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DEPARTMENT OF MINES AND RESOURCES

MINES AND GEOLOGY BRANCH

GEOLOGICAL SURVEY

PAPER 40-11

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BY

G. S. Hume and C. O. Hage

J. O. PATENAUDE, I.S.O.
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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Illustration

The Lloydminster Gas and Oil Area, Alberta and Saskatchewan

INTRODUCTION

Lloydminster is a town of 1,400 to 1,500 people situated on the 4th meridian, the dividing line between Alberta and Saskatchewan. It is 24 miles south of North Saskatchewan River. It is on the Jasper highway connecting Edmonton and Saskatoon, and is the centre of a prosperous farming community established by English settlers in 1903. The surrounding country is relatively flat with poplar groves, and the underlying bedrock is almost wholly concealed beneath a cover of glacial drift.

Deep wells indicate the presence of the following formations:

- Upper Cretaceous
  - Ribstone Creek formation—sands and shales
  - Lea Park formation—marine shales
  - Alberta shales—marine shales
- Lower Cretaceous—sands and shales
- Palæozoic limestone

Prior to the drilling of deep wells most of the information relative to the bedrock had been obtained from water wells, and from outcrops on North Saskatchewan River and Big Gully at a considerable distance from the town. The records of the water wells drilled to 200 feet or more into water-bearing sands in the Ribstone Creek formation give no information of structural importance that might lead to the supposition that oil and gas occurred in the area. As has been proved by deep wells, and as is indicated by the uniformity of depth of water wells to the same horizon, the structure is practically flat.

GAS WELLS AND THEIR SIGNIFICANCE

The Lloydminster area first came into prominence in 1934 on the completion of Lloydminster No. 1 well, less than one mile north of the town. The well after encountering some gas and oil shows and passing through one salt water horizon at 1,895 feet, reached a gas sand in Lower Cretaceous strata at a depth of 1,970 feet, which gave a measured flow of 16,750 M cubic feet at a pressure of 565 pounds. During the summer of 1934 the gas from the well was piped into Lloydminster, and deliveries of gas began in September of the same year.

The second well, also drilled by the Lloydminster Gas Company, was a mile east of No. 1 well. The sand correlative with the gas sand of No. 1 well was not productive in the second well. The well was drilled to the Palæozoic limestone, but abandoned at a depth of 2,330 feet after striking salt water in a number of horizons in the Lower Cretaceous and in the limestone itself. Interest in the area was stimulated, however, by the completion in 1935 of Colony No. 1 well about 2 miles southeast of the town. This well reached a gas sand at a depth of 1,709 feet and was estimated to have a gas flow of 42,600 M cubic feet at a pressure of 420 pounds. As there was no immediate need for this gas, the well was shut in and a measured flow of the well made in 1938 was 25,600 M cubic feet. This gas occurs in a sand at the contact between Upper and Lower Cretaceous strata, whereas in Lloydminster No. 2 well, 2 miles to the north, salt water was reported in a sand immediately below this contact. The elevation of this contact in the two wells, as shown in Table I, is at 427 feet above sea-level in Colony No. 1 well and 407 feet in Lloydminster No. 2 well. It is difficult to decide how much importance should be attached to this small difference in elevation, as on account of the character of the sediments at this contact a determination of its position can only be moderately precise. Also, in drilling, the samples are usually taken every 10 feet, but should not be regarded as having an accuracy greater than a 10-foot limit. Despite these limitations, however, it is possible, by using the data supplied by the thirteen wells in the area, to draw a contour map (Figure 1) of the top of the Lower Cretaceous. It may be, therefore, that the small differences in elevation of the top of the Lower Cretaceous indicated by the wells actually exist, and that they explain why Lloydminster No. 2 well encountered water and Colony No. 1 well obtained gas in what is presumed to be the same sand. The small differences in elevation may also explain why Lloydminster No. 1 well after producing gas for 3 years finally became flooded by water in the spring of 1938. It is obvious that in any structure with such small differences in elevation on the producing sands as in the Lloydminster area, water will be a serious problem in the continued production of both gas and oil wells.

STRUCTURE INDICATED BY UPPER CRETACEOUS HORIZONS

From calculations that can be made from the data given in Table I it is obvious that the local structure on the top of the Lower Cretaceous sediments, as indicated in Figure 1, has no counterpart either on the Ribstone Creek-Lea Park contact or on the Lea Park-Alberta shale contact. For instance, in Lloydminster No. 2 well the Ribstone Creek-Lea Park contact occurs at an elevation of 1,927 feet above sea-level and in Colony No. 1 well at an elevation of 1,908 feet. The Lea Park-Alberta shale contact is at 1,117 feet above sea-level in Lloydminster No. 2 well and at 1,108 feet in Colony No. 1 well. This indicates that Lloydminster No. 2 well is structurally higher than Colony No. 1 well on these horizons, whereas the reverse is indicated by the recorded elevations of the top of the Lower Cretaceous strata. The apparent differences in elevation of these two contacts are small, and perhaps have little significance, especially as the contacts are not sharply defined and, therefore, cannot be determined exactly.

In the Lloydminster area the Belly River series, of which the Ribstone Creek is the lowest formation, consists of alternating marine and non-marine beds. To the east, these are wholly represented by marine beds.

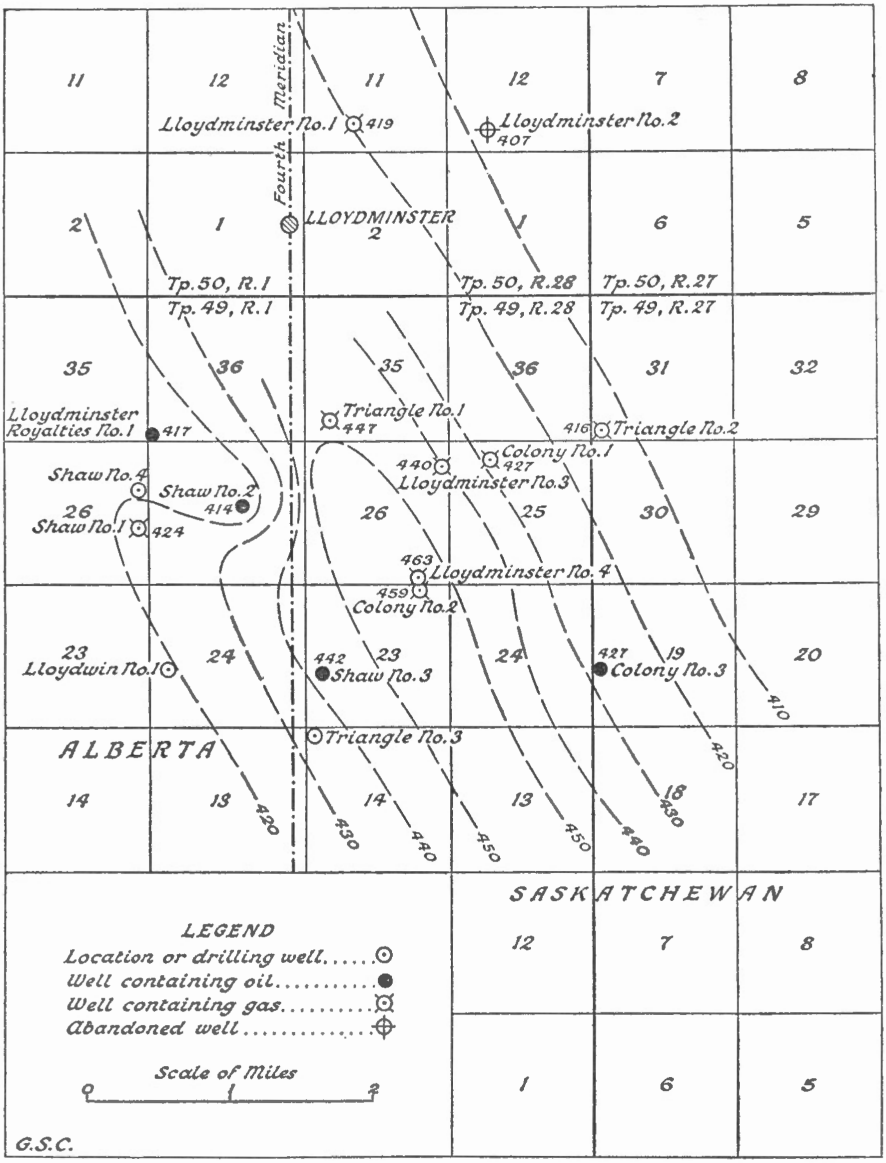

Figure 1. Well locations and structural contours on top of Lower Cretaceous, Lloydminster area, Alberta and Saskatchewan.

In the Lloydminster area, marine and non-marine beds are interfingered even within the Ribstone Creek formation. Sands, 6 miles northeast of Lloydminster, carry marine fossils, whereas farther west similar sands are thought to be non-marine. Where the basal beds of the Ribstone Creek are non-marine, they are sands that are rather sharply defined against the shales of the underlying Lea Park formation, but where they are at least partly marine in the Lloydminster area they are in many places shaly and no sharp division is possible. Under such conditons, although the position of the contact can be readily recognized in a general way, it cannot be precisely fixed. It is thus obvious that the Ribstone Creek-Lea Park contact is not a good horizon for the determination of small structural differences such as have been inferred from the study of the elevations of the top of the Lower Cretaceous sediments in the Lloydminster area. The contact between the Lea Park and Alberta shales is also of little importance for small structural differences. The top of the Alberta shale is placed at a zone of shale that carries a large number of white, calcareous particles. As the contact is between two shale formations and as the origin and significance of the calcareous particles are not known, it is uncertain if the contact as determined represents a single definite horizon.

RELATION OF POSSIBLE STRUCTURE TO PRODUCTION

Thirteen wells have now been drilled in the immediate vicinity of Lloydminster, and three others in Saskatchewan a short distance to the southeast. Some of the thirteen wells contain gas in commercial volumes and four contain oil. Two of the oil wells are in Alberta and two in Saskatchewan. If the local structure on the top of the Lower Cretaceous sediments, as shown on Figure 1, is at least partly responsible for the arrangement of gas, oil, and water in the field, as found in the various wells, then it appears that Colony No. 2 and Lloydminster No. 4 wells are located on the apex of the structure, and the oil wells, Lloydminster Royalties No. 1, Shaw No. 2, and Shaw No. 3, are on the west flank of the field in a northwest-southeast line apparently parallel to the trend of the structure. Shaw No. 1 well to the west of the line of the oil wells, and from which only gas has been reported, is somewhat higher structurally than the nearest oil well, Shaw No. 2. The difference, however, is only 10 feet, and without further evidence on the relationship of the structure to the gas, oil, and water, not much importance should be attached to such small variations, and it should be noted that the elevation of the top of the Lower Cretaceous is higher in Shaw No. 3, an oil well, than it is in Shaw No. 1, a gas well.

It is a matter of speculation at the present time whether the structure that appears to be shown on the top of the Lower Cretaceous (Figure 1) is tectonic or is the result of uneven settling of sediments following deposition. There is no doubt that some of the sands in the Lower Cretaceous are lenticular, and the resulting uneven distribution of sands and shales might have caused uneven settling under a superimposed load of younger deposits. No reasons for any local folding can be given, although the area undoubtedly has been influenced by regional forces.

REGIONAL STRUCTURE

The available data pertaining to the altitude of the top of the Lower Cretaceous and the top of the Palæozoic limestone over a considerable region extending south and west from Lloydminster is given in Table II.

Considering the long distances separating some of the wells, the elevation of each horizon is not so very different. The top of the Lower Cretaceous is high in the Lloydminster area and slopes southwestward through the Ribstone area to Wainwright and thence to Viking, but it is difficult to judge what effect this has on oil and gas concentration. This slope is the regional dip and may, of course, have local undulations. The dip on the top of the Lower Cretaceous between Lloydminster and Viking is 389 feet in 75 miles, or about 5 feet to the mile. A similar rate of dip exists from Lloydminster to Wainwright on the same horizon, so that it may be assumed that the regional dip is somewhat uniform. The thickness of the Lower Cretaceous, however, is not at all constant and thins from Lloydminster to Wainwright and Viking.

Data from the few wells that have been drilled into the Palæozoic limestone suggest that the local variation on the top of the erosional limestone surface is almost as great, if not greater, in many places than the regional differences. For example, the difference in elevation of the top of the limestone in the two wells drilled near Lloydminster, namely, Lloydminster No. 2 and Altoba No. 2 wells, is 40 feet and at Wainwright the difference between the top of the Palæozoic limestone in Admiral No. 1 and Montreal Alberta wells is 51 feet, whereas the difference between Lloydminster No. 2 and Admiral No. 1 wells is only 19 feet and between Lloydminster No. 2 and Montreal Alberta wells is 70 feet. This suggests that the differences of elevation of the top of the Palæozoic limestone are erosional rather than structural. The wide variation in thickness of the Lower Cretaceous (*See* Table II) suggests that the dip of the top of the Lower Cretaceous may be depositional and not due to regional structure.

LOWER CRETACEOUS SEDIMENTS IN RELATION TO PRODUCTION

In the Lloydminster-Wainwright-Vermilion area the top of the lower Cretaceous is placed at a definite break in lithology. The shales above the break are placed in the Alberta formation and the sands and shales of a different character below it, in the Lower Cretaceous. Over a wide area of this part of the plains small chert pebbles, commonly the size of rice grains, occur in the shales immediately above the contact. Usually these pebbles, where present, are in the lower 20 feet of the beds above the contact, but in Shaw No. 1 well the pebbles are in the samples for 100 feet above the contact. These pebbles are probably related to an erosional break, and it is, therefore, possible that some of the shales now placed in the Upper Cretaceous are in reality Lower Cretaceous in age. For the purposes of this report, however, the lithological break previously noted is considered the division between Upper and Lower Cretaceous strata.

In the McMurray area on Athabaska River, the Lower Cretaceous consists of alternating marine and non-marine formations, with a total thickness of not less than 750 feet. In southern Alberta the whole of the Lower Cretaceous is composed of non-marine strata, so that the shorelines of the seas that deposited the marine beds in the McMurray area must have been south of that area and north of southern Alberta. From information available from wells it is believed that these shorelines trend northwest and southeast, cross the Wainwright-Lloydminster areas, and extend southeast into Saskachewan. It is the thickening of the Lower Cretaceous marine deposits in a northeast direction at right angles to the shoreline trends that seems to account for the thickening of the Lower Cretaceous from Viking and Wainwright to Lloydminster. Because the Lower Cretaceous in the McMurray area is at least 750 feet thick, it is suspected that this thickening is greater northward than it is eastward. However, owing to the nature of this near shore and shoreline deposition, a uniform increase in thickness north and northeast is not to be expected. Considerable variation occurs locally, as at Ribstone and Wainwright and as shown by Table II. It is probable that in these and other areas limestone ridges existed during the early stages of Lower Cretaceous sedimentation, and locally they may have had a very pronounced effect on the depositional dip of the materials. It does not seem probable that a limestone ridge existed at Lloydminster because the limestone surface is low compared with that in neighbouring areas and the Lower Cretaceous sediments are thicker than in some other areas. Table II shows that from a low place at Lloydminster, as shown by Lloydminster No. 2 well, the limestone surface rises southeastward through Altoba No. 2 well to Vera and then decreases in elevation again to Muddy Lake. The few known depths to the limestone surface, however, are not sufficient to justify any conclusions.

Although it seems probable that the increase in thickness of the Lower Cretaceous sediments to the north and northeast of Wainwright results from the inclusion of more marine deposits, it is not possible at the present time to state what proportion of the Lower Cretaceous is marine in the Lloydminster area. Except for one shaly zone between 1,840 and 1,940 feet in depth, by far the greater proportion of the Lower Cretaceous sediments in Lloydminster No. 2 well, for example, are sands. In Altoba No. 2 well the sediments are more shaly than in Lloydminster No. 2 well, and shale occurs between 1,890 and 1,970 feet in depth. White, granular quartz sands are prominent in the Lower Cretaceous of the Ribstone and Lloydminster areas, and commonly these are water bearing.

In the Wainwright and Ribstone areas a coal seam occurs 130 feet below the top of the Lower Cretaceous, and the oil at the Dina wells at Ribstone comes from a sand about 20 feet below this coal seam, as it does in the Onalta and Bethwain No. 2 wells at Wainwright. In Lloydminster No. 1 well a prominent coal seam occurs at 1,838 feet, i.e., 148 feet below the top of the Lower Cretaceous, and a similar coal seam was reported at 1,840 feet or 150 feet below the top of the Lower Cretaceous in Lloydminster No. 2 well. Carbonaceous shale and coal occur at 1,760 feet or 150 feet below the top of the Lower Cretaceous in Altoba No. 2 well, and carbonaceous shales occur in Lloydminster Royalties well at various horizons from 1,836 to 1,922 feet. In the Lloydminster Royalties well the oil sand at 1,925 feet is 165 feet below the top of the Lower Cretaceous, whereas in Meridian No. 1 well, 20 miles south of Lloydminster, the top of the oil sand is 159 feet below the same horizon. It appears from this information that not only is the coal seam a very definite horizon at about the same depth below the top of the Lower Cretaceous in the Wainwright and Ribstone areas, but it also occurs although somewhat more indefinitely in the Lloydminster area. The oil sand under it also shows a rather unexpected uniformity in the Wainwright, Ribstone, and Lloydminster areas.

The gas sand in Lloydminster No. 1 well at 1,970 feet is 280 feet below the top of the Lower Cretaceous and apparently is a totally different horizon from any other that has been productive. As will be seen from Table I, the oil sand in Lloydminster Royalties No. 1 well is at a different horizon from that in Shaw Nos. 2 and 3 wells, where the oil occurs at the top of the Lower Cretaceous presumably in its uppermost sand.

The sands immediately under the contact are those that have been found to be oil bearing in Shaw Nos. 2 and 3 wells and gas bearing in a number of other wells, as Lloydminster Nos. 3 and 4, Colony Nos. 1 and 2, Shaw No. 1, and Triangle No. 1 wells. This horizon has been reported to contain gas, oil, and water in various Wainwright wells, and is presumed to be the productive gas horizon in Battleview No. 1 well on the Battleview anticline.

SHALLOW GAS PRODUCTION

Gas occurs not only in the Lower Cretaceous, but also in nearly every well drilled at Lloydminster and Ribstone in sandy shales in the upper part of the Alberta formation. In Lloydminster No. 4 well the gas was reported at 1,365 to 1,368 feet, in Colony No. 1 well at 1,396 feet, and in Triangle No. 2 well at 1,367 feet. The flow varies greatly from a few thousand feet up to 250,000 feet or even slightly more. The producing horizon is evidently sandy shale and is probably not highly porous.

PRODUCTION OF GAS AND OIL

The gas production[1] of Lloydminster No. 1 well from October 1934 to September 1938, when the well was flooded by water and production ceased, was 267,763,000 cubic feet. This gas was supplied to the town of Lloydminster. From information recently available, this well when shut in quickly builds up a pressure of about 400 pounds. The water is assumed to be from the producing horizon. Gas for Lloydminster is now being supplied from Lloydminster Nos. 3 and 4 wells and Colony No. 2 well.

Four wells in the Lloydminster area contain oil. Two of these, Lloydminster Royalties and Shaw No. 2, are in Alberta, and Shaw No. 3 and Colony No. 3 are in Saskatchewan. As has already been pointed out, the oil sand in Lloydminster Royalties well is 165 feet below the top of the Lower Cretaceous, whereas the oil in the other three wells occurs at or just below the contact. Although some oil has been taken from these wells the writers have no data on continuous pumping tests over any definite period, so that no rate of production is available at present. Colony No. 3 well was drilled to a depth of 325 feet below the top of the Lower Cretaceous, but was later plugged back to the oil sand at that horizon. At the time of completion, 900 feet of fluid was reported in the hole, of which a part was water. So far as known, only a small amount of oil has been taken from this well by bailing, and no pumping test has ever been made.

[1]Swain, E.: Dept. of Natural Resources, Saskatchewan.

ANALYSIS OF GAS

The analysis[1] of gas from Lloydminster No. 1 well is as follows:

	Per cent
Hydrocarbons	94·7
Carbon dioxide	0·6
Oxygen	1·0
Nitrogen (by diff.)	4·5
	100·9

ANALYSES OF PETROLEUM

Analyses of the petroleum, made by H. McD. Chantler, Division of Fuels, Bureau of Mines, Mines and Geology Branch, Department of Mines and Resources, Ottawa, are as follows:

—	Shaw No. 2	Lloydminster Royalties
Colour	Black	Black
Water and sediments % by volume (Centrifuge method)	16	3·4
Specific gravity at 60° F	0·976	0·983
Equivalent degrees A.P.I.	13·5	12·5
Sulphur % by weight	3·05	3·95
Pour point (A.S.T.M.)	10° F.	30° F.
Viscosity (Saybolt Furol at 122° F.)	176 sec.	510 sec.

Distillation Summary (Dehydrated Oil)
(By Hempel method)

—	Shaw No. 2	Lloydminster Royalties
Gasoline and naphtha	....	....
Kerosene distillate	....	....
Gas oil	19·3	15·4
Nonviscous lub. dist	9·4	8·4
Medium lub. dist	9·1	7·8
Viscous lub. dist	8·0	8·2
Residuum	53·1	59·1
Distillation loss	1·1	1·1
Base of crude	Naphthene (wax bearing)	Naphthene (wax bearing)
Carbon residue of residuum	19·1% by wt.	20·0% by wt.
Carbon residue of crude	10·1% by wt.	11·8% by wt.

[1]Ann. Rept., Dept. of Natural Resources, Mines Branch, Saskatchewan, 1935, p. 23.

TABLE I

Well[1]	Legal subdivision	Section	Township	Range	Meridian	Elevation of well[2]	Depth to Ribstone Creek-Lea Park formation	Depth to Lea Park-Alberta shale contact	Depth to top of Lower Cretaceous	Depth to top of Palaeozoic limestone	Final depth of well	Thickness of Lea Park	Thickness of Alberta shale	Combined thickness of Lea Park and Alberta shale	Thickness of Lower Cretaceous	Elevation on top of Lower Cretaceous	Remarks
						Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
Lloydminster No. 1......	3	11	50	28	3	2,109	200	1,000	1,690	....	1,970	800	690	1,490	......	419	Gas 1,600 ft.; oil show 1,880-2 ft.; water 1,895 ft., rose to 730 ft.; oil show 1,944 ft.; gas 1,970 ft. 16,750 M. cu. ft. at 565 lbs. pressure. Well used to supply town of Lloydminster 1934-1937. Well flooded with salt water in spring of 1938.
Lloydminster No. 2......	3	12	50	28	3	2,097	170	980	1,690	2,250 Elev. -153 ft.	2,330	810	710	1,520	560	407	Salt water and show of oil at 1,705 ft.; water at 2,070, 2,217, 2,304, 2,324 ft.
Lloydminster No. 3.....	16	26	49	28	3	2,120	220	1,010	1,680	....	1,707	790	670	1,460	......	440	Water 95-112, 160-163, 217-220 ft.; gas at 1,677 ft. about 605 M cu. ft. at 430 lbs. pressure. Some heavy oil and water with gas.
Lloydminster No. 4......	1	26	49	28	3	2,133	230	1,010	1,670+	....	1,679	780	660+	1,440+	......	463−	Water 111-112 ft.; gas 1,365-68 ft. 50 M cu. ft.; gas 1,450-60, 1,536-42 ft.=35 M cu. ft.; gas 1,676 ft.= 6,750 M cu. ft. at 430 lbs. pressure (est.).
Colony No. 1...........	14	25	49	28	3	2,128	220	1,020	1,701	....	1,709	800	681	1,481	......	427	Gas 995, 1,080, 1,115, 1,396 ft.=16 M cu. ft.; gas at 1,701 ft. measured in 1938=25,600 M cu. ft. Original pressure of 420 lbs.
Colony No. 2...........	16	23	49	28	3	2,139	220	1,020	1,680	....	1,700	800	660	1,460	......	459	Water 130 ft.; gas 1,065, 1,115, 1,315, 1,382, 1,630, 1,693 ft. At 1,382 ft.= 10 M cu. ft.; at 1,693 ft. = 8,470 M cu. ft. at a pressure of 430 lbs. Sand in Lea Park formation at 350 ft.
Colony No. 3...........	5	19	49	27	3	2,117	180	960?	1,690	....	2,015	780?	730	1,510	......	427	Water at 1,785, 1,920, 1,990, 2,015 ft. Plugged back to 1,700 ft. Brown oil sand 1,690 ft.

TABLE I—Continued

Well[1]	Legal subdivision	Section	Township	Range	Meridian	Elevation of well[2]	Depth to Ribstone Creek-Lea Park formation	Depth to Lea Park-Alberta shale contact	Depth to top of Lower Cretaceous	Depth to top of Palæozoic limestone	Final depth of well	Thickness of Lea Park	Thickness of Alberta shale	Combined thickness of Lea Park and Alberta shale	Thickness of Lower Cretaceous	Elevation on top of Lower Cretaceous	Remarks
Shaw No. 1	8	26	49	1	4	2,171	230	1,060	1,747	....	1,753	830	687	1,517	......	424	Gas 1,747 ft.=6,500 M cu. ft. Chert pebbles 1,650 to 1,753 ft.
Shaw No. 2	10	25	49	1	4	2,164	210	1,050	1,750	....	1,760	840	700	1,540	......	414	Oil sand 1,755-60 ft. Some gas—oil 13·5° A.P.I.
Shaw No. 3 (Colony No. 4)	5	23	49	28	3	2,152	240	1,040	1,710	....	1,712	800	670	1,470	......	442	Gas at 1,480 ft. = 250 M cu. ft. Oil at 1,710 ft.
Triangle No. 1	4	35	49	28	3	2,132	230	1,030	1,685	....	1,703	800	655	1,455	......	447	Water at 125, 185-195 ft.; gas 770-775, 1,135, 1,310-20, 1,455 ft. At 1,685-95 ft. = 760 M cu. ft. at pressure of 412 lbs.
Triangle No. 2	4	31	49	27	3	2,096	200	1,020	1,680	....	1,705	820	660	1,480	......	416	Water at 25, 90, 160-165 ft.; gas 865, 935, 1,367 ft.; salt water 1,705 ft. rose to 1,200 ft. in well. Small gas flow at 1,367 ft.
Triangle No. 3	13	14	49	28	3	....	....	....	....	....	......	......	......	....	......	......	Drilling.
Lloydminster Royalties No. 1	4	36	49	1	4	2,177	240	1,080	1,760	....	1,928	840	680	1,520	......	417	Oil sand 1,925 ft.; 13 ft. thick as reported by driller.
Altoba No. 1	13	22	47	27	3	2,083	200	990	1,688	....	1,688	790	698	1,488	......	395	Gas at 1,688 ft. = 1,000 M. cu. ft. at a pressure of 625 lbs.
Altoba No. 2	9	29	47	26	3	2,017	140	910	1,590	2,130 Elev. −113 ft.	2,275	770	680	1,450	540	427	Gas at 950, 1,215, 1,940 ft.; water 1,890-95, 1,920-30 ft. No production.
Altoba No. 3	13	24	48	28	3	2,137	180[3]	1,040	1,732	....	1,763	860	692	1,552	......	405	Water at 124, 170 ft. Chert pebbles at 1,700 ft. No production.

[1] Logs of wells in part supplied by R. T. D. Wickenden.
[2] Elevation of wells by Mr. McLean—Lloydminster Gas Company.
[3] Contact not definite, may be at 240 feet.

TABLE II

Well	Legal subdivision	Section	Township	Range	Meridian	Elevation of well	Depth to top of Lower Cretaceous	Elevation of top of Lower Cretaceous	Depth to top of Palæozoic limestone	Elevation of top of Palæozoic limestone	Thickness of Lower Cretaceous	Remarks
						Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
Lloydminster[1] No. 2	3	12	50	28	3	2,097	1,690	407	2,250	−153	560	Lloydminster area. No production.
Altoba No. 2	9	29	47	26	3	2,017	1,590	427	2,130	−113	540	Southeast of Lloydminster. No production.
Vera Oilfields No. 2	5	23	41	24	3	1,934	1,750	184	2,140	−106	390	65 miles south-southeast of Lloydminster at Vera, Sask.
Muddy Lake (Northwest Co.)	11	7	39	22	3	1,894	1,790	104	2,130	−236	340	15 miles southeast of Vera.
Ribstone Oils No. 2	5	25	46	1	4	2,087	1,739	348	2,271	−184	532	Ribstone area in Alberta 20 miles south of Lloydminster.
Rayco No. 1	3	4	47	1	4	2,194	1,820	374	2,250	−56	430	Ribstone area.
Highwood Blackfoot No. 1	1	36	47	2	4	2,178	1,820	358	2,306	−128	486	Blackfoot Hills, 5 miles northwest of Rayco well.
Pacalta No. 1	3	5	48	5	4	2,194	1,859	335	2,329	−135	470	Battleview anticline.
Bethwain No. 1	13	6	45	6	4	2,247	2,050	197	2,372	−125	322	Wainwright area. Small gas flow.
Admiral No. 1	16	36	44	7	4	2,226	2,054	172	2,360	−134	306	Wainwright area. No production.
Montreal Alberta No. 1	2	15	45	7	4	2,238	2,060	178	2,321	−83	261	Wainwright area. No production, drilling in limestone.
Beaumont No. 2	10	30	45	7	4	2,196	2,040	156	2,303	−107	263	Wainwright area. No production.
Imperial Fabyan No. 1	16	18	45	7	4	2,040	1,890	150	2,140	−100	250	Fabyan area, 8 miles northwest of Wainwright. Gas well.
Altoba Wainwright No. 2	1	35	47	7	4	2,233	1,953	280	2,249	−16	296	South of Vermilion. Some oil in Lower Cretaceous.
Tenwell No. 1	9	36	50	7	4	2,035	1,800±	235±	2,098	−63	298±	At Vermilion. No production.
Duvernay No. 1	5	34	55	12	4	1,856	1,500	356	2,075	−219	575	On North Saskatchewan River. No production.
H. B. Viking No. 1	5	8	49	12	4	2,273	2,255	18	2,535	−262	280	Viking gas field.

[1]For other wells at Lloydminster *See* Table I.

CONCLUSIONS

Gas and oil occur in the Lloydminster area and gas has been used since 1934 to supply local needs. Most of the gas and oil occurs in sands at or just below the top of the Lower Cretaceous sediments. Exceptions to this are Lloydminster No. 1 well where gas production was from a sand 280 feet below this horizon and Lloydminster Royalties No. 1 well where oil occurs in a sand 165 feet in the Lower Cretaceous. Most of the wells that yield gas from the top of the Lower Cretaceous give an initial pressure of slightly more than 400 pounds from a depth of approximately 1,700 feet. The structure based on the top of the Lower Cretaceous is relatively flat, and water occurs in the oil and gas horizon in Lloydminster No. 2 well at a somewhat lower elevation than in the producing wells. No continuous production tests over any considerable period have yet been made of any of the oil wells, so that it is not known to what extent, if any, oil can be produced without some accompanying water. The separation between oil and water in the producing sands may not be very sharp because of the relatively small difference in specific gravity between the heavy oil and water, and in some of the wells water may be in the base of the same sand under the oil. Heavy oils of this kind when agitated by production have a tendency to form emulsions with water, and in certain cases the water will not separate of its own accord from such emulsions, so that water troubles are to be avoided where at all possible. The disposal of salt water, if produced in any volume, also constitutes a serious problem, as it cannot be allowed to drain off to contaminate fresh waters and it destroys the productivity of the land on which it is impounded. The fact, however, that gas and oil occur in the Lloydminster area in what appears now to be a structure of low relief is not only decidedly important in itself, but even of greater importance as an indication of what may be eventually expected from the large area included within central eastern Alberta and western Saskatchewan.