CANADA
DEPARTMENT OF MINES

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BUREAU OF ECONOMIC GEOLOGY

GEOLOGICAL SURVEY

PRELIMINARY REPORT

OIL AND GAS POSSIBILITIES ALONG MILK RIVER SOUTHEASTERN ALBERTA

BY

L. S. Russell

Paper 36-12

OTTAWA

1936

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INTRODUCTION

This preliminary report deals with a portion of southeastern Alberta adjacent to Milk River valley. More specifically, the area discussed comprises parts of tps. 1 and 2, range 4 to 13, W. 4th mer. This is an eastward extension of the area mapped by C.S. Evans.[1]

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[1] Geol. Surv. Canada, Sum. Rept. 1930, pt.B, pp. 1-30.

The information here submitted was obtained during the field seasons of 1934 and 1935, and forms part of the results of a larger project, not yet completed, for the revised geological mapping of southern Alberta. The writer was assisted in the field by R.W. Landes, R.M. Sternberg, W. Hutchinson, J.H. Jacobs, and L.M. Dwarkin.

STRATIGRAPHY

The following table summarizes the stratigraphical succession in this area, with emphasis on those features of interest to the driller and to those engaged in structural surveys.

		Formation	Thickness, feet	Lithology
Upper Cretaceous	Belly River Series	"Pale" beds	±480	Light grey, greenish grey, and buff sandstone and plastic shale with thin carbonaceous bands and indurated beds. Coarse sandstones, buff in colour partly indurated, crossbedded and conglomeratic, occur at various levels, but most persistently 130 to 160 feet from base. Freshwater fossils present.
		Foremost	270 or less	Interbedded shale and coal in upper 50 feet, underlain by shale with silty streaks, with sandstone and ironstone bands, becoming predominantly shaly to the base. Oysters and other brackish water fossils.
	Montana group	Pakowki	470	Grey and brown shale, with sandstone beds in upper part. Chert pebbles at base. Marine fossils.
		Upper Milk River	130 or less	Light grey and brown sandstone and sandy shale, with thin lignitic beds; indurated buff sandstone lenses.
		Lower Milk River	150-200	Massive buff sandstone, medium grained, weathering to castellated forms; persistent indurated "cap rock" at top; lower part shaly and transitional to underlying formation.
	Colorado group	Alberta	1,600-1,800	Dark grey shale, with bentonite bands; interbedded sandstone in lower 600 feet.
Lower Cretaceous		Blairmore-Kootenay	420	Green, grey, and reddish shale, with grey sandstone beds in lower part.
Jurassic		Ellis	170-200	Grey and greenish grey shale, mostly calcareous, with sandstone beds; fragments of Belemnites in well samples
Mississippian		Madison	±1,000	Light-coloured, crystalline limestone, with some calcareous shale in lower part.

For those desiring a more detailed description of the stratigraphy the following paragraphs are presented. The sequence is given from top to bottom, to correspond with the manner in which the formations are encountered in borings. Special reference is given to persistent horizons, and to zones that might yield flows of water, gas, or oil.

"Pale" Beds. These make up the upper part of the Belly River series, and constitute the highest stratigraphical unit in the area. As only the lower part is present, the thickness cannot be given, but farther north, outside the area, a thickness of 480 feet has been measured. The predominant sediments are light grey, greenish grey, and brown sandstones and plastic shales. Carbonaceous bands are present, but they are very impure, and usually of a brown or maroon colour, in contrast to the darker lignitic beds of the underlying Foremost. Lateral variation is pronounced in the "Pale" beds, and good horizons, therefore, are rare. Within the present area a very persistent, coarse-grained, crossbedded, and somewhat conglomeratic sandstone occurs 130 to 160 feet above the base. Indurated masses are common in this sandstone. The base of this sandstone is mapped on the "Calgary sheet"[1] as the Pale-Foremost contact.

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[1] Geol. Surv., Canada, Map 204A, 1928.

Foremost. This is the lower subdivision of the Belly River series. Over most of the southern Alberta plains the Foremost beds show marked variation, but within the area the succession is fairly constant. The thickness is about 270 feet, the upper 50 or 60 feet being a lignitic zone, consisting of dark shales, interbedded with coal seams and carbonaceous bands. The contrast between these dark beds and the overlying "Pale" beds makes the contact a conspicuous horizon. The remaining 220 feet

of the Foremost consists principally of grey and brown shale with interbedded silt streaks, occasional sandstone beds, and thin indurated bands. Lignitic beds occur sparingly in this zone. The base, or contact with the Pakowki, is placed by the writer at the transition from sandstone to shale which occurs 10 to 20 feet below the lowest carbonaceous bed. Commonly there is an indurated ironstone band a little below the carbonaceous bed, and a rich bed of oysters or other brackish water fossils also is frequently present here. These brackish water shells are excellent indices of Foremost beds, in contrast to the freshwater fossils of the "Pale" beds and the marine fossils in the Pakowki. However, in a few cases brackish water fossils were found in the upper part of the Pakowki and marine shells in the Foremost.

The best horizons for structural surveying in the Foremost are the top of, or some conspicuous member within, the lignitic zone, also the indurated oyster beds about 200 feet above the base, and the basal beds.

Pakowki. The thickness of this formation in township 1, range 9, was determined by the writer as 470 feet. This decreases to the west, and in township 2, range 17, Evans[1] reports only 182.5

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[1] Geol. Surv. Canada, Sum. Rept. 1930, pt.B, p.17.

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feet in test wells. In the present area only the upper part of the formation is well exposed. A continuous section of this part may be studied in Bear gulch, township 1, range 9, and from there down Milk River valley to range 7. The lower beds are imperfectly exposed in tributary valleys south of Milk river, in township 1, ranges 10,11, and 12.

In the area here discussed the Pakowki may be subdivided into four lithological zones. The uppermost zone consists of soft, brownish grey shale, commonly sandy, with occasional sandstone beds and indurated bands. This is the best exposed part of the formation

and is about 100 feet thick. Below this is a zone of soft shale, bounded above and below by fine-grained, fossiliferous sandstone members. These sandstones are good horizons for structural work; the upper one has been mistaken for the base of the Foremost in Halfbreed coulée (township 1, range 10). The total thickness of this zone, including the sandstones, is about 150 feet. The remaining two zones are poorly exposed, but make up a combined thickness of about 220 feet. The upper one consists mostly of soft, brown shale, whereas the lower zone is composed of a harder, grey shale, with fossiliferous concretions and bentonite beds. At the base of this lowermost zone is a conglomeratic bed, a few inches thick, which marks the base of the Pakowki formation throughout a large part of southern Alberta. This conglomerate consists of black chert pebbles, about 1 cm. in diameter, in a matrix of sandy shale. This rests directly upon the top of the Milk River formation. In some cases the pebbles are scarce, but usually they are very abundant, and may be recognized in well samples.

Upper Milk River. The Milk River formation is divisible into two well-marked members, which, for the purpose of this discussion, may be treated as separate formations. The upper subdivision varies in thickness from 130 feet in township 1, range 11, to only 50 feet in the Comrey well, township 1, range 5. Seen on the surface these beds appear as soft, impure sandstones and sandy clays, with indurated lenses. The colours are dull grey and brown, with numerous dark bands, due to the presence of thin, lignitic beds. Massive, buff-coloured sandstones occur in places, and when present in the lower part of the member may be mistaken for Lower Milk River beds, although softer, finer grained, and more argillaceous. In well samples the Upper Milk River beds appear as light grey, sandy shale, not readily distinguishable from the overlying Pakowki except for the presence of coal fragments.

It is difficult to carry structural surveys on Upper Milk River beds, as they vary within short distances. An exception to this is the uppermost bed, which is usually a reddish indurated band about 6 inches to 1 foot thick. This bed directly underlies the drift over considerable areas, all but an occasional trace of the overlying Pakowki beds having been removed. The best exposures of Upper Milk River beds are in Milk River valley, ranges 12 and 13, and in Deadhorse and Verdigris coulées.

Lower Milk River. The lower member of the Milk River formation is called the Virgelle sandstone, in Montana. The thickness varies from 150 to 200 feet. The upper 100 feet or more is composed of a massive, medium-grained sandstone, buff in colour, and commonly weathering in castellated forms. The top is marked by an indurated brown bed, 2 or 3 feet thick, which is called the "cap rock" by drillers. It makes an excellent horizon, but must not be confused with similar beds which occur as irregular lenses at random within the sandstone. At about 100 feet below the top shaly streaks appear in the sandstone, which becomes more fine grained. From here down the shale becomes more and more predominant and the transition to the underlying Alberta shale is gradual. Some geologists classify all of these transitional sandy shales with the Alberta (Colorado) formation. However, it is convenient practice, and apparently justifiable theoretically, to place the top of the Alberta beds at a zone of shale with minute white specks. This shale is readily identified in well samples on microscopic examination.

The best exposures of Lower Milk River sandstone occur on Milk River in ranges 12 to 15, and in tributary valleys to the south. It also appears on the north flank of West butte, and as smaller inliers to the north and northeast. The sandstone is an excellent aquifer and is the source of artesian water over much of

southeastern Alberta. Small quantities of gas emerge with the water in places. Depth to the "cap rock" in the artesian wells is generally obtainable from the driller.

Alberta. This widespread formation is the "Benton" of drillers, but is more nearly the equivalent of the entire Colorado group. However, as the Alberta formation is defined, it includes equivalents of part or all of the Telegraph Creek formation, which is excluded from the Colorado group in the United States.

The Alberta formation is predominantly a grey shale, more or less fissile, with bentonite bands and ironstone concretions. The thickness in this area varies from about 1,800 feet in the western part to 1,630 feet in the Comrey well on the east. In the lower 600 feet of the formation sandstone beds appear and may reach considerable thicknesses. The sandstone is fine grained, grey in colour, and, when obtained in undisintegrated fragments, commonly shows fine light and dark banding. This sandstone zone is called the Blackleaf member[1],. following the practice in Montana. It

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[1] Spratt, J.G.: Bull. Am. Assoc. Petrol. Geol., vol. 15, pp. 1172-1178 (1931).

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includes the Bow Island gas sand, 300-400 feet above the base, and, in the Red Coulée field, the "Colorado water sand", about 50 feet above the base. Oil in commercial quantities is obtained from the Blackleaf member in the Whitlash field[2], of northern Montana and

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[2] Dobbin and Erdmann, "Problems of Petroleum Geology", p.712, 1934

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the natural gas of the Bow Island, Foremost, Pinhorn, and Whitlash fields comes from some part of this zone.

The Alberta shale is principally known in this area from drill records, but the upper part is well exposed in Deer Creek valley on the north flank of the West butte. The formation extends a few hundred yards across the International Boundary into Canada

before disappearing beneath the Milk River sandstone, and so constitutes the only known outcrop of Alberta shale on the southern Alberta plains.

Blairmore-Kootenay. These two formations, representing the Lower Cretaceous, are not differentiated from each other in this area. They are exposed on the East butte of the Sweetgrass hills where they were studied by Slipper[1]. In wells on the

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[1] Geol. Surv., Canada, Mem. 93, p.66 (1917)

Canadian side the Lower Cretaceous strata make up a thickness of slightly over 400 feet. The predominant sediment is a coloured shale, usually greenish or maroon, but sandy beds are present in the lower part. The best-developed sandstone occurs at or near the base; it is about 60 feet in thickness and is fine grained and light grey or "pepper and salt" in colour. It is locally known as the Sunburst sand, but has a position and thickness more analogous with those of the Vanalta or Cosmos sand of the Border-Red Coulée field. This general zone of basal Lower Cretaceous sandstones has produced oil in commercial quantities in the Border-Red Coulée, Cutbank, and Flat Coulée fields, and natural gas in the Kevin-Sunburst, Whitlash, Pritchard Coulée, and Deadhorse Coulée fields. It is probably the most important potential oil and gas horizon in the area here discussed. Where oil or gas is absent it is frequently water-bearing.

Ellis. The Jurassic Ellis formation is completely exposed on East butte, where Sanderson[2] determined the thickness

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[2] Bull. Am. Assoc. Petrol. Geol., vol.15, pp.1157-1160 (1931)

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as 305 feet. In wells on the Canadian side the thickness encountered is less, barely exceeding 200 feet, and usually about 175 feet. The principal rock is a grey or greenish grey shale,

commonly calcareous, with beds of sandstone and limestone in the lower part. Well samples from the Ellis frequently yield fragments of Belemnites.

Oil in commercial quantities was encountered in the Ellis of the Skiff field, and large flows of gas from basal Ellis strata in the Erickson Coulée field.

Madison. The "lime" of drillers is usually the lowest formation penetrated by wells in southern Alberta. A few have continued down into the Devonian and Cambrian rocks. For a full description of these buried Palaeozoic sediments See P.D. Moore[1].

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[1] Bull. Am. Assoc. Petrol. Geol., vol.15, pp.1141-1155 (1931).

Like other formations known only from well samples on the Alberta plains, the Madison beds are exposed on the East butte of the Sweetgrass hills. The predominant rock is a light grey to buff limestone, massive and crystalline. Other phases are darker and more dense, with argillaceous streaks. The contact with the overlying Ellis is an unconformity, and the thickness is therefore variable, but is in the order of 1,000 feet.

The Kevin-Sunburst field of northwestern Montana obtains most of its oil production from the top of the Madison limestone, and a large flow of sulphurous gas was encountered at the Ellis-Madison contact in the Deadhorse Coulée field (See below).

Sweetgrass Intrusives. Although not part of the sedimentary sequence these rocks may be mentioned because of their relationships to the structure. The principal intrusive rock in the Sweetgrass hills is a feldspar porphyry. This appears in Alberta only as a small mass in McTaggart Coulée, SW. $\frac{1}{4}$, sec. 18, tp. 1, range 11, W.4th mer. A second type is a greenish grey, dense rock, with biotite phenocrysts. This is called minette, and occurs in five dykes and a boss on the Alberta side of the International Boundary. The dykes all appear to radiate from the East butte.

GENERAL STRUCTURE

The regional dip in the area is to the northeast. This is due to the combined effect of two earth movements, the Sweetgrass fold, and the Sweetgrass Hills uplift. The Sweetgrass fold is an anticlinal structure plunging northeastward from the Little Belt mountains of Montana. The present area is situated on the southeastern flank of this fold, and thus should have a general dip to the southeast. But the laccolithic intrusions of the Sweetgrass hills have tilted the surrounding strata so that they slope away from the hills on all sides. On the north side this changes the southeast dip to a northeasterly one. It has also developed the small plunging folds which are described below.

ACTUAL OR POTENTIAL GAS AND OIL FIELDS

This section deals with the structural geology and the oil and gas possibilities of certain localized areas in the vicinity of Milk River valley.

Erickson Coulée Field. (Fig. 1). This field is situated in secs. 7,8,17, and 18, tp. 1, range 12, W. 4th mer. It is about 17 miles east of the town of Coutts, from which it is readily accessible by the Boundary trail. Only one well has been drilled here, the Erickson Coulée well of the Northwest Company, Limited; this was completed in 1927. A condensed log of this well follows.

Log of Erickson Coulée Well

(Ls.13, Sec.8, Tp.1, Range 12, W.4th Mer.; Elevation,3,616 Feet)

	Thickness, feet	Depth, feet
Missing		770
Alberta		
Shale, grey	40	810
Shale, grey, with some fine sandstone	60	870
Shale, grey, with bentonite	120	990
Shale, grey	90	1,080
Shale, silty, grey	120	1,200
Shale, grey, with much bentonite	20	1,220
Shale, grey	30	1,250
Shale, grey, with bentonite	80	1,330
Shale, grey, with sandstone and bentonite	20	1,350
Shale, grey, somewhat silty	60	1,410
Shale, grey, changing to bentonite	30	1,440
Shale, grey	30	1,470
Shale, grey, with sandstone	90	1,560
Shale, grey, somewhat bentonitic	110	1,670
Shale, grey, with some sandstone	40	1,710
Shale, grey, bentonitic	10	1,720
Shale, grey, with sandstone	60	1,780
Shale, grey	10	1,790
Shale, grey, with some sandstone and bentonite	30	1,820
Shale, grey	40	1,860
Blairmore-Kootenay		
Shale, grey, green, and reddish, with sandstone	140	2,000
Shale, grey, somewhat bentonitic	30	2,030
Shale, grey, reddish, and greenish, with sandstone	280	2,310
Sandstone, light grey	10	2,320
Missing	50	2,370

	Thickness, feet	Depth, Feet
Ellis		
Shale, dark grey, reddish, and greenish, with glauconite	20	2,390
Sand, glauconitic	10	2,400
Shale, somewhat calcareous, dark grey, reddish, and greenish	10	2,410
Shale, calcareous, grey and greenish grey	60	2,470
Shale, calcareous, grey and reddish, with glauconite	10	2,480
Shale, calcareous, grey	20	2,500
Madison		
Limestone, light grey, with some grey shale	50	2,550
Limestone, light cream to white, with some rusty streaks	710	3,260
Limestone, light coloured, with grey shale	30	3,290
Limestone, light grey, with rusty streaks; cherty in part	160	3,450
Limestone, sandy, light grey	80	3,530
Three Forks; Devonian		
Shale, dark grey, bituminous	10	3,540
Limestone, light grey, and shale, calcareous, grey	10	3,550
Shale, grey, with anhydrite	40	3,590
Anhydrite and gypsum, with some grey shale	60	3,650

This well encountered water at 2,680 feet and in large quantity at 2,915 feet. Large flows of gas were obtained 2,376, 2,488, and 2,531 feet. It thus appears that the base of the Blairmore-Kootenay and of the Ellis, and the top of the Madison, are gas-bearing here. Total measured flow was 2,000,000 cubic feet. The well was capped and has since remained idle.

The surface expression of the Erickson Coulée structure consists of two small inliers of Lower Milk River sandstone, situated to the east and west, respectively, of the well. Elevations on the top of this member were obtained here. Contours of these elevations

are indicated by a solid line on the accompanying map (Figure 1). The contours, drawn by computation from elevations and dip readings obtained on horizons in the Upper Milk River, are shown as broken lines. The contours shown as line- and -dot-lines are largely hypothetical. It is to be noted that outcrops are absent between the well and the vicinity of the International Boundary.

Plotting of the structure as indicated above shows that it takes the form of a narrow nose, steeper on the west side, and broadening to the north. The writer's data do not preclude the possibility of some closure on the south side, but the present interpretation is considered more probable.

Although large quantities of gas are present here, there is no evidence as yet of oil in commercial quantities. The value of the structure as a reservoir depends upon the character of the southern side, and this should be determined by test drilling before any further development is undertaken.

Deadhorse Coulée Field (Fig. 2). This is located in the northwest part of tp. 1, range 11, W. 4th mer. It may be reached from the Boundary trail by the road allowance east of section 17, or by a trail that follows the bottom of Deadhorse coulée eastward from the bridge in sec. 3, tp.2, range 12.

The first well drilled here was the Rogers-Imperial, also called Range No. 1 and Deadhorse Coulée No. 1; it was completed in 1925. This well is located in the northeast quarter of section 29, at an elevation of 3,245 feet. The log records water at the following depths: 130, 920, 1,545, 1,620, 1,665, 1,840, 1,860, 2,030 feet. Between 2,526 and 2,530 feet, in the base of the Blairmore-Kootenay, a gas flow of over 20,000,000 cubic feet was obtained. On further deepening, a flow of 5,000,000 cubic feet was obtained at 2,655 feet, within the Ellis, and another of 20,000,000 cubic feet at 2,720 feet, or the top of the Madison. Total gas flow, therefore, was over

45,000,000 cubic feet. Subsequently the lower gas, which is sulphurous, was closed off. A pipe-line was constructed southeastward to the Whitlash field of Montana, and by this means gas in considerable quantities is being exported.

Drilling of Deadhorse Coulée No.2 well by the Northwest Company, Limited, was begun shortly after that of the Rogers-Imperial, and was completed late in 1925. Deadhorse Coulée No.2 was located in the bottom of the coulée, close to the northwest corner of the southwest quarter of section 32 at an elevation of 2,996 feet. Water was encountered at depths of 15, 60, 300, 1,330, 1,990, and 2,578 feet. As no commercial production was obtained, the well was plugged and abandoned.

The third well of the field is Range No.2, commonly called the Range; it was completed in 1930. A condensed log of this well follows.

Log of Range Well No.2

(Ls.6, Sec.21, Tp.1, Range 11, W.4th Mer.; Elevation, 3,321 Feet)

	Thickness, feet	Depth, feet
Missing		110
Pakowki		
Shale, brownish grey	10	120
Upper Milk River		
Sandstone, light grey, fine, clayey, with black chert pebbles	30	150
Sandstone, light grey	10	160
Sandstone, light grey, clayey, and shale, arenaceous, with some carbonaceous fragments in places	80	240
Lower Milk River		
Sandstone, medium grained, pale grey, with dark specs	30	270
Missing	10	280
Sandstone, medium grained, "pepper and salt"	60	340

	Thickness, feet	Depth, feet
Sandstone, as above, but with some light grey shale	30	370
Shale, light grey, with some sandstone	10	380
Sandstone, fine, clayey, light grey, with a little shale	40	420
Sandstone, clayey, and shale, sandy, grey, with carbonaceous shale and coal	30	450
Shale, light grey	100	550
Alberta		
Shale, grey, with some fine whitish specks	170	720
Shale, grey	260	980
Missing	10	990
Shale, grey, with a little sandstone, fine light grey	50	1,040
Shale, grey	180	1,220
Shale, light grey	80	1,300
Shale, grey	270	1,570
Shale, grey, with some sandstone, fine, bentonitic	170	1,740
Shale and Clayey sandstone, grey	40	1,780
Sandstone, light grey, and shale, grey	100	1,880
Shale, grey	30	1,910
Sandstone and shale, grey	100	2,010
Shale, grey	10	2,020
Sandstone, medium to fine grained, "pepper and salt"	60	2,080
Shale, sandy, grey	30	2,110
Shale, grey	40	2,150
Sandstone, grey, with some shale	80	2,230
Shale, grey	10	2,240
Shale, sandy, grey	30	2,270
Sandstone, "pepper and salt", medium to coarse grained, with quartzite and chert pebbles and some shale	60	2,330

	Thickness, feet	Depth, feet
Blairmore-Kootenay		
Shale, grey, green, and reddish, with some sandstone	10	2,340
Sandstone, medium grained, "pepper and salt"	10	2,350
Shale, grey, reddish, and greenish, with some sandstone in places	250	2,600
Sandstone, medium grained, "pepper and salt"	10	2,610
Shale, grey and greenish, and light buff calcareous shale	10	2,620
Shale, grey	20	2,640
Shale, grey and greenish, with some light buff calcareous shale	10	2,650
Sandstone, medium grained, light grey, with grey, greenish, and reddish shale	40	2,690
Sandstone, medium grained, almost pure quartz, with some black specks	10	2,700
Sandstone, as above, but with some green and grey shale	10	2,710
Sandstone, grey with rusty streaks, and some shale	10	2,720
Shale, grey, greenish, and reddish, becoming sandy below	30	2,750
Ellis		
Shale, calcareous, grey	80	2,830
Shale and sandstone, grey	10	2,840
Sandstone, medium grained, mostly quartz	30	2,870
Shale, calcareous, grey, with some sandstone	30	2,900
Limestone, buff, and shale, green, calcareous	12	2,912
Shale, green, calcareous	3	2,915
Madison		
Limestone, cherty, bluish grey and light buff with shale, green, calcareous	3	2,918

Samples below 2,907 feet were not examined by the writer and the lowermost 11 feet of the above log are from the descriptions of J.G. Spratt. Presence of water is recorded from 205, 250, 300, 400, 1,720, 1,780, 2,026, 2,705, and 2,845 feet. The gas horizons of the Rogers-Imperial well proved barren in the Range No.2, and it was abandoned.

The surface expression of the Deadhorse Coulée structure consists of extensive outcropping of the Lower Milk River sandstone on both sides of the coulée in section 32. Dips to the west, northwest, and northeast are visible to the eye. Elevations were determined on the top of this member wherever exposed, and from these were plotted the continuous-line contours shown on Figure 2. The structure was followed to the west and south on sandstone beds in the Upper Milk River member. In the southwest quarter of section 20 the contact with the Pakowki shale is exposed. This exposure appears to traverse an anticlinal axis. Elevations on the Lower Milk River were also obtained from the logs of the Rogers-Imperial and Range wells. The top of the Milk River beds is exposed in an excavation in the northwest quarter of section 28. From the data thus obtained the broken- and dotted-line contours were plotted. The resultant interpretation (Figure 2) indicates that the structure is a narrow nose, with perhaps 50 feet of closure on the south. It appears that the Deadhorse Coulée and Range No.2 wells are down the flanks of the nose, whereas the Rogers-Imperial is about on the crest. It seems likely that large flows of gas might be obtained from a well drilled about half a mile due south of the Rogers-Imperial well.

Pinhorn Field (Figure 3). This name is applied, probably for the first time, to an area just north of the International Boundary, in tp. 1, range 9, W.4th mer. It is about 4 miles west of Pinhorn post office and 6 miles east of Aden post office. The Boundary trail, here only a partly improved road, traverses the

north side of the field, and numerous prairie trails branch off. The area is an irregular upland, sloping toward Bear gulch on the west and Philps ("Police") coulée on the east, and rising toward the East butte on the south.

The first well drilled here was the Mayland Southern No.1, completed in 1932. It is situated close to the northwest corner of section 4. The log of this well follows.

Log of Mayland Southern Well No.1

(Ls. 13, Sec. 4, Tp. 1, Range 9, W.4th Mer.; Elevation, 3,688 Feet)

	Thickness, feet	Depth, feet
Missing		50
Pakowki		
Shale, grey, with some coal fragments	110	160
Shale, silty, grey	10	170
Upper Milk River		
Sandstone, fine, grey, with silty shale (chert pebbles reported by Owen)	10	180
Shale, grey, with some coal	10	190
Shale, silty, light grey	30	220
Shale, silty, carbonaceous, grey	10	230
Shale, silty, light grey, with some coal	40	270
Lower Milk River		
Sandstone, medium grained, light grey, with some shale and coal	40	310
Sandstone, medium grained, light grey	50	360
Sandstone, medium grained, light grey, with some shale	10	370
Sandstone, fine grained, clayey, light grey	30	400
Missing	100	500
Shale, silty, light grey, partly carbonaceous	60	560

Alberta	Thickness, feet	Depth, feet
Shale, grey, some white specks	60	620
Shale, grey with black specks, partly bentonitic	20	780
Shale, grey, somewhat silty	260	1,040
Shale, grey, silty in places, with traces of bentonite and shell fragments	460	1,500
Shale, grey, banded with fine, light grey sandstone	10	1,510
Shale, grey, with traces of bentonite	20	1,530
Shale, grey, finely banded and silty in places	100	1,630
Missing	30	1,660
Shale, grey, with sandstone coming in below	20	1,680
Sandstone, grey, clayey, with grey shale	70	1,750
Shale, grey, silty, banded in places	30	1,780
Sandstone, fine grained, grey, with some shale	50	1,830
Shale, grey, silty, with traces of bentonite	30	1,860
Shale, grey, bentonitic	10	1,870
Sandstone, grey, medium grained, clayey, with some bentonite	30	1,900
Shale, grey, silty, with some bentonite	20	1,920
Shale, grey, partly bentonitic	10	1,930
Missing	10	1,940
Sandstone, grey, clayey, with numerous quartzite fragments	20	1,960
Shale, grey, silty, with some bentonite	20	1,980
Sandstone, fine, clayey, with some greenish grains, and some shale	20	2,000
Shale, grey, with some sandstone and bentonite	60	2,060
Sandstone, grey, clayey, with some shale	40	2,100
Shale, grey, partly silty	80	2,180
Shale, grey, with some sandstone	20	2,200
Shale, grey, silty	10	2,210
Sandstone, grey and greenish grey, with some shale	40	2,250
Missing	10	2,260

	Thickness, feet	Depth, feet
Blairmore-Kootenay		
Sandstone, medium grained, mostly angular grains of quartz	20	2,280
Sandstone, as above, with grey and green shale	10	2,290
Shale, grey, greenish, and reddish, with some sandstone and silt	70	2,360
Sandstone, grey, clayey, with some shale	80	2,440
Shale, grey, silty	20	2,460
Shale, grey, greenish, and reddish, with some sandstone	90	2,550
Sandstone, very fine grained, whitish, with some grey and greenish shale	10	2,560
Missing	40	2,600
Shale, grey, non-calcareous, somewhat silty	20	2,620
Ellis		
Shale, grey, calcareous	180	2,800
Madison		
Limestone, pale grey, and grey calcareous shale	20	2,820
Limestone, grey, light brown, and whitish	20	2,840
Missing	30	2,870
Limestone, whitish, with a little grey shale	70	2,940
Limestone, whitish and light brown, with considerable grey shale	20	2,960
Limestone, whitish, with rusty stains	50	3,010

This well encountered water at 380 feet. Gas was obtained at numerous horizons, including a flow of 500,000 cubic feet at 278 feet and one of 4.6 million cubic feet at 2,250 feet. Total measured gas flow of this well was 16,000,000 cubic feet. The well is equipped to supply gas under control, but is idle at present.

A second well was completed in 1934 by the Rialto Oils, Limited. This was located in legal subdivision 4, section 15, or about 1½ miles northeast of Mayland Southern No. 1, from which gas was piped for power and heating. Elevation of the Rialto

well is 3,605 feet. The top of the Upper Milk River was encountered at 430 feet, top of the Lower Milk River at 570 feet, top of the Alberta at 810 feet, top of the Blairemore-Kootenay at 2,470 feet, top of the Ellis at 2,860 feet, and top of the Madison at 3,030 feet. Water is recorded at 235, 610, 2,180, and 3,072 feet. No important flows of gas were obtained, and the well was subsequently plugged.

Direct evidence for structural uplift in the Pinhorn field is obtainable only on the west and northwest sides, where numerous small coulées expose lower Foremost and Upper Pakowki beds. The contact may be observed in two places, as shown on the map (Figure 3). Elevations, and strike and dip readings, taken on these beds, indicate that the dip is to the northwest and west, with the strike swinging around in sections 8 and 5 as shown (Figure 3). There is some evidence of a synclinal area farther west, as the beds rise again somewhat toward Bear gulch. Some indication of the structure on the north side is given by the log of the Rialto well. To the east and southeast there are no significant outcrops until Philps coulée is reached. Here apparently flat-lying "Pale" beds are exposed. From the known thicknesses of the underlying formations it may be calculated that the top of the Lower Milk River beds lies over 850 feet below the surface here. In the Rialto well the same horizon is 570 feet deep, and in the Mayland Southern well, 270 feet deep. These data together with the elevations obtained by the writer, indicate that there is a structural drop of over 450 feet between the Rialto well and Philps coulée, and of over 800 feet between the Mayland Southern well and Philps coulée. Thus, while the precise character of the structure on the northeast and east sides cannot be determined, the amount of closure present here is fairly evident. Data on the southeast side are of a similar

nature. "Pale" beds outcrop in sec. 5, tp. 37 N., range 4E., about half a mile south of the International Boundary. As determined by C.E. Erdmann[1], there is a synclinal axis in this

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[1] U.S. Geol. Surv., Preliminary structure contour map of the Bears Den-Flat Coulée-Whitlash districts, North-central Montana, 1930.

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locality, trending somewhat north of west. This is indicated on the accompanying map (Figure 3), together with the calculated structural rise between here and the Mayland Southern well. Only on the south side of the Pinhorn field is all information lacking. Here the writer's interpretation is an attempt to merge the Pinhorn structure with the north side of the Whitlash dome, as mapped by Erdmann. It should be noted that the datum used by Erdmann is 250 feet or more lower than that employed by the writer.

The Pinhorn structure thus appears to be dome-like, with closure on the west, north, and east of some hundreds of feet. On the south it probably connects with the Whitlash dome, occupying a position somewhat analogous to that of the Flat Coulée dome, as mapped by Erdmann. Closure may be completely absent on the south, but dip readings obtained in section 5 suggest that some exists.

The presence of gas in commercial quantities in the Pinhorn field has been demonstrated by the drilling of the Mayland Southern well, and need not be discussed further, except to note that a cheap fuel is available for drilling operations. With regard to petroleum, the writer considers the Pinhorn structure to be the most favourable for oil accumulation of any described in this report. The structure is a pronounced one, with large closures on at least three sides. Furthermore, the presence of oil in this general vicinity has been demonstrated. Thus, in the Whitlash field of Montana, about 5 miles south of the Mayland Southern well, there are at present three wells pumping oil in

commercial quantities from the basal part of the Colorado shale. In the Flat Coulée field, 5½ miles to the southeast of the Mayland Southern well, considerable oil has been encountered in the base of the Blairmore-Kootenay. It is of interest that almost the entire output of the Whitlash oil wells is sold to Canadian consumers, who use it without further treatment as fuel in Diesel tractors. A point to be noted from the history of these Montana fields is that the area of oil accumulation is of small extent, and may require several borings for its location.

It thus appears that the Pinhorn field is worthy of further exploration. It must be strongly emphasized, however, that the structure contours of the accompanying map (Figure 3) are too hypothetical to be used in the location of new wells. It is recommended that, prior to any further deep drilling, at least two shallow test borings be made, to locate the apex of the structure, and to determine the amount of closure on the south side. Two good key horizons, the base of the Pakowki and the top of the Lower Milk River, will be encountered at depths of several hundred feet. The suggested locations of these two test holes are 1 mile east and 1 mile south, respectively, of the Mayland Southern well.

Comrey Field (Figure 4). This is situated in the southwest part of tp. 1, range 5, W.4th mer., about 8 miles southeast of Comrey post office. It is accessible by prairie trails branching off southward from the Wildhorse road. The area is traversed by Milk River valley, and by large tributary coulée. Outcrops are abundant, giving continuous exposure of the Foremost-"Pale" contact, and of the channel sandstone 130-140 feet above. Undulations of these horizons are visible to the eye, but the nature of the structure cannot be determined without detailed instrumental surveys. There are so many minor variations in the

dip that individual observers are certain to differ in the details of their interpretations. Compilation of the writer's observations indicates that the structure is a broad nose, enclosing an irregular dome on the west side. The valley of Milk river seems to follow the synclinal zone along the southwest and south sides.

This structure was discovered by Dr. T.A. Link, of Imperial Oil, Limited. Drilling of the Comrey No. 1, also known as the McDougall-McLeod well, was begun in 1934, and recommenced in 1935. This well is situated near the northwest corner of the southwest quarter of section 9. The elevation is 3,035 feet, at the time of writing the reported depth is 3,200 feet. The Lower Milk River sandstone was encountered at 835 feet, from which water rose to overflow the casing head. This determination of the depth to the Lower Milk River indicates that the apex of the structure is somewhat more to the northwest than might have been supposed previously. If the results from this well appear to justify further drilling, such might be undertaken in the southwestern part of section 17.

Other Areas. A number of wells not mentioned above have been drilled in the district studied by the writer. These wells and their locations are as follows: Capitol, northwest corner of sec. 32, tp. 1, range 12, W.4th mer.; Grand Trunk Pacific, ls.3, sec. 1, tp.1, range 12, W.4th mer.; Madison, ls.10, sec. 24, tp.2, range 11, W.4th mer.; Beaver, ls.8, sec.24, tp.2, range 11, W.4th mer. No information was obtained in the vicinity of these wells to indicate that further drilling should be carried on there.

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