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FOREMOST-SKIFF AREA, SOUTHERN ALBERTA

BY

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INTRODUCTION

The area discussed in this report includes townships 5, 6, and part of 7, ranges 10, 11, 12, 13, and 14, west of the 4th meridian. It is traversed by the Lethbridge-Assiniboia branch of the Canadian Pacific railway, and by a dirt highway which follows the railway east from Stirling. Side roads or trails are present in most of the road allowances. The principal town is Foremost, and there are villages at Nemiscam and Skiff. Wheat farming is the main industry, with some sheep and cattle ranching.

During the field season of 1935 the writer carried on a geological investigation in this area and parts of adjacent districts. This was primarily a structural study. The Foremost formation, which underlies the area, is lenticular, and not satisfactory for the determination of detailed structure. Stadia traverses, however, were run on all beds that showed any continuity in outcrops. Structural information obtained in this manner was supplemented by data from the many artesian and gas wells, and some oil wells, drilled in the area. The work was under the general supervision of L.S. Russell.

Able assistance was given by J.H. Jacobs, who carried out the instrumental surveys. For the latter part of the season W.J. Ibey acted as assistant. The writer is greatly indebted to Mr. S.E. Slipper of the Canadian Western Natural Gas, Light, Heat, and Power Company, Limited, for allowing access to the logs of the company wells, and for other information.

PHYSICAL FEATURES

The Foremost-Skiff area of the present report is part of the southern plains of Alberta, described by a number of previous workers. The land surface is a gently rolling plain, with some barely noticeable features, probably formed by small morainal dumps. The whole surface is covered by a mantle of glacial deposits of variable thickness. The area is dissected by two large coulées, averaging some 200 feet in depth and trending from west to east. The more northerly is Chin coulée, the southern one, Etzikom coulée. These form part of an extensive system of glacial drainage, as described by D.B. Dowling.[1] The coulées are normally dry, except for a few

[1] Dowling, D.B.: Geol. Surv., Mem. 93, pp. 3,4 (1917)

scattered lakes. Of these the only one within the present area is Crow Indian ("Kings") lake, located in Etzikom coulée due south of Skiff. This lake retains a fair body of water, due to the presence of an excellent dam at the east end. In the spring sufficient moisture collects in the many small depressions within the coulées to supply water for stock during the early summer. Ranchers have augmented this supply by drilling artesian wells.

All geological traverses were conducted along these coulées, as no outcrops of bedrock occur at other points.

Table of Formations

			Formation	Thickness in Feet	Description
Upper Cretaceous	Montana group	Belly River series	Pale beds		Light grey and greenish grey, clayey sandstone, with indurated beds; not exposed and probably not present in this area.
Upper Cretaceous	Montana group	Belly River series	Foremost	At least 490	Alternating grey and brown sandstone and dark shales; carbonaceous bands and coal seams; numerous oyster beds. For detailed description See below
Upper Cretaceous	Montana group		Pakowki	190-220	Dark grey shale, becoming sandy toward base; chert pebbles often present at base.
Upper Cretaceous	Montana group		Upper Milk River	160-40	Grey shale and sandy shale, with carbonaceous matter.
Upper Cretaceous	Montana group		Lower Milk River	150-100	Grey sandstone, medium grained, with some carbonaceous matter; becoming shaly below; artesian water at top.
Upper Cretaceous	Colorado group		Alberta	1,700-1,800	Dark grey shale, with sandstone beds in lower part, carrying gas and water.
Lower Cretaceous			Blairmore-Kootenay	±400	Grey, green, and red shale, and grey sandstone, the shale predominating above, the sandstone below. Gas, oil, or water may occur in lower sandstone beds.
Jurassic			Ellis	180	Dark grey, calcareous shale, with grey sandstone in lower part. Sandstone beds may contain oil, gas, or water.
Mississippian			Madison	±1,000	Grey limestone, with occasional shale or chert.

STRATIGRAPHY

Some portions of Foremost-Skiff area have been mapped as underlain by Pale beds, but, according to the writer's observations, the only strata exposed are the Foremost beds, which make up the lower member of the Belly River series.

The Foremost beds consist chiefly of brackish water, lagoonal types of deposits, with subordinate freshwater beds occurring mostly in the upper part. Extreme lateral variation is the rule, and a description of one stratigraphical section will not apply to another in an adjacent locality. The thickest section measured is in Chin coulée, north and east of Foremost. A water well drilled in Chin coulée north of Foremost during the summer of 1935 encountered an oyster bed at 104 to 104.7 feet. This is good evidence that the Foremost beds extend to that depth. The well head is 29.5 feet below the base of the section exposed in the coulée, which has a thickness of 125 feet. There are thus at least 259 feet of Foremost beds present here. Dowling[1] assigned 359 feet of beds in this locality to the Foremost on the basis of well core information. This is in general agreement with the figure used by Slipper.[2] By traversing eastward into Sevenpersons coulée, an additional 131 feet of higher Foremost beds were measured. Adding this figure to the thickness at Foremost as given by Dowling, a thickness of 490 feet is obtained for the Foremost beds in this area.

The Foremost beds consist of an alternating series of fine-grained, indurated or soft, grey to pale brown sandstone,

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[1] Dowling, D.B.: Geol. Surv., Summ. Rept. 1922, pt.B, p. 119

[2] Slipper, S.E.:"Geology of Natural Gas", Am. Ass. Pet. Geol., p. 31 (1935)

and dark grey to greenish grey shale, silty shale, and sandy shale. Carbonaceous zones form prominent features, although individual beds as a rule show little continuity. Shell beds of Ostrea and Corbula are quite common in the upper middle zone of the Foremost. Ostrea beds are the most persistent and easily recognizable beds and were used as key horizons for structural work. Coal seams were also used.

The grey, indurated, sandstone phases, which owe their hardness to a calcite cement, weather to a brown colour, and are usually associated with ironstone and brown, limy, argillaceous material. It has been suggested that the very fine-grained, highly calcareous material was chemically precipitated from lakes.[1] Ironstone and sandstone beds and concretions occur

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[1] Williams, M.Y., and Dyer, W.S.: Geol. Surv., Mem. 163, p.20 (1930).

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in many places, and when fractured reveal an abundance of calcite crystals. Cone-in-cone structure is often developed around these concretionary beds. This type of structure is in some cases well developed in relatively pure calcite. The indurated phases form prominent bands from 1 to 2 feet thick in many localities. They act as protective caps for underlying beds, and often grade down through well-laminated, light grey sandstone to slightly indurated, fine-grained sandstone. This light grey, soft sandstone is prominent among the Foremost beds, and due to its usual occurrence below the indurated protective phases, forms most of the outcrops. Where exposed, this type of sandstone develops a badland appearance on weathering, and, but for the overlying harder rocks, would soon be eroded. The thickness of individual, soft sandstone beds rarely exceeds 20 feet. Thin, carbonaceous, and ferruginous bands, and intermittent ironstone layers, up to 6 inches in thickness, give the light grey sandstone its sombre colour. Large, ovoid, concretionary masses of indurated sandstone sometimes occur in this phase. The soft sandstone is most common in the lower part of the Foremost section exposed in the area.

The shale and sandy shale show great variation in colour and hardness. The colour ranges from black (due to carbonaceous matter) to greenish grey, and the hardness from a very soft, shaly silt or sandy shale, to a fissile, friable, and in some cases very hard shale. True silts are not very common, but when present are usually associated with highly carbonaceous shale and coal beds. Carbonaceous zones are composed chiefly of dark grey to black or brown, fissile, carbonaceous shale, which in some places grades into good coal seams, particularly near the top of the section. These zones form prominent, continuous horizons at least locally, but individual seams are mostly discontinuous. The upper carbonaceous zone is the most productive of commercial seams in Foremost-Skiff area, and is considered by some to be the equivalent of the Taber coal measures, although the writer obtained no field evidence to substantiate this correlation.

Other beds showing some prominence are the Ostrea and Corbula beds. These beds have indurated phases locally. The Ostrea beds are the thicker and one of them attains a thickness of 5 feet 8 inches. These beds are usually silicified, and when struck sharply give off a fetid odour due to the abundance of organic matter in the rock. As many as four Ostrea beds were noted in one section in Chin coulée. Corbula beds are usually less than 1 foot in thickness and are neither as continuous nor as useful for key horizons as the Ostrea beds. Besides the abundant fossil shells, of which Ostrea and Corbula are most common, bones and teeth of vertebrates occur, as well as much poorly preserved plant remains. Some selenite occurs in the bedding planes of the coal and carbonaceous seams. Bentonite beds were found at two localities.

STRUCTURE

<u>General Structure</u>. Owing to the scattered nature of the outcrops in the area and the great lateral variability of the beds, little in the way of general structure could be determined from the surface geology alone. In conjunction, however, with information from well drillings, the structural traverses proved very valuable. It was necessary, in most instances, to rise or drop from one key horizon to another, due to the discontinuity or the unsuitable nature of the bed being used. All elevations were later reduced to a common datum, and finally to the general datum, the artesian water horizon, by tying in the traverses to nearby wells, from which the elevation of the top of the Lower Milk River sandstone could be obtained. The elevations of all oil and gas wells, and many water wells, were determined. Information as to the depth of the water sand in many wells has been lost or is not authentically recorded, but wells are sufficiently plentiful and generally distributed to permit of a judicious choice.

The top of the Lower Milk River sandstone was chosen as the general datum plane, chiefly because it is the artesian water horizon, and its elevation can thus be readily obtained from most of the wells. Objections to the choice of this horizon as the plane of reference are: (1) that it has been suggested that the artesian water does not necessarily occur at the top of the sandstone; and (2) that the sandstone becomes thinner in a northeasterly direction. Slipper and Hunter[1] have

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[1] Slipper, S.E., and Hunter, H.M.: Bull. Am. Ass. Pet. Geol., vol. 15, p. 1193, Fig. 4, (1931).

mapped the limits of the Upper Milk River beds as running approximately northwest-southeast just east of Foremost-Skiff area. The Lower Milk River sandstone becomes thinner northeast of this line, and at Medicine Hat has a thickness of approximately 10 to 20 feet. In spite of this thinning the top of the Lower Milk River sandstone was chosen as the datum, as the variation is not sufficiently marked within the present area to affect the structural interpretation seriously. Also, from information supplied by water well drillers, it appears that the main artesian flow does occur, at least in Foremost-Skiff area, just below an ironstone band 3 feet or less in thickness, which is considered to be the top of the Lower Milk River sandstone.

The top of the Alberta shale would appear to be a more logical choice as a datum, for this formation continues with little change from Montana to Bow Island,[1] but unfortunately

[1] Spratt, J.G.: Bull. Am. Ass. Pet. Geol., vol. 15, p. 1175, Fig. 3 (1931).

few wells have been drilled to this depth. Also, the presence of a transition zone from Milk River sandstone to Alberta shale gives rise to conflicting opinions as to the actual position of the contact.

Foremost-Skiff area is situated within the northern extension of the Sweetgrass arch, the axis of which runs north in the vicinity of Skiff. The pitch of the axis is north and approximately 20 feet to the mile. Evidence of the general trend of the anticline is indicated on the accompanying map. In the vicinity of Skiff the strike is about east. To the west it gradually changes to a northeast direction, and to the east, to a northwest direction. The dip is variable, reaching as high as 50 feet to the mile in some localities and becoming as low as 10 feet to the mile in others.

Two subsidiary folds occur in the area. One of these, the Foremost anticline, has been known in part for some time, as it has been extensively drilled for gas. The other is a small anticline or irregular nose occurring just east of the Skiff oil field. G.S. Hume[1] has suggested that anticlinal conditions exist

[1] Hume, G.S.: Geol. Surv., Econ. Geol. Ser. No. 5, 2nd ed., p. 141 (1933).

between Foremost and Skiff, from the study of the well records from the two fields. The writer's conclusions, based upon the results of more recently drilled wells, and also upon surface studies, indicate that Hume's suggestion was essentially correct, although there are actually two anticlinal zones, with a synclinal tract between.

Foremost Anticline. Two interpretations of the structure in the Foremost gas field have been offered by previous workers. S.E. Slipper[2] considers the structure to be monoclinal, with an

[2] Slipper, S.E.: "Geology of Natural Gas", Am. Ass. Pet. Geol., pp. 32, 33, Figs. 12, 13 (1935).

easterly dip, the gas occurring along the tilted edge of a sand lens in the lower Alberta shales. M.Y. Williams[3] interpreted the

[3] Williams, M.Y., and Dyer, W.S.: Geol. Surv., Mem. 163, p. 121 (1930).

structure as a northwest-pitching anticline, having a width of 12 miles south of this area.

Both well log information and surface evidence show that the strata in the vicinity of the present gas field dip east. However, continuing westward from the most westerly gas well in Etzikom coulée, the beds are seen to take on a westerly dip. The harmony between surface and subsurface structure on the east suggests that a similar agreement occurs on this western side. Projecting the structure based upon the surface studies to join with that obtained from the well logs, the interpretation of the accompanying map is obtained. The structure appears to be a sharp anticline, which is without closure on the south, and which loses its identity to the west, north, and east. The axis of the fold strikes north-northwest. The major dips, of approximately 40 feet to the mile, occur on the east and west flanks of the fold near the southern part of the present gas field. No wells have been drilled on the west flank of the structure, west of the gas field, to give conclusive proof of the above interpretation.

Skiff Anticline. Structural features in the vicinity of Skiff cannot be determined from the surface. One small series of outcrops in Etzikom coulée to the south, and scattered outcrops in Chin coulée to the north, were found to be inadequate for structural determinations.

Most of the information in this district was obtained from water wells. Data on some of the older wells are open to question, but those obtained from recently drilled wells are considered trustworthy. In addition, there are the deep wells of the Skiff oil field. The log of Devenish Petroleums Well No. 1 has been published by Hume.[1] Compilation of the data from

[1] Hume, G.S.: Geol. Surv., Econ. Geol. ser. No. 5, 2nd ed., pp. 142, 143 (1933)

these sources indicates that there is some arching of the strata just northeast of the present Skiff oil field. The structure is a small anticlinal nose, which is open to the southeast, and which rapidly loses its identity to the north. The axis strikes west-northwest. The dip is abrupt on the southeast, approximately 50 feet to the mile, and gentle on the opposite flank.

OIL AND GAS POSSIBILITIES

A number of gas and oil horizons have been found in the many scattered wells in the southern plains of Alberta. Most of these horizons can be roughly correlated from area to area, but some appear peculiar to certain localities. Apart from the wells now producing in the various fields, there are a number that have been equally productive, but which have been abandoned due to flooding.

In the Foremost field the gas sands occur near the base of the Alberta shale, approximately 350 to 500 feet above the top of the Lower Cretaceous. A salt water sand, which seems to be fairly persistent, is present about 50 feet below the lower gas horizon. United Oils of Alberta Well No. 3, the discovery well, was drilled in 1916 in the SW. $\frac{1}{4}$, sec. 31, tp. 5, range 10. Apart from large flows of gas encountered in the lower Alberta shale, this well penetrated a sand, 65 feet thick, near the Lower Cretaceous-Jurassic contact, which was saturated with heavy oil. This potential oil-producing sand has not been investigated further. Salt water, which could easily be controlled, occurs about 60 feet above the oil sand, but none occurs within it or below. This discovery well became flooded and was finally abandoned. Later, in 1923-27, an extensive drilling campaign was carried out by the Canadian Western Natural Gas, Light, Heat, and Power Company, Limited, and some excellent producing gas wells were brought in. The log of Foremost Well No. 7, SW. $\frac{1}{4}$, sec. 24, tp. 5, range 11, has been published by Hume.[1] Further exploration was carried

[1] Hume, G.S.: Geol. Surv., Econ. Geol. Ser. No. 5, 2nd ed., p. 144 (1933).

on by the company, and a number of test wells were drilled to the north and northwest of the field. A deep well was finally drilled in the SE. $\frac{1}{4}$, sec. 6, tp. 7, range 11, but was subsequently abandoned.

The Foremost gas sand, although described by Slipper[1]

[1] Slipper, S.E.: "Geology of Natural Gas", Am. Ass. Pet. Geol., p. 32 (1935).

as lenticular, could reasonably be expected to occur on the western side of the Foremost anticline, as gas is widespread at or near this horizon within the area. Evidence from Foremost Well No. 3 indicates that the sand is thinning toward the top of the fold, but this does not exclude the possibility of gradual thickening down the western flank. One carefully conducted prospect on the west side of the Foremost anticline would conclusively prove the oil and gas potentialities of this western flank.

A number of wells have been drilled for oil in the district south of Skiff. At present, Devenish Petroleums Well No. 3, SW.$\frac{1}{4}$, sec. 27, tp. 5, range 14, is the only oil producer in the field. The oil is obtained from a sand near the base of the Jurassic; it is fairly heavy, ±22° Beaumé, and, as a result, the rate of production is slow, about 25 barrels a day.

If the interpretation given above for the Skiff structure is correct the Devenish wells are somewhat off the anticlinal zone. It seems very probable that oil in commercial quantities occurs on the southwest flank, or at the top of the structure, a short distance to the northeast of the present producing well. The positions of the various water horizons are now fairly well known, and flow from these could be readily controlled. The structure is small and production per well would probably be low, but, if proved to be commercially profitable, the development would be comparatively inexpensive. Wells could be closely spaced, due to the low Beaumé gravity of the oil, and production could be controlled from a central pumping station. Another factor that makes the structure appear favourable is its location on the axis of the Sweetgrass arch. Gas probably would occur with the oil, and this would increase the production, due to lessened viscosity and added "lifting power".

In prospecting either of the above recommended structures it would be advisable to drill the first well with standard tools, to determine the exact position of all oil, gas, and water horizons. With this and other structural information, the speedier, and perhaps more economical, rotary drilling tools could be safely used.

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