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PRELIMINARY REPORT

THE STRATIGRAPHY AND STRUCTURE OF TURNER VALLEY, ALBERTA

BY

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The Stratigraph and Structure of Turner Valley, Alberta

INTRODUCTION

Turner Valley gas and oil field is on the eastern edge of the foothills, southwest of Calgary, Alberta. The field, as at present developed, extends from Highwood River northwest for 17 miles, almost to Quirk Creek.[1] The northern part of the field is a valley flanked by northwesterly trending ridges. Southward the valley is abruptly terminated by the northeasterly trending Longview Hill, which is an erosional rather than a structural feature. Since the discovery, in the autumn of 1924, of naphtha-laden gas in Royalite No. 4 well, drilled in l.s. 12, sec. 7, tp. 20, range 2, the Turner Valley field has been undergoing continuous development, with periods of great drilling activity. From 1924 to 1936 drilling was mainly done to obtain a production of gas with naphtha, but when, in June 1936, it was established by Turner Valley Royalties well that crude oil existed in the west flank of the Turner Valley structure, in the same porous zones as the gas and naphtha, drilling was undertaken wholly for the production of crude oil. During the period from 1924 to the end of 1938 a gas-bearing area almost a mile wide and an oil-bearing area only slightly less than 2 miles wide have been determined for certain areas. The whole west flank of Turner Valley for a distance of 17 miles and an additional northwest extension of yet undetermined length is structurally favourable for the occurrence of crude oil.

The writer, during the last 2 years, has made a study of the stratigraphy and structure of the field as revealed by the wells and by detailed plane-table surveys of the whole area. The results of the field work for 1937, with such subsurface information on wells as was then available, were published in the Preliminary Report 38-22, with maps and cross-sections. As drilling proceeded it became obvious that the faults shown were too steeply inclined in these sections. The present report, with accompanying maps, is a revision of the earlier report and maps and cross-sections of the south half of Turner Valley. In addition, it contains information obtained by field and office study in 1938 of the north half of Turner Valley and its extension northwest to Whiskey Creek, in tp. 22, range 4, W. 5th mer., where the structure plunges strongly northward and presumably ends.

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[1] Shown on previous maps as North Branch of Sheep River.

STRATIGRAPHY

Table of Formations

Paskapoo formation
Sandstone alternating with shale; thin coal seams; non-marine.

Edmonton formation
Sandstone and shale; coal seams; non-marine; thickness unknown, presumed to be 1,100 to 1,600 feet.

Bearpaw formation
Shale with some bands of sandstone; some coal seams; marine fossils; a near shore deposit; thickness not definitely known, in places may be 400 feet but in others is only 150 to 200 feet.

Belly River formation
Sandstone alternating with shale; coal seams; non-marine; thickness 1,600 to 1,800 feet.

Upper Alberta shale
Shale and sandy shale; marine; thickness 1,700 to 1,800 feet.

Cardium formation
Grey sandstone and sandy shale; thickness 30 to 40 feet.

Lower Alberta shale
Shale and thin sandstone bands; marine; thickness 800 to 900 feet.

Blairmore formation
Sandstone and shale; one coal seam; thickness in northern Turner Valley is about 1,200 feet, in south end the thickness in places as low as 1,050 feet.

Kootenay formation
Sandstone, coaly shale, and coal; absent in places, elsewhere thickness varies, maximum is 100 feet.

Fernie formation
Shale; marine; thickness 200 feet.

Palæozoic limestone
Limestone, in part dolomitic.

PASKAPOO FORMATION

The youngest formation is the Paskapoo, which is Tertiary in age. It does not occur within the area being drilled, but is well exposed along Highwood River. It consists of light grey sandstone alternating with dark grey and greenish shales and holds thin coal seams. The boundary between the Paskapoo and the underlying Edmonton was formerly drawn[1] at an exposure of massive sandstones and shales on the south side of Highwood River, in sec. 10, tp. 18, range 2. The presence of well-preserved dinosaur vertebræ definitely places these beds in the Edmonton formation. A zone of pebbles and cobbles from 3 to 5 inches in length occurs at the base of a massive sandstone on the southward bend of Highwood River, between sections 10 and 11. This zone is identical with that at the Edmonton-Paskapoo contact on Pekisko Creek, in sec. 34, tp. 17, range 2. The zone is also known to occur in the Priddis area and on Elbow and Bow Rivers, farther north. Thus, it is now inferred that the contact between the Edmonton and Paskapoo in this part of the foothills is marked by a very definite break in sedimentation, such as has been described elsewhere.[2]

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[1] *See* Map 257A, Geol. Surv., Canada.
[2] Allan, J. A.: Trans. Can. Inst. Min. and Met., vol. 28, p. 240 (1925).

This contact is not exposed on Longview Hill, but it is now thought that the exposures of sandstone near the centre of section 26 are basal Paskapoo instead of lying some distance within the formation as formerly believed. There is also good grounds for the belief that the exposures on the small hill in the northwest quarter of section 14 and the southwest quarter of sec. 23, tp. 19, range 2, are basal Paskapoo and that the beds formerly mapped as Paskapoo on the west side of the hill in the north part of sec. 15, tp. 19, range 2, are Edmonton. This interpretation is in accord with the extension of the Edmonton-Paskapoo contact southeast from Black Diamond parallel to the other features of Turner Valley to the west.

EDMONTON FORMATION

It is very difficult to determine the sequence of beds composing the Edmonton formation, and altogether impossible to determine the total thickness from the exposures on Highwood River in secs. 9 and 16, tp. 18, range 2, because of the extremely deformed state of this formation. The lower part of the Edmonton formation consists of soft sandstones and contains much coaly and dark carbonaceous shale with coal seams. These measures, lying between the more resistant Belly River sandstones below, and the harder, upper part of the Edmonton formation and the overlying, massive Paskapoo sandstones above, yielded to deformation. The coaly beds under extreme pressure were excessively drag-folded and broken, the coal and coaly shales acting as gliding planes. In a few places, however, the base of the Edmonton formation is recognizable and consists of a fairly massive sandstone, in part conglomeratic. It is present among the extremely deformed beds on the southeast quarter of section 8, near the mouth of Bull Creek. It also outcrops on the south side of Highwood River at the Oliver pumping station, on the southwest quarter of section 20, and along Highwood River in the northwest quarter of the same section. In all these places it is underlain by dark Bearpaw shales holding an occasional rather fragile *Oxytoma* and beds of fossiliferous sandstone. Above the basal sandstone member comes the coaly shale, dark shale with ironstone bands, and coal beds, previously mentioned. It is thought, but the evidence is not at all conclusive, that these beds with the basal sandstone constitute the lower 150 feet of the Edmonton formation. Within them is an oyster bed, which in some places, as on Bull Creek near Highwood River in section 8, is more than a foot thick and is almost wholly composed of oyster shells. The same bed occurs on the west side of the southeast quarter of section 9, on the south bank of what is mostly a dry channel of Highwood River. It is also present in a small anticline on the extreme southeast part of the northeast quarter of the same section, where the bed is thicker and more massive than elsewhere. The major fault east of Turner Valley is assumed to pass east of this anticline and along it the lower Edmonton beds have been thrust onto higher Edmonton strata. The fault, however, is not exposed. East of the fault Edmonton strata, consisting of some bands of hard, resistant sandstone alternating with shales, dip easterly at 5 to 40 degrees, extend to the Paskapoo contact, and have an estimated thickness of 1,450 feet. This, with the estimated 150 feet of lower coaly beds and shales, makes a total thickness for the Edmonton formation of 1,600 feet. Owing to the difficulty of precisely measuring the thickness

of highly deformed beds, the above thickness must be considered as only approximate, especially as the beds are broken by the fault, and the displacement along it in the Highwood River area has not been determined, although it is thought to be much less than farther north.

BEARPAW FORMATION

In Highwood River area the Edmonton formation is underlain by Bearpaw beds consisting for the most part of soft, grey shales alternating with some bands of hard, grey and pink sandstones. A few wells, as for example, National No. 2, Richwell, Prairie, Sunset No. 1, and Royal Canadian No. 1, and a number started since the end of 1937, are believed to have commenced drilling in this formation. Bearpaw beds outcrop on Highwood River on the west side of sec. 20, tp. 18, range 2, but the structural conditions in this area are so difficult to interpret, because of extreme distortion, that it is impossible to determine completely the sequence of beds. In a few places in shales and sandstone beds marine fossils, as for example *Artica*, occur, but it is suspected that other yellow weathering sandstones not found to be fossiliferous also belong to the Bearpaw formation. Coal seams occur at the top of the Belly River formation in a series of beds that are relatively soft and partly bentonitic. These coal seams are involved in extreme structural complications, and the contact between the Belly River and Bearpaw beds, generally considered as the top of the coal zone of the Belly River, is not easily determined. Some further confusion may be caused, also, because small coal seams occur within the Bearpaw formation, that is, between beds that carry marine fossils. An occurrence of coal, thought to be within this formation, has been noted on Pekisko Creek on the south of sec. 20, tp. 17, range 2, where in a series of shales and bentonitic sandstones one sandstone bed carries fairly abundant and very large oyster shells. Close to this occurrence some thin sandstone beds contain an abundance of glauconite, a green mineral usually ascribed to marine deposition. It is inferred that the Bearpaw in this locality is a shore or near shore deposit that was subject to periodic fluctuations between marine and non-marine conditions. That this part of the foothills region was close to the shoreline of the Bearpaw Sea is further indicated by the fact that Bearpaw beds have not been identified in the foothills north of the Turner Valley area. Studies of the outcrops of Bearpaw indicate that the formation is relatively thin, perhaps not more than 100 to 200 feet thick, but wells drilled through the formation seem to show that it may be as much as 400 feet thick. Estimates of thickness are, however, difficult to make, as everywhere at its outcrops the Bearpaw formation is excessively deformed.

BELLY RIVER FORMATION

Underlying the Bearpaw is a series of non-marine sandstones and shales, constituting the Belly River formation. These are well exposed on Highwood River, in sec. 19, tp. 18, range 2. Drilling has shown that the apparent thickness on Highwood River is excessive, and it is now known that repetition is caused by an easterly dipping fault, to which sufficient importance was not attached in former studies.[1] In this Belly River section

[1] Hume, G. S.: Geol. Surv., Canada, Sum. Rept. 1929, pt. B, p. 10.

all beds dip east from the contact with the underlying Alberta shales in the northwest part of section 19 to the sharp bend in the river on the east side of the same section. At this point there is a sharp anticlinal fold with, presumably, an easterly dipping fault to the west of it, and coal seams, coaly and bentonitic shales, and sandstones, rather badly deformed, to the east of it. These coaly beds have been thrust westward. They are partly repeated by folding in exposures on the north side of Highwood River, on the northwest quarter of section 20. The coaly shales, sandstones, and coal seams constitute the upper part of the formation. The remainder of the formation is mainly composed of grey sandstones and dark green and grey shales, in part with much ironstone. About 950 to 1,000 feet above the base of the formation there is a zone of massive sandstones. On Highwood River within this zone are two layers of conglomerate 140 feet apart. A *Unio* bed occurs 90 feet below the lower conglomerate. About 20 to 30 feet above the base of the greenish sandstones and shales at the base of the formation there is a thin, carbonaceous shale layer with a thin coal seam. This horizon is very persistent in this area. It occurs on Highwood River just east of Okalta No. 6 well, in sec. 30, tp. 18, range 2, and on Bull Creek, in the southwest quarter of section 8 of the same township and range. In Turner Valley area it has also been observed on Quirk Creek. In studying well samples it forms a convenient marker to divide the Belly River from the underlying Alberta shales, although, as already indicated, there are a few feet of Belly River strata below it. The total thickness of the Belly River formation is 1,600 to 1,800 feet.

UPPER ALBERTA SHALE

On Highwood River, in the southwest quarter of sec. 30, tp. 18, range 2, the Belly River is underlain by 300 feet of Upper Alberta shales, in turn underlain by a yellow weathering sandstone at least 35 feet thick. This sandstone has been called[1] the Highwood sandstone. It is capped by a thin conglomerate holding greenish, grey, and black chert and quartzite pebbles, such as are frequently found in well samples from this horizon. All wells on the west flank of the south end of Turner Valley have drilled the Highwood sandstone, and in a number of them it is repeated by faulting. It is suspected that the interval of 300 feet as measured on Highwood River between the base of the Belly River and the top of the Highwood sandstone is usually less elsewhere, and that the Highwood sandstone is of local occurrence. From the base of the Highwood sandstone to the base of the Upper Alberta shale the formation is 1,400 to 1,500 feet thick. The total thickness in this area is, therefore, 1,700 to 1,800 feet. The upper part of the Upper Alberta shale, including the Highwood sandstone and some sandy shales under it, is Montana in age, as it contains the well known fossil *Baculites ovatus*. The lower part of the formation is Colorado in age, containing the *Scaphites ventricosus* fauna. On Sheep River west of Turner Valley, in sec. 2, tp. 20, range 3, the Highwood sandstone is present in a small syncline. This sandstone was formerly included in the Belly River formation and was previously so mapped (*See* Maps 257A and 262A). Farther north in Turner Valley the Highwood sandstone is not so prominent, and it is

[1] Webb, J. B., and Hertlein, L. G.: Bull. Am. Assoc., Pet. Geol., vol. 18, No. 11, p. 1402 (1934).

believed the beds between it and the Belly River are thinner than on Highwood River, thus accounting for a slightly less thickness of upper Alberta shales in north Turner Valley than on Highwood River.

CARDIUM MEMBER

In Turner Valley the Cardium is composed of grey sandstone and sandy shale 30 to 40 feet thick. It outcrops at the Royalite bridge over Sheep River, in sec. 6, tp. 20, range 2. About 150 feet above the Cardium is a thin, pebble-bearing zone, perhaps not much more than 2 inches thick, and pebbles from this zone are commonly found in well samples. About 100 feet below the Cardium is another somewhat similar pebble band, apparently also quite thin but very persistent. The pebbles of both zones are of blue, green, and black chert and quartzite. In the area to the west of Turner Valley these pebble bands are associated with sandstones, and there the Cardium is usually considered as embracing all strata between the upper and lower sandstone members.

LOWER ALBERTA SHALE

The Lower Alberta shales are dark grey to black, with thinly laminated, crossbedded, sandy beds. About 300 feet above the base of the formation is a somewhat coarser sandstone, known as the Jumpingpound member. It is a very persistent horizon, although somewhat poorly defined as it grades into the overlying and underlying shales. Close to the base of the formation is a fairly coarse, quartzitic sandstone known as the "grit." In many places there are a few feet of dark shales under the "grit," so that although the "grit" is commonly considered as marking the contact with the underlying Blairmore beds it really lies within the Alberta shales. In the southern part of Turner Valley the Lower Alberta shales are 800 to 900 feet thick, making the combined thickness of Upper and Lower Alberta shales at least 2,700 feet. In northern Turner Valley the combined thickness is somewhat less because the Upper Alberta shales are somewhat thinner than in the south.

BLAIRMORE FORMATION

The Blairmore formation consists of an upper part of alternating green, grey, and dark shales and sandstones and a lower part of dark shales and arenaceous, limy bands. The two are separated by a white or grey, granular sandstone known as the Home sand. The thickness of the Blairmore varies between 1,050 and 1,200 feet, and ordinarily the Home sand is 900 to 1,000 feet below the top of the formation in southern Turner Valley wells, where the formation is less thick than farther north.

In the upper part of the Blairmore formation are several poorly defined sandstone zones. Two of these, the Stockmens about 100 feet, and the McDougall-Segur about 220 feet, below the top of the formation, are important in the northern part of Turner Valley, but much less so in the southern part. The McDougall-Segur sandstone zone may be fairly thick, up to nearly 200 feet, and usually consists of sandstones separated by some shales, with, in some places, at the base a carbonaceous zone of

thin coaly beds. In places part of the sandstone is replaced by a conglomerate with pebbles of considerable size, some of which are porphyries but most of which are black cherts and quartzites. A carbonaceous layer or coal seam occurs about 650 feet below the top of the formation, and is a fairly persistent marker in well samples.

Below the Home sand the lower Blairmore contains limy sandstones and limestone beds that carry non-marine fossils. The base of the formation is a coarse sandstone known as the Dalhousie sand. It is the equivalent of the basal conglomerate so well known in western foothills areas. In the wells in Turner Valley the Dalhousie sand is 20 to 30 feet thick.

The Stockmens sand has produced gas, the McDougall-Segur sand oil, the Home sand gas and oil, and the Dalhousie sand gas and oil, but the various sands are not everywhere equally productive and in places are non-productive.

KOOTENAY FORMATION

The Kootenay in Turner Valley is a relatively thin formation, consisting of sandstones and dark, carbonaceous shales with coal. The division between the Kootenay and underlying Fernie formation is rather arbitrarily placed at the top of the so-called "Brown sand." On this basis of division the Kootenay is mostly 20 to 100 feet thick, but in certain places may be slightly thicker. It is persistently coal-bearing.

FERNIE FORMATION

As already stated, the Fernie formation contains the co-called "Brown sand." This is a granular, brown sandstone 60 to 80 feet thick, underlain by dark to black shales with some limestone bands. In the upper part of these shales glauconite with abundant pyrite is present, and belemnites and phosphatic nodules occur. About 160 to 170 feet below the top of the Brown sand is a belemnites conglomerate in sandstone with black, phosphatic pellets. Below this conglomerate and above the Palæozoic limestone are 40 to 50 feet of beds designated as "poker chip" shales, from their habit of breaking in part into rounded chips.

PALÆOZOIC LIMESTONE

The top of the Palæozoic limestone is in places a chert conglomerate, and in wells in Turner Valley chert commonly occurs in the first samples taken. The limestone is largely crystalline, and in the south end of the field three porous zones occur. The first of these is in the upper beds, the second 150 to 200 feet below the top of the limestone, and the third is above the so-called "black lime," which occurs at a depth of about 450 feet within the formation. The porous zones are relatively soft and within them drilling is fairly rapid. They are, however, separated by denser beds, in part very hard. Drilling is stopped in the "black lime" in Turner Valley wells. The recently completed Home Millarville No. 2 well has shown that the same porous zones are present as in the south end of the field.

STRUCTURE

The structure of Turner Valley is indicated on twelve cross-sections accompanying this report. These cross-sections were made after a number of peg models were constructed to cover the area from the south of secs. 20 and 21, tp. 18, range 2, to the north of secs. 19 and 20, tp. 19, range 2. The models were built on a scale of 200 feet to 1 inch (vertical and horizontal), and the wells were represented by brass rods coloured to represent the various formations penetrated by the wells. Similar geological horizons were connected by coloured cords, and faults were indicated by cords of a different colour. In the determination of faulting, the samples from the wells, available at 10-foot intervals, were examined by binocular microscope to determine repetitions and slickensided zones. The advantage of such models is that conditions in three dimensions can be seen at one time, and in complicated faulted areas the study by models is the only effective means of representation that gives a comprehensive picture that can readily be seen. By this method of study several types of faults became known, and in certain instances the evidence seems clear that one system of faulting is cut by another.

TURNER VALLEY EAST SIDE FAULT

For a number of years it has been known that the Turner Valley structure is cut off on the east side by a major overthrust fault. This was first discovered by drilling in central Turner Valley, and it has now been penetrated in the wells listed below.

Well	Location				Formation above fault	Depth to fault in feet
	L.s.	Sec.	Tp.	Range		
National Pete No. 2	13	9	18	2	Palæozoic limestone	7,660
Union Freehold	8	21	18	2	" "	6,440
Longview C. and E.	5	27	18	2	" "	6,207
Sterling Pacific No. 1	15	33	18	2	" "	6,436
Mercury No. 5	2	4	19	2	Fernie	5,780±
Mill City No. 1A	14	4	19	2	Palæozoic limestone	5,010
British Dominion No. 1	4	5	20	2	Alberta shales	5,480
Great West No. 1	2	7	20	2	" "	5,010
McLeod No. 4	16	1	20	3	Palæozoic limestone	5,870, 5,980, 6,012
United No. 4	2	24	20	3	" "	6,060, 6,200
Dome No. 1	2	24	20	3	Blairmore	5,660

These wells rather closely define the position of the fault that cuts off the east side of the Turner Valley structure, even though the surface evidence of faulting is almost entirely lacking. On Highwood River this fault is believed to occur at the boundary between secs. 9 and 10, tp. 18, range 2, east of a small anticline in an oyster-shell bed in the Edmonton formation. On the surface the fault does not appear to have a large stratigraphic displacement, as Edmonton strata occur on both sides of it. At a number of other places, as on Elbow River on the fault east of the Jumpingpound anticline, similar faults have been studied and found to be a fault zone rather than a single fault plane. In the fault zone on

Elbow River Bearpaw beds, presumably only 100 to 200 feet thick, are greatly distorted, slickensided, and repeated in outcrops occurring along the river bank for a distance of more than 1,000 feet. The explanation apparently is that there are numerous faults, each with a relatively small displacement and each repeating approximately the same strata. The numerous repetitions, resulting in the wide outcrop of the same beds, give, however, a large aggregate displacement, which at depth when faults of this type are drilled may be mainly or solely represented by a large stratigraphic displacement on a single fault plane. The fault limiting the Turner Valley structure on the east side may be of this type. At no place on the surface is there any significant stratigraphic break, and yet in Great West No. 1 and British Dominion No. 1 wells, the first wells to penetrate the fault at depth, the break was from Alberta shales to Belly River strata. When the fault was drilled in McLeod No. 4 well, not only was it shown to have a low westward inclination under central Turner Valley but the stratigraphic break was found to be approximately 4,000 feet, in three stages from the Banff shales to Alberta shales. In this well the fault was encountered at a depth of 5,870 feet, where the well after having been for 2,140 feet in the Palæozoic limestone and having reached the Banff shales under the Rundle (Madison) limestone passed into Fernie strata. At 5,980 feet the well encountered a second fault and passed from the Fernie into Blairmore strata. At 6,012 feet a third fault was drilled, and under it Alberta shales close to the Cardium zone occurred. Thus, in this well there is striking evidence of the composite nature of the fault. Similar evidence was found in United No. 4 well. In this case the top of the Palæozoic limestone was reached at a depth of 5,880 feet. The fault occurred at 6,060 feet, and there the well passed into strata, that because of their content of belemnite fragments were definitely identified as Fernie. At 6,200 feet a second fault was encountered, and below it the well passed into Alberta shales with pebbles of the Cardium zone present from 6,290 to 6,360 feet. In a number of other wells, however, only a single fault plane has been recognized. It is inferred, therefore, that the low-angle fault under Turner Valley may split into a number of faults in the steeper, upper part, thus accounting for the lack of marked stratigraphic displacement at the outcrop of any one fault in the fault zone. No information is available as to how far this fault zone may extend east of the assumed position of the fault as shown on the map. The implication that a fault zone extends some considerable distance in front of the east ridge of Turner Valley is rather important in regard to the structure in an area that is being tested by the New Valley and Sentinel wells. In the Sentinel well, for example, there were a number of coal seams recorded to a depth of 2,495 feet. These are obviously repetitions due to faulting of the Edmonton formation. At the bridge over Sheep River at the Sentinel well the strata are very much deformed, and this deformation was formerly regarded by the writer (*See* Map 257A) as marking the outcrop of the Turner Valley east side fault. In 1934 Link and Moore[1] showed that the outcrop of the fault was probably at the abandoned Black Diamond (McPherson) coal mines, and

[1] Link, T. A., and Moore, P. D.: Structure of Turner Valley Gas and Oil Field, Alberta; Bull. Am. Assoc. Pet. Geol., vol. 18, No. 11, pp. 1422-3 (1934).

with this conclusion the writer now agrees. The fold at the surface at the Sentinel well, however, is undoubtedly faulted, as shown by the repetitions of the coal seams in the well. If a fault zone composed of a number of faults exists east of the east Turner Valley ridge it is probable that these faults join at depth to form the Turner Valley sole fault, as described by Link and Moore, who gave expression to this idea in cross-sections B-B and C-C in their 1934 paper. In the Sentinel well a coarse sandstone that may be the basal Edmonton bed occurs at a depth of 2,730 feet. Below this and down to at least 3,020 feet the drilling chips have the appearance of Bearpaw sediments, and glauconite presumably definitely indicating Bearpaw beds is present between depths of 2,870 and 2,900 feet. However, the top of the Belly River formation, which normally would be directly under the Bearpaw, is thought to be at 4,420 feet. Thus, below the Bearpaw, identified between 2,730 and 3,020 feet, and above the top of the Belly River at 4,420 feet, there is at least one more fault. The question arises as to whether this fault is steeply inclined or has a low inclination. In the latter case it could be part of the Turner Valley east side fault. If the Turner Valley east side fault as known in McLeod No. 4 and Great West No. 1 wells is projected eastward it will cross the Sentinel well between the bottom of the Bearpaw at 3,020 feet and the top of the Belly River at 4,420 feet, where, as stated above, a fault apparently must occur (*See* Cross-section J-J), causing a repetition of beds presumably of Edmonton and Belly River ages. Thus, conditions at least suggest that the faults encountered in the Sentinel well are parts of the Turner Valley east side fault. Some further evidence in the area occupied by Edmonton beds in front of Turner Valley is suggestive of a similar conclusion. On Highwood River the Edmonton beds there exposed are so excessively deformed that measurements are almost impossible, but it is probable the thickness is not less than 1,100 feet and not greater than 1,600 feet. On Sheep River, where Edmonton strata are exposed northwest of the bridge at the Sentinel well, the dip is moderate, decreasing eastward in the few outcrops that are available for study. The area occupied by the formation is much wider than is required by the thickness of beds believed to occur in it, suggesting that faults are present which because of lack of outcrops cannot be located. The structure east of the Pekisko uplift, south of Turner Valley, is comparable. Here again although no faults were definitely known in the Edmonton they were assumed to be present because the width of the Edmonton outcrop, which in certain places can be determined quite precisely between Bearpaw beds and a conglomeratic sandstone at the base of the Paskapoo formation, was too great for the known thickness of Edmonton beds. Anglo-Canadian No. 2 well, drilled on sec. 33, tp. 16, range 2, proved that this contention was sound. In that well, which started in Edmonton beds, at least two faults were encountered, drilling being finally suspended at 6,280 feet in Belly River strata. Faulting is also known to occur in New Valley well, drilling on sec. 6, tp. 21, range 2, east of the north end of Turner Valley. This well presumably begins in Edmonton strata. Due to faulting, non-marine beds with coal belonging either to the Edmonton or Belly River are repeated at 2,410 to 2,430, 2,840 to 2,870, 2,910, 3,050 to 3,070, and 3,190 to 3,350 feet. The top of the Belly River is presumably at about 3,460 feet and the top of the Alberta shale at 4,930 feet. As already stated, the well presumably

begins in Edmonton beds that are thought to be only 1,100 to 1,600 feet thick. The well section above the top of the Belly River at 3,460 feet is very difficult to interpret. A coarse sandstone at 870 feet may be the base of the Edmonton formation and another finer grained sandstone at 1,080 feet may be the top of the Belly River. At 2,410 feet there is a thick coal seam and, as indicated above, coal occurs in a number of samples from 2,410 to 3,460 feet. A coarse sandstone at 3,040 feet resembles the basal Edmonton bed. Thus, faulting below 1,080 feet may repeat the basal part of this formation and the upper part of the Belly River. This fault is shown on the map a short distance east of the New Valley well. Its projection southward would place it at about 2,700 feet east of the Sentinel well, and it would be the fault indicated on cross-section J-J as occurring in the Sentinel well below a depth of 2,900 feet. The fault might, therefore, be assumed to have a relatively steep west inclination at the surface, but must flatten very considerably to have been encountered below 2,900 feet in the Sentinel well. It is inferred that the fault cannot have a steep west inclination or otherwise it would have been encountered in the Sentinel well at a depth where no fault is present. Thus this indirect evidence strongly supports the belief that the Turner Valley east side fault divides at depth into a number of branches that occur across a very considerable width where they reach the surface. The application of this conclusion is of very practical importance. It is now believed that the Turner Valley east side fault splits in two before reaching the surface on sec. 25, tp. 20, range 3. One of these faults swings northwestward across the east flank of Turner Valley and is thought to join with another fault west of the east flank of the structure, possibly in the vicinity of the Home water-pumping station on Quirk Creek on sec. 3, tp. 21, range 3. This interpretation differs from that formerly made for this part of the area, where it was considered that the change in strike and the northerly dip of the beds on the nose of the hill on sec. 26, tp. 20, range 3, was due to a cross fault. The drilling of Royalite No. 29 well in sec. 27, tp. 20, range 3, yielded data indicating that faults present to the south cut across the supposed cross fault without any break. This can only mean that the supposed cross fault does not exist. The present interpretation of the splitting of the Turner Valley east side fault with the west branch cutting across the plunging end of the Royalite No. 4 subsidiary anticline[1] is in harmony with the present known facts. The east branch of the fault continues through sec. 36, tp. 20, range 3, as shown on the map. It is probable that the two branches join at depth (*See* Section M-M), in which case the more easterly branch has a low-angle part at depth. If this is so the low-angle part of the fault probably passes above the Palæozoic limestone, and hence eliminates prospects for oil in that part of Turner Valley east of the west branch of the fault. Thus, the west branch of the fault continuing northwest from Quirk Creek becomes the main Turner Valley east side fault. As shown on cross-section M-M, it has a high westward inclination. This same inference is derived from a study of the well samples of Invaders well on section 9 and Old McDougall-Segur well on sec. 16, tp. 21, range 3, in relation to the fault that passes between the two wells. The underground trace of the Turner Valley east side fault

[1] Link, T. A., and Moore, P. D.: Bull. Am. Assoc., Pet. Geol., vol. 18, No. 11, 1934, p. 1432.

where it cuts the Palæozoic limestone is shown on the map as the " faulted east edge of limestone." It shows a marked curve westward where the outcrop of the Turner Valley east side fault passes across the east flank of the Turner Valley structure, but as the west branch of the fault has a steep inclination and a northwesterly trend on the surface, as pointed out above, the underground trace will continue also northwesterly, approximately parallel with it and only diverge westward from a parallel course to the extent that the structure plunges and thereby causes the limestone to occur at greater depths.

In township 21, range 3, from section 11 to the north end of the map-area of the "North Half of Turner Valley" and continuing to at least the northwest part of sec. 19, tp. 22, range 3, there is a well-marked anticline in Belly River strata. Should the inferences made in this report in regard to the fan-like nature of the Turner Valley east side fault be correct, this anticline is underlain by a low-angle fault which passes above the Palæozoic limestone. Whether such a fault eliminates the oil and gas prospects depends on the structure under the fault plane rather than that above it. In this connection the successful completion of Sentinel well would have a very important bearing, as the fault that cuts under the anticline above described is also believed to have been penetrated by the Sentinel well. The outcrops of highly contorted shales and sandstones on the north bank of the south fork of Fish Creek, on the northeast corner of sec. 4, tp. 22, range 3, are believed to be a part of the beds deformed by this fault. The shales are very highly slickensided and excessively folded. The lithology of these beds with abundant ironstone nodules closely resembles a part of the Bearpaw formation, although no trace of fossils could be found. The beds are shown on the map as belonging to the Edmonton, because no division of Edmonton and Bearpaw strata is possible in this area. This fault was encountered in the upper part of the New Valley well and is the fault that is believed to lie east of the Jumpingpound anticline in townships 24 and 25, range 4. It was encountered in Imperial Bow River Nos. 1 and 2 wells in the Jumpingpound structure, and for this reason is known to have a low-angle part at depth. It is thought, however, that stratigraphically much lower beds are present in the Jumpingpound area above the fault than is the case farther south in the anticline from sec. 11, tp. 21, range 3, to sec. 19, tp. 22, range 3. This anticline at its north end is slightly west of the southern end of the Jumpingpound anticline, which continues southward across the Sarcee Indian Reserve, and whose south end is well defined by westerly dipping outcrops on sec. 30, tp. 22, range 3, and easterly dipping outcrops on section 29 of the same township and range. The crest of the south end of the Jumpingpound anticline is apparently on the west side of section 30, whereas the north end of the anticline that extends northwest from sec. 11, tp. 21, range 3, is less than one mile west on the northwest of sec. 19, tp. 22, range 3, or on the southwest of section 30 immediately north of section 19. The conclusion from the available evidence in regard to the anticline from sec. 11, tp. 21, range 3, to sec. 19, tp. 22, range 3, is that it is underlain by a low-angle fault passing above the Palæozoic limestone, and that the prospects below the fault cannot at present be predicted.

SOUTH END OF TURNER VALLEY

The prospects of the Turner Valley structure continuing southward beyond its present most southerly known limit, are dependent on the position of the subsurface trace of the Turner Valley east side fault. The subsurface trace of the Palæozoic limestone has been accurately determined at National Petroleums No. 2 well on sec. 9, tp. 18, range 2. This well encountered the top of the Palæozoic limestone at 7,073 feet. At 7,660 feet the fault was drilled and the well is believed to have passed into upper Blairmore strata, in which it was stopped at a depth of 7,705 feet. Subsequently, a survey of the well showed it was only a few feet off the vertical at the bottom of the hole. Thus, the position of the fault is precisely known at this location. The position of the fault is approximately known on Highwood River, and from this information the position of the outcrop of the fault east of National No. 2 well is inferred. As the depth to the fault in National No. 2 well is known its inclination can be approximately calculated from the inferred position of the fault on the surface. This angle is at least 60 degrees, and may be slightly steeper. Thus, the Turner Valley east side fault at this location is relatively high. The southwesterly trend of the subsurface trace from Union Freehold to National No. 2 well, and farther southwest, is due primarily to the limestone occurring at progressively greater depths southward owing to the plunge of the structure. The subsurface trace of the fault will become parallel to the surface trace if the southward plunge of the structure, as it exists from Longview Hill to Highwood River, ceases. It is thought that the course of the surface trace of the fault becomes more southerly south of Highwood River than it is north of the river, the fault being inferred to cross Pekisko Creek on the east part of sec. 33, tp. 17, range 2. If this is the position of the fault then it is evident that the surface trace of the fault must turn southward from Highwood River. The plunge of the south end of the Turner Valley structure is apparently much less from Highwood River southward than it is from Longview Hill to Highwood River. Thus, it follows that the subsurface trace of the fault on the limestone south of Highwood River will approximately parallel the surface trace, and hence the Turner Valley structure will probably extend farther south than might be expected if the southwesterly trend of the subsurface trace of the fault on the limestone at National No. 2 well had continued for any considerable distance southwest across Highwood River. In the absence of precise information regarding the position of the subsurface trace of the fault on the limestone south and west of National No. 2 well, it might be advisable to have several profiles run by geophysical methods to determine the position of the faulted edge of the limestone. If, as suggested here, the subsurface fault trace on the limestone turns south from the southwesterly trend at National No. 2 well, then the Turner Valley structure will continue southward to the west of the faulted limestone, and presumably will be productive until the oil-water line is reached. At present the only information in regard to the presence of water comes from Okalta No. 6 well, where the top of the limestone was encountered at a depth of approxi-

mately 5,700 feet below sea-level and water was present in the lower porous limestone zone.

STRUCTURE WITHIN TURNER VALLEY

The details of the structure within southern Turner Valley have been greatly influenced by a change in structural trend from north to northwest in the vicinity of the north side of township 18. A fault, here called the Commoil fault, was encountered in Commoil No. 1 well at a depth of 1,920 feet, where the well passed from Alberta shales to Belly River after having encountered the top of the Alberta shale at 1,460 feet. This fault increased the drilling depth of this well by 1,290 feet, as under the fault the top of the Alberta shale was again encountered at 2,750 feet. As the fault is now known from drilling to have a west inclination of about 60 degrees, it presumably outcrops about 1,000 feet east of Commoil No. 1 well (*See* Cross-section E-E), although its outcrop is completely concealed. From Commoil No. 1 well its trend is southerly and toward the south end of the field southeasterly toward National No. 2 well. This fault has now been encountered in southern Turner Valley in many wells, some of which are as follows: Globe No. 1 well at 2,030 feet; West Turner No. 1 at 2,090 feet; West Turner No. 2 at 1,590 feet; Davies No. 4 at 1,440 feet; Royalite No. 33 at 1,550 feet; Royalite No. 34 at 970 feet; Royal Canadian No. 2 at 2,050 feet. In all the above wells the strata repeated were partly lower Belly River and partly Upper Alberta shales. In a number of other wells situated farther west the repetition due to the fault was in Upper Alberta shales, as for example in the cases of Davies No. 1, Royal Canadian No. 1, and Sunset No. 1 and No. 2. In others still farther west the Cardium is repeated, as for example in Royalite No. 31 where it occurred at 4,610 and again at 5,200 feet, and in Royalite No. 36 where it occurred at 4,300 and 5,000 feet. In other wells still farther west of the outcrop of the fault, the repetition occurred in Lower Alberta shales, as for example in Extension No. 1 and Producers No. 1 wells. There is some difference of opinion as to whether the fault cuts the Palæozoic limestone or flattens off above it. On the accompanying cross-sections the fault is shown as continuing downward at about 60 degrees and cutting the limestone. Under these conditions it would be expected that the fault would be encountered in Anglo-Canadian No. 1 well at a depth of about 7,300 feet, but no fault was there indicated. In this well the top of the Blairmore was encountered at 6,320 feet, the Home sand at 7,230 feet, the Dalhousie sand at 7,400 feet, the Brown sand at 7,520 feet, and the top of the Palæozoic limestone at 7,770 feet. The intervals between these horizons are the normal drilling thickness, so that no fault is present. Obviously, therefore, the fault if it cuts the limestone must be east of the well, in which case the lower part would be assumed to be somewhat steeper than at present postulated. The completion of such wells as Vantage, British Colonial No. 1, or P. and H. Alco will give more data on this problem. The Commoil fault is assumed to continue northwest from the southern end of Turner Valley. Its presence in sec. 5, tp. 19, range 2, is definitely known from wells drilled there and it was encountered in Brown No. 3 well, on sec. 19, tp. 19, range 2, where the Cardium, first encountered at a depth of 2,420 feet, was repeated at 3,390 feet. From

this well it presumably continues northwest, and on the map has been represented as joining with a fault that cuts through sec. 1, tp. 20, range 3, and apparently continues nothwestward.

Within Turner Valley are many faults, and in several areas the structure is difficult to interpret. This is particularly true in the area adjoining sec. 20, tp. 19, range 2, where owing to the large number of wells drilled it might seem the details of the structure would be known. This is, however, not the case, mainly because many of the wells are very crooked and only in a few cases are surveys available. Two sections, G-G and H-H, have been drawn to illustrate the type of structure in this area, and in some respects the sections have been generalized. As directional surveys of holes known to be very crooked are not available, the wells adjoining the sections have not been shown on them.

UNDERTHRUSTS IN SOUTHERN TURNER VALLEY

It is believed that in the southern part of Turner Valley, in secs. 33, 28, 21, and 16, tp. 18, range 2, there are east dipping faults or underthrusts that are cut by the west dipping faults or overthrusts. The evidence for the existence of these underthrusts was worked out in detail in section 28 by an examination of the samples from many wells and by a study of the information from a peg model. Only part of the information is given here, as the whole study involves a large amount of data. In Model Spooner No. 2, Richland Nos. 1 and 2, B. and B., Turner Valley Royalties, Four Star, and Sterling Pacific Nos. 4, 5, and 6 wells there is in most cases ample evidence of a number of repetitions of the Highwood sandstone that normally occurs near the top of the upper Alberta shales. In wells like Richland No. 2 and B. and B., for example, the Highwood sandstone occurs three times. In Richland No. 2 the Belly River-Alberta shale contact is at 650 feet. The Highwood sandstone occurs at 930 to 1,070 feet, 1,230 to 1,400 feet, and at 1,990 to 2,040 feet. Obviously, therefore, the Highwood sandstone is here repeated by two faults and another fault occurs between the Highwood sandstone at 1,990 feet and the Cardium at 3,860 feet. In B. and B. well the base of the Belly River occurs at 490 feet, with some Highwood sandstone between 970 and 1,320 feet and again at 1,680 to 1,740 feet. In this well the Cardium occurs at 3,490 feet. Again, as in Richland No. 2 well, two faults repeat the Highwood sandstone and a third cuts below it and above the Cardium. This lower fault is particularly apparent in British Dominion No. 4, Richland No. 3, and Century wells, where the Jumpingpound sandstone is repeated. In British Dominion No. 4 well the Cardium occurs at 1,960 feet, the Jumpingpound sandstone at 2,510 to 2,560, 3,320 to 3,370 feet, and probably again at 3,710 to 3,720 feet, with the "grit" at 4,080 feet. This repetition of the Jumpingpound sandstone by two faults is taken as evidence that between this well and the next location west, at Richland No. 2 well, one of the east dipping faults has split upwards into two, as shown on cross-section D-D. This is believed to be confirmed by the evidence from Richland No. 3 and Century wells, with the lower fault repeating the Jumpingpound sandstone in Richland No. 3 at 2,720 to 2,780 and at 3,210 to 3,230 feet, and in Century at 2,500 to 2,580 and at 3,130 to 3,200 feet. The east dipping faults are cut by the

north trending, west dipping fault through the west side of sec. 33, tp. 18, range 2, and sec. 4, tp. 19, range 2. Near the north side of section 4 one of these east dipping faults becomes much more steeply inclined than elsewhere and cuts into the limestone, thrusting it up between Miracle No. 1 and Mill City No. 1A wells. These relationships are indicated on cross-section F-F. The surface trace of these east dipping faults as shown on the map is only approximate, as change of inclination and lack of sufficient precise information do not permit them to be readily outlined.

OUTWEST FAULT PLATE

On the west side of Turner Valley is the overlying Outwest fault plate. This is shown on cross-section C-C, and to a less extent on cross-sections A-A, B-B, D-D, and E-E. Great difficulties have been experienced in tracing the eastern edge of this fault plate because of lack of outcrops, except on Highwood River, and of exceptionally complex structural conditions. The complexity of structure is nearly all within the soft, coal-bearing beds of the upper Belly River, the soft shales, in part coaly, of the Bearpaw, and the soft, coal-bearing beds of the lower Edmonton formation. It is with great difficulty that these coaly zones are distinguished from one another, and in highly deformed beds the correct division, and hence the correct interpretation of the details of the structure, is almost impossible. Within the eastern part of the Outwest fault plate, both east and west dipping faults are present, and several repetitions of strata occur. The Outwest fault plate, with its structurally complex east part, has no bearing on the oil prospects of the west flank of the Turner Valley structure, as the strata below the fault plate in orderly succession show a continuation of the west dip of Turner Valley. From information from Okalta No. 6 well, drilled on sec. 30, tp. 19, range 2, it is known there are faults under the Outwest fault plate that do not appear at the surface. One fault of very considerable displacement repeats part of the Belly River and part of the Upper Alberta shale, in Okalta No. 6 well. It is probable though that this fault toward the surface merges into the Outwest fault, as shown on cross-section C-C. Such an interpretation, however, means that the near surface part of the Outwest fault is less steeply inclined than the dip of the Edmonton beds under it. For this reason the interpretation as given may be open to serious question, although at the present time no alternative explanation can be suggested. In the study of faults in the foothills it has almost universally been found that the dip of the fault plane exceeds the the dip of the beds under it, so that the fault cuts progressively lower stratigraphic beds as its course is traced downwards. Any departure from this, such as shown for the Edmonton beds in cross-section C-C under the Outwest fault is, therefore, very unusual. In regard to the age of such a fault under the Outwest fault, very little evidence is available. If it is conceded that these fault plates develop from below outwards, as normally would be expected, so that the Turner Valley fault plate developed under the Outwest thrust plate, then faults in the Turner Valley fault plate would be expected to merge into the major sole fault between the two fault plates without cutting the overlying one. This seems to be the case with the fault in Okalta No. 6 well under the Outwest fault plate, as the Outwest fault plate is not believed to be cut by it.

The Outwest fault is known at a number of places. It was named by Link and Moore from the fact that the Outwest well on sec. 35, tp. 19, range 2, penetrated it at a depth of 2,520 feet and thus gave proof that it was relatively low-angled, as the outcrop of the fault is more than a mile east of the well. The Outwest well was drilled on what was commonly known as the New Black Diamond structure, a superficial fold that on Sheep River has a core of Alberta shales. Weymarn No. 1 well, on sec. 3, tp. 20, range 3, penetrated this same fault at 2,130 feet, passing from Alberta shale to Belly River strata. United No. 1 well, on the same section, penetrated the fault at 2,970 feet. To the northwest of Sheep River the fault is known at a few places. Highly slickensided Belly River beds occur on the northeast quarter of sec. 10, tp. 20, range 3. Apparently though there is no evidence of the Outwest fault in Phillips well, sec. 16, tp. 20, range 3, but on Quirk Creek, on the southeast of sec. 6, tp. 21, range 3, Alberta shales are overthrust by it onto Belly River strata. From this place the fault is shown on the North Half of Turner Valley map swinging in a broad arc to the southwest corner of sec. 3, tp. 22, range 4, where on the east edge of some hills south of Whiskey Creek there are very highly contorted and slickensided Belly River strata. Northwest of this the position of the Outwest fault is even more doubtful, but on a branch of Fish Creek on the northwest of sec. 28, tp. 22, range 4, it is believed there is a fault thrusting lower Belly River strata onto the upper, coal-bearing part of the formation. The position of this fault suggests that it is the northwest continuation of the Outwest fault which still farther northwest, on Elbow River in the Sarcee Indian Reserve close to its west boundary, overthrusts Alberta shales onto the same coal-bearing beds of upper Belly River age. If this is the continuation of the Outwest fault it becomes the main fault east of the Two Pine anticline. As the Outwest fault in the vicinity of Highwood River is known from the drilling of Okalta No. 6 well to have a low-angle part, and as a similar low-angle part is known on Sheep River from the drilling of Weymarn, Outwest, and United No. 1 wells, it might be expected to continue to have a low-angle part in the area east of the Two Pine anticline. Such an inference would lead to the conclusion that the fault would probably pass above the Palæozoic limestone under the Two Pine anticline, but from the drilling of the Graystone No. 1 (Signal Hill) well, on sec. 34, tp. 23, range 5, such a conclusion is not justified. This well encountered a repetition of lower Alberta shales and reached the top of the Blairmore at 1,760 feet. From this depth to the bottom of the well, at slightly more than 4,200 feet, there was, so far as known, no repetitions, and the well finished in the limy series of the Lower Blairmore close to the Dalhousie sand. Owing to mechanical troubles at this place the well could not be continued, but the danger point so far as a fault is concerned would have been reached in possibly the next 100 feet, at the coal-bearing beds of the Kootenay. From the depth of the well and the assumed position of the fault on the surface, it can readily be shown that the fault must have a westerly inclination of not less than 40 degrees, as the fault was not encountered by the well. It is not the object of this report to discuss the merits of the Two Pine anticline in reference to the fault that occurs east of it, but in Elbow

River area the fault is much farther east of the main anticlinal uplift than farther north. A well on the west flank of the Two Pine structure on Elbow River could not encounter this fault above a very considerable depth, provided the angle of the fault is 40 degrees or steeper as it is 3 miles north in the area east of the Graystone well. Farther south in the extension of the Two Pine anticline southward to Whiskey Creek, east of Fisher Mountain, the outcrop of the Outwest fault is even farther east of the structure than it is at Elbow River. It is possible, though, that northward from Sheep River the low-angle surface part of the Outwest fault may become progressively deeper buried with a steeper surface part. In such a case the deeper buried, low-angle part of the Two Pine area might still pass above the Palæozoic limestone, and thus eliminate prospects for oil from that formation. The drilling of one well in a critical locality will give the data on which a satisfactory conclusion can be made.

NORTH TURNER VALLEY EXTENSION

The successful completion of Home Millarville No. 2 well on sec. 33, tp. 20, range 3, has drawn attention to the prospects of extending the Turner Valley field northward. On the map of North Turner Valley "the faulted east edge of the limestone" is shown. This line divides Turner Valley productive area on the west from the probable non-productive area on the east. On the map, as already pointed out, the line is shown as swinging to the west in the area just south of Quirk Creek. This results in the productive area being more to the west in the north than in the south. The area to the north of Quirk Creek along the strike of the north extension of Turner Valley is largely underlain by Belly River strata in numerous fault blocks. Outcrops occur only on the hills, and to the north in the vicinity of Whiskey Creek the hills are largely wood covered and on many of them the rock exposures are poor. For these various reasons the geology is difficult to interpret, and the faults are not well defined and hence difficult to trace. There seems no doubt, though, that on the surface the extension of the Turner Valley structure from Home Millarville No. 2 well ends in the vicinity of secs. 2 and 12, tp. 22, range 4, on the north bank of Whiskey Creek. From this place northward there is a steep north plunge to the structure, and strata of upper Belly River or Edmonton occur in the area to the northwest in the valley of the south fork of Fish Creek. There is no further continuation of the Turner Valley structure northward from the plunging end of the structure on secs. 2 and 12, tp. 22, range 4. The fact that at the surface the greatly faulted structure continues this far north does not necessarily mean oil production will be continuous throughout the whole length from Home Millarville No. 2 well, as production is dependent on the limestone being reached above the level of the oil-water line. It is also impossible with present data to predict accurately the position of the east edge of the limestone, which will be the eastern limit of production, but with the greater depths to the limestone in the north this line will tend to move gradually farther westward, as the fault that cuts off the limestone has a westward inclination. The fact, however, that this fault is steep, as is shown on cross-section M-M, tends to make its subsurface trace roughly parallel its

surface trace, only diverging from it because of the greater depths to the limestone northward. It is, however, inferred that the limestone west of its faulted east edge can be reached at least as far north as sec. 2, tp. 22, range 4. It is also inferred that the eastern part of the anticlinal structure, whose east flank is very apparent at the surface through secs. 30 and 31, tp. 21, range 3, and sec. 1, tp. 22, range 4, will have little or no counterpart in the limestone, but will have been cut off by the fault that cuts off the limestone on its east edge. The depth to the oil-water line will determine whether or not oil production is found as far north as sec. 2, tp. 22, range 4. In Okalta No. 6 well water was found in the lower porous zone of the limestone, and the top of the limestone is slightly more than 5,700 feet below sea-level. The surface elevation in the vicinity of Whiskey Creek, on sec. 2, tp. 22, range 4, is approximately 4,250 feet above sea-level. If wells could reach the limestone at not more than 9,000 feet they should, therefore, have a fair prospect of obtaining oil in this area. For certain locations west of the probable position of the east faulted edge of the limestone it would seem possible to reach the limestone at depths not greatly exceeding 9,000 feet, although it should be realized that for such great depths predictions are difficult because of the complications of the structure. The dip on the west flank of the structure farther south is best shown in cross-section L-L in the vicinity of Phillips' well. It is very considerably steeper than at the south end of Turner Valley, and hence the width of the zone of production is likely to be appreciably narrower in the north end than in the south end. In the north end, in the extension northwest from Home Millarville No. 2 well, the structure is also more complicated by faulting than farther south. At the surface Belly River beds are in places contorted by local folds and faults, the importance of which are not readily evaluated in relation to the major structure. Such local disturbances may also occur at depth, as is indicated by the extreme amount of slickensiding in the Fernie shales of Home Millarville No. 2 well and the excessive thickness of strata between the Home sandstone and the top of the limestone (*See* Cross-section M-M). All these zones of contortion increase the drilling depths to the limestone, and some of them may in this respect be of considerable importance. In spite of this, however, it would appear that there is a very considerable area in the north extension of Turner Valley west of the faulted east edge of the limestone where the limestone can be reached above 5,000 feet below sea-level, and hence probably above the oil-water line. It is also possible that this prospective productive area may extend as far north as sec. 2, tp. 22, range 4, although its width will probably not be as great as the width of the oil productive area of southern Turner Valley.