CANADA

DEPARTMENT OF MINES

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

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

Summary Report, 1926, Part B

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OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1927

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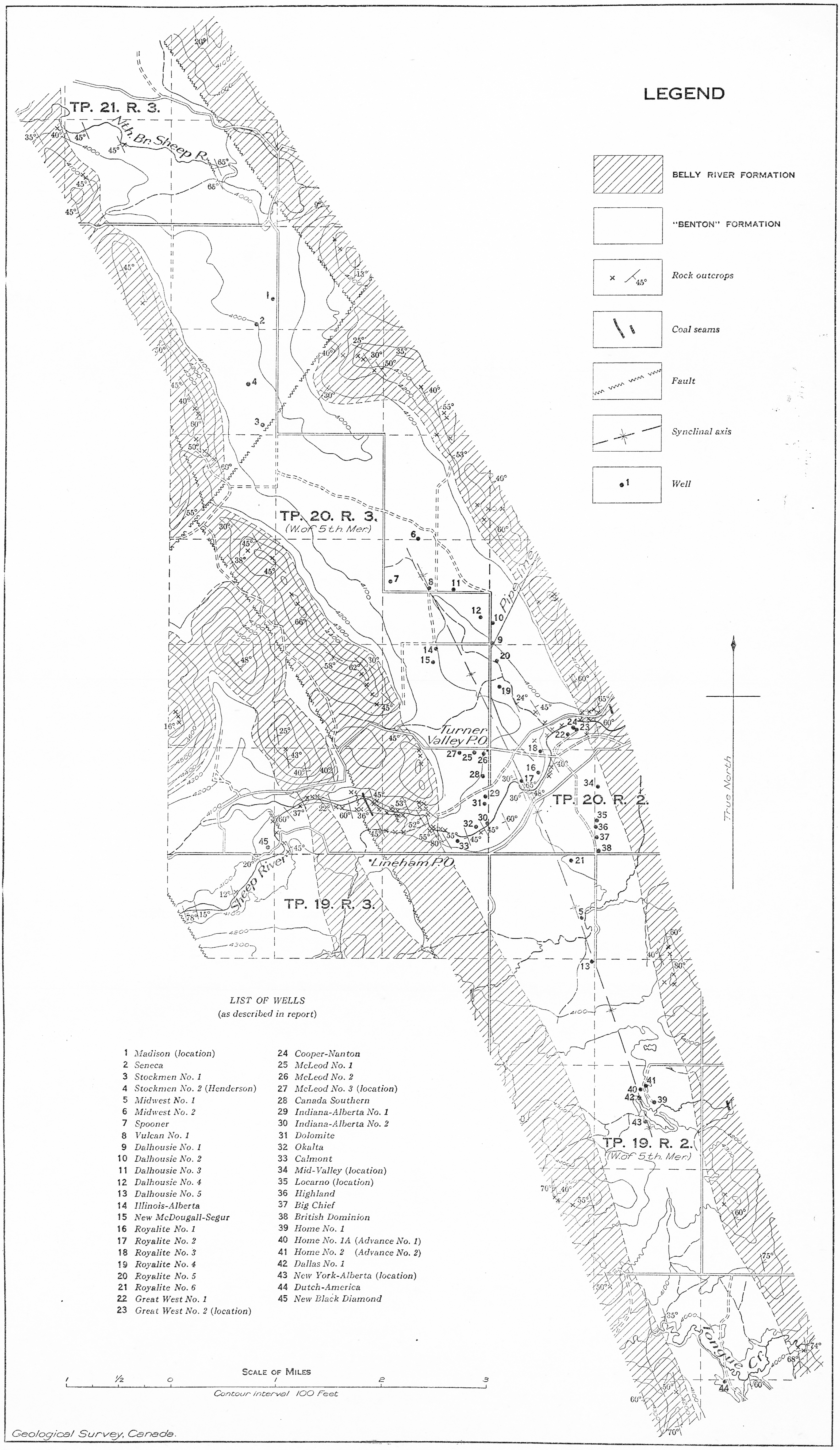

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Figure 1. Turner Valley oil area, Alberta.

SUMMARY REPORT, 1926, PART B

TURNER VALLEY OIL AREA, ALBERTA

By G. S. Hume

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INTRODUCTION AND ACKNOWLEDGMENTS

Owing to recent developments in Turner valley, southwestern Alberta, the Geological Survey undertook during the summer of 1926 a further study of the stratigraphy and structure in order to acquire information that may aid in developing the field and may be applied to prospective oil areas within the foothills. Accordingly, the writer, assisted by A. J. Childerhose, G. C. McCartney, and R. P. Quinn, spent June and July in Turner valley revising the map that was prepared by S. E. Slipper and published in 1921.[1] The edition of the report by Mr. Slipper, Memoir 122, is now exhausted, but a thousand copies of the accompanying map are still available for distribution. Until more field work can be done and a more complete report and map prepared, the present report and these remaining copies of Mr. Slipper's map are intended to meet immediate requirements for geological information. The map (Figure 1) prepared by the writer differs but little from that prepared by Mr. Slipper. In a few places details of geological boundaries are somewhat different and in a few instances new information from drilling has made it possible to add some structural details.

During the early part of the summer Mr. A. C. T. Sheppard revised the topography of the Turner Valley sheet and added such new information as was then available. The locations of new wells were accurately determined and levels run to each well. A list of levels is given in this report, such information being essential for correlation purposes.

During the progress of the work the Calgary office staff of the North West Territories and Yukon Branch, Department of the Interior, under the supervision of Mr. C. C. Ross, co-operated with the writer, and acknowledgment is made for much assistance received. The management of various drilling companies placed detailed information at the disposal of the writer, who gratefully acknowledges the assistance thus received.

STRATIGRAPHY

The following table of formations is based largely on that presented by S. E. Slipper on page 4 of Memoir 122, Geological Survey, Canada.

[1] Slipper, S. E.: Geol. Surv., Canada, Mem. 122 (1921).

Table of Formations

Age		Formation	Lithology	Deposit	Topographic expression	Thickness	Remarks
Tertiary		Paskapoo	Light, ash-coloured, massive sandstone beds, greenish clays and shales	Freshwater	Eroded into irregular hills and depressions	Feet 4,000±	In certain places a conglomeratic sandstone with quartzite pebbles up to 3 inches in diameter is exposed at what is considered the base of the Paskapoo. Below the conglomeratic sandstone is green clay shale presumed to be Edmonton. The division is not made on fossil evidence
Cretaceous		Edmonton	Dark, green clays with hard, greenish sandstones. A carbonaceous horizon at base	Brackish water	Underlies a broad depression formed in upturned beds east of Turner valley and extending northwestward to Priddis	1,300	
Cretaceous	Montana	Bearpaw	Black shales, carbonaceous in places	Marine			Not definitely known to be present in Turner Valley area
Cretaceous	Montana	Belly River	Light green clays and shales, light grey and greenish, massive, and thin-bedded sandstones. A coal seam at the top of the formation	Brackish water	Upturned beds form prominent ridges	1,800 to 1,900	
Cretaceous	Colorado	"Benton"	Blue-black shales with several thin sandstone members	Marine	In contrast with the Belly River rocks these are easily eroded and form valleys	2,500 to 3,000	Fossils from the upper part of the "Benton" appear to be Montana in age, whereas lower down Colorado fossils are common
Cretaceous		Blairmore	Thin-bedded, variegated shales, massive and thin-bedded, green and grey sandstones	Land and freshwater (plants)	Form ridges	*See* Note below	In the Blairmore area there are two floras, an upper dicotyledon flora of Upper Cretaceous age and a lower cycad flora. Only the lower has so far been found in Turner valley
Cretaceous		Kootenay	Coal, black shales, and hard sandstones	Continental	Does not ourcrop in Turner Valley area	*See* Note below	A conglomerate of varying thickness occurs at the base of the Blairmore. It is not known to have been recognized in well samples

Jurassic	Fernie	Mostly dark shales, in part calcareous	Marine	Does not outcrop in Turner Valley area	400 to 500	May be in part Triassic
Palæozoic (?)		Limestones and dolomites	Marine	Does not outcrop in Turner Valley area	(?)	The age is not definitely known. Fossils from a core sample of Illinois-Alberta well, at 3,811 feet, although poorly preserved, are considered by E. M. Kindle to be late Palæozoic

NOTE.—The thickness of the Blairmore and Kootenay may be less than 1,000 feet. In Royalite No. 4 well the depth from the top of the Blairmore to the Kootenay coal horizon is approximately 725 feet and from the top of the Blairmore to what is considered to be the Fernie it is 1,050 feet. It is thought Royalite No. 4 well starts at the surface in westward dipping beds, but that because of a westward dip of the axial plane of the anticline, the angle of dip decreases downwards to approximately horizontal at the top of the Blairmore. Below this point, however, to the bottom of the well, the angle of dip presumably increases and is to the east. The stratigraphical thickness of the Blairmore and Kootenay, therefore, is less than 1,050 feet by an amount depending on the varying angle of dip of the strata in which the well was drilled. For the same reason the Fernie, which was penetrated for 650 feet in the well, is less than 650 feet in stratigraphic thickness.

PRE-FERNIE SEDIMENTS

The age of the limestone and dolomite underlying supposed Fernie strata and penetrated in various wells, is unknown. Some geologists have thought it to be Triassic. The Illinois-Alberta Oil Company, however, has recovered diamond drill-core samples from this horizon and one small sample of core taken at a depth of 3,811 feet showed some poorly preserved fossils. These have been reported on by E. M. Kindle as follows: "The pieces of drill-core show a dolomitic limestone in which small fragments of fossils, including sections of crinoid stems, are present. Slender coralite fragments not determinable are also present. These fragmentary fossils represent a marine fauna which is probably of late Palæozoic age."

FERNIE FORMATION

Samples of the Fernie formation obtained from wells consist of black shales and calcareous shales. The formation is not exposed within Turner Valley area and where exposed in nearby areas only calcareous shales were observed in the very limited thickness of strata visible. The shales at these exposures hold oil between the bedding planes and along joint and fracture planes. It is thought the oil has been derived from the shales rather than from an outside source. The evidence, however, is not conclusive.

BLAIRMORE[1]-KOOTENAY FORMATIONS

The Kootenay is not exposed in Turner Valley area. Northwest of Turner valley outcrops were seen, but no continuous section was studied. For the most part, therefore, the character of the Kootenay sediments in this area has been deduced from well records.

The basal beds of the Blairmore are a massive conglomerate, but so far as the writer is aware this conglomerate has not been recognized in well samples from Turner Valley field and, therefore, no division is possible between the Blairmore and the underlying Kootenay. The most continuous and best-exposed section of the Blairmore studied is on Sheep river in the vicinity of Macabee creek. The section in part is as follows:

	Feet
Dark "Benton" shales	
Hard sandstones with thin conglomeratic beds near the contact with the "Benton"	10
Dark greenish shale	4·4
Fine-grained, greenish sandstone	1·3
Dark shale, partly covered	7·5
Light grey sandstone	1·2
Dark greenish shale	8·8
Light grey sandstone	1·5
Sandy, green shale	10·4
Greenish, shaly sandstone	8·5
Dark, shaly sandstone	1·5
Covered interval	18·5
Dark greenish sandstone	2·0
Covered interval	10·8
Sandstone	1·5
Shale and thin sandstone beds	6·2
Greenish shale	17·7
Dark sandstone	3·5

[1] The name Blairmore is used instead of "Dakota" which was applied to the same series of sediments in previous reports. It has been shown that the so-called Dakota is pre-Dakota in age.

	Feet
Greenish shale	9·0
Dark grey sandstone and rusty shale partly covered	11·4
Dark green sandstone	1·9
Shaly sandstone	21·0
Hard, dark sandstone	2·6
Covered—in part sandstone	50
Covered	12·5
Red shale	2
Green and sandy shale	13·1
Hard, dark olive green sandstone	1·6
Greenish shale	8·3
Heavy, massive, greenish sandstone	11·4
Dark, thinly laminated sandstone	5·3

This part of the section is given in detail because the pronounced red and green shales which occur 220 to 225 feet down in the section are easily recognized in drill samples and hence form a good horizon marker. Knowing that the red shales occur approximately 220 feet below the top of the Blairmore formation the data may also be used to determine the angle of dip of the strata on any well where both the top of the Blairmore and the red and green shale horizons have been recognized. One example will serve as an illustration. The McLeod No. 2 well encountered the Blairmore at a depth of 1,745 feet and the red shales at a depth of 2,055 feet. The difference between these two depths, i.e., 310 feet where the stratigraphical thickness is only 220 feet, indicates that the beds dip at an angle of 45 degrees for at least this part of the section. Such a conclusion based on detailed knowledge of the stratigraphy is obviously valuable. A study of recognizable horizons, however, in the case of the McLeod as in other wells, indicates in various instances that the angle of dip of the strata varies with depth, so that predictions regarding the depth at which any given horizon will be encountered are not always reliable.

Since the conglomerate that occurs elsewhere at the base of the Blairmore formation is either absent in Turner Valley field or else has not been noted in well samples, the thickness of the Blairmore has not been determined. The combined thickness of the Blairmore and Kootenay has not been measured at the surface, and owing to the difficulty of determining the possibly varying angle of dip of the strata in which various wells were drilled, no reliable estimate is available. It is thought, however, that the thickness is approximately 1,000 feet, but this is a maximum rather than a minimum value.

In a clearly exposed section of "Benton" and Blairmore strata near the mouth of Macabee creek on Sheep river, about one foot of volcanic tuff is present in the Blairmore just below the base of the "Benton." Samples of this volcanic tuff have been submitted to various geologists familiar with this type of rock and they consider the material to represent rewashed volcanic ash. A few well-rounded pebbles are present in the tuff and undoubtedly point to sedimentary deposition. The tuff as a whole is so extremely porous as to have a superficial resemblance to pumice. It occurs at an horizon equivalent to that of the Crowsnest Volcanics. Such an extremely porous horizon would be an exceptionally good reservoir for oil and gas and it is well known that a persistent gas horizon in Turner Valley field occurs near the top of the Blairmore formation. The distribution of the tuff, however, may be very restricted. The rock is not known to be present in any well so far drilled, but material suggestive of volcanic ash occurs in Stockmen No. 1 well at about 60 feet below the top of the Blairmore formation. In a personal communication from Dr. O. B. Hopkins the belief is expressed that no well of the Imperial Oil or subsidiary companies has encountered this horizon. If the tuff is related in origin to the Crowsnest Volcanics, it presumably would increase in thickness southward from Turner valley and might be encountered in wells. An examination of the "Benton"-Blairmore contact at a number of places on Highwood river, however, revealed no such tuff horizon, so that the presence of the tuff near the mouth of Macabee creek may have no regional significance.

"BENTON" FORMATION[1]

As described by Slipper the "Benton" formation consists of dark shales with numerous sandstone beds, particularly in the lower part. The thickness of the "Benton" has not been accurately determined on account of the varying dip of the strata on which the wells are drilled. In measured sections the thickness seems to be between 2,500 and 3,000 feet, but because the shales are folded, exact measurements of thickness are difficult and the results obtained are liable to exceed the true amount.

A surprising feature of the "Benton" is the presence of small pebble layers at three or possibly more horizons. Two of these horizons were seen in outcrops and in spite of the fact that the pebble beds are rarely more than 1 to 2 inches thick they are apparently very persistent in extent. Most of the pebbles consist of black chert. By measurement in the field the two outcropping pebble zones were determined to occur at, respectively, 1,450 and 1,790 feet below the Belly River-"Benton" contact. The upper zone is supposed to be represented by a zone of pebbles found by D. C. Maddox, of the Borings Division, in samples from the Great West well. The lower zone was not located in this well. Two pebble zones have been found in the samples from the Calmont well, the upper one at a vertical depth of 710 feet and the lower one at 1,570 feet. Since the Calmont well is thought to have started on strata having a 50-degree dip the two depths would correspond to stratigraphical thicknesses of respectively 460 and 1,010 feet below the top of the well. By measurement in the field it was determined that the Calmont well began at an horizon in the "Benton" 770 feet below the Belly River-"Benton" contact. This determination should not be accepted as absolute because of variations in the dip of the strata and the consequent liability to err in calculating the thickness. However, it is the best estimate available and it indicates that the two pebble zones encountered in the Calmont well are, respectively, 1,230 and 1,780 feet below the Belly River-"Benton" contact. The lower of these two pebble zones, therefore, seems to be the one which as determined by measurements of outcrops occurs 1,790 feet below the Belly River-"Benton" contact. If this is so, the conclusion is that there are at least three pebble horizons in the "Benton" at, respectively, 1,230, 1,450, and 1,790 feet below the Belly River-"Benton" contact.

[1] Since the marine strata, largely shales, which in Turner Valley field pass under the name of Benton, hold in their upper part fossils of Montana age, it is evident that the assemblage is not Benton as this division is of Colorado age. These shales are at least roughly equivalent to strata which in neighbouring districts have been termed Colorado shales, but as indicated above, the term Colorado is not applicable either. As local usage in Turner Valley area had firmly established the name Benton, the term has also been employed in this report.

A fourth pebble zone higher than the 1,230-foot zone is indicated in samples from other wells, but no definite information regarding its stratigraphic position is yet available. According to determinations by F. H. McLearn large Baculites which occur at the top of this formation are of Montana age, although the fossils lower down are distinctly Colorado. It seems probable, therefore, that the division between the Montana and Colorado occurs within the "Benton", although for mapping purposes this marine formation is considered to be a unit. In Moose Mountain area Cairnes[1] considered the upper 150 to 300 feet of shales immediately below the Belly River to be Claggett in age. The writer has no data either to support or disprove this contention, although, as has been stated, the Montana age is recognized.

BELLY RIVER FORMATION

A section of the Belly River is given, in Memoir 122, by S. E. Slipper, who makes the total thickness to be 1,900 feet. The present writer agrees with this estimate of the thickness. At various places conglomeratic sandstones appear in the Belly River, but their exact stratigraphic positions have not been determined. It is thought that they may occur at different horizons in different localities.

BEARPAW FORMATION

No shales that could be definitely proved to be Bearpaw occur within Turner Valley area, but as mentioned by Slipper dark shales overlying the Belly River coal do occur and may be Bearpaw. Shales of Bearpaw age were recognized by Slipper on Highwood river and their presence in Turner Valley area is suspected.

EDMONTON FORMATION

According to Slipper the Edmonton formation has an estimated thickness of 1,300 feet in Turner Valley area. The best-exposed section is on Sheep river in the vicinity of the Black Diamond bridge and northwards. At the base of the formation in other parts of the foothills an Ostrea bed occurs. Search was made for this Ostrea bed in the Sheep River section, but it was not found, presumably because the base of the formation is not exposed. In the upper part of the section numerous *Unio* horizons were detected and *Vivipari* occur in certain of these *Unio* horizons.

PASKAPOO FORMATION

In most places any attempt to fix precisely the dividing line between the Edmonton and Paskapoo yields rather unsatisfactory results. As stated by Slipper, the greenish mudstones and sandstones of the Edmonton gradually grade upwards into the more massive and lighter-coloured sandstones of the Paskapoo. In a section exposed east of the bridge over Fish creek at Priddis, a conglomeratic sandstone with quartzite pebbles up to 3 inches in diameter overlies greenish clay shales presumed to be Edmonton in age. This conglomeratic sandstone may be of more than

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[1] Cairnes, D. D.: Geol. Surv., Canada, Mem. 61 (2nd edition) (1914).

local significance and may represent the base of the Paskapoo, since Allan[1] has reported that an erosional interval separates the Paskapoo and Edmonton in the plains region. The conglomeratic sandstone outcrops in various places on the ridge southeast from Priddis, but was not seen elsewhere.

STRUCTURE

The structure of the Turner Valley field as described by Slipper[2] is an

....."Anticlinal fold which is topographically indicated by Turner valley and its continuation southward...... The crest has been eroded to a considerable extent, forming a central valley up to 2 miles wide in which the underlying Benton shale is exposed. The Belly River beds form two parallel ridges on the flanks. The beds on the east limb have a general dip of 60 to 70 degrees and on the west of 50 to 60 degrees; but these dips vary considerably along the fold...... North of Sheep river, the Belly River beds on the eastern limb show irregular structure and farther north the strata exposed on the ridge which is apparently the eastern limb, dip west. North of the North branch there are four northwest trending sandstone ridges on the strike of the valley, all dipping 35 to 40 degrees west. It would seem, therefore, that the anticlinal structure of Turner valley is replaced by a series of overthrust faults at a point 4 or 5 miles north of Sheep river."

These relationships are clearly shown on the map that accompanies Mr. Slipper's report.

A study of the outcrops on the eastern flank of the Turner Valley anticline reveals a decided, local change in both dip and strike on the nose of a hill which extends westward from the main ridge to the centre of sec. 26, tp. 20, range 3. Southwest of this place the ridge forming the western flank of Turner valley is broken in sec. 22, tp. 20, range 3, by a deep cross-valley and the ridge north of the break is offset slightly to the east. These conditions are explained by assuming that a normal fault with downthrow to the north crosses Turner valley northeastward from about the centre of section 22 and passes north of the nose of the hill in section 26, such a fault being later than the folding of the Turner Valley anticline. A fault is shown on Slipper's map on section 22, but is not extended across Turner valley. However, the evidence of faulting on both the eastern and western flanks of the anticline is so conclusive that there is little reason to doubt that a zone of dislocation or faulting is continuous across Turner valley, it being recognized that the "Benton" shales might react to stresses in a manner somewhat different from that exhibited by the harder Belly River rocks and, therefore, might yield in a drag-fold. This zone of dislocation divides northern Turner valley into two areas, each with a distinct geological structure; the strata of the south part form the Turner Valley anticline, whereas the beds of the north part form a westward-dipping fault-block.

In the central part of Turner valley, in the vicinity of Sheep river, the anticlinal structure is well shown by outcrops of "Benton" shales on the banks of Sheep river, as well as by the flanking ridges of Belly River rocks extending north from the river. The anticlinal structure is, however, modified by a sharp syncline on sec. 6, tp. 20, range 2, which is clearly visible in outcrops of "Benton" shale on the river banks. To what extent faulting, if any, accompanied this synclinal folding is not evident from the outcrops. In the Vulcan well, drilled close to the centre of sec. 13, tp. 20,

[1] Allan, J. A.: Can. Inst. Min. and Met., April ,1925, p. 396.
[2] Geol. Surv., Canada, Mem. 122, p. 11.

range 3, the pre-Fernie limestone and dolomite were penetrated at a depth slightly more than 1,400 feet greater than in Royalite No. 4 well which was drilled on the west side of sec. 7, tp. 20, range 2, and an examination of the Vulcan well samples shows no evidence of any structure not explainable as due to sharp folding. It is concluded, therefore, that the Vulcan well was drilled in a continuation of the syncline visible on Sheep river and this conclusion is supported by the fact that a straight line joining the Vulcan well and the axis of the syncline on Sheep river corresponds in direction to the strike of the rocks outcropping on Sheep river. It is further concluded that for this part of the field the position of the synclinal axis can be plotted with a fair degree of accuracy. Northwest of the Vulcan well there are no available data regarding the course of the synclinal axis, but since the direction of the anticline swings somewhat to the west in the vicinity of, and as a result of, the transverse fault, the synclinal axis also probably swings to the west. The transverse fault is a very important feature, since if it did not exist the natural assumption would be that the folds continued with a uniform direction into and through the north part of Turner valley. But undoubtedly on the north side of the transverse fault the syncline has been offset eastwards. The position of the synclinal axis in the fault-block is not known, but as pointed out by Dr. O. B. Hopkins in conversation with the writer, unless some such structure as a syncline is present in the fault-block the thickness of the "Benton" as indicated by the observed dips would be much too great.

South of Sheep river the syncline cannot be definitely traced, but the thickness of "Benton", encountered in the Dallas well on sec. 20, tp. 19, range 2, strongly suggests the presence of the syncline at this location. On the map, therefore, the synclinal axis is assumed to extend from Sheep river to the Dallas well, but its position as shown should only be accepted as being approximate.

Drilling already done in the central part of Turner valley has demonstrated that the Vulcan syncline divides Turner Valley field into two anticlines, on both of which the prospects for oil and gas are excellent.

NEW BLACK DIAMOND ANTICLINE

This anticline is named after the New Black Diamond Oil Company which is drilling a well on it in sec. 3, tp. 20, range 3, about 2 miles west of the Turner Valley anticline where it crosses Sheep river. The fold is distinct from that of Turner valley from which it is separated by a thrust fault which brings "Benton" rocks into contact with the top of the Belly River formation, indicating a throw of almost 2,000 feet. About a half mile west of the fault there is a small syncline in which Belly River rocks lie at the level of the river. Southwest of this the outcrops clearly indicate an anticline with the crest near the northeast corner of sec. 34, tp. 19, range 3. The strata on the east flank near the crest dip 45 or more degrees to the northeast, but the angle of dip decreases toward the small syncline occupied by Belly River rocks. At one place about one-quarter mile northeast of the New Black Diamond well there is evidence of minor faulting. On the west flank for over a mile southwest the angles of dip are rarely over 20 degrees, but a very short distance west of sec. 34, tp. 19, range 3, there is a strongly faulted and folded area in which both the

Blairmore and "Benton" formations outcrop. Since the folding on this anticline is less sharp than on that of Turner valley the base of the "Benton" should be reached in the New Black Diamond well at a less depth than in the wells being drilled in Turner valley. The direction of the axis of this anticline has not been determined, but it is presumed to be roughly parallel to the Turner Valley structure.

Elevations of Wells

No. on Map	Name	L.S.	Sec.	Tp.	Range	Mer.	Elev.
							Feet
1	Madison	8	34	20	3	5	3,951·1
2	Seneca	1	34	20	3	5	3,986·6 (ground)
3	Stockmen No. 1	1	27	20	3	5	4,041·8
4	" No. 2 (Henderson)	7	27	20	3	5	4,036·3 (ground)
5	Midwest No. 1	8	31	19	2	5	4,028·4
6	" No. 2	3	24	20	3	5	4,023·8
7	Spooner	4	13	20	3	5	4,060·1
8	Vulcan No. 1	11	13	20	3	5	4,012·4
9	Dalhousie No. 1	4	18	20	2	5	4,002·1
*10	" No. 2	4	18	20	2	5	4,015·6
11	" No. 3	10	13	20	3	5	4,045·7
*12	" No. 4	8	13	20	3	5	4,011·7
13	" No. 5	16	30	19	2	5	4,035·9
14	Illinois-Alberta	14	12	20	3	5	4,007·8
15	New McDougall-Segur	14	12	20	3	5	4,013·8
*16	Royalite No. 1	14	6	20	2	5	3,958·9
*17	" No. 2	11	6	20	2	5	3,964·6
*18	" No. 3	15	6	20	2	5	3,913·7
*19	" No. 4	12	7	20	2	5	3,978·1
*20	" No. 5	13	7	20	2	5	3,984·2
21	" No. 6	16	31	19	2	5	4,000·0
22	Great West No. 1	2	7	20	2	5	3,902·9
23	" No. 2	......	7	20	2	5	3,900·6
24	Cooper-Nanton	2	7	20	2	5	3,901·1
25	McLeod No. 1	16	1	20	3	5	4,012·5
26	" No. 2	16	1	20	3	5	4,004·9
27	" No. 3	......	1	20	3	5	4,029·0
*28	Canada Southern	9	1	20	3	5	3,996·2
29	Indiana-Alberta No. 1	9	1	20	3	5	3,979·1
30	" No. 2	8	1	20	3	5	3,955·3
*31	Dolomite	8	1	20	3	5	3,971·5
*32	Okalta	1	1	20	3	5	3,958·9
33	Calmont	2	1	20	3	5	4,015·5
*34	Mid-Valley	12	5	20	2	5	3,976·4
*35	Locarno	5	5	20	2	5	3,985·7
36	Highland	5	5	20	2	5	3,985·8
37	Big Chief	5	5	20	2	5	3,993·4
38	British Dominion	4	5	20	2	5	3,985·7
39	Home No. 1	10	20	19	2	5	4,198·7
40	Home No. 1A (Advance No. 1)	14	20	19	2	5	4,203·2
41	Home No. 2 (Advance No. 2)	14	20	19	2	5	4,204·6
42	Dallas No. 1	11	20	19	2	5	4,204·4
43	New York-Alberta	6	20	19	2	5	4,211·0
44	Dutch-America	14	4	19	2	5	....
45	New Black Diamond	1	3	20	3	5	....
*	New Valley	4	6	21	2	5	3,872·9
*	Sentinel	......	8	20	2	5	3,857·9
Bench-mark on southwest corner sec. 6, tp. 21, range 2=							3,876·56
Bench-mark on northeast corner sec. 8, tp. 20, range 2=							3,863
Bench-mark on northeast corner sec. 36, tp. 19, range 3=							4,037·57
Bench-mark on northwest corner sec. 6, tp. 20, range 2=							3,963·14

* Levels by A. J. Childerhose, all other levels run by A. C. T. Sheppard.

DEVELOPMENTS AND OIL PROSPECTS

During the year 1926 Royalite No. 4 well has continued without diminution its production of more than 500 barrels of naphtha (73° Baumé) per diem from the dolomite horizon productive in this well at a depth of 3,740 feet. This well is on the anticline on the eastern side of the Vulcan syncline. From structural studies it is believed by the writer that this well was begun in westward dipping beds, but that at an horizon which corresponds approximately to the top of the Blairmore it passed through almost horizontal strata. The evidence further seems to indicate that below the top of the Blairmore the strata dip easterly and it is assumed that this easterly dip increases to the bottom of the well. The varying direction and angle of dip are due to a westward dip of the axial plane of the anticline as indicated by a study of the logs of Royalite No. 4 and No. 5 wells. Since the forces causing the folding acted from west to east and in many places in the foothills caused overthrust faults, it is thought that the westward dip of the axial plane of the eastern anticline is a response to the thrust from the west, tending to cause overthrusting, but in this case resulting in an asymmetrical fold. If this be so, it may be assumed that a similar condition will also be found to hold in the case of the west anticline of the Turner Valley anticlinal structure, but so far the evidence of this being the case, though very suggestive, is not conclusive. Because of the westward inclination of the axial plane of the eastern anticline, wells drilled on the eastern part of this anticline will probably pass through strata whose angles of dip increase with depth, whereas wells drilled on the westerly part of the west anticline are likely to encounter decreasing dips with depth if this fold is asymmetrical as is the eastern one. Wells that commence west of the axial line of the east anticline may if located close to the axial line, as in the case of Royalite No. 4 well, pass through the axial plane at a depth depending on their location. Such wells would, therefore, commence in westerly dipping beds, pass through horizontal beds at a depth where the axial plane was encountered, and continue in strata with increasing easterly dips for the remaining depth of the well. If the west anticline is also asymmetrical with its axial plane dipping west, the same conditions will affect wells located west of the axial plane. As the inclination of the axial plane is not known it is hazardous to attempt to predict the depths at which various horizons are likely to be encountered in wells. The changes in the angles of dip with depth also make it almost impossible to correlate well logs except at definitely determinable horizons, such as the top of the Blairmore. As previously stated the "Benton" contains at least three pebble horizons. Such horizons are indicated by samples from a number of wells, but since each well is drilled in strata with a local and perhaps varying rate of dip, therefore, the depth between pebble horizons as measured in different wells varies greatly, although it is believed that the pebbles occur at definite horizons. As data from well drilling accumulate, it may be possible to correlate wells by the use of the pebble zones of the "Benton," but at present the Geological Survey has not sufficient information to make correlation possible.

The Vulcan well drilled in the syncline in the centre of the field encountered the pre-Fernie dolomite more than 1,400 feet deeper than Royalite No. 4 well and has obtained production within the dolomite. It might seem, therefore, justifiable to assume that the strata will also be productive 1,400 feet down the dip on either flank of the main anticlinal structure, although it should be recognized that oil and gas in some fields may go to a much lower level on one part of the fold than on another part. In the absence of any data regarding the limits in depth at which production may be obtainable on the flanks of the main anticlinal structure, it only seems permissible to hope that any wells located within the Turner Valley structure and which can reach the pre-Fernie dolomite at any elevation above 850 feet below sea-level, corresponding to a depth of 4,865 feet in the Vulcan well, will prove to be productive, provided, of course, that the porosity of the productive horizon is continuous throughout the whole area. The extent of the productive area in a northwest and southeast direction depends on the extent of the productive horizon, as structural conditions seem favourable from the transverse fault in the north end of Turner Valley field to at least the vicinity of the Home wells in the south. Even on Tongue creek in the south the anticlinal structure is plainly discernible, but exact information is lacking as regards the amount of plunge of the anticline southward, a condition suggested by the disappearance of the "Benton" under later rocks at the south end of the map-area.

In addition to the two productive wells already mentioned, i.e., the Vulcan and Royalite No. 4, the Illinois Alberta on sec. 12, tp. 20, range 3, and McLeod No. 2 on sec. 1, tp. 20, range 3, have obtained a production of gas carrying naphtha of about the same grade as Royalite No. 4. Both of these wells are located on the western anticline of the Turner Valley anticlinal structure.

Besides the production that has been secured from the deep dolomitic horizon a number of wells have found favourable indications at other higher horizons. The most persistent of these is a sandstone member near the top of the Blairmore and from this horizon considerable flows of oil were reported in the New McDougall-Segur well on sec. 12, tp. 20, range 3, and in the Home No. 1 well on sec. 10, tp. 20, range 2. Smaller flows have also been encountered at the same horizon in other wells. Several other horizons in the Blairmore and Kootenay have yielded some gas. Prior to the discovery of production in the pre-Fernie dolomitic zone the total production of wet gas was from horizons within the Blairmore and Kootenay.

Two wells in the northern part of Turner valley are of special importance: the first, the Stockmen well, because of its situation with respect to the transverse fault cutting off the northern end of Turner valley; and the second, the Seneca well, because of its location with respect to fault-block structures.

The exact position of the transverse fault is not known, but it is close to the Stockmen well. The relationships indicated by the offset ridges of Belly River strata admit of only two possible interpretations: (1) a normal fault with fault-plane dipping northwestward in the direction of the downthrown side; (2) a thrust fault with fault-plane dipping southeast. The writer considers the Stockmen well to be northwest of the fault and if it be, the fault must be a normal fault with fault-plane dipping northwest. The displacement due to faulting may be small, but the increasing dips of the rocks from south to north on the eastern Belly River ridge in the neighbourhood of the fault show that the strata close to the fault are inclined at high angles, suggesting a zone of drag-folding of considerable width. Any well drilling through the fault zone must, therefore, pass through steeply inclined strata within the zone of drag-folding, but under ordinary conditions after passing through the fault zone and entering the upthrown side of the normal fault, should reach strata lower than any passed through on the downthrown side. Apparently, however, this is not the case in the Stockmen well, for after passing through the fault zone the well entered higher strata than those encountered at the fault on the downthrown side. This seems to contradict the explanation by normal faulting, but the suggestion is made that the Stockmen well after penetrating the fault zone passed into the northwest extension of the Vulcan syncline. This condition is suggested by a study of the general structure of the field. Southeast of the transverse fault, the main anticlinal axis is marked by a pronounced synclinal fold and if the course of the synclinal axis is continued northwesterly in the same relation to the general structure as it has where known, it would intersect the transverse fault almost directly south of the Stockmen well. Since the axial plane of the syncline probably dips west in conformity with the asymmetry of the anticlines on either side of it, it would be offset eastward north of the transverse fault whether this is a thrust fault from the southeast or a normal fault with downthrow to the northwest, and consequently would not affect the strata penetrated by the Stockmen well until it passed through the zone of faulting. Although this explanation of the apparent situation is more complicated than an explanation assuming thrust faulting, it is believed to be more in harmony with all the known data. Whichever explanation is accepted, the southeast side of the fault is the upthrown side and although close to the fault zone, due to a drag resulting from the movement along the fault, the strata dip abruptly toward the fault, they must be broadly arched away from it in a southeast direction. This arching, it is thought, should affect the beds in sec. 23, tp. 20, range 3, and since this locality is also on the anticlinal part of the Turner Valley structure, the conditions for an accumulation of oil and gas would be exceptionally good, but it must be remembered that the northern extension of the Vulcan syncline should also be present in this vicinity.

The Turner Valley field north of the transverse fault is a westward-dipping fault-block. It has been shown, however, that the strata within the fault-block must be faulted or folded, since otherwise the apparent thickness of the "Benton" would be much too great. Since the transverse faulting is later than the folding the syncline known elsewhere in the central part of the Turner Valley anticlinal structure may be continued in the fault-block structure, but north of the transverse fault it is probably offset to the east. In general, the structure of this fault-block is believed to be correctly shown in the cross-section on the published Sheep River map by S. E. Slipper, although if faulting or folding occurs within the fault-block, as here assumed, some modification of the section may be necessary. The strike fault on the east side of the fault-block may be regarded as indicating closure in that direction, since it has been proved in other faulted oil fields that even though a fault zone may have originally offered a channel of escape for oil and gas yet, it would be sealed by the deposition of mineral matter carried by the escaping solutions accompanying the oil and gas. Since in general the fault-block dips westward, it seems proper to assume that any oil and gas present in the fault-block would tend to migrate to the east towards the structurally high places, and if escape were prevented an accumulation would result against the fault. Such a concentration, however, might to a certain extent be modified by any faults or folds present within the fault-block. The Seneca well now being drilled on sec. 34, tp. 20, range 3, will be a test of the possibilities of oil and gas within this fault-block. Since the dip of the eastern strike fault-plane is unknown it is at present impossible to predict where or at what depth the fault will cut the prospective pre-Fernie productive horizon. Under the hypothesis adopted it would be expected that the largest production would occur where a well penetrated the productive horizon close to and west of the fault, although as already stated it is recognized that faulting or folding within the fault-block might have a distinct bearing on production. If, however, a well cut the fault before reaching the productive horizon the prospects for production would be negative. It appears to the writer, from an examination of all available data, that the Seneca well is located sufficiently far west of the strike fault to escape any possibility of penetrating it before reaching the lower dolomitic horizon of supposed Palæozoic age and the well is regarded as a good test of possible production in this fault-block.

The importance of the Seneca well as a test of the possibilities of obtaining oil and gas from fault-block structure is obvious to any one familiar with foothills structure. Within the foothills there are many fault-blocks comparable with the one on which the Seneca well is now being drilled. If the Seneca well be successful many of these other fault-blocks should offer favourable prospects for oil and gas in properly located wells and in structures where metamorphism does not seem more severe than in northern Turner valley. In a few known instances wells could commence in the Blairmore or even lower horizons. A successful termination in the case of the Seneca well, therefore, will greatly increase the amount of territory within the foothills where oil and gas prospects may be considered favourable.

GEOLOGICAL STRUCTURE IN THE WESTERN END OF CYPRESS HILLS, ALBERTA

By W. S. Dyer

CONTENTS

Illustrations

INTRODUCTION

During the summers of 1925 and 1926, while revising the geology of southern Alberta, the writer spent several weeks in the country southeast of Medicine Hat, including the west end of Cypress hills. Evidence was obtained which necessitates a fresh interpretation of the structure of the rocks underlying the hills, and as this structure appears favourable for the accumulation of oil or gas a description of it is given here.

Cypress hills are a prominent physical feature of the southern Great Plains. Beginning about 30 miles southeast of Medicine Hat they extend eastwardly for more than 80 miles. They reach their greatest altitude at the western end—Head of the Mountain—where they are 4,800 feet above the sea, or 2,600 feet above South Saskatchewan river at Medicine Hat. Eastward they sink until south of Swift Current they merge into the general level of the prairies. The central part of the hills, or the hills proper as McConnell[1] regarded them, is a plateau with the flat, featureless summit characteristic of this type of land form. The plateau is bounded by steep slopes which, in the western part of the hills, descend 800 feet to the more gently sloping country below. The summit of the plateau is treeless, but covered with rank-growing grasses upon which feed the stock belonging to the ranchers settled on the top of the hills. The steeper sides of the plateau are forested with poplar, spruce, and pine, and on them the Dominion Government has blocked out several square miles as a forest reserve. The country surrounding the plateau for distances of 15 or 20 miles is characterized by gradually diminishing slopes. It is, however, comparatively rugged, with many hills capped by the weathered product of the soft, underlying Cretaceous and Tertiary sands and shales, or by glacial drift. Near the plateau solitary buttes rise to elevations of 4,000 and 4,300 feet above the sea. Glacial erratics have been found as high as 4,300 feet, but above 3,800 feet the mantle of boulder clay is very thin.

Ready access can be had to almost any part of the hills. There are several dirt roads which are mostly in a fair state of repair, but after heavy rains are rendered almost impassable by the fine, clay character of

[1] McConnell, R. G.: Geol. Surv., Canada, Rept. of Prog. 1885.

the soil. An excellent road leads from Elkwater lake to the Canadian Pacific railway at Irvine, a distance of 20 miles, and another road leads directly from Eagle Butte to Medicine Hat, a distance of 35 miles.

Valuable assistance was rendered in the field by C. H. Crickmay, J. B. Webb, and A. Pentland.

STRATIGRAPHY

The rocks exposed in the western end of Cypress hills clearly show the gradual transition from marine to freshwater deposits, which occurs in the uppermost part of the "Mesozoic" in many parts of the northwestern United States and the Prairie Provinces of Canada. The lowest beds exposed are marine shales of Bearpaw or upper Pierre age, and above them follow without a break sandstones representing the shallow-water, near-shore phase of the retreating Pierre sea. These in turn gradually pass upwards into freshwater beds of sand or sandy clay, with fragmentary plant remains and lignite, which continue nearly to the top of the section. These freshwater beds are clearly divisible into three formations which agree with the threefold division made by Davis[1] of the rocks of the same age in Saskatchewan, i.e., in descending order, the Ravenscrag, Whitemud, and Estevan. The terminology used by Davis is, therefore, extended to include the beds of the west end of the hills. The Estevan beds are undoubtedly of Lance age, as Lance dinosaurs have been found in them on Rock creek in Saskatchewan. The Lance dinosaur "Triceratops" has also been reported by Sternberg from the Whitemud beds.[2] No dinosaurs have been found in the Ravenscrag beds, but plant remains and invertebrates of Lance or Fort Union age have been found in them. The upper slopes of the hills are covered by talus and by vegetation, and outcrops are rare. Toward the top of the plateau, however, silts and sands of uncertain age have been found, and capping the plateau there is a 25-foot bed of conglomerate which has yielded mammal remains of Oligocene age at localities north of East End, Saskatchewan.

Table of Formations

Geological time	Formation	Character and thickness of formations
Tertiary or Cretaceous	Ravenscrag	Yellow, crossbedded sandstone (continental). Thickness 128 + feet
Cretaceous	Whitemud	Light grey clays and fine sands weathering white (continental). Thickness 25 feet
	Estevan	Grey, buff, and brown sands and sandy clays with lignite (continental). Thickness 235 feet
	Fox Hills	Crossbedded, grey and brown, ledge-making sandstone (marine). Thickness 150 feet
	Bearpaw	Dark grey, soft shales (marine). Thickness 500–550 feet

[1] Davis, N. B.: Mines Branch, Dept. of Mines, Canada, No. 468, p. 9.
[2] Sternberg, C. M.: Can. Field Nat., vol. 38, No. 4, p. 69.

BEARPAW

The Bearpaw shales are exposed on both the north and south sides of Cypress hills, but especially well on the north side where highly fossiliferous outcrops can be found on any of the small creeks draining the hills, such as Boxelder, Ross, Gros Ventre, and Bullshead creeks. Within the area included on the accompanying Figure 2 they outcrop at two points only. On the upthrown side of the fault, in sec. 11, tp. 9, range 5, W. 4th mer., a thickness of 100 feet was found on the north bank of Bullshead creek, and a small exposure was seen in Medicine Lodge coulée west of Thelma, in sec. 8, tp. 7, range 3, W. 4th mer. They probably, however, form the bottom of a large part of Medicine Lodge coulée. They consist of dark grey or greenish grey, soft shales and contain marine fossils of Cretaceous age. At the outcrop on Medicine Lodge coulée a fragment of *Placenticeras* was found, and at the outcrop on Bullshead creek the following fossils were found: *Baculites ovatus*, *Baculites compressus*, *Placenticeras whitfieldi*, *Corbicula* sp., and *Pteria linguiformis*. The thickness of the formation is difficult to determine owing to the lack of exposures in the hills, but evidence was obtained on the creeks on the north side of the hills which made possible an estimate of the thickness. Certain fossil zones were found which were correlated from creek to creek and on certain creeks the distance of the lowest zone above the base of the formation and the highest zone below the top of the formation was determined.[1] In this way a thickness for the formation of between 500 and 550 feet was worked out.

FOX HILLS

This formation is best exposed in Medicine Lodge coulée. Sandstone ledges referred to it flank the hills on both sides of the coulée for several miles, but owing to the large amount of outwash from the hills they are exposed in only a few places. The best exposure is perhaps on the east side of the coulée in sec. 6, tp. 8, range 5, W. 4th mer. They also outcrop in a gully in the SE. ¼ sec. 30, tp. 9, range 1, W. 4th mer. The formation consists of grey, medium-grained, massive-bedded quartzose sandstone with a large biotite content. Crossbedding is prevalent, and the sand is sufficiently coherent to form ledges. Gentle slopes occurring between the steep sandstone ledges suggest the presence of shale, but the shale itself is nowhere exposed. Toward the base the sandstone becomes soft and shaly and passes gradually into Bearpaw shale. Toward the top the sands are incoherent and light grey and cannot be distinguished from the overlying Estevan beds. The upper part contains silicified wood and is probably continental in origin. Thinner bedded, calcareous sandstone in the middle of the formation yielded the following marine fossils of Fox Hills or Bearpaw age: *Linearia formosa*, *Inoceramus* sp., *Protocardia borealis*, *Mactra warrenana*, *Yoldia evansi*, *Protocardia subquadrata*, *Pteria nebrascana*, *Scaphites* sp., *Nucula* cf. *subplana*. Stanton[2] reports finding the following additional species at the same locality: *Tancredia americana*, *Callista nebrascensis*, *Scaphites nodosus* var. *quadrangularis*. He says, "Part of these species are in the Fox Hills beds in other regions and most of them occur in the

[1] This work will be described in full in a later publication.
[2] Stanton, T. W., and Hatcher, J. B.: U.S. Geol. Surv., Bull. 257, p. 55.

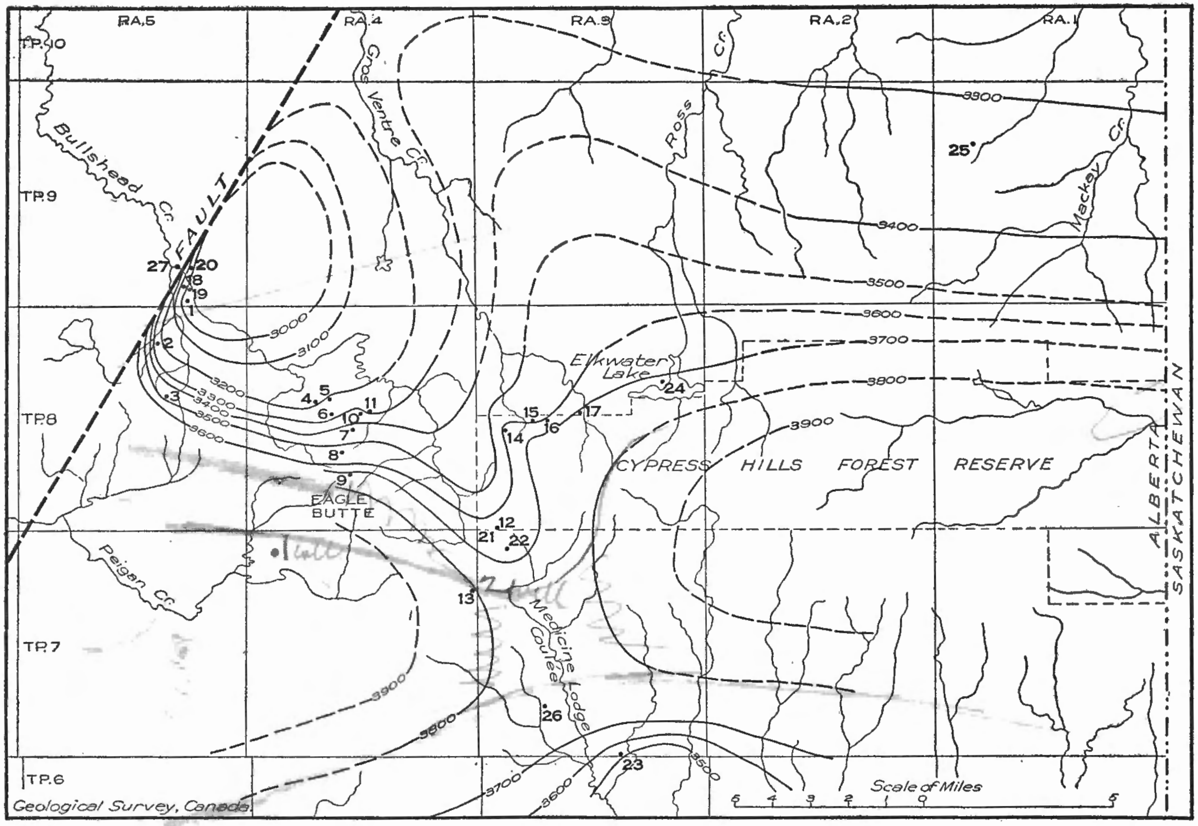

Figure 2. West end of Cypress hills showing structure contours representing top of the Bearpaw shale; numbered localities are places where the elevations of definite geological horizons have been accurately determined.

Pierre and Bearpaw shales. It has long been known that the faunas of the Fox Hills and the Pierre are too closely related to be considered really distinct."

ESTEVAN

The Estevan beds overlie the Fox Hills sandstone in Medicine Lodge coulée. They are also found along the road south of Elkwater lake, on the north side of the west arm of Elkwater lake, on Bullshead creek, and on Willow creek near Thelma. They consist of grey, buff, and brown sands and sandy shales with occasional rows of brown, ironstone concretions. In the lower part of the formation beds of compact, grey clay are found which on exposure weather to a bright red. Seams of lignite are present. The chief one, 2 feet in thickness, occurs about 175 feet above the base of the formation and 60 feet below the Whitemud beds.

This series of beds is placed in the Estevan of Davis because of its position between the Fox Hills sandstone and the Whitemud beds, and because of its continental origin. It differs somewhat from the Estevan beds of the more typical Saskatchewan localities in being more sandy, lighter in colour, and without the fine banding of clay and sandy clay, so characteristic of the beds in Saskatchewan. The thickness of 235 feet represents the interval between the ledgy sandstones of the Fox Hills and the Whitemud beds.

WHITEMUD

Numerous outcrops of these beds were found in Medicine Lodge coulée; and in the long, narrow, coulée which extends from the western end of Elkwater lake to the small lake in sec. 7, tp. 8, range 3, W. 4th mer., and thence southwestward to Medicine Lodge coulée. They are also found on Bullshead creek on the downthrown side of the fault, and at various points on Eagle butte. Owing to the pure white colour of the beds on exposure, they show up very plainly and serve as an ideal horizon marker for structural work. They were used for most of the structural work in the hills. Beds referable to the same formation have been found at many widely scattered points in southern Saskatchewan,[1] and at many localities the clay part of the beds is refractory. At Claybank they are made use of for the manufacture of fire-brick. No analyses have been made as yet of the clays in the western part of the hills, and it is not known whether they are refractory or not.

The following section of the formation was measured in Medicine Lodge coulée in sec. 31, tp. 7, range 3, W. 4th mer.

Section Through the Whitemud Beds

	Feet
Soft, light grey clay, weathering pure white	10
Black or dark brown (bentonitic?) clay	1
Yellowish green bentonite	½
Light grey, soft, very fine-grained sand, weathering pure wnite	10
Light grey clay apparently grading downward into the buff-coloured sands of the Estevan	4

[1] Dyer, W. S.: Present Summary Report, p. 33.

RAVENSCRAG

The yellow sands of the Ravenscrag formation were found above the Whitemud beds at numerous localities throughout the hills. They are exposed to best advantage, however, in Medicine Lodge coulée in sec. 31, tp. 7, range 3, W. 4th mer., and a good section was also obtained on the road south of Elkwater lake on the north side of the hills from 175 to 255 feet above the lake.

The formation consists of yellow and brown, crossbedded, medium-grained sandstone, and in many places includes sandstone concretions of large size. Beds of intraformational conglomerate consisting of clay pellets and pebbles of sandstone are also present. The contact with the Whitemud beds is not seen clearly, but in a gully on the north side of Eagle butte in the SE. ¼ sec. 20, tp. 8, range 4, W. 4th mer., beds of hard, grey shale and dark brown, soft, clay shale lie between the Whitemud beds and the yellow sands of the Ravenscrag. At the base of the formation the following freshwater fossils were found: *Campeloma producta*, *Campeloma cypressensis* (n.sp.), *Thaumastus limnaeiformis tenuis*, *Hydrobia recta*, *Unio* sp., and *Sphaerium* sp. These at least indicate a post-Bearpaw and probably a Fort Union age.

The greatest thickness measured for the Ravenscrag was 128 feet; but it is probably much greater. The upward extent of the beds could not be seen as the upper slopes of the hills are talus covered and afford very few outcrops.

STRUCTURAL GEOLOGY

METHODS USED IN WORKING OUT THE STRUCTURE

Two well-marked geological horizons permit the determination of structure in the hills. These are the Whitemud beds and the lignite seam in the Estevan formation. Elevations were obtained on these horizons at several points and a structure contour map was constructed which revealed a rather well-defined dome of considerable proportions. In addition a fault with about 500 feet throw was found on Bullshead creek.

Wherever possible the black, bentonitic clay band in the middle of the Whitemud beds was used, but in some cases only a small part of the beds, of uncertain stratigraphic position, was exposed. Elevations on any part of the Whitemud beds, however, would not leave room for great error as the whole formation is only 25 feet thick. Elevations on the Whitemud beds were determined by telescopic alidade and vertical circle at seventeen points as follows:

Elevations on the Whitemud Beds

No. of locality on Figure 2	Locality	Elevation of top of Whitemud formation	Elevation of reference horizon top of Bearpaw shale
1	Section 2, tp. 9, range 5, W. 4th mer.	3,349·6	2,949·6
2	Section 34, tp. 8, range 5, W. 4th mer.	3,622·8	3,222·8
3	Section 22, tp. 8, range 5, W. 4th mer.	3,881·9	3,481·9
4	Section 20, tp. 8, range 4, W. 4th mer., SE.¼	3,575·6	3,175·6
5	Section 20, tp. 8, range 4, W. 4th mer., NE.¼	3,613·6	3,213·6
6	Section 21, tp. 8, range 4, W. 4th mer., SW.¼	3,650·6	3,250·6
7	Section 16, tp. 8, range 4, W. 4th mer., NE.¼	3,870·9	3,470·9
8	Section 16, tp. 8, range 4, W. 4th mer., SW.¼	3,946·9	3,546·9
9	Section 9, tp. 8, range 4, W. 4th mer., NE.¼	4,118·9	3,718·9
10	Section 22, tp. 8, range 4, W. 4th mer., SW.¼	3,733·7	3,333·7
11	Section 22, tp. 8, range 4, W. 4th mer., SW.¼	3,695·5	3,295·5
12	Section 6, tp. 8, range 3, W. 4th mer., SE.¼	4,038·0	3,638·0
13	Section 25, tp. 7, range 4, W. 4th mer.	4,202·4	3,802·4
14	Section 18, tp. 8, range 3, W. 4th mer. (centre of)	4,007·3	3,607·3
15	Section 17, tp. 8, range 3, W. 4th mer., NE.¼	3,989·6	3,589·6
16	Section 17, tp. 8, range 3, W. 4th mer., NE.¼	4,006·4	3,606·4
17	Section 15, tp. 8, range 3, W. 4th mer.	4,113·5	3,713·5

The chief lignite seam in the Estevan beds occurs 60 feet below the Whitemud beds and approximately 175 feet above the base of the formation. Its elevation was determined at the following points:

Elevations on the Lignite Seam in the Estevan Formation

No. of locality on Figure 2	Locality	Elevation of lignite seam	Elevation of reference horizon top of Bearpaw shale
18	Section 2, tp. 9, range 5, W. 4th mer.	3,330·1	3,005·1
19	Section 2, tp. 9, range 5, W. 4th mer. (100 yards east of 18)	3,283·8	2,958·8
20	Section 11, tp. 9, range 5, W. 4th mer.	3,343·1	3,018·1
21	Section 6, tp. 8, range 3, W. 4th mer.	3,955·5	3,630·5
22	Section 31, tp. 7, range 3, W. 4th mer., ½ mile south of 4	4,003·9	3,678·9
23	Section 3, tp. 7, range 3, W. 4th mer.	3,837·0	3,512·0
24	Section 23, tp. 8, range 3, W. 4th mer. (north shore Elkwater lake)	4,050·0	3,725·0

A third horizon, which may prove useful in future work, is uppermost sandstone ledge of the Fox Hills formation. In Medicine Lodge coulée it occurs 150 feet above the base of the formation. It was used with reservation in the present work, because it could not be shown definitely that the same ledge was developed in all cases.

An important outcrop was one of Fox Hills sandstone in the SW. sec. 30, tp. 9, range 1, W. 4th mer. (point 25 on Figure 2). A ledge of sandstone is exposed there which undoubtedly represents an horizon closely equivalent to the ledge of sandstone occurring 150 feet above the base of the Fox Hills in Medicine Lodge coulée. The importance of the outcrop lies in the fact that it occurs a considerable distance away from the other exposures in the hills and hence affords an opportunity of determining the dip on the north side of the hills. The elevation of the top of the ledge is 3,516 feet, making the reference horizon 3,366 feet.

At point 26 on Figure 2 the top of the Bearpaw shale is 3,762·7 feet above sea-level, and at point 27 a Bearpaw exposure reaches an elevation of 3,350 feet, and the top of the formation is probably 100 feet higher at 3,450 feet.

In constructing the structure contour map the top of the Bearpaw shale was chosen as a reference horizon. Although not a well-marked horizon itself, it was chosen because it underlies the whole area, whereas the Whitemud formation, the best-marked horizon, owing to its higher position in the stratigraphic series, has been eroded at many points. The contour lines, therefore, represent elevations at the top of the Bearpaw shale.

DESCRIPTION OF STRUCTURE

The structure contour map (Figure 2) reveals a structure of rather large proportions. There are really two structures, an eastern and a western, separated by a syncline which runs through Medicine Lodge coulée. The beds in the syncline, however, are structurally higher than the beds on both the north and south sides of the hills.

The eastern structure is an elongated dome with its axis running approximately east and west. It has an actually determined closure on the north of 360 feet in about 6 miles, but the closure is probably greater than this, because it is natural to assume that the structure does not become abruptly flat under the higher part of the hills, but rather that the highest part occurs there. It is, therefore, fairly safe to add 100 to 200 feet to the closure. The northward dip actually extends to Irvine, as plane-table work on the fossil zone characterized by *Arctica ovata*, which occurs about 100 feet above the base of the Bearpaw formation, showed that on Ross creek dips exist of between 10 and 25 feet to the mile, to the north, with the rate increasing to the south. North of Irvine the rocks are very flat. Immediately south of the eastern structure the closure has not been determined, but is probably much the same as in Medicine Lodge coulée where a closure of 250 feet in 2 miles has been worked out. On the east the structure is closed by the regional dip of about 25 feet to the mile.

The western structure is also a dome. The closure on its north side is even greater than on the eastern structure, but it may be affected to some extent by the Bullshead Creek fault (page 23). Between point 3 and point 1, Figure 2, the Whitemud beds dip 532 feet in 2½ miles, and between points 9 and 4 the same beds dip 543 feet in 2 miles. Immediately south of the structure no data have been obtained, but the southward dip shown to exist in Medicine Lodge coulée probably extends to the west. It is quite possible that the Bullshead Creek fault extends southward through the hills and if so it would afford closure on the west side.

Cypress hills appear to be in part structural in origin. If this be the case then the anticlinal structure should extend several miles east of the area described in this report.

Faults

A fault of large dimensions for the plains occurs on the upper end of Bullshead creek in sec. 11, tp. 9, range 5, W. 4th mer. Figure 3 illustrates its position and character. At locality A, Figure 3, on the west side of the creek, the Whitemud beds occur near the top of the bank at an elevation of 3,349·6 feet, and below them are visible about 70 feet of slumped beds of the Estevan. About one-half mile farther down the creek, still on the west side, at locality B, there is a coal mine where the Estevan lignite seam is worked spasmodically. There are two or more openings on the seam; at a western opening the coal is 3,330·1 feet in elevation, whereas 100 yards to the east the same seam is at an elevation of 3,283·8 feet, or 46 feet lower. A little less than a half mile to the north on the east side of the creek there

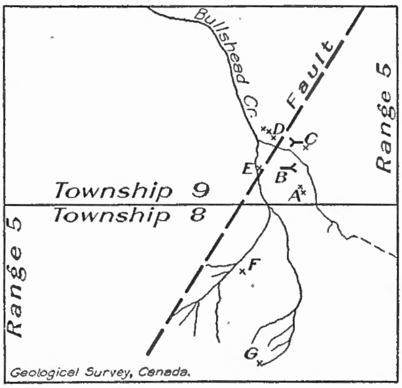

Figure 3. Position of fault, rock outcrops, and coal "mines" in the vicinity of Bullshead creek.

is a second coal mine where the elevation of the coal is 3,343·1 feet, and just east of the mine about 25 feet higher up the bank at locality C the Whitemud beds are again exposed. In the northern mine a dip of 28 degrees was measured on the coal seam in a direction north 120 degrees east. About 500 yards to the west on the north bank of the creek at locality D there is a 100-foot outcrop of Bearpaw shale. The elevation of the top of the Bearpaw here is 3,350·2 feet, but judging from the assemblage of fossils found (page 17) it would appear to be 100 feet or more short of the upper limit of the formation. Since the Whitemud beds are normally 400 feet above the Bearpaw the total vertical displacement must be at least 400 feet and possibly as much as 550 feet. At a point E, Figure 3, on a second small creek which flows into the Bullshead, a small outcrop of Bearpaw shale was found and at localities F and G the Whitemud beds were found. The strike of the fault-plane must, therefore, lie within the directions north 30 degrees east and north 60 degrees east, but it is probably nearer the latter figure which agrees with the strike of the coal seam in the northern mine. The eastward dip of the seam is very likely caused by the drag away from the fault on its downthrown side and the strike of the seam would compare closely with the strike of the fault-plane. This strong easterly dip is present only very near the fault, since a short distance to the east the beds first flatten out and then rise again into the flank of the main structure.

Two small faults occur in the gully on Graburn butte in sec. 30, tp. 9, range 1, W. 4th mer., where grey shales and soft sands which normally occur above the ledge-making sandstones of the Fox Hills have been down-faulted to a level with them. The vertical displacement is not known, but it is thought to be small. Owing to the small size of the exposure it was impossible to determine the direction of the fault-plane.

At certain points greater dips than the average were found, the cause of which could not be determined. Thus in NE. ¼ sec. 14, tp. 8, range 4, W. 4th mer., extensive ledges of Fox Hills sandstone and overlying Estevan beds dip to the east at angles approaching 45 degrees. This may be due to slumping or may be caused by a fault, the existence of which is not otherwise in evidence. In SE. ¼ sec. 20, tp. 8, range 4, W. 4th mer., in a small gully near the base of Eagle butte, a section showing Whitemud beds and Ravenscrag beds dips quite strongly to the north or northwest. At a point near the northern end of the outcrop a dip of 10 degrees was measured in a direction north 5 degrees east. However, the elevations of certain horizons were determined at different points, which gave a lower average dip of 175 feet a mile in a northwest direction. The lower dip is probably the true one for this locality, the large one being caused by slumping. In SE. ¼ sec. 16, tp. 8, range 4, W. 4th mer., a little more than half-way up Eagle butte, a dip of between 2 degrees and 5 degrees in a direction north 40 degrees east was measured; this was probably caused by slumping.

PROSPECTS FOR OIL AND GAS

The Cypress Hills structures are much better defined than any other structure found to date in Alberta, with the exception, of course, of those of the foothills. They are commensurate in area and rate of dip with the Kevin-Sunburst dome of northern Montana. They should prove to hold oil or gas provided the underground conditions are right. These include the presence of porous sands suitable for reservoirs, and beds capable of generating petroleum. The Milk River sandstones which hold so much gas at Medicine Hat might quite possibly be oil-bearing in this more pronounced structure. Other favourable horizons would be sand-stone beds in the Colorado, the Blairmore-Kootenay sands, the Jurassic (Ellis) sand or limestone, and the Palæozoic (Madison) limestone, all of which can be reached at reasonable depths. Oil showings were met with in the Drazan well in the Many Island field, in the Blairmore-Kootenay, and in the Jurassic. In the Roth well at Medicine Hat oil showings were found in the Ellis and at the top of the Palæozoic, and several strong flows of water indicating porous horizons were struck in the Colorado, Blairmore-Kootenay, and Palæozoic. These wells were both located on very much flatter structure.

It would require deeper drilling than at Medicine Hat to reach the same horizons in Cypress hills, owing to the higher stratigraphic position of the beds exposed. At Medicine Hat the Roth well No. 1 was started about 100 feet above the top of the Foremost beds. It reached the Milk River sandstone at a depth of 1,080 feet, the Blairmore at 2,520 feet, the Jurassic (Ellis) at 2,800 feet, and the Palæozoic at 3,000 feet. Adding 775 feet to these figures, which represents the distance between the horizon at which the Roth well was started and the top of the Bearpaw, figures are obtained showing the depths at which the various horizons would be reached in a well started at the top of the Bearpaw on Cypress hills, assuming there is no change in the thicknesses of formations. Thus the Milk River sandstone would be reached at a depth of 1,855 feet, the Blairmore at 3,295 feet, the Ellis at 3,575 feet, and the Palæozoic at 3,775 feet.

It would be best to choose sites for the first wells on the northern side of the structures, because more detail is known and greater dips exist.

Certain deep coulées dissect the hills and afford an opportunity of starting wells at the lowest horizons (the top of the Bearpaw). Such coulées are Medicine Lodge coulée, and the long coulée which extends from the western end of Elkwater lake to the small lake in sec. 17, tp. 8, range 3, W. 4th mer., and thence southwestward to Medicine Lodge coulée. Still another coulée runs from the corner of the road near the centre of sec. 20, tp. 8, range 4, W. 4th mer., westward to the Medicine Hat-Manyberries high road. A well located on the shores of Elkwater lake would begin about 50 feet below the Estevan coal seam, or 275 feet above the top of the Bearpaw.

The effect that the Bullshead Creek fault would have on the accumulation of oil or gas is very hypothetical. It is a dip fault, i.e., the strike of the fault-plane runs more or less parallel to the direction of dip, and, hence, is not of so much importance as would be the case with a strike fault.

LOGS OF WELLS

DRAZAN WELL NO. 1 OF THE MANY ISLAND OIL AND GAS COMPANY[1]

Location: NW. ¼ sec. 34, tp. 13, range 2, W. 4th mer.
Elevation: 2,368 feet.

—	Depth in feet	
	From	To
Recent—		
Surface sands and gravels	0	55
Foremost—		
Light-coloured clays and sandy clays (possibly Pale beds)	55	123
Grey sand, clay bands	123	159
Light grey and greenish clay, thin beds of sand	159	194
Brown, carbonaceous shale and coal	194	205
Very hard sandstone	205	219
Shale and clay, light grey, slightly sandy at intervals	219	289
Shale, grey, darker	289	335
Shale, grey and brown, coal seams, and oyster beds	335	357
Shale, blue-grey	357	375
Sandstone, greenish grey	375	390

[1] This log and the log of the Roth No. 1 well at Medicine Hat are introduced for the guidance of drillers. In each case the horizon at which the well started is about 100 feet above the top of the Foremost beds, which is about 775 feet below the top of the Bearpaw shale, the reference horizon in the structure contour map of Cypress hills.

DRAZAN WELL NO. 1 OF THE MANY ISLAND OIL AND GAS COMPANY—*Con.*

—	Depth in feet	
	From	To
Pakowki—		
Shale, blue-grey	390	460
Sandstone, hard	460	462
Shale, blue-grey	462	830
Shale, brown	830	840
Sandy shale, black	842	851
Shale, grey, dark, fissile	851	865
Shale, grey, dark, slightly sandy	865	885
Shale, blue-black, compact, and fairly hard, containing some fine sand, thin bands of bentonite	885	985
Shale, blue-black, and fine sand, steel-grey intermixed in variable proportions (Milk River sandstone probably occurs at the base of this interval)	985	1,115
Benton (*Colorado*)—		
Shale, blue-grey, fissile, laden with iron pyrites	1,115	1,172
Shale, dark, compact	1,172	1,195
Shale, blue-grey, iron-stained from pyrites	1,195	1,220
Shale, dark, compact, with fine sand partings, yielding *gas*	1,220	1,247
Shale, dark, compact	1,247	1,275
Shale and fine sand. *Gas*	1,275	1,375
Shale, dark. Bands of bentonite	1,375	1,427
Shale and find sand. *Gas?*	1,427	1,440
Shale, dark, with bands of bentonite	1,440	1,476
Dark, hard material	1,476	1,530
Soft, dark material	1,530	1,550
Soft, dark brown material	1,550	1,570
Hard, dark brown material, and shale	1,570	1,575
Soft and muddy, dark brown material	1,575	1,591
Hard, dark brown material, oyster shells	1,591	1,592
Hard, dark, sandy material and shale	1,592	1,630
Grey, soft material, muddy	1,630	1,660
Hard rock, 2 feet very hard	1,660	1,662
Dark brown, soft material, muddy shale	1,662	1,670
Hard rock for 1 foot	1,670	1,671
Soft, dark brown, sandy material	1,671	1,680
Very hard rock	1,680	1,681½
Dark brown, not very hard, but coarse, sandy material	1,681½	1,720
Dark brown, hard, and tough material, and fine sand	1,720	1,806
Hard, dark brown material, sand, some shale	1,806	1,810
Light brown, hard material, sand, and some shale	1,810	1,820
Hard, brown material, sand, and shale	1,820	1,830
Light brown, hard material, sand, and shale	1,830	1,840
Brown, hard material, sand, and shale	1,840	1,850
Light brown, hard material, turning grey, sand, and shale	1,850	1,860
Hard, brown material. Very hard rock from 1,869 to 1,870 feet	1,860	1,870
Hard, grey rock. At this point the jetting machine was discarded for the diamond drill	1,870	1,882
Shale and sandy shale	1,882	1,925
Shale	1,925	1,962
Shale, mostly missing	1,962	2,010
Sand and shaly sand, not all recovered	2,010	2,033
Missing	2,033	2,040
Shale	2,040	2,083
Shale, in a few places grading to sandy shale	2,083	2,103
Only a few inches of shale recovered	2,103	2,121
Shale, a few inches of sandstone at 2,160 feet	2,121	2,160
Shale	2,160	2,184
Core lost except for a few inches of shale	2,184	2,208
Shale	2,208	2,232
Shale	2,232	2,272
Shale	2,272	2,294

DRAZAN WELL NO. 1 OF THE MANY ISLAND OIL AND GAS COMPANY—*Con.*

—	Depth in feet	
	From	To
Benton (Colorado)—Con.		
Sandy shale to sandstone	2,294	2,298
Sandstone and sandy shale	2,298	2,335
Sandstone	2,335	2,360
Sandstone and sandy shale	2,360	2,425
Shale	2,425	2,430
Missing, except for a little shale and bentonite(?)	2,430	2,441
Sandstone and shaly sandstone	2,441	2,455
Sandstone and shaly sandstone. Bentonite reported at 2,456 feet	2,455	2,488
Sandy shale	2,488	2,520
Only 1 foot of shale recovered and some bentonite(?) at 2,530 feet	2,520	2,532
Shale, only part of the core recovered	2,532	2,582
Shales, dark	2,582	2,667
Blairmore-Kootenay—		
Yellowish grey, crossbedded sandstone	2,667	2,754
Shale, green	2,754	2,761
Shale, grey, green, and reddish	2,761	2,793
Sandstone, grey	2,793	2,808
Shale, black	2,808	2,816
Sandstone, grey	2,816	2,818
Shale, red	2,818	2,822
Oil showing 2,808 to 2,822 feet		
Shale, grey, sandy	2,822	2,835
Shale, chocolate red	2,835	2,840
Shale, grey	2,840	2,849
Shale, black	2,849	2,850
Shale, red	2,850	2,858
Shale, grey	2,858	2,870
Shale, black, carbonaceous in places	2,870	2,873
Shale, grey, sandy	2,873	2,889
Sandstone, grey	2,889	2,904
Coarse grey sandstone	2,904	2,937
Jurassic (Ellis?)—		
Light-coloured, hard, sandy limestone	2,937	2,942
Grey shale	2,942	2,963
Grey, arenaceous limestone and some shale	2,963	2,971
Hard, grey shale	2,971	2,976
Grey shale with streaks of limestone and sandstone	2,976	2,986
White or light grey, argillaceous limestone. *Showing of oil* between 3,005 and 3,018 feet	2,986	3,036
Grey, fine-grained, argillaceous limestone (*Jurassic fossils*)	3,036	3,045
Grey, fine-grained sandstone	3,045	3,058
Light grey, hard, argillaceous limestone	3,058	3,065
Very hard, grey, sandy shale	3,065	3,067
Pale grey, argillaceous limestone	3,067	3,069
Black shale	3,069	3,070
Soft, black shale	3,070	3,071
Grey, argillaceous limestone	3,071	3,076
Shale and limestone, grey, hard	3,076	3,080
Dark grey, soft shale	3,080	3,082
Dark grey shale	3,082	3,083
Grey limestone, hard	3,083	3,086
Grey shale	3,086	3,087
Dark shale	3,087	3,091
Grey, sandy shale	3,091	3,099
Black shale	3,099	3,103
Green, sandy shale with pyrite	3,103	3,110
Light grey, argillaceous limestone, with crystalline quartz	3,110	3,113

DRAZAN WELL NO. 1 OF THE MANY ISLAND OIL AND GAS COMPANY—*Con.*

—	Depth in feet	
	From	To
Jurassic (Ellis?)—Con.		
White, rather hard limestone, very porous, *with showing of heavy, black oil* between 3,113, and 3,123 feet	3,113	3,140
White, chalky limestone, porous toward top	3,140	3,155
Green, soapy shale	3,155	3,163
Hard, white limestone	3,163	3,165
Green shale	3,165	3,166
Hard limestone	3,166	3,174
Softer limestone	3,174	3,176
Hard, white limestone	3,176	3,178
Soapy, green shale	3,178	3,183
Grey limestone	3,183	3,184
Greenish grey, soft shale	3,184	3,190
Palæozoic (Madison?)—		
Light grey limestone, crystalline	3,190	3,193
Somewhat mottled (brown and grey), very hard limestone	3,193	3,195
Grey and white crystalline limestone	3,195	3,221
Cherty limestone not crystalline—grey and brown, mottled	3,221	3,233
Grey, sandy shale	3,233	3,234
Cherty, mottled limestone, grey and brown	3,234	3,240
Grey limestone—crystalline in places	3,240	3,258
Grey, non-crystalline limestone, with crinoid columns	3,258	3,269
Similar limestone, somewhat more crystalline	3,269	3,272
Grey limestone with crinoid columns	3,272	3,290
Hard, grey limestone, *Spirifer* at 3,292 feet	3,290	3,324
Hard, grey limestone, more crystalline. Large brachiopod like *Productus* at 3,325 feet	3,324	3,328
Grey limestone with very numerous crinoid columns and section of brachiopods	3,328	3,341
Grey, sandy limestone	3,341	3,345
Grey limestone full of crinoid columns and with some brachiopods, black chert from 3,353 to 3,354 feet	3,345	3,374
Dark, hard limestone with fossils	3,374	3,383
Dark grey shale—hard	3,383	3,390
Calcareous shale—hard	3,390	3,401
Calcareous shale—streaked with sandstone layers	3,401	3,435
Dark brown limestone	3,435	3,445
Grey, fine-grained, sandy limestone with black chert	3,445	3,540

ROTH WELL NO. 1, MEDICINE HAT

Location: Sec. 3, tp. 12, range 5, W. 4th mer.
Elevation: 2,329·76 feet.

—	Depth in feet	
	From	To
Recent—		
Glacial drift and gravel	0	110
Pakowki[1]—		
Grey clay shale	110	1,070
Milk River—		
Fine-grained, grey sandstone (*gas*)	1,070	1,130
Colorado—		
Blue-grey shale chiefly, with some interbedded grey sandstone and bentonite. Chert pebbles at 2,170 and 2,525 feet	1,130	2,525
Blairmore-Kootenay—		
Sandstone, coarse-grained, micaceous, *Strong water flow*	2,525	2,530
Coarse-grained, micaceous sandstone; black and white, medium-grained, and fine-grained sandstone	2,530	2,585
Light green, chocolate, and maroon shales with some specks of coal at 2,645 feet	2,585	2,720
Coarse, grey sandstone, brown sandstone, with some coal and carbonaceous shale	2,720	2,800
Upper Jurassic (Ellis)—		
Brown, calcareous shale	2,800	2,840
Sand at 2,845 feet, with *gas and water*; bluish black and black and white, very calcareous sandstone	2,840	2,860
Sandstone, medium-grained, slightly calcareous, *showing oil and asphalt, probably carried water as well*	2,860	2,870
Brown to white sandstone with calcareous cement, stained with red iron oxide	2,870	2,975
Brownish grey sandstone, 20 per cent limestone. Water flowing too hard to obtain sample. *Showing of heavy, black, asphaltic oil*	2,975	2,977
Palæozoic—		
Light brown to pink limestone with some greenish grey shale	3,000	3,010
Very light brown, chalky limestone	3,010	3,090
Cream-coloured limestone	3,090	3,120
Light brown limestone chiefly, with some oxidized, reddish limestone and brown, shaly limestone	3,120	3,620
Light brown, sandy shale	3,620	3,670
Dark grey, very calcareous shale	3,670	3,700
Grey and greenish grey shale, slightly calcareous	3,700	3,740
Light grey shale with a little calcareous material	3,740	3,860
Variegated anhydrite, reddish brown, flesh colour, white; with some greenish grey and red shale and subordinate dolomite	3,860	3,920
Light brownish grey, sandy, magnesian limestone	3,920	3,940

[1] Upper part probably Foremost, but cannot be separated.

OIL AND GAS PROSPECTS IN SOUTHERN SASKATCHEWAN

By W. S. Dyer

CONTENTS

Illustration

INTRODUCTION

The following report is based on information gained during a short expedition into southern Saskatchewan in August, 1926, to examine reported oil seepages and the geological formations and structure near these seepages, and near where drilling for oil or gas was contemplated or in progress. Most of the time was spent near Verwood, on the Weyburn-Lethbridge branch of the Canadian Pacific railway, where Big Muddy valley, an abandoned post-Glacial river channel, has deeply dissected the country and has opened to view many sections of rocks of Lance and Fort Union age. Short trips were also made to other points of interest, including: Claybank, 30 miles south of Moose Jaw, on the Gravelbourg branch of the Canadian National railway, where a very interesting example of deceptive structure caused by rock flowage occurs in rocks of Lance age; Souris river near Halbrite, on the Moose Jaw-Estevan branch of the Canadian Pacific railway, where good sections of Lance rocks were found; and East End, in Frenchman River valley, in the southeastern part of Cypress hills, where complete sections of the rocks from the Fox Hills sandstones to the Fort Union formation may be studied.

Dawson, McConnell, Dowling, Keele, and other geologists have visited the district in past years, and in 1916 the Geological Survey published Memoir 89 by Rose containing an exhaustive account of the Wood Mountain-Willowbunch coal area. It was left, however, for Davis [1] to make the greatest contribution toward elucidating the geology of southern Saskatchewan. He recognized the threefold lithological division of the rocks above the Fox Hills sandstone, which can be followed so far through the country, and which is so necessary to a proper understanding of the stratigraphy. He also outlined the extent of the most characteristic and best-defined division, which he named the Whitemud beds. Perhaps the most useful purpose served by the present paper is to emphasize the use which can be made of the Whitemud beds in problems of correlation in the district and as an horizon marker for future structural work.

[1] Davis, N. B.: Mines Branch, Dept. of Mines, Canada, No. 468.

PHYSICAL FEATURES

The physical features have been fully dealt with by Rose and need only to be summarized here. Southern Saskatchewan forms part of the Great Plains topographic province, which consists essentially of a more or less flat, base-levelled surface. It owes its flatness to the nearly flat-lying strata which underlie it and to base-levelling by normal erosion. The flatness has been accentuated by the filling in of hollows by Glacial drift which covers the whole area except where cut through by post-Glacial streams.

The most prominent physical features of the area are the two large remnants of Lance and Fort Union rocks, one of them forming Wood Mountain plateau which rises in the south-central part of the province and extends southward into the states of Montana and North Dakota, the other forming Cypress hills which rise in the southwestern part of the province and extend westward into the neighbouring province of Alberta. The surface of the plateaux, like the plains, consists of rolling prairie, but the plateaux are developed on Lance and Fort Union clays and sands, whereas the plains about them are underlain by the soft, easily eroded Pierre shales. With the exception of the eastern edge of Wood Mountain plateau, which is formed by Missouri coteau, the plateaux rise very gradually above the plains.

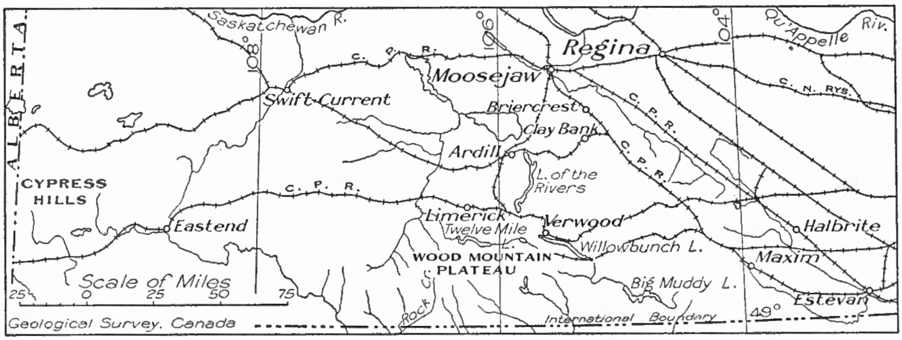

Figure 4. Sketch map of southern Saskatchewan.

Missouri coteau is a northeastwardly facing escarpment which rises rather abruptly above the plains, in some places to heights of more than 800 feet. It crosses the International Boundary about 10 miles east of longitude 104 degrees, runs northwestwardly, and passes about 15 miles west of Moose Jaw, northwest of which it gradually merges into the flat prairie. The escarpment is made more prominent by the enormous quantity of glacial debris which is heaped over it. This great thickness of debris is responsible for a rather distinctive type of topography which is best developed in a belt about 20 miles wide on the southwest side of the coteau. The large number of small, irregularly shaped hills, interspersed with small lakes, which are found here, give quite a wild and rugged aspect to the country.

A feature of considerable interest in the physiographic history of the Great Plains is the series of abandoned river channels which are so numerous in southern Saskatchewan and southern Alberta. Saskatchewan examples are: Frenchman River valley which cuts through the southeastern part of Cypress hills, and Big Muddy valley which dissects Wood Mountain plateau. Big Muddy valley was of special interest to the writer as its banks furnished rock exposures in the vicinity of many of the oil seepages. It is the abandoned channel of a large, post-Glacial river which must have carried water from the melting ice-sheet southeastwardly into Missouri river. The banks vary from 100 to 300 feet in height. There are two branches of the valley; the northern one is now marked by a chain of long, narrow, very shallow lakes, including lake of the Rivers and Willowbunch lake; the southern by Twelvemile lake, Montagne lake, and several other small lakes. The two branches join in tp. 3, range 5, W. 2nd mer.; and the main valley continues southeast across the International Boundary, in its course including Big Muddy lake.

STRATIGRAPHY

Table of Formations

—	Standard time divisions	Formations
Tertiary or Cretaceous	Fort Union?	Ravenscrag
Cretaceous	Lance	Whitemud
		Estevan
	Fox Hills	Fox Hills
	Pierre	Pierre

PIERRE AND UNDERLYING FORMATIONS

The Pierre shale is known to underlie all of southern Saskatchewan. No exposures were found in the area visited, but its presence is known by the fact that it has been penetrated in many water wells, especially in the vicinity of Limerick and Verwood. It consists largely of dark grey and greenish grey, soft, fissile shale containing many marine fossils. Its thickness is approximately 1,500 feet. Certain sandy beds found in its upper part in a deep well at Moose Jaw may possibly represent the extension eastward of the Belly River formation so well developed in Alberta. Thin beds of sandstone were also found in the Moose Jaw well somewhat below the middle of the formation. These sands may or may not extend to the south.

The Pierre passes downward into the "Colorado," a second marine shale formation about 1,300 feet thick and similar to the Pierre in character. Below the "Colorado" lie the sandstones of the Blairmore-Kootenay division[1] of the Cretaceous. A drill having entered the Pierre

[1]This includes the so-called Dakota formation of the plains.

would pass continuously through nearly 3,000 feet of much the same type of sediment before striking a change of formation, with the possible exception of the sandstone beds mentioned above.

FOX HILLS

This formation consists of rusty-brown, crossbedded sandstone and shale which represent the near-shore phase of the retreating Pierre sea. Its thickness is usually not greater than 75 feet in south-central Saskatchewan, although it is about twice this thickness in Cypress hills. The best exposures were found on Twelvemile lake where it forms bluffs along the northern shore.

ESTEVAN

The Fox Hills sandstones are overlain by the series of freshwater sands, shales, and clays which was for years termed the "Laramie." This term, however, is now applied only to certain beds at the type locality in the state of Colorado and has been dropped from Canadian geological literature. These beds are clearly divisible into three lithological units, a fact which was brought out most clearly by Davis. The lowest of the divisions, named by Davis the Estevan beds after the type locality, consists of grey to dark grey and brown sands, clays, and sandy clays with seams of lignite. Many of the clays are colloidal. They underlie the distinctive Whitemud beds at several points, such as along Souris river near Halbrite, on Big Muddy lake, in Big Muddy valley near Verwood, on lake of the Rivers, and even as far west as the west end of Cypress hills. Remains of dinosaurs of Lance age have been found in them on Rock creek. They are probably nowhere thicker than 200 feet and at East End are thought to be absent altogether, allowing the "Whitemud" to rest directly on the "Fox Hills."

WHITEMUD

These beds consist of light grey clays and sands which on exposure weather pure white. They contain the refractory clays which have been used with success to make fire-brick at Claybank. The typical white part of the beds is not as a rule more than 20 feet thick, but if certain grey clay beds overlying them be included the thickness in places would be 50 feet. The white beds are always of sand in their lower part and of clay in their upper part; at certain localities the two parts grade into each other, and at others they are separated by a carbonaceous band 6 inches to 1 foot thick. The Whitemud formation is probably of Lance age, as Sternberg[1] has reported finding the remains of "Triceratops," a typical Lance dinosaur, in beds which he considers Whitemud. The Whitemud beds are found at many points in Cypress hills and in Wood Mountain plateau where they can be very quickly detected on account of their pure white colour. They are also found on Souris river near Halbrite to the east of Missouri coteau, but are missing at Estevan and on Rock creek where the Ravenscrag beds lie directly upon the Estevan formation.

[1] Sternberg, C. M.: Can. Field. Nat., vol. 38, No. 4, p. 69.

An examination of samples of the Whitemud formation from several widely scattered localities shows that the sand varies greatly in coarseness of grain from east to west, being much coarser in the eastern exposures. It thus appears that the drainage at the time of deposition was from the east or northeast and that the sediments came from the Precambrian highlands of northeastern Manitoba. In contrast with this it is well known that the sediments of similar age in western Alberta were brought down by rivers from the mountain ranges to the west. Davis[1] found on testing samples of clay from the Whitemud formation that those from eastern localities were more refractory and purer than those from western localities, which is not contrary to the conception of drainage from the east or northeast. A section of the Whitemud formation occurring 2 miles southeast of Willows on the railway south of lake of the Rivers, follows:

	Thickness in feet
Purplish grey clay (Ravenscrag or Whitemud)	10
Pure white clay grading downward into white sand (Whitemud)	12
Brown, carbonaceous shale (Estevan)	1
Grey, banded sand and sandy clay with some brown beds (Estevan)	25

RAVENSCRAG

These beds are somewhat similar in appearance to the Estevan and consist of about the same type of rock. They are, however, lighter in colour, yellows and browns predominating, and they contain less colloidal clay. Their age is not known definitely, but invertebrate fossils and fossil plants have been found in them which suggest the Lance or Fort Union. The yellow Ravenscrag beds form most of the higher parts of the country in Wood Mountain plateau as well as in Cypress hills, but the best exposures are near East End, in Frenchman River valley. Here Davis measured the following section.

	Thickness in feet
Yellow silts and sands, calcareous	40
Hard, yellow sandstone	1
Yellow clays and silts	20
Dark grey, carbonaceous clay	6
Yellow sands and silts	15
Dark brown, carbonaceous clay	11
Fine sands and thin lignite seams	12
Dark brown, carbonaceous clay	1
Strong, greenish yellow clay	8
Dark grey clay	2
Yellow, silty clay	5
Yellow sands partly indurated	7
Hard, calcareous material	1
Yellowish, silty clay and sand	10
Black, carbonaceous clay	1
Light brown clay	6
Carbonaceous, silty clay and lignite seams	4
Yellow silts and silty clay	18
Yellow sands	16
Brown, carbonaceous shale	4
Lignite (poor quality)	4
Yellowish brown, sticky clay containing selenite crystals	27
Dark brown, carbonaceous clay	2
Brown clay showing iron oxide stains	5
Thin, irregular bed of limonite	½
Base of Ravenscrag formation, total thickness	226½

[1] A detailed study of the mineralogical composition and origin of the Whitemud formation is now being made by J. B. Webb.

	Thickness in feet
Fine, grey clay weathering white	11
Dark brown, carbonaceous clay	1
Light brown clay weathering white	5
White clay silt (mostly fine quartz)	6½
Lignite and carbonaceous material	1
Light grey clay (these two beds probably represent all of the Estevan)	2
White to grey sands made up of angular quartz grains, clay matter, and minute, limonite concretions	55
Probable base of Whitemud formation, total thickness	81½
Coarse, rusty sands and clays (Fox Hills)	125
Lead-grey shales (Pierre)	50
Total thickness of section	483

STRUCTURAL GEOLOGY

REGIONAL

The best horizon marker in southern Saskatchewan, as previously stated, is the Whitemud formation, and by determining the elevation of the contact of the white clay part of the formation with the overlying light grey or purplish grey clay at several points a very good idea of the attitude of the rocks was obtained. The elevation of this contact was obtained accurately by telescopic alidade and vertical circle at seven points in the vicinity of Verwood. At other points the elevation of the top of the white clay was determined approximately by reference to previously determined bench-marks, or to contour maps.

Elevations on the Top of the Whitemud Beds

	Feet above sea-level
Accurately determined—	
Verwood, sec. 6, tp. 7, range 27, W. 2nd mer	2,310·1
Between Verwood and Willowbunch lake, sec. 12, tp. 6, range 28, W. 2nd mer	2,287·5
Six miles northwest of Verwood, sec. 24, tp. 7, range 29, W. 2nd mer	2,286·4
Readlyn station, 4 miles north of Verwood	2,251·6
One mile west of Readlyn station, sec. 25, tp. 7, range 28, W. 2nd mer	2,257·3
Three miles west of Readlyn station, sec. 28, tp. 7, range 29, W. 2nd mer	2,287·4
South end of lake of the Rivers, sec. 12, tp. 8, range 29, W. 2nd mer	2,287·7
Approximately determined—	
East End	3,300
Twelvemile lake	2,500
Claybank	2,250
West of Claybank, sec. 19, tp. 13, range 25, W. 2nd mer	2,300
North end of lake of the Rivers	2,200
Big Muddy valley, west of Harptree	2,330
Souris river, west of Halbrite	1,900

This work brought out very clearly the flat-lying character of the strata. The regional dip is eastward. Between East End and Verwood, a distance of 140 miles, the dip is at the rate of 7 feet a mile, and between Verwood and Halbrite, a distance of 90 miles, it is at the rate of 4½ feet a mile. In the vicinity of Verwood, where detailed work was done, the greatest dip between any two points is 15 feet a mile. It should be remembered that by no means all parts of the country were visited, and it is quite possible that further structural work will reveal greater dips than these. For instance, it would appear by reading Davis' report that the Whitemud beds occur at considerably greater elevations on the high parts of Wood Mountain plateau south of Twelvemile lake in tp. 4, range 2, W. 3rd mer., than they do 6 miles to the north on the shores of the lake. If this is found to be the case there should be a rather strong northerly dip between these two points.

DECEPTIVE STRUCTURES CAUSED BY ROCK FLOWAGE

One mile south of Claybank in sec. 28, tp. 12, range 24, W. 2nd mer., there is a very interesting case of deceptive structure apparently caused by rock flowage, and, therefore, of a superficial character. Along the north side of Dirt hills, a part of Missouri coteau which rises higher than elsewhere, there is a series of knolls extending in an east and west direction along the face of the hills. Each knoll consists of a block of strata dipping usually westwardly[1] at angles varying from 25 degrees to 45 degrees, with the west sides showing gentle, grass-covered slopes, and the east sides steeper, rock slopes. In the knolls themselves the rocks have been little disturbed and the succession is seen to be as follows: at the base 100 to 200 feet of the soft, brownish, sandy, in many places colloidal, shale of the Estevan formation, then 20 feet of the pure white sands and clays of the Whitemud formation, and finally a small thickness of the yellow sands and shales of the Ravenscrag formation. Each knoll shows the same succession of rocks and there is no doubt that the beds in the different knolls are repetitions of the same series. Probably not more than 300 feet of beds are exposed in all. At first sight the knolls appear to be fault-blocks formed by the buckling of the earth's crust, but since the rocks in other parts of Saskatchewan are very flat and since the locality is far removed from any area of disturbance such as the Rocky mountains, or the Sweetgrass uplift, some other cause should be looked for. There are three possible explanations. The first is slumping or land-sliding of a normal character. This can be discounted as it would have to be assumed that undercutting had taken place of a kind which does not occur in such rocks. And in normal slides the blocks slide directly away from the hills, the strike of the resulting blocks being parallel to the face of the hill. At Claybank the strike of the blocks is nearly at right angles to the face of the hill. The second explanation brings in the agency of glaciers, but in this case it would be necessary to assume that the glaciers moved eastward or southeastward to bring the blocks into their present attitudes, whereas it is known that the ice moved either westward or southwestward.

The third explanation seems to be most in accord with the facts. The Estevan beds which underlie the Whitemud formation are quite highly colloidal and rock flowage is known to occur in them. In Souris river west of Halbrite they have assumed very peculiar contortional shapes apparently due to their having become thoroughly soaked with water and having, as a consequence, swelled and flowed to a considerable extent. Contortion was also seen in these beds at Claybank. Let it be supposed

[1] Although the dip is westward or southwestward, various directions have been noted, thus 280 degrees, 295 degrees, and even 180 degrees and 360 degrees.

that differential weathering took place at Claybank, and that at certain points water found its way downward into the flowable Estevan beds. These beds would then quickly wash away or become contorted. Hollows would be formed, and, finally, large blocks of the Whitemud beds would slide off into the hollows thus formed. The rather uniform western dip of the blocks would be caused either by a small vertical dip of the rocks to the west or by a westward or northwestward direction of the underground drainage, which might have existed at the time.

Since it is thus thought that the rocks were brought into their present position by superficial agencies, the rocks below the surface are probably more or less flat as elsewhere in the province. It would, therefore, not be advisable to drill for oil or gas at this locality.

OIL SEEPAGES

The first locality visited where an oil seepage had been reported was at Maxim about 25 miles south of Weyburn. Interest was first attracted to the place some years ago by the striking of gas in water wells, and recently a syndicate of Weyburn men was instrumental in having one of these holes deepened to a depth of 1,150 feet, by an ordinary water drilling outfit. The original well had met with some gas at a depth of 400 feet, and the deepened well struck a very small quantity of oil at a depth of 900 feet. This was in evidence at the time of the visit as a thin film floating on top of the drilling water. No log and very few reliable samples were available, owing to the method of drilling, but judging from the few isolated rock exposures which were found in the district, it would appear that the hole started in the Estevan beds and the oil came from a depth of 500 to 600 feet in the Pierre shale.

The second locality visited was the farm of J. D. O. Cayer 4 miles southwest of Verwood. At the time of the visit very little could be seen in the way of oil, but Mr. Cayer and Mr. Levengood who were in charge of drilling reported that a rather strong show of oil had been encountered in a water well at a depth of 560 feet. A log of the well was available, but it furnished no clue as to the formations passed through. Judging from the regional geology it was thought that the oil came from a depth of 200 to 300 feet in the Pierre shale.

On the farm of M. A. Bourk, 5 miles north of Readlyn, and 9 miles north of Verwood, a small oil seepage first became apparent in the spring of 1926 and was still apparent at the time of visiting the property. It occurs at a depth of 120 feet in a water well. Judging from the character of the samples of rock brought up from the bottom of the well and the regional geology the seepage appears to be from the Ravenscrag formation.

An interesting seepage was that reported by O. A. Lacell, a farmer living 3 miles north of Briercrest. This seepage occurred in a shallow depression in a field on his farm. Mr. Lacell reported that the oil was present in considerable quantities at one time, but at the time of visiting the property nothing could be seen. Pierre shale underlies the district about Briercrest and the seepage undoubtedly comes from this formation, but the depth in the formation could not be determined.

At Ardill a well has been drilled for oil to a depth of 1,100 feet, but no log of the well and very little reliable information of any kind was available. The well probably started close to the horizon of the Whitemud beds, as these beds are exposed a few miles away at the north end of lake of the Rivers at about the same elevation as the top of the well.

At Limerick the Great Plains Oil and Gas Company has been formed for the purpose of drilling for oil at a location a few miles northwest of the village. There are no outcrops within a radius of 15 miles of the village and, hence, no idea could be formed of the geological structure. The district is undoubtedly underlain by Pierre shale, as the numerous water wells which have been drilled strike a rock described as "soapstone," evidently the Pierre, a few feet below the surface.

OIL AND GAS PROSPECTS

Two facts appear unfavourable to the finding of oil or gas in any quantity in southern Saskatchewan: (1), the flat-lying character of the strata; and, (2), the character of the formations themselves. As mentioned above, the greatest amount of dip found is 15 feet to the mile and the regional dip 4 to 6 feet a mile. Unless greater dips than these be found oil accumulation cannot be expected. No oil can be expected from the freshwater formations of Lance and Fort Union age, and, up to the present, oil in quantity has never been found in the "Pierre." The uppermost horizon at which oil or gas would be expected, judging from productive fields, is the lower part of the Colorado shale. To reach this horizon would mean drilling at least 2,000 feet and probably considerably more. Oil, however, might originate in the Pierre, and the oil which has been found in the seepages undoubtedly comes from this formation. There is thus a chance of striking oil in the Pierre, although the quantity would probably be small. It should be remembered, however, that the finding of oil seepages or small pockets of gas does not necessarily imply the presence of either oil or gas in commercial quantities. Only when the geological structure is favourable and when horizons are present that are suitable as containers of oil and gas, is it reasonable to expect important reservoirs. Until such structure has been located, any drilling operations undertaken should be regarded as being purely speculative. By no means all parts of southern Saskatchewan were visited and it is quite possible that future work will reveal geological structures favourable to the accumulation of oil or gas, in which case it would be advisable to drill. In all future structural work it would be wise for oil geologists to consider the Whitemud formation as the most clearly defined horizon marker and to use it as the basis of their structural determinations.

GEOLOGY AND OIL PROSPECTS IN THE VICINITY OF RIVERHURST, SASKATCHEWAN

By P. S. Warren

CONTENTS

INTRODUCTION

The town of Riverhurst, Saskatchewan, is situated close to South Saskatchewan river, in sec. 26, tp. 22, range 7, W. 3rd mer. It is connected with Moose Jaw by a branch of the Canadian National railway. It lies in the centre of a well-settled farming district.

The striking of a considerable flow of gas in a shallow well drilled at the river's edge near Riverhurst led to a geological investigation of this area by the writer in the summer of 1926. A traverse was made along South Saskatchewan river in a canoe, and a general survey of the surrounding country was made in a motor car. In this work the writer was assisted by Mr. L. V. Bell.

PHYSICAL FEATURES

Riverhurst is situated on the extreme western part of the second prairie level at an elevation of 1,953 feet. Immediately west rises the irregular line of hills, known over a wide area as the Missouri coteau, or merely "the Coteau," which separate the second and third prairie levels. Near Riverhurst the general elevation of the Coteau is about 2,500 feet, though some hills rise to over 2,600 feet. The general nature of the hills is that of a plateau, the surface features being due partly to erosion and partly to the irregular moraines of glacial drift which cover the area. East of the Coteau the surface is rolling, with only occasional hills, and is largely the result of glacial moraine. The elevation is about 2,000 feet, with a general slope to the east.

South Saskatchewan river is the main drainage channel through the area. Its banks are high, especially where the river cuts through the Coteau. Here banks 500 feet in height are not uncommon. Near Riverhurst they are not more than 300 feet high. Tributaries are as a rule small and inconsequential. This lack of drainage results in a large number of small, blocked lakes throughout the area, especially in Coteau region, where the drainage is least developed.

GENERAL GEOLOGY

The vicinity of Riverhurst is underlain by a series of dark grey or blue shale. Fossils collected from these beds testify to their marine origin and place their position definitely in the Montana group of the Cretaceous system. There are two such shale beds in the Montana group with similar lithologic characteristics and fossil content—the Pakowki shale and the Bearpaw shale. These shale beds are separated by the Belly River sandstone. To which of these formations the shales in question should be ascribed is not evident from a study of the beds in the immediate vicinity of Riverhurst, but a study of their field relationships over a wide area leaves little doubt that the shales in question are of Bearpaw age. This conclusion was deduced from the following facts.

Observation on South Saskatchewan river between Rapid narrows in tp. 17, range 3, W. 4th mer., and Empress in tp. 23, range 1, W. 4th mer., show that the Belly River-Bearpaw contact dips northeast at the rate of about 5 feet a mile. On the main line of the Canadian Pacific railway between Irvine and Maple Creek this contact dips east at the rate of about 8 feet a mile.[1] Also, from the record of a well drilled at Moose Jaw[2] the dip of the contact from Maple Creek to Moose Jaw is to the northeast at the rate of about 5 feet a mile. These points establish the general dip of the Belly River-Bearpaw contact through this area.

On South Saskatchewan river east of Empress no exposures occur for a distance of about 70 miles, thus creating a gap between the known horizons south of Empress and the beds exposed west of Riverhurst. In tp. 21, range 18, W. 3rd mer., exposures of sandstones and sandy shales occur, extending to a height of 50 feet above the river. Farther down the river, these sandy beds were observed, overlain by dark grey, marine shales. It was considered that the sandy beds represented the eastward extension of the Belly River series and that the overlying dark shales represented the Bearpaw. This contention is supported by the fact that the elevation of the contact between the formations at this place permits a dip of 6·6 feet a mile to the northeast from the Rapid Narrows section which corresponds closely with the general dip of the Belly River-Bearpaw contact through this area, as was demonstrated previously.

The contact between the Belly River and the Bearpaw may be traced down river for a considerable distance by intermittent exposures, showing a gradual dip to the east. The point where the contact passes below the river could not be determined, but it is probably about range 13. The contact may be obtained again in the well at Riverhurst, demonstrating a dip to the northeast of 6·5 feet a mile.

The Belly River beds exposed on South Saskatchewan river west of Riverhurst differ in certain lithologic characteristics from those exposed on the river south of Empress. Yellowish sands and sandy shales are quite characteristic and a small coal seam occurs. The uppermost beds, in places, are a hard, massive sandstone. In its eastern extension, the formation takes on more and more the characteristics of marine sedimentation. R. G. McConnell reports finding fossils in a hard sandstone bed in these exposures.[3]

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[1] Personal communication from Mr. W. S. Dyer.
[2] Geol. Surv., Canada, Mem. 116, p. 43.
[3] Geol. Surv., Canada, Ann. Rept., vol. I, pt. C, p. 60 (1886).

The thickness of the Belly River beds cannot be measured in any of the sections along the river, as the base is not exposed. The log of the Imperial Oil Company's well which was drilled on SE. ¼ sec. 30, tp. 19, range 11, W. 3rd mer., and commenced at about the top of the Belly River, shows that formation to be at least 455 feet thick and probably 620 feet. The latter figure agrees well with the thickness of the Belly River sandstone as shown in the log of the Moose Jaw well. The log of the Imperial Oil Company's well shows the formation to be more shaly than in its typical development farther west.

The Bearpaw shales, which overlie the Belly River series, become quite sandy in places, especially in the vicinity of the mouth of Swift Current creek. These sandy beds appear to be only a local phase, as they were not observed in the excellent exposures along the river in range 16, W. 3rd mer., or in the vicinity of Riverhurst. The formation is quite fossiliferous and such characteristic Montana marine forms as *Pteria linguiformis* E. and H., *Inoceramus barabini* Morton, *Gervillia recta* var. *borealis* Whiteaves, *Arctica ovata* (M. and H.), *Protocardia borealis* Whiteaves, *Callista deweyi* M. and H., *Baculites compressus* Say, and *Scaphites nodosus* Owen are abundant.

Beneath the Belly River series lie the Pakowki shale and the Colorado shale. These formations are not exposed in this vicinity. The log of the Imperial Oil Company's well shows the combined thickness of these formations to be about 1,715 feet, which thickness corresponds quite closely with that shown in the log of the Moose Jaw well. The two formations resemble each other so closely in lithologic characteristics that it is impossible from the data supplied in the log of the Imperial well to distinguish them. The Milk River sandstone, which separates the two formations in southern Alberta and forms the upper gas horizon in the Medicine Hat field, is apparently absent in this locality.

No structure could be determined from any of the exposures in the river section, apart from the regular easterly dip of the strata.

ECONOMIC GEOLOGY

A well was drilled near Riverhurst at the edge of the river in L.S.D. 4, sec. 33, tp. 22, range 7, W. 3rd mer., which struck a flow of gas at a depth of 518 feet. The elevation of the well is 1,698 feet and the driller reports a gas pressure of 97 pounds. The log of the well was not analysed systematically, but information obtained from the driller demonstrates that the gas horizon occurs in the Belly River sandstones. The top of the Belly River is about 100 feet below the surface, or at an elevation of about 1,500 feet above sea-level. A second well is being drilled by the Riverhurst Oil and Gas Company close beside the first, at an elevation of 1,710 feet. The samples from the second well are being sent to Mr. C. C. Ross, Supervisory Engineer, Calgary. From information supplied by Mr. Ross, the well has reached a depth of 230 feet. Sands, believed to represent the Belly River series, were encountered at a depth of about 120 feet, and the same formation continues to the bottom of the hole.

The occurrence of gas in commercial quantities in the vicinity of Riverhurst depends largely on the structure of the underlying strata. Rock exposures in the immediate neighbourhood of the present operations are of little value in determining structural details. The uniformity of the dip of the beds exposed on the river to the west of Riverhurst leads to the conclusion that there is little probability of the necessary structure occurring in this neighbourhood.

It is not considered that the gas encountered in the Belly River sandstone in the Riverhurst well will prove of commercial importance, as this horizon has not been productive of large quantities of gas in other areas in the west. The Milk River sandstone, which forms an important gas horizon in southern Alberta, is apparently absent here. The nearest horizon likely to be productive of a large supply of gas or oil, dependent on the presence of the necessary structure, is the sandy beds at the base of the Benton shale. This horizon should occur at Riverhurst at a depth of about 2,430 feet. The Imperial Oil Company tapped these beds in their well to the west of Riverhurst and report them to be unproductive.

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

By E. D. Ingall

The Borings Division of the Geological Survey accumulates and studies records of borings made in any part of Canada, in order that the geological information thus rendered available may be utilized for the guidance of operators, and in geological research. The control of boring operations in the Prairie Provinces and the North West Territories is vested in the North West Territories and Yukon Branch of the Department of the Interior which has legal power to enforce regulations and to collect well logs and samples from borings for gas or oil on lands controlled by the Federal Government. These samples are subsequently forwarded to the Borings Division of the Geological Survey for intensive study, chiefly with a view to obtaining more extended knowledge of the geology in depth. Information is also gained directly from operators drilling for water supplies, etc.

The list given (Table I) presents in tabular form particulars of the records of borings in the Prairie Provinces added to the files of the Borings Division during 1926. Where need arose and time permitted, the series of cuttings from certain wells were intensively studied by laboratory methods and the results placed at the disposal of operators and geologists.

The tabulated records represent borings which add to our knowledge of the belt of country in Alberta and Saskatchewan extending from the International Boundary at Coutts-Sweetgrass district, through Medicine Hat, Acadia Valley, Wainwright, Ribstone, and Coalspur districts. In the western foothills zone records were received representative of Nanton, Turner Valley, and Bow River districts. Besides the preceding, some scattered records were received of borings elsewhere in Saskatchewan and the North West Territories. The two borings in Mafeking district, Manitoba, are situated close to the Cretaceous escarpment, where in depth the borings pass down into the underlying Palæozoic limestones and dolomites, etc. A number of logs of shallow wells have been added to the files, giving further knowledge of the occurrence of water in the recent deposits of clay, gravel, etc., overlying the bedrock formation.

Although a great deal of boring in search for gas and oil has been done throughout the Prairie Provinces and North West Territories by a number of different companies, the systematic campaign of the Imperial Oil Company and its subsidiaries has been the most prominent feature for the past few years. This organization has shown the greatest courage and persistence, and they have through the assistant chief of the geological staff, Mr. John Ness, assisted greatly in the work of the Borings Division. Table II gives particulars of the borings made by this company and its subsidiaries.

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

TABLE I

Location						Description						Remarks
L.S.	Sec.	Tp.	Range	Mer.	At or near	Year drilled	Elevation (above sea-level) Feet	Depth in feet covered by records	Yield	Depth in feet to first rock	Number of samples received	
						COUTTS-SWEETGRASS						
	36	5	11	W. 4th.	Coutts.	1923–26	....	2,050	....	....	108	United Oils of Alberta, Ltd.
5	32	1	11	W. 4th.	"	1924–25	3,275	1,600	....	....	46	Imperial Oil Co., Deadhorse coulée No. 2
9	SW. 29	1	11	W. 4th.	"	....	....	2,797	....	....	....	Canadian Oil and Refining Co.
						MEDICINE HAT						
4	6	13	5	W. 4th.	Crescent Heights	1924–25	2,330	3,940	Gas.	....	88	Roth No. 1
						ACADIA VALLEY						
	NE. 34	25	4	W. 4th.	Oyen.	1924–26	2,800	....	Gas.	....	....	Fuego Oil Co., No. 1
						IRMA-WAINWRIGHT						
16	28	45	9	W. 4th.	Irma.	1924–26	2,252·16	1,600	....	....	128	Irma Oil Development Co.
11	30	45	6	W. 4th.	Wainwright	1926	2,233	2,100	....	....	66	Western Consolidated Oils, Ltd., No. 2
						RIBSTONE						
3	16	45	1	W. 4th.	Ribstone.	1926	2,077	300	....	....	34	Advance Ribstone, No.1 A. (Prospect hole)
1	1	46	1	W. 4th.	"	1926	....	630	....	....	32	Ribstone Oils, Ltd., No. 1
	2	46	1	W. 4th.	"	1926	....	28	....	....	8	Ribstone Oils, Ltd., No. 3 (Prospect hole)

COALSPUR

10	3	49	21	W. 5th..	Coalspur..	1924–26	3,776·3	4,300	Gas....	10	149	Northwest Co., Coalspur No. 2

NANTON

12	4	14	2	W. 5th..	Rice creek	1924–26	....	5,740	....	....	190	Imperial Oil Co., Rice Creek No. 2

TURNER VALLEY

5	5	20	2	W. 5th..	Turner valley	1925–26	3,993·4	2,000	....	....	108	Big Chief Oil Co. No. 1
	5	20	2	W. 5th..	“	1925–26	3,985·7	3,790	....	....	257	British Dominion Oil and Development Co.
2	1	20	3	W. 5th..	“	1926	4,015·5	1,610	....	....	186	Calmont No. 1
10	13	20	3	W. 5th..	“	....	4,043·7	3,280	Gas and oil	....	17	Dalhousie No. 3, formerly Alberta Southern No. 1
11	20	19	2	W. 5th..	“	1926	4,204·4	2,750	....	....	104	Dallas Oil Co. No. 1
	SE.¼ 7	20	2	W. 5th..	“	1926	3,902·9	5,160	....	....	509	Great West No. 1
10	20	19	2	W. 5th..	“	1926	4,198·7	1,520	....	....	....	Home Oil Co. No. 1A, formerly Acme
14	12	20	3	W. 5th..	“	1926	4,007·8	3,770	Gas and oil	....	53	Illinois-Alberta Oils, Ltd.
16	1	20	3	W. 5th..	“	1926	4,004·9	3,645	“	....	125	McLeod Oil Co., No. 2
14	12	20	3	W. 5th..	“	1926	4,013·8	2,060	....	....	209	New McDougall-Segur
	6	21	2	W. 5th..	“	1926	3,872·9	1,420	....	....	48	New Valley Oil Co.
13	7	20	2	W. 5th..	“	1925–26	3,983·08	3,140	....	....	92	Imperial Oil Co., Royalite No. 5
16	31	19	2	W. 5th..	“	1926	3,999·17	2,960	....	....	62	Imperial Oil Co., Royalite No. 6
1	34	20	3	W. 5th..	“	1926	3,986·6	2,680	....	....	266	Seneca Oils Ltd.
1	27	20	3	W. 5th..	“	1926	4,041·8	2,150	....	....	173	Stockmens Oil Co.
11	13	20	3	W. 5th..	“	1926	4,012·4	4,880	....	....	181	Vulcan Oil Co.

BOW RIVER

15	12	25	5	W. 5th..	Bow river	1925–26	....	1,900	....	....	194	Imperial Oil Co., No. 1

TABLE I—*Continued*

Location						Description						
L.S.	Sec.	Tp.	Range	Mer.	At or near	Year drilled	Elevation (above sea-level) Feet	Depth in feet covered by records	Yield	Depth in feet to first rock	Number of samples received	Remarks
						LESSER SLAVE LAKE						
	14	74	4	W. 5th..	Lesser Slave lake	1926	....	390	....	12	....	International Oils, Ltd.
						FORT VERMILION						
	34	107	8	W. 5th..	Fort Vermilion	1925–26	....	230	....	....	31	Black Rock Petroleums No. 2
						SASKATCHEWAN						
	2	52	28	W. 3rd..	Lloydminster	1926	....	300	....	140	29	Driller, H. J. Keck, C.P.R. well
7	31	6	21	W. 3rd..	East End.	1924–25	3,000	1,600	Gas....	15	38	Eastend Oil and Gas Co., No. 2
4	33	22	7	W. 3rd..	....	1926	....	527	....	....	23	Riverhurst Oil and Gas Co.
2	9	29	25	W. 2nd..	....	1926	....	300	....	....	4	Simpson Oil Co.
						MANITOBA						
4	23	43	26	W. 1st..	Mafeking.	1925–26	....	770	....	10	31	E. Doherty (H. Johnson well)
12	2	43	26	W. 1st..	" ..	1926	....	1,630	....	....	43	E. Doherty
	SE. 18	25	23	W. 1st..	Grandview	1926	....	130	....	....	2	W. T. Ross

OTHER BORINGS

	SW.¼ 36	32	17	W. 4th..	Craig-myle	1923		400	Gas....		20	Prairie Natural Gas
	3	37		W. 4th..	Northern Montana	1926		2,600			210	Monalta No. 1, U.S.A. Close to International Boundary, included for comparison
	4	43	25	W. 4th..	Ponoka...	1916–25	2,645	2,890	Gas....		42	Provincial Government
												SHALLOW BORINGS
	NE.¼ 36	29	3	W. 5th..		1926		96	Water, soft			Soldiers' Settlement Board
	SE.¼ 17	34	20	W. 4th..		1926		112	"	79		" "
		32	11	W. 4th..		1926		220	"	86		" "
	26	46	12	W. 3rd..	Richard..	1926	2,400	54	"			Duncan Bros., for Wm. McDougall
	26	46	12	W. 3rd..	Mayfair...	1926	2,500	88	Water, iron			Duncan Bros., for Wm. Reinhardt
	36	48	13	W. 3rd..	Rabbit Lake	1926	2,800	25	Water, hard			Duncan Bros., for Louis Schliemann
		44	13	W. 3rd..	Rossall...	1926		115	Dry....			Duncan Bros.
		44	13	W. 3rd..	" ..	1926	1,900	37	Water, iron			"
		44	13	W. 3rd..	" ..	1926		30	Water, soft			"
		44	14	W. 3rd..	Denholm.	1926	2,000	37				"
	4	44	13	W. 3rd..	Richard..	1926	2,200	44	Water, hard			Duncan Bros., for Oscar Poupart
	26	45	13	W. 3rd..	Whitkow.	1926	2,500	33	"			Duncan Bros., for Nick Buziak
	9	48	13	W. 3rd..	Redfield..	1926	3,000	60	"			Duncan Bros., for Cornelius Martens
	7	45	18	W. 2nd..	Melfort...	1926						Melfort Municipality (information as to water supply)
	18	29	25	W. 2nd..		1926		452	Water, poor		107	Donovan farm
13	30	11	28	W. 2nd..	Ardill....	1926		692		14		Canadian Well Supply, per John Hinton
										Total...	4,093	

TABLE II

Records Received from the Imperial Oil Company and Subsidiaries.

Name of well	Location: LS.	Location: Sec.	Location: Tp.	Location: Range	Location: Mer.	Elev. Feet	Depth Feet	Remarks
ALBERTA								
Ribstone No. 1	....	5	45	1	W. 4	....	1,895	Rotary. Drilling in progress
Grattan or Fabyan No. 1	16	18	45	7	W. 4	2,044	2,730	Samples 10 to 2,730 feet. Rotary
Grattan No. 1	....	4	45	8	W. 4	1,938	1,900	
Grattan or Fabyan No. 2	2	14	45	8	W. 4	1,954	2,015	Rotary
Misty Hills No. 1	NE. ½	29	32	4	W. 4	2,451·1	3,304	Samples from 10 to 3,300 feet
Tit Hills	NE. ¼	17	39	7	W. 4	2,267	3,500	Samples from 10 to 3,490 feet
N.W. No. 2 (McMurray No. 2)	SW. ¼	27	85	7	W. 4	1,525–50	820	
Christina Well No. 1	....	......	87	7	W. 4	....	500	
N.W. No. 1	SW. ¼	16	87	7	W. 4	(about 1,320)	504	Samples from 10 to 500 feet
Rogers-Imperial No. 1	9	29	1	11	W. 4	3,275	2,797	Standard
Dead Horse Coulée No. 2	5	32	1	11	W. 4	....	2,758	Samples 10 to 1,600 feet. Rotary
Burdett No. 1	....	8	11	11	W. 4	....	3,055	Rotary. Drilling in progress
Erickson Coulée No. 1	13	8	1	12	W. 4	....	2,918	Standard. Drilling in progress
Red Coulée	NE. ¼6	5	1	16	W. 4	3,545·0	2,706	Samples 10 to 2,695 feet
Twin Butte No. 2	SE. ¼	20	3	29	W. 4	4,470·7	4,375	Samples 10 to 4,375 feet
Twin Butte No. 1	NE. ¼	14	4	30	W. 4	4,506·9	2,780	Samples 10 to 2,760 feet
Rice Creek No. 2	12	4	14	2	W. 5	....	5,747	Samples 10 to 4,020 feet. Standard. Drilling in progress
Willow Creek No. 1	NE. ¼	29	14	2	W. 5	....	3,600	Samples 10 to 3,600 feet
Alberta Associated Oils No. 2	SW. ¼	7	16	2	W. 5	....	2,600	
Highwood No. 1	3	36	18	3	W. 5	....	1,531	Standard. Drilling in progress
Royalite No. 1 (Cal. Pet. Prods.)	14	6	20	2	W. 5	3,932·7	3,924	
Royalite No. 2 (Dingman)	11	6	20	2	W. 5	3,415	3,170	
Royalite No. 3	14	6	20	2	W. 5	3,911·3	2,830	
Royalite No. 4	12	7	20	2	W. 5	3,976·77	3,740	Samples from 290 to 3,740 feet
Royalite No. 5	13	7	20	2	W. 5	3,983·08	3,477	Samples from 246 to 2,520 feet. Rotary
Royalite No. 6	16	31	19	2	W. 5	3,999·17	3,079	Samples from 2,129 to 2,189 feet. Rotary. Drilling in progress
Dalhousie No. 1 (Alberta S. No. 1)	4	18	20	2	W. 5	4,002·1	3,600	Standard. Drilling in progress
Dalhousie No. 2 (Alberta S. No. 2)	4	18	20	2	W. 5	4,014·44	3,700	
Dalhousie No. 3 (Alberta S. No. 1)	10	13	20	3	W. 5	4,043·7	3,345	
Dalhousie No. 4 (Alberta S. No. 2)	8	13	20	3	W. 5	....	1,400	
Dalhousie No. 5	16	30	19	2	W. 5	4,035·9	2,957	Standard. Drilling in progress

Bow River No. 1	15	12	25	5	W. 5	....	4,970	Standard. Drilling in progress
Coalspur No. 1	10	3	49	21	W. 5	....	1,490	Samples from 10 to 1,490 feet
Coalspur No. 2	10	34	49	21	W. 5	3,776·3	4,300	Samples from 10 to 3,890 feet. Standard
Dalhousie No. 6	....	13	20	3	W. 5	....	880	Standard. Drilling in progress
Pouce Coupé No. 1	10	26	80	13	W. 6	....	3,057	Samples from 24 to 3,057 feet

SASKATCHEWAN

Rush Lake	SE. ¼	30	19	11	W. 3	....	2,335	Samples from 10 to 2,270 feet
Muddy Lake	11	7	39	22	W. 3	1,897·4	2,900	Samples from 40 to 2,900 feet
Boundary No. 1	4	9	1	27	W. 3	....	3,960	Samples from 10 to 3,960 feet

NORTH WEST TERRITORIES

Windy Point No. 1 (Great Slave lake)	....	......	......	....	......	....	1,806	
Discovery No. 1	....	......	......	....	......	....	1,025	40 miles below Norman, near Bosworth creek
Discovery No. 2 (new test)	....	......	......	....	......	....	1,600	150 feet from No. 1. Samples from 30 to 1,600 feet
"D" Location	....	......	......	....	......	....	2,304	2 miles from discovery. Samples from 10 to 2,304 feet
"B" Location	....	......	......	....	......	....	450	8 miles below Norman, near Bluefish creek. Samples 10 to 490 feet
"C" Location No. 1	....	......	......	....	......	....	1,705	Opposite Bear island, on left bank. Samples 10 to 1,705 feet
"C" Location No. 2	....	......	......	....	......	....	3,057	Samples from 60 to 3,057 feet

During the closing months of 1926 all samples and records which were not confidential, covering the Prairie Provinces and North West Territories, were placed at the disposal of members of the geological corps of the Hudson Bay-Marland Oil Company for purposes of study preparatory to the campaign of drilling contemplated by that company. As a result of this co-operation, not only has great assistance to the company resulted, but the records of the Borings Division have been considerably enriched.

The intensive study of the cuttings from the sedimentary strata by microscopic and chemical methods is necessarily tedious and time-consuming and so can only be undertaken for specially selected wells. This matter is dealt with by D. C. Maddox of the Borings Division staff, who is entrusted with this phase of the work, and who reports as follows:

LABORATORY REPORT

During the first three months of 1926 considerable time was devoted to the search for possible foraminifera horizons in the Cretaceous formations of the Western Plains. With this object in view, the following eleven wells were selected as being as representative as possible of the general area in question, and samples from these wells were examined:

Northern Manitoba Oil Company	Sec. 33,	tp. 42,	range 26,	W. P. mer.
Canora	" 25,	" 30,	" 4,	W. 2nd mer.
Estlin	" 13,	" 15,	" 19,	W. 2nd mer.
Rush Lake	" 30,	" 19,	" 11,	W. 3rd mer.
Muddy Lake	" 7,	" 39,	" 22,	W. 3rd mer.
Boundary	" 9,	" 1,	" 27,	W. 3rd mer.
Misty Hills	" 29,	" 32,	" 4,	W. 4th mer.
Viking	" 6,	" 49,	" 12,	W. 4th mer.
Pelican Rapids	" 6,	" 79,	" 17,	W. 4th mer.
Willow Creek	" 29,	" 14,	" 2,	W. 5th mer.
Pouce Coupé	" 26,	" 80,	" 13,	W. 6th mer.

All of the above wells were drilled with a standard cable tool outfit. In addition to the samples obtained from these wells a few samples were examined that had been obtained by a rotary core-drilling outfit in the Wainwright area, from British Petroleums well No. 3, sec. 29, tp. 45, range 6, W. 4th mer., at depths of 1,751 to 1,759, 1,815 to 1,820, 1,896 to 1,904, 1,921 to 1,929, 2,044 to 2,050, and 2,080 to 2,086 feet.

In the case of the eleven above-mentioned wells the samples were taken at intervals of 50 feet, unless special considerations caused a variation from this rule. No samples were taken from sandstone horizons and horizons of known non-marine character. In the case of the Estlin well, the sample interval was very irregular, some samples covering an interval of over 100 feet. In all, 335 samples were examined.

In the disintegration method which was used in the isolation of the foraminifera, weighed charges of the samples were allowed to disintegrate in water. When disintegration appeared to be complete, the mud was screened through a 200-mesh screen, the openings of which averaged 0·074 mm. in diameter. The material remaining on the screen was dried, weighed, and examined with the binocular microscope. During the course of the disintegration process certain observations as to the colour and comparative volume of the shale were made and recorded, as also some observations on the nature of the supernatant liquid as regards clarity, etc.

The depths between which samples were taken and the depths of the samples from which foraminifera were obtained in these wells are given below:

Name of well	Depth limits	Depth of samples yielding foraminifera
	Feet	Feet
N. Manitoba Oil Co......	30 to 620	30 to 80 and 260 to 310
Canora..................	40 to 875	200 to 250, 375 to 445, 485 to 825
Estlin....................	65 to 2,420	65 to 441, 642 to 1,000, 1,052 to 1,500, 1,545 to 1,725, 1,809 to 1,819, 1,847 to 1,905, 2,068 to 2,070
Rush Lake.............	500 to 2,270	500 to 560, 650 to 660, 750 to 860, 950 to 960, 1,200 to 1,310, 1,700 to 1,760, 2,240 to 2,260
Muddy Lake............	350 to 1,810	1,140 to 1,150, 1,450 to 1,460, 1,500 to 1,510, 1,700 to 1,710
Boundary................	800 to 2,610	800 to 810, 1,000 to 1,060, 1,550 to 1,560, 2,000 to 2,010, 2,150 to 2,210, 2,300 to 2,360
Misty Hills.............	940 to 2,910	940 to 1,050, 1,440 to 1,750, 2,190 to 2,200, 2,340 to 2,400, 2,490 to 2,500, 2,590 to 2,600, 2,800 to 2,810
Viking....................	730 to 2,137	1,085 to 1,125, 1,195 to 1,245, 1,505 to 1,510, 1,635 to 1,745, 1,935 to 1,940, 2,130 to 2,135
Pelican Rapids...........	110 to 780	110 to 150, 500, 600, 680 to 770

Samples from certain of these wells were found to be much too indurated to disintegrate in water without further treatment. This was the case in all samples from the Willow Creek well and to a less extent in samples from the Pouce Coupé well. In addition to the isolation of foraminifera much other detailed work was done on the disintegrated samples as regards minerals and fossils other than foraminifera. For this work quantitative conventions were used, so that within certain limits the amount of these constituents in the original samples could be stated. For comparative work this method offers many advantages over the more qualitative method. The average size of the sand grains was also noted and recorded. The foraminifera were mounted on slides for future reference. The work was of necessity very slow and detailed, the presence in most of the disintegrated samples of numerous grains of quartz, pyrite, or other minerals, in most cases obscured the presence of the foraminifera and it was as a rule necessary to pass the whole charge through a small nest of screens to remove the grains larger or smaller than these microscopic fossils.

A number of samples from the Royalite No. 4 well, L.S. 12, sec. 7, tp. 20, range 2, W. 5th mer., were subjected to an alternate freezing and thawing process for several months in an attempt to disintegrate them for examination for foraminifera. At the end of the process the samples, however, did not appear to have broken down to any appreciable extent.

The general results as far as the foraminifera were concerned were rather disappointing. The actual number of these fossils obtained from any one sample was in general very low. In many cases, more especially in the samples from the British Petroleum No. 3 well, arenaceous forms only were obtained and these in many cases were badly pressed out of shape. In many cases, also, the internal cast or mould of the shell was the only part preserved. Many broken forms were also found. In general the number of genera and species appeared to be low. No foraminifera were obtained from either the Willow Creek or Pouce Coupé wells.

It might be possible, however, by more extended work, to get better results. The interval of 50 feet is admittedly a long one and, had time permitted, this interval might with great advantage have been reduced to 10 feet. It should also be remembered that the Borings Division officials exercise no control over the sampling process, either as regards the size of the samples taken or as regards any treatment such as washing which the samples may undergo previous to their delivery to the division. The adoption of methods of disintegration other than soaking of the samples in water might facilitate operations.

During the period July 20 to September 4, D. C. Maddox was stationed at the Calgary office of the North West Territories and Yukon Branch of the Department of the Interior to assist in the work of sample examination. The methods employed were of necessity more rapid and less detailed than those in use at the Borings Division, but were even then probably too slow for the amount of work on hand. In rapid preliminary work of this kind a very large proportion of the time taken in examination is occupied by the mechanical operations of sorting samples, opening up the sample bags, laying out the sample, and returning the sample to the container when it is examined. About 900 samples were examined in this period, over 400 of these being also bottled as type samples for the area in question.

In addition to the work done at Calgary considerable work was done on samples obtained from wells bored in the western provinces. The methods of examination varied widely as regards time consumed and detail desired. Most of the samples from Turner Valley field were rewashed previous to examination. Many samples from the more central region of the Great Plains, such as the Ribstone-Blackfoot area, were disintegrated and examined for foraminifera. Five hundred and seventy samples in all were examined.

Some work was done during the course of the year on samples of rocks considered by the sender possibly to contain oil.

On December 3, 1926, Mr. J. G. Spratt, of the Geological Survey, Department of Mines, reported for temporary duty at the Calgary office of the North West Territories and Yukon Branch of the Department of the Interior, to assist the officers of that department in the work of sample examination. The results of his work will form in future some part of the work done by the Borings Division of the Geological Survey.

OTHER FIELD WORK

Geological

B. R. MacKay. B. R. MacKay completed a systematic geological survey of the coal measures and associated formations in the vicinity of Mountain Park, Cadomin, and Lovett collieries, Alberta. The area mapped is about 1,200 square miles and lies between latitudes 52 ° 45′ and 53° 15′ and longitudes 116° 30′ and 117° 30′. Four geological sheets, each 15 minutes of latitude by 30 minutes of longitude, on a uniform scale of 1 mile to 1 inch, will be published, with a report.

M. Y. Williams and W. S. Dyer. M. Y. Williams and W. S. Dyer completed a systematic geological resurvey of an area between latitudes 49° and 50° 30′ and longitudes 109° and 115° 30′ in southern Alberta and adjacent parts of Saskatchewan. The results of this work will be incorporated in a report and on a map on a scale of 8 miles to 1 inch, dealing with an area extending north from the International Boundary to latitude 52°.

P. S. Warren. P. S. Warren was engaged in the geological examination of an area in central Saskatchewan and Alberta lying between North Saskatchewan river and latitude 54° and between longitudes 108° and 112°.

J. F. Wright. J. F. Wright studied further the geology and gold deposits of the Rice Lake and Beresford Lake areas, eastern Manitoba. A final report and map dealing with the area are now being prepared.

C. H. Stockwell. C. H. Stockwell investigated recently discovered lithia-bearing deposits east of Point du Bois, east of Bernice lake, and in the vicinity of Cat lake and Hawk lake, all in southeastern Manitoba. A complete report is in process of preparation.

W. A. Johnston. W. A. Johnston investigated the surface geology of southern Manitoba. The results of this field work will appear in a series of map-sheets on a scale of 1 inch to 3 miles. Two sheets, the Brandon and Dufferin sectional maps, have been completed.

C. M. Sternberg. C. M. Sternberg collected dinosaurian and other fossil remains from the upper part of the Edmonton formation along Red Deer river above Drumheller, Alberta. The most important specimens collected were: a nearly complete skull of *Hypacrosaurus*, a disarticulated skull of *Saurolophus*, two fairly complete skeletons of *Ornithomimus*, part of a skeleton including a complete fore-limb of a small *Albertosaurus*, and fish remains. Among the fish remains are representations of two genera not hitherto reported from the Edmonton beds.

Topographical

A. C. T. Sheppard. A. C. T. Sheppard revised the Sheep River map-sheet which embraces the Turner Valley oil field, Alberta. Mr. Sheppard also mapped, on 1 inch to 800 feet with 50-foot contour interval, a coal-bearing area near Brûlé Mines, Alberta, where there are important colliery workings.

J. W. Spence. J. W. Spence completed the topographical mapping of the coal-bearing area around Mountain Park, Cadomin, and Lovett collieries, Alberta. Four topographical sheets, each 15 minutes of latitude by 30 minutes of longitude, on a uniform scale of 1 inch to 1 mile, will be issued.

J. A. Macdonald. J. A. Macdonald commenced mapping, on a scale of 1 inch to 1 mile, the east half of the Bragg Creek sheet, Alberta, between latitudes 50° 45′ and 51° and longitude 114° 30′ and 114° 45′. This area and that of the Jumpingpound sheet mentioned below are of prospective importance in view of the developments taking place in the Turner Valley oil field.

D. A. Nichols. D. A. Nichols commenced mapping, on a scale of 1 inch to 1 mile, the east half of the Jumpingpound sheet, between latitudes 51° and 51° 15′ and longitudes 114° 30′ and 114° 45′. This area also is of prospective importance for exploration for petroleum and natural gas.

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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.