Manitoba escarpment, and carried forward the lignite bands, to be eventually distributed in the glacial drift

SEE ALSO—

The Coal Fields of Manitoba, Saskatchewan, Alberta and Eastern British Columbia, (G S C Memoir 53, No 1363, 1914, 142 pages), by D B Dowling

Peat, Lignite and Coal, (Mines Branch, Dept of Mines, Ottawa, 1924), by B F Haanel

OIL AND GAS

Geological Horizons—

There has been considerable prospecting for oil and gas in Manitoba during the past 20 years, more particularly in the western areas of the province The main incentive to search for oil has been the evidences of the presence of oil at the surface in the shales which occur in the Benton and in the Niobrara horizons of the Cretaceous formation The outcrops are most numerous, and most easily available, on the eastern flank of the hills which form the Manitoba escarpment, extending from the Pasquia hills south through the Porcupine, Duck and Riding mountains to the Pembina hills in the south In the Niobrara shales, particularly, immediately above the limestone band which outcrops, for example, on the Assiniboine river, northwest of Treherne (N E ¼, Sec 36, Tp 8, Rge 11W), the oil content in the shale is highest (8 to 10 gallons per ton) In the exposures of this horizon, the evidences of oil are numerous, wherever the shale is exposed and weathered, and in those indications, as a rule, drilling has been begun Such drilling has been carried on at Neepawa, Manitou, Treherne, Mafeking, and at Old Man river on the west side of Pasquia hills Some evidence of oil in the shales also occurs in the Pierre shale overlying the Niobrara shale, as at Rapid City, but to a lesser degree than in the oil shales in the Niobrara horizon

The other geological series in which considerable prospecting has been done is the limestone series of the Palaeozoic formations —the Ordovician, Silurian and Devonian systems in the great lakes area of Manitoba In this there has been drilling at Winnipegosis, Rabbit Point, Lilyfield, and there has been very considerable deep drilling for water as well The total thickness above the granite of the limestone with the basal sandstone is at Winnipegosis (N W ¼, Sec 20, Tp 30, Rge 17), over 1,507 feet, and at Lilyfield approximately 714 feet The limestone series is on the whole fairly flat lying, with a dip of 2 to 3 feet per mile to the southwest, and occasional dome structures, particularly in the Devonian limestones In a typical dome or anticlinal fold southeast of Winnipegosis, drilling was carried on to

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the granite through the limestone series, but without obtaining any evidence of oil Nor have any of the other holes in the Palaeozoic limestones shown indications of oil that would justify any considerable expenditures in investigating the Palaeozoic limestones No structures more favorable than the Devonian domes have yet been found, and the limestones which, in Ontario and neighboring states to the south are oil-bearing do not, from exploration to date, give much encouragement here

In the Cretaceous shales the conditions are to this extent more favorable that there are oil shale horizons This is not in itself necessarily favorable for oil, and would only be favorable if major folds made possible the expressing of the oil from the shale into a carrying horizon such as the underlying Dakota sandstone where it would be capped and prevented from escaping by the impervious overlying shales Where the Dakota sandstone is exposed, as on the Swan river or on the Carrot river, there is no indication of bituminous material or oil residue, but the Dakota sandstone is rarely exposed There is the danger that if oil had accumulated in this formation, it may have escaped through insufficient capping on the eastern flank of the Manitoba escarpment More definite traces of the former presence of oil would probably have been left in the sandstone than have yet been found The structures which have been determined are minor flexures, probably insufficient to be of importance in the accumulation of oil No major flexure has been noted, and the suggestion that the line of hills of the Manitoba escarpment is in itself the result of a fold has no basis in geological fact, and should not be entertained Only where there can be definitely worked out a structural fold of considerable proportions, at a place where the oil shales immediately overlying the limestone horizon of the Niobrara formation are well capped, should drilling be carried on The indications of oil in exposed Niobrara oil shale are no justification in themselves for oil exploration

Particular Localities—

At Rapid City, and in the district southwards to Levine and northwards to Minnedosa, there has been some prospecting for oil The exposed rock in this area in the cuttings of the C N R , eastwards to Tremaine, are in Pierre shale, which shows several local flexures, but has a general northeasterly dip so far as the limited exposures would indicate The exact position in the Pierre shales could not be ascertained A limestone formation north of Levine which it had been suggested might possibly be the limestone of the Niobrara, thus indicating an important elevation of the Niobrara and a major flexure, was found on examination to be a marl deposit from surface springs, and of recent age, and consequently of no significance in interpreting structure There has been practically no drilling for oil, though

some little work was done in the valley of the Minnedosa river, southwest of Minnedosa The deepest water-well was 400 feet, but no direct information is available as to the nature of the shale obtained With the normal regional dip to the southwest, the limestone formation of the Niobrara immediately overlying the oil shales would be 669 feet below the valley of the Minnedosa river at Rapid City, and the top of the Dakota sandstone would be 1,013 feet below the surface at the same place Six miles northwest of Rapid City the depths would be 250 feet more than the figures above quoted, owing to the higher elevations These are maximum figures, estimated on the assumption of a gradual southwestward dip At Rapid City the dip is locally in the reverse direction, and the depths would probably be somewhat smaller than the figures above given There is a possibility that this reversal of dip may indicate the eastern limb of a fold, but exposures of shale have not been found to the west such as might assist in unravelling the structure The railway cuts at Rivers are all in glacial material, and do not reach the shales Further examination carried on up the Minnedosa river beyond Newdale will assist in interpreting the structure of this area

In the Mafeking district on the east flank of the Porcupine mountain there has been very considerable prospecting for oil during the last five years by three organizations, six holes having been sunk (one by core drill) to a depth varying from 1,200 to 1,800 feet Activity was confined to the area between Steep Rock river (to the north), Bell river (to the south), the foothills or first terrace of the mountain to the west, and a line approximately one mile east of the railway line to the east The elevation of the railway line in this block is from 1,061 to 1,068 (Mafeking), and the first terrace of the mountain rises some 400 feet above that elevation Sections on Bell river (3 miles above railway crossing) and on Steep Rock river (one and a half miles above railway crossing), indicate that the foothill terrace is very dark Benton shale incrusted with sulphur on surface exposures, and that the sandy plain below the terrace is in Dakota sandstone which contains some glauconitic sand The Steep Rock river exposure shows the Dakota sandstone, and the Bell river exposure the Benton shale Two of the drill holes began in Benton shale and the other three (including the core drill), in Dakota sandstone One hole was drilled where the Bell river cuts through the foothill scarp—about 300 feet in elevation above the railway crossing—to a depth of approximately 1,400 feet, another on the foothill terrace three miles west southwest of Mafeking, to a depth of approximately 1,800 feet These were drilled in Benton and underlying formations Two test holes were put down on Steep Rock river, one a mile below and the other one-and-a quarter miles above the railway crossing, both to a depth of approximately 1,200 feet, while the core drill hole was

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sunk one mile west of Mafeking, at an elevation of approximately 1,140 feet in Dakota sandstone and underlying formations Granite was reached at 1,562 feet, and the drilling stopped at 1,627 feet depth In all the drilling in this district the aim seemed to be to prospect for oil in the Palaeozoic limestones underneath the Dakota sandstone, even although they are capped in this area, and their structures cannot be prospected at the surface As already indicated, it would seem more profitable here as elsewhere on the escarpment to base exploration work on the possibility of the oil in the shales overlying the Benton (particularly the Niobrara) being expressed by folding and held in the Dakota sandstones or other possible Cretaceous horizon For this it would be necessary to drill much further back in the Porcupine hills than the first scarp (the foothills), which is made up of the lower Benton shales The core drill section of the whole of the Palaeozoic series is of great value from many points of view, and the exploration work, while unsuccessful in finding oil, has provided a record which will be of assistance in future exploration

At Ochre river the McIntosh well is on the N W corner of Sec 30, Tp 22, Rge 17W The Riddell (Holmes) well is about half a mile further east Ochre River station is 10 miles north of the wells The elevation of the McIntosh well is 1,247 feet, that of the Riddell well 1,200 feet The occurrence of a heavy limestone band (5 feet) in the cut bank of carbonaceous shale immediately below the site of the Riddell well would indicate that the well is in Niobrara shales immediately above the top of the Benton series The Riddell well is sunk on an 8 inch band of bluish limestone, separated from an overlying 5 foot bed of brownish limestone by 20 feet of carbonaceous shale The core drill shows a remarkable thickness of gypsum From a depth of 428 feet to 625 feet, gypsum is associated with the limestone, and again from 700 feet to 830 feet gypsum occurs again associated with the limestone The gypsum does not appear to run in massive beds, but rather in thin bands, and as pockets in the limestone The solid limestone begins at a depth of 390 feet from the surface, being overlaid by calcareous shale

At Grandview some drilling was done during 1926 on the N W ¼ of Sec 18, Tp 16, Rge 24W , seven miles northwest of Grandview The elevation is approximately 1,557 feet, in open country with no exposures in the immediate vicinity Two shallow holes were put down in the drift and underlying Pierre shales

The drilling at Treherne will be discussed under the heading of Gas A deep well was also sunk at Neepawa (altitude 1,208 feet) A strong flow of salt water was struck at a depth of 1,165 feet Gypsum was reported at a depth of somewhat over 1,100 feet The following is the log of the well drilled south of Manitou (S E ¼ Sec 23, Tp 2, Rge 9), 1 270 feet above sea level

Depth	Description of Strata	Formation
0 to 450 feet	Dark and light-grey soft shales with nodules of pyrites	Pierre shales, Cretaceous
About 425 to about 610 feet	Soft blue grey lime shales with pyrite and shells of lime	Niobrara, Cretaceous
About 610 to 716 feet	Dark blue green glauconitic shales, shells of lime and with two beds of limestone at 675 ft (natural gas very strong flow) and 714 ft	Benton, Cretaceous
716 to 760 feet	Coarse white soft sand with a great deal of iron pyrites and fragments of coal This sand proved to be a regular quick sand which ran in the well and at the bottom of it passed for a few feet into a calcareous conglomerate of arkose	Dakota sand and lower Cretaceous
760 to 790 feet	Vermilion and yellow clay shale or shaly limestone with pyrites	Upper Devonian
790 to 925 feet bottom of well	Greyish greenish and light grey soft lime unctuous shales often described by drillers as soapstone	Devonian
925 feet	Strong showing of gas and film of blue oil	

In the Palaeozoic limestones the most important investigations have been made southeast of Winnipegosis (N W ¼ Sec 29, Tp 30, Rge 17W), near the lake, immediately south of Snake island Some indications of oil in a well near Dauphin led to the investigation of a typical Devonian dome by the Provincial Government, and this particular dome was chosen The Palaeozoic section was found to be much thicker (over 1,507 feet) than was expected, but no indication of oil was obtained At Lilyfield west of Stony Mountain, the granite was reached on core drilling at 714 feet, and was penetrated for several hundred feet In this latter case the selection of drilling location was not made on the basis of any structural features, and the results do not justify further exploration in this area A very interesting feature in this core drill section was the evidence that the granite underlying the Palaeozoic series is much weathered, and to a very considerable depth

The results of the work to date on search for oil point to the need for care in any future explorations Little of a reassuring nature has yet been found, and future work should be based on clear-cut evidence of oil seepage, or on carefully worked out struc-

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tures of a favorable type Much work will yet be done on the higher elevations of the Riding, Duck and Porcupine mountains, and the more northerly limestone areas will yet be explored It has recently been suggested that the elevations of the pre-Cambrian surface buried beneath the Palaeozoic series might serve as gathering ground for oil A striking elevation reaches the surface at the Narrows of lake St Martin and northwestward The presence of such buried elevations, if they occur, might best be indicated by torsion balance or magnetometric survey

Gas

The presence of gas, which has been found mainly in the oil shale horizons has been taken as an indication of oil in the Treherne district The gas well on E C Haskell's farm (N E ¼ Sec 28, Tp 7, Rge 10W), was sunk at an elevation of 1265 feet to a depth of 250 feet The gas was obtained at 150 feet, and has been used for 15 years for kitchen and dining-room lighting and occasionally for a small gas heater for cooking Drilling for oil has been carried on in 1926 more than half a mile away on the southeast corner of the same quarter section at an elevation of 1281 feet It is understood that the drilling reached a depth of 250 feet when financial difficulties arose and work has not been resumed The cement beds of the Babcock horizon are exposed here at an elevation of 1244 feet (N E corner of Sec 34) and the limestone horizon of the Niobrara at an elevation of 975 feet (N E ¼ Sec 36 Tp 8 Rge 11W) on the Assiniboine river, with the oil shales immediately overlying the limestone band The depth from the top of the casing to the Dakota sandstone may be estimated at 650 feet maximum and might be 100 feet less It would be inadvisable in any event to drill below the base of the Dakota sandstone into the limestones as the Dakota sandstone would be the receptacle for any oil which might be connected in origin with the oil shales No folding of significance for oil prospecting was noted in this area Gas is being used as well south of Rathwell (S W ¼ Sec 21 Tp 7 Rge 8W) at the farm of Frank Bosc, where a well was sunk at an elevation of 1200 feet to a depth of 210 feet Gas was got at 170 feet and is used continuously for one light in the kitchen, and has been used for six years The gas in both cases (south of Rathwell and southwest of Treherne) evidently comes from the 200 feet horizon of carbonaceous shale (G S C Summary Report 1915 p 132) overlying the hard limestone band of the Niobrara horizon

At Robert Hall s farm (N W ¼ Sec 14 Tp 6 Rge 22W) gas was struck in 1926 at a depth of 190-210 feet in a search for water The elevation of the top of the well is approximately 1480 feet When the well was examined in November 1926 it was found to be capped by half inch pipe, and the gas pressure registered 48 pounds which was reduced to 35 pounds on permitting the gas to escape for several minutes A measurement taken after permitting the gas to escape for five hours gave a pressure of 45 pounds A sample of the gas was handed to Dr Shipley of the University for analysis who reported as follows —

	Percent
Combustible, mostly methane, but a small percentage of a heavier hydrocarbon	75 4
CO_2	0 0
O_2	4 0
H_2	0 0
Residual non-combustible	20 6

Practically 80% of the gas is of value for light or heat the remainder being of no value If the pressure can be maintained, the gas could be of value for cooking and probably for heating purposes

At Waskada four wells are in active use—those of F Clement, G R McLean and W S Cameron in town and that of I Wright on Sec 8 Tp 2, Rge 25W one mile N E of town The wells were dug about 15 years ago and showed a pressure several years ago of 14 pounds The depth varies from 190 to 240 feet in Pierre shales The elevation at Waskada is 1549 feet The gas is used for lighting and cooking purposes and has been found though not used in several of the wells which have been dug in the neighborhood of Waskada The gas is almost odorless and dry The pipelines which in the Clement and McLean wells run a considerable distance along the street are unprotected and are not blocked by freezing No attempt has been made in the Waskada district to use the gas for heating purposes The greatest pressure is at F Clement's well where a cookstove and seven lights are in operation South of Souris ford at the farm of J B Elliott (S W ½ Sec 10 Tp 2 Rge 27W) 12 miles south of Melita a well was drilled for gas on the east bank of South Antler creek about 20 years ago The depth of the well was 212 feet and the gas was got some distance above that depth The gas was led into the house 800 feet away and has been used for cooking and for a five-burner lamp continuously since that time The pressure was at one time measured at 19 pounds Gas is seen to escape at several places on South Antler creek in this vicinity At Melita gas was used for lighting purposes in the engine room of the grist mill (now dismantled) nearly 20 years ago There has been some indication of gas

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SEE ALSO—

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As far as the general situation is concerned, there are apparently several pockets in Niobrara and Pierre shale which are of sufficient importance to make it worth while to pipe the gas into the houses for lighting and cooking purposes The greatest pressure which has been registered is 45 pounds The most extensive field is in the Pierre shale in the Waskada—Sourisford —Melita district which is probably connected with the Bottineau gas field of North Dakota It might be feasible to increase the volume by combining a number of wells and use the gas for general distribution in Waskada or Melita It would, however be more advisable for preliminary development to extend greatly the use of individual wells This source of light and fuel supply should be taken advantage of by the inhabitants of the district to a much greater extent than is at present the case

SEE ALSO—

Oil and Gas Prospects of the Northwest Provinces of Canada (Memoir No 29, 1913 G S C), by W Malcolm

Cretaceous Shales of Manitoba and Saskatchewan—Their Economic Value as a Possible Source of Crude Petroleum (Mines Branch Dept of Mines Can Mem Series Dec 1921 No 3) by S C Ells

OILSHALES

The demands which are being made in this continent on the available resources of oil in the form of reservoirs are so great that it will be necessary within 20 years—unless very large oil pools are discovered—to turn to the supplies available by distillation of oilshales This means of obtaining oil has long been made use of in older countries In Scotland for example, oil bearing shales are mined at depth like coal and supply on distillation not only oil but ammonium sulphate for fertilizing purposes as well Up to the present time it has not been found possible to distil oilshales in the North American continent in competition with the very large supply of oil available from wells The bituminous shales are found in quantity—particularly in Utah Colorado and Montana where attempts have already been made to distil by retorts of the Scottish and other types In these states the shales contain up to 35-40 gallons of oil per ton and are easily available in high exposures There is not yet, however a large market for the ammonium sulphate by-product in the Western United States though this market will undoubtedly arise with the impoverishing of the nitrogenous content of the soil

In Manitoba the Cretaceous shales of Niobrara and Pierreage are in part bituminous The Benton shales are carbon-

aceous and show coatings of sulphur on exposed surfaces The Niobrara shales are in part calcareous containing a limestone bed filled with Ostrea and Inoceramus shells as exposed on Assiniboine river northwest of Treherne (N E ¼ Sec 36 Tp 8, Rge 11W) and a cement bed from which natural cement has been manufactured at Babcock Between these two horizons lie 200 feet of carbonaceous shales from which the highest values in oil have been obtained The elevation of the limestone ledge which is the bottom of the shales on the Assiniboine river northwest of Treherne (N E ¼ Sec 36 Tp 8 Rge 11W) is 975 feet The strike of the shales is N N W and this elevation may be taken to represent approximately the bottom of the shales along a north-north-westerly line passing through this point

Shales from some of the most accessible exposures of the Niobrara formations in the Manitoba escarpment have been sampled by Ells with the following results —

Locality	Imperial gals crude petroleum per ton*	Spr gr of crude petroleum at 60°F	Imperial gals water per ton
Birch river 31–39–26W	0		42 7
Favel river 30–35–25W	6 2	0 972	12 1
26–35–26W	6 8	0 984	7 0
26–35–26W	5 9	0 965	15 2
Sclater river 15–34–23W	4 8–7 5	0 966–0 968	9 2–18 7
Pine river 6–33–22W	3 3	0 969	4 5
Vermilion river 12–21–20W	1 1–5 1	0 952	8 1–22 0
Ochre river 29–22–17W	4 0–5 3	0 955	14 6–15 2

These values are much too low for successful operation, though they might provide the source of oil reservoirs in suitable carrying formations, if widespread folding has anywhere taken place Search has been made in several districts (see under Oil and Gas) for such reservoirs to date without success Pockets of gas, in some cases under considerable pressure have been found apparently associated with the carbonaceous shale of the Niobrara formations south of Treherne and of Rathwell, while south of Souris and at Sourisford gas is found associated with the upper Pierre shales

On the farm of W Hunter, Sec 30 Tp 35 Rge 25W four miles south of Minitonas carbonaceous oil shale has been burning for the past 10 years This is at a cutbank of 25 feet of shale on the East Favel river, at an elevation of approximately 1220 feet The only indication at the surface of the burning shale is the strong smell of SO_2 and the fact that the shales are slightly

(*) Calculations based on ton of 2 000 pounds.

warm One mile north and approximately 6400 feet west of this exposure the following section of Niobrara shale is exposed

5 feet brownish soft limestone
30 feet soft black carbonaceous shale
4 inches bentonitic clay
15 feet soft black carbonaceous shale

The burning shale is probably above the five-foot bed, which is by barometer 1213 feet in elevation

SEE ALSO—

Pembina Mountains Manitoba, (XVIII pages 131-133 Summary Report Geol Survey of Canada 1913) by A MacLean.

Cretaceous Shales of Manitoba and Saskatchewan—Their Economic Value as a Possible Source of Crude Petroleum (Mines Branch Dept of Mines Can Mem Series, Dec 1921 No 3) by S C Ells

PEAT

Many parts of Manitoba particularly some of the Pre-Cambrian areas are very swampy as a result of glacial action blocking up the older drainage systems These swamps and muskegs are gradually filling up with plant growth, some of which has already been partly transformed into peat The following tables present the salient facts concerning the investigated peat bogs of Manitoba (*)

For Table, see page 59

Partial Analysis of Absolutely Dry Peat

Peat Bog	Volatile Matter	Fixed Carbon	Ash	Nitrogen	Calorific Value B T U
	Percent	Percent	Percent	Percent	Per lb
Lac du Bonnet	59 4	25 0	15 6		
Transmission	56 8	24 2	19 0		
Corduroy	56 1	34 8	9 1		
Boggy Creek	65 0	26 7	8 3		8730
Mud Lake	69 1	23 2	7 7		8760
Litter	66 1	26 2	7 7		9090

In addition to the above, some 236,000 acres of peat bogs in southern Manitoba have been surveyed in a preliminary fashion, the most important being the Whitemouth bog, it having an area

(*) Investigations of the Peat Bogs and Peat Industry of Canada 1910 11 (Mines Branch Can Dept of Mines) by A Anrep