CANADA

DEPARTMENT OF MINES

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BUREAU OF ECONOMIC GEOLOGY

GEOLOGICAL SURVEY

PRELIMINARY REPORT

BATTLEVIEW ANTICLINE WAINWRIGHT AREA, ALBERTA

By

G. S. Hume

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INTRODUCTION

During the summer of 1935 the Geological Survey investigated the oil and gas prospects of a large area in the central part of eastern Alberta and western Saskatchewan. The work comprised: (1) a study of the stratigraphy of the various formations, using this as a basis for the determination of the structure with which oil and gas fields are related; (2) the collection of data on water wells, especially those that penetrate and receive their water from horizons within the different formations, in an attempt to trace the various horizons and thus obtain supporting evidence for the structural interpetations. The field work was carried out under the supervision of G.S. Hume and the sub-party working in the Wainwright area was under the direction of P.S. Warren of the Department of Geology, University of Alberta, assisted by L.H. Bergman, A.G.A. Piercey, J.S. Michener, J.B. Miller, and for a shorter period by L.A. Park.

A certain amount of geological work in the Wainwright area was done by the writer in 1924, and at that time evidence was found[1] for a broad warp on Battle river between Buffalo and Grizzly Bear coulées. The present report is based on a more detailed study of this

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1. Hume, G.S.: Geol. Surv., Canada, Sum. Rept., 1924, pt. B, p. 10.

fold which is now thought to be of much larger proportions and more important from the standpoint of oil and gas prospects than formerly was believed.

STRATIGRAPHY

The sequence of strata in this area is shown in the following table:

		Formation	Thickness in Feet	Description
UPPER CRETACEOUS	Montana Group	Belly River	Pale Beds	About 600	Pale, crossbedded, bentonitic sandstones, greenish grey and dark shales, in some cases quite carbonaceous and with thin coal seams. Rusty brown and purplish ironstone nodules. Selenite crystals. Silicified wood and freshwater fossils.
			Variegated Beds	About 200	Interbedded sandstones and shales of various tints of green, brown, and yellow. Not as much bentonitic sand as in Pale beds, but similar in character. Coal seams. Plant remains probably indicating freshwater deposition.
			Birch Lake	60 to 100	Upper and lower part of massive, crossbedded sand with nodules and sandstone beds. Central part mostly alternating shale with thin, sandy shales. A discontinuous oyster bed in some places 2 feet thick at or near the base. Marine fossils in lower part in some localities, but upper part probably non-marine.

		Formation	Thickness in Feet	Description
UPPER CRETACEOUS	Montana Group — Belly River	Grizzly Bear	40 to 100	Dark grey shales in part sandy, containing ironstone and sandstone nodules. Marine.
		Ribstone Creek	210 to 240	Greenish yellow to light grey sand and sandstone, especially in the upper and lower part. Blocky grey shale in the central part. Thin coal seams in the upper part. Non-marine in the Wainwright area.
		Lea Park	980 to 1,020	Grey shales and sandy shales with ironstone nodules. Marine
	Colorado Group	Alberta shale (Not exposed in the Wainwright area)	525	Dark shales and sandy shales with ironstone nodules and bands. Marine.
Lower Cretaceous formations (Not exposed in the Wainwright area)			250 to 300	Light grey sand alternating with dark shales. Coal seams. May be some marine beds alternating with non-marine beds.
MISSISSIPPIAN AND DEVONIAN (Not exposed in the Wainwright area)				Mostly grey limestones with some greenish and purplish shale near the top. Marine.

Palaeozoic

The nearest outcrops of Palaeozoic strata are several hundred miles distant from the Wainwright area. However, a few wells in the Viking[1], Fabyan, Wainwright,

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1. See Hume, G.S.: Ec. Geol. Ser., No. 5 (1933).

and Ribstone areas have penetrated the upper part of the Palaeozoic and shown it to be mostly composed of white to grey dolomite and limestone with some calcareous shale in the upper part. In Admiral No. 1, one of the few wells drilled into the Palaeozoic limestone at Wainwright, the upper 30 feet of Palaeozoic strata consist of light buff dolomite with green and red calcareous shale. At Fabyan, 8 miles northwest of Wainwright, Imperial Fabyan No. 1 well penetrated only about 10 feet of greenish shale at the top of the Palaeozoic and this was followed by about 600 feet of grey, bluish, or brownish limestone which was arenaceous in the lower part. In Ribstone Oils No. 2 well, north of Battle river near the Alberta-Saskatchewan boundary and 35 miles east of Wainwright, the Palaeozoic was penetrated for nearly 1,000 feet, mostly in light buff limestone.

There is a slight amount of evidence to support the belief that the upper part of the Palaeozoic may be Mississippian in age. In southern Alberta there is a 20-foot band of oil-shale at the top of the Devonian separating it from the Mississippian. This band of oil-shale is not known to be present in the area from Viking east to the Alberta boundary, but a zone of several bands of oil-shale occurs in the Duvernay well drilled close to North Saskatchewan river 75 miles northwest of Wainwright. The assumed presence of Mississippian strata in the Duvernay well, therefore, leads to the belief that beds of similar age are probably present at Wainwright, even though they are not readily divisible from the underlying Devonian.

Lower Cretaceous

Lower Cretaceous sands and shales rest on the eroded surface of the Palaeozoic. As would be expected, therefore, the thickness varies in different localities, the difference, in part, being marked by the amount of sand present, particularly in the lower part. In Hudson's Bay Marland No. 1 well at Viking the thickness of the sand is 280 feet; in Imperial Fabyan No. 1 well at Fabyan it is 250 feet; in Admiral No. 1 well at Wainwright it is slightly more than 300 feet; whereas in Ribstone Oils No. 2 well near the Alberta-Saskatchewan boundary it is 538 feet. In the Viking and Fabyan wells there is a very considerable amount of shale and carbonaceous shale in the lower 100 feet of beds and to a less extent in the Admiral well at Wainwright, whereas in Ribstone Oils No. 2 well the lower 130 feet consists almost entirely of sand with a small amount of sandstone. Thus the variations in thickness in the Viking, Fabyan, and Wainwright areas are relatively small in comparison with the thickness in the Ribstone area. It is well known that in the Athabaska area, 270 miles north of Wainwright, there is an alternation of marine and non-marine strata in the Lower Cretaceous. The seas in which the marine sediments were deposited evidently advanced and receded in Lower Cretaceous time over the northeast part of Alberta, with the shorelines to the south and west.[1] This gave a

[1] McLearn, F.H.: Trans. Roy. Soc, Canada, vol. XXVI, sec. IV, p. 173 (1932).

deposition of alternating marine and non-marine beds in the Wainwright-Ribstone area, a condition that, together

with the irregularity of the Palaeozoic floor, probably accounts for the variation in thickness in different localities.

Alberta Shale and Lea Park

The Lower Cretaceous is overlain by marine shales of Upper Cretaceous age. The Alberta shale is nowhere exposed in the Wainwright area and hence is known only from deep wells. The Lea Park outcrops on Battle river in the vicinity of the Alberta-Saskatchewan boundary and on North Saskatchewan river, particularly at Lea Park, 60 miles north and slightly east of Wainwright. In the wells the division between the Alberta shale and Lower Cretaceous strata is made at a pebble horizon at the base of the shales and in many cases this occurs with a sand or sandstone bed. The pebbles are usually black chert with smooth, shiny surfaces. Mostly they are very small, up to the size of peas, and ellipsoidal in shape. This chert pebble horizon makes a very satisfactory horizon marker where present. Its exact age, however, may be questioned as in the Athabaska area conglomerate occurs near the top of the Pelican sandstone, a formation of Upper Cretaceous age. If the pebble bed in the Wainwright wells corresponds in age to the conglomerate of the Pelican formation, some Upper Cretaceous strata may lie below the pebble zone, although the lithology as far as can be deduced from well samples is very like that of Lower Cretaceous strata. These pebbles have been noted in wells from Viking, Wainwright, Ribstone, Lloydminster, and other places.

In the Viking area the Viking gas sand 20 to 25 feet thick occurs 140 to 150 feet above the pebble horizon. This sand apparently thins and disappears eastward, as no wells drilled in the Wainwright area obtained commercial supplies of gas at this horizon. Near the top of the Alberta shales in the Ribstone area and to a less extent in the Wainwright area are highly bituminous dark shales which when heated yield a copious supply of natural gas. Unfortunately there is no porous reservoir sand in close contact with this shale zone, but in wells in the Ribstone area the shales themselves have yielded gas flows of as much as 500,000 cubic feet a day. At the top of the Alberta shale is a zone containing small particles of white calcium carbonate and the upper limit of this zone is considered to be the contact between the Alberta shale and Lea Park.

The Lea Park is composed of dark shales and sandy shales not unlike the Alberta shales. Ironstone bands and nodules are present. From a study of well logs from west to east it is believed the Lea Park thickens eastward in Alberta and near the Saskatchewan boundary there is a 60- to 70-foot sand about 110 feet below the top of the formation. This sand, however, as far as known is of local occurrence. It is found in the Oxville well in township 46, range 2, but its western limit has not been determined. It is not recognizable in the Wainwright wells in range 6.

Ribstone Creek

Ribstone Creek sands with sandstone beds and nodular bands, in all about 25 feet thick, rest on Lea Park shales. The central part of the formation is very

poorly exposed and is believed to be composed of grey, blocky shale alternating with sandy shales and sand beds. On the east side of Battle river, in sec. 13, tp. 46, range 7, close to the top of the formation, coal has been mined from a poor seam. The mine is now abandoned and caved so that the seam is not exposed. The coal dump indicates, however, that the coal occurs in dark, carbonaceous shales. In many localities wells indicate that the upper part of the Ribstone Creek formation is composed of sand at least 20 feet thick. In this are some hard sandstone layers and below it sandy shales alternating with thin sand beds.

Grizzly Bear

The Grizzly Bear formation is composed of dark grey shales with some sandy shales and sand resting on the sands of the Ribstone Creek formation. Within the shale beds and apparently quite diagnostic of this formation are sandstone nodules 6 inches or less in diameter. These nodules, however, are not abundant. They may or may not contain fossils, although the formation is marine. In the Wainwright area the formation is thought to be about 100 feet thick.

Birch Lake

The Birch Lake formation rests on the Grizzly Bear shales. At or near the base of the formation is an oyster horizon composed wholly of oyster shells mixed with a small amount of sand. In a few localities this oyster zone is several feet thick. This zone makes a good horizon marker, but oyster beds are found in some of the other formations as well although their stratigraphic

position is not as definitely known. A section of the Birch Lake formation exposed on Buffalo coulée in sec. 3, tp. 47, range 7, is as follows:

Description	Thickness In Feet
Yellow weathering sand and nodular sandstone	15
Thinly bedded shale and sandy shale	26
Unexposed interval, probably shale	14
Grey, fine sand	10
Yellow weathering sand with oyster bed at base	8
Total...	73

From other sections it is believed the upper sand is at least 28 feet thicker than in the Buffalo coulée section, making the total thickness about 100 feet for this area.

Variegated Beds

Resting on Birch Lake sand are shales and sands with thin coal seams. There is little doubt but that the Variegated and the overlying Pale beds form a continuous series of deposition, but there is a darker colour to the Variegated than the Pale beds due to the greater abundance of bentonic materials in the latter. The Variegated beds contain considerably more shales than sands which are mostly light grey or greenish in colour. The shales are various shades of colour, as for example greenish yellow, grey, purple, and brown. The brown colour is associated with abundant carbonaceous material and thin coal seams.

Pale Beds

The Pale beds are so named from their characteristic, pale appearance due to their content of bentonite. The bentonite is easily washed by rain over the surface of the outcrop and in it small fragments of ironstone

become embedded. In some sections sands and shales are present in about equal amounts, whereas in others the shales predominate. It is thought that only Variegated beds occur in the Wainwright area with Pale beds to the west of it.

STRUCTURE

In general there is a regional southwest dip from the Alberta-Saskatchewan boundary through the Wainwright area. The regional dip, however, is broken by small folds. The relationships of such folds as Hawkins, Fabyan, Battle River-Wainwright, and Ribstone have already been discussed.[1] It has been pointed out[2], also, that a fold was known to occur on Battle river between Buffalo and Grizzly Bear coulées. The importance of this fold, however, was not fully realized until work was done in 1935 and for convenience it is proposed to call it the Battleview anticline.

1. Hume, G.S.: Geol. Surv., Canada, Ec. Geol. Ser., No. 5, 1933, pp. 199-215.

2. Hume, G.S.: Geol. Surv., Canada, Sum. Rept. 1924, pt.B, p. 10.

The main basis for the structural interpretation of the Battleview fold is shown by the geological map, Figure 1, and the cross-sections, Figures 2 and 3. On the north side of Battle river just above the water-level on the west side of the Wainwright-Vermilion road close to the centre of sec. 33, tp. 46, range 6, Ribstone Creek sandstone beds have an elevation of 1,905 feet, and near the crest of the hill on the edge of a narrow terrace Birch Lake sand and sandstone beds occur at an elevation of 2,117 feet. The Ribstone Creek outcrop is close to the top of the formation and the Birch Lake outcrop

belongs to the upper sand horizon of that formation. For the most part the intervening strata are concealed, but it is inferred that the lower part is occupied by Grizzly Bear shales. About 3½ miles in a northeast direction in SW.¼ sec. 13, tp. 47, range 6, presumably the top of the Ribstone Creek formation occurs at an elevation of 2,086 feet, with the base of the exposure at an elevation of 2,070 feet. Below this sandstone outcrop and coming from the Ribstone Creek sand are strong springs that form a small pond of water. As shown on Figure 3 a well 202 feet deep, on SW. ¼ sec. 14, tp. 47, range 6, reaches this same water horizon. A number of other outcrops of Birch Lake sandstone exposed along the north bank of Battle river also support the evidence of this west dip which in 3½ miles amounts to 180 feet or about 50 feet to the mile. About one mile east of the outcrop on section 13 there is another exposure of Ribstone Creek sandstone on NW. ¼ sec. 18, tp. 47, range 5, at an elevation of 2,081 feet. It is not by any means certain that this means a slight east dip between sec. 13, range 6, and sec. 18, range 5, of township 47, because it is not known which part of the upper sandstone of the Ribstone Creek formation is represented by the outcrop on section 18. It seems safe to infer, however, that the crest of the Battleview anticline is either on section 13 or section 18, because east of section 18 the strata apparently dip eastward, as near the mouth of Grizzly Bear coulée in sec. 26, tp. 47, range 5, the upper sandstone of the Ribstone Creek formation has an elevation of 1,887 feet. This represents an east dip of almost 40 feet to the mile from sec. 18 to sec. 26, tp. 47, range 5. Apparently the strata

continue to dip eastward from the mouth of Grizzly Bear coulée, but information in this regard is not very definite due to lack of outcrops. It is known, however, that the centre of a syncline occurs on Battle river in sec. 7, tp. 46, range 3, east of which the strata again rise into the Ribstone-Blackfoot fold.

Further evidence of the magnitude of the Battleview anticline was found in outcrops exposed by road construction on the north boundary of township 47. On the road on the north side of section 31, township 47, on the line between ranges 5 and 6, Birch Lake sandstone outcrops at an elevation of 2,263 feet. East of this, other outcrops occur at lower elevations until 3¼ miles east an outcrop immediately west of Grizzly Bear coulée on the north side of section 34 has an elevation of 2,132 feet. This is an east dip of just slightly more than 40 feet to the mile, confirming the evidence of dip found along Battle river east from sec. 18, tp. 47, range 5, to the mouth of Grizzly Bear coulée. Three miles west of the Birch Lake outcrop on the line between ranges 5 and 6 on the north side of township 47 there are outcrops of Birch Lake formation showing on the surface of the ground as flat slabs of sandstone up to an elevation of 2,175 feet. It is presumed that these sandstones are somewhat higher than the outcrop on the line between ranges 5 and 6, so that in the 3 miles between the two points there is a drop in elevation of the same horizon of more than 88 feet. This probably does not represent the total amount of west dip, because it is inferred from regional evidence that the crest of the Battleview fold should lie within range 6. The crest

must represent a higher elevation on the same horizon than does the Birch Lake outcrop on the line between ranges 5 and 6 and in addition is less than 3 miles from the outcrop to the west. These deductions are illustrated on figure 2 and the west dip on the base of the Birch Lake is shown as probably greater than 40 feet to the mile. Beyond the north boundary of township 47 no information is available on the Battleview anticline as no outcrops were found in township 48 on its possible extension. Similarly no evidence has been obtained south of Battle river in regard to the south or southeastward extension and it is believed that structural test drilling or some method of geophysical investigation will have to be used to find the limits of this fold outside of township 47.

OIL AND GAS PROSPECTS

In the amount of known closure, that is the difference in elevation between the crest of the anticline and the trough of the syncline, the Battleview anticline exceeds each of the Hawkins, Fabyan, and Wainwright-Battle River folds[1] to the west of it and is apparently sharper than the Ribstone-Blackfoot anticline to the east of it. As the Battleview fold is intermediate in position between the Wainwright-Battle River fold on the west and the Ribstone-Blackfoot fold on the east, the same productive horizons for oil and gas should occur in it as are present in both the others. Some of the wells in the area 4 miles north of Wainwright have been productive for about 10 years, although the daily yield of oil in any one well was

1. See Hume, G.S.: Geol. Surv., Canada, Ec. Geol. Ser., No. 5, (1933).

never large. The productive horizon in these wells, as also at Ribstone, is in Lower Cretaceous strata in a sand about 20 feet below a coal seam and about 140 feet below the chert pebble zone that supposedly represents the division between the Upper and Lower Cretaceous strata. Also, at Wainwright, British Petroleums' Nos. 2 and 4 wells found oil at the contact between the Upper and Lower Cretaceous beds. As far as known to the writer neither of these wells produced for any great length of time from this horizon, although the oil in British Petroleums No.4 well overflowed at the top of the casing when the well was brought in. In the Ribstone field several wells started production with a capacity said to be 75 barrels a day. The productive sand, however, was presumably very thin and may not have exceeded 2 feet. It was also quite fine grained. The result was a rapid decline to a rather small production which was considered too low to be commercial in the circumstances then existing in that field. Several thousand barrels of oil were reported to have been produced at Ribstone and the field may yet have prospects worth developing. It is considered, therefore, in the light of this information, that the productive oil horizons should occur in the Battleview anticline.

So far as value of structure in causing accumulations of oil and gas is concerned no fair comparison can be made between the oil-productive Wainwright-Battle River fold and the Battleview anticline, as the Wainwright-Battle River fold is so poorly outlined even after considerable drilling. The wells drilled on it by rotary methods did not provide sufficiently accurate samples of the upper formations for correlation purposes and hence, as these are

the only horizons known on the Battleview fold, no detailed comparison is possible. It is believed, however, that the lower horizons in the Wainwright-Battle River fold show a less dip than do the upper stratigraphic horizons in the Battleview anticline. If the same amount of dip present on the surface is continued to depth in the Battleview anticline then it may be anticipated that a better concentration of oil than is present in the Wainwright-Battle River fold should occur.

Very little can be said in regard to the gas prospects of the Battleview fold. At Ribstone a small production of gas up to 500,000 cubic feet a day has been found about 310 feet above the base of the Alberta shales. This gas was sufficient to run a gas engine for pumping purposes and supply other camp requirements. In Meridian No. 1 well at Ribstone an estimated flow of 30,000,000 cubic feet of gas was struck above the oil-productive sand in Lower Cretaceous strata. This gas, however, soon diminished in quantity and with deeper drilling and the in-flow of oil the gas flow was not maintained. On the Wainwright-Battle River fold National Exploration No. 1 well drilled in proximity to some productive oil wells struck a flow of gas of 15,000,000 cubic feet a day at or close to the oil-producing horizon of the other wells. At that time no use could be made of this gas and the well was closed. On the south end of what has been presumed to be the Fabyan fold, about half a mile west of Wainwright, Wainwell No. 2A well encountered gas with an initial flow of 33,000,000 cubic feet a day. This flow apparently comes from above the oil sand of the nearby Wainwell No. 1 well, although no large gas flow

occurred in that well from the same stratigraphic horizon. It is probable, therefore, that in both the Ribstone and Wainwright areas the oil and gas occur in a sand zone in which the individual sand beds may be lenticular and this condition may also be expected to occur in the Battleview anticline. In conclusion, therefore, it would seem reasonable to infer from regional conditions that oil and gas may be expected to occur in the Battleview anticline, but the amount of production cannot be predicted and will be dependent on the amount of porosity, thickness, and continuity of the prospective oil and gas sands.

Depth to Prospective Oil and Gas Sands

The depth from the base of the Birch Lake formation to the top of the Lower Cretaceous sands where the first oil zone occurs in the Wainwright area is approximately 1,900 feet. The lower productive horizon of the Wainwright area is 140 feet deeper. A well started in the valley of Battle river on either the east side of sec. 13, tp. 47, range 6, or the west side of sec. 18, tp. 47, range 5, would probably reach the deeper Lower Cretaceous horizon at somewhat less than 2,000 feet as such a well would start within the Ribstone Creek formation.

RECOMMENDATIONS

The extension of the Battleview anticline north or south of township 47 cannot be made on present data. Owing to the fact that the position of the crest of the fold has not been accurately determined due to lack of surface information the trend of the structure is not precisely known. In projecting outcrops onto the line of

section for Figures 2 and 3 a strike of 15 degrees west of north has been used. It may be, however, that the trend is more northwest and southeast than this, although such information as is available points to the more nearly north-south strike. The position of the crest and the trend can very easily be determined, however, by drilling shallow test wells to one of the known sand-shale contacts such as the base of the Birch Lake formation or the top of the Ribstone Creek formation and it would seem advisable that this be done before any extensive deep drilling program be undertaken. It is recommended, also, that the first deep wells drilled in this area use standard drilling equipment.

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