CANADA
DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

Summary Report, 1925, Part B

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OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1926

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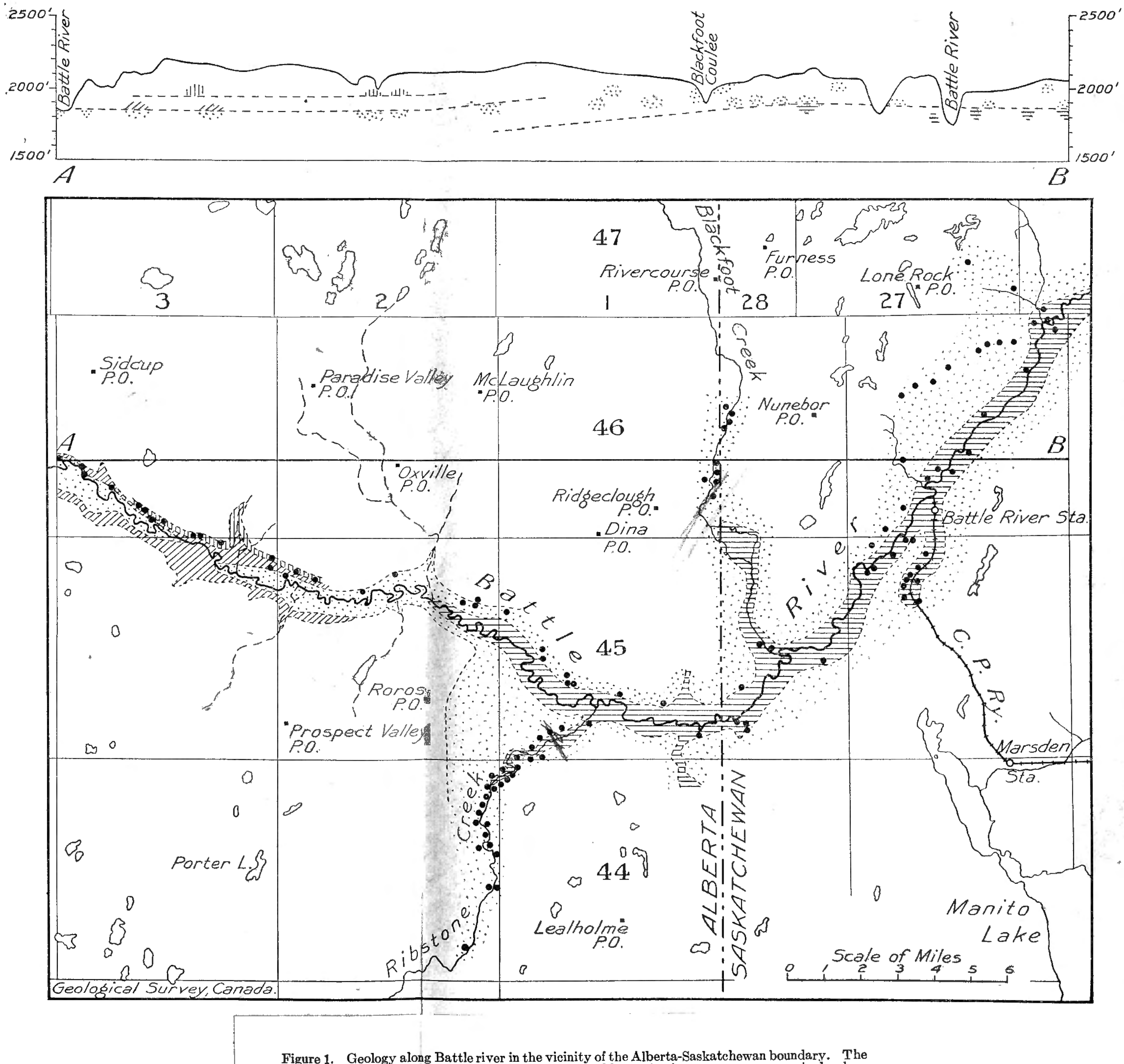

Figure 1. Geology along Battle river in the vicinity of the Alberta-Saskatchewan boundary. The east-west structural section has been constructed by projecting outcrops upon a single plane and by assuming a strike of north 45 degrees east. Areas of Birch Lake formation are indicated by a pattern of vertical lines; of Grizzly Bear, by inclined parallel lines; of Ribstone Creek, by stipple; of Lea Park, by horizontal lines; and rock outcrops by large dots.

SUMMARY REPORT, 1925, PART B

OIL PROSPECTS IN THE VICINITY OF BATTLE RIVER AT THE ALBERTA-SASKATCHEWAN BOUNDARY

By G. S. Hume

CONTENTS

INTRODUCTION

A reconnaissance study was made in 1924 of a large area in Alberta east of the oil-producing district north of Wainwright. As a result of this work the existence of certain possible geological structures of economic interest was suggested in the Summary Report, 1924, part B. During 1925 a more detailed examination was made of the area in the vicinity of Battle river from range 3, west of the fourth meridian, to range 24, west of the third meridian, the object being to determine the accuracy of deductions based on the reconnaissance study of 1924. Following this detailed work a reconnaissance survey was extended over an area in Saskatchewan south of North Saskatchewan river and from the fourth meridian east to longitude 108 degrees and south to latitude 52 degrees. This work was also continued westward into Alberta south of the Wainwright sheet in an area bounded on the west by the fourth meridian, on the east by longitude 111 degrees, and on the south by latitude 52 degrees.

In this work the writer was assisted by A. J. Childerhose, Allan Smith, and W. A. Scott. Mr. Childerhose was in charge of detailed levelling work and much of the exact information presented in this report is due to his careful and efficient work, in which he was assisted by Mr. Scott. The efforts of the writer, who was assisted by Mr. Smith, were directed toward the mapping of the various formations and the determination of the stratigraphic position of outcrops to which lines of level were run. The reconnnaissance work in the latter part of the season was mainly a search for outcrops, in which all three assistants equally shared.

STRATIGRAPHY

The sequence of formations over the whole area studied is the same as that described in Summary Report, 1924, part B, and briefly is as follows:

Bearpaw formation............Marine.
Pale and Variegated beds.....Non-marine.
Birch Lake formation.........Mostly non-marine.
Grizzly Bear formation.......Marine.
Ribstone Creek formation.....Non-marine in Alberta; partly marine in Saskatchewan.
Lea Park formation...........Marine.
Benton formation.............Marine (not exposed).
Lower Cretaceous (?).........Not exposed.
Palæozoic limestone..........Not exposed.

PALÆOZOIC LIMESTONE

Palæozoic limestone has been encountered in three wells, but other wells drilled outside the area give much information concerning regional relationships and, therefore, their consideration is also necessary. A list of wells drilled to the Palæozoic limestones is as follows.

Name	Location	Elevation of Palæozoic-Mesozoic contact Feet
Imperial (Fabyan) No. 1	Sec. 18, tp. 45, range 7, W. 4th mer	110
Imperial, Muddy Lake	Sec. 7, tp. 39, range 22, W. 3rd mer	520 (?)
West Regents well	Sec. 19, tp. 34, range 4, W. 4th mer	840
Tit Hills, Czar (Imperial)	Sec. 17, tp. 39, range 7, W. 4th mer	970

Since the change from the Lower Cretaceous sediments to the Palæozoic limestones is sharply marked and easily detected, it might be thought that the elevation of the limestone surface would give a good idea of the regional structure. This, however, is not the case, for the Palæozoic limestones prior to Cretaceous sedimentation were subjected to erosion and it is altogether likely that erosion proceeded to different levels in different localities, with the result that the first Palæozoic limestones encountered in the various wells possibly belong to different horizons.

No Palæozoic limestones are exposed within the area studied. The nearest outcrops are 200 to 300 miles to the north and northwest on Athabaska river where Cretaceous sediments overlie Devonian limestones. It is, therefore, assumed that the Palæozoic within the area now under consideration is also Devonian. Several hundred miles to the west in the Foothills and mountain area a great thickness of sediments of other ages lies below the Cretaceous. It is thought that the thickness of these post-Devonian, pre-Cretaceous sediments gradually decreases eastward to where, during the interval preceding Cretaceous deposition, erosional forces stripped them off if they ever were there. To the eastward, therefore, their thickness gradually decreases and the rocks representing the interval between Devonian and Cretaceous assume a wedge-like form with the unknown position of the eastern thin edge of the wedge concealed under sediments of younger age.

LOWER CRETACEOUS (?) SEDIMENTS

Lower Cretaceous sediments are not exposed in the area under consideration, but strata conjectured to be of this age have been penetrated in the wells that reached the Palæozoic limestones and partly penetrated in British Petroleums wells, Nos. 3 and 3B, sec. 29, tp. 45, range 6, W. 4th mer., and in the Fusilier well, sec. 23, tp. 34, range 28, W. 3rd mer. The supposed Lower Cretaceous sediments are probably mostly non-marine, as in all the wells thin coal seams were encountered with them. In the British Petroleums No. 3 well, 9 feet of coal and carbonaceous shale was passed through. The Lower Cretaceous (?) sediments are alternating sands and shales, the former of which is the producing oil zone of British Petroleums No. 3 B well. Since the logs of the various wells indicate no marked lithological difference between the base of the Benton and the supposed Lower Cretaceous strata, the interpretation of well logs is a matter of personal opinion and consequently no definite statement can be made regarding the thickness of either the Lower Cretaceous or the immediately overlying Upper Cretaceous member. There is, however, no doubt that the thickness of the basal Cretaceous member is very variable. This variation is probably due, in part, to irregularities of the Palæozoic floor on which the sediments were deposited and perhaps, in part, to original differences in the thicknesses such as would be expected from the character of the sediments. The log of the Imperial (Fabyan) No. 1 well shows a relatively slight amount of sand immediately above what has been logged as limestone, whereas 8 miles eastward, in the British Petroleums wells, although the total thickness has not been penetrated, there is little doubt that a much greater thickness occurs; and in the Czar well from 2,500 feet downwards through a thickness of 720 feet, coal occurs at frequent intervals, particularly in the upper part, with a predominance of arenaceous material over shale in the lower part. The presence of coal seams may not imply, in every case, that the associated strata are of Lower Cretaceous age, for several small seams of lignite were recorded in the Muddy Lake well between depths of 1,150 and 1,260 feet. If these coal beds are interpreted as belonging to the Lower Cretaceous, the thickness of this formation would be more than 1,000 feet, which is excessive, and the thickness of the earliest Upper Cretaceous horizon would be comparatively small. It seems, therefore, highly probable, that the coal in the Muddy Lake well between the depths 1,150 and 1,260 feet, is in the Benton, a feature which, if correctly interpreted, would mean that the Benton is not entirely marine. These conditions make impossible any exact separation of the Lower from the Upper Cretaceous, although a rough separation is usually possible, due to the fact that the Benton is predominantly a shale formation, whereas the Lower Cretaceous is decidedly arenaceous. Basing his conclusions on the varying altitude of the assumed bottom of the Benton, Hopkins[1] has stated that the dip of the strata between Muddy Lake and Fusilier wells is southwest at the rate of 5 feet a mile; between Fusilier and Misty Hills wells is west at the rate of 6½ feet a mile; between West Regent and Misty Hills wells is south at the rate of 7 feet a mile; and between Fabyan and

[1]Hopkins, Oliver B: "Some Structural Features of the Plains Area of Alberta Caused by Pleistocene Glaciation"; Geol. Soc. Am., Bull., vol. 34, pp. 419–430 (1923).

Czar wells is south at the rate of 9½ feet a mile. These dips accord with the present writer's opinion regarding the direction of dip, but the amounts given in each case are a matter of interpreting the position of the Lower Cretaceous-Upper Cretaceous contact.

BENTON AND LEA PARK SHALES

It is probable that sedimentation from Benton (Colorado) to Lea Park (Montana) time was continuous and any division between the two formations must depend on fossil evidence. As such evidence is lacking in well logs and as the Benton is not exposed within the area studied, no division can be made. Toward the base of what is regarded as the Benton, gas and oil-bearing sands occur at a number of horizons and, as has been already pointed out, the Benton may contain thin lignite seams.

The writer has no definite information regarding the thickness of the Lea Park. The formation takes its name from Lea Park at the junction of Vermilion and North Saskatchewan rivers, where shales of this formation outcrop and contain a marine fauna of Montana age. The thickness, however, in the type section, is questionable, since it is thought the base is not exposed. No outcrops of Lea Park were seen by the writer south of the area of the Battleford sheet in the western part of Saskatchewan. It is assumed that the formation extends southward, but the southern limit is unknown and as yet the formation has not been definitely correlated with any member of the section in southern Alberta.

Lea Park fossils, identified by F. H. McLearn, were collected at the following places:

Sec. 5, tp. 45, range 1, W. 4th mer.
Gervillia sp.

Sec. 9, tp. 45, range 28, W. 3rd mer.
Gervillia sp.

From Canadian Pacific railway cut in tp. 45, range 27, W. 3rd mer.
Baculites sp.
Liopistha undata Meek and Hayden
Corbula ? sp.
Protocardia borealis Whiteaves

RIBSTONE CREEK FORMATION

On Ribstone creek sands and shales of non-marine origin are exposed along the banks, as has been described in Summary Report, 1924, part B. In 1925, it was definitely determined that the lowest shales of this section carry marine fossils and presumably belong to the Lea Park formation, the contact occurring at an elevation of about 1,900 feet. Eastward along Battle river marine shales were found in tp. 45, range 27, W. 3rd mer., on a Canadian Pacific railway cut at an elevation of 1,840 feet, with hard sandstone beds above them at an elevation of 1,860 feet. The hard sandstone beds are interpreted as belonging to the Ribstone Creek formation and the shales to the Lea Park formation. Farther eastward along Battle river, there are exposures of sands and sandy shales, as well as hard sandstone beds carrying a marine fauna identified by F. H. McLearn as follows:

Sec. 21, tp. 46, range 24, W. 3rd mer.
Baculites cf. *grandis*

Sec. 9, tp. 47, range 25, W. 3rd mer.
Goniomya americana
Oxytoma nebrascana
Protocardia cf. *pertenuis*
Astarte sp.
Baculites cf. *grandis* Hall and Meek

Sec. 15, tp. 47, range 25, W. 3rd mer.
Pecten n. sp. cf. *silentiensis*
Baculites cf. *grandis* Hall and Meek

Sec. 36, tp. 46, range 27, W. 3rd mer.
Pecten n. sp. cf. *silentiensis*
Callista sp.

Sec. 1, tp. 47, range 27, W. 3rd mer.
Callista nebrascensis

The same fauna occurs on Big gully in the following localities: Sec. 19, tp. 49, range 24, and sec. 24, tp. 49, range 25, W. 3rd mer.
Axinea sp.
Oxytoma sp.
Lunatia concinna Hall and Meek
Protocardia cf. *pertenuis*
Modiola meeki
Baculites sp.

Sec. 5, tp. 50, range 26, W. 3rd mer.
Protocardia sp.
Oxytoma sp.

Sec. 24, tp. 50, range 27, W. 3rd mer.
Tancredia americana Meek and Hayden
Protocardia cf. *pertenuis*
Lunatia concinna Hall and Meek

On Big gully the fossiliferous strata are assigned to the Ribstone Creek formation: (1) because the strata seem lithologically closely allied to the sediments found in this formation elsewhere; and (2) because such an interpretation is in accord with what is known concerning the regional structure.

The data given above indicate that the Ribstone Creek-Lea Park contact must dip eastward from Ribstone creek to the Canadian Pacific railway section in range 27, W. 3rd mer., south of Battle river. Coal is reported to occur on the banks of Battle river south of Paynton, and an outcrop assigned to the Ribstone Creek was seen on the north bank of Battle river on the Little Pine and Lucky Man Indian reserve south of Maskwa hill in tp. 46, range 22, W. 3rd mer. As the elevation of these occurrences of the Ribstone Creek formation is considerably lower than the exposures on the Canadian Pacific railway track in range 27, the dip must be considered to be eastward. This eastward dip is also proved by the fact that on Pipestone creek, a small tributary of Battle river flowing past Prongua, the base of the Ribstone Creek formation is approximately at an elevation of 1,620 feet, so that there is an eastward dip of 220 feet between the Canadian Pacific railway track exposures on range 27 and the exposures on Pipestone creek on range 18—a distance of 60 miles. If this value of the dip in an eastward direction be accepted as correct it follows that the marine sediments in township 47, ranges 25 to 27, already referred to, lie above the base of the Ribstone Creek and consequently, as assumed for other reasons, must belong to the Ribstone Creek formation.

The change eastward of the Ribstone Creek formation from non-marine on Ribstone creek to marine in part in township 47, ranges 25 to

27, would not be surprising if the Ribstone Creek formation continued eastward as partly marine. There is no evidence, however, that such is the case, since on Pipestone creek near Prongua no marine fossils could be found, and small coal seams have been reported. To the north, on Big gully, there are many exposures of sands and sandstones carrying marine fossils, the same as those found in township 47, ranges 25 to 27. At one locality on the north bank of Big gully, on the west side of tp. 49, range 24, W. 3rd mer., there is a most unusual occurrence of fossils in many cases in masses of 5 inches or so in diameter, in a sand so soft that it may be scooped out of the bank by hand. The shells of *Axinea* sp. occur in many cases with both valves attached and in perfect preservation; the shells have the superficial appearance of having undergone no change whatever since their deposition. Along with these shells was found a baculite less perfectly preserved, although with it was an oxytoma shell so thin that it was translucent. It would appear from the number of unbroken shells with both valves attached that the shells had been engulfed in the sand deposit, for in a number of instances, although the interior of the shell was filled with sand, the valves were closed. This is considered good evidence for deposition in situ, although the poorer preservation of the baculite might indicate transportation.

No geological investigations have been made northeast of North Saskatchewan river, so that the extent in that direction of this marine phase of the Ribstone Creek formation is as yet unknown. Coal, that is presumed to be of this age, has been washed up by the waves from the bottom of Tramping lake, but southward from Battle river, with the exception of the area near Prongua, no outcrops of this age were observed. The meagre evidence from Tramping lake would indicate non-marine conditions to the south and in a number of wells small coal seams are reported from depths at which the Ribstone Creek formation would be expected to be encountered.

GRIZZLY BEAR FORMATION

The Grizzly Bear formation has been described in Summary Report, 1924, part B. Shales of this age occur in cuts along the railway track west of Prongua station where the shales overlie the Ribstone Creek formation. At this locality the shales carry rounded nodules of crystalline selenite in which the crystals are thin plates disposed with their outer thin edges tangential to the nodules. Similar shales were seen elsewhere only on the west shore of Tramping lake in township 35. They presumably belong to the Grizzly Bear formation which, therefore, may extend farther south, beyond the limits of the area studied. Because this formation is thought to be not more than 100 feet thick at the maximum it has been used as a datum plane on which to base structure.

BIRCH LAKE FORMATION

Along Battle river, in the vicinity of the fourth meridian, the rock outcrops are of lower formations than the Birch Lake and this condition continues eastward. In the vicinity of Prongua, hills rise several hundred feet above the level of the outcrops of the Grizzly Bear shale, but a search made on these hills for exposures of Birch Lake formation revealed no outcrops whatever, the hills being covered with glacial materials. The elongated character of individual ridges suggests that they are products of glacial action rather than erosion remnants due to a hard capping of sandstone beds.

A small outcrop of sands carrying ironstone layers was found in a small cut along the Canadian National railway tracks east of Vera. The country in the vicinity of the railway from Vera, through Winter and Artland to the Alberta boundary, is occupied by sand-hills. This area of sand-hills extends west into the southeastern part of the Wainwright sheet and to slightly north of the Canadian National railway tracks on the western side of Manitou lake. It is believed that the outcrop seen near Vera belongs to the Birch Lake formation and that the large area covered by sand-hills has resulted from the disintegration of the sands of this formation. To the southeast, in that part of country where it would be suspected the Birch Lake beds might outcrop, no exposures were found and it is possible that to the southeast the Birch Lake formation thins and entirely disappears within the area studied.

PALE AND VARIEGATED BEDS

These beds are well exposed on the west side of the area of the Tramping Lake sheet, particularly in the vicinity of Muddy lake and on Eyehill creek southwest of Macklin. They occur also on the northern part of the area of the Sullivan Lake sheet in the vicinity of Tit hills southwest of Czar. The beds are sands and shales, the sands being usually light grey and in many places very much crossbedded. Coal seams occur at various horizons and there are many occurrences of fragmentary dinosaur bones and fossilized wood. The whole series is considered to be non-marine. The beds exposed at Muddy lake are thought to be lower beds of the Pale Beds or the Variegated Beds; those at Tit hills probably belong to the Pale Beds, although no boundary between Pale and Variageted Beds could be drawn.

In the vicinity of Tit hills, southwest of Czar, the beds are very much disturbed. Faults are common and the angle and direction of dip vary widely. The disturbed condition of the strata is regarded by Hopkins[1] as being superficial and he states that "the surficial nature of the force and its direction leads naturally to the assumption that the thrusting force was the great ice-sheet because it was the only competent force". With the idea of superficial disturbance, the present writer agrees, but he cannot concur with the idea that the thrusting force was the ice-sheet. The objection to such an explanation is mainly that outcrops of other formations do not show the same disturbed structure and since the disturbance is apparently confined to one formation—the Pale Beds—it seems reasonable to look within this formation itself for an explanation of the conditions. A close study of the Pale Beds at various localities reveals the fact that there are beds in places as much as 3 feet thick, which are highly bentonitic in character. One of the striking characteristics of bentonite is the fact

[1]Hopkins, O. B.: "Some Structural Features of the Plains Area of Alberta Caused by Pleistocene Glaciation"; Geol. Soc. Am., Bull., vol. 34, pp. 419–430 (1923).

that when soaked in water it swells to many times its original volume. In the case of bentonites from western Canada and United States, examined by the Mines Branch,[1] the increase in volume is as much as five to thirteen times. Bentonite when wet also assumes an exceedingly slippery character and it was noted that the bentonitic layers in the Pale Beds formed planes along which landslides could readily occur. The suggested cause of the superficial disturbance noted in certain outcrops of the Pale Beds is, therefore, that as a result of water filtration and migration, there is an increase in volume of the bentonitic beds, thus causing distortion and fracturing of the overlying strata, which, with combined ease of movement of overlying beds along the slippery surface of the wet bentonitic layers, results in landslides and related phenomena. The Pale Beds contain numerous sand horizons that can carry water, as is shown by a number of shallow wells, and such horizons might supply water for the saturation of the bentonitic beds even at a long distance from the outcrop. The writer has not studied Mud buttes south of Monitor which have been referred to by Hopkins in connexion with his study of the cause of the local disturbances exhibited by the strata. The beds at Mud buttes have, according to Hopkins, a south dip of 7 feet to the mile. Surface water would, therefore, naturally enter the porous beds at the northern side of the exposures and migrate southward down the dip. The maximum amount of deformation, due to the swelling of the bentonitic beds in contact with water horizons, with the consequent warping and possible faulting of the overlying beds, should be more pronounced on the northern than on the southern side of the buttes, a fact which Hopkins observed but explained as due to thrust of the ice-sheet from the north. Also, since the dip is southward, any slipping of the beds along planes afforded by the water-soaked bentonitic layers would tend to take place down the dip slope, in which case the thrust faults described by Hopkins might be formed. It thus appears that there is no need to look beyond the Pale Beds themselves for the cause of a force which might, given proper conditions, cause considerable distortion and faulting on a scale comparable with that observed in a number of localities where Pale Beds carrying bentonitic layers form the surface exposures. In the exposures in the vicinity of Tit hills faulting was observed, but since it is very difficult to correlate the strata even over short distances estimates of the amount of faulting were uncertain, except where a throw of a few feet only was involved. No matter what caused the disturbance of the beds it seems certain that this disturbance is superficial, a fact which is of great importance in that the dips observed on the surface are in no way an indication of underground structure.

BEARPAW FORMATION

Outcrops of Bearpaw shales were noted on Nose hill in the extreme southwestern part of the area studied. It is probable that shales of the same age occur on Neutral hills and form the capping of Tit hills. No detailed examination of beds of this formation was made.

[1]Spence, Hugh, S.: "Bentonite"; Mines Branch, Pub. No. 626.

STRUCTURE AND OIL POSSIBILITIES

Everywhere in the area studied the regional dip is gentle. Local dips in the Pale Beds in the vicinity of Tit hills are, as already explained, believed to be due to superficial causes and have no relation to underground structure. Local structures which might be considered possible oil and gas structures are difficult to detect except where a definite horizon can be followed and the structure determined by carefully run lines of levels. No such structures were found, with the exception of those located by reconnaissance work during the previous summer (1924). As far as the writer observed, no horizon within the Pale and Variegated beds could be traced laterally for any considerable distance, owing to the local variations in the character of the sediments and, therefore, in Tramping Lake area and the part of the Sullivan Lake sheet studied, it seems impossible to decipher any detailed structures by the methods used in the Wainwright area, that is by the levelling of key horizons which can be traced over considerable distances. Detailed levelling was done on one structure only, namely, the anticline discovered by reconnaissance work during 1924 on Battle river in the vicinity of the Alberta-Saskatchewan boundary. Since this anticline appears to be of some considerable importance it is proposed for convenience to call it the Ribstone-Blackfoot anticline.

RIBSTONE-BLACKFOOT ANTICLINE

As the result of finding marine fossils in the shales below the heavy sandstone beds near the mouth of Ribstone creek, the shales are now believed to represent the top of the Lea Park formation, a conclusion not recognized in 1924 and not indicated by the map issued with the Summary Report for that year. The elevation on Ribstone creek of the Ribstone Creek-Lea Park contact is about 1,900 feet. There are a number of outcrops of hard sandstone beds of the Ribstone Creek formation on Blackfoot coulée in sec. 12, tp. 46, range 1, W. 4th mer. The lowest outcrop has an elevation of 1,890 feet, but possibly does not represent the lowest hard band in the Ribstone Creek formation, so that the Ribstone Creek-Lea Park contact may be somewhat lower than 1,890 feet. In sec. 1, tp. 45, range 1, W. 4th mer., Lea Park shale is exposed and the highest visible bed has an elevation of 1,863 feet. The Ribstone Creek-Lea Park contact is not exposed here, but is believed to be only slightly higher than the shale outcrops. East of the 4th meridian in sec. 3, tp. 45, range 28, W. 3rd mer., the hard beds of the Ribstone Creek are exposed in contact with the Lea Park shales at an elevation of 1,845 feet. Thus, eastward from the exposures on Ribstone creek the strata seem to dip to the east. Northeastward, on a cut on the Canadian Pacific railway on the southeast of sec. 29, tp. 45, range 27, W. 3rd mer., the Ribstone Creek-Lea Park contact occurs at an elevation of about 1,840 feet. Thus the easterly dip seems to continue, but the amount of dip appears small because, so it is thought, the outcrop on the Canadian Pacific railway track is only slightly east of the strike of the outcrop on section 3, referred to previously. Detailed levelling along Battle river from Ribstone creek northwestward showed a northwest dip. In sec. 4, tp. 46, range 3, W. 4th mer., the Grizzly Bear-Ribstone Creek contact is at an elevation of 1,825 feet.

On Ribstone creek, the Ribstone Creek-Lea Park contact is at an elevation of 1,900 feet. If, as is reasonable, it be assumed that the Ribstone Creek in this locality is about 200 feet thick, a northwestward dip of 275 feet in 12 miles is indicated, that is, about 23 feet a mile. Thus various lines of evidence indicate the existence of a fold or anticline with a northeast-southwest strike, the crest of which is in the vicinity of the exposures of the Ribstone Creek formation 2 miles southwest of the mouth of Ribstone creek. With a northeast-southwest strike the crest of this anticline should lie slightly east of the exposures of Ribstone Creek rocks on Blackfoot coulée, in sec. 12, tp. 46, range 1, W. 4th mer. The rate of dip on the northwestern flank of this anticline is about 23 feet a mile for 12 miles in a northwest direction and on the southeastern flank 7 to 10 feet a mile southeasterly for an unknown distance.

Whether such a broad anticline is likely to have caused an accumulation of gas and oil is a question not easy to answer without drilling, even supposing other conditions than structure are entirely favourable. As stated in the Summary Report, 1924, part B, a flow of gas was obtained at 290 feet in a water well drilled on NW. sec. 24, tp. 46, range 1, W. 4th mer. It is thought that this gas flow must be derived from the base of the Ribstone Creek formation and the fact that the well is located on the northwest flank of the anticline leads to the conclusion that this shallow gas is associated with the structure. If such is the case it would seem reasonable to suppose that a structure sufficient to cause an accumulation of gas at a shallow depth where seepage to the surface would be comparatively easy, might also cause a much larger accumulation at depth, provided strata of sufficient porosity to act as a gas reservoir are present under conditions favourable for the retention of the gas. From wells drilled in various localities on the Plains, sands of sufficient porosity to carry oil and gas are known to be present at the base of the Colorado and in the Lower Cretaceous. There is no known reason to assume their absence at this locality and the Benton shales form an effective cover for a gas or oil field. Thus, although the structure as interpreted seems to be quite broad, it is the best known structure to test for gas, in this part of Alberta and Saskatchewan, the closure of the structure in an east-west direction being several times that of the Wainwright structure in which oil and gas have been found. In the above discussion, the merits of this fold as a cause of the accumulation of oil and gas have been considered only in relation to the fold itself. It happens that the crest of this minor fold coincides with that of a much broader regional one, the minor fold being superimposed on the larger one. Evidence for this broader regional folding is quite conclusive. On Ribstone creek the top of the Lea Park formation is exposed. Westwards the higher formations appear, until in the Irma-Viking area the Pale and Variegated beds outcrop. The sequence of formations from east to west indicates a southwest dip which, however, is modified in a number of places by local variations giving small structures. The amount of dip from tp. 45, range 1, W. 4th mer., to the Imperial (Fabyan) well in tp. 45, range 7, W. 4th mer., is about 230 feet, whereas there is a southeast dip of about 500 feet from tp. 45, range 1, W. 4th mer. to the Muddy Lake well in tp. 39, range 22, W. 3rd mer., this latter dip being about 10 feet to the mile. It is a reasonable conclusion that the larger regional structure, as well as the smaller local structures, has had some influence on the accumulation of oil and gas, and since the tendency is for oil and gas to accumulate toward the crest of any structure, the crest of the major structure would be considered to be a favourable location. But since, as has been pointed out, the crest of the major structure coincides with that of a well-marked minor structure there is a further reason for regarding the minor anticline as a structure favouring the accumulation of oil and gas.

Predictions regarding the presence of oil in this structure are hazardous, but there are reasons, based on certain assumptions, which suggest that the Ribstone-Blackfoot anticline may offer favourable prospects for oil. A consideration of the regional distribution of oil and gas leads to this belief. The distribution in eastern central Alberta is as follows:

Viking fold: 12 gas wells of large capacity; no oil
Hawkins fold: gas in Gratton No. 1 well; no oil
Fabyan fold: gas in Imperial (Fabyan) No. 1 well
gas in Maple Leaf No. 1 well
small amount of oil in Imperial (Fabyan) No. 1 well
Battle River-Wainwright fold: British Petroleums Nos. 2, 3B, and 4 wells are oil wells with some gas

Thus from west to east there seems to be in these local folds a tendency for more oil to be present toward the east. This may be a concidence, but on the other hand there is a possible explanation which is based on the hydraulic theory of oil migration and accumulation.

The hydraulic theory of oil migration and accumulation was developed by Munn[1] and has been elaborated by Rich[2] who states......

. . . "the principal cause of the migration of oil and gas is the movement of underground water which carried with it minute globules of oil and bubbles of gas, possibly as fast as they are formed. Accumulation results from the selective segregation of oil and gas, which on account of their buoyancy always tended to work their way upward as they are carried along and are caught and retained in anticlinal or other suitable traps". "The nature of the trap necessary to cause accumulation depends on the rate of movement of the water and corresponding texture of the sands or other medium through which it flows. Where the sands are porous and there is a strong hydraulic head a sharp anticline with large closure is necessary to retain the oil, in fact where the movement is especially rapid, even such a structure may be inadequate. Where the sands are fine and the water movement is slow, slight structural and textural variations are enough to arrest the movement of the oil and gas. Under such conditions broad, flat anticlines with little closure, terraces, or even minor flattenings of the regional dip are enough to cause accumulation" . . . . .

This theory has been applied by Rich to such basins as the Big Horn in Wyoming and other larger basins in the United States and not only is the theory apparently in accord with the facts, but by means of it the locations of oil and gas fields can be predicted.

If the theory is applied to the structural conditions in Alberta it is apparent that there is no reason why water should not enter porous horizons in the Cretaceous of the foothills and travel eastward through the Alberta syncline towards the outcrops of the same formations at the much lower elevations on the plains east of the syncline. It has been pointed out by Rich that where the flow is rapid, sharp structures of large closure are necessary to prevent flushing of the oil and gas; structures of similar magnitude away from the inlet or near the outlet have been demonstrated

[1]Munn, Malcolm J.: "The Anticlinal and Hydraulic Theories of Oil and Gas Accumulation"; Ec. Geol., vol. 4, pp. 509–529 (1909).

[2]Rich, John L.: "Moving Underground Water as a Primary Cause of the Migration and Accumulation of Oil and Gas"; Ec. Geol., vol. 16, pp. 347–371 (1921).

to be highly productive. It has also been shown by Rich that "near the limit of complete flushing, gas, on account of its greater buoyancy, would be retained on structures which were unable to hold oil". Also starting "from the intake rim the normal sequence in such a basin would be: anticlines completely flushed; anticlines holding only gas; anticlines holding gas and a little oil; anticlines holding oil and gas". The similarity of these conditions which have been shown to hold in oil fields of United States and the conditions found in the folds of eastern central Alberta is very impressive. In fact the conditions as known, that is, gas in the Viking fold, gas in the Hawkins fold, gas with a little oil in the Fabyan fold, and oil and gas in the Battle River-Wainwright fold, are exactly what would be predicted on the basis of the hydraulic theory, on the assumption that water movement was fairly strong in the Viking gas field and the closure of the fold was insufficient to retain oil, whereas farther east in the Battle River-Wainwright fold the structure was sufficient to restrict the water movement and allow the accumulation of both oil and gas. In Alberta there can be no doubt of the direction of possible migration because of the high inlet in the foothills and the lower outlet on the plains. The Viking gas field is far removed from the inlet and at this distance water movement might be expected to be comparatively slow, but the Viking fold has a relatively small closure and for this reason may have been flushed of oil. In only one well, as far as the writer is aware, a showing of oil of no importance was encountered, and, if any oil was originally present in the Viking structure, the results of drilling to date give no indication that oil may be expected to be found there now. Since the flushing effect due to water movement should be progressively less eastwards, because of the wider dispersion of the water, the folds to the east, provided they are of sufficient magnitude, should have received the oil. It would be expected, therefore, that as regards oil, folds east of the Battle River-Wainwright fold should be even more favourably situated than is the Battle River-Wainwright fold and on this basis the Ribstone-Blackfoot anticline is favourably situated for oil accumulation. This is even more the case than position alone indicates, since the closure of the Ribstone-Blackfoot anticline in a northwest-southeast direction is several times that of the Battle River-Wainwright fold. Also, as the Ribstone-Blackfoot anticline is on the crest of a broad regional fold there will be a tendency to restrict water movement farther eastward and to cause oil and gas to accumulate in the area of stagnation. Thus, on the basis of the hydraulic theory, not only is an explanation offered that accounts for the distribution of oil and gas in this part of Alberta, but a consideration of the factors involved also makes very plausible the conclusion that there is an accumulation of oil in the Ribstone-Blackfoot anticline. These conclusions are of far-reaching importance as regards the possibilities of oil in Alberta and Saskatchewan. A report being prepared discusses the situation in detail.

As a test of the applicability of the hydraulic theory in Alberta, the positions of seepages of oil and gas are instructive, and it would seem in this case, also, that the facts fit predictions that the application of the theory would justify. If in Alberta there has been this water movement flushing the oil and gas eastward, then seepages of oil and gas should appear at the outcrops of the oil-bearing beds where the water finds outlet. The writer regards the bituminous sands of Alberta on Athabaska river as representing such a seepage on a large scale and believes that the bitumen has been derived from alteration of oil which was present and originated in Cretaceous strata. A fuller discussion of this will be given in a report now in preparation, but it is believed that this explanation is in accord with the facts. Seepages of gas are reported at a number of places on the banks of North Saskatchewan river. These seepages may be explained on the basis of the hydraulic theory, on the assumption that the gas and oil have been carried eastward by the movement of underground water and that the seepages occur at the outcrops of the oil and gas-bearing beds. Inte - preted in this manner, oil and gas seepages in Saskatchewan may mean only that porous beds there outcrop and that such seepages are no indication of oil and gas accumulations below or in the vicinity of the point of seepage. It must, however, be borne in mind that seepages also result from deep-lying accumulations, but at such points structures such as cause accumulation would be expected to be present.

Recommendations for Drilling. If test wells are sunk on the Ribstone-Blackfoot anticline it is recommended that the first be in the vicinity of Blackfoot coulée near the present gas flow from the shallow well. It is believed this location would be a considerable distance down the northwest flank of this fold and would thus be a fair test of the oil possibilities of the fold. It is possible, however, if oil is present in this fold, it will also occupy the crest of the fold as in the Battle River-Wainwright structure. Since the highest known point on the structure is on Ribstone creek 2 miles southwest of Battle river, this place might be considered as an alternative to the other location. Further locations will depend on conditions found in the first well, but in no case is it believed that one dry hole will entirely disprove the oil and gas possibilities of this anticline.

The depth in any well of the productive oil and gas horizon will depend on the position of the well relative to the geological structure, but in no instance is it thought that the depth to the sands at the base of the Benton will be less than 1,500 feet, or more than 1,800 feet, and the equivalent of the Lower Cretaceous horizon producing the oil in No. 3 B British Petroleums well will be 200 to 225 feet lower.

NOTES ON DEVELOPMENTS DURING 1925 IN THE WAINRIGHT FIELD, ALBERTA

By G. S. Hume

At the end of 1925 British Petroleums, Limited, had drilled five wells in the Wainwright field. These wells are all on one fold which, for convenience, it is proposed to call the *Battle River-Wainwright fold.*[1] The positions of the wells and their present condition is indicated in the following statements.

British Petroleums No. 1 well, sec. 36, tp. 45, range 7, W. 4th mer.: Gas flow reported, indication of oil, well abandoned. Hole filled with water.

British Petroleums No. 2 well, sec. 30, tp. 45, range 6, W. 4th mer.: Heavy flow of gas, considerable heavy oil, water troubles giving an emulsion with the oil. Gas used in 1925 for fuel in drilling No. 3 B well. Oil horizon is in the Benton formation at a depth in the well of 2,019 to 2,036 feet.

British Petroleums No. 3 well, sec. 29, tp. 45, range 6, W. 4th mer., drilled in 1924: Sands encountered in the Benton formation, giving a show of oil and some gas, but no production. Well deepened to formation (Lower Cretaceous) underlying the Benton and a good indication of oil found. Well abandoned on account of production troubles. Well plugged during 1925.

British Petroleums No. 3 B well, sec. 29, tp. 45, range 6, W. 4th mer., location only a short distance from No. 3 well, drilled in 1925: Came in as an oil well from sands in Lower Cretaceous at a depth of 2,239 to 2,259 feet. Production estimated at 50 to 75 barrels a day. Well is being pumped.

British Petroleums No. 4 well, sec. 30, tp. 45, range 6, W. 4th mer., drilled in 1924: Flow of oil accompanied by gas from the same horizon as that which gave the oil in No. 2 well. Considerable oil produced and shipped for use of the Canadian National railways. Gravity of oil about 13·9 Baumé. Well showing water in 1925.

The only other wells being drilled during 1925 in the Wainwright area were one by the Western Consolidated, Limited, and one by the Interior Oil Company, formerly the Wainwright Producers Syndicate. The well being drilled by the Interior Oil Company is located about half a mile west of Wainwright. This well has not yet reached a depth at which production is to be expected, but drilling is being continued. Drilling at the Western Consolidated well has temporarily ceased without reaching the depths at which oil was encountered in the British Petroleums wells.

The finding of oil in No. 3 B[2] British Petroleums well at a depth of 2,239 to 2,259 feet in Lower Cretaceous sands is an encouraging feature.

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[1]Since no single geographical name adequately describes this fold and since the name Wainwright fold is objectionable because the axis of the Fabyan fold, if produced, will pass through Wainwright, the name Battle River-Wainwright fold is suggested. This is appropriate because this fold crosses Battle river and because it comprises what is generally known as the Wainwright field.

[2]Attention is called to an error in a press report sent out in November, 1924, in which British Petroleums No. 3 B well was called No. 3 A well. There are only two wells at this location, i.e. No. 3 well now abandoned and No. 3 B well now producing oil.

Not only is the oil superior in quality to that produced by Nos. 2 and 4 British Petroleums wells, but at the time of the writer's last visit to this well in the autumn of 1925, no water was showing with the oil and the well was finished off in such good condition that it was hoped no water troubles would develop. An analysis of this oil as made from a sample collected at the well by the writer and analysed by Mr. P. V. Rosewarne, Fuel Testing Division, Mines Branch, is as follows:

Specific gravity at 60° F., 0·940 = 18·9° Be
Water = 0·7 per cent
Sulphur = 1·6 per cent
Distillation range of water-free oil

up to 150° C. (crude naphtha)	2·1 per cent by volume
150° to 300° C. (crude illuminants)	21·3 per cent by volume
Over 300° C. (crude lubricants)	69·0 per cent by volume
Coke	10·9 per cent by weight

The finding of oil in the Lower Cretaceous sands leads to the expectation that oil may be present in the same horizon at other locations. Of all the wells drilled by British Petroleums, Limited, No. 2 well contains much the largest supply of gas. Since gas dissolved in the oil is the propulsive force which brings oil to a well, it is reasonable to expect that if at other locations more gas than is present in No. 3 B well was found in connexion with this deeper oil horizon, larger productions would result. From the information now available the location giving the highest promise of such a larger gas flow is in the vicinity of No. 2 British Petroleums well and it is thought that a test of the deeper horizon at this locality would be worth undertaking. In making such a test it should be realized that nothing is known of the extent of the lower productive oil horizon encountered in No. 3 B well. If this horizon were found to be oil-bearing in the vicinity of No. 2 British Petroleums well and if it gave a flow of gas larger than at No. 3 B well and under higher pressure, a good flow of oil might be obtained. Nothing, however, can be foretold regarding these conditions until a test is made. It is understood the Dome Oil Company are endeavouring to arrange to drill such a test in 1926, the location for their test being about 300 feet from No. 5[1] British Petroleums location, that is, on L.S. 7, sec. 31, tp. 45, range 6, W. 4th mer.

PROSPECTS FOR DRILLING DURING 1926

Besides the test of the Dome Oil Company it is understood that preparations are already under way to drill about 600 feet north of British Petroleums No. 3 B well. This drilling is to be done by the Edmonton-Wainwright Company, who have also made arrangements to complete the well of the Irma Oil Development Company on sec. 28, tp. 45, range 9, W. 4th mer. This location is west of the town of Irma and, as is indicated in Summary Report, 1924, part B, may be on the northwest extension of the Hawkins fold.

The wells of the Western Consolidated Oil Company and the Interior Oil Company are not yet deep enough to reach possible oil or gas horizons. The companies expect to complete these wells in 1926. Information regarding them is given in Summary Report, 1924, part B.

It may safely be said that the results obtained from No. 3 B British Petroleums well have greatly increased the importance of the Wainwright field and a considerable development in the near future is to be expected.

[1]No. 5 British Petroleums is a location only.

OXFORD AND KNEE LAKES AREA, NORTHERN MANITOBA

By J. F. Wright

CONTENTS

Illustration

INTRODUCTION

FIELD WORK AND ACKNOWLEDGMENTS

During the 1925 field season the writer made a geological survey of Oxford lake and vicinity, northeastern Manitoba. In 1919, E. L. Bruce mapped and geologically examined the country about Knee lake which lies immediately east of Oxford lake.[1] The results of the two seasons' investigations are incorporated in the accompanying map (No. 2109) and in this report.

Assistance in the field work of 1925 was efficiently rendered by Mr. Jas. Maynard and Don Brise of the University of Manitoba. Thanks are due Mr. J. A. Cargill, Oxford House, Mr. C. A. Clarke, Norway House, and Mr. N. Mattson for many courtesies extended the party and for much general information about the country.

LOCATION AND ACCESS

Oxford House post of the Hudson's Bay Company is the important trading centre of the district and is situated at the outlet of Oxford lake, at the northeast end of the lake, and is near the centre of Oxford-Knee Lakes area. Oxford House can be reached by canoe in summer or dog team in winter either from Norway House or Mileage 214 on the Hudson Bay railway. The route usually followed is that from Norway House on Nelson river at the end of navigation for steamboats plying on lake Winnipeg. From Norway House the canoe route follows Nelson river down to the mouth of Echimamish river, up this river to Painted Stone portage at the height of land between Echimamish and Hayes rivers, and down Hayes river to Oxford lake. The distance by canoe is approximately 150 miles with eight portages, the longest of which is Robinson portage, where there is a pole tram-line. The trip takes from four to ten days, depending upon the amount of freight being carried and weather conditions.

The canoe route from Mileage 214 on the Hudson Bay railway is up Nelson river to Clearwater river; up this river to and across Clearwater lake; then southeast up a small stream with several short portages and

[1]Bruce, E. L.: Geol. Surv., Canada, Sum. Rept. 1919, pt. D, pp. 1-11.

small lakes to a large lake; across this lake to its east end and over a portage about three-quarters mile long to Bigstone lake; southwest through Bigstone lake and up Bigstone river to Bear lake; from east end of Bear lake over a portage three-quarters mile long leading south to a small lake; south across this lake to a portage one mile long to another lake; across the east end of this lake and along a small stream, with two short portages, to Sucker lake; and down Sucker river to Oxford lake. When the water is high only two short portages need be made on Sucker river, although a number of bad rapids have to be run. This route was first explored in 1923, by R. C. McDonald, and is about 75 miles long. The canoe trip from the railway can be made easily in three days when travelling light, and with good connexions from The Pas on the Hudson Bay railway Oxford House can be reached from Winnipeg in four or five days, whereas by boat up lake Winnipeg, via Norway House, the trip takes from seven to fifteen days, depending on weather conditions.

NATURAL RESOURCES

As stated by Bruce,[1] the fur trade is the oldest and still the most important industry of the area, but fur-bearing animals and moose are becoming scarcer year by year. Some of the lakes are well stocked with fish of good quality and if adequate transportation facilities were available fishing might become a considerable industry, but "in Knee lake, however, the fish are not of good quality and are seldom eaten"...... "Much of the area has been burned over and the second growth trees are still small. In well-drained areas trees attain a fair size, but in the poorly-drained areas, at some distance from the streams and lakes, growth is very slow and trees seem never to have attained a large size."

PREVIOUS WORK

Hayes river, of which Knee and Oxford lakes are expansions, was geologically explored between 1877 and 1879, by R. Bell[2]. Between 1879 and 1919 no extensive geological work was done in the vicinity of the lakes. Brock[3] and Tyrrell[4] have given accounts of information obtained while quickly traversing Hayes river, and McInnes[5] compiled all available geological information. In 1919, E. L. Bruce mapped and geologically examined the country about Knee lake, Hayes river from Oxford to Knee lake, and a route leading northward from Oxford House through Pemow and Whitemud lakes. The information obtained by Bruce is represented on the map accompanying this report. The present writer is responsible only for the geology in the vicinity of Oxford lake, Meechikinabish lake, and the route north, by way of Sucker river. A short account by Bruce[6] of his work during 1919 has been freely quoted in preparing this report on the general area and is the sole authority for the statements concerning the territory traversed by Bruce.

[1]Bruce, E. L.: Geol. Surv., Canada, Sum. Rept. 1919, pt. D, p. 3.
[2]Bell, R.: Geol. Surv., Canada, Rept. of Prog. 1877-78, pt. CC; Geol. Surv., Canada, Rept. of Prog. 1879-80, pt. C.
[3]Brock, R. W.: Geol. Surv., Canada, Sum. Rept. 1910, pp. 14-26.
[4]Tyrrell, J. B.: Trans. Roy. Soc., Canada, 3d. ser., vol. X, sec. IV, pp. 1-27 (1917).
[5]McInnes, W.: Geol. Surv., Canada, Mem. 30, "The Basins of Nelson and Churchill Rivers" (1914).
[6]Bruce, E. L.: Geol. Surv., Canada, Sum. Rept. 1919, pt. D. pp. 1-11.

GENERAL CHARACTER OF THE AREA

The Oxford-Knee Lakes area is almost flat, and only locally a hill rises as much as 50 feet above the water-level of the lakes which occupy the larger depressions. This general flat character is due to a thick mantle of stratified clay and sand that covers much of the surface and has almost completely smoothed out the original irregularities of the rock floor. Rock exposures are numerous along parts of the shores of the many lakes, but inland outcrops are few or absent over much of the area. The most rugged part of the area is between Knee and Oxford lakes where narrow, discontinuous, east-west rock ridges rise abruptly as much as 40 or 50 feet above the surrounding muskeg and spruce swamps. North of Oxford lake the low hills have steep slopes, but no bedrock was noted along their sides and these northeast trending ridges probably represent glacial deposits. At the lower end of Knee lake the country is exceptionally flat, "rock outcrops are rare even along the shore, and sand and boulder beaches extend for long distances, forming a natural levee behind which lie swamps and muskegs." The general flat surface covered with large, poorly drained muskeg, spruce swamp, and numerous shallow, irregular-shaped lakes, are the characteristic topographical features of Oxford-Knee Lakes area.

GENERAL GEOLOGY

GENERAL STATEMENT

The bedrocks of Oxford-Knee Lakes area are of Precambrian age and consist of metamorphosed sediments and volcanics intruded by gabbro dykes or sills, quartz porphyry dykes, and granite. These are overlain and almost completely hidden by a mantle of glacial drift, stratified clay, and sand, of late Quaternary age. The ancient sediments and lavas occupy an elongated, lens-shaped area, with a longer axis striking in a general east-northeast direction for about 80 miles, and with a maximum width of 10 or 12 miles. Oxford and Knee lakes are long and comparatively narrow and lie within, and with their longer directions parallel with, the strike of the lens-shaped area of sediments and lavas, which thus occupy only a narrow fringe along the lake shores, and in few places extend inland more than 2 miles, with the result that outcrops of granite are generally found at the heads of the deeper bays, and also in several places along the main shoreline for long stretches.

The geological succession as known at present is tabulated below. This classification is essentially the same as adopted by Bruce and is only tentative.

Table of Formations

Age	Group	Component rocks
Quaternary....	Unconsolidated deposits.......	Post-glacial stratified clay and sand
		Glacial boulder clay and gravel

Table of Formations—Continued

Great unconformity

Age	Group	Component rocks
Precambrian...	Intrusives....................	Diabase
		Granite and granite gneiss with some pegmatite
		Quartz porphyry
		Gabbro and diorite
	Volcanics and sediments......	Andesite and trachyte and derived schists
		Conglomerate, greywacke, arkose, slate, and derived schists

SEDIMENTS

Outcrops of black, slaty rocks are abundant along the south shore and adjacent islands of Oxford lake from a point a mile east of the east point of Old Mission bay. Bedding lines were recognized in some outcrops, but in many others the rock is dense, black, fine grained, and lacks evidence of stratification, but possesses a poorly developed slaty cleavage. The slaty cleavage and bedding are parallel where the two have been observed in the same outcrop, and it is probable that the original lamination, where not well developed, was destroyed when the secondary cleavage was impressed upon these rocks. The strike of cleavage and bedding varies from north 70 degrees east to south 75 degrees east and the dip at angles of from 80 to 90 degrees is, in most localities, to the north, but locally to the south. Some outcrops show interbedded layers of greyish metargillite and impure quartzite from 4 feet up to 10 feet in thickness, and where there are several such alternating narrow beds the surface back a few feet from the water-levels of the lake shows a ribbed pattern, due to the softer slaty rocks weathering faster than the more resistant quartzose beds. Many of the slaty beds between the quartzose beds are drag-folded. Slaty rock of some outcrops on the islands just east of the outlet of Oxford lake closely resembles some of the lava flows and associated ash beds of the volcanic group. One thin section of slate was studied microscopically and showed quartz grains less than 0·04 inch in diameter embedded in a matrix of carbonate, sericite, and greyish, clayey-looking material.

Greywacke outcrops with slate on the south shore of Old Mission bay, on the islands in the central part of Oxford lake, and along the south side of Cargill island. The rocks of this group show all gradations from fine-grained, almost dense, dark grey types to light grey varieties with abundant small grains of quartz and feldspar recognizable on the weathered surface. Some of the fine-grained, dark grey beds are calcareous enough to effervesce slightly with hydrochloric acid; others are sheared and are now quartz-sericite schist. The weathered surface of some outcrops of these rocks shows small pinkish garnets. Bedding planes are seldom recognizable in the thick, massive greywacke.

A few specimens of greywacke from near the southeast end of Cargill island are seen under the microscope to consist of both angular and rounded grains of quartz and feldspar, averaging 0·1 inch in diameter, in a dense groundmass of a dark grey material, together with some chlorite, calcite, epidote, and magnetite. Other thin sections show less of the dark grey, unresolvable material, and a larger proportion of the angular quartz and feldspar (orthoclase, microcline, and oligoclase) grains.

Outcrops on the islands west of Eightmile point are typical arkose, consisting predominantly of angular quartz and feldspar grains up to 0·3 inch in length, but averaging about 0·15 inch in diameter.

Along the shore of Hyres island, near the west end of Oxford lake, the greywacke is metamorphosed to greenish and white schists. In thin section the dark, greenish schists consist of calcite and quartz with abundant chlorite. One thin section contains a few small grains of bluish green ottrelite. The white schist consists of quartz, sericite, and talc, with some narrow beds containing a high percentage of talc.

A conglomeratic horizon from 500 to 3,000 feet thick outcrops along the south shore of Oxford lake from Eightmile point east to near the east end of the lake. No conglomerate was noted on the islands in Oxford lake west of Eightmile point, but several small outcrops were seen along the shore of Old Mission bay. The pebbles and boulders of this conglomerate vary greatly in size from place to place, some outcrops showing one-quarter of the pebbles 2 feet or more in diameter, although in most outcrops the average diameter is about 5 inches. All the pebbles are waterworn and are round or ellipsoidal in outline. The variety of pebbles is not great; granite forms at least 95 per cent, a dark quartzose rock and a schistose porphyritic dioritic rock make up most of the balance. No pebbles typical of the lavas to the north were noted. A thin section of a specimen from one of the larger granite pebbles shows under the microscope that many of the feldspar grains are altered to quartz, calcite, epidote, and chlorite, the remaining grains containing many inclusions, as do the feldspars of the greywacke. A notable feature of this thin section is the several large crystals of apatite and titanite. The granite of this pebble is considerably more altered than the granite at present outcropping in this area. The matrix of the conglomerate is greywacke or a fine conglomeratic grit, which in places is schistified and the smaller pebbles distributed with their longer axes parallel with the shear planes.

The sedimentary areas described above extend east and, in the words of E. L. Bruce,...

......"outcrop at the rapids between Oxford lake and Knee lake and along the southern shore of Knee lake as far east as the winter trail to Gods lake. Presumably they occupy a large area south of Knee lake, but exposures are not found far inland. The member of this group most commonly seen is a fine-grained, grey gneiss. Exposures along the river below Oxford lake consist of various facies of the rock. It is made up of quartz, feldspar, both orthoclase and plagioclase, and biotite, with brownish red garnets abundantly developed in some bands. The biotite foils lie between the grains of other minerals or cut across them...... On the fresh surface the rock is greyish with narrow bands of light and dark shades. In some localities a massive, biotite rock occurs......(otherwise) very similar to the foliated rock...... A fragmental rock is also a very prominent member of this group; it is in part at least a true conglomerate, but in part may be a volcanic fragmental with the fragments somewhat rounded and sorted. The pebbles in some of the exposures are granite, granite porphyry, and quartz, but in many exposures the greater number is a dark, greenstone-like rock very similar to some rocks of the volcanic bands in this (sedimentary) group, and to the greenstone that forms the greater part of the upper (i.e. volcanic) group. Pebbles of rock similar to the gneisses also occur...... Many soft, black or greenish, slaty bands occur...... The most striking of these is a soft, green weathering rock that in places is conglomeratic. The bedding is well marked ...... It has the appearance of a volcanic mud rock. Bands of hard, extremely fine-grained, siliceous rock occur. They are impure quartzites...... Flow rocks of two types are found. Some of the lavas are fine-grained greenstones...... Others are porphyritic and somewhat coarser in grain, are much less altered, and have the composition of andesites. Other more basic types......occur. The flows are comparatively thin and are subordinate in total thickness to the sedimentary part of the group."

VOLCANICS

Light grey to black, fine-grained volcanic rocks of intermediate composition outcrop along the north shore of Oxford lake from the west end to near the mouth of Sucker creek. Associated with these rocks are a few thin beds of laminated slaty rock and some cherty layers, believed to represent local water-sorted beds of volcanic material. Several dykes or sills of gabbro and diorite also occur with the volcanic rocks. Smaller belts of volcanic rock outcrop within the granite north of Oxford lake, the largest known area being 2 miles wide and extending from near the middle of Sucker lake west and northwest 7 miles or more.

The specimens of volcanic rocks studied indicate that this group is fairly uniform in mineral composition and texture over wide areas. Light grey, dense to very fine-grained trachyte outcrops along the south shore of Cargill channel near its east entrance. In thin section under the microscope the average grain of this rock varies from 0·03 to 0·05 inch in diameter and the feldspars are orthoclase and oligoclase-albite within a matrix of chloritic-looking material and carbonate, together with some brown biotite, quartz, magnetite, and epidote. By far the larger proportion of the volcanic rocks is fine to medium-grained, dark grey to black, and slightly more basic in composition, the abundant feldspar being andesine or between oligoclase and andesine in composition. A green, highly pleochroic hornblende is always present, together with considerable titanite, leucoxene, magnetite, epidote, biotite, and secondary quartz. Many outcrops of both trachyte and andesite show excellent pillow structure. Locally, the volcanic rocks have been sheared and chlorite and sericite schists are developed.

Around Knee lake...

......"the volcanic group consists mostly of ellipsoidal weathering greenstone that seems to have had the composition of an andesite. With this, there is the usual minor development of amygdaloidal rocks, autoclastic phases and massive types which may have been ash rocks originally. A few bands of ash rocks occur with the lavas, but these are acidic and contain fragments that may be trachyte or rhyolite. These bands are conspicuous as they weather white."

"Sedimentary rocks of two types occur in the group. On Painkiller point a narrow band of conglomerate and banded chert outcrops. The conglomerate contains rounded and subangular fragments of chert and greenstone. Some of the pebbles are a foot or more in length. The banded chert has thin, dark grey and light grey laminations, some of which are truncated by later laminations. Across the bay north of this occurrence an outcrop of ellipsoidal weathering greenstone occurs in which the ellipsoids are embedded in chert...... At times there was locally some erosion, truncating chert beds already deposited and producing pebbles which were included in somewhat later deposits. It is probable that the conglomerate is intraformational and does not mark any general unconformity."

"The other sedimentary member in the volcanic group is a thin band of iron formation which consists of somewhat granular, white silica and magnetite. In the same locality at which the true iron formation outcrops are some exposures of a black slate that belongs probably to the same period. It is very like some of the rocks of the sedimentary group described above."

STRUCTURE AND SUCCESSION OF SEDIMENTS AND VOLCANICS

The structure and succession of the sediments and volcanics of Oxford Lake basin could not be definitely determined because of the lack of evidence necessary to permit distinguishing between the top and bottom of beds, without which it is impossible to decipher structure where the strata stand vertical or dip steeply, as they do in this area. Another handicap in this work was the scarcity of outcrops inland and at critical points along the lake shore. However, the evidence noted indicates that the dominantly volcanic group of rocks is younger than the sedimentary group. In the case of Knee Lake area the following facts are cited by Bruce to support this conclusion: (1) "The rocks of the sedimentary group in proximity to the volcanic group have dips that vary from 90 to 60 degrees. Where the dip varies from vertical it is in all cases underneath the greenstone series. (2) The rocks are not overturned, since at one exposure at least the top of beds dipping underneath the greenstone appears to be towards the volcanic rock. (3) At one locality there seems to be a gradation from one group to the other."

In Oxford Lake area evidence indicating that the top side of the lava flows is to the north was noted about 1¼ miles north of a point near the east end of Cargill channel. There the country has been swept by fire and five lava flows are fairly well exposed within a distance of 1,500 feet across their strike. The lava is andesite and is not badly metamorphosed. The flows strike about north 70 degrees east and dip 80 to 85 degrees to the north. The andesite along the south side of each flow is very fine grained and the size of the grain increases towards the north until the rock is a medium-grained andesite. The northern half of the flow contains excellent pillow structure and the top 4 feet contains white quartz and calcite nodules thought to be amygdules. No fragmental or pyroclastic material was noted along the north side of any of the flows.

Other evidence suggesting that the sediments are older than the volcanics is the general absence of pebbles of typical volcanic rocks in the thick conglomerate horizon exposed eastward from Eightmile point, Oxford lake. If this conglomerate has been deposited on the surface of a great lava field, it is difficult to explain the presence of abundant granite pebbles and the scarcity of pebbles of the volcanics.

Since the sediments outcrop south of the volcanics, and the prevailing dip of both series is to the north, with the top of the beds, where determined, to the north, it is concluded that the sedimentary series underlies and is older than the volcanic series.

INTRUSIVES

Long, narrow, intrusive bodies of gabbro and diorite were noted within the volcanic group, especially along Cargill channel, but no such intrusives were noted cutting the sediments. Where these intrusive bodies are 30 feet or more wide, the rock is easily distinguished from andesite lava by the coarser grain and massive, uniform appearance. Also, many of the outcrops of the intrusives weather black and white in a very irregular pattern. The few specimens examined under the microscope are uniform in texture and mineral composition, with feldspar varying from andesine to labradorite and a green, highly pleochroic hornblende, as the abundant constituents. Minor amounts of titanite and magnetite are present, together with considerable chlorite and calcite as secondary minerals. The larger feldspar crystals are broken and contain inclusions. Near the edges of the gabbro masses, the compass at numerous points indicated marked local attraction, due apparently to small segregations of magnetite. Gabbro and granite were seen in contact north of Cargill channel and along Hayes river, about 1 mile from Oxford lake. At these two localities the gabbro is cut by granite.

Quartz Porphyry

No quartz porphyry dykes were noted in Oxford Lake area, but Bruce states that in Knee Lake area a few such dykes cut the greenstone...

"The rock is granular, with phenocrysts of bluish quartz set in a groundmass of white to pinkish colour. The rock weathers white and is rather conspicuous. It has suffered considerable shearing in places and there is some alteration to sericite. Many of the dykes have been fractured and in the fractures quartz has been deposited...... (The relation of the quartz porphyry to the granite) is not definitely known, but since the granite is in all cases fresh and unaltered, whereas the quartz porphyry is in places sheared and metamorphosed, it may be presumed that the granite is the younger rock."

Granitic rocks outcrop over wide areas in northeastern Manitoba and wherever examined are remarkably uniform in appearance and mineral composition. The long area of sediments and volcanics of Oxford-Knee Lakes area is completely surrounded by granite, which, wherever the contact has been observed, is intrusive into these two groups of rocks. The granite varies from grey to pink and from medium to coarse grained. Locally, both gneissic and porphyritic phases are developed. Quartz, microcline, oligoclase-albite, and biotite are the important minerals of the granite. Small pegmatite dykes and pegmatitic phases were noted at a few localities, but the general absence of pegmatite is the rule in the area examined.

A few, narrow diabase dykes were noted cutting granite in the northeast part of Oxford Lake area. The general strike of the dykes is north 25 degrees to north 40 degrees east and the width varies from 10 to 50 feet. No dyke noted was exposed for more than 200 feet along its strike. The dyke rock is black, fine grained, and massive. In thin section it shows the diabase texture; the plagioclase is near labradorite, there is some augite, and considerable green chloritic-looking material.

UNCONSOLIDATED DEPOSITS

In most of the area examined the glacial drift is covered by stratified clay and sand. At a few places along Oxford Lake shore unstratified boulder clay and gravel are exposed at the bottom of sections, the stratified deposits passing downward within a foot or two into unstratified material. Hills and small ridges north of Oxford House are believed to be formed of glacial drift, although no sections could be found in this heavily wooded area. East of Sucker lake, esker-like ridges, striking in a general northeast direction, consist of gravel and sand, as is indicated by the material brought to the surface at the entrance of the numerous fox burrows along the side of such ridges. Evidently much of the glacial drift has been reworked and deposited as stratified clay and sand by the waters of post-Glacial Lake Agassiz.

Sections of clay and sand with horizontal or slightly undulating bedding lines were noted in a number of cuts along the lake shores. The surface of most of these sections is weathered and slumped, so that the bedded character of the deposit is not apparent without close inspection. The thickest section of these deposits noted was on the east shore of the southwest arm of Meechikinabish lake, where the exposed section is 45 feet. The stratified clays vary in thickness from place to place as they were deposited as a thin mantle over an irregular surface. These clays were deposited in a large, shallow lake, known as Lake Agassiz, which extended for a short period over a large part of southern and northeastern Manitoba. The north shore of this lake was the front of the retreating ice-sheet and a large part of the materials forming these clays was carried into the lake by rivers from the ice-field.

ECONOMIC GEOLOGY

In the summer of 1925 several prospectors visited Oxford Lake area, but no extensive systematic prospecting has yet been undertaken in the district. The two serious handicaps to detailed prospecting in northeastern Manitoba are the widespread drift deposits and the long distance from the railway or deep-water transportation routes. In many parts of the district outcrops of bedrock are small and scattered and it is estimated that over 90 per cent of the surface is drift-covered. However, in certain parts of the district, outcrops are more numerous than elsewhere, and such areas, especially if underlain by volcanic rocks, are the most favourable for prospecting. Prospectors intending to work in this district should bear in mind that the swamps are so flooded and the mosquitoes are so thick that it is almost impossible to leave the lake shores until the first of August. The best prospecting season is between August and December and especially after the middle of October, when the swamps and muskegs are frozen and all the outcrops in the low areas can be visited with ease.

Mineral claims have been staked by Mr. N. Mattson and others at two localities along the shore of Oxford lake. The first group of twelve claims, known as the Lynx group, was staked in July, 1922, and in August and September, 1923. These claims are along the south shore, are south of Cargill island, and just east of the entrance to the channel between the mainland and the two large islands lying at the entrance of the bay into which Hayes river flows. The rocks exposed along the shore are greywacke and granite. The greywacke is badly sheared and one shear-zone exposed along the lake shore near the east side of the Blue Lynx mineral claim is impregnated with pyrite, chalcopyrite, sphalerite, and galena. This mineralized zone strikes south 70 degrees east and dips steeply to the north. It is exposed for about 250 feet along the shore. To the west it passes under the lake and to the east it disappears beneath drift. About 400 feet farther east a shear-zone with but little mineralization is exposed in a small prospect pit. On the point about 3,000 feet west of the location line of the Blue Lynx mineral claim the greywacke is also badly sheared and is mineralized with some chalcopyrite, sphalerite, and galena. These shear-zones parallel the general direction of the granite-greywacke contact and are about 100 feet north of it.

The second group of mineral claims is on Hyres island at the west end of Oxford lake. In April, 1925, stibnite was discovered on the New Falu mineral claim located at the southeast corner of Hyres island. At this place are greywacke-like sediments, for the most part altered to quartz-sericite-talc schist. The stibnite occurs along a shear-zone in quartz-sericite-ottrelite schist, the stibnite-bearing part averaging about 3 feet in width and being exposed for 100 feet along the strike, which is about east and west. A pit was sunk 6 feet on a small, lens-shaped body of massive stibnite, and several tons of stibnite ore, estimated to assay over 50 per cent antimony, were piled on the dump. The stibnite, besides occurring in this massive form, is also scattered in small flakes throughout the shear-zone. Some chalcopyrite and pyrite were also noted along this mineralized zone, and there is considerable quartz in small veinlets and in bunches of perfectly developed crystals. A few crystals of labradorite feldspar were noted with the massive stibnite. A channel sample across this mineralized zone assayed 0·30 ounce in gold. The mineralized zone passes under the lake to the east. To the west, on the north shore of the island, several shear-zones are visible. They carry quartz and calcite veinlets and some chalcopyrite and stibnite. The sericite-talc schist along the east shore of the island is mineralized with chalcopyrite at a number of places, but no large, continuous body of such mineralized rock is exposed. The thickness of clay on Hyres island, as indicated by exposures along the shore, is from 3 to 30 feet. The source of the mineralization of these shear-zones is attributed to the granite outcropping to the north.

A number of quartz veins were noted on the islands near the north shore of Oxford lake and especially on the group of islands south of the granite contact and about 4 miles west of the east end of Cargill channel. Sulphides are only sparingly present in the quartz, and no free gold was noted. A grab sample from one of these veins gave no gold on assaying.

Little prospecting has been done around Knee lake since 1919 and since then the walls of the prospect trenches cut in clay have slumped so that little mineralized rock is now exposed at the two localities to which practically all the work done in the district was confined. The following is Bruce's description of these two localities........................

"One group of claims occupies the eastern end of Magennis island 7 miles from the inlet of the lake, the other group is on a point in Painkiller bay......(The claims of the first group were) located along the same mineralized zone......(which) at the eastern end, ... lies in a dyke of quartz porphyry, but at the western end the dyke is north of the quartz zone. In the altered and sheared dyke are numerous intersecting veinlets of quartz one inch or less in width. The quartz in the schistose greenstone is in lenticular masses, the long axis parallel to the direction of schistosity. The largest of the lenses uncovered is 25 feet in length and has a maximum width of 12 feet. Some pyrite occurs in the quartz; chalcopyrite and arsenopyrite are sparingly present in the wall-rocks. No gold is visible and assays of samples across the main lens at its widest part give only 0·09 ounce of gold per ton."

The point in Painkiller bay where the second group of claims was staked...

......"has been almost completely cleared and many trenches have been dug through the clay overburden. The rocks are greenstone and conglomerate with chert and greenstone pebbles, intruded by a quartz-porphyry dyke. The dyke has been factured and in the fractures veins of quartz up to an inch in width had been deposited. The whole body of the dyke was said to carry values in gold, but assays of samples of the quartz veins which seemed to be the most likely source of the gold, showed only traces."

BIGSTONE AND FOX RIVERS AREA, NORTHERN MANITOBA

By C. A. Merritt

CONTENTS

Illustration

INTRODUCTION

The following report is descriptive of the geology along Bigstone river from Bigstone lake to the junction with Fox river, and along Fox river to its junction with Hayes river. The route was surveyed by R. C. McDonald in 1924; the completion of the survey and the study of the geology was undertaken by the present writer in 1925 with the efficient service in the field of G. Brownell and H. Fraser.

The river system traversed in 1925 extends across a considerable area and the different parts are best reached by different routes. Bigstone lake in the southwest of the area may be approached from Oxford lake via Sucker creek, Sucker lake, Bear lake, etc., as shown on the map (No. 2109) accompanying the report by J. F. Wright, in this volume. The lower part of Fox river may best be entered from Hayes river either by ascending the latter river from York Factory or by descending it from Oxford House. The headwaters of Fox river are accessible from the Hudson Bay railway via Kettle lake and Fox lake.

The district has the characteristic low relief of the general region of which it is a part. Only in a few places is it hummocky. Most of the district is deeply covered by drift which has smoothed out any inequalities of the original bedrock surface. Rock exposures occur only along the waterways. On Fox river the clay cover forms steep banks in places 50 feet high.

GENERAL GEOLOGY

GENERAL STATEMENT

The bedrocks of the area are all of Precambrian age and consist of a group of volcanic and sedimentary strata invaded by granite and granite gneiss and cut by dykes of diabase and pegmatite. These rocks are overlain and largely concealed by a mantle of Pleistocene and Recent drift and alluvium. No indications were noted of the existence of mineral deposits of value.

Table of Formations

Quaternary	Recent	River alluvium, peat, etc.
	Pleistocene	Clay, sand, gravel
Precambrian	Intrusives	Diabase and pegmatite dykes
		Granite, granite gneiss
	Sediments and volcanics	Biotite schist, garnet schist, staurolite schist
		Lavas and derived schists

VOLCANICS

The volcanic rocks of the area occur in three main bands. One cuts across Bigstone lake, forming the southeast shore and most of the north shore; a second band crosses Bigstone river 15 miles below the lake; and a third band follows Fox river for a considerable distance.

The volcanic rocks of the Bigstone Lake band are massive and schistose basic rocks with a prevailing greenish shade and are commonly termed greenstones. The massive greenstones have well-developed ellipsoidal or pillow structure. Pillows measuring as much as 3 feet in length are common on several of the islands of Bigstone lake. They probably indicate that the lava was poured out and congealed under water. The greenstones vary considerably in composition, but are mostly intermediate, chiefly andesite. In thin section they show andesine and green hornblende with small amounts of biotite and magnetite. Quartz is also present and many of the rocks grade into dacites. Diabases with typical ophitic texture are common. This greenstone complex also contains diorites, but whether they are intrusive or merely the inner parts of deep flows is not certain. They consist essentially of hornblende and andesine. The plagioclase commonly has numerous inclusions, generally of quartz.

The planes of schistosity in the greenstone schists strike north 70 degrees east and dip southerly at angles of 70 to 80 degrees. The schists examined with the microscope are found to consist of from 50 to 75 per cent green hornblende and quartz. A small amount of plagioclase and magnetite is present in many cases, and, in some instances, pyrite which is generally altered to hematite. The hornblende is comparatively fresh, though some chlorite is usually present. Quartz inclusions in the hornblende are very common and there is considerable evidence that the rock has suffered complete recrystallization. Hornblende-quartz schists near granite contacts commonly grade into hornblende schists which consist almost entirely of coarse, black, glistening hornblende crystals.

The greenstones of the second band of volcanics crossing Bigstone river are essentially similar to those found on Bigstone lake, though no pillow lavas were noticed.

The volcanic rocks of the Fox River band are in general massive, though occasionally schistose; the schistosity of the latter striking north 80 degrees east and dipping 80 degrees south. The massive varieties are chiefly hard, dense, rhyolites which are dark grey on freshly broken surfaces, but pinkish grey on weathered surfaces. In thin section they are seen to be porphyritic, with phenocrysts of quartz and orthoclase and a fine-grained groundmass of the same minerals, together with minor amounts of biotite, andesine, and magnetite. The quartz phenocrysts are considerably corroded and resorbed. Fragmental volcanic acid rocks are common in this band. These contain large bombs which stand out in relief on weathered surfaces. The bombs are amygdaloidal, the amygdules small and closely packed together.

A serpentine rock outcrops about 6 miles below the lower junction of Bigstone and Fox rivers. It extends for a mile along the northern shore, and reaches 50 feet above the river. In thin section it is seen to be an altered peridotite, the olivine altered to serpentine and magnetite. Monoclinic and orthorhombic pyroxenes are present and are in part altered to serpentine.

SEDIMENTS

There are two bands of apparently sedimentary rocks, one of which occurs on Bigstone lake and the other along the lower stretches of Fox river.

The sediments of the Bigstone Lake area outcrop on the southern shore and nearby islands of the lake. They strike north 70 degrees east and dip south at high angles. They adjoin and lie south of the volcanic rocks. Their attitude suggests that they overlie the lavas.

The sediments are highly schistose, dark grey rocks in which biotite and quartz and occasionally garnet can be seen. In places the schist weathers to a reddish brown, friable rock. Under the microscope, quartz and biotite are seen to compose 90 per cent or more of the rock. The quartz is angular, comparatively free of inclusions, and shows cataclastic structures. The biotite is partly altered to chlorite. Garnets when present are small, colourless, and show anomalous double refraction. The accessories are orthoclase, plagioclase, apatite, tourmaline, and magnetite. The mineral constituents of the schists are essentially the same, yet there is a great variation in the relative amounts of the various constituents, the size of the garnets, etc. The variations distinctly characterize bands, which fact, together with the mineralogical composition of the schists, suggests strongly that they are of sedimentary origin. These sediments are thought to be younger than the lavas of Bigstone Lake area, for the following reasons: (1) they seem to overlie the lavas with similar strike and dip; (2) the lavas have pillows facing the sediments, indicating that the top of the lava flow faces south and underlies the sediments; (3) the schistosity of the sediments is steeper than the bedding, indicating that the anticlinal axis lies to the north and that the strata are not overturned. The contact between sediments and volcanics is not exposed and it is not possible to determine whether there is an unconformity. The sediments may represent merely an inter-volcanic phase or an entirely distinct period.

The strata of the second band of sediments outcrop at intervals for a distance of 25 miles along the lower stretches of Fox river. Their strike is somewhat irregular, varying from north 45 to 80 degrees east. They dip south at angles of 45 to 65 degrees.

The rocks change in composition in short distances across the bedding. Quartz-biotite schists and garnet schists are common and are similar to those on Bigstone lake. In addition, staurolite schists occur and these grade into the other types. The staurolite schists show prominent staurolite crystals on weathered surfaces. Many of them are the characteristic cross twins. In thin section the rock is seen to consist essentially of quartz, biotite, muscovite, garnet, and staurolite. Sillimanite was noted in several slides and cyanite in one. Tourmaline and orthoclase are common accessories. The staurolite is in large individuals with characteristic, yellowish pleochroism, and has inclusions symmetrically arranged or in sub-parallel bands. Many of these inclusions are garnets. The staurolite crystals are later than the adjacent mineral grains. The garnets are developed across the schistosity. The sillimanite is in long, slender needles, in many cases aggregated in rosettes, and shows typical cross parting.

INTRUSIVES

The most prevalent rocks in the area are granites and related types. These occur as batholithic masses between the volcanic bands and as stocks and dykes intrusive into the volcanics and sediments. In composition the granites are all extremely acid, but in appearance they vary considerably and a few of the more important types are described below.

The most characteristic type on Bigstone lake is a coarse, light-coloured, extremely acid granite consisting almost entirely of feldspar and quartz. In thin section, quartz, microcline, orthoclase, and microperthite, make up about 98 per cent of the rock and biotite the remainder. Variations of this rock in some cases show oligoclase, hornblende, zircon, and magnetite.

A fine-grained, massive, red variety occurs in the eastern part of Bigstone lake. In thin section its essential constituents are biotite, orthoclase, microcline, and albite. The quartz is in a mosaic between larger quartz crystals. The granites along Bigstone river to the point where it divides are extremely acid like those on Bigstone lake. A granite gneiss with blue opalescent quartz is characteristic of the area where Bigstone river divides. In thin section it is very acid, consisting essentially of biotite, quartz, and orthoclase. The quartz and orthoclase are crowded with zoisite inclusions. The granites on Fox river are also very acid and similar to those on Bigstone lake.

Pegmatite dykes were noted principally on Bigstone lake, where some of them are 500 feet wide. They are intrusive into the volcanics, the sediments, and the granites. The pegmatite is of a very acid, coarse, granite type with practically no rare minerals. It consists essentially of quartz, microcline, orthoclase, and microperthite, with "books" of coarse biotite, the latter chiefly in cracks in the quartz.

Near the portage from Bear river to Bigstone lake are a few diabase dykes cutting granite. They are dense, aphanitic rocks and under the microscope are seen to be typical diabases. They are composed essentially of labradorite and augite, the latter filling the interstices between the lath-shaped feldspar crystals. Similar diabase dykes are also found cutting the lavas on Bigstone lake.

DEEP BORINGS IN THE PRAIRIE PROVINCES AND NORTH WEST TERRITORIES[1]

By E. D. Ingall

The Borings Division exists for the purpose of accumulating and studying records of borings made in any part of Canada, so that the information may be available for the guidance of drill operators and others.

An essential feature of the work consists in an exact study of samples of the strata passed through by bore-holes. In order that such samples may be as accurately representative of the strata penetrated as drilling methods permit, it is most important that *the samples be sent direct without previous washing or other preparatory operations.* Samples should be taken at short intervals because unsuspected, important variations may exist in material appearing to be homogeneous.

In the Prairie Provinces and North West Territories boring operations were prosecuted at various points, but especially in the Wainwright-Irma and in the Turner Valley fields following on the discoveries of oil in the British Petroleums wells and Royalite No. 4 well. As in past years the Borings Division has acted in co-operation with the officials of the North West Territories and Yukon Branch of the Department of the Interior. Through their courtesy logs and sets of samples were received from most of the important wells, supplementing the information which was obtained by direct correspondence. Through various agencies, sample sand records of borings were received, as shown in the accompanying table.

[1]Information regarding boring records for British Columbia will be found in part A of the Summary Report, and for eastern Canada in part C.

Records Received from the Prairie Provinces

LOCATION						DESCRIPTION							REMARKS
L.S.D.	Section	Township	Range	Meridian	At or near village, lake, river, etc.	Year made	Elevation (above sea-level) Feet	Total depth in feet	Yield	Character of water	To first rock Depth in feet	No. of samples received	Name of well, drilling company, or driller
						Turner Valley Group							
13	4	14	II	W. of 5th	Rice creek	1924		4,020				621	Imperial Oil Co.
12	7	20	II	"	Okotoks	1923–24	3,976·97	3,740				98	Royalite No. 4
13	7	20	II	"	"	1925	3,983·00	2,200				70	" No. 5
16	31	19	II	"	"	1925	3,999·17	1,995				48	" No. 6
11	13	20	III	"	"	1925	4,010·49	3,080				208	Vulcan Oil Co.
9	1	20	III	"	"	1925		2,510				10	Canada Southern Oil Co.
16	1	20	III	"	"	1925	4,003·90	2,620				218	McLeod Oil Co. No. 2
						Sweet Grass Group							
	29	1	XI	W. of 4th	St. Kilda	1924–25	3,270	2,800	Gas	Fresh		12	Canadian Oil Refinery No. 1 (Rogers Imperial)
5	32	1	XI	"		1924–25		1,100	"	"		107	Northwest Co., Ltd., Dead Horse Coulée No.2
	1	1	XV	"		1925		2,675					Coutts, Sweetgrass Oils, Ltd.
						Wainwright—Irma Group							
	29	45	VI	W. of 4th	Wainwright	1924–25	2,304	2,296	Oil Gas	Fresh Salt	160	Cores	British Petroleums No. 3 B
4	29	45	VI	"	"	1924–25	2,304·3						British Petroleums No. 3
8	20	45	VI	"	"	1924–25	2,270·1	807					Western Consolidated Oil Co.
	36	44	VII	"	"	1924–25	2,216·80	530				4	Interior Oil Co.
9	36	44	VII	"	"	1924–25		530					Wainwright Oil and Development Co.
16	28	45	IX	"	Irma	1924–25	2,251·16	225				10	Irma Oil Holdings

Viking Group

16.......	6	49	XII	W. of 4th.	Viking........	1925	....	2,137	Gas.....	Fresh..........	427	Northwest Utilities (Viking No. 11)
9.......	12	49	XIII	" ..	"	1925	....	1,300	"	"	175	Northwest Utilities (Viking No. 12)

Foremost Group

	14	6	XI	W. of 4th.	....	1925	2,809·9	2,215	Gas.....	Fresh..........	....	Canadian Western Natural Gas, Light, Heat, and Power Co. No. 5
	2	6	XI	" ..	....	1925	3,048·6	2,221	"	"	....	Canadian Western Natural Gas, Light, Heat, and Power Co. No. 6

Medicine Hat Well

4........	6	13	V	W. of 4th.	Crescent Heights	1924–25	....	2,535	Gas.....	Fresh..........	221	Roth, C.E., for the city of Medicine Hat

Many Island Well

13.......	34	13	II	W. of 4th.	....	1923–25	2,368	3,455	Gas.....	Fresh..........	15	Many Island Oil and Gas Co. (Core samples)

Peace River Well

	36	83	XXII	W. of 5th.	Peace River..	1924–25	1,280	100	....	....	....	P.M. Oil Co.

Records Received from the Prairie Provinces—Continued

LOCATION						DESCRIPTION							REMARKS
L.S.D.	Section	Township	Range	Meridian	At or near village, lake, river, etc.	Year made	Elevation (above sea-level) Feet	Total depth in feet	Yield	Character of water	To first rock Depth in feet	No. of samples received	Name of well, drilling company, or driller
						Athabasca Well							
14......	1	97	XI	W. of 4th.	....	1925	785	135	....	....	....	13	Athabasca Bitumen Co.
						Fort Norman Well							
Bosworth creek, Mackenzie river, Fort Norman........						1924–25	....	970	Gas Oil	....	....	95	Imperial Oil well (Discovery No. 2)
						Mafeking Group							
5........	25	43	XXVI	W. of 1st..	Mafeking....	1925	....	235	....	....	....	22	E. Dougherty (W. E. Reid well)
4........	23	43	XXVI	" ..	" ..	1925	....	400	....	....	....	60	E. Dougherty (H. Johnson well)
						Other Districts							
	9	38	XVIII	W. of 3rd.	Landis.......	1925	....	90	....	....	....	9	Thos Moore, driller
SE.....	6	37	XVIII	" ..	"	1925	....	36	....	....	....	4	" "
NE.....	6	49	XIII	" ..	Glenbush....	1925	....	35	....	....	....	4	Thos. Duncan, driller
SW.....	34	48	XIII	" ..	....	1925	....	35	....	....	....	3	" "
SW.....	27	48	XII	" ..	Rabbit lake..	1925	....	45	....	....	....	4	" "
SE.....	27	35	XVIII	" ..	....	1925	....	105	....	....	....	11	Thos. Moore "

	21	11	XX	W. of 4th.	Iron Springs..	1925	....	480	....	....	....	39	A. N. Duff, driller
	26	27	V	W. of 3rd.	Strongfield...	1925	....	540	....	....	....	28	Dominion Drilling Co.
16.......	34	25	IV	W. of 4th.	Oyen........	....	2,800	2,120	....	....	....	39	Fuego Oil Co.
	26	27	V	W. of 3rd.	Strongfield...	....	....	604	....	....	....	....	Dominion Drilling Co.
14.......	34	48	XXI	W. of 5th.	Coalspur......	....	3,776	3,980	Gas.....	....	....	428	Northwest Co. No. 2, Coalspur
	2	47	XX	W. of 4th.	....	....	....	250	....	....	....	....	W. D. Martin
NW.....	36	12	VI	W. of 4th.	....	....	....	1,014	....	....	....	....	Canadian Pacific Railway Co.

Other Wells

	10	8	XXX	W. of 2nd.	Assiniboia....	....	....	54	....	Fresh...	....	....	A. N. Duff, Well No. 1
	10	8	XXX	"	"	....	....	54	....	"	....	....	" " No. 2
	10	8	XXX	"	"	....	....	50	....	"	....	....	" " No. 3
	10	8	XXX	"	"	....	....	59	....	....	....	....	" " No. 4
	10	8	XXX	"	"	....	....	60	....	....	....	....	" " No. 5
	10	8	XXX	"	"	....	....	25	....	....	....	....	" " No. 6
	10	8	XXX	"	"	....	....	25	....	....	....	....	" " No. 7
	10	8	XXX	"	"	....	....	46	....	....	....	....	" " No. 8
	29	22	VI	"	Melville.....	....	....	105	....	Fresh...	....	....	A. N. Duff, Town well No. 3
	29	22	VI	"	"	....	....	105	....	"	....	....	A. N. Duff, Creamery well
	36	29	III	W. of 5th.	....	....	....	96	....	....	....	....	H. Tarry, for Soldiers Settlement Board
	9	32	XI	W. of 4th.	....	....	....	220	....	....	....	....	Clem Brady, for Soldiers Settlement Board
SE.½.....	17	4	XX	"	....	....	....	112	....	....	....	....	Clem Brady, for Soldiers Settlement Board

Logs of a number of shallow wells put down in search of water at various points in the Prairie Provinces were received through the courtesy of the Soldiers Settlement Board, per Messrs. H. Tarry and Clem Brady, to whom thanks are due. The division is also indebted to Messrs. Thos. Moore, A. N. Duff, Thos. Duncan, W. D. Martin, The Dominion Drilling Company, and the Canadian Pacific Railway Company for logs of other shallow wells. Thanks are also due to Mr. E. Dougherty for sending samples and information relating to the W. E. Reid and the H. Johnson wells being put down by him, in seach for oil, on the Cretaceous escarpment near Mafeking in Manitoba.

Apart from the general work of the division in collecting data regarding borings, much work has been done to meet the needs of operators for information regarding the general geological conditions to be expected in various districts. Considerable research work was done on material resulting from borings in search for gas and oil, and important data relating to the formations passed through have been accumulated. The results as they have become available have been sent to the operators who furnished the samples. This work involves examinations with the microscope for fossil evidences and lithological detail, as well as chemical and physical tests for porosity, specific gravity, etc. D. C. Maddox, who has charge of this work, has prepared the following reports.

REPORTS ON SAMPLES FROM THE PRAIRIE PROVINCES AND NORTH WEST TERRITORIES

(Examined by D. C. Maddox)

(BRITISH PETROLEUMS WELL NO. 3)

(S.W. corner L.S. 4, sec. 29, tp. 45, range VI, W. 4th mer.)

A sample of rock from this well, suspected to be Devonian limestone, was examined. Effervescence tests with both hot and cold acids, tests for material insoluble in acid, and specific gravity tests were made on it. In addition to this, the ferrous iron content was roughly determined and found to indicate the presence of about 70 per cent of ferrous carbonate, with both calcium and magnesium very low. The tests appeared to prove conclusively that the rock was ironstone.

Thirty-four rotary core samples were received, covering depths of 2,086 to 2,224 feet. The samples were carefully examined and lithological and fossil contents were determined. Acid tests for the presence of carbonates were made every 6 inches throughout the length of the core. Sixteen disintegration tests on weighed charges were made and the mineral and fossil contents of the coarser material were determined with the binocular microscope. Several permanent slides of the foraminifera obtained in this process were made. Twenty-three tests for the presence of sulphates and chlorides were made on samples taken at certain horizons in the core.

BRITISH PETROLEUMS WELL NO. 3 B

(L.S. 4, sec. 29, tp. 45, range VI, W. 4th mer.)

Four rotary core samples from this well were examined. The methods used were generally similar to those used in the examination of similar material from British Petroleums well No. 3. Detailed work was done on six samples of the oil-sand horizon in this well, the depths ranging from 2,239 to 2,253 feet. The oil content of each sample was determined, and a complete mechanical analysis of the oil-free sand was made and plotted graphically. A porosity determination was also made of one fragment of the oil-sand from the 2,242-foot horizon.

BRITISH PETROLEUMS WELL NO. 4

(Sec. 30, tp. 45, range VI, W. 4th mer.)

A sample of the oil-sand horizon at a depth of 2,025 to 2,036 feet was examined. It was first freed from oil, after which a complete mechanical analysis of the oil-free sand was made.

ROGERS IMPERIAL WELL

(Sec. 29, tp. 1, range XI, W. 4th mer.)

Five samples covering depths of from 2,635 to 2,690 feet were subjected to a detailed examination. This involved the optical examination of the washed samples, the determination of the rapidity of effervescence with acid, the determination of the material insoluble in acid, an estimation of the oil content, and an optical examination of the residue insoluble in acid.

A sample of rock blown out by the gas was also examined in detail. In addition to the usual tests, a porosity test was run on a piece of sandstone contained in the sample and some exceptionally porous dolomite was also detected.

A disintegration test was run on a sample from 2,635 feet. In the course of this work a large number of small gasteropods, as well as a few foraminifera, were found.

WESTERN CONSOLIDATED NO. 1 WELL

(L.S. 8, sec. 20, tp. 45, range VI, W. 4th mer.)

Five samples covering depths from 295 to 755 feet were examined in detail, disintegration tests were run on all.

Five samples of sandstone from depths of 157 to 230·5 feet and 475 to 482 feet were examined in detail.

DRAZAN NO. 1 WELL

(L.S. 13, sec. 34, tp. 13, range II, W. 4th mer.)

Thirteen samples from the diamond-drill core of this well were examined in detail. A microscopic examination of the washed material was made. Effervescence tests with hot and cold acids and quantitative insolubility tests were run on all samples.

ROYALITE NO. 4 WELL

(L.S. 12, sec. 7, tp. 20, range II, W. 5th mer.)

Three hundred and twenty-eight samples from this well, in Turner valley, were examined. The samples represented range in depth from 290 to 3,720 feet. A microscopic examination of all samples, supplemented by the use of acid, was made. As the limestone horizon was one of special interest, more detailed work was done on the samples from it than on any others. The thirty-three samples from depths of 3,410 to 3,720 feet were subjected to the following tests: effervescence in hot and cold acid; insolubility tests in acid; optical examination of insoluble residues obtained in the above process; tests for sulphates; tests for phosphates; determinations of ferrous iron content; rough comparative estimation of ferric iron content.

The last five tests were employed in an attempt to determine if possibly two limestone horizons were separated by an erosional unconformity. It was considered possible that an erosional unconformity would be indicated by surface oxidation shown by the presence of sulphates, abnormally high proportion of iron in the ferric condition, and abnormally low proportion of iron in the ferrous condition; and by residual accumulations such as the presence of an abnormally high proportion of phosphates and of chert. The results of the examination were not conclusive.

The magnesium content of three samples taken from depths of 3,620, 3,670, and 3,720 feet, respectively, were determined. These tests indicate that the composition of samples from depths of 3,670 and 3,720 feet, respectively, corresponds quite closely to that of a true dolomite and the sample from 3,620 feet showed a magnesium content of only about two-thirds of that shown by the other two. The samples from 3,720 feet were found to have a specific gravity corresponding to that of dolomite.

Specific gravity tests by means of heavy solutions, in conjunction with the results of the effervescence tests in hot and cold acid, confirmed the fact that the limestone horizons above are underlain by magnesian limestones passing into dolomites towards the base of the well.

Four disintegration tests were run on samples taken from the upper 500 feet. The samples from depths below this were found to be too hard to disintegrate.

MCLEOD OIL COMPANY NO. 2 WELL

(L.S. 16, sec. 1, tp. 20, range III, W. 5th mer.)

One hundred and ninety-five samples from this well were examined.

VULCAN OIL COMPANY'S WELL

(L.S. 11, sec. 13, tp. 20, range III, W. 5th mer.)

Ninety-seven samples from this well were examined.

CANADA SOUTHERN OIL AND REFINING COMPANY

(L.S. 9, sec. 1, tp. 20, range III, W. 5th mer.)

Nine samples from this well were examined.

NORTHERN MANITOBA WELLS

Samples obtained from two wells in the district of Mafeking, Manitoba, were examined.

Well No. 1

(L.S. 5, sec. 25, tp. 43, range XXVI, W. prin. mer.)

Twenty-two samples were examined covering depths from 0 to 235 feet. Two tests for insolubility in acid were made in addition to the optical examination of the washed samples.

Well No. 2

(L.S. 4, sec. 23, tp. 43, range XXVI, W. prin. mer.)

Thirty-four samples were examined covering depths of 0 to 270 feet. Six disintegration tests were made. Twelve samples were tested with hot and cold acid, the amount of material insoluble in acid was determined, and this material was examined. Tests for sulphates and phosphates were also made.

REPORT ON MECHANICAL ANALYSES OF OIL-SANDS

From British Petroleums Wells Nos. 3 B and 4, Irma-Wainwright Field

Sample No.	Well No.	Depth	Oil content per cent by weight	Percentage of					
				Clay	Silt	Sand, grade 1	Sand, grade 2	Sand, grade 3	Sand, grade 4
		Feet							
1	3B	2,239	5·69	10·75	87·30	0·30	1·25	0·25	0·15
2	3B	2,240	3·82	12·85	49·20	5·40	26·50	5·90	0·15
3A	3B	2,242	8·10	10·32	41·40	7·98	40·22	0·80	
3B	3B	2,242	7·10	7·32	28·00	6·40	57·88	0·28	0·12
4	3B	2,248	8·30	8·08	68·80	20·00	3·00	0·12	
5	3B	2,253	6·85	6·74	88·70	4·13	0·23	0·10	0·10
6	4	....	2·12	5·00	23·90	5·01	32·10	24·01	9·98

NOTE. Sand grades are, according to screen sizes, as here stated: No. 1, 0·05 to –0·075; No. 2, 0·075 to –0·15; No. 3, 0·15 to –0·25; No. 4, 0·25 to –0·50. Silt and clay were separated by centrifugal methods; speed 800 R.P.M.; time 3 minutes. Clay was calculated by difference, any loss during analysis being credited to this material.

Of the samples submitted, Nos. 1 and 3A showed closely-spaced shale partings; No. 2 showed shale partings less closely spaced than the preceding. The remainder showed no shale partings, most of the material being too much broken down to show much original structure. In the 3A sample were rock fragments fairly large in their original condition. Sample 3B was disintegrated material showing no original structure.

Samples from well 3B, depth 2,242 feet, showed a difference in general type and also colour.

The samples were searched for fossils without success.

DETAILED REPORT ON THIRTY-FOUR ROTARY CORE SAMPLES FROM BRITISH PETROLEUMS WELL NO. 3

(SW. corner L.S. 4, sec. 29, tp. 45, range VI, W. 4th mer.)

The depth covered by the samples was from 2,086 feet to 2,224 feet, and they continue the section reported on in the Summary Report for 1924 (pages 114-116).

Disintegration tests, sixteen in all, on weighed charges, were made. The tests were largely confined to samples of the upper and the lower parts of the section, the middle part of the section being composed largely of fine-grained sands from which it was not probable that much information could have been obtained by this method. By the use of this method the lower limit of the marine shale was determined quite closely. Three disintegration tests run on core No. 1 (2,086 to 2,093 feet) showed foraminifera in all cases, but noticeably fewer at the bottom than at the middle or the top. A thin, shell bed was located at the base of this core also. Disintegration tests on the next core (2,093 to 2,096 feet) showed a considerable amount of coal fragments. All tests run on samples from depths below this core also showed the presence of coal.

Thirty-two tests for the presence of sulphates were made. These tests were made on the supernatant liquid obtained while the shales or sands were being disintegrated in the presence of water. Some value was attached to the possible presence of sulphates as regards the effect on the quality of the oil which they might have. A rough comparative estimate of the bulk of the disintegrating sample, clarity of the supernatent liquid, and the chlorid ion content of this latter were made.

Below are given the results of the preliminary examination:

Core sample No.	Depth represented		Actual length of core	Description of core
	From	To		
	Feet	Feet	Feet	
1	2,086	2,093	4·00	0·0 to 0·17 foot, shale, brownish grey, with very thin non-bituminous sand partings. Dark grey shale 0·17 foot to base. Sandy partings at 2·7, 3·4, and 3·7 feet, the last being bituminous. 2·7 feet to base, numerous broken shell fragments, mostly thin, but some showing hexagonal columns structure.
2	2,093	2,096	1·90	Sandy shale upper foot, remainder is grey shale. Coal fragments 0·55 foot to base, distributed through the shale.
3	2,096	2,098	1·32	Upper foot is light grey silt, remainder is interlaminated light grey silt and dark grey shale.
4	2,098	2,105	2·85	Light grey, finely banded silt with some black patches, probably organic upper 6 inches. 0·5 to 0·75 foot brownish grey, very fine-grained, non-bituminous sand. 0·75 to 1·25 feet, interbanded, light grey, very fine-grained sand and dark grey shale. A little black carbonaceous material at the top. 1·25 feet to base, very fine-grained sand with some thin shale partings. Colour light grey with a brownish tinge. Odour bituminous. One sample at the top gave a brown colour to carbon tetrachloride solution.

Core sample No.	Depth represented		Actual length of core	Description of core
	From	To		
	Feet	Feet	Feet	
5	2,105	2,108	1·63	Upper 6 inches light grey, very fine-grained sand with shale partings. Some patches of sand show oil. Lower part—light grey shale with a few carbonaceous fragments, becoming slightly sandy towards the base.
6	2,108	2,113	4·90	Upper 6 inches—light grey, sandy shale. 0·5 to 1·5 feet very fine-grained oil-sand, badly disturbed by the drill. 1·5 feet to base, grey laminated shale.
7	2,113	2,120	5·40	Upper 2·9 feet—light grey shale. 2·9 to 4·3 feet grey shale with a fine, light grey sand band. 4·3 feet to base, very fine-grained sand with a few shale partings.
8	2,120	2,122	1·63	Upper foot—grey and dark grey, shaly sandstone Lower part—grey, very fine-grained sandstone with a trace of oil.
9	2,122	2,126	1·85	0·0 to 1·2 feet, very fine-grained sandstone with a few shale bands, light grey and brown. 1·2 feet to base, very light grey, very fine-grained, loosely cemented sandstone. A trace of oil in a few bands in both the above.
10	2,126	2,128	1·20	0 to 1·2 feet, light grey sand with a trace of oil at certain horizons. 1·2 feet to base, grey shale with some sandy bands.
11	2,128	2,130	1·50	Very light brown, fine-grained sands with a trace of oil, a shale band 0·1 foot thick near top.
12	2,130	2,135	2·00	Brownish grey, fine-grained sand, a shale band at the top. Sand becomes very light in colour towards base. A thin ironstone band at base.
13	2,135	2,137	2·00	Ironstone band 0·1 foot thick at top. Fine-grained sand remainder of core, the part between 0·3 foot and 1·4 feet being shaly. Light brownish colour of lower part suggests possible presence of a trace of oil.
14	2,137	2,139	1·20	0·0 to 0·9 foot brownish grey sand with a band of sandy shale at centre. 0·9 foot to base, dark grey shale with sandy partings, some bituminous.
15	2,139	2,141	1·75	0·0 to 0·4 foot grey shale with sand partings. 0·4 to base, fine-grained sand, a little of it stained by oil.
16 and 17	2,141	2,143	2·00	Fine-grained sand, nearly white, except for some oil-stained areas, narrow shale partings generally present.
18	2,143	2,145	1·30	As above.
19	2,145	2,148	1·50	Generally as above, but rather more shaly.
20	2,148	2,151	1·00	Thin ironstone band at top. Remainder is light brownish grey sandstone, rather coaser grained than above and more coherent.
21	2,151	2,153	1·80	Upper 0·4 foot, brownish grey sandstone; 0·4 to 0·5 foot, ironstone band softer than normal; 0·5 to 1·2 feet, light grey, sandy shale; 1·2 feet to base, light grey sandstone with shale partings.
22	2,153	2,155	0·95	Light brownish grey sandstone very loosely cemented with numerous black films, apparently plant remains.
23	2,155	2,157	1·00	0·0 to 0·25 foot hard, mottled grey, calcareous stone. 0·25 foot to base, grey shale becoming more sandy to the base, some calcareous films.
24	2,157	2,160	1·70	0·0 to 1·3 feet, hard, grey mottled sandstone; 1·3 feet to base, greyish white sandstone.
25	2,160	2,166	3·50	0·0 to 0·6 foot, grey shale; 0·6 to 3·8 feet, hard, mottled grey sandstone with black carbonaceous film; 3·8 feet to base, sandstone, as above, but soft.
26	2,166	2,171	1·50	Light grey, soft, shaly sandstone.
27	2,171	2,177	1·50	As above, but shows lamination.

Core sample No.	Depth represented		Actual length of core	Description of core
	From	To		
	Feet	Feet	Feet	
28	2,177	2,188	4·50	0·0 to 1·5 feet, greyish black, very soft, very carbonaceous, shaly sandstone; 1·5 feet to base, light grey, shaly sandstone, carbonaceous.
29	2,188	2,194	1·20	Light grey, very soft, shaly sandstone.
	2,194	2,200	....	Missing.
30	2,200	2,205	1·50	0·0 to 0·5 foot, grey, sandy shale; 0·5 foot to base, grey, shaly sandstone.
31	2,205	2,211	3·00	Dark grey, very finely laminated, carbonaceous shale, grading at the base into black laminated coal.
32	2,211	2,217	1·50	Coal.
33	2,217	2,222	3·50	Brownish grey, very soft, laminated shale with many coal fragments, harder towards the base, with carbonaceous films.
34	2,222	2,224	2·00	0·0 to 0·8 foot, brownish grey shale; 0·08 foot to base, soft grey, laminated shale, with carbonaceous films, some fragments contain a little oil. An ironstone band near the base.

Acid tests indicated that calcareous horizons occur in core sample No. 4 (2,098 to 2,105 feet), and to a lesser extent in core sample No. 24 (2,157 to 2,160 feet). The latter core is slightly calcareous throughout, as is core sample No. 25 (2,160 to 2,166 feet). Sulphate tests on the supernatant liquid occurring in the disintegration tests, showed the absence of anything more than a trace in all cases except in core sample No. 33 (2,217 to 2,222 feet). Two tests on materials of this core sample taken, respectively, from depths of 0·5 foot and 3·3 feet both showed the presence of sulphates.

Tests for chlorides on the same materials tested for sulphates showed the presence of chlorides in nearly all core samples from No. 22 (2,153 to 2,155 feet), to the base.

OTHER FIELD WORK

Geological

B. R. MacKay continued a systematic geological survey of the coal measures and associated rock formations in the vicinity of Mountain Park, Cadomin, and Lovett collieries, Alberta. The area to be mapped is about 1,200 square miles and lies between latitudes 52° 45′ and 53° 15′ and longitudes 116° 30′ and 117° 30′. Four topographically contoured sheets and four geological sheets, each 15 minutes latitude by 30 minutes longitude, on a uniform scale of one inch to one mile, will be published when the field work is completed in 1926. A report will also be published. At present about 700 square miles have been surveyed. To meet the needs until report and maps can be issued, hand-coloured geological maps of the coal measures have been prepared for the use of coal mining companies within the area.

B. Rose resumed a geological mapping of the Flathead-Crowsnest map-area, lying between latitudes 49° and 50° and longitudes 114° and 115°, partly in Alberta and partly in British Columbia. This is in continuation of work which Mr. Rose had begun just prior to 1919, when he left the service of the Geological Survey. The area contains important coal deposits, as well as some other minerals. Further field work is required before a report and map can be prepared.

M. Y. Williams and W. S. Dyer continued a systematic geological resurvey of an area between latitudes 49° and 52° and longitudes 109° and 115° 30′, occupying southern Alberta and adjacent parts of Saskatchewan and British Columbia. This work will be concluded in 1926, after which it is proposed to prepare a report upon the geology and mineral resources of the area and a geological map to show the structure and distribution of the rock formations.

C. M. Sternberg collected fossil remains of dinosaurs and other extinct vertebrate animals from the badlands of Red Deer river, near Rumsey, Alberta. He secured a nearly complete skeleton of *Thescelosaurus*, footprints of a new genus of dinosaur, and a nearly complete skeleton of a horned dinosaur, the only good skeleton of this family thus far obtained from the Edmonton formation.

P. S. Warren resurveyed the geology of an area in Saskatchewan lying south of latitude 52° and west of longitude 109°, constituting the north-east corner of the large area in which M. Y. Williams and W. S. Dyer were engaged. His results will be included in the report and map of the larger area.

Topographical

J. W. Spence continued topographical mapping of the coal-bearing area around Mountain Park, Cadomin, and Lovett collieries in advance of the geological work being done by B. R. MacKay. About 900 square miles has been surveyed and it is expected that the work will be concluded next year. The maps will be published in 15 by 30 minute sheets, on a uniform scale of one inch to one mile.

R. C. McDonald continued the geographical control surveys for geographical and geological work. The route surveyed was from, and included, Gods lake, along Gods and Island Lake rivers, to and including Island lake. One hundred and twenty-nine permanent reference posts were established along the route at conspicuous places, such as entrance to deep bays and the mouths of tributary rivers. A permanent reference post was also established at the east end of Island lake. The positions of the Hudson Bay posts at Gods and Island lakes were established in latitude and longitude, using a radio receiving set for time signals. The total length of traverse run was 550 miles. Eleven hundred miles of shoreline was mapped.

Mr. McDonald also surveyed the new route from Hayes river to Gods lake. This route was located by Indians in the winter of 1922-23. This route shortens the canoe route from Norway House to Gods lake by about 50 miles.

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The annual Summary Report of the Geological Survey is issued in parts, referring to particular subjects or districts. This year there are three parts, A, B, and C. A review of the work of the Geological Survey for the year forms part of the Annual Report of the Department of Mines.