and interbedded with heavy bands of hard calcareous shale, usually highly fossiliferous, and almost black in colour. Shale weathers to light grey colour. Comparatively weather resistant.

Benton. -- Very dark, soft, non-calcareous, somewhat carbonaceous, evenly bedded shale, poor in fossils. Weathers to small thin flakes, which rapidly disintegrate into dark plastic clay.

Dakota. -- White, light grey or greenish sandstone. Usually somewnat soft, but in places having the hardness of quartzite. .

With the exception of the upper and the lower members of the Cretaceous system, the sediments exposed within the area under consideration thus consist chiefly of rather soft, greenish grey, clay shales, more or less darkened owing to the presence of hydrocarbons and iron sulphides. Moreover, many of these shales, when freshly broken, emit a marked odour of petroleum, which, on exposure, rapidly passes off. When disintegrated by the drilling tools, in the presence of water, the shale forms an emulsion of a dark green colour. This emulsion gives off a faint odour of petroleum, and, after standing for a time, exhibits a thin film of petroleum on the surface. It is, therefore, not surprising that the presence of free petroleum in wells drilled through the shales has been reported from time to time.

Of upper Cretaceous shales, the Niobrara formation is the most highly fossiliferous, hence it is within this horizon that bands of oil shales might have been anticipated. Fossils observed in this formation comprise a large number of foraminifera, among which Globigerina cretacea is conspicuous, and an abundance of shells of a large Inoceramus, together with the following species.

Serpula semicoalita (Whiteaves. N. sp.).
Ostrea congesta (Contad).
Anomia obliqua (Meek and Hayden).
Inoceramus problematicus (Schlotheim).
Belemnitella Manitobensis (Whiteaves. N. sp.).
Loricula Canadensis (Whiteaves. N. sp.).
Ptychodus parvulus (Whiteaves. N. sp.).
Lemna Manitobensis (Whiteaves. N. sp.).
Enchodus Shumardii (Leidy).
Cladocyclus occidentalis (Leidy).

Origin of Shale

Oil shales of New Brunswick and Nova Scotia were deposited under different conditions from those of Manitoba and Saskatchewan. In

the former provinces, material from which the shale beds were derived was originally deposited in the form of fine clays on the bottom of swamps and lagoons. If the theory of Steuart² is accepted, there was associated with these sediments vegetable matter converted into a pulp, as a result of maceration and microbe action in water, together with richer materials of various kinds, such as spores, and a proportion of animal matter. We may, therefore, conclude that the origin of the petroleum in the shales may be traced to fermentation and decomposition of organic matter, through microbe action. On the other hand, the shales of Manitoba and Saskatchewan were laid down in a muddy sea, and were, therefore, not subjected to the various influences that affected the shales of the Maritime Provinces.

PHYSICAL CHARACTERISTICS OF SHALES IN THE PROVINCES OF Manitoba and Sasketchewen.

It is evident that great areas of Cretaceous shales, with their notable content of organic matter, have been subjected to very slight disturbance. Had the shales been affected by folding or by compression, as a result of great earth movements, distillation of organic remains, due to heat and pressure, would doubtless have resulted in the formation of gas and petroleum.

Attempts to ignite fine splinters of the various shales examined, by means of a match, failed in nearly every instance. Niobrara shales, when partially dried, will, however, frequently ignite when placed on an open wood fire. Pierre shales examined ignite but rarely, an and then with difficulty. Benton shales showed no evidence of being combustible. Sampling was, therefore, confined largely to Niobrara shales.

In appearance and physical characteristics, as well as in the conditions under which they were deposited, these upper Cretaceous shales are thus in marked contrast to the oil shales of Nova Scotia and New Brunswick. In these provinces, two general types of shale are recognized, viz., plain and curly. A sub-variety, usually referred to as paper shale, is apparently a weathered form of plain oil shale. It is thin-bedded or papyraceous, separating readily into thin flexible sheets of considerable surface dimensions. Plain oil shales are usually flat surfaced, showing more or less well defined lamination. On the other hand, curly shale usually occurs as massive bands, somewhat curled and contorted. It is very tough, breaks with a conchoidal fracture, and is, usually very rich in hydrocarbons.

As a rule, oil shales of Nova Scotia and New Brunswick are free from grit, and, although readily cut with a sharp knife, do not yield thin, flexible shavings as do the Scotch shales. They are strongly resistant to

Steuart, D. R., The Chemistry of Oil Shales, Oil Shales of the Lothians, Geol. Surv., Scotland, 1912.

weathering, and fragments have remained, for many years, exposed to action of atmospheric agencies, with but little loss of their hydrocarbon content. When placed in a grate, fragments may be readily ignited, giving off an intense heat, and continuing to burn with a long yellow flame for periods of from one to three hours. Small splinters of the shale may usually be ignited by means of a match.

Oil shales of New Brunswick, Nova Scotia, and Scotland, do not contain hydrocarbons which are liquid at atmospheric temperature. Numerous wells have been drilled through the shales by various companies, but, although free petroleum has been encountered in interbedded sands and sandstones, practically none has been met with in the shales themselves.

WEATHERING OF SHALES

Weathering of the Cretaceous shales presents an interesting study. As a rule, the hydrocarbon content of shales examined does not prevent rapid weathering, while, on the other hand, the shales contain within themselves a variety of potent disruptive agencies. Apart from the high percentage of water present, this disintegration, due to the formation of secondary minerals, as iron and calcium sulphates, hydrated iron oxides, etc., and circulating solutions containing acids and sulphates, is very marked.

ASSOCIATED MINERALS

Incidental to the examination of the Cretaceous shales, the presence of certain associated minerals was noted. None of these minerals were observed in sufficient quantity to be of present economic importance, but, pending a complete chemical analysis of the shales, their somewhat complex geochemistry may be briefly alluded to.

These associated minerals fall into two classes, viz., those which, being deep seated, have not been subjected to oxidizing influences, and others, which have been deposited at, or near the surface, in the presence of circulating waters, and under the influence of other oxidizing agencies. In addition to bentonite, the principal deep seated minerals comprise pyrite, siderite, and glauconite. Owing to the length of time during which they have been forming, these minerals occur in considerable quantity and exhibit comparative purity. Surface deposits comprise marcasite, iron sulphate, limonite, gypsum (in the forms of selenite and satinspar) native sulphur, and small amounts of iron oxide. Pyrite, in the form of small cubes, sometimes occurs in narrow lenses, but is more often disseminated and invisible to the naked eye. Siderite is most abundant in the Pierre series, at times forming beds a few inches thick. Bentonite occurs as uniform, sharply defined beds, having a maximum observed thickness of 24 inches. Pyrite and marcasite, in the presence of oxidation agents, give rise to the formation of small quantities of sulphurous and sulphuric acids. It may be possible that these acids, circulating through the shales, form soluble sulphates which are subsequently leached out, leaving bentonite as a residual product. To the oxidation of iron sulphides may also be attributed the nauseating sulphurous odour which, at times, emanates from

shale banks, and has frequently been construed as indicating the presence of natural gas.

Absorption of oxygen, assisted by oxidation of iron sulphides, is respondible for slow spontaneous combustion in progress in many of the banks of shale. At one locality a column of thin blue smoke was observed rising from a smouldering bank, the talus at the foot of the bank being cemented together by various sulphates. Moreover, traces of free petroleum, released as a result of recognized chemical reactions, as well as small amounts of colloidal iron hydroxide, frequently accumulate to form a scum, which, at times, has been mistaken for a true petroleum seepage.

SAMPLING AND ANALYSES

In securing samples overburden was removed and trenches cut from top to bottom of exposed sections. The depth at which samples were taken varied from four to eight feet from the face, but it is considered that in each instance unaltered shale was procured. A number of samples were tested in the field, and satisfactory results were obtained by the use of a retorting apparatus somewnat similar to that recommended by the United States Bureau of Mines. Only the petroleum content was determined. In the case of certain other samples, subsequently tested in the laboratory, the yield of ammonium sulphate was also determined. Nineteen representative samples were procured from Steeprock river, Birch river, Favel river (east and west branches), Sinclair river, North Duck river, Sclater river, North Pine river, Vermilion river and Ochre river, in the province of Manitoba.

Certain of these samples showed merely a trace of hydrocarbons, hence reference to them is omitted in the following summary.

Reports of Investigations, U.S. Bureau of Mines, Serial No. 2229.

Determinations by Chemical Laboratories, Mines Branch, Department of Mines.

ANALYSES

Locality	Imperial gals.crude petroleum per ton	Spr.gr. of crude pet- roleum at 60° F.	Imperial gals. water per ton	Pounds ammonium sulphate per ton
Birch River, Sec.31, Tp.39, R.26, W.1st. Favel River, Sec.30, Tp.35, R.25, W.1st. Sec. 26, Tp. 35, R. 26, W. 1st.	0 6.2 6.8 5.9	0.972 0.984 0.965	42.7 12.1 7.0 15.2	••••
Sec. 15, Tp. 34, R. 23, W. 1st Pine river, Sec. 6, Tp. 33, R. 22, W. 1st Vermilion river, (2 samples),	4.8-7.5 3.3	0.966-0.968 0.969	9.2-18.7 4.5	••••
Sec. 12, Tp. 24, R. 20, W. 1st Ochre river, (2 samples), Sec. 29, Tp. 22, R. 17 W. 1st	1.1-5.1 4.0-5.3	0.952	8.1-22.0 14.6-15.2	••••

¹ Calculations based on ton of 2,000 pounds.

The sulphur content of the crude petroleum recovered from six representative samples of shale varied from 5.3 per cent to 7.7 per cent, with an average for the six samples of 6.5 per cent. A sample of crude petroleum distilled from shale secured on Ochre river, Manitoba, (Sec. 29, Tp. 22, R. 17, W. of 1st) was fractionated with the following result.

Distillation range	Barom.	766.0 m	<u>n</u> .
lst drop	79	degrees	c.
10 p.c	149	11	C.
20 p.c			C.
30 p.c.	221	#	C.
40 p.c.	254	. 11	Ċ.
50 p.c.	281	11	Ċ.
60 p.c.	301	Ħ	Ċ.
70 p.e			G.
80 p.c.			Ċ.
90 p.c.		n	Ċ.
92 p.c. dry point (cracking occur		Y*	•

The gas yield from 13 representative samples of shale was also determined, and varied from 410 to 1,130 cubic feet per ton, with an average yield of 695 cubic feet. Analyses of two samples of gas recovered from shales secured on Man river, Sask., (Tp. 50, R. 5, W. of 2nd) are as follows.

	Sample 1825 p.c.		Sample 1831 p.c.	L
Carbon dioxide Oxygen Ethylene Carbon monoxide Methane Hydrogen Nitrogen Inflammable gas Calorific value, gross	32.6 2.1 3.7 2.4 28.7 9.1 21.4 43.9 383		23.3 3.1 3.8 1.9 30.6 7.5 29.8 43.8	D. 00% 11
Calorific value, net	346	•••••	359	B.Th.U per cu. ft.

CONCLUSION

It is, therefore, obvious that shales examined during the past season in the provinces of Manitoba and Saskatchewan are of little present economiv importance as a possible source of petroleum or of ammonium sulphate. Should conditions at any time warrant commercial development, open cut mining could be undertaken in many areas under favourable conditions. Over very considerable areas the shales examined are covered by a comparatively light overburden, consisting chiefly of boulder clays and gravel, which could be readily removed by hydraulicing methods.

Dept of Mines Canada Summary Report

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Market Prices —The market prices for alkalis are constantly varying The following figures, is reported in the Oil Paint, and Drug Reporter, New York, give the New York market prices for the years 1911 to date—

	Aug 14 1914	Ju 1 1915	Jan 1 1917	J _{in 1} 1918	* 1919	± 1920	* 1921
	\$	\$	\$	8	\$	3	
Salt cike ground— bbl jer ton Cliuber's salt—ent Lpsom salt USP— ent Lpsom alt tech— ent	to 13 00 0 to 1 to 0 75	11 00 13 00 0 60 to 0 75 octcl pror 1 75 to 2 00	0 60 to 0 to to 1918	30 00 to 3 > 00 0 90 to 1 00 > 622 to 3 90 3 72 to 3 90	12 00 to 30 00 1 00 to 2 25 2 75 to 5 62 ¹ 1 80 to 3 37 ¹ / ₂	17 f0 to 80 00 1 1 1 to 2 1 2 2 30 to 3 30 1 7 2 to 6 30	17 00 to 28 00 1 00 to 1 7 2 20 to 2 7a to 1 7a

^{*}High and low figures for year

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CRETACEOUS SHALES OF MANITOBA AND SASKATCHEWAN, AS A POSSIBLE SOURCE OF CRUDE PETROLEUM

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INTRODUCTORY

During recent years attention has been directed to reported occurrences of oil shale in the provinces of Manitoba and Saskatchewan. The shales are exposed along the escarpment of the Pembina, Riding, Duck, and Porcupine mountains, which border the lake plain and Red River valley of Manitoba. They are also found in the escarpment of the Pasquia hills, a northern extension of the same series. These hills, dignified by the name of mountains, constitute the erosion escarpment of the Cretaceous beds which form the flist prairie step. The eastern edge is indeated by draining valleys of varying importance, which separate the hill features into groups. The Pasquia hills, and Porcapine, Duck, and Riding nountains, occupy in area which is bounded toward the north and northwest by the Carrot river, and toward the east by waterways, which include Moose lake, Cedar lake and lake Winnipegosis. Broad, low-lying, slightly undulating, lacustral plains, which formed the bed of glacial Indea Agassiz, stretch away from the various waterways of the lower stopes of the hills. These lower slopes are marked by a scries of old lake beaches, and rise by easy gradients, through some five or six hundred feet, to the more abrupt escupinent of the main ridge.

The whole area is well watered by numerous small streams few of which have a width greater than 60 feet. In descending from the table lands, these streams, for the most part flow with rapid current along boulder-strewn channels, deeply entrenched in precipitous valleys and raymes, where active erosion and landslides are much in evidence. On reaching the lower slopes of the hills, the current slackens, and many excellent geological sections are exposed in cut banks at concave bends

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Outcrops of shales examined on Buch river, Twel river, Sclater river, Pine river, Vermilion river and Ochre river, are all near the Winnipeg-Prince Albert branch of the Canadian National Railways, and may be easily reached by highway roads. Outcrops examined on the Tee river—a branch of Pasquir river, Man river Cracking river, and Papikwan river in the Pasquia hills, are somewhat remote from rail

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Toward the cast and northeast, the slopes of the Pisquia hills are marked by somewhat sharp gradients. In passing westward, however the slopes become more gentle, and rock exposures along the various streams less frequent. The elevation of the summit has not been accurately determined, but apparently ranges from 2,000 to 2,300 feet above sea level datum. The area throughout is densely wooded. Apart from a number of comparatively limited areas reserved as timber beiths, the forest growth consists, principally, of large poplar and birch. Much of the land is of excellent quality, and, when cleared, should prove well adapted to agricultural development.

Outcrops of shale along streams which drain the northeastern slopes of the bills (as on Lee river and Main river) can best be reached from the Pas. From Mountain cabin on Carrot river, some 60 miles WSW from the Pas, a good summer trul, approximately 2½ miles in length, leads south to Tee river. From Camp No. 6 on Carrot river, some 90 miles from the Pas, a fur bush road, approximately 17 miles in length, leads to Main

river

Papikwin and Cracking rivers can best be reached from McDonald's siding, 2½ miles west of Mistation station, on the Canadian National Railwiys. From McDonald's siding, a tim wigon road, some 24 miles in length, leads to Connell cabin. From Connell cabin to Papikwan cabin, a distance of approximately 12 miles, a fair pack trail is available, but between Papikwin cabi and the shale outcrops at the forks of Cracking river, the trail is wet and difficult. Other trails indicated on the accompanying map are, for the most part, poor, and in many mstances, difficult to follow.

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GEOI OG Y

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	Montana	Pierre (upper) Od mah hales (lower) Millwood shales	400 fcet 650
Cretaceous	Colorado	(Boyne shale) Niobrara (Morder shale) (Assimbora shale)	170-240
		Ber ton shale Dakota sandstone	180'
Devonian		Unconformity	

The detailed geological structure his not been accurately worked out, although numerous exposed sections, together with correlated elevations, indicate that the general dip of strike of Creticeous age is almost horizontal. Between Winnipegosis and the well drilled by the Manitoba Oil Company, 11 miles southwest of Dauphin, the dip of Upper Paleozoic limestones is apparently about four feet to the mile in a southwesterly direction. South of Swan Rivervalley, Creticeous sediments also dip it a very low angle toward the southwest. North of this point, the strate flatten out and finally dip toward the north. The same general horizontal structure apparently typics strate underlying the Pasquar hills. Minor local folding was observed, but this in itself can scarcely be considered as of economic importance. The general physical characteristics of members of the Cretaceous system may be briefly summarized as follows.—

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Map show

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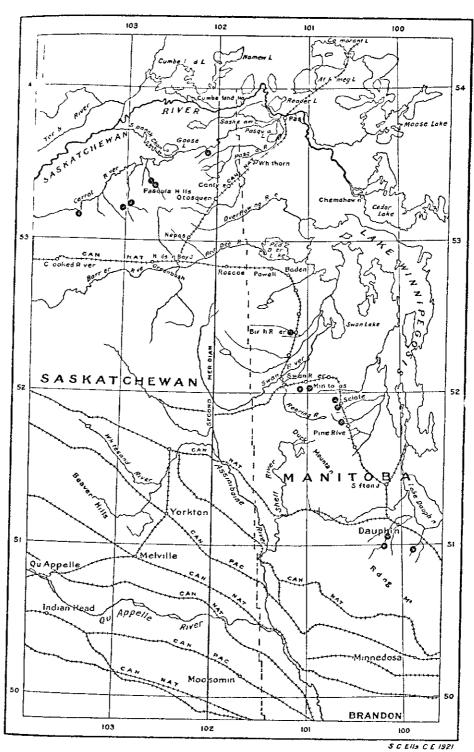
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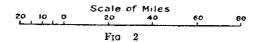
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Map showing position of Outcrops of Cretaceous Shales sampled during year 1921, in Manitoba and Saskatchewan



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therefore, commed logely to Niobiun shiles

In appearance and physical characteristics, as well as in the conditions under which they were deposited, these upper Creticeous shales are thus in marked contrast to the oil shales of Nova Scotia and New Brunswick In these provinces, two general types of shale are recognized, we plan and curly A sub a mety usually interied to as paper shale, is appraiently weathe cd form of plan oil shile. It is then-bedded, or paper acous, separating readily into thin, flexible sheets of considerable surface dimensions. Plum oil shales are usually flat surriced, showing more or less well defined lamination. On the other hand, only stale usually occurs as massive bands, somewhat curled and contented. It is very tough, breaks with a conchoid if freture, and is usually very rich in hydrographons. As a rule, oil shales of Nova Scotia and New Brunswick are free from

girt, and, although readily cut with a sharp knife, do not yield thun, flexible shavings as do the Scotch shales They we strongly resistant to veithering, and fragments have remained, for many years, exposed to action of atmospheric agencies, with but little loss of their hydrocubon content When placed in a grate, fragments may be readily agrited, giving off an intense heat, and continuing to burn with a long vellow filme for periods of from one to three hours Small solutions of the shale may usually be

ignited by ricars of a match

Oil shiles of New Brunswick, Nova Scour, and Scotland, do not contain hydrocubous which he liquid it itmospheric temperature. Numerous wells have been dulled through the shales by various companies but, although free petroleum has been encountered in interbedded sands and syndstones, practically none has been met with in the shales themselves

WEATHELING OF SHALLS

Weathering of the Cictaceous shales presents in interesting study a rule, the hydrocarbon content of shales examined does not prevent rapid werthering, while, on the other hand the shales contain within themselves a variety of potent disruptive agencies. Apart from the high percentage of water present this disintegration, due to the formation of secondary minerals as non and calcium sulphates hydrated non oxides, etc., and enculating solutions containing acids and sulphates, is very marked

ASSOCIATED MINERALS

Incidental to the examination of the Cretaceous shales the presence of certain associated minerals was noted. None of these minerals were observed in sufficient quantity to be of present economic importance but, pending a complete chemical in disas of the shales, then somewhat complex geochemistry may be briefly alluded to

These associated minerals fall into two classes, viz those which, being deep seited have not been subjected to oxidizing influences and others, which have been deposited it, or near the surface, in the presence of circulating waters, and under the influence of other oxidizing agencies. In

addition to bei siderite, and g have been for Chibit compa sulphate, limoi sulphur, and tunes, sometir and invisible t series at time: form, shuply mches Print use to the four It may be por soluble sulph is a residual attributed the from shale be presence of n

Absorptic pensible for sl of shale from a smould together by released as a mounts of (scum, which,

In securi top to botter taken varied in each insta were tested n of a retorting United State maned In t Taboratory, th two represent Painer M (wint river >t cprock riv r of North and Othre riv Certun

hence referen i i por of Inv

ligles examined by obrara shales, when placed on an open then with difficulty le Sampling was,

as in the conditions ous shales are thus d New Brunswick gnized, viz, plum hale, is apparently I, or papyraceous, ble inface dimen-; more or less well usually occurs as ery tough, breaks hydroen bons aick aic free from yield thin, flexible istant to weitherosed to action of ocarbon content ted, giving oft an flume for periods mny usually be

id, do not contain ture Numerous compinies, but, idded sands and rdes themselves

sting study of pievent rapid thin themselves high percentage n of secondary Aldes, etc., and v marked

s, the presence minerals were aportance but, ewhat complex

se which, being es, and others, nescace of ciragencies In

to on to bentonite the principal deep seated minerals complise pyrite, . . to and glauconite Owing to the length of time during which they the been forming, these minerals occur in considerable quantity and with a comparative purity. Surface deposits compaise maissite, iron al phate, limonite, gi psum (in the forms of scienite and satinspar), native all him, and small amounts of non ox de Parite, in the form of small it's sometimes occurs in narrow lenses, but is more often disseminated und invisible to the nuked eye. Siderite is most abund int in the Picire s rus, at times forming beds a tew inches thick. Bentonite occurs as unitorm, sharply defined beds, having a maximum observed thickness of 24 mehes Printe and marcasite, in the presence of oxidation agents give rise to the formation of small quantities of sulphurous and sulphuric acids It may be possible that these acids, circulating through the shales, form soluble sulphates which are subsequently leached out leaving bentonite is a residual product. To the oxidation of non sulphides may also be ittributed the niuseiting sulphurous odour which, at times emanates from shale banks, and has frequently been construed as indicating the presence of natural gas

Absorption of oxygen, assisted by oxidation of non sulphides, is respensible for slow spont meous combustion in progress in many of the banks At one locality a column of thin blue smoke was observed using from a smouldering bank, the talus at the foot of the bank being cemented together by various sulphates Moreover, traces of free petroleum, released as a result of recognized chemical reactions, as well as small unounts of colloidal non hydroxide, frequently accumulate to form a seum, which, at times, has been mistaken for a true petroleum seepage

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SIMILING IND ANALYSES

In securing samples overburden was removed and trenches cut from top to bottom of exposed sections. The depth it which simples were taken viried from four to eight feet from the face, but it is considered that in each instance unaltered shale was procured. A number of samples were tested in the field, and satisfactory results were obtained by the use of a retorting apparatus' somewhat similar to that recommended by the United States Bureau of Mines Only the petroleum content was determined In the case of certain other samples, subsequently tested in the liboratory the yield of immonium sulphate was also determined. I wentytwo representative samples were produced on the northern branch of the Pas inver Man inver, Crucking river, Papikwan inver, Jordan river, and Curot iver, in the province of Sisl itchewin, and nineteen simples from Steeprock river, Buch inci, I wel incr (east and west branches), Sinclur mei North Duck river, Schiter men, North Pine men, Vermilion river, and Othre river, in the province of Manitoba

Certum of these samples showed merely a trace of hydrocarbons,

hence reference to them is omitted in the following summary

R ports of Investinations U.S. Bureau of Min. Serial No. 2229
3 Determinations by Chemical Laboratories, Mine Branch, Department of Mines

Analyses

Locality	Imperial gals crude petroleum rer ton ¹	Spr gr of crude petroleum it 60 F	Imperial fila witer per ton	Pounds ammonium sulphate per ton
Tee river Sask (2 samples) Ip o3 R I W of 2nd Man river Sask (8 samples) Tp o0 R 5 W of 2nd Cracking river Sask (6 samples) Ip 49 R 7 W of 2nd Dordan river Sask (float) Sec 6 Tp 48 R 10 W of 2nd Carrot river Sask (2 samples) Sec 25 Ip 45 R 11 W of 2nd Birch river Win Sec 31 Tp 39 R 26 W of	0 0 - 9 4 7 0 - 12 8 10 9 4 9 - 6 0 0	0 972—0 981 0 912—0 964 0 919—0 970 0 964 958—0 959	12 5—16 0 11 5—28 0	
Favel river Man Sec 30 Tp o5 R 25 W of 1st Sec 26 Fp 3, R 26 W of 1st Sclateriner Wan (2 samples Sec 1) Tp 34	0 6 2 6 8 5 9	0 972 0 984 0 96a	42 7 12 1 7 0 15 2	
Pine river Man Sec 6 Tp 33 R 22 W of 1st serminon river Man (2 samples) Sec 12 1p 21 R 20 W of 1st School Man (2 samples) Sec 29 Tp 22 R 17 W of 1st	4 8- 7 5 0 3 3 1 1 - 5 1 4 0- 5 3	0 969 0 952	9 2-18 7 4 5 8 1-22 0 14 6-15 2	

¹Calculations based on ton of 2 000 pourds

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The sulphur content of the crude petroleum recovered from six representative samples of shale varied from 5 3 per cent to 7 7 per cent, with an average for the six samples of 6 5 per cent. A sample of crude petroleum distilled from shale secured on Ochre river, Man, (Sec 29, Tp 22, R 17, W of 1st) was fractionated with the following result -

	- From Tomowing result —
Distillat on range	,
1st drop	Palom 766 0 mm
10 p c 20	79 C
30	149 C
40 "	170 C
>0	221 C 2-4 C
60 70	281 C
80	301° C
90	336 C
92 dry pairt (cricking occurred)	3-9 C 3-1 C
Pros.	

The gas yield from 13 representative samples of shale was also determined, and varied from 410 to 1,130 cubic feet per ton, with an average yield of 695 cubic feet. Analyses of two samples of gas recovered from shale secured on Manracr, Sask (Tp 50, R 5 W of 2nd) are as follows —

Cirbon Ourgen 1 thylen Methane Hydroga Ntroget Infianm (alorific

Culorific

It is, there in the provinc economic impo sulphate -Shopment, open cut ble conditions covered by a co class and gravel

Occurrences within the Domin Verertbeless, with his hid to depen petroleum and pe and again in 1862 to retort local shall wine to the rapidly discovered pools of pse of nearly sixi a creal value of C Thus it is that ~ Ppeared to w

terequently, muc be definitely ultilde mir be The write Yen Brins ~ datchew in 1 (1 (11 m ormatic

_		
-	Imperial Lals water per ton	Pounds ammonium sulphate per ton
1	12 5—16 0	3 1-8 7
)	11 6—28 0	2 6—4 a
	42 7	1 7—2 8
	12 1 7 0 15 2	
	9 2—18 7 4 o	
	8 1—22 0 14 6—15 2	
l 		

and from six repre-7 7 per cent, with ple of crude petro-, (Sec 29, Tp 22, esult —

P nom 766 0 mm 79 C 119 C 170 C 221 C 254 C 251 C 356 C 356 C 361 C

ale was also deter-5 With an average as recovered from f) are as follows —

	Sample No. 1825	Simple No 1831	
Curl on di xide	p c 32 6 2 1	p c 23 3 3 1	
Oxygen Lithylene Curbon menoxili Mechare	3 7 2 4 28 7	3 8 1 9 30 6	
Hydrogen Ytrogen Inflynmyblegys	9 1 21 4 43 9	7 5 29 8 43 8	
Calorific value gross	383 346	297 B 1 h U cu fţ 319	per
C HOURT FAMEet			

CONCLUSION

It is, therefore, obvious that shales examined during the past season m the provinces of Munitola and Saskatchewan are of little present economic importance is a pessible source of petroleum or of ammonium Should conditions at any time warrant commercial development, open cut mining could be undertaken in many areas under favourable conditions. Over very considerable users the shales examined are covered by a comparatively light overburden, consisting chiefly of boulder class and gravel, which could be readily removed by hydraulicing methods

VII

OH SHALES OF CANADA

S C Lils

(SUMMARY AND REVIEW OF AVAILABLE INTOLMATION)

Occurrences of petroliferous shales (commonly termed oil shales), within the Dominion of Canada, have for many years been known to exist Nevertheless with the exception of a comparatively brief period, Canada has had to depend lugely on foreign sources for its supplies of crude petroleum and petroleum products. In 1859, near Collir gi ood, Ontario, und ig im in 1862 neur Baltimore, New Brunswick, attempts were made to retort local shales. In each instance these attempts were abandoned cwing to the rapidly mere using production of well petroleum from the newly Now, after a discovered pools of western Ontario and Pennsylvania lipse of nearly sixty years, attention is once more directed to the commercial value of Canadian shales as a possible source of crude petroleum

Thus it is that only within very recent years, changing economic conditions appeared to warrant detailed study of existing shale bodies in Canada Consequently, much work still remains to be done, not only in the field but in the laboratory, before the economic importance of such areas Memwhile such information as is can be definitely determined will the, may be credited almost wholly to the Geological Survey of Canada. The writer is personally familiar with the oil shales of Nova Scotti, New Brunswick, Gispe peninsula northern Ontario, Manitoba, and Siskatchewin Reference to occurrences outside of these are is

based on information secured indirectly

cution, the shales should ton Judging however rity of the majority of le seams of commercial

I, appear to have little

duk, fissile bituminous i southwestern Ontailo, ambton co, along the tie. They underlie a eavy drift, then bound-

Ohio shale of northern by Meximder Murrix, and C.R. Stiuffers storts, having a duly of shile, were elected to recover petroleum hale yielded some two about three per centition of these retorts, one ceased about 1861 uskillen.

ed by the writer, but ent (conomic import-Williams' indicate a hate and 10 Imperial r samples taken from d of crude petroleum ammonium sulphate buthwestern Ontario, chemic d laboratory

These showed an 8 Imperial gillons sulph te per ton of mated by Williams⁸

level, sedimentary alan extends south basin is underlaid outh and southwest

the interest of Pic-Cumbian rocks. The near is travered by a liber of large streams, notably the Abitibi, Mattagami and Missingibi tong these Paleozoic sections, including strata of Ordovician, Silurian, and Devoman age, are exposed.

The possibility of discovering well petioleum in Puleozoic rocks of to times Biv coistal plain, his recently drawn attention to certain coolinerous shales which outcrop on the Abitibi and Mattagami rivers had e shales, which belong to the Ohio formation are well exposed at the Long rapids on the Abitibi river, and to a limited extent above the Long rapids on the Mattagami river. Sections exposed along the Abitibi are rarked by a series of low folds, the general stake of which is approximately east and west. The maximum thickness of shale observed at any norm was approximately 55 feet.

In places the shales are covered by a comparatively light overburden of boulder clay and other unconsolidated materials. The construction of the proposed extension of the Timiskaming and Northern Ontario railway would bring the deposits within reach of a ultranspartation.

In 1911 these shales were examined by the writer, and samples subsequently tested in the laboratory showed a content of petroleum ranging from 7 to 16 Imperial gallons per long ton. The maximum yield of ammorium sulphate was equivalent to 16 pounds per long ton of shale. Patral analyses of three other samples, collected by Dr. M. Y. Williams, indicated a yield of from 3.5 to 12 Imperial gallons (1.2 to 14.4 U.S. gallons) caude petroleum per ton of shale. The calculated yield of ammorium sulphate, based on the introgen content, was equivalent to from 18.8 to 38.6 pounds per ton. The amount recoverable in actual commercial practice would be considerably less.

Provinces of Manitoba and Saskatchewan

NTL — During the field sea on of 1921 the writer undertook a recommissance with a view of determining the probable economic importance of the Creticeous shakes of the Lisquis hills. Porcupine Duck and Hiding mountains A complete report embedying their cuits of this work is in course of preparation?

During recent years, attention has been directed to reported occurrences of oil shales of Cictaceous age in the provinces of Maintoba and Saskatchewin. Forty-one simples of the shales, representative of a wide irea were collected by the writer during the field season of 1921 and were subsequently tested in the laboratory. The maximum yield of crude ictioleum from any sample was 10.9 Imperial gallons (13.1 U.S. gallons), while the maximum yield of ammonium sulphate was equivalent to 3 pounds per ton of shale. The specific gravity of the crude petroleum yaries from 944 to 984. All shales examined carry a high percentage of water the average content of 15 samples being equivalent to 15.4 Imperial gallons (18.4 U.S. gallons) per ton

It appears, therefore that the shales examined in the provinces of Mantoba and Saskatchewan are of little present economic importance as a possible source of petroleum or ammonium sulphate. Should conditions it any time warrant commercial development, open cut mining

Report on James Bay Surveys 1917 S C Fils

Mines Branch Dept of Mine Memorandum S ries No. 3, 1921

* 158.4

could be undertaken in many areas under favourable conditions. Over very considerable areas, shales examined are covered by a comparatively light overbuilden, consisting chaffy of boulder clays and gravel, which could be readily acmoved by hydraulicing methods.

Province of British Columbia

The occurrence of oil shales has been reported near Harper's camp in the Cariboo district, near Lytton, and along Calder creek, a tributary of Flathead river. Detailed exploration of these occurrences has not been undertaken, but from present information it appears that the maximum yield of crude petroleum from any sample tested does not exceed 7 Imperial gallons per ton

On Graham island, the most northerly of the Queen Charlotte group, viscous hydrocarbons have a wide distribution throughout sedimentary and intrusive rocks of Cenozoic and Mesozoic age. Scinifluid bitumen is seen as thin films along bedding planes and joint surfaces, as veinlets in various fractured rocks, and in amygdules of certain bisalts, as at Tian point. This condition was observed by the writer in 1905, and has subsequently been fully described by J. D. Mackenzie in a report dealing with the geology of Graham island.

The presence of traces of bitumen over a wide mea on Graham island was, at one time, interpreted as a possible indication of petioleum pools. Mackenzie considers that the bitumen originates in the Maude formation, a series of dark coloured, fine-grained, thinly laminated and highly fossiliferous nigillates, of Lower Junessic age. He considers that the possibility of discovering commercial pools of petioleum, associated with sediments of Graham island may be regarded as remote, but suggests the possibility that oil shale bands of commercial value may be found associated with the Maude formation.

Provisional District of Mackenzie

From time to time, during the pist 30 years the occurrence of oil shale his been reported along the Mackenzie liver between Foit Norman and Fort Good Hope. These shales are associated with rocks of Devonian age, but little information is as yet available regarding their thickness, extent, and value as a possible source of petroleum and various by-products. The outcrops occur some 1,500 miles to the north of the cits of I dmoi ton, the nearest large centre of population, and apart from other considerations, their geographical position thus renders them of little present economic importance.

Among the special the SS Arctic in the beach of Melvil Lindling readily whe same class and pro Brunswick, Newfour

The results of Branch showed 64 gallons of crude oil

In referring to p Americal many write years has attended recognized factors are Scotch oil shale wor operating costs, mer from established fick unproductive oil bear by declining market other than oil shale ficance only

Certum of the or gutton. These depotreshile, and there tryourable condition constitute the basis of

Commercial des question of supply actors adapted to the Apparently mining of a roduction costs, a velopment. Exception high values, in a number of culd condition the immediate futuritheless, be regard.

¹Ann Rept of Min of Min s BC 1003 p 24 Ann Rept of Min of Mines BC 1004 pp 23 24

Can Gool Surv Mem 88 1916

*McConnell R G An Paploration in th Yukov and Mickenzic basins NWT Gool Surv Can Act Rept new serie vol IV pt D 1888 80 (1840) p 31

Kindle E M and Bosworth T O Gil Bearing Rocks of Lower Mackenzic Valley Gool Surv Can Sum 1 Rept 1970 Pt B

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