CANADA
DEPARTMENT OF MINES
HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR

Summary Report, 1930, Part B

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OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1931

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Note. Part B of the Summary Report formerly included reports relating to the provinces of Manitoba, Saskatchewan, and Alberta, and to the part of the North West Territories lying north of these provinces. It now contains only reports that deal with the southern and western parts of this region underlain chiefly by Palæozoic and later formations. Part C is a new part comprising reports that relate to the northern and eastern portions of the same region, which are underlain chiefly by Pre-cambrian formations. What has hitherto been called Part C is now Part D. It relates to the provinces of Ontario, Quebec, New Brunswick, Prince Edward Island, and Nova Scotia, and to the part of the North West Territories lying north of these provinces and east of Hudson bay.

MILK RIVER AREA AND THE RED COULÉE OIL FIELD, ALBERTA

By C. S. Evans

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Illustrations

INTRODUCTION

The area covered by this report lies in southern Alberta, just north of the International Boundary, and includes townships 1, 2, and 3, in ranges 13 to 19 inclusive, west of the 4th meridian.

Milk river flows eastward through the middle of the area, and, with its south branch, is the only permanent stream.

The eastern part of Milk River ridge lies north of Milk river in the western half of the area, and its upper surface is 500 to 600 feet above the elevation of the river. The northeast slopes of the ridge are fairly steep down to the prairie around Warner, 200 feet below Milk river, whereas the slopes to the south are long and gentle down to the valley of Milk river. A low prolongation of Milk River ridge extends eastward from the town of Milk River into range 15. South of Milk river, in ranges 17 and 18, there is a northeast-southwest trending ridge whose highest parts reach an elevation of about 4,300 feet, about 100 feet higher than the highest part of Milk River ridge within the area.

The remainder of the area is flat or rolling prairie, into which Milk river and its seasonal tributaries, as well as no longer existing streams, have eroded steep-walled valleys and coulées along which most of the outcrops of the area occur. Many of the coulées cannot be seen from the prairie surface except at their very edges.

There is abundant morainic and glacial outwash material over the area, in which boulders and rock fragments from the Canadian Shield predominate. No glacial material was recognized as being derived from the Rocky mountains. Most of township 1, range 18, is typical pot-hole country with many small lakes.

Springs are fairly common in the western part of the area, along Milk river and Red coulée, and in an unnamed coulée in the south of township 2, range 17. These springs come from Pale, Foremost, Pakowki, and Milk River strata. East of the town of Milk River only two springs of potable water were found. Alkali lakes are present in Verdigris coulée and in the neighbourhood of Red coulée and these dry up during the summer. Red creek has not been known to dry up completely, but in the summer water is present only in isolated pools along its course.

A good, gravelled highway runs south from Warner, through Milk River to Coutts at the border. A secondary road runs west from Milk River to the Cardston district, and another runs eastward from Milk River. There are dirt roads along the road allowances in the farming districts, and in summer cars may be taken over the prairie surface, so that all parts of the area are readily accessible in dry weather.

A branch line of the Canadian Pacific railway runs south from Lethbridge through Milk River to Coutts.

The field work on which this report is based was done in the summer of 1930. Township plans were used as base maps. Traverses were run by stadia and plane-table. Temporary bench marks were set by stadia and transit. Elevations were carried on all known stratigraphic horizons exposed. Messrs. J. F. Caley, B. E. Souch, and John Souch, acted as assistants.

The writer wishes to acknowledge the co-operation of Mr. C. C. Ross, Supervisory Mining Engineer, and his staff at Calgary in providing ready access to logs and samples from the wells.

The writer is indebted to Alberta Pacific Consolidated Oils, Limited, Dalco Oil and Gas Company, Limited, Dixie Oil Company, Limited, Celtic Oils, Limited, Commonwealth Petroleum, Limited, Southern Alberta Exploration Company, Limited, Vanalta Oils, Limited, and Northwest Company, Limited, for permission to publish partial or complete logs of wells.

The writer wishes to thank Mr. S. E. Slipper, of the Canadian Western Natural Gas, Light, Heat, and Power Company, Limited, for records of sections of the Pakowki from shallow wells along Milk river, without which no full section of this formation could have been given.

GENERAL GEOLOGY

The area is underlain by Upper Cretaceous strata with dips measured in a few tens of feet a mile, so that the strata appear to be horizontal. The area is mantled by morainic and outwash material and soil, and the outcrops are confined to steeper slopes, often at springs, and along the sides of steep valleys and coulées.

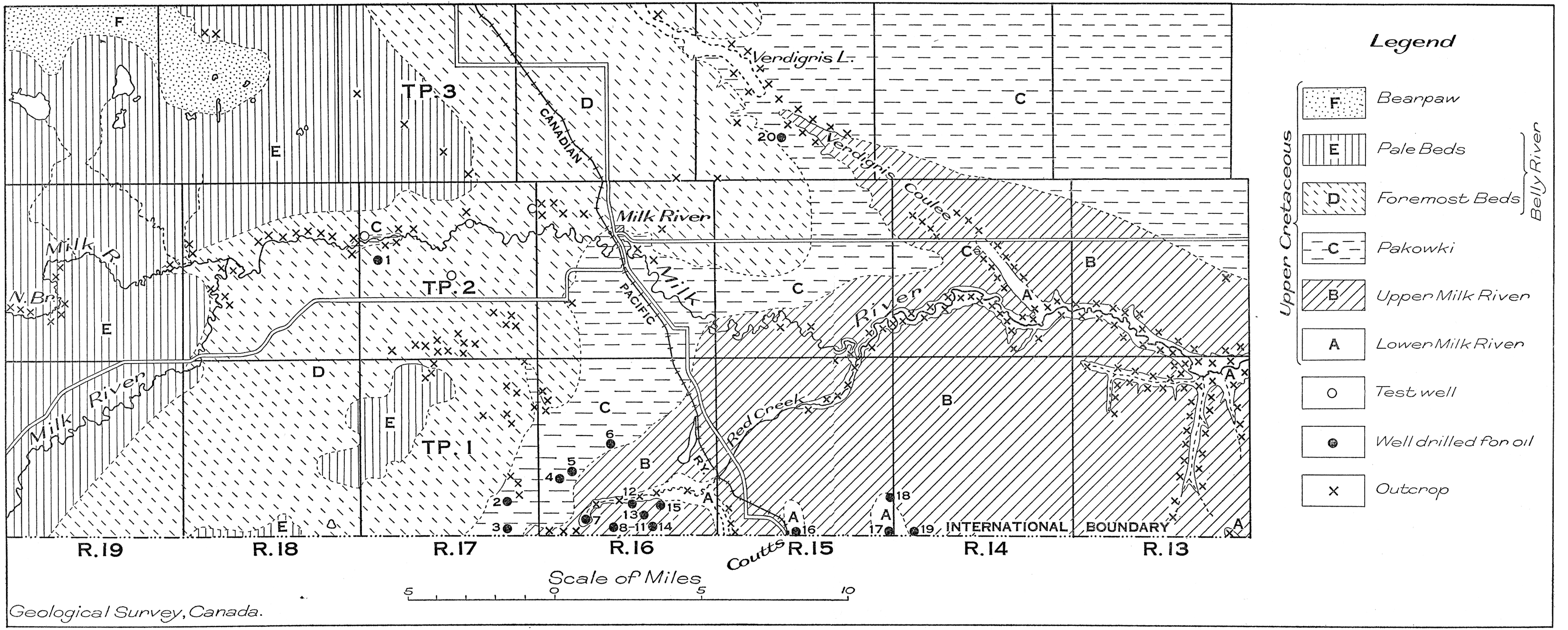

Figure 1. Milk River area, west of 4th meridian, Alberta. Oil wells: 1, Dalco No. 2; 2, Holgar; 3, Ko-Top No. 1; 4, Dixie No. 1A; 5, Celtic No. 1; 6, Capitol No. 1; 7, Imperial Red Coulée No.1; 8, Taylor No. 1; 9, Vanalta No. 2; 10, Vanalta No. 1; 11, Alberta Pacific Consolidated Red Coulée No. 1; 12, Devonshire No. 1; 13, Commonwealth Red Coulée No. 1; 14, Southern Alberta Exploration No. 1; 15, Dalco No. 1; 16, Urban; 17, Coutts-Sweet Grass; 18, Lethbridge Oils; 19, Border Oils; 20, Commonwealth Milk River No. 1.

Table of Formations

Upper Cretaceous	Bearpaw		No exposures found. Thought to be present on top of Milk River ridge
	Belly River	Pale Beds	Light grey, greenish grey shale and sandstone. Concretionary layers
		Foremost Beds	Grey sandstones and shales, with dark grey and brown lignitic shales. Some lignite. Some impure bentonite. Concretionary beds with Unios and Corbula. Heavy bed of medium sandstone at base
	Pakowki		Grey and greenish grey sandstone and shale. Black chert pebble bed at base
	Milk River	Upper Milk River	Fine to medium, light grey sandstone. Grey, greenish, and lignitic sandy shales. A little lignite
		Lower Milk River	Heavily bedded, medium-grained, light grey sandstone. Shaly at base
	Alberta shales		Mostly dark shales. Sandy at top and base. Bentonite, glauconite
Lower Cretaceous	Kootenay (?)		Grey, light grey, green, and red shales. Fine and medium-grained, grey and greenish grey sandstone. Traces of coal. Some bituminous shale
Upper Jurassic	Ellis		Grey, greenish grey, shale and calcareous shale, with quartz and black chert grains. Sandy and limy at base. Glauconitic beds
	Pre-Ellis		Limestone, sandy limestone, bituminous shale, gypsum

NOTE. Strata below the Milk River are not exposed within the area.

PRE-ELLIS STRATA

Pre-Ellis strata are reached by three of the deeper wells. Summaries of parts of the logs of these wells are given below.

Commonwealth Petroleum, Limited, Milk River Well No. 1; L.S.D. 8, Sec. 9, Tp. 3, Range 15, W. 4th Mer., Elevation 3,163 Feet

Drilling depth	
2,750	Base of Ellis
2,750–3,570	White limestone
3,570–3,670	Missing
3,670–3,730	Dark bituminous limestone
3,730–3,750	Shaly, dark limestone, a little glauconite
3,750–3,830	Sandy, light grey limestone—50 per cent very fine quartz sand
3,830–3,840	Cement?
3,840–3,870	Richly bituminous shale
3,870–4,735	Light grey and grey limestone and dolomitic limestone. Much gypsum at top and some gypsum throughout. Samples are quite brownish, mostly due to iron rust, presumably from bit chips

Northwest Company, Limited, Erickson Coulée Well No. 1; L.S.D. 13, Sec. 8, Tp. 1, Range 12, W. 4th Mer., Elevation (?)

Drilling depth	
2,500	Base of Ellis
2,500-3,360	White limestone, cherty from 3,330–3,360
3,360–3,450	Grey and dark grey limestone
3,450–3,530	40–50 per cent soluble in HCl, remainder very fine quartz sand
3,530–3,540	Mostly highly bituminous dark shale
3,540–3,550	Mostly white limestone, some bituminous matter
3,550–3,590	Mostly calcareous, greenish grey shale; pyrite and some fragments of anhydrite
3,590–3,650	Mostly gypsum and anhydrite

Urban Oils, Limited, Well No. 1; L.S.D. 2, Sec. 4, Tp. 1, Range 15, W. 4th Mer., Elevation about 3,450 Feet

Drilling depth	
2,570	Base of Ellis
2,570–2,580	Mostly white limestone
2,580–2,611	30 per cent white limestone, 30 per cent grey, calcareous, and sandy shale, 30 per cent white, calcareous, and sandy shale; some glauconite
2,611–3,310	Mostly white limestone. Some samples missing and some represented by cement
3,310–3,390	Grey limestone
3,390–3,418	Dark grey limestone

The Erickson Coulée and Commonwealth Milk River well logs show a fairly close similarity in these deeper strata; the succession from top to bottom, in both, being:

1. White limestone
2. Dark limestone (bituminous in Commonwealth Milk River well)
3. Sandy, light grey limestone (50 per cent very fine quartz sand)
4. Richly bituminous shale

. Gypsum and anhydrite with limestone

The depths of these zones below the base of the Ellis are:

—	Commonwealth Milk River well	Erickson Coulée well
1	0 to 920	0 to 860
2	920 to 980	860 to 950
3	1,000 to 1,080	950 to 1,030
4	1,090 to 1,120	1,030 to 1,050
5	1,120 to –	1,090 to –

E. S. Perry[1] in writing on the Kevin-Sunburst field, states that there the Ellis is underlain by the Mississippian (Madison) limestone, 1,075 feet thick, and reports that fossils of Upper Devonian character were found in green shale that occurs 15 feet below black oil-shale. He also reports that Devonian fossils were blown from the Potlatch well by gas struck about 600 feet below the base of the Madison. He names the Devonian the Potlatch anhydrite formation and places its upper limit at the top of the bituminous shales and the base at the top of a light grey limestone about 940 feet below. The present writer knows of no fossil evidence indicating the age of the pre-Ellis strata in southern Alberta.

Applying this interpretation of Perry's to the Alberta field, the sandy limestones, zone 3, just above the dark bituminous shale would belong to the Mississippian and the underlying strata to the Devonian. Possibly the sandy character of the limestones of zone 3 might be regarded as a reflection of some change of conditions and thus indicate the contact of the Mississippian and Devonian strata. A more practical consideration is that the bituminous shale is readily spotted in the well samples and its top serves as a handy arbitrary horizon at which to place the contact.

Oil in commercial amounts was not obtained below the Mississippian limestone from any of the nine deep wells of the Kevin-Sunburst field[2] drilled to below this horizon, and no production has been encountered up to the present from the same strata in southern Alberta.

ELLIS

In the Kevin-Sunburst field, 15 miles to the south of Red Coulée field, 200 to 300 feet of shaly or limy sandstone and shaly limestone, lie above the Mississippian (Madison) limestone and are correlated with the Ellis formation of Upper Jurassic age. In the wells of the Red Coulée field, marine strata that occur between the top of the Mississippian limestone and the base of the continental deposits of Kootenay (?) age are also termed Ellis by the oil men, and this correlation, although not proved, is probably correct.

[1]Perry, E. S.: State Bureau of Mines and Geology, Butte, Montana, Mem. No. 1, 2nd Edit., Sept. 1929.
[2]Perry, E. S.: Op. cit.

The Ellis of the Red Coulée field has a thickness of from 60 to 180 feet and consists of:

Upper part—Grey, brownish grey, and light greenish grey, slightly calcareous shales with disseminated pyrite and grains of quartz and black and red chert. Some beds hold glauconite.

Lower part—Light greenish grey, highly calcareous shales with disseminated pyrite and grains of quartz and red and black chert. Glauconite present but less prevalent than in upper part. Fine, shaly sandstone at base in one well.

Since the Ellis (and, or, Fernie) strata are regarded as favourable source rocks of oil, detailed descriptions of them as revealed in samples from the wells are given.

Commonwealth Petroleum Limited, Red Coulée Well No. 1; L.S.D. 10, Sec. 3, Tp. 1, Range 16, W. 4th Mer., Elevation 3,527 Feet

Drilling depth	
2,514	Shaly sandstone and sandy shale; abundant carbonaceous remains
2,514–2,553	Medium-grained, quartz and black chert sandstone with slightly calcareous matrix. Some siliceous grey shale. At base some black chert grains, 5 mm. diameter
	Few small fragments of coal and several microspores
	Top of Ellis
2,553–2,572	Mostly light grey, sandy shale. Some medium to coarse chert and quartz sandstone. Much pyrite
2,572–2,576	70 per cent light greenish grey, calcareous 'pencil' shale
	15 per cent loose chert grains to 1·5 mm. diameter
	10 per cent pyrite and marcasite
2,576–2,580	90 per cent light greenish grey, calcareous 'pencil' shale containing scattered sand grains. Pyrite
2,580–2,590	95 per cent light greenish grey, calcareous 'pencil' shale; disseminated pyrite and marcasite. Minor glauconite and medium-grained chert and quartz sandstone
2,590–2,598	90 per cent light greenish grey, calcareous 'pencil' shale; disseminated pyrite. Several thin bands of highly calcareous, fine-grained sandstone. A little medium-grained quartz and black chert sandstone. Minor glauconite. Several small, tubular structures in limestone.
2,598–2,603	90 per cent light greenish grey, finely sandy and calcareous shale, with disseminated pyrite. Minor glauconite, quartz and black chert sandstone, and highly calcareous fine sandstone
2,603–2,614	85 per cent of shale as above with 10 per cent fine, white, highly calcareous sandstone. Minor chert and pyrite
	Base of Ellis
2,614	White, siliceous, dolomitic limestone

Celtic Oils, Limited, Red Coulée Well No. 1; L.S.D. 4, Sec. 17, Tp. 1, Range 16, W. 4th Mer., Elevation 3,531 Feet

Drilling depth	
2,530–2,540	Light grey, dark grey, green, and red shales, with abundant carbonaceous remains
2,540–2,550	Missing
2,550–2,580	Medium-grained, quartz and black chert sandstone
	Coal fragments

Top of Ellis

Drilling depth	
2,580–2,590	90 per cent slightly greenish grey, calcareous 'pencil' shale 10 per cent pyrite and marcasite
2,590–2,600	As above
2,600–2,610	As above, with some marcasite balls and a few grains of black chert to 7 mm. diameter
2,610–2,620	As above, with a few fragments of red shale
2,620–2,630	70 per cent slightly greenish grey, calcareous shale. 20 per cent pyrite 10 per cent chert grains, some 1 cm. diameter. A little red shale
2,630–2,650	35 per cent shale as above; 60 per cent fine, light greenish, highly calcareous sandstone. Scattered larger quartz and chert grains. Pyrite and a little glauconite
2,650–2,660	Much as above with 75 per cent of fine sandstone
	Base of Ellis
Below 2,660	White limestone

Dalco Oil and Gas Company, Limited, Red Coulée Well No. 1; L.S.D. 4, Sec. 11, Tp. 1, Range 16, W. 4th Mer., Elevation 3,508 Feet

Drilling depth	
2,400–2,440	Mostly red shale. A little fine sandstone
2,440–2,450	50 per cent red shale, 40 per cent grey, sandy shale. A little medium sandstone
2,450–2,460	65 per cent sandy grey shale and shaly sandstone, 30 per cent red shale. Minor quartz and red chert grains
2,460–2,490	55 per cent grey, limy shale, 45 per cent red shale. Carbonaceous remains
2,490–2,510	70 per cent limy, light grey shale, disseminated pyrite 30 per cent red shale. Minor quartz and red chert grains
2,510–2,520	70 per cent light greenish grey, calcareous shale 20 per cent light grey, sandy, and calcareous shale 10 per cent red shale A few carbonaceous remains
	Top ? of Ellis
2,520–2,530	50 per cent light grey, sandy, and calcareous shale 20 per cent light greenish grey shale with disseminated pyrite 25 per cent red shale Several specks of glauconite
2,530–2,540	65 per cent light greenish grey, sandy, and calcareous shale 30 per cent red shale A little fine white sandstone A few specks of glauconite
2,540–2,550	60 per cent light grey, calcareous shale with disseminated pyrite 25 per cent red shale 15 per cent light grey, sandy shale
2,550–2,570	40 per cent soluble in hot HCl Of remainder, 60 per cent grey shale 25 per cent red shale 10 per cent quartz grains A little pyrite, white chert, and a few coal fragments
	Base of Ellis
2,570–2,590	93 per cent soluble in hot HCl, remainder white chert, a little pyrite, and several grains of glauconite

Northwest Company, Limited, Erickson Coulée Well No. 1; L.S.D. 13, Sec. 8, Tp. 1, Range 12, W. 4th Mer., Elevation (?)

Drilling depth	
2,300–2,310	Dark grey, green, red shale. Coal fragments
2,310–2,320	Medium-grained, quartz and black chert sandstone, slightly calcareous. Carbonaceous fragments (resembles Vanalta oil sand)
2,320–2,370	Missing

Top of Ellis, probably at about 2,360 feet

Drilling depth	
2,370–2,380	85 per cent grey, sandy, slightly calcareous shale 10 per cent glauconite Some pyrite
2,380–2,390	Same as above, but glauconite appears to occur in thin bands of dark sandy shale in which glauconite makes up about 40 per cent
2,390–2,400	60 per cent grey and light grey shale 35 per cent glauconite Some quartz grains and pyrite
2,400–2,420	Mostly light grey shale, some glauconite and pyrite
2,420–2,440	Mostly light grey, highly calcareous shale A little glauconite and pyrite Pyrite cast of small gasteropod A little light grey shale showing mottling to red
2,440–2,450	Missing
2,450–2,470	Mostly light grey, highly calcareous shale Some pyrite and a little calcareous quartz and chert sandstone A few fragments of red shale
2,470–2,490	Mostly greenish grey, shaly limestone with disseminated pyrite Some glauconite
2,490–2,500	As above, with a little, fine, calcareous sandstone

Base of Ellis

2,500–2,520	65 per cent soluble in hot HCl, remainder white chert, fine white sandstone, and light greenish shale
2,520–2,530	60 per cent soluble in hot HCl, remainder 90 per cent spongy chert

Urban Oils, Limited, Well No. 1; L.S.D. 2, Sec. 4, Tp. 1, Range 15, W. 4th Mer., Elevation about 3,450 Feet

Drilling depth	
2,370–2,390	Mostly light grey and dark grey, sandy shale, with minor red shale and green shale. Carbonaceous remains

Top of Ellis

2,390–2,400	40 per cent brown, sandy shale 30 per cent fine, white sandstone Minor glauconite, red, green, and light grey shale
2,400–2,410	Mostly dark brown, slightly calcareous shale, also greenish grey and dark grey, calcareous shales, with disseminated sand grains and red chert grains Some fragments with high per cent of glauconite A little red shale
2,410–2,420	Equal amounts of brownish grey, greenish grey, and dark grey shales as above Some glauconite
2,420–2,430	50 per cent greenish grey, calcareous shale 30 per cent brownish grey, calcareous shale Some red shale Minor glauconite, chert, quartz grains, and pyrite
2,430–2,450	Mostly light greenish grey, calcareous shale Abundant pyrite Minor glauconite, and quartz and red chert grains
2,450–2,470	As above, but no glauconite
2,470–2,480	Mostly light greenish grey, light brownish grey, and brown shale with scattered sand grains Some red shale and minor red chert grains and pyrite
2,480–2,490	Mostly grey, calcareous shale and light greenish grey shale with disseminated pyrite Minor red chert grains and red shale
2,490–2,500	Calcareous, grey shale and light greenish grey shale with disseminated pyrite
2,500–2,520	Mostly very finely sandy, and shaly limestone and calcareous shale. Disseminated pyrite and minor red and black chert grains
2,520–2,525	Mostly brownish grey, sandy, and calcareous shale Minor quartz and red chert grains
2,525–2,530	65 per cent grey, sandy, and light greenish grey, calcareous shale 25 per cent limestone Minor glauconite

Drilling depth	
2,530–2,535	80 per cent white, shaly limestone 10 per cent grey, calcareous shale Minor quartz, glauconite, and pyrite
2,535–2,545	40 per cent white limestone 30 per cent light grey, calcareous shale 15 per cent quartz grains Minor glauconite and pyrite
2,545–2,550	30 per cent white limestone; 65 per cent light greenish grey and brownish grey, sandy, and calcareous shale with disseminated pyrite Minor glauconite
2,550–2,565	75 per cent cherty and siliceous limestone 20 per cent grey, calcareous shale Minor glauconite and pyrite
2,565–2,568	Mostly shaly, dark limestone, some white limestone Abundant black chert grains. Some pyrite
2,568–2,570	30 per cent white limestone, 60 per cent grey, calcareous shale. Minor glauconite, and white and black chert and quartz grains
	Base of Ellis
2,570–2,580	Mostly white limestone

Commonwealth Petroleum, Limited, Milk River Well No. 1; L.S.D. 8, Sec. 9, Tp. 3, Range 15, W. 4th Mer., Elevation 3,163 Feet

Drilling depth	
2,560–2,570	30 per cent brown, sandy shale 45 per cent shaly, fine sandstone 15 per cent white, sandy shale Minor red and black chert and quartz grains Few carbonaceous remains
2,570–2,580	Mostly white, slightly calcareous, fine sandstone Some brown, sandy shale Minor red and black chert and quartz grains; pyrite
2,580–2,600	Mostly medium-grained quartz and black and brown chert grains (this resembles the Vanalta oil sand)
	Top of Ellis
2,600–2,160	Mostly brownish grey, sandy shale Some glauconite
2,610–2,620	60 per cent brownish grey shale, 30 per cent ironstone Abundant glauconite Some bentonitic clay
2,620–2,630	Mostly grey shale Some fragments nearly all glauconite in a black shale matrix
2,630–2,640	Brownish grey, sandy, and calcareous shale Some glauconite and pyrite
2,640–2,650	Light greenish grey, highly calcareous shale A little glauconite Pyrite cast of small gasteropod; few marcasite balls
2,650–2,670	Mostly light greenish grey, highly calcareous shale Minor glauconite, ironstone, black chert, and fine white sandstone
2,670–2,680	Mostly light greenish grey, highly calcareous shale A few fragments of green shale Abundant pyrite
2,680–2,700	Mostly light greenish grey, calcareous 'pencil' shale Some brownish shale Much pyrite and marcasite Some glauconite Pyrite cast of small gasteropod
2,700–2,710	As above, with a little white, medium-grained sandstone
2,710–2,730	Light greenish grey, calcareous, and sandy shale with much disseminated pyrite
2,730–2,740	As above, some white limestone, some chert, and quartz grains A few fragments of coal A little reddish shale
	Base of Ellis
2,740–2,750	Practically all white limestone

Of the logs given above, those of the three eastern wells, the Commonwealth Petroleum, Limited, Milk River well No. 1, Urban Oils, Limited, well No. 1, and Northwest Company, Limited, Erickson Coulée well No. 1, agree fairly closely in thickness and general character of the sediments, and show some similarity in the detail of the succession of the different types. In each of these wells glauconite occurs at or near the base, above which it is absent until near the top of the section where it occurs much more abundantly than at the base. The quartz grains and the red and black chert grains that are scattered through the shales and limy shales are small, few being larger than 1 mm. in diameter. Comparing the logs of the three wells mentioned above with those of the Commonwealth Petroleum, Limited, Red Coulée well No. 1, and the Celtic Oils, Limited, Red Coulée well No. 1, in the western part of the area, certain marked differences are noted. In the eastern wells the thicknesses are greater (from 140 to 180 feet) than in the western wells (60 to 80 feet) and though a small amount of glauconite occurs at the base of the section of the western wells, as in the case of the eastern wells, no higher, more abundant glauconite is present. In the western wells the quartz and the red and black chert grains are more numerous and larger (a few reaching a diameter of 1 cm.) than in the eastern wells.

The presence in the west of the more numerous and larger quartz and chert grains renders it probable that the Ellis strata at the site of the western wells were laid down nearer shore than those to the east; the absence of the upper glauconite horizon and the markedly decreased thickness, in the western wells, probably indicate that either the sea receded from the western area before the time of deposition of the upper glauconite or that such deposits in the west were later eroded. In all five wells, beds of sand occur above the Ellis, and the sand is very similar in all of the wells, so that it appears that if erosion were responsible for the missing beds to the west, such erosion must have taken place before the deposition of this sand.

In the case of Dalco Oil and Gas Company well No. 1, in the western part of the area, it will be noted that red shale (very rare in all other logs) is very abundant, and that there is no sand that may be considered to be the Vanalta oil sand, that is, the sand that occurs just above the Ellis in all the other logs. The sand that does appear higher up in the Dalco No. 1 well is of a type wholly different from that of the Vanalta sand of the other wells. The 50 feet of sediments assigned to the Ellis contain material (aside from the red shale) very similar to that found at the base of the Ellis in all the other wells, though glauconite is quite minor in amount. The succeeding shale has a different aspect and compares closely with that found in the other wells in the Lower Cretaceous (Kootenay?). It appears as if erosion took place locally during or after the deposition of the Vanalta sand, and probably produced an erosion channel filled later with shale of continental deposition, much of which is now red shale.

The writer is of the opinion, then, that in this area erosion took place at the end of Ellis deposition, as might be expected during a recession of the sea. Definite evidence of erosion at the end of Ellis deposition in southern Montana is given by Knappen and Moulton.[1]

[1]Knappen, R. S., and Moulton, G. F.: U.S. Geol. Surv., Bull. 822A, pp. 9, 20 (1930).

Below is given a representative list of general descriptions of the Ellis in Montana.

Locality	Formation	Thickness	Character of strata
		Feet	
Kevin-Sunburst,[1] Mont..	Ellis........	200–300	Light brown to grey (locally yellowish), shaly or limy sandstone in upper part. Dove-coloured to black, shaly limestones in lower. Locally a pebble conglomerate at base. Marine fossils abundant. Sandstone members present. Great unconformity at base
Great Falls coal field[2], Mont.................	Ellis........	80–120	Dove-coloured limestone, overlain by reddish brown, coarse-grained sandstone, coarsely conglomeratic at base Unconformably on Madison and Quadrant formations
Carbon county[3], Mont...	Sundance...	to 475	50-100 —sandstone and sandy clay 200—olive-brown clay with subordinate sandy layers 175—very regularly interbedded, olive-brown clay and shale, pink and rose-coloured clay—thin limestone and a few thin beds of gypsum Bounded by erosional unconformities between Chugwater (Triassic?) below and Morrison (Cretaceous?) above
Birch River area,[4] Mont...................	Ellis........	240–310	Black to grey, calcareous shale with a few, thin, irregular beds of limestone and sandstone Disconformably on Mississippian limestone
South of Bearpaw mountains,[5] Mont.............	Ellis........	310	Buff and grey, petroliferous and fossiliferous limy shale and thin beds of limestone, with 75 feet of blue to black, thin-bedded, petroliferous and fossiliferous limestone at base
Lewistown coal field[6], Mont.................	Ellis........	250	148 feet partly concealed—mostly grey sandstone 80 feet concealed 10 feet fossiliferous limestone and shaly limestone 4 red sandy shale 20 pure white gypsum 92 feet limestone and gypsiferous shale On Madison limestone without apparent unconformity
Sweet Grass hills[7], Mont.	....	201	40 feet green, soft shales with dark stains 50 feet dark blue, calcareous shale with *Belemnites densus* 45 feet dark blue, impure limestone containing *Gryphaea calceola* 66 feet probably dark greenish, sandy shales, concealed

[1]Perry, E. S.: State Bureau of Mines and Geology, Montana, Mem. No. 1, 2nd Edit., Table 1 (1929).
[2]Fisher, C. A.: U.S. Geol. Surv., Bull. 356, pp. 23, 27 (1909).
[3]Knappen, R. S., and Moulton, G. F.: U.S. Geol. Surv., Bull. 822-A, pp. 17-20 (1930).
[4]Stebinger, E.: U.S. Geol. Surv., Bull. 691-E, p. 155 (1918).
[5]Reeves, F.: U.S. Geol. Surv., Bull. 751-C, p. 75 (1924).
[6]Calvert, W. R.: U.S. Geol. Surv., Bull. 390, p. 20 (1909).
[7]Slipper, S. E.: Geol. Surv., Canada, Mem. 93, p. 66 (1917).

Fossils have been collected from the Ellis of most of these sections and in every case were reported as being of Upper Jurassic age. The rather marked variation in thickness and type must thus be attributed to local conditions of deposition in the Upper Jurassic sea. Thus, probably, in places and at times, conditions were favourable for the formation of source rocks of oil, whereas at other places and times decidedly unfavourable.

A detailed section of the Ellis from the southern Bearpaw mountains[1], that seems to be a type distinctly favourable for oil, is given below:

50 feet brownish shale with characteristic Ellis fossils
20 feet igneous sill
15 feet dark shales and shaly limestones, petroliferous and characteristic Ellis fossils
20 feet drab, limy shale
10 feet thin-bedded, shaly, drab limestone. Belemnites
40 feet limy shale to black limestone, weathers in grey, barren surfaces. Characteristic Ellis fossils
20 feet igneous sill
50 feet grey, limy shales, petroliferous
5 feet dark blue, marly limestone, weathers light yellow. Petroliferous
30 feet limy, brown shale
10 feet limy shale and grey, hard limestone full of *Gryphaea calceola*
6 feet limy brown shale, weathers yellow-grey
6 inches black to bluish grey, thinly laminated limestone with finely crenulated partings, probably of organic origin. Very petroliferous and on fresh fracture is brownish black. Algal layer
70 feet blue to black limestone, thin bedded, petroliferous, and fossiliferous. Beds ½ to 6 feet. Upper part very oolitic. Top surface has a reddish tinge with ripple-marks in places
6 inches brown, sandy clay
2 feet soft, limy clay to argillaceous limestone
2 inches argillaceous, irregularly platy limestone in sharp basal contact with—
21 inches breccia or conglomerate of limestone and chert

None of the six wells furnishing the detailed sections of the Ellis given in this report has produced oil. The Ellis in them when compared with the section from the southern Bearpaw mountains, given above, does not appear to be a favourable source rock. In the case of the other wells now producing oil in the Red Coulée field, the oil comes from the Vanalta sand and, therefore, the underlying Ellis was not penetrated. It may be that at the sites of the producing wells local conditions were favourable for the deposition of source rocks during the time of accumulation of the Ellis strata; on the other hand the oil may have come from other strata.

Lower Cretaceous (Kootenay) Strata

The strata assigned to the Lower Cretaceous consist of grey, brownish grey, green, and red shales with thin (few inches to a few feet) sandstone beds, and a heavy sandstone bed at the base. No exposures of these strata occur within the area. They lie above the Ellis and vary in thickness from 580 feet in the western part of the area (range 16) to 490 feet in the eastern part (range 12). In general the upper part is predominantly shaly, and it is here that grey and green shales predominate, though some red shale is present in most of the well logs. Sandstone is greater in amount and present in thicker beds in the lower part where it is associated with red shales, though grey, green, and brown shales also occur.

The contact with the overlying Alberta shales is placed, in the logs, at the point where green shale or, in some instances, red shale occurs below drab-grey shales or grey sandstone. In some logs the grey shales and sand-

[1]Howe, M. A., and Goldman, M.: Am. Jour. Sci., vol. 10, p. 314 (1925).

stones, above this colour change, are fairly carbonaceous, whereas in other well logs little carbonaceous material is found and they contain small amounts of glauconite. Although this contact may not actually mark the upper limit of the Lower Cretaceous or of the Lower Cretaceous continental deposits, it is a useful horizon, for it occurs in all the Red Coulée wells at a uniform distance below the horizon of the Colorado water sand (*See* later). The base of the Lower Cretaceous is placed in most of the wells at the base of a medium-grained sand (the Vanalta oil sand) lying just above the limy shales or shales containing glauconite that the writer has assigned to the Ellis. This sand is placed in the Lower Cretaceous rather than in the Ellis since it generally contains carbonaceous fragments.

The name Kootenai is applied to strata similar to the above in the Kevin-Sunburst field and this term (or rather Kootenay) is in general use by the oil men in the Red Coulée field.

Bituminous shales were found in five of the logs in the Lower Cretaceous. They occur in the Celtic Oils, Limited, well, between 2,250 and 2,270 feet drilling depths, where this 20 feet is practically all bituminous shale. This same band is represented in Dalco Oil and Gas Company well No. 1; Southern Alberta Exploration Company well No. 1, and Urban Oils well No. 1 at about the same horizon as in the Celtic well, that is, 200 to 240 feet below the top of the Lower Cretaceous. In all but the Celtic well this band appears to be in several thin beds separated by other sediments. A small amount of bituminous shale occurs about 400 feet below the top of the Lower Cretaceous in the Capital Red Coulée well, but this horizon was not recognized in any other well.

The bituminous shales, though not regarded as source rocks for oil, are at least related to source rocks in origin, and their occurrence in the Lower Cretaceous (Kootenay?) indicates that these strata should not be disregarded in considering the source of oil in this area.

ALBERTA SHALES

The Alberta shales are not exposed in the area, but in the wells a thick (1,750 feet) series of drab and dark grey shales and grey sandstones lies on the green and red shales of the Lower Cretaceous. These strata are generally termed Colorado, but since the writer collected from the upper part of these strata in Buckley coulée, Montana, specimens of *Baculites* cf. *ovatus*, of large size, that resemble very much those found in the lower part of the Montana strata to the northwest in the foothills, it may be that some Montana strata are present, and for this reason, the term Alberta shale[1] is used in this report.

In the wells, the Alberta shales appear as a thick zone of fairly dark shales. Close inspection of drill samples shows, however, that the top 200 feet and the bottom 600 feet are distinctly greyer than the part between. This grey hue is due to the presence of sandstone and sandy shale fragments in the samples, and since no single 10-foot sample is wholly of sandstone fragments, probably none of the sandstone beds is as thick as 10 feet. Although the upper and lower sandy zones are present in most of the wells, so that a general correlation may be made of these zones, yet

[1]Hume, G. S.: Geol. Surv., Canada, Sum. Rept. 1929, pt. B, p. 6.

only one sandstone bed seems to persist at about the same horizon throughout the field. This bed, termed the "Colorado water sand," carries water in some of the wells. The section between the upper and lower sandy zones is chiefly dark shale with occasionally sandy shales, limy shales, ironstone bands, and bentonitic beds. No single, highly bentonitic bed can be recognized as a horizon marker. Bentonitic beds are chiefly confined to three fairly thick, poorly defined zones, as follows:

At 250–550 feet above the base (in the lower sandy zone)
At 700–800 feet above the base
At 1,050 to 1,250 feet above the base

The contact of the Alberta shales with the underlying Lower Cretaceous has been described on a preceding page. The contact with the overlying Lower Milk River sandstone is very poorly defined, for between the Lower Milk River massive sandstone above, and the Alberta dark, marine shale below, there is a gradational zone, the lower part of which is of shales with but few thin bands of sandstone, whereas in the upper part thin sandstones predominate. In Buckley coulée, Montana, just south of the border, good exposures of the Lower Milk River-Alberta shales contact were seen. In the eastern part of the coulée the contact is as described above, and in one section, at about 50 feet below the base of the massive sandstone of the Lower Milk River a 1-foot bed of sandstone occurs in a zone that is predominantly shale. This bed can be traced westward for 4 miles, in which direction it gradually thickens, until at a point 3 miles west, where its base is last exposed, it has a thickness of 50 feet. At this point the top of the sandstone is about 25 feet below the base of the massive Milk River sandstone, a little over a mile farther west this interval has decreased to about 19 feet. The sandstone of this wedge-shaped body is in every way comparable with that of the massive Lower Milk River sandstone, but marine (and probably Montana) fossils were found in an ironstone band just above it. It thus appears as if this sandstone wedge interfingers eastward with the shale, and the shale and sandstone of definitely known marine origin, and westward becomes one with the Lower Milk River sandstone. No fossils and only a little coaly material are found in the Lower Milk River sandstone, so that so far as known it may be of marine shore, brackish, or continental deposition.

In an attempt to use the top of the Alberta shales as an horizon marker the writer has tried placing the contact at several places; at the base of the section showing nothing but sandstone; where sand and shale are equal in amount; and where sand is first found in quite minor amounts. However, no single method gives a consistent thickness for the Alberta shales, nor gives an horizon that accords with the structure as indicated by several deeper horizons which check with one another. An indication of the difficulties to be expected in trying to use the Lower Milk River-Alberta shales contact as an horizon is furnished by the sandstone wedge occurring in Buckley coulée, as described above. It seems likely that farther west the top of this wedge joins the base of the massive sandstone above, so that in the west the contact would most likely be placed from 50 to 75 feet lower than in the east.

Foraminifera have been found in the Alberta shales and one horizon has been established by their use (*See* later).

MILK RIVER SANDSTONE

The Milk River sandstone is the oldest formation exposed within the area. It is readily divisible into two parts; the Lower Milk River (Virgelle of oil men) and the Upper Milk River. The Lower Milk River consists of thick (70 to 100 feet), massive, fine to medium sandstone, composed chiefly of quartz grains (with minor black and brown mica) rather loosely cemented with a calcareous and shaly matrix. At its base, the massive sandstone gives way to alternations of sand and shale, and in the well logs the base is usually placed where sand first becomes subordinate to dark shale. The base is not exposed within the area covered by this report, but was examined in Buckley coulée just to the south, in Montana. Towards the top of the Lower Milk River, the sandstones are markedly crossbedded and there are many large (up to 10 feet diameter) ovoid concretions of sandstone cemented with ferruginous carbonate, which characteristically form the cappings of ledges and pillars or "hoodoos."

The contact with the Upper Milk River is placed where white or yellowish sand, either loose or firmly cemented into a hard ledge, is overlain by dark grey or brown, sandy shale. Where exposed the contact is usually sharp, but along the rivers and coulées the contact is commonly concealed, for it generally occurs on a narrow terrace covered by surface wash from higher exposures of Upper Milk River that are supported by several strong sandstone beds. The contact may be found, however, with a little digging. This contact is the only definite horizon exposed at the surface, and, accordingly, levels were run along it in an attempt to make a structural contour map.

The Lower Milk River maintains its massive character in all but one outcrop. On the north bank of Milk river, in the west part of sec. 16, tp. 2, range 14, the massive sandstone passes laterally into sandstone and shale, which continue for about half a mile, beyond which the massive character is resumed.

The Upper Milk River consists, for the most part, of shales and sandy shales with several thick (8 to 20 feet) beds of sandstone. The shales and sandy shales are grey, dark grey (usually lignitic), yellowish and greenish grey. Weathered exposures are characterized by light grey, yellowish grey, black, purplish grey, and brownish bands.

The succession varies both in lithology and thickness from place to place, but in general is as follows:

Pebble bed at base of Pakowki
20–30 feet of grey and yellowish shales and sandy shales; some bentonite and selenite
8–24 feet of coarse and medium-grained, yellowish sandstone
45 feet of shales, carbonaceous and sandy, with thin sandstone beds and beds and layers of nodules of iron carbonate, and greenish sandstone cemented with iron carbonate. These layers and nodules weather dark brown
8–22 feet of medium and coarse-grained, yellowish sandstone
45–50 feet of grey, greenish grey, and dark grey, sandy shales, with 2 to 4 thin lignitic bands
White or yellowish sand or sandstone, top of Lower Milk River

The two massive sandstone layers were used locally to determine the position of the contact with the Lower Milk River where this horizon could not be more directly determined.

The contact with the overlying Pakowki is placed at a bed of hard, grey, calcareous sandstone that contains black chert pebbles, averaging

1 cm. in diameter. Locally the pebbles are very numerous, at other places they are quite scarce.

A measured section in Buckley coulée gave the thickness of the Lower Milk River (Virgelle) as 167 feet. No single complete section of the Upper Milk River was found, but in Verdigris coulée, in the southwest part of sec. 22, tp. 2, range 14, the base and top are exposed within half a mile of one another, and the thickness, estimated from elevations and attitude of local horizons, is here 158 feet. These two measurements give a total thickness of 325 feet.

Only two wells in the area afford complete sections of the Milk River, unobscured by surface cavings. In the Commonwealth Petroleum Company Milk River well in sec. 9, tp. 3, range 15, the Upper Milk River has a thickness of 180 feet and the Lower Milk River a thickness of 240 feet, a total of 420 feet. In Dalco Oil and Gas Company No. 2 well, in sec. 19, tp. 2, range 17, the position of the contact between Upper and Lower Milk River is somewhat doubtful, but the total thickness is 340 feet. The Upper Milk River is probably 150 feet thick and the Lower, 190 feet. The thickness indicated by the Commonwealth well seems excessive, but since a thick wedge of sandstone occurs beneath the normal, massive Lower Milk River (Virgelle) in Buckley coulée, it is not at all improbable that similar conditions exist in the locality of the Commonwealth Milk River well.

The outcrops of Milk River sandstone in Alberta are continuous with those of the Eagle sandstone of the Sweet Grass arch of Montana, where the Lower Milk River is called the Virgelle[1]. The fauna is described as Montana in age. No fossils were found in the Lower Milk River in the Alberta field, though Montana fossils were found just above the sandstone wedge near the Milk River-Alberta shale contact in Buckley coulée, Montana. The Lower Milk River is probably a marine shore deposit. The Upper Milk River contains thin (1 inch to 6 inches) beds of lignite and has yielded a small, deciduous flora. It is of continental origin and is continuous with the upper Eagle of the Sweet Grass arch.

PAKOWKI

Within the area the Pakowki consists of shales and sandstones containing marine fossils. The Pakowki lies above the Upper Milk River and below the Foremost beds. The base is placed at a thin, hard band of calcareous sandstone containing rounded black chert pebbles. The top was seen in only one small area on Milk river, in sec 25, tp. 2, range 18, and sec. 30, tp. 2, range 17, and there the contact with the Foremost was placed at an horizon where a massive sandstone of the basal Foremost passes into alternations of dark grey shale and thin sandstone beds in which are *Pteria nebrascana*. Williams[2] notes that the upper contact is marked by the occurrence of "thin lenses of 2 to 3 inches thick consisting of 'cones' of calcite starting at the top and bottom and interlocking near the centre". The writer found a bed of this type at the top of the Pakowki in sec. 30, tp. 2, range 17, on the south bank of Milk river, though just to the west on the north bank it was not present. Similar cone-in-cone concretionary layers were seen in Upper and Lower Milk River sandstones and in the Foremost, as well as within the Pakowki.

[1]Stebinger, E.: U.S. Geol. Surv., Bull. 641-C, p. 58 (1916).
[2]Williams, M. Y., and Dyer, W. S.: Geol. Surv., Canada, Mem. 163, p, 14 (1930).

No good sections of the Pakowki occur within the area, but Dr. S. E. Slipper, of the Canadian Western Natural Gas, Light, Heat, and Power Company, Limited, very kindly provided the writer with logs of test wells drilled along Milk river, through the Pakowki, and allowed him to examine the core samples. A typical section is given below:

Drilling depth Ft.	In.	Ft.	In.	
0		10		Overburden
10		39	6	Mostly fine to medium-grained, grey and greenish grey sandstone, wtih a few thin shale bands
				(Top of Pakowki)
39	6	58		Interbedded, dark grey shale and fine to medium-grained, grey sandstone
58		64	6	Dark grey shale with a few layers of fine-grained sandstone
64	6	64	9	Hard ironstone, cone-in-cone structure
64	9	91	6	Dark grey shale
91	6	92		Dark grey, sandy shale
92		94		Greenish grey, shaly sandstone
94		94	3	Hard ironstone
94	3	110		Greenish, fine sandstone
110		118	6	Light grey, fine-grained sandstone
118	6	120		Dark grey, sandy shale
120		129		Dark grey shale
129		131		Greenish grey sandstone
131		137		Dark grey, sandy shale
137		137	6	Greenish, fine-grained sandstone
137	6	139		Dark grey, sandy shale
139		143		Dark grey shale
143		146		Greenish grey, fine-grained sandstone
146		147	6	Dark grey, fine-grained, shaly sandstone
147	6	150		Greenish to grey, fine-grained sandstone (Fragment of Baculite at this horizon in another log)
150		166		Drab to dark grey, very shaly sandstone
166		170		Dark grey, sandy shale
170		191	6	Dark grey shale
191	6	192		Bentonite
192		214		Dark grey shale
214		222		Dark grey, sandy shale, black chert pebble
				(Base of Pakowki)
222		224		Light grey sandstone
224		227		Grey shale and sandy shale

Small collections of typical Pierre fossils were obtained from the Pakowki. Among the species, identified by L. S. Russell, are the following:

	Other occurrence
Inoceramus subdepressus Meek and Hayden?	Claggett
Pteria nebrascana (Evans and Shumard)	Uppermost Alberta shale to Fox Hills
Cardium speciosum Meek and Hayden?	Eagle to Claggett
Callista deweyi (Meek and Hayden)	Bearpaw to Cannonball
Mactra formosa Meek and Hayden	Claggett
Panopaea occidentalis Meek and Hayden	Claggett
Baculites compressus Say	Uppermost Alberta shale to Bearpaw
Baculites cf. *anceps* Lamarck	

BELLY RIVER

Lying above the Pakowki and below the Bearpaw is a series of fresh-water shales and sandstones. Williams and Dyer[1] review the nomenclature of these beds and propose "to follow Dawson's original intention and to define the Belly River as being composed of the continental beds lying between the Pakowki and the Bearpaw". This proposal is followed in this report. In the disturbed belt to the northwest, the name is commonly applied to the continental series lying above the Alberta shale and below Bearpaw or Edmonton. It is obvious, of course, that this greater series of continental beds includes more than the Belly River as defined above.

Williams and Dyer[2] accept the division of the Belly River of southern Alberta, into two parts, Foremost below and Pale beds above. They state "although the two members are more or less alike and the boundary between them is by no means definite, they are sufficiently different to form desirable mapping units. The outstanding difference . . . is a difference in colour, the Pale beds being very much lighter than the Foremost . . . . . The Pale beds include massive strata of hard, yellow, and grey sandstone which are rare in the Foremost . . . . . Coal seams are common in the Foremost but occur only near the top of the Pale beds."

The Foremost and lower Pale beds are intermittently exposed along a watercourse on the ridge in secs. 32 and 33, tp. 1, range 17. At about 300 feet above the base the strata quite definitely have the characteristics of the Pale beds, and at about 240 feet above the base they are fairly definitely Foremost. Between these horizons are exposed several sandstone layers that could not be assigned definitely. The same difficulty was met with in connexion with exposures along Milk river near the junction of the south branch. Up to a certain exposure in going west there is little doubt but that the strata belong to the Foremost, but just west of this, beds outcrop that can not be placed definitely, whereas still farther west they are certainly Pale beds. The nature of the exposures makes it impossible to say whether the change from Foremost to Pale beds is gradational or abrupt, or whether it does or does not take place at a fairly uniform horizon.

A partial section (114 feet) of the Foremost was obtained by trenching in sec. 2, tp. 2, range 17. It showed alternations of drab grey shale, brown lignitic shale, and shaly sandstone with a few thin seams of lignite and several concretionary ironstone layers, one of which held Unios and *Corbula perundata.* At the base just below a thin seam of lignite, is a 4-foot bed of impure, white to yellowish bentonite. Similar bentonitic beds were found in separate outcrops westward for about 2 miles, and were used as a local horizon.

In sec. 25, tp. 2, range 18, about 30 feet of yellowish grey, medium-grained sandstone forms the base of the Foremost. A heavy bed of similar sandstone was found to occur near the base of the Foremost in sec. 35, tp. 1, range 17, and again in sec. 12, tp. 2, range 17, where, however, the total thickness of the sandstone is not exposed.

Good exposures of part of the Pale beds occur along Milk river in tp. 2, range 19. They consist of light grey and light greenish grey sandstones, in beds from 1 foot to 20 feet thick, alternating with grey and greenish shales, and occasional 1-foot ironstone concretionary layers.

[1]Williams, M. Y., and Dyer, W. S.: Geol. Surv., Canada, Mem. 163, pp. 16, 17 (1930).
[2]Op. cit., p. 17.

BEARPAW

No exposures of Bearpaw were found, but it seems likely that it occurs under the drift on the highest parts of Milk River ridge within the area.

STRUCTURE

In an attempt to determine the structure of the area, the elevations of all exposed horizons were determined. Of these horizons, that at the top of the Lower Milk River is much more widely exposed. Other well-established horizons include the base and the top of the Pakowi. Locally developed horizons were used where available to give an indication of

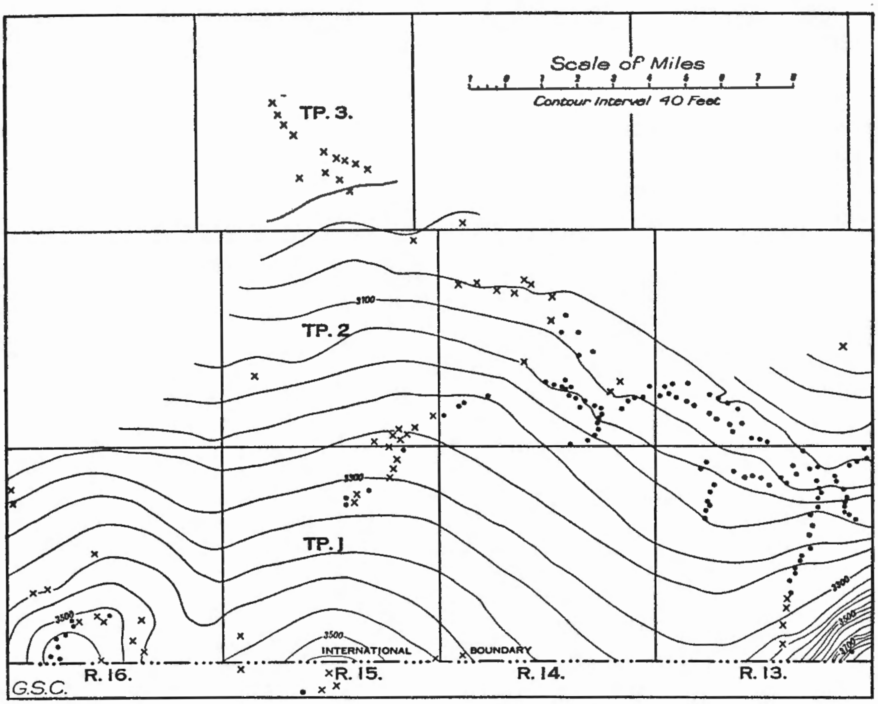

Figure 2. Structural contour map of part of Milk River area, west of 4th meridian, Alberta; contours are approximate and represent surface of top of Lower Milk River; outcrops where the elevation of top of Lower Milk River was directly determined are indicated by solid circular dots, outcrops where elevation of same datum plane was indirectly determined are indicated by crosses.

local dip. Exposures of recognizable horizons were found to be fairly continuous on parts of Red creek, along Milk river east of the town of Milk River, and in Verdigris, Van Cleeve, and Police coulées, but over most of the remaining parts of the area exposures are widely separated and at many of them no established horizon could be recognized. As a result of the general conditions found to obtain, an interpretation of the structure of only a part of the field could be made. This part of the area is mainly confined to townships 1 and 2, ranges 13, 14, 15, and 16, represented in outline on the accompanying figure (Figure 2). The structural contours of this figure represent the attitude of the top of the Lower Milk River and depend on measured elevations of outcrops of this and other horizons. From an inspection of the figure it is evident that the outcrops permitting determination of the elevation of the datum horizon are so distributed that the structure can be only approximated. It is realized that if the outcrops were more uniformly distributed over the whole area, the structures would probably markedly differ from those depicted. Furthermore, wells in the Red Coulée field seem to indicate that the top of the Lower Milk River may not follow in detail the deeper structures. The present writer, therefore, is inclined to believe that the top of the Lower Milk River may be used only to indicate the broad, general structure.

The evidence from the wells in the Red Coulée field that seems to indicate that the structure of the top of the Lower Milk River is different from that of lower horizons is as follows. The elevation of the top of the Lower Milk River is 50 feet higher in the Commonwealth Petroleum Company Red Coulée well No. 1 than in the Southern Alberta Exploration Company well and some other nearby wells, whereas elevations of three deeper horizons, as determined in all the wells, agree in showing that the top of the Lower Milk River in the Commonwealth well should be 30 feet lower than it is in the Southern Alberta Exploration Company well if the structure on this horizon is the same as those of the lower horizons. The apparent vertical discrepancy is 80 feet, possibly part of this may be due to the fact that it has not been possible to locate definitely the top of the Lower Milk River in any of the wells being compared except the Commonwealth well. It does not seem likely, however, that the assumed positions of the horizon can be in error by an amount so great as 80 feet.

In attempting to determine the general structure of part of the area represented in Figure 2 and the structure of the Red Coulée field as represented in Figure 3, use was made of the various horizons described in the next paragraphs.

Top of Pakowki. This horizon was found outcropping in one locality and was placed where dark shale and medium-grained sandstone became about equal in amount, just below a massive sandstone at the base of the Foremost, and just above sandy beds containing *Pteria nebrascana.* Arenaceous foraminifera were found at the top of the *Pakowki* in samples from Dalco Oil and Gas Company No. 2 well.

Base of Pakowki. The base of the Pakowki is marked in Verdigris coulée by limy sandstone beds containing rounded black chert pebbles of 1 cm. average diameter. Numerous pebbles occur in the bed at one place, whereas a few hundred feet distant they are quite scattered. This probably explains why samples from this horizon from certain wells that have penetrated the Pakowki show no chert pebbles.

Top of Lower Milk River. This contact where exposed on Milk river and in the various coulées is fairly sharp. The writer placed it at the contact of sandy and carbonaceous shale above with sandstone below. The sandstone in places is very loosely consolidated and at other places is cemented into a hard ledge.

Bullopora-Clavulina Horizon. R. T. D. Wickenden of the Geological Survey has found a foraminiferal zone in the upper part of the Alberta shales of the Red Coulée field. The horizon is marked by the highest occurrence of two foraminifera: a species of Bullopora occurring 20 to 30 feet above a species of Clavulina. This horizon has been found in five wells. It lies about 400 feet below the top of the Alberta shale.

Colorado Water Sand. In many of the wells of the Red Coulée field and the Montana Border field, a water horizon is found 65 to 75 feet above the top of the Lower Cretaceous. Since the wells were drilled by standard cable, chip samples only are available, so that the thickness of this sand cannot be determined. The sand present in the samples representing 10-foot intervals varies from 30 to 75 per cent of the sample and in some wells is present in several 10-foot samples. It is probable that at this horizon there are several thin beds of sand. In spite of the sand not being clearly defined in the logs, this horizon as determined in wells where water was encountered, or in the other wells by the most sandy 10-foot sample at this general horizon, occurs at very uniform distances above the top of the Lower Cretaceous and below the foraminiferal horizon in the Alberta shale.

The Colorado water sand consists of fine to medium-grained quartz sand with a few scattered black chert grains and pieces of black mica. The cement is sparse and is clayey and limy.

Three analyses of the water at this horizon, made by W. P. Campbell, Assistant Chemist of the Supervisory Mining Engineer's office, Calgary, are given below.

Well	Parts per million							
	Total solids	K and, or, Na	Ca	Mg	Cl	SO_4	Bicarb.	Carbonate
Dalco 1............	13,064	4,803	68	31	6,932	44	1,120	0
A. P. Con..........	13,336	4,896	44	23	6,567	21	1,912	0
Vanalta............	14,074	4,528	318	203	6,901	33	2,085	0

Top of Lower Cretaceous. The contact of Lower Cretaceous and Alberta shale is placed at the place where greenish sand or shale or red shale, or both, occur below grey sand and drab shale.

Vanalta Gas Sand. In most of the wells a fine white sandstone occurs with its base 47 to 60 feet above the top of the Vanalta oil sand. This sandstone seems to be less than 10 feet thick, since from 10 to 70 per cent of the 10-foot samples in which it occurs consist of shale. It is probable that there are several beds of this sandstone, since it is present as fragments in two or three of the 10-foot samples. Small flows of gas were encountered at this horizon in several of the wells.

Vanalta Oil Sand. The Vanalta oil sand is the horizon from which all commercial production of oil has been obtained in the Red Coulée field. Here it consists of from 45 to more than 59 feet of fine to medium-grained, loosely cemented, quartz and black chert sand. In two wells the black chert grains are quite coarse towards the base. Much pyrite occurs in the sand. In five wells the sand is continuous and in two others, 4- and 5-foot bands of sandy shale occur within it. It could not be located in the Dalco No. 1 well and was represented only by scattered sand, of the type noted, in shale in the Urban well.

In the Border oil field in Montana, just south and continuous with the Red Coulée field of Alberta, the basal part of the Lower Cretaceous is thought to be as follows:[1]

	Feet
Gas sand	10–45
Variegated shale	40–80
Vanalta sand	5–15
Grey, green, pyritic shale	10–15
Cosmos sandstone	30–40
Ellis formation	40–225

"The gas sand is commonly regarded as the counterpart of the Sunburst sand in the Kevin-Sunburst field, but it probably occupies a slightly higher stratigraphic horizon. The variegated shale is regarded as the westward expansion of the 'yellow shale' horizon of the Kevin-Sunburst field. The Vanalta and Cosmos sandstones occupy the horizon of the 'laminated sandstones' of the Kevin-Sunburst field."

Ellis Water Sand. Water was encountered in Dalco No. 1, Celtic No. 1, and in the Commonwealth Red Coulée No. 1 wells close to the base of the Ellis, in highly calcareous, fine sandstones. The drilling report of the Dalco No. 1 well gives this as a "sulphur water".

Top of the Limestone. This is placed at the top of the white or white and cherty limestone at the summit of the pre-Ellis strata.

STRUCTURE OF THE RED COULÉE FIELD

Four of the horizons listed above were employed in an endeavour to determine the structure at depth in the Red Coulée field.

(1) *Vanalta Oil Sand.* This horizon has been located definitely in seven wells. In one well it does not seem to be present, in three others it has not been reached, in the case of another well the samples are missing, and in one other the horizon is doubtful, as samples from the well are not available.

(2) *Top of Lower Cretaceous.* This horizon is well established in nine wells; three others are not deep enough to reach it, and in one it is doubtful.

(3) *Colorado Water Sand.* This horizon is present in eleven of the wells; two others are not deep enough to reach it.

(4) *Bullopora-Clavulina Horizon.* This horizon has been found in all the wells in which it has been looked for, five in number in this field.

The Colorado water sand has been chosen as a datum plane to interpret the structure of the Red Coulée field, and the results are shown in Figure 3. The Colorado water sand was used in preference to either the Vanalta sand or the top of the Lower Cretaceous because it is known in more wells and is a bed deposited under marine conditions, and, furthermore, because the elevation of this horizon in most of the wells just south in Montana is also known.

[1]Personal communication, Dr. C. E. Erdmann, 1931.

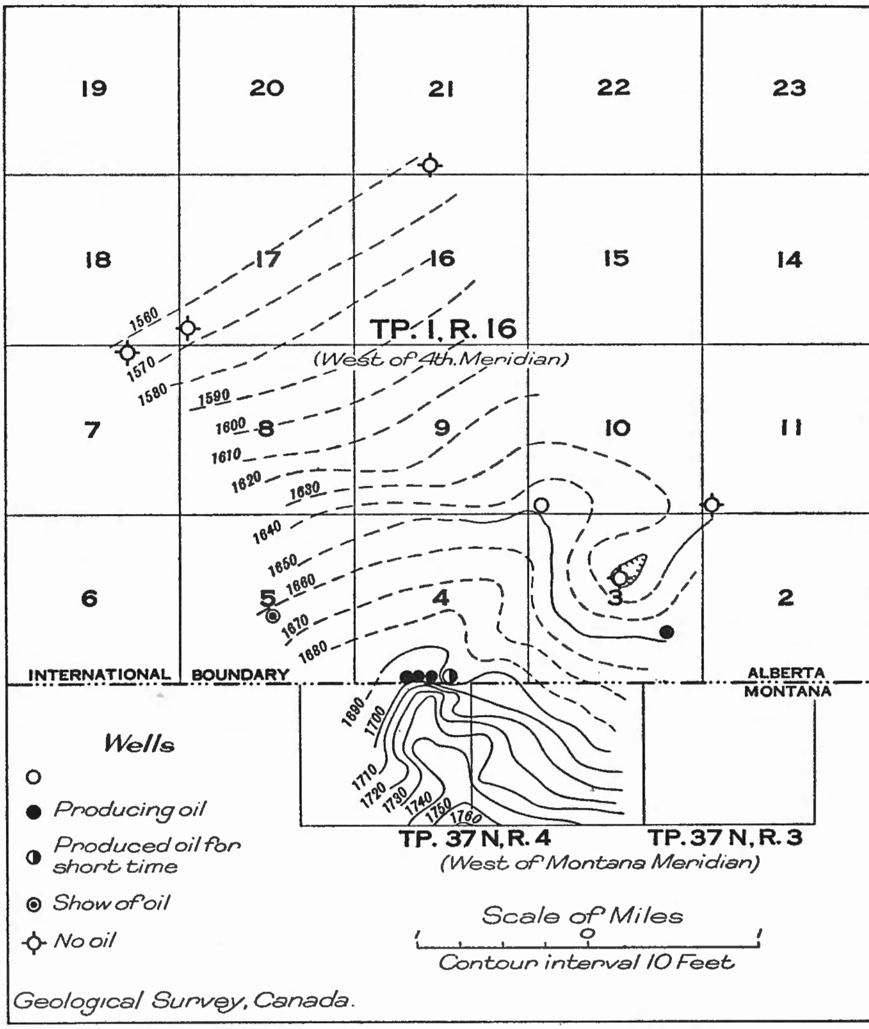

Figure 3. Structural contour map of Red Coulée field, west of 4th meridian, Alberta, contours represent surface of Colorado water sand.

The three wells, Vanalta No. 1 and No. 2, and Taylor No. 1, are close together in the south of sec. 4, tp. 1, range 16, W. 4th mer., and lie on the crest of a narrow, plunging arch and close to the foot of a fairly steep terrace slope. Vanalta No. 4, drilled since the close of field work and reported as a producer, lies about 1,000 feet due north of Taylor No. 1 and, apparently, on the same "flat" as the three wells first mentioned. Southern Alberta Exploration well No. 1, the only other producer, is in sec. 3, tp. 1, range 16, and since it is the most easterly well the details of the structure in its vicinity are unknown. However, between this well and the Commonwealth Red Coulée well No. 1 to the northwest, the structural contours must bend sharply northeast, and it is not improbable that the Southern Alberta Exploration Company well lies west of a small arch. Devonshire well No. 1 is farther northwest, in the southwest corner of sec. 10, tp. 1, and appears to be on a "nose" northwest of a depression reached by Commonwealth Red Coulée well No. 1. The structural elevation is about the same as at the Southern Alberta Exploration well No. 1. The Devonshire well is a possible producer. Should it prove dry the search for other producers would be confined to short distances north and west of the Vanalta No. 1 and No. 2, and Taylor No. 1, wells and to the east and south of the Southern Alberta Exploration well No. 1.

STRUCTURE IN THE VICINITY OF DALCO OIL AND GAS COMPANY WELL No. 2

The Dalco No. 2 well is in L.S.D. 7, sec. 19, tp. 2, range 17, W. 4th mer., just south of a small "window" of Pakowki within Foremost outcrops along Milk river. Along the river the attitude of the top of the Pakowki indicates an easterly dip of about 20 feet to the mile. One mile to the west of the Pakowki outcrop local horizons in the Foremost along the river indicate a westerly dip of about 60 feet to the mile. Outcrops in secs. 3 and 4, tp. 2, range 17, about 4 miles south of the river and to the east of the Pakowki outcrop, show an easterly dip of about 15 feet a mile. The regional dip, as indicated by the elevation of the Pale beds-Foremost contact, located just south of the south boundary of tp. 2, range 17, and again near the north boundary of the township, is northward at the rate of about 45 feet to the mile. It thus appears that the Dalco well No. 2 is on the crest of an arch, but it is not known whether there is closure to the south of the well or whether the strata rise gradually and continuously in that direction. If the arch rises gradually to the south there is a possibility that a structure might be found close to the border, near the boundary of ranges 17 and 18. Any well drilled there should be regarded as exploratory.

WELL LOGS

Vanalta Oils, Limited, Red Coulée Well No. 1; L.S.D. 3, Sec. 4, Tp. 1, Range 16, W. 4th Mer., Elevation 3,571 Feet

Drilling depth	Horizons	Lithology
0– 190	....	Missing
190– 220	220, base of Lower Milk River	Fine-grained, grey sandstone and shaly sandstone
220– 250	....	Dark grey shale; some shaly sandstone
250–1,480	....	Dark grey shale, with sandy shale at 350-360, 390-420, and 1,150-1,170. Some bentonite at 740-750, 780-790, 820-830, and 860-870
1,480–1,490	....	50 per cent light grey, fine to medium-grained sandstone, remainder shale
1,490–1,520	....	Dark shale
1,520–1,540 1,540–1,550	....	Dark shale and white bentonite, 50 per cent fine-grained, light greenish grey sandstone, remainder shale and bentonite
1,550–1,610	....	Dark grey and brownish grey shale, small amount of bentonite
1,610–1,940	.... 1875, Colorado water sand	Dark grey, brownish grey, and grey shale and sandy shale with sandstone beds as follows: 1,650–1,660—50 per cent fine grey sandstone 1,710–1,720—70 per cent fine grey sandstone, some glauconite 1,850–1,860—50 per cent fine to medium, grey sandstone 1,870–1,900—40 per cent fine to medium, white sandstone Some bentonite at 1,680-1,710, 1,820-1,840, 1,860-1,870, and 1,920-1,930
1,940–1,980	1940, top of Lower Cretaceous	Grey shale, some green and red shale; few coal fragments, some bentonite
1,980–1,990	....	Grey and green shale and greenish grey, fine sandstone
1,990–2,030	....	Grey and green and some red shale
2,030–2,060	....	70 per cent fine, greenish grey sandstone; remainder grey and green shale
2,060–2,080	....	Grey, green, and red shale
2,080–2,090	....	60 per cent fine, greenish grey sandstone
2,090–2,110	....	Grey and greenish shale, some light greenish grey sandstone
2,110–2,120	....	80 per cent fine, light grey sandstone
2,120–2,180	....	Green and brownish grey shale
2,180–2,290	....	Predominantly fine, brownish grey sandstone and medium, light grey sandstone. Some grey, green, red, and light grey shale
2,290–2,320	....	Light grey, green, and red shale; a few coal fragments
2,320–2,340	....	As above, with a little sandstone
2,340–2,350	....	80 per cent fine to medium, light grey sandstone; 20 per cent red shale
2,350–2,380	....	Light grey, green, red shale
2,380–2,400	Gas reported at 2,390 (gas sand)?	Missing
2,400–2,410	....	90 per cent fine, light grey sandstone
2,410–2,450	2,450, top of Vanalta oil sand	Variegated shale and fine sandstone
2,450–2,470		Fine-grained, light grey sandstone
2,470–2,477	Oil 2,470–2,477..........	Missing

Alberta Pacific Consolidated Oils, Limited, Well; L.S.D. 2, Sec. 4, Tp. 1, Range 16, W. 4th Mer., Elevation 3,585 Feet

Drilling depth	Horizons	Lithology
0– 60	60, base (?) of Upper Milk River	Drift and medium, brownish grey sandstone; a few fragments of coal
60– 110	....	Drift and brownish grey, medium sandstone
110– 240	240, base (?) of Lower Milk River	Fine to medium, light grey sandstone
240– 310	....	Missing
310– 480	....	Grey, shaly, fine sandstone and sandy, dark shale
480–1,200	....	Mostly dark grey shale, partly sandy
	610, top of *Bullopora* zone	
	640, top of *Clavulina* zone	
1,200–1,600	....	Missing
1,600–1,670	....	Dark shale and sandy, bentonitic shale
1,670–1,690	....	Grey, shaly sandstone
1,690–1,750	....	Grey shale and brownish grey, bentonitic and sandy shale; a little glauconite at 1,740
1,750–1,880	....	Dark shale, a little sandstone; traces of bentonite at 1,750–1,760, 1,780–1,800, and 1,840–1,850; a little glauconite at 1,760–1,770 and 1,810–1,820
1,880–1,930	1,910 Colorado water sand (water)	50 per cent fine white sandstone
1,930–1,975	1,975, top of Lower Cretaceous	Mostly dark grey shale, a little white sandstone
1,975–2,030	....	Grey, brownish grey, and greenish shale
2,030–2,040	....	60 per cent medium, light grey sandstone; a few coal fragments
2,040–2,130	....	Grey, light grey, brownish grey, and green shale
2,130–2,140	....	Fine grey, pyritic sandstone
2,140–2,160	....	Missing
2,160–2,180	....	Fine to medium, quartz and black chert sandstone
2,180–2,190	....	Missing
2,190–2,200	....	Fine, grey sandstone
2,200–2,210	....	Grey and green shale, sandy
2,210–2,220	....	Missing
2,220–2,240	....	Grey and green shale, a little sandstone
2,240–2,260	....	Missing
2,260–2,270	....	Light greenish grey and brownish grey shale
2,270–2,300	....	Missing
2,300–2,310	....	60 per cent fine to medium, grey sandstone; remainder greenish and brownish grey shale
2,310–2,320	....	Mostly red shale, some green and brownish grey shale
2,320–2,340	....	60 per cent fine to medium grey sandstone; red, green, and grey shale
2,340–2,400	....	Missing
2,400–2,410	2,400, gas sand..........	Mostly white sandstone, a little red shale
2,410–2,430	....	Red shale
2,430–2,440	....	Green and red shale, some light greenish sandstone
2,440–2,447	2,445, oil showing.......	Brownish grey, red, and green shale
2,447–2,452	....	Missing
2,452–2,462	2,452, top of Vanalta oil sand	Fine to medium, quartz and black chert sand
2,462–2,468	....	Grey and greenish grey, sandy shale
2,468–2,480	....	Fine, light grey sandstone and green shale
2,480–2,487	....	Fine quartz and black chert sandstone
2,487–2,493	....	Grey and greenish shale and fine, greenish sandstone
2,493–2,500	Oil....................	Fine to medium, quartz and black chert sandstone
2,500–2,515	2,515, water............	Sample missing

Southern Alberta Exploration Company, Limited, Well No. 1; L.S.D. 8, Sec. 3, Tp. 1, Range 16, W. 4th Mer., Elevation 3,502 Feet

Drilling depth	Horizons	Lithology
0– 10	....	Missing
10– 40	....	Weathered, fine to medium, yellowish sandstone
40– 70	70, water................	Medium, light grey sandstone
70– 220	220, base of Lower Milk River	Fine, light grey sandstone and shaly sandstone; few coal fragments
220– 260	....	Dark grey shale and grey, sandy shale
260– 360	....	Dark shale
360– 390	....	Fine, grey sandstone and grey, sandy shale
390–1,130	....	Dark shale, with traces of bentonite at 590–610 and 720–730
	580, top of *Clavulina* zone	
1,130–1,140	....	Fine, grey sandstone and dark shale
1,140–1,180	....	Dark shale
1,180–1,240	....	Dark shale with some bentonite
1,240–1,250	....	Fine, grey sandstone and dark shale
1,250–1,310	....	Dark grey shale; a little sandstone and bentonite
1,310–1,380	....	Dark shale
1,380–1,420	1,395, water............	Fine-grained, grey sandstone, medium, light grey sandstone, and dark shale
1,420–1,460	....	Dark shale
1,460–1,520	....	Dark shale and light grey, bentonitic shale
1,520–1,610	....	Shaly and bentonitic, fine, grey sandstone and grey shale
1,610–1,680	....	Dark shale
1,680–1,860	1,855, (water) Colorado water sand	Grey, sandy shale and light grey, brownish grey, fine and medium sandstones, partly bentonitic and containing some glauconite
1,860–1,870	....	Missing
1,870–1,890	....	Dark shale
1,890–1,900	....	60 per cent fine, grey sandstone
1,900–1,910	....	Dark shale
1,910–1,920	1,920, top of Lower Cretaceous	Dark shale and fine, grey sandstone
1,920–2,110	....	Grey, green, and red shale with trace of bentonitic material
2,110–2,150	....	Grey and green shale with 30 per cent fine to medium, light greenish sandstone; a little red shale
2,150–2,230	Bituminous shale, 2,150-2,170	Brownish grey shale, impure bentonitic material, and a little fine, greenish grey sandstone; some of the brown shale is highly bituminous
2,230–2,240	....	Missing
2,240–2,260	....	Fine, grey sandstone; medium, light grey sandstone; grey shale
2,260–2,270	....	Red and light grey shale
2,270–2,300	....	Fine, light grey sandstone; grey shale and a little red shale
2,300–2,340	2,310, gas showing......	Grey, light grey, green, red shale
2,340–2,350	2,340, gas sand (?)......	Fine, light grey sandstone
2,350–2,360	....	Grey shale
2,360–2,390	....	Missing
2,390–2,410	....	Grey, light grey, and green shale
2,410–2,440	Vanalta oil sand, gas at 2,429; oil at 2,429-2,439	Medium to coarse, quartz and black chert sand

Commonwealth Petroleum, Limited, Red Coulée Well No. 1; L.S.D. 10, Sec. 3, Tp. 1, Range 16, W. 4th Mer., Elevation 3,527 Feet

Drilling depth	Horizons	Lithology
0– 20	20, top of Lower Milk River	Drift; some yellowish sandstone
20– 90	....	Yellowish, medium-grained sandstone
90– 160	....	Fine to medium, light grey sandstone
160– 200	200, base of Lower Milk River	Fine, light grey, shaly sandstone
200– 670	630, top of *Clavulina* zone	Dark shale and sandy shale; little grey sandstone, some beds limy
670–1,180	....	Dark shale
1,180–1,220	....	Dark, sandy shale and fine, grey sandstone
1,220–1,280	....	Dark shale, bentonitic
1,280–1,310	....	Dark shale
1,310–1,370	....	Dark shale and sandy shale; some fine, grey sandstone
1,370–1,450	....	Dark shale, some bentonite
1,450–1,470	....	Sandy shale and 40 per cent medium, quartz and black chert sandstone
1,470–1,520	....	Dark shale, a little thin sandstone
1,520–1,530	....	Dark shale and bentonitic, medium sandstone
1,530–1,680	....	Dark shale, some bentonite
1,680–1,700	....	Dark shale and bentonitic, fine to medium sandstone
1,700–1,740	....	Dark shale
1,740–1,820	....	Dark shale and fine to medium sandstone with some glauconite
1,820–1,850	....	Grey shale, some bentonite
1,850–1,890	....	Grey shale and bentonitic, sandy shale
1,890–1,910	....	Dark shale and fine, grey sandstone
1,910–1,920	1,910, Colorado water sand	Medium-grained sandstone and dark shale, a little glauconite
1,920–1,980	....	Dark grey shale, some sandy and some bentonitic beds
1,980–2,020	1,980, top of Lower Cretaceous	Grey and greenish grey shale, some greenish, bentonitic sandstone
2,020–2,100	....	Dark grey, light grey, green, and red shale
2,100–2,150		Fine to medium, grey and greenish grey sandstone
2,150–2,160	....	Grey, green, and red shale
2,160–2,270	....	Grey, green, and red shale; minor grey and greenish sandstone; little coal
2,270–2,280	....	Missing
2,280–2,290	....	Grey, green, and red shale
2,290–2,310	....	Grey and green shale, some red shale, 20 per cent white, medium sandstone
2,310–2,370	....	Grey and green shale
2,370–2,390	....	Red shale
2,390–2,400	....	60 per cent medium, light grey sandstone
2,400–2,430	....	Grey, greenish, red shale, some grey sandstone
2,430–2,450	?Gas sand..............	Medium, light grey sandstone
2,450–2,495	....	Brownish shale
2,495–2,505	....	Brownish shale and medium to coarse, grey sandstone
2,505–2,553	Vanalta oil sand, water at 2,535	Medium to coarse, quartz and black chert sandstone; pyrite, some coal fragments
2,553–2,610	2,553, top of Ellis.......	Light greenish grey shale and shaly limestone; pyrite; some calcareous and glauconitic sandy beds at base
2,160–2,614	2,614, water............	White, sandy dolomite, 30 per cent sand
2,614–2,625	....	Sandy dolomite and grey shale
2,625–2,732	2,625, top of limestone..	White limestone; some grey shale 2,689 to 2,695

Celtic Oils, Limited, Red Coulée Well No. 1; L.S.D. 4, Sec. 17, Tp. 1, Range 16, W. 4th Mer., Elevation 3,531 Feet

Drilling depth	Horizons	Lithology
0– 110	....	Mostly drift; some yellowish sandstone
110– 150	....	Light brownish sandstone; some traces of coal
150– 290	290, base of Lower Milk River	Fine to medium, light grey sandstone, quite shaly 200–220 and at base
290– 340	....	Dark grey shale with thin bands of grey sandstone
340– 350	....	Missing
350– 360	....	Dark grey, sandy shale
360– 370	....	Missing
370– 410	....	Dark grey shale
410– 440	....	Dark shale ribboned with thin sandstone layers; thin ribbons of coal
440– 460	....	Dark grey shale
460– 470	....	Missing
470– 500	....	Dark grey shale
500– 750	....	Missing
750–1,100	....	Dark grey shale
1,100–1,140	....	Dark grey shale and fine grey sandstone
1,140–1,280	....	Dark grey shale, traces of bentonite at 1,170–1,180 and 1,230–1,240
1,280–1,340	....	Dark grey shale and sandy shale and fine, grey sandstone
1,340–1,440	....	Dark grey shale, bentonitic 1,340–60
1,440–1,480	....	Dark grey shale with 30 per cent fine, grey, shaly sandstone
1,480–1,490	....	Missing
1,490–1,560	....	Dark grey shale with bentonite
1,560–1,570	....	Fine, grey, shaly sandstone
1,570–1,590	....	Dark grey shale
1,590–1,600	Water..................	30 per cent medium, quartz and black chert sandstone, remainder shale
1,600–1,680	....	Dark shale, bentonitic and slightly sandy
1,680–1,930	....	Dark shale, sandy at 1,730–1,750, bentonitic at 1,770–1,820 and 1,920–1,930, glauconitic at 1,890–1,900
1,930–2,040	1,960, Colorado water sand	Dark shale; some glauconite at 1,930–50, 50 per cent grey sand at 1,960–1,970
2,040–2,080	2,040, top of Lower Cretaceous	Fine to medium, light grey and greenish grey sandstone
2,080–2,240	....	Grey, brownish grey, and green shale, somewhat sandy
2,240–2,250	....	Missing
2,250–2,270	Bituminous shale.......	Dark bituminous shale
2,270–2,290	....	Light grey sandstone, grey and greenish grey shale
2,290–2,300	....	Missing
2,300–2,330	....	Mostly fine, light grey sandstone
2,330–2,380	....	Grey, greenish grey, brownish grey shale, and some grey sandstone
2,380–2,420	....	Missing
2,420–2,540	....	Dark grey, grey, brownish grey shale, some red shale
2,540–2,550	2,540, top of Vanalta sand; water at 2,543	Medium, quartz and black chert sandstone, with minor grey, green, and red shale
2,550–2,560	....	Fine, white sandstone and medium, quartz and black chert sandstone
2,560–2,570	....	Missing
2,570–2,580	Water at 2,573..........	Fine to medium, quartz and black chert sandstone
2,580–2,630	2,580, top of Ellis.......	Grey, slightly greenish, calcareous shale with pyrite and marcasite; some chert pebbles, largest 1 cm. diameter
2,630–2,650	....	Greenish grey shale, with 60 per cent of fine, light greenish sandstone; pyrite, black chert grains, and a little glauconite
2,650–2,660	....	As above, with a little white limestone
2,660–2,670	2,660, top of limestone..	White limestone

Dalco Oil and Gas Company, Limited, Red Coulée Well No. 1; L.S.D. 4, Sec. 11, Tp. 1, Range 16, W. 4th Mer., Elevation 3,508 Feet

Drilling depth	Horizons	Lithology
0–220	220, base of Lower Milk River	Missing
220–1,550	....	Dark shale, some sandstone and bentonite
	1,880, (water) Colorado water sand(?)	
	1945, top of Lower Cretaceous (?)	
2,150–2,170	Bituminous shale........	Some bituminous shale in fine, greenish sandstone
2,350–2,360	Gas sand (?)	
2,420–2,435	....	Reported as coarse sand, very little sand present in samples, which are mostly red shale; typical Vanalta sand not indicated in samples
2,520–2,570	2,560, sulphur water.....	Looks like Ellis
2,570–2,620	2,570, top of limestone...	White limestone

NOTE. An outline only is given of this well, since Lower Cretaceous appears in the samples at 1,550 feet in disagreement with the drilling records. The writer is of the opinion, however, that the samples are correct from 2,150 feet down, as the bituminous shales at that depth agree with those found in the Southern Alberta Exploration well No. 1 and the Celtic No. 1 well.

Dalco Oil and Gas Company, Limited, Red Coulée Well No. 2; L.S.D. 7, Sec. 19, Tp. 2, Range 17, W. 4th Mer., Elevation 3,630 Feet

Drilling depth	Horizons	Lithology
0–50	....	Missing
50– 120	120, base of Foremost...	Drift; grey sandstone, dark carbonaceous shale, a few coal fragments
120–290	290?, base of Pakowki...	Grey and slightly greenish grey, fine sandstone; shaly sandstone and sandy, grey shale; foraminifera present at 130–150 and 280–290
290– 310	....	Mostly cavings of drift; a little grey shale and grey sandstone
310– 340	....	Light grey, shaly sandstone, a little greenish sandstone, and white "mud"
340– 380	....	Mostly white, sandy "mud," some greenish and brown shale
380– 400	....	Light grey and greenish grey shale, some brown shale
400 420	....	Fine, light grey, shaly sandstone
420– 430	....	Fine, light grey sandstone, brown shale, and coal fragments
430– 440	....	Grey, sandy shale and shaly, medium sandstone
440– 460	440?, top of Lower Milk River	Light grey, medium sandstone
460– 470	....	As above, with some brown shale
470– 480	....	Light grey, sandy shale and brown shale
480– 540	500, water..............	Light grey, fine and medium sandstone and shaly sandstone
540– 650	550, water; 650, base of Lower Milk River	Light grey, fine to medium sandstone and shaly sandstone
650–1,890	1,040, top of *Bullopora* zone 1,070, top of *Clavulina* zones 1,900, water	Dark grey shale, some sandy shale
1,890–1,920	....	Dark shale and some light grey, medium sandstone; a little bentonite
1,930–1,970	....	Dark shale, a little bentonite

SOME CLAY DEPOSITS OF WILLOWBUNCH AREA, SASKATCHEWAN

By F. H. McLearn

CONTENTS

INTRODUCTION

In the field season of 1930 the west half of the Willowbunch sheet[1] was studied. In particular, areas in the vicinity of Willows, Willowbunch lake, Bonneau lake, Harptree, Big Muddy, and Rockglen were examined. Particular attention was devoted to stratigraphy, structure, oil possibilities, and the clay deposits. The results regarding oil possibilities are largely negative. In this preliminary report, therefore, on last season's activities, attention is confined chiefly to the clay deposits. A brief account of the stratigraphy is given, however, for a thorough understanding of it is a necessary prelude to all economic studies in southern Saskatchewan.

Very satisfactory field assistance was given by O. L. Backman, Edward Leith, and L. S. Russell. All instrument work, including the running of levels, was done by Backman. The clay tests were made in the Ceramics Division of the Mines Branch, H. Frechette, Chief of Division, and were reported on by J. G. Phillips. Acknowledgment is made to Professor W. G. Worcester for valuable advice on clay deposits.

By Lake of the Rivers valley is meant the valley containing Lake of the Rivers and Willowbunch lake. By Twelvemile Lake valley is meant the valley containing Twelvemile lake, Bonneau lake, Rivard lake, etc. The two valleys unite near sec. 6, tp. 4, range 25, W. 2nd mer., to form Big Muddy valley which extends eastward to Big Muddy lake and thence directly south to cross the International Boundary in sec. 3, tp. 1, range 22, W. 2nd mer.

The refractory and semi-refractory clays are the most important of the mineral resources of southern Saskatchewan. They are suited to the manufacture of a great variety of ceramic products, include some of the most refractory clays in Canada, and form the basis of a growing industry.

From an early date the Geological Survey and Mines Branch have directed attention to these clays and have endeavoured to encourage their utilization. In 1885, McConnell noted the "white band" near the bottom of the "Laramie."[2] In 1895, Hoffmann examined a sample from sec. 28, tp. 12, range 24, W. 2nd mer. (Claybank), recorded its refractoriness and recommended its suitability for fairly refractory fire-brick and pottery.[3] In 1906, Chambers observed the winter haulage of clay from the hills near Wood Mountain to Moose Jaw for manufacture into common brick and

[1]Dept. of Interior, Top. Surv., Canada, sec. sheet No. 19.
[2]McConnell, R. G.: Geol. Surv., Canada, Ann. Rept. 1885, N. S., vol. I, pt. C, pp. 27, 28 (1886).
[3]Hoffmann, G. C.: Geol. Surv., Canada, Ann. Rept. 1892-3, N. S., vol. VI, pt. R., p. 91 (1895).

some fire-brick.[1] The next records, those of Ries and Keele, based on field work of 1910 and later years and published between 1912 and 1915, are more elaborate and include the results of actual sampling of deposits and laboratory tests.[2] Between 1914 and 1916 Rose published the results of some clay tests.[3] Davis' valuable work, published in 1916, treated the clays in very considerable detail.[4] These studies between 1910 and 1916 gave great encouragement to the commercial development of this important resource. The recent work of the Geological Survey has included primarily a study of the distribution of the deposits as controlled by geological conditions, a study of the origin of the deposits, and the location of some prospects.[5]

Worcester notes that the first private report on the clays, known to him, was by Professor Edward Orton, jun., in 1907, and was based on samples from Dirt hills, collected by Daniel Diver, a prospector.[6] Worcester's own valuable investigations,[7] made under provincial auspices, have included much sampling of deposits in the field, laboratory tests, and the devising of methods of treatment and utilization.

STRATIGRAPHY

The formations in the west half of the Willowbunch sheet, studied in 1930, are given in the following table, as well as some important stratigraphic data.

As the stratigraphy has been fully treated in previous reports,[8] a description of it need not be repeated here. It is not known whether the *Triceràtops* (Lance) or basal zone of the Ravenscrag extends as far east as Willowbunch area. Near Willows dinosaur bones were found on the surface of beds just above the Whitemud, but whether they came from the bottom of the Ravenscrag or from the glacial drift could not be proved. Owing to lack of persistent and reliable lithologic boundaries it is not possible to subdivide the Ravenscrag nor to apply to the Canadian sections the formational classification used in Montana.[9] Divisions into grey and yellow or buff facies have locally considerable value, but it is not proved that they are of general application to all of southern Saskatchewan. It does not seem possible to make the beds above and below the Willowbunch member separate mapping units or formations, for the Willowbunch member is difficult to identify and trace; in places it passes laterally into beds difficult to recognize as typical of it and refractory and non-refractory beds do occur at other horizons in the Ravenscrag. Moreover, the beds over and below it are not markedly different. The Colgate member in Montana is possibly an equivalent of the Whitemud beds.

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[1]Chambers, R.: Geol. Surv., Canada, Sum. Rept. 1905, p. 74.

[2]Ries, Heinrich, and Keele, Joseph: Geol. Surv., Canada, Mem. 24E (1912); Mem. 25 (1913); Mem. 65 (1915); Mem. 66 (1915).

[3]Rose, Bruce: Geol. Surv., Canada, Mem. 89, pp. 69-83 (1916).

[4]Davis, N. B.: Mines Branch, Dept. of Mines, Canada, "Rept. on Clay Resources of Southern Saskatchewan" (1918).

[5]McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1927, pt. B, pp. 21-43; 1928, pt. B, pp. 30-44; 1929, pt. B, pp. 48-63.

[6]Worcester, W. G.: Trans., Can. Inst. Min. Met., 32, p. 256 (1929).

[7]Worcester, W. G.: Trans., Can. Inst., Min. Met., 32, pp. 255-269 (1929). Also other papers, including unpublished reports to the Saskatchewan government.

[8]McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1927, pt. B, pp. 24-39; 1928, pt. B, pp. 30-42; 1929, pt. B, pp. 49-59.

[9]*See* Thom, W. T., jun., and Dobbin, C. E.: Bull. G.S.A., vol. 35, pp. 481-506 (1924).

TABLE I

AGE			FORMATION	Invertebrate faunas	Vertebrate faunas	Floras	Refractory, semirefractory clays	Volcanic ash	Some coal seams: Horizons	Some coal seams: Names
TERTIARY	MIOCENE		Wood Mountain		Merychippus					
TERTIARY	OLIGOCENE		*Absent*							
TERTIARY	EOCENE	LATER EOCENE (POSTPALEOCENE)	*Absent*							
TERTIARY	EOCENE	EARLIEST EOCENE (PALEOCENE)	? Ravenscrag	V. trochiformis		Upper flora				BIG MUDDY
TERTIARY	EOCENE	EARLIEST EOCENE (PALEOCENE)	Ravenscrag: Willowbunch							
TERTIARY	EOCENE	EARLIEST EOCENE (PALEOCENE)	Ravenscrag	V. trochiformis	Leidyosuchus Echmatemys	Upper flora Middle flora (P. crassifolia)				HARPTREE MINE KEOGH CONTACT GYE ST. VICTOR KRIEG ANXIETY BUTTE No.1 or FERRIS
MESOZOIC	LATE CRETACEOUS		Ravenscrag: *Basal part present ?*		Triceratops present ?	Lower flora (F. ceratops) present ?				
MESOZOIC	LATE CRETACEOUS		Whitemud	Anodonta sp. 1.		Whitemud flora (Nelumbites n.sp.)				WHITEMUD
MESOZOIC	LATE CRETACEOUS		Sandstone E	Anodonta sp. 2.	Sauropterygian rib					
MESOZOIC	LATE CRETACEOUS		Bearpaw							

The stratigraphic data shown in the table include faunas, floras, refractory and semi-refractory clay zones, a volcanic ash zone, and some coal seams. In the following tentative correlation of coal seams the assumption is made that refractory and semi-refractory, clay-bearing zones, identified as the Willowbunch member in the cliffs south of Big Muddy and Harptree, are exactly equivalent stratigraphically to the typical Willowbunch south of the town of Willowbunch.

HORIZONS OF COAL SEAMS

By Big Muddy seam is meant the thick one over the Willowbunch member south of Big Muddy lake. At a similar horizon, but not necessarily exactly the same seams nor exactly at the same horizon, are the thick seam over the Willowbunch zone south of Harptree and the Willowbunch seam which just overlies the Willowbunch clay member south of the town of Willowbunch.

By Harptree Mine seam is meant the one high in the Ravenscrag but below the Willowbunch member and the one mined south of Harptree in NW. $\frac{1}{4}$ sec. 34, tp. 3, range 26, W. 2nd mer. In the same area, but at a lower horizon, is the Contact seam, which occurs at the contact between a grey below and a yellow or buff facies above. The beds for a few feet just over it are white, pale grey, and pale purplish weathering silts and clays and with the Contact seam form locally an important key horizon or zone. Where measured in SW. $\frac{1}{4}$ sec. 3, tp. 4, range 26, W. 2nd mer., it is 1 foot 8 inches thick, but it is thicker at other localities.

It is probable that the Keogh seam south of Big Muddy lake is at a somewhat higher horizon than the Contact seam. The Keogh occurs near the top of a grey facies in the area south of Big Muddy lake and is the one worked on a small scale near the Keogh ranch buildings. Locally two seams of fair thickness occur over it.

West of Harptree area, and south and west of Gye, is a fairly thick seam worked in an adit and an open pit near the middle of sec. 26, tp. 4, range 27, W. 2nd mer., near valley-bottom level. This may be called the Gye seam. It is at the same or at a somewhat lower horizon than the Contact seam to the east. A seam which occurs a little above it in Gye area may be designated the Bonneau seam. A seam mined near valley-bottom level at Willowbunch is at an horizon similar to that of the Gye seam.

Yet, farther west near St. Victor the St. Victor seam lies just over the volcanic ash horizon and possibly at a little lower horizon than the Gye seam, but not much lower. It is mined east of St. Victor in the Brenner mine. Two or three seams of fair thickness occur over the St. Victor seam in the yellow or buff facies, west of St. Victor on the south side of the valley.

East of Twelvemile lake a small seam is present near the top of the grey facies and just under the horizon at which volcanic ash discontinuously occurs. This is the Krieg seam. It thins out eastwardly toward St. Victor, just as the slightly higher St. Victor seam does not extend west to Twelvemile lake. The Krieg seam has two small seams under it in the grey facies and at least two fair seams over it in the yellow or buff facies in the area east of Twelvemile lake.

The first seam in the Ravenscrag is poorly developed in Lake of the Rivers valley and Big Muddy valley. It is more distinct and thicker at Twelvemile lake, but is variable there. Far to the west, in East End area, the No. 1 or Ferris seam is more uniform and persistent. It is not necessarily the same seam nor exactly at the same horizon as the first seam in the east, however. In East End area seams occur over the No. 1 seam, including the Anxiety Butte seam, which occurs at the base of the cliff at Anxiety butte and has been mined there.

By Anchor seam is meant the one low in the Ravenscrag formation, about 55 feet over the No. 1 seam, on the south shore of Willowbunch lake and recently opened near the west boundary of sec. 10, tp. 6, range 27, W. 2nd mer. It is a useful horizon marker locally. The No. 1 seam is here 1 foot 8 inches, including some lignitic shale, but not including an 8-inch shale parting. It occurs just over the Whitemud beds and is the lowest seam in the area, as there is no coal below the Whitemud beds. As pointed out in previous reports there is no coal-bearing Estevan formation below these Whitemud beds.

Another seam that may have some stratigraphic value in Wood Mountain district is the Vogelberg seam in the buff facies of the Ravenscrag formation, more than 100 feet below the Willowbunch member. It is worked in the Six-mile mine in sec. 16, tp. 4, range 4, W. 3rd mer. In this district, the No. 1 seam, a little over the Whitemud beds, is a well-developed and workable seam and a good horizon marker.

CLAYS

Refractory and semi-refractory clays occur at two horizons.[1] The lower is that of the Whitemud formation in late Cretaceous age and the higher is that of the Willowbunch member of Palæocene age.

The origin of the Whitemud clays and the geological conditions affecting their distribution have been considered by the writer in recent reports.[2] Only a few observations need be added now. The writer's theory of intra-regional origin includes the kaolinization of feldspathic sands after deposition and in Whitemud time. This part of the theory is also held by Worcester.[3] C. S. Ross, describing the sands of the Colgate member of Montana, notes that "Clay minerals make up a considerable part of the interstitial material and most of these appear to have formed in place by the alteration of detrital rock grains."[4]

Additional evidence supporting a non-marine origin of the Whitemud beds was obtained. At one locality the freshwater pelecypod *Anodonta* was found. At another very fine, paper-thin, bedded clays carry leaves of the "water lilies" *Nelumbo* and *Nelumbites,* which record a freshwater aquatic environment.

Long, vertical, tap-like roots occur in some of the Whitemud beds. That these were roots penetrating downward and not buried stems or stalks can be proved, for they pierce fossil leaves lying prone along the bedding. This is considered to be evidence that the water-table, at times at least,

[1]McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1928, pt. B, p. 35; 1929, pt. B, p. 58.
[2]McLearn, F. H.: Trans. Roy. Soc., Canada, 3rd ser., vol. 22, p. CIX (1928); Geol. Surv., Canada, Sum. Rept. 1927, pt. B, pp. 25-39; 1928, pt. B, pp. 35-38; 1929, pt. B, pp. 51-55.
[3]Worcester, W. G.: Trans. Can. Inst. Min. Met., vol. 32, p. 260 (1929).
[4]Dobbin, C. E., and Reeside, John B., jun.: U.S. Geol. Surv., Prof. Paper 158 B, p. 25 (1929).

was at some appreciable depth below the surface. A periodic fall of the water-table to promote weathering was postulated[1], as part of the local or intraregional theory of origin of the Whitemud beds.

Although the Whitemud clays of the area studied in 1930, i.e., the west half of the Willowbunch sheet, vary from place to place, they maintain a good average quality and some of the best clays of Saskatchewan are found in this area and at this horizon. The original deposition and alteration all seem to have been largely favourable to them and they were little affected by the erosion at the end of Whitemud time which destroyed so much of the clays in other areas. The best clays occur at the tops of the sections.

Over most of the west half of the Willowbunch sheet the Whitemud formation is deeply buried. It occurs, however, on both sides of Lake of the Rivers valley from the south end of Lake of the Rivers to the west end of Willowbunch lake, where it is carried below lake-level in about sec. 9, tp. 6, range 27, W. 2nd mer., by the east dip. It reappears in a low, broad arch on both sides of Big Muddy valley between sec. 2, tp. 4, range 25, W. 2nd mer., and the west end of Big Muddy lake, where it is carried below lake-level by the east dip.

The clays of the Willowbunch member high in the Ravenscrag formation occur just under the highest uplands. They are widely distributed in the west half of the Willowbunch sheet. The upland south of the town of Willowbunch is high enough to carry them and they are exposed in the tributary coulées heading southward into this upland. They can be traced in a southeastward direction along the north border of the upland to a long tributary coulée west of Bonneau lake in sec. 4, tp. 5, range 27, W. 2nd mer. Exposures reappear on the south side of the main valley south of Harptree, where the upland is also high enough to carry the clays of this zone. The high upland in the vicinity of Buffalo gap and the highest part of the upland east of the Bengough (34) highway on the south side of Big Muddy valley carry them. They are also exposed in the northern edge of the high upland south of Big Muddy lake, on both sides of Big Muddy valley between the lake and the International Boundary, and on a small, high, upland remnant in about sec. 6, tp. 2, range 23, W. 2nd mer. A small, and the highest part of the ridge, near the International Boundary in about sec. 2, tp. 1, range 24, W. 2nd mer., appears to carry it. In Rockglen valley, north, south, and southeast of the town of Rockglen the highest ridges carry what appear to be clays of this zone.

Small sections of semi-refractory or refractory clays occur also at other horizons near that of the Willowbunch member. South of Harptree there is a thin zone about 40 or 50 feet over it. In the Rockglen there is such a zone 80 or 100 feet below the probable Willowbunch member. The occurrence of these additional zones makes the identification of the true Willowbunch member difficult and even tentative in places, e.g., at Rockglen and possibly south of Harptree.

The Willowbunch clays vary much from place to place, are mostly in thinner sections than those of the Whitemud, and on the whole are not the commercial equal of them. Locally, however, very good Willowbunch clays are found.

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[1]McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1927, pt. B, p. 36.

The tests recorded below are not complete, but serve to show the location of some promising refractory clay deposits.

The following symbols are used in the tables:

Sd = selected, not general, sample.
S = sticky
St = stiff
p = plastic
f.p. = fairly plastic
v.p. = very plastic
s.p. = slightly plastic
v.s. = very sticky
G = greasy
T = tough
p.c.e. = pyrometric cone equivalent

In the tables, where the grade has been determined, it is recorded as such, i.e., clay, sandy clay, etc. Elsewhere the rock term, based on field observation, is given, i.e., shale, etc. In the tables all beds are given in their natural stratigraphic order, i.e., the highest beds are at the top of the page.

WHITEMUD SECTIONS

Good exposures of Whitemud clays are found in the vicinity of Willows, and several quarries have been operated. An unworked deposit, containing good clays, occurs in SW. ¼ sec. 7, tp. 8, range 28, W. 2nd mer. A section is as follows:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
0	2	....	Coal..........	....	....	....
1	0	W1189	Purplish grey clay..........	33·0	v.p.	32
1	3	W1188	Purplish brown clay..........	32·6	v.p.	32
2	0	W1186	Pale mauve-grey clay, yellow stains.	33·3	v.p.	29
3	0	W1185	Pale mauve-grey clay	31·6	v.p.	29
1	6	W1184	Brownish clay..........	29·6	p	30
0	9	W1183	Brownish clay..........	30·0	p	28
3	0	W1190	Thin beds, pale mauve-green clay and silt..........	30·6	v.p.	31
2	0	W1192	Brownish grey clay..........	32·0	v.p.	27
1	6	W1193	Brown, carbonaceous clay..........	30·0	v.p.	28+
1	10	W1194	Light grey, silty clay..........	28·3	p	31
0	10	W1195	Light brownish grey clay..........	34·0	v.p.	29
0	6	W1196	Light brown clay..........	32·0	v.p.	28+
2	6	W1197	Grey clay..........	34·3	v.p.	26
0	8	W1198	Light grey, sandy clay..........	22·0	s.p.	20
1	8	W1199	Brown, carbonaceous, silty clay.....	36·3	p	25+
0	6	W1200	Light brownish grey, hard clay......	34·6	v.p.	15
3	6	W1201	Grey, silty clay..........	26·4	p	20
0	8	W1202	Brownish grey, hard clay..........	32·3	v.p.	14
5	6	W1203	Grey, hard, silty clay..........	27·0	p	14
1	0	W1204	Dark brown, hard clay..........	30·3	v.p.	5

Nos. W1189, W1188, and W1190 are very high-grade refractory. The others from W1197 up are second or low-grade refractory clays.

In SW. ¼ sec. 3, tp. 8, range 29, W. 2nd mer., on the north side of a coulée northwest of Willows, the lower part of the Whitemud is exposed. The high zones with plastic clay have been eroded here, but are probably present farther back in the bank. Only the lower zone of sandy clays is present. The section exposed is as follows:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
......	......	....	Grey clay, boulder clay, etc.........	....	....	....
2	6	W1205	Light grey, sandy clay, grey clay lenses........................	24·0	p	28
2	0	W1206	Light brown clay....................	29·3	v.p.	20
2	2	W1207	Light brown, sandy clay............	20·0	p	27
5	8	W1208	Light grey, sandy clay...............	22·0	s.p.	29
5	0	W1209	Light grey, very sandy clay.........	22·3	s.p.	23
4	0	W1210	Light grey, sandy clay...............	25·0	s.p.	20
0	8	W1211	Light brownish grey, very sandy clay...........................	19·0	s.p.	14
3	0	W1212	Light grey, very sandy clay.........	20	s.p.	13
4	0	W1213	Grey, very sandy clay..............	23·0	s.p.	10

The above section is interesting for it shows decreased refractoriness below. Mechanical separation tests show that this is co-ordinated with less clay content below. Therefore, the kaolinization that took place in Whitemud time was dying out below.

In the SE. ¼ sec. 24, tp. 7, range 29, W. 2nd mer., on the north side of a small coulée to the west of the highway, a rather thin section of the Whitemud occurs:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
2	6	W1350	Pale brownish grey clay.............	33·0	v.p.	28
1	0	W1352	Pale grey, iron-stained clay..........	27·3	v.p.	26
1	5	W1351	Pale grey, silty clay..................	27·3	v.p.	26
3	6	W1354	Pale grey, sandy clay................	25·6	f.p.	29
5	6	W1353	White, sandy clay...................	24·3	p	29
0	3	....	Clay ironstone......................	....	....	....
0	5	W1355	Brown, silty clay....................	34·6	p	23
1	0	W1356	Grey, silty clay.....................	30·6	p	23

The top of the section was probably not obtained here.

There is a good deposit of Whitemud clays in SW. ¼ sec. 30, tp. 7, range 28, W. 2nd mer.

Thickness Ft.	Thickness Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
0	11	....	Lignite...........................	....	....	....
0	2½	....	Brownish grey, carbonaceous silt....	....	....	....
0	9	....	Lignite...........................	....	....	....
0	3	....	Brown clay........................	....	....	....
1	3	W1269	Grey clay.........................	34·0	v.p.	31+
1	11	W1268	Pale brown clay...................	32·3	v.p.	31+
4	6	W1267	Grey clay, iron spots..............	28·3	v.p.	31
2	8	W1266	Grey clay, iron spots..............	30·0	v.p.	31
1	10	W1265	Brownish grey clay.................	28·3	v.p.	31
0	9	W1280	Pale brownish grey clay............	30·6	v.p., G	30
1	1	W1279	Brownish grey clay.................	34·0	v.p., G	29+
4	4	W1278Sd	Silty clay and grey clay-sample, mostly of latter...................	30·6	v.p., G	30
2	11	W1277	Grey, sandy clay...................	22·6	p	30+
2	2	W1276	Grey clay.........................	31·3	v.p.	29
2	5	W1275	Light grey, sandy clay..............	22·6	p	29
1	4	W1274	Very fine sandstone and dark grey clay..............................	29	p	29
4	8	W1273	Light grey, sandy clay..............	22·0	s.p.	28+
2	6	W1272	Thin layers grey, very fine, sandy, and silty clay..........................	28·3	v.p.	19
2	0	W1271	Grey, sandy clay...................	25·8	p	23

The two top beds, samples W1269, W1268, are very high-grade refractory clays. The beds with samples W1267, W1266, W1265, W1280, and W1278 are high grade.

North of highway 13 and east of the Canadian Pacific Railway trestle, at end of a spur, in SE. ¼ sec. 6, tp. 7, range 27, W. 2nd mer., is a deposit of Whitemud clay:

Thickness Ft.	Thickness Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
......	......	....	Fissile green shale..................	....	....	....
5	0	W1219	Pale mauve-grey clay................	32·3	v.p.	31
2	9	W1218	Light mauve-grey clay..............	31·0	v.p.	31
3	0	W1217	Light mauve-grey, silty clay.........	30·0	v.p.	31
3	6	W1216	White, silty clay....................	30·3	p	30
1	0	W1215	Light grey to white clay, silty clay..	28·0	p	29
3	5	W1214	White, sandy clay...................	25·6	p	30

The clays of W1219, W1218, and W1217 are very high-grade refractory.

Just south of the above and just north of highway 13, east of trestle, is a small pit from which a test shipment has been made. Three feet of clay in the upper part of the exposed section gave the following results:

Thickness Ft.	Thickness Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
3	0	W1178	Light grey clay....................	30·0	v.p.	28+

This is a low-grade refractory clay.

In a coulée on the south side of Willowbunch lake, near its western end and about in sec. 7, tp. 6, range 27, W. 2nd mer., is a good deposit of the Whitemud. The section exposed just south of a fault on the east side of the coulée is as follows:

Thickness Ft.	Thickness Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
0	7	....	Lignite..............................	....	....	....
0	3	....	Silt..................................	....	....	....
0	8	....	Lignite..............................	....	....	....
0	4	....	Dark purplish grey shale...........	....	....	....
2	2	W1307	Light brownish, mauve-grey clay...	30·0	v.p.	30+
1	4	W1306	Light brownish, mauve-grey clay, iron stains........................	32·0	v.p., S	30+
2	8	W1305	Light mauve to brownish grey clay..	30·3	v.p.	30+
4	0	W1304	Grey clay..........................	28·6	p, G	30+
1	0	W1303	Yellow clay—many minute ferruginous concretions...................	29·6	p	15+
0	10	W1302	Grey clay..........................	31·0	v.p.	30+
0	10	W1301	Grey clay..........................	29·3	v.p., G	28+
6	6	W1300	Brownish, grey, silty clay..........	29·3	v.p.	28+
1	4	W1299	Grey to white, sandy clay..........	25·3	p	30+
2	5	W1298	Grey to white, sandy clay..........	23·3	f.p.	28+
1	5	W1297	Grey to white, sandy clay..........	21·6	s.p.	28+
2	4	W1296	Grey to white, sandy clay..........	21·6	s.p.	28

Samples W1307, W1306, W1305, W1304, and W1302 are high-grade refractory clays. From W1301 down are low-grade refractory clays.

On the south side of Willowbunch lake and in approximately the SW. ¼ sec. 10, tp. 6, range 27, W. 2nd mer., at about lake-level, is the following section:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
......	......	....	Shale and lignite....................	....	....	....
5	0	W1176Sd	Grey clay, minute ferruginous concretions..........................	30·7	v.p.	32

The grey clay is a very high-grade refractory. The sample, however, is not representative of the entire 5 feet and the occurrence can only be regarded as a promising prospect for refractory clay.

On the south side of Big Muddy valley west of the Bengough highway (34), and near the centre of sec. 27, tp. 3, range 24, W. 2nd mer., is a good deposit of Whitemud clays.

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
0	3	....	Lignite and lignitic shale...........	....	....	....
0	4	....	Shale..............................	....	....	....
0	4	....	Black, lignitic shale..................	....	....	....
0	2	....	Shale..............................	....	....	....
0	6	....	Lignite............................	....	....	....
7	0	W1167	Brownish grey clay..................	28·3	v.p.	32
0	6	....	Dark, coaly shale..................	....	....	....
1	6	W1166	Very dark, carbonaceous clay........	36·6	p	31
4	0	W1165	Dark brown, sandy clay, bands white silt..........................	24·3	s.p.	26—
3	6	W1164	Light brownish, silty clay...........	29·3	p	20+
0	6	W1163	Brownish grey clay..................	33·3	v.p.	20
1	1	W1162	Light brown clay....................	29·3	v.p.	17
4	0	W1168	Light grey, sandy clay...............	22·6	s.p.	29
4	6	W1169	Light grey, sandy clay...............	22·3	s.p.	29
3	2	W1170	Grey, coarse, sandy clay............	23·3	s.p.	29
4	8	W1171	Light grey, sandy clay...............	22·3	s.p.	28

Samples W1167 and W1166 are very high-grade refractory.

At the end of a spur in NE. ¼ sec. 24, tp. 3, range 25, W. 2nd mer., the top of a section of the Whitemud is exposed:

Thickness Ft.	Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
0	5	W1465	Bentonite	61·6	T, v.s.	8
0	3	....	Lignite	....	....	....
0	9	....	Brown, fissile shale	....	....	....
0	3	....	Lignite	....	....	....
0	4	....	Brown to black, carbonaceous shale, top of Whitemud	....	....	....
1	2	W1464	Greyish brown clay	29·7	v.p.	31
1	5	W1463	Grey clay	29·0	p	31
1	9	W1462Sd	Light grey silt, admixed ferruginous concretions and yellow clay not included in sample	28·6	p	31

These are high-grade refractory clays.

Some good clay occurs near the top of a section on the south side of Big Muddy valley, in about the middle of sec. 25, tp. 3, range 25, W. 2nd mer.

Thickness Ft.	Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
1	0	....	Lignite	....	....	.....
1	1	W1461	Dark brown, carbonaceous clay, ferruginous	31·0	s.p.	31
0	6	W1460	Brown clay	28·6	p	31
2	5	W1459	Grey clay, some ferruginous concretionary lenses	25·0	p	29+
3	8	W1458	Pale greyish green clay, ferruginous lenses	29·3	v.p.	30
1	5	W1457	Pale greyish green, silty clay, ferruginous	29·6	p.	26
0	9	W1456	Greyish green clay, ferruginous lenses	29·3	v.p.	29
1	5	W1455	Pale greenish grey clay, dark streaks	30·3	v.p.	29
1	7	W1454	Pale brownish grey, silty clay	32·6	v.p., S	26
0	8	W1453	Grey, silty clay	34·0	p	29
0	8	....	Brown, carbonaceous and lignitic shale	....	....	.....
1	9	W1452	Brown, silty clay	32·3	p	27
0	6	W1450	Brownish grey clay	25·0	p	26
0	3	....	Fine, sandy clay	....	....	.....
0	1	....	Hard, purplish silt	....	....	.....
0	7	W1451	Dark grey, sandy clay	27·3	p	30
0	1	....	Purplish shale	....	....	.....
0	1	....	Fine, grey, sandy clay	....	....	.....
0	4	....	Lignite and lignitic shale	....	....	.....
0	8	W1449	Brown, carbonaceous, lignitic, silty clay	36·6	s.p.	17
1	5	W1448	Brownish clay	34·0	p	16
1	5	W1447	Very dark grey clay, films fine white sand	34·3	v.p.	17
6	2	W1446	Light grey, sandy clay	21·0	s.p.	23
0	5	....	Finely banded silt, carbonaceous films	....	....	.....
0	3	W1445	Brownish clay, fine ferruginous concretions	40·3	v.p.	14
0	5	....	Finely banded, coarse silt	....	....	.....
5	8	W1444	Grey, sandy clay	23·0	short	15

The samples W1461, W1460, W1458, and W1451 are high-grade refractory. Samples W1447 and W1445 crack in drying. There is also some low-grade refractory clay in the section.

Near the west end of Big Muddy lake on the south side of the valley, the Whitemud outcrops in a few places. On a small butte in sec. 14, tp. 3, range 23, W. 2nd mer., sandy clay is overlain by pale greenish grey clay. Just to the southeast of this, at the end of a short spur, one foot of clay at the very top of the Whitemud shows. A sample gave the following results:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
1	0	W1473	Light brown clay....................	32·6	p	32

This is a high-grade clay and the locality should be further investigated.

The top of the Whitemud also shows in NE. ¼ sec. 15, tp. 3, range 23, W. 2nd mer. Only a few feet of clay are exposed. A sample from 1 foot of section gives the following results:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
1	0	W1475	Greyish brown clay.................	27·3	p	31

WILLOWBUNCH SECTIONS

Sections of the clays of the Willowbunch member south of the town of Willowbunch were described in a recent report.[1] These clays are also exposed to the southeast of Willowbunch in a long tributary coulée west of Bonneau lake. In NE. ¼ sec. 4, tp. 5, range 27, W. 2nd mer., high on the coulée side, is the following section of the Willowbunch member:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
1	0	W1324	Grey and yellowish, sandy clay......	23·3	s.p.	14
3	8	W1323	Dark, brownish grey clay............	30·0	p, G, T	30
1	9	W1322	Pale grey to white, mottled, sandy clay..............................	24·3	p	28+
1	0	W1321Sd	Light grey clay, yellowish at top....	32·6	v.p.	23
0	6	....	Brown, carbonaceous shale, coaly streaks..........................	....	....	....
3	6	W1320	Light grey, sandy clay..............	21·0	short	23
0	9	....	Fine, banded silt, some grey shale..	....	....	....
0	8	W1319	Light brownish grey clay............	30·6	v.p.	14
0	9	....	Coal and brown, carbonaceous shale	....	....	....
1	0	W1318	Light brown clay...................	30·0	v.p.	14

W1323 is a high-grade refractory clay.

[1]McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1929, pt. B, p. 61.

In the same valley, to the southeast of the above, in SW. ¼ sec. 3, tp. 5, range 27, W. 2nd mer., and about 120 feet stratigraphically below the Willowbunch member, is a zone which contains some very low-grade, semi-refractory clay:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
......	......	....	Lignite and lignitic shale...........	....	....	....
0	8	W1330	Brownish grey, mottled clay........	33·0	v.p., S	15
0	2	....	Lignite, etc.........................	....	....	....
4	5	W1329	Dark grey clay......................	34·0	v.p.	9
0	9	W1328	Dark grey to black clay............	35·6	p, T	11
0	10	W1327	Grey clay...........................	31·6	v.p., T	13
0	6	W1326	Light brownish grey clay...........	24·0	p	13
1	1	W1325	Grey, somewhat mottled clay.......	30·0	v.p.	12
1	0	....	Lignite..............................	....	....	....
......	......	....	Brown shale.........................	....	....	....

A good section of the Willowbunch member is exposed a little below the level of the high upland on the south side of Twelvemile Lake valley, south of Harptree, just west of the road to Coronach and in about NE. ¼ sec. 33, tp. 3, range 26, W. 2nd mer.

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
			Top section			
3	6	W1257	Grey and yellowish grey, silty clay..	22·6	p	20+
2	10	W1256	Pale grey to white, sandy clay.......	25·0	p	27
3	0	W1255	Dirty grey clay.....................	27·0	p	23
1	8	W1254	Pale purplish and yellowish clay.....	28·0	v.p.	28+
5	1	W1253	Light grey, yellowish in places, clay	29·0	v.p.	23
1	11	W1252	Pale greenish grey clay.............	29·0	v.p.	23
0	4	W1251	Grey clay...........................	32·1	v.p.	29
1	2	W1250	Dirty white clay, some fine iron spherules..........................	27·0	p	18
0	2	....	Purplish brown, silty clay..........	....	....	....
2	8	W1249	Light grey to white, sandy clay as below, but yellow.................	21·6	s.p	26—
0	4					
1	0	W1248	Light grey and green, film-banded clay..............................	31·6	p	16
0	10	W1247	Dirty mauve-grey clay..............	32·6	v.p.	15
0	4	....	Dark grey silt, light silt bands.......	....	....	....
0	6	W1246	Light grey, silty clay...............	25·4	s.p	19
1	1	W1245	v.f. banded, bluish grey and light grey clay..........................	27·6	p	18
2	4	W1244	Light yellowish grey, sandy clay....	22·6	s.p.	23

W1251-W1257 might serve as low heat duty refractory clays.

The Willowbunch member was also sampled in NE. ¼ sec. 5, tp. 4, range 26, W. 2nd mer.

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
3	6	W1317	Very calcareous, light yellowish green clay............................	30·3	p	2
4	0	W1316	Light purplish grey, silty clay......	24·0	p	23
5	4	W1315	Grey and yellowish grey, sandy clay	20·0	s.p.	23
7	9	W1314	Pale purplish grey, sandy clay.......	19·0	short	23

At this locality the Willowbunch clays are rather poor, and they are very variable in this vicinity. About 40 feet over the Willowbunch member at this place is a zone containing some semi-refractory clay and low-grade refractory clay:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
1	7	W1311	Brownish to purplish clay...........	20·3	p	16
1	11	W1310	Dark grey and brown, carbonaceous silt..............................	26·6	p, T, G	26
0	10	W1308Sd	Grey and dark grey, mottled silt....	29·0	v.p.	15

W1310 is a low-grade refractory clay.

In this area south of Harptree the Willowbunch member was also sampled in NW. ¼ sec. 5, tp. 4, range 26, W. 2nd mer.:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
			Top section			
2	10	W1262	Pale mauve-grey clay................	24·0	v.p.	27+
2	0	W1261	Grey clay..........................	28·6	v.p.	26
2	10	W1260	Grey, partly mottled clay...........	23·3	p	19
3	7	W1259	Light purplish and yellowish grey, silty clay.........................	21·6	p	23
2	9	W1258	Light brownish grey clay............	28·6	v.p.	28
1	0	W1263	Brown, hard, silty clay..............	23·3	s.p.	20

Omitting W1260 and W1263, this section contains low-grade refractory clay.

Refractory and semi-refractory clays also occur in the vicinity of Buffalo gap. They appear to be at the horizon of the Willowbunch member. Outcrops are few, however, and the exact stratigraphic position is difficult to determine. On the east side of the road through the gap and in about the southern part of sec. 11, tp. 3, range 25, W. 2nd mer., under burnt shale, is some grey shale from which a sample was taken:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
......	......	W1443Sd	Light grey clay......................	24·6	p	28+

This is a prospect for low-grade refractory clay.

About 3½ miles northwest of Buffalo gap, near the end of a northward extending spur, and in about sec. 17, tp. 3, range 25, W. 2nd mer., are fine sandstones, shales, etc., weathering pale yellowish, etc. High in the exposed section are the following beds:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
......	......	....	Light greenish, silty clay...........	....	....	....
1	0	W1182Sd	Purplish clay.......................	35·9	v.p.	33+

The above sample was taken from only about one foot of section, but the results are enough to show that refractory clay of very high grade does, locally, occur in the Willowbunch or near zones and that this is a prospect that invites further examination.

On the south side of Big Muddy valley, east of the Bengough (34) highway, and in sec. 13, tp. 3, range 24, W. 2nd mer., the following section was studied:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
3	0	W1442	Pale grey to white, silty clay........	28·0	v.p.	20+
4	0	W1441	Light grey, silty clay................	30·0	v.p.	26
4	7	W1440	Light grey to white, sandy clay.....	24·3	f.p.	26
1	0	....	Ferruginous, sandy clay.............	....	....	....
3	5	W1439	Hard grey clay......................	32·6	p	9

W1441 and W1440 are low-grade refractory clays.

A section of the Willowbunch member in Big Muddy valley south of the lake was described in a recent report.[1]

[1]McLearn, F. H.: Geol. Surv., Canada, Sum. Rept. 1929, pt. B, p. 61.

Near the International Boundary and in sec. 2, tp. 1, range 24, W. 2nd mer., about 10 to 15 feet of whitish silt is exposed that may be of the Willowbunch member. A sample was taken from near the middle of the section:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
1	0	W1145Sd	White, silty clay....................	26·1	p	18

This, of course, is a poor clay.

North of Rockglen, in about the centre of sec. 11, tp. 3, range 30, W. 2nd mer., at the top of a cone-shaped hill, is a section of what is probably the Willowbunch member:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
0	2	W1425	Brownish grey silt..................	24·0	v. short	30+
0	2	....	White silt..........................	....	....	....
2	5	W1424	Light brown clay and silt............	25·0	p	23
2	5	W1423	Light brownish grey clay and sandy clay..............................	21·5	p	20
3	6	W1422	Pale green, silty clay................	27·5	p	23

Near the above and at the same horizon, in about NW. ¼ sec. 11, tp. 3, range 30, W. 2nd mer., is the following section:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
0	5	W1421	Brown clay..........................	43·0	v.p., S	11
0	2	....	Green shale.........................	....	....	....
0	5	....	Yellow, concretionary sandstone....	....	....	....
0	6	W1420	Grey clay...........................	32·5	v.p.	15
2	8	W1419	Light grey, almost white, clay.......	29·0	p	15

W1421 cracks on drying. The Willowbunch carries poor clay at this locality.

Better refractory clay occurs at a lower horizon, i.e., about 80 or 100 feet below the above described and apparent Willowbunch zone. This lower zone was sampled in SW. ¼ sec. 11, tp. 3, range 30, W. 2nd mer.:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
1	0	W1434	Purplish brown clay..................	29·0	p, T, St	29
2	0	W1433	Grey and brownish clay.............	26·0	p	15

What is probably the same lower zone occurs southwest of Rockglen, in about SW. ¼ sec. 33, tp. 2, range 30, W. 2nd mer.:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
1	2	W1382	Dolomitic, grey, irregularly banded clay	34·6	v.p.	3
0	½	....	Lignitic layer	....	....	....
0	4	W1381	Brownish clay, pea-like white lenses	29·3	p	32
0	½	....	Lignitic layer	....	....	....
0	7	W1380	Brown clay	29·6	p	30
1	2	W1379	Mottled brown and grey clay	27·3	p	20

The clay of W1381 is very high-grade refractory. That of W1380 is high-grade refractory.

The higher and probable Willowbunch zone was sampled at the east end of a high ridge in the southern part of sec. 26, tp. 2, range 30, W. 2nd mer.:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
......	......	....	Yellow weathering silt	....	....	....
2	1	W1416	Dark grey clay	42·6	v.p.,T,S	28
1	5	W1415	Mixed dark grey clay and fine sand	19·0	s.p.	23
1	0[1]	W1414	Dark grey, sandy clay	24·0	p	23
1	0[1]	W1413	Dirty light grey, sandy clay	23·3	s.p.	23
1	5[1]	W1412	Whitish, sandy clay	24·0	s.p.	23
2	0	W1411	Pale green clay	31·0	v.p.	14

[1]Approximate.

W1416 cracks in drying.

A good section of the Ravenscrag is exposed on the east side of Rockglen valley, in SW. ¼ sec. 29, tp. 2, range 29, W. 2nd mer. At the top is what possibly may be the Willowbunch zone:

Thickness		Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
Ft.	Ins.					
2	0	W1409	Dark grey to chocolate clay	26·6	p	15
1	10	W1408	Pale greenish grey clay	28·0	p	17
3	0	W1407	Pale green to white clay	29·0	p	15

About 10 feet below the above is the following section:

Thickness Ft.	Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
0	2	W1405	Whitish, silty clay	20·0	p	13
0	7	W1404	Mottled, dark grey and whitish clay	27·3	p	15
2	0	W1403	Mottled, dark grey, silty clay	30·0	v.p.	14
1	0	....	Fine, yellowish grey silt	....	....	....
1	0	W1402	Yellowish green, sandy clay	22·2	v. short	14

About 25 feet below the above is the following section:

Thickness Ft.	Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
4	4	W1399	Dark grey, calcareous clay	37·6	v.p.	9
1	1	W1397	Greenish grey clay	34·0	v.p.	14
1	0	W1398	Grey clay	34·4	p	3

About 100 feet below the above is the following section:

Thickness Ft.	Ins.	Sample No.	Colour, grade	Tempering water, per cent	Working properties	P.c.e.
.....	.....	....	Coaly streak	....	....	....
1	0	W1410	Dark brown, carbonaceous clay	27·3	p	14

GROUND WATER RESOURCES OF MOOSE JAW, SASKATCHEWAN

By W. A. Johnston and R. T. D. Wickenden

CONTENTS

Illustrations

INTRODUCTION

An investigation of the ground water resources of Moose Jaw area was made in the summer of 1930, with a view to determining what new sources of water supply for the city could be made available. In 1929 new developments in connexion with water supply were undertaken, as it was realized that, on account of the exceptionally dry year and the increased demand for water for industrial and other purposes, there was likely to be a shortage of water. A large gravel-walled well was put down at Sandy creek, one of the existing sources of water about 20 miles west of the city, and for a time it was thought that the well would yield nearly a million gallons a day and that an adequate supply at least for the immediate future had been obtained. But after prolonged tests the yield was found to be only about 450,000 gallons a day, and this additional supply, together with the supplies available from other sources, was scarcely sufficient to satisfy the present needs.

An area of about 2,500 square miles, extending in a belt 10 to 50 miles wide southeast through Moose Jaw and Regina nearly to Weyburn, is a clay plain in which supplies of ground water are limited and in places are lacking. The area is a very important one agriculturally and devoted almost exclusively to grain growing, so that the water supply problem has not been very acute, but if the farmers are forced by soil drifting and by other factors to undertake mixed farming the water supply problem will be a very important one. Diversion of water from South Saskatchewan river to supply the needs of towns and villages in the clay plain as well as the cities of Regina and Moose Jaw was long ago proposed, and was shown by elaborate surveys and investigations to be a feasible but costly scheme. The work, however, may not be undertaken for some time, partly because of the large expenditure involved, several million dollars, and partly because there is sufficient water in the vicinity of Regina to supply the city for a number of years, even allowing for a growth of the city equal to that of the past few years. The water resources of the clay plain were investigated to some extent as well as those in the vicinity of Moose Jaw.

It was found that these were limited in general, but that there is a large artesian water area lying between Moose Jaw and South Saskatchewan river. This area, described in a later part of the report, may prove to be of importance as a future source of supply not only for Moose Jaw but for the clay plain in general, as the water, although not of very good quality, can be used when mixed with a proportion of hard water and can be obtained at much less cost than that from South Saskatchewan river.

Acknowledgments are made to Mr. H. C. Ritchie, City Engineer, for co-operation in the present investigation, to Mr. L. McManamna, of the Layne Canadian Water Supply Company, Limited, for information regarding test drillings, to Mr. D. M. McNeely, Moose Jaw, and to Mr. Chris Olemen, Riverhurst, for information regarding deep wells drilled by them in the Mawer area.

GENERAL CHARACTER OF THE DISTRICT

TOPOGRAPHY AND DRAINAGE

Moose Jaw is located (*See* Figure 4) at the junction of Moosejaw creek, flowing northwest in a valley that is nearly 100 feet deep in its lower part and is narrow and steepsided, but has a flat bottom, and Thunder creek, flowing east in a wider valley that is flat bottomed in places and has gently sloping sides. Moosejaw creek is the larger, though its bed, as well as that of Thunder creek, is nearly dry in summer. Below the city it flows in the main valley northeast for 20 miles to Qu'Appelle river, draining east into the Assiniboine. Thunder Creek valley extends west and northwest for many miles into the hilly upland country near Riverhurst, on South Saskatchewan river, and is a broad, deep valley which, however, is nearly dry. The area north of Thunder Creek valley and lying between it and Qu'Appelle valley is an undulating plain, the highest part of which is near Qu'Appelle valley and is about 100 feet above Thunder Creek valley. There is very little drainage from this area into Thunder Creek valley; most of the surface drainage is impounded by dams in the tributary valleys. The area south of Thunder creek is a gently sloping plain interrupted in places by low hills and ridges and extending for 15 to 20 miles to the abrupt rise known as the Missouri escarpment near Buttress, south of Moose Jaw and extending northwest to near Riverhurst. There is a rise of about 500 feet within 2 or 3 miles in places, and a more gradual slope in other places, to an upland that has many irregular hills and undrained hollows and slopes towards the southwest to the broad, shallow basins occupied by lakes Johnstone and Chaplin. These lakes, as well as much of the upland region, have no drainage to the sea. There are, however, broad valleys, of which Sandy creek, draining into Thunder creek, is the most important in the Moose Jaw region, which extend far back into the upland and receive part of their water supply from it. Other valleys, which drain into Thunder creek from the south, but do not enter the upland, are Forsythe creek, about 4 miles east of Sandy creek, and Snowdy Springs creek, entering about 4 miles west of Moose Jaw.

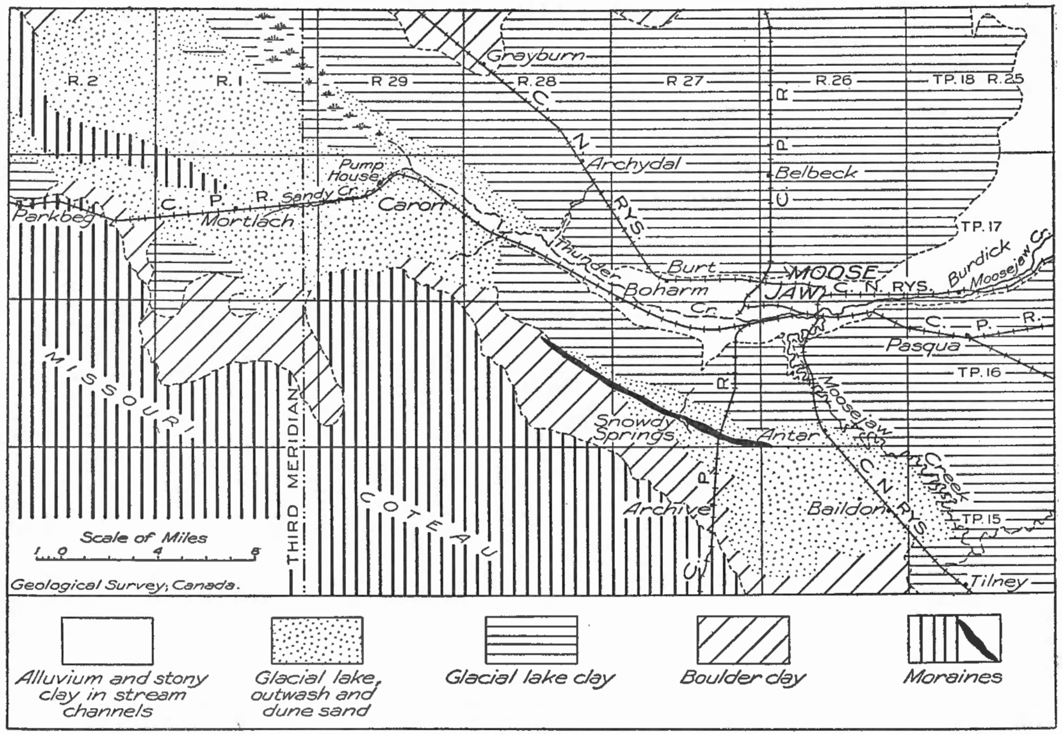

Figure 4. Surface deposits of Moose Jaw area, Saskatchewan.

PRECIPITATION

One of the chief conditions affecting ground water supply in Moose Jaw area is the comparatively small amount of the annual precipitation. The annual precipitation according to records of the Meteorological Service of Canada is shown in Table I.

TABLE I

Precipitation, Moose Jaw, Saskatchewan

Year	Rainfall	Snowfall	Total precipitation
			Inches
1910	10·16	24·3	12·59
1911	12·57	36·8	16·25
1912	12·61	14·2	14·03
1913	12·77	21·7	14·94
1914	....	....	14·55
1915	11·33	23·7	13·70
1916	10·84	56·9	16·53
1917	8·80	59·0	14·70
1918	8·51	56·5	14·60
1919	9·52	48·9	14·41
1920	12·74	49·1	17·65
1921	17·52	32·9	19·81
1922	11·95	45·9	16·54
1923	13·94	30·1	16·95
1924	9·26	36·0	12·86
1925	13·26	32·5	16·51
1926	11·41	40·3	15·44
1927	11·16	37·2	14·88
1928	10·00	21·7	12·70
1929	4·95	51·5	10·10
Means	11·22	37·87	15·0

The precipitation in 1929 was the smallest since 1908. It was somewhat greater in 1930 up to the end of October than in 1929, but was considerably below the normal. The precipitation at Sandy creek was practically the same as that of Moose Jaw, although the amount each month differed considerably at the two places. The mean annual precipitation is practically the same at Moose Jaw as at Regina, although it differs considerably in some years. It decreases somewhat towards the south and southwest, but that of Moose Jaw probably is nearly the average for the area extending west and southwest of the city to Missouri coteau. Table I shows that during the past 20 years only in 1929 did the precipitation fall below 12 inches. In the 20-year period previous to 1910, judging by partial records at Moose Jaw and at Regina, the average was 1 or 2 inches less than during the past 20 years, and was below 12 inches in several years. There were three consecutive dry years, 1892-3-4, and in 1897 and 1908 the precipitation was less than in 1929. The recurrence of exceptionally dry years at irregular intervals, and especially two or even three dry years in succession, is of particular importance in the case of the Moose Jaw water supply, as the water is derived mainly from surface sands, which are affected by drought to a much greater extent than a deeply buried reservoir; in times of drought much of the water in the sandy beds near the surface is lost by operation, whereas in deeply buried, water-bearing beds this is not the case. It is necessary, therefore, to provide for a supply that will be adequate, not only in normal years but during periods of low rainfall which may last from 1 to 3 years.

GENERAL GEOLOGY

The surface deposits of the area are the unconsolidated, chiefly glacial, deposits, which overlie the older consolidated or partly hardened bedrocks. They consist of wind-blown sand, alluvial sand, and clay deposited on the flood-plains of the present streams, stratified clay and sand deposited in ancient glacial lakes, and stony clay and sand deposited by the ancient glaciers, partly in the form of moraines and partly as outwash and boulder clay plains.

Wind blown sand, in the form of old dunes that have begun to drift somewhat in recent years, occurs in Sandy Creek area and south of Moose Jaw. Much of the alluvium in Thunder Creek valley above Moose Jaw is a heavy clay that is nearly impervious to water, so that the valley bottom does not form a good reservoir for ground water; the water brought into the valley by tributary streams appears to disappear largely by evaporation.

Stratified lake clay and sand deposited in an ancient lake, known as glacial Lake Regina,[1] formed as a result of damming of South Saskatchewan river by the retreating ice-sheet, occur in Moose Jaw district in places up to an elevation of about 1,950 feet above sea-level, and to a somewhat higher level near Mortlach and Parkbeg west of Moose Jaw, where an earlier glacial lake existed at a higher level. The sands occur in the higher parts near the shores of the ancient lake basin, as at Sandy Creek and south of Moose Jaw; much of the wind-blown sand has been formed from the lake sand. The clay occupies a large part of the area north of Thunder Creek valley, has been eroded away in the valley itself, and forms a belt a few miles wide along the south side of the valley. The sands readily absorb the rainfall and, therefore, form good sources of ground water, whereas the clay because of its extremely heavy character is nearly impervious to water. The distribution of the lake sands in the vicinity of Moose Jaw is shown on Figure 4.

Outwash sands and gravels occur in the area northwest of Mortlach and are favourable for the accumulation of ground water, but are not very extensive and are underlain at shallow depths by clay.

A narrow, morainic ridge, composed in part of sand and gravel, occurs at Snowdy springs and extends northwest nearly to Sandy creek and southwest nearly to Moosejaw creek. It forms a sort of natural dam of the drainage of the sandy area to the southeast, so that most of the water from this area passes through Snowdy Springs valley, the only opening through the ridge. A great, broad, morainic belt occurs along the Missouri coteau or upland, but there is very little drainage from this moraine towards Moose Jaw and much of the water stored in the moraine has no free drainage and is saline.

[1]Trans. Roy. Soc., Canada, sec. IV, 1930, pp. 41-49.

Boulder clay plains—much of the boulder clay contains few boulders, but is unstratified and usually contains at least a few small stones—extend over parts of the area north and south of Thunder Creek valley. Areas along Thunder Creek valley, particularly below Moose Jaw, are very bouldery. The boulders were derived from the drift and were concentrated in ancient stream channels.

The boulder clay plains are not very favourable for the storage of ground water as the material is not very permeable and the water usually is hard and saline, at least to some extent, except in places where sand and gravel deposits are included in the clay, and these deposits as a rule are not very large.

The thickness of the glacial drift varies greatly from place to place and there is no way of predicting what the thickness is at any locality, as the contours of the underlying bedrock differ greatly from those on the surface. The thickness in Thunder Creek valley at Moose Jaw is only 15 to 30 feet, at Sandy creek it may be about 80 feet, and at a few places is upwards of 300 feet.

The bedrock underlying the surface deposits in the vicinity of Moose Jaw is the Pierre (Bearpaw) shale of Upper Cretaceous age. As the shale is of considerable thickness and does not contain potable water in this region it is important in drilling to distinguish between it and the glacial drift. But this is not always easy, for much of the drift is derived from the shale and in places is nearly similar to the weathered upper part of the shale. It can be distinguished as a rule by the presence in it of pebbles and stones of limestone and granitic rocks that are foreign to the district and were transported by the ice-sheets for long distances from the northeast.

DESCRIPTION OF AREAS FROM WHICH WATER IS OBTAINED

The present water supply is derived from four sources: Snowdy springs, 7½ miles southwest of the city; from a well and collecting gallery at Sandy creek, 20 miles west of the city; from a collecting gallery in Thunder Creek valley, just west of the city; and from a well on Forsythe creek, 2 miles south of Caron. The last source was developed during the present investigations and has yielded an additional supply of about 300,000 gallons a day.

Snowdy springs are on the southeast quarter of sec. 9, tp. 16, range 27. The springs are seepages from sand and gravel overlain by clay and extend for about 200 feet along the south side of a pond formed by a concrete dam placed across the outlet of the depression in which the springs occur. The spring pond is on the south side of a valley about 50 feet deep, draining a sandy area lying to the southeast. The valley is cut through a drift ridge below the spring pond and is dammed to form a large reservoir which, when full, is at the same level as the spring pond and adjoins it. The large reservoir becomes filled in the spring from melting snow and from the flow of the creek, which is fed in part from springs higher up the valley. In the latter part of the summer and in autumn there is practically no flow of the creek into the large pond or overflow from the small pond, so that the water in the reservoir becomes stagnant and unfit for use except after filtering and even then has an objectional odour, especially at times when a considerable part of the water has been drawn off. There are small "secondary" springs in the valley bottom about 1,000 feet below the main dam. This water probably is seepage water coming from the sides of the valley or from higher up in the valley and may be affected by back wash from the filters. The springs in the small pond are the main source of supply, and derive their water from the sandy area lying to the southeast. This is shown by the fact that the water is not highly mineralized. The water found in the clay areas to the south is very hard and saline in places and it is evident that the spring water if it were derived from the hilly region to the south and southwest would likewise be saline. The sandy area supplying the springs consists in part of dune sand in irregular hills and in part of lake sand and silt. The extent of the sandy area drained by Snowdy Springs Creek valley is about 25 square miles. Though the area is not large it is favourable for the absorption of rain water, so that the springs are permanent. Furthermore, the morainic ridge crossing Snowdy Springs creek below the springs acts as a dam preventing escape of the underground water except at the springs.

Sandy creek joins Thunder Creek valley about 2 miles northwest of Caron and drains a large area to the southwest. The creek valley in its lower part passes through a sandy area which extends west nearly to Mortlach and from 2 to 4 miles northwest and southeast of the valley. The greater part of the area is underlain at the surface by old sand dunes; a part is lake sand. In the valley of the creek itself there is alluvial and lake sand interbedded with thin layers of silt and clay. The clay layers are nearly impervious and tend to prevent absorption of the surface water that accumulates in the spring, so that a part of this water is lost by runoff and by evaporation. Some water seeps into the valley from the sides, but the main flow of the creek, except during freshets and in wet years, comes from springs on the south side of the valley bottom 2 to 3 miles east of Mortlach. The springs occur in the northwest quarter of sec. 19, tp. 17, range 29, and in the north half of the adjoining section to the west. The water comes from sand and fine gravel which may overlie clay at a shallow depth. The creek above the springs has a very large drainage area extending west into the Coteau hilly country. During freshets considerable water may be derived from the upper part of the basin, but in dry years the creek bed above the springs contains little or no water. The springs, however, may be supplied by underground water coming from the southwest part of the basin and, therefore, may be permanent. The flow of the springs increases somewhat in the autumn but is said to be fairly uniform throughout the year, though the flow is much less in dry years than in wet years, apparently because the water comes mainly from the surface sand and not from any deep artesian basin.

Trouble has been experienced in the collecting gallery at Sandy creek by plugging of the holes with small stones, and with caving. The section at the lower end was relaid in 1930 and crushed stone placed on the outer side, apparently with better results. The ground, however, in which the pipe is laid consists of fine sand and there are thin clay layers interbedded with the sand, so that the water does not readily drain into the gallery from the sides. Though the pipe extends upstream for about half a mile to where it receives the main flow of the creek, the water obtained by pumping in exceptionally dry periods is little greater than the flow of the creek as determined by weir measurements about 1 mile upstream. The sandy deposits near the lower end of the gallery have a thickness of 25 feet to 40 feet, as shown by test borings, and the material is reported to be somewhat coarser in the lowest 2 to 3 feet.

The new gravel-walled well at Sandy creek is 80 feet deep and derives its water from sand and gravel at depths of 51 to 79 feet. A layer of clay, probably boulder clay, separates the lower sand from the surface sand and clay. The water is artesian, but is lowered about 57 feet by pumping and recovery amounts to only about 1 inch a day. In 1912 two test wells had been put down, one near the site of the present No. 1 well and the other 300 feet downstream. These wells had a small flow and suggested that artesian conditions existed. The log of the new well from the surface down showed: sand and silt with layers of clay 25 feet, clay 11 feet, dirty sand 2 feet, clay 13 feet, sand 5 feet, clay and boulders 6 feet, sand and gravel 17 feet, and clay 1 foot. The marked draw down of water in the well when pumped, and slow recovery, show that there is no very large supply of water in the gravel buried beneath clay; probably the surface water does not readily find access to the gravel because of the wide extent of the overlying clay. Two other gravel-walled wells, one a mile upstream and the other 700 feet downstream from the pump house, were put down to the same sand and gravel beds and also showed a marked draw down of the water. The one well probably obtains all the water that can be drawn from these beds without exhausting the supply. The drawing of water from the gravel beds beneath the clay does not appear to affect the supply obtained from the flow of the creek, as this supply comes from springs issuing from the sand and gravel above the clay. A number of test borings in Sandy Creek valley both above and below No. 1 well were made by the Layne Canadian Water Supply Company, and the possibilities of lower, water-bearing beds appear to have been thoroughly tested.

Forsythe creek flows into Thunder Creek valley from the southwest about 2½ miles east of Caron and is a spring creek deriving its water locally from sandy beds overlying clay. The creek is only about 5 miles long and in dry seasons the upper 2 or 3 miles where the valley is shallow contain no water except in ponds formed by dams across the valley. The springs, which are merely seepages from the sand, are in the lower part where the valley is about 40 feet deep. Test borings by the Layne Canadian Water Supply Company showed that the depth of the sand in the valley bottom in the southeast quarter of sec. 13, tp. 17, range 29, is 30 to 55 feet and that the depth decreases down stream to about 12 feet ¼ mile to the east. The new well was placed at a point where the sand was deepest near the line between sections 12 and 13 and about 500 feet west of the east line of the sections. The spring water is derived from the sandy beds through which the creek flows and as these are only a few square miles in extent it is not to be expected that a supply greatly in excess of the flow of the creek, about 150,000 gallons a day, can be obtained from one or more wells. The springs, however, flowed at about this rate in August, 1930, after two exceptionally dry summers, and it is probable that the flow in wet years will be considerably increased.

Britannia Park collecting gallery is excavated in alluvial sand, gravel, and clay down to the shale or bedrock. A large well about 15 feet in diameter was also put down nearly to the bedrock in the valley flat beyond the southern end of the gallery, but yielded only about 13,000 gallons a day. The gallery extends only a part of the distance across the flat, but the small yield from the large well indicates that production would not be greatly increased by extension of the gallery. Moreover, the character of the water renders it less desirable than that from other sources.

MINERAL CHARACTER OF THE WATER

The mineral character of the water from the various sources is shown in the following table. The analyses were made at the Provincial Laboratories, Regina, for the city of Moose Jaw. The results are shown in parts per million.

Water Analyses

—	Forsythe Creek well	Snowdy springs	Sandy Creek gallery	No. 1 well, Sandy creek	Britannia Park gallery
Total solids	586	729	494	1,218	1,814
Solids in solution	....	686	486	1,218	1,674
Solids in suspension	....	43	8	nil	141
Ignited residue	....	640	440	1,106	1,514
Organic and volatile matter	....	46	46	112	160
Chlorides	....	39	19	79	18
Sulphates	....	160	94	363	814
Carbonates	....	197	171	282	189
Calcium	....	66	110	50	224
Magnesium	....	42	28	19	82
Sodium	....	98	9	348	134
Iron	....	0·4	0·3	nil	7
Total hardness	....	316	350	189	860

The city tap water is a mixture of these waters in various proportions, depending upon the amounts available from each source at different periods. In winter when the storage water from the large pond at Snowdy springs has been used the main supply is from Sandy creek. This water is comparatively soft and of good quality. The Britannia Park water is much harder than any of the other waters, it contains some iron, and there is some danger of pollution of the water because of nearness to the city and the sluggish character of the drainage in the valley. The analysis of the Forsythe Creek well showed that the total solids in the water are 41·0 grains a gallon, made up of the following constituents in the order of comparative quantity: calcium sulphate, magnesium sulphate, calcium carbonate, and calcium chloride. The water from No. 1 well at Sandy creek differs somewhat from the water derived from the surface sand. It contains a much higher proportion of sodium sulphate and sodium carbonate, but is a softer and, therefore, a more desirable water.

WATER REQUIREMENTS

The population of Moose Jaw is about 21,000. There are very few private water wells in the city, there is a large industrial consumption of water amounting to about one-third of the total, and in dry years such as

1929 and 1930 only a small supply of water from rainfall is caught in cisterns. Based on an allowance of 75 gallons a person a day, the average daily requirement should be about 1,575,000 gallons a day. Because of the importance of abundant water for industries and of the shortage of water from sources other than the city water supply, it is probable that 2,000,000 gallons of good water could be used to advantage, and, allowing for normal growth of the city, the amount should be increased to 3,000,000 within a few years.

The average daily consumption of water in 1929 was about 1,000,000 gallons and was somewhat greater in 1930. The average consumption was small partly because of shortage of water. The shortage of water in spite of the new source developed at Sandy creek was due to the exceptionally dry season; in a normal year there would have been an abundant supply of water. As it is necessary to provide for an ample water supply in dry years as well as in normal years, the amounts of water that can be obtained in dry years need only be considered. The yield of the present sources with the addition of the supply from the Forsythe well is approximately 1,300,000 gallons a day, of which nearly one-half is obtained from Sandy creek.

OTHER POSSIBLE SOURCES OF WATER SUPPLY

Surface Water Supplies

Moosejaw creek has a very large drainage area, but is dry in summer except in the lower part for 3 or 4 miles up from the junction with Thunder creek where one or more springs furnish a small flow. There had been no overflow of the dam at Moose Jaw, however, for two years previous to August, 1930. The dam is below the junction of Moosejaw and Thunder creeks. It is obvious, therefore, that water impounded by a dam higher up in the valley of Moosejaw creek would be stagnant and unfit for use as a city supply. There are other objections: the cost of the undertaking would be large and the Canadian Pacific railway have water rights on the creek.

Storage of surface water in Snowdy Springs valley is already developed to the capacity of the valley. The quality of the water, however, could be greatly improved by cleaning of the reservoir. Thunder Creek valley is wide and flat-bottomed; there is practically no surface water in the valley in dry seasons except in the marsh known as Goose lake in the part of the valley 4 miles northwest of Caron, and this water is saline and unfit for use. Flood water impounded in the valley by a dam or subsurface water held back by a pile dam across the valley would become saline in character, as the soil contains considerable amounts of salts.

The only other localities where important quantities of surface water can be impounded within reasonable distances of the pipe-line are on Forsythe creek and on Sandy creek above the present pumping station. The Forsythe Creek water supply is being developed from a well and it is doubtful whether the expense of damming the valley and impounding flood water, although the valley is narrow and deep in the lower part, would be justified owing to the small drainage area of the creek. Sandy creek has a large drainage area and flood water in spring passes down the valley, but there is a difficulty in holding the water by means of a dam much above the level of the existing pile dam, because of the presence of the railway that extends through the valley and is only slightly above the level of the valley flat. The flood water, at least in part, could be stored by excavating a basin in the surface sandy deposits and by putting down perforated casings screened at the top to carry the surface water down into the lower beds. The presence of thin clay layers in the upper part of the sandy beds prevents the flood water in spring from seeping downwards, so that it lies on the surface and is lost partly by run off and partly by evaporation.

Bedrock Waters

The deep well at the powerhouse, Moose Jaw, extended to a depth of 3,302 feet. No important flows of water were found until a depth of about 900 feet was reached. A flow of water amounting to about 4,000 gallons per hour was obtained at 980 feet, and somewhat larger flows at greater depths. The water flowing from the well in August, 1930, had a temperature of 60 degrees F. and probably comes from a depth of about 1,000 feet. The water from a depth of 2,950 feet is said to have had a temperature of 81 degrees F. According to an analysis of the well water made in 1928 by the Provincial Laboratories, Regina, for the city of Moose Jaw, the water contains 6,280 parts per million of soluble salts consisting chiefly of sodium chloride or common salt.

A well on the farm of Mr. Hans, 2 miles north of Caron, is reported to be 735 feet deep and to be mostly in the bedrock. Water was struck at 316 feet, but the supply proved insufficient. Deepening of the well provided a good supply, but the water is salty as was also that at 316 feet. Another well in Thunder Creek valley about 4 miles east of Caron is said to have been sunk to a depth of 500 feet without finding potable water. A well in Sandy Creek valley on the north bank of the creek about three-fifths of a mile above the pump house is said to be 400 feet deep. The casing of this well appears to be in good condition but is open to a depth of only 20 feet, a plug apparently having been inserted. The results of the drilling are not known. In the areas north and south of Thunder Creek valley a number of wells have been drilled in the bedrock to shallower depths, and in places have obtained small supplies of potable water, which, however, is fairly high in soluble salts. A number of test wells in Thunder Créek valley in the vicinity of Moose Jaw were put down by the Layne Canadian Water Supply Company without finding potable water. One of the wells was 200 feet deep and was in the bedrock except for the upper few feet. Some of the wells in the lower part of Moose Jaw valley above the city appear to be partly in the bedrock and the water is of poor quality.

It is improbable, therefore, that potable water can be obtained by drilling in the bedrock in Thunder Creek valley or in adjacent areas. Large supplies of water, however, can be obtained in wells drilled into the bedrock in the Darmody area northwest of Moose Jaw. This possible source of water is described in a later part of this report.

Waters from the Glacial Drift

The present water supplies are derived from sandy areas forming part of the glacial drift or unconsolidated deposits overlying the bedrock. There are sandy and gravelly areas and numerous springs in the hilly

Coteau country to the southwest of Moose Jaw, but these areas are small and so far as known there is no large supply of water at any one locality. There are no large streams coming from the Coteau; the bedrock forms a considerable part of the upland and its surface slopes towards the southwest, so that there is very little underground drainage towards the northeast. There are very few springs along the northeast face of the Coteau. The water from many of the springs on the upland is potable, but nearly all of the numerous ponds and lakes are saline, as are also Johnstone and Chaplin lakes. It is improbable, therefore, that any large supplies of potable water can be derived from the Coteau region, although it is high above Moose Jaw so that water derived from that region would flow into the city under a good head.

Water can be obtained from the alluvial sand and gravel in the valley flat of Moosejaw creek below the city, but there would be danger of pollution of the water from sewage. The water is mainly the creek water draining down the valley underground and is filtered to some extent by passing through the sand and gravel deposits at the surface, which, however, are only a few feet thick, and can hardly be regarded as a safe water for use.

The only large, sandy areas favourable for the storage of ground water and within a reasonable distance of the city are those drained by Snowdy Springs, Sandy, and Forsythe creeks. Any new developments to augment the present water supply must be undertaken in these areas unless a distant source is sought. Moreover, the present sources are widely scattered, and, therefore, the cost of supplying water is high, so that any new source sought should be a permanent one and sufficient for many years. It does not appear that any very large additional supplies can be obtained from the present sources, though sufficient water probably can be obtained to meet the requirements for a few years, so as to give time for careful consideration of the most economical and satisfactory future source of supply.

Snowdy springs, as already stated, were developed to the limit of their capacity a number of years ago and independently of the storage water produced only about 150,000 gallons a day. In the winter of 1929-30 the production was about 100,000 gallons a day, the water having been drawn directly from the spring pond through a 6-inch pipe leading to the pumping station below the lower dam. It is probable that the flow of the springs might be increased somewhat by excavating part of the face of the bank along which the springs occur and thereby removing the clay that has slidden down over the sand and gravel from which the spring water issues. Lowering of the water in the spring pond by pumping might also increase the flow by increasing the head. A larger yield probably could be obtained by pumping from a gravel-walled well at the spring. As the springs are fed by water coming from the sandy area to the southeast it is probable that pumping from wells in the sandy area would rob the springs and not greatly increase the total yield. Test borings in the valley bottom below the lower dam were made in 1930 by the Layne Canadian Water Supply Company and showed that there is only a foot or so of gravel at the surface and no water in the clay below.

Sandy creek is the largest spring creek in the region and is the most important source of water supply. More water than is made available by the collecting gallery and by the new well can be obtained from the surface sand either by deepening the gallery or by a gravel-walled well near the lower end of the gallery. Probably the latter would be preferable as it would be difficult to deepen the gallery on account of the wet, caving nature of the sand. It would be advisable to put down a new well in the surface sand rather than to replace with screen the blank casing in the upper part of No. 1 well, as the depth of the surface sand in this well is only about 25 feet, whereas the depth in the central part of the valley near the lower end of the gallery is reported to be about 40 feet. Test borings should be made at the springs in the upper part of the valley, on the northwest quarter of sec. 19, tp. 17, range 29, near the highway where it turns north, and possibly on the adjoining section to the west, and pumping tests made in order to determine whether any large flow of water can be obtained. It is possible that the spring water comes from the sand and gravel above the clay and that there is no very large supply, but the water is of good quality and the area, because of its sandy character and the large extent of the drainage basin, is the most favourable one found anywhere in the district. The water obtained from one or more gravel-walled wells at the springs could be pumped into the creek supplying the collecting gallery or piped down stream to the upper end of the gallery. It is impossible to determine how much additional water can be obtained from the suggested shallow wells near the lower end of the gallery and at the springs but, judging by the fact that the springs continued to flow and spring ponds existed in the valley bottom after two exceptionally dry summers, the supply may be fairly large.

Darmody-Mawer Artesian Area

There are a number of flowing wells in the area along the Canadian National railways from Darmody nearly to Central Butte and north to within about 3 miles of Bridgeford (*See* Figure 5). The wells are 400 to 450 feet deep and derive their water from sandy beds overlain by shale, which forms an impervious cover. The thickness of the drift overlying the shale is about 60 feet in places and somewhat more in other places. Wells sunk to the same horizon are also obtained in the area extending west to South Saskatchewan river and even beyond the river, but in most of these the water does not rise quite to the surface because of the higher altitudes. The water in the wells near Mawer has a temperature of 48 degrees F. and rises to about 1,987 feet above sea-level, but the height varies somewhat in different parts of the area. Several of the wells have been flowing for 10 to 15 years without any great diminution in flow. Most of them were put down with a jetting machine and have about 3-inch casings. As the material passed through is soft a well was put down ordinarily in 4 or 5 days. The Canadian National Railways well at Mawer, put down in 1913, is a 6-inch well and has a large flow which, however, is throttled down to a very small flow. The smaller wells have flows of 10 to 30 gallons a minute from a 1-inch pipe and there is no question that a very large supply exists. There is a "hardpan" layer a few inches to several feet thick at the top of sandy, water-bearing beds. The layer consists of concretionary iron pyrites and probably other salts and gives some trouble in drilling because of its hardness. The sand is fine; about 42 per cent of one sample passed a 40-mesh to the inch screen and is held on a 60-mesh screen, and the balance is finer. It is so loose that large quantities are brought out of the wells by the flow of the water. There is comparatively little trouble, however, from the sand choking the wells so long as the water is allowed to flow fairly freely.

An analysis of the water from the Canadian National Railways well at Mawer was made by Andrews and Cruickshank, Regina, and is as follows:

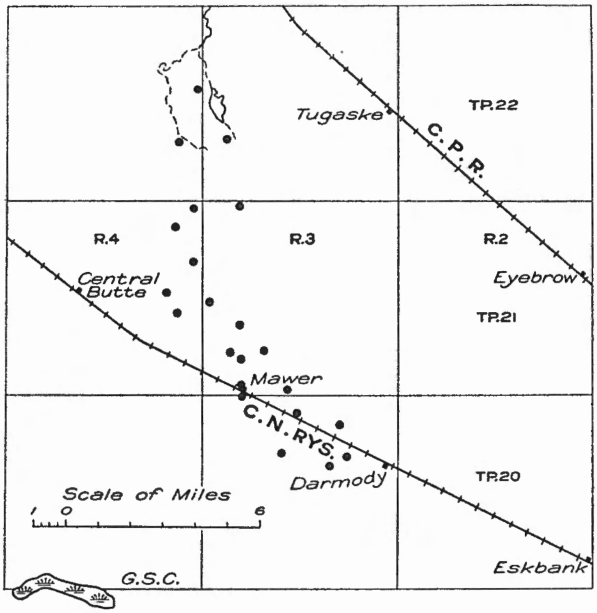

Figure 5. Location of flowing water wells in Darmody-Mawer area (west of 3rd meridian), Saskatchewan.

Analysis of Water from Mawer Well

(Results in parts per million)

Calcium bicarbonate (as carbonate)	35·00
Calcium sulphate	
Calcium chloride	
Magnesium bicarbonate (as carbonate)	10·00
Magnesium sulphate	
Magnesium chloride	
Sodium carbonate	498·00
Sodium sulphate	789·00
Sodium chloride	163·00
Silica	2·00
Iron and alumina	2·00
Total solids by calculation	1,499·00
Total solids by evaporation	1,560·00
Temporary hardness	5·00
Permanent hardness	Nil
Total hardness	5·00

The almost entire absence of hardening salts in the water is a remarkable feature, especially as most of the ground waters found in southern Saskatchewan are objectionable because of their hardness. The water comes from a sand that contains appreciable quantities of green sand, a water softening mineral, and, therefore, is naturally softened. Unfortunately the water contains a fairly large proportion of non-hardening salts, is corrosive to some extent, although it does not appear to greatly affect the casings in the old wells, many of which are in good condition, and is unsuitable for irrigation because of the presence of large amounts of sodium carbonate in the water. It has, however, been used for many years at Mawer as the town supply and at other places with no apparent bad effects. In some of the wells that have a smaller flow than the one at Mawer the amount of salts present appears to be less, but only one analysis is available. It is possible that the water could be used satisfactorily when mixed with a proportion of hard water, which would reduce the corrosiveness and remove the flat taste. If, for example, the water was mixed in equal proportions with the water from the Sandy Creek gallery the mineral character of the mixture would be practically the same as that of the water from the new well at Sandy creek, and this water is considered to be very good.

In order to determine whether the water is suitable as a city supply it would be advisable to have analyses made of the water from other wells in the vicinity of Darmody. The point nearest to the city at which the artesian water can be obtained is just west of Darmody, about 27 miles from the reservoir at the end of the pipe-line at Sandy creek in a direction measured along the railway and south to the reservoir. The most easterly well in which the artesian water has been obtained is about 1 mile west of Darmody, but the basin may extend a short distance east of this village. Numerous deep borings near Eskbank, the next town to the east on the railway, showed that the basin does not extend that far to the east, as only salt water was found. If the water is to be used, one or more test wells would have to be put down and a large well packed with gravel and screened in the lower part and a pump installed. A gravel-walled well and screen are necessary in order to avoid difficulties with sand coming into the well. The wells that are several feet down in the sand—which is said to be about 60 feet thick—and have a small flow of water with little or no sand, appear to produce better water than those that have a large flow of water from the upper part of the sand and from which large quantities of sand have issued. Pumping will be necessary, for, although the water in a large well probably will rise to the surface, if the well is placed at an elevation of about 1,970 feet above sea-level or lower, the fall to the reservoir at Sandy Creek from this elevation is only about 75 feet; if the pipe-line is placed along the railway there would be a slight rise at Lake Valley amounting to about 30 feet. There is no doubt that the supply would be permanent. The amount probably would be limited only by the capacity of the wells put down.

INTERGLACIAL DEPOSITS IN SOUTHERN SASKATCHEWAN

By R. T. D. Wickenden

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INTRODUCTION

The Pleistocene deposits in southern Saskatchewan in many places are exceptionally thick—the region was one of accumulation of drift rather than erosion—and, therefore, the occurrence of interglacial deposits, known in many other regions, is to be expected. The ice-sheet extended beyond the area and precipitation throughout Pleistocene time may have been small, as it is at present; erosion during interglacial times probably would be not very great and records of these times may have been preserved. Interglacial deposits have not previously been reported from the region, although parts of it have been examined by several geologists. Good sections of the drift are not numerous and are found chiefly along newly constructed railways.

Investigation of the region southwest and west of Regina has shown that evidences of interglacial periods, such as sands and gravels containing organic matter and other fossil remains or exhibiting weathered zones, occur at seven widely separated localities (*See* Figure 6). At a number of other places two tills are shown in sections, but these are not separated by other deposits and are distinguished by merely a break in structure. In one locality two sets of interglacial beds are shown and numerous well sections also appear to show this relation. The interglacial sands and gravels are of importance as a source of ground water supply at many places, for example, at Regina where the city supply is derived from deposits of this character.

DESCRIPTIONS OF OCCURRENCES

Most of the interglacial deposits are in, or just in front of, the moraine covering the Missouri coteau, which extends from the International Boundary, at a point about 40 miles west of Portal, to South Saskatchewan river near Riverhurst. The only exception is a deposit in a small moraine about 55 miles west of the coteau near Lac Pelletier. All the exposures except those in the lower part of the valley of Swift Current creek are in railway cuts, and, therefore, not very large.

Beaubier

The most southerly occurrence is in Willowbunch area about a mile east of Beaubier station on the Canadian Pacific railway. In a cut on the south side of the track, 75 feet west of the road crossing, there is a lens of sand and silt surrounded by till. Near the top of the lens, there is a thin band of white, weathered silt and clay containing fossils. The fauna is made up chiefly of gasteropods with a few species of ostracods. A number of plant impressions were also observed and examination under

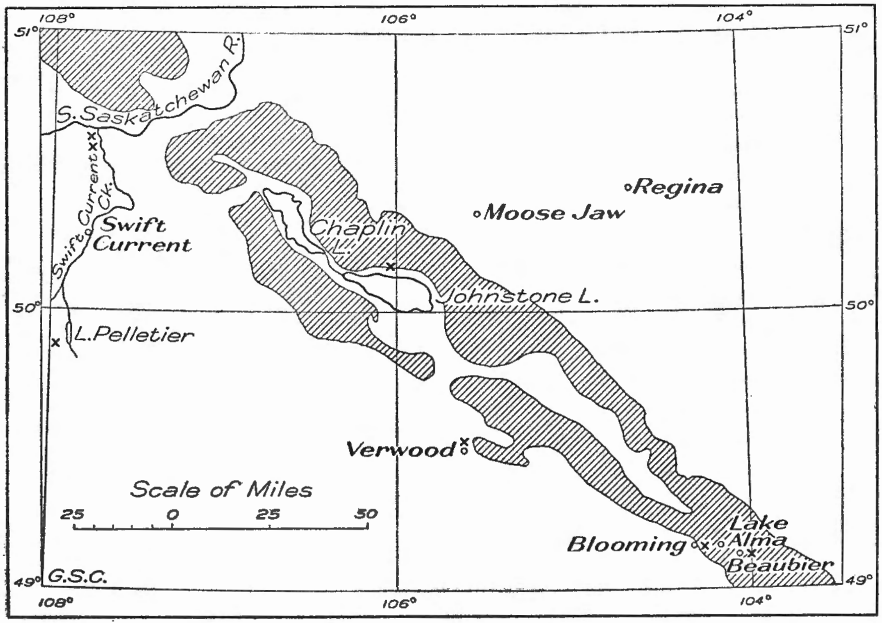

Figure 6. Locations of interglacial deposits in southern Saskatchewan; exposures of interglacial deposits are shown by crosses, the Missouri Coteau moraine by inclined ruling.

the microscope showed chara seeds. The deposit is somewhat distorted, probably owing to overriding by the ice-sheet. The lens is only about 20 feet long and 4 feet thick. Where the two tills are not separated by stratified deposits they show slight differences in structure.

Blooming

Several cuts along the same railway line between Lake Alma and Blooming show interglacial beds. The best section is on the north side of the track about a mile west of the main road south from Radville (NW. ¼ sec. 25, tp. 2, range 18, W. 2nd mer.), and is as follows:

Till	12–15 feet
White, calcareous clay with shells	8–12 inches
Sand and gravel	2– 3 feet
Dark grey to brown till	4– 5 feet

The shells include small pelecypods, several species of gasteropods, nd ostracods. Some chara seeds and other traces of plant remains were also observed. A few limestone and granite pebbles in the sand and gravel are partly disintegrated, but this cannot be taken as evidence of interglacial weathering as most of the pebbles are unweathered. In places the beds are somewhat distorted like those near Beaubier.

In the vicinity of these sections there are cuts showing shell beds apparently in place on top of the upper till. These beds do not appear to be related to a higher stage of the present sloughs and ponds. The shells are much larger and many more species are present than in the proven interglacial deposits. Whether they represent deposits, which were not covered, of another interglacial period, or whether they were laid down during a much higher stage of water in ponds during post-Glacial time is not known.

Verwood

A section showing two tills, the lower of which is weathered at the top, occurs on the east side of the railway track about 2 miles northwest of the village of Verwood (SE. ¼ sec. 6, tp. 7, range 7, W. 2nd mer.). The cut is through a ridge, probably part of the same moraine as at Beaubier, and exposes the following section:

Brown till	3–50 feet
Weathered zone, buff till with plant roots	8–12 inches
Dark grey till	15–20 feet

The pebbles in the buff till are not weathered any more than are the pebbles elsewhere in the section.

Lake Johnstone

North of lake Johnstone and west of Oldwives station on the new Canadian Pacific branch line there is a cut (SW. ¼ sec. 25, tp. 14, range 1, W. 3rd mer.), in which good sections showing interglacial deposits are exposed. The section (Figure 7) on the south side of the track is as follows:

Brown and dark grey till	5–10 feet
Sand and silt containing shells and plant remains	0–15 inches
Gravel and sand	0–10 feet
Dark grey till	0– 3 feet

The lower till in places appears to have been ploughed up by the ice-sheet and it is difficult to see the contact of the upper and lower tills where they are not separated by other deposits. However, on the north side of the track such a contact could be made out. The lower till is more compact and shows some banding. In places a slight amount of buff or cream-coloured soil occurs at the contact. This soil resembles a present day leached forest soil. Pieces of tree trunks and conifer branches occur in the upper till and in the reworked material. Several cones and branches with impressions of needles which resemble those of spruce were found. A piece of a tree about 6 inches in diameter was dug out and it is reported that some similar pieces up to 12 inches were seen when the cut was made. The wood which the writer found was identified at the Forest Products laboratory of the Department of Interior at Ottawa as belonging to the genus Picea. It resembles the species *Picea canadensis* very closely but the material is not well enough preserved to be certain of this.

The small band of sand and silt which lies on top of the lower till contains a few small gasteropods and pelecypod shells and numerous specimens of at least six species of ostracods. The impression of a moss-

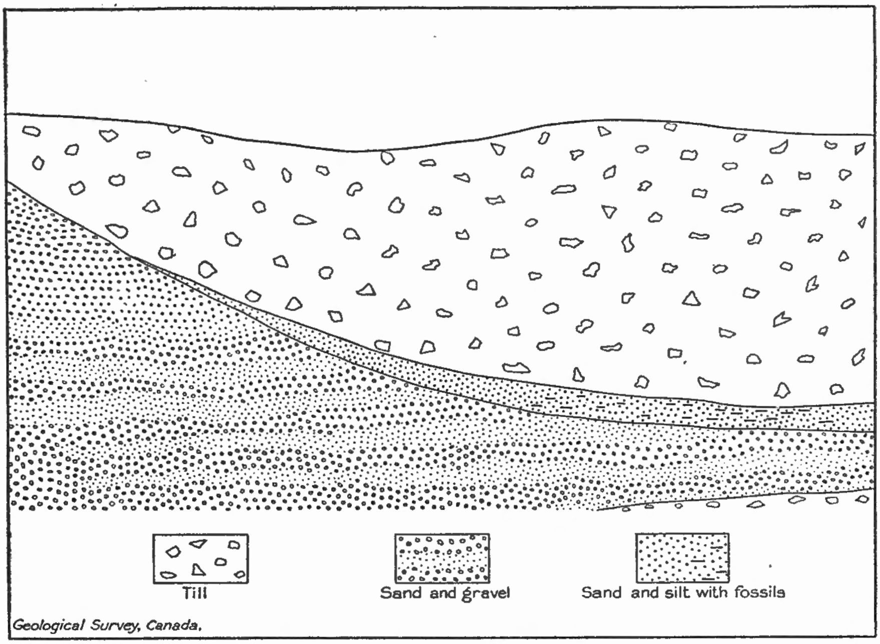

Figure 7. Section showing interglacial deposits near lake Johnstone, Saskatchewan.

like plant is also very common, as well as numerous chara seeds. The sand and silt layer lies on the surface of the gravel lens in an irregular manner, as shown in the diagram (Figure 7), but the bedding of the two does not merge.

Swift Current Valley

The best exposures are in the lower part of the valley of Swift Current creek and a small tributary gulch. They are just southwest of Missouri coteau in an area the surface of which, except for the stream valleys, is nearly level and is underlain by boulder clay. The surface may be in part an ancient terrace of South Saskatchewan river. The sections in places show three tills and two series of interglacial deposits.

A section on the west side of the valley in the east half of sec. 21, tp. 19, range 13, W. 3rd mer., shows, for nearly half a mile, three layers of till.

Measurements were made of this section at two places near the middle of the exposures, A being about 400 feet north of B.

—	A	B
	Feet	Feet
Brown till	39	30
Dark grey till	3	3
Stratified sand, silt, and gravel with plant remains	72	57
Brown to yellow till	25	96
Total	139	186

The two upper tills are separated by only a break in the structure. Elsewhere in a different series of exposures in the valley these two tills are separated by water-laid deposits which contain plant remains.

The stratified deposits in sections A and B show discoloration at the bottom, probably caused by weathering or leaching by ground water. Some poorly preserved plant remains were observed in silt layers near the middle of the water-laid material.

A section, referred to as section C, is located on the east side of a tributary valley in SW. ¼ sec. 15, tp. 19, range 13, W. 3rd mer., about 2 miles south of these exposures, and is as follows:

Section C	Feet
Brown till	70
White sand and gravel; traces of plants	23
Dark grey till	7
Stratified sands and gravel; traces of lignite	225
Total	355

The upper series of stratified deposits contains a few indefinite plant remains. In the lower series the lignite occurs in thin bands. In both of the stratified deposits much of the sand is pure white: examination of the heavy minerals in the sand shows the same abundance of hornblende and other easily weathered minerals as in other Pleistocene deposits in the region, which indicates that the sand was not derived by concentration from the drift, but its mode of origin is not apparent.

A comparison of the sections shows that the break in structure between the two upper tills in sections A and B is represented in section C by 23 feet of sand and gravel. The lower series of sands and gravels in section C represents the sands and gravels in sections A and B. The lower till of the latter sections probably was completely eroded at this point, for the stratified material appears to rest directly on Cretaceous shales.

About 1,000 feet farther up the same tributary valley on the northwest side an exposure, referred to as section D, was observed.

Section D	Feet
Yellowish brown till	30
Stratified sands and gravel	35
Dark grey till	45
Light grey to white weathered till	8
Dark brown till	75
	193

The upper two tills and the sands and gravel seem to represent the two tills in section C. The thick sands and gravels of section C are apparently represented by 8 feet of weathered material and the lowest till of section D is the same as that seen in sections A and B. The weathered zone is full of traces of plants and roots. The thick zone of weathering indicates a long period, although the pebbles in this zone do not show any more effect of weathering than do those in the till above or below.

Lac Pelletier

About 4 miles due west of Lac Pelletier, in SE. ¼ sec. 7, tp. 12, range 15, W. 3rd mer., a fresh railroad cut shows about 30 feet of drift. The following section was observed:

	Feet
Brown till	20
White sand	3–5
Dark grey till	7–10

Some traces of plants were found in the sand beds, but no shells. This section is interesting in that it lies nearly 40 miles beyond the outermost moraine of Missouri coteau.

Moose Jaw

Along the railroad track at the northern edge of the city of Moose Jaw, in NE. ¼ sec. 4, tp. 17, range 26, W. 2nd mer., several exposures show two tills distinguished by differences in structure. The lower till is somewhat darker and more compact than the upper and shows columnar jointing in the upper part, but is not greatly weathered. The sections are northeast of Missouri coteau.

Several wells in the vicinity of Regina and Moose Jaw pass through two or three tills separated in places by sands and gravel. Lignite is reported from the sand and gravel at the base in some of the wells, but in most cases the sands appear to be free from organic matter. It is reasonable, however, to consider the sands and gravel as interglacial. The evidences in Swift Current valley indicate how such a condition is possible. Moreover, glacial outwash associated with the moraines of the last glaciation is not abundant in the region and this suggests that the buried sands and gravels are interglacial deposits and not entirely glacial outwash.

AGE AND EXTENT OF DEPOSITS

The main question in connexion with the age of the deposits is, were they formed during interglacial warm climate periods and can they be correlated with other deposits of similar character, the age of which has been approximately determined. It is fairly certain that the Missouri Coteau moraine, which is a continuation of the Altamont moraine[1] of North Dakota, is Winsconsin in age. It is probable, therefore, that the uppermost till at all the localities, except possibly near Lac Pelletier, is Wisconsin. There are two lower tills the ages of which are unknown.

The fauna and flora of the upper series of interglacial deposits do not appear to indicate a climate as warm as the present. The shells are small and thin. The fauna found in the Assiniboine delta in glacial Lake Agassiz

[1]Leonard, A. G.: "Geology and Natural Resources of North Dakota"; Jour. Geol., vol. 24 (1916).

basin, Manitoba, may be taken as an example of the development of life in a region during or shortly after the retreat of the ice-sheet. The fauna shows much larger forms than those found in the Saskatchewan deposits and very similar types of ostracods to those found in the deposits near lake Johnstone. The occurrence of well-developed spruce trees indicates a more moist climate than the present, as the area is nearly treeless owing to deficiency in moisture.

The thickness of the weathered zone at the top of the lowest till in Swift Current valley and the stratified sands and gravels containing lignite appear to indicate a long period during which the region was free of ice. The smaller, weathered zone observed in the exposure near Verwood may represent a period as great as post-Glacial time in this region; similar zones in cuts at the surface in this area show weathering down to only about one foot. As the interglacial climate, however, probably was more moist than the present, weathering may have been more rapid. The Verwood exposure probably represents the same stage as the deposits near Beaubier, Blooming, and lake Johnstone, as all these are nearly similar in character. The fact that the later deposits do not have a very thick covering of till is not of much significance because the thickness of till is variable. The younger interglacial beds evidently correspond to a period of deglaciation of no great length and of cool climate between the Wisconsin and Iowan or Illinoian or between Early and Late Wisconsin; the older beds represented in the exposures near Swift Current probably belong to an earlier period of considerable length. A fairly warm and moist climate may be indicated by the lignite, which, however, is too much altered to determine the character of the organic material. It is not clear to which stage the Lac Pelletier deposits belong as it is not certain whether the uppermost till in this area is Wisconsin in age or belongs to an earlier stage.

The deposits occur at widely separated localities and may be of considerable extent, but appear to be confined to buried stream valleys and to former basins of small ponds. They are most extensive in the morainic areas and on the southwest side of the moraines. As the deposits largely consist of well-washed sands and gravels they are of importance as a source of ground water. Prospecting for them is necessarily done by drilling and by tracing the courses of the ancient valleys by means of records of borings and by the regional slopes which indicate the direction of drainage.

VARIATIONS IN THICKNESS OF CRETACEOUS FORMATIONS IN SOUTHERN MANITOBA

By. R. T. D. Wickenden

A study of well sections in southern Manitoba reveals marked differences in thickness of some of the Cretaceous formations in different areas. The studies were based on an examination of the micro-fossils in the well samples and the lithology of the samples from the Deloraine well drilled in 1892, and the Pembina Valley well drilled in 1930 by the Commonwealth Petroleum Company, Limited. The subdivisions of the Cretaceous of the Manitoba escarpment as described by S. R. Kirk[1] have been followed, and comparison is made with the thicknesses of the various formations as determined by him. Examination of foraminifera from outcrop and well samples indicates that identification of horizons for correlation purposes and structural determinations can be based on the micro-faunas of the Boyne and Assiniboine beds. Over fifty species of foraminifera have been observed in material from the Boyne beds. Many of these species are easily recognized, are abundant, and have a short stratigraphic range. Close correlations in limited areas can, therefore, be made by means of the micro-fauna of the Boyne beds. The Assiniboine beds, on the other hand, have a small micro-fauna of only four species, which occur throughout the beds. In some parts of the beds, particularly near the top of the series, the foraminifera are so abundant that the rock can be called a fossil globigerina ooze. The fauna and its occurrence are consistent and characteristic of these beds over a wide area, thus making the Assiniboine beds a dependable and easily recognized horizon.

The samples of the Pembina Valley well down to 740 feet were received from the Calgary office of the Supervisory Mining Engineer, Department of the Interior, and those from 750 feet to 1,070 feet from Hon. S. Michener, President of the Commonwealth Oil Company, Limited.

Log of Pembina Valley Well No. 1, L.S.D. 4, Sec. 23, Tp. 2, Range 9, W. Prin. Mer.

Formation	Depth in feet	Description
Pembina beds.......	20	Dark grey to brown, non-calcareous shales
Boyne and Morden beds	40 to 425	Dark grey, calcareous shales Foraminifera: large fauna of calcareous forms in the upper beds, arenaceous forms in the lower beds
Assiniboine and Keld beds...........	445–545	Dark grey, speckled and unspeckled, calcareous shales, with pelagic micro-fauna
	565	Limestone band, inoceramus prisms and foraminifera
	585–620	Dark grey, calcareous shales with foraminifera
	630–640	Dark grey, calcareous shales with bentonite
Ashville beds........	650–740	Dark grey, calcareous and non-calcareous shales; some green sand and arenaceous foraminifera in the lower samples
Basal beds...........	750	Fine, white, calcareous sandstone with much pyrite
	760–780	Medium to coarse, white, quartz sand
	790	Dark grey, non-calcareous shale with some coarse quartz sand
——	800	Very coarse sand and quartz pebbles up to 8 mm.

[1]Kirk, S. R.: Geol. Surv., Canada, Sum. Rept. 1929, pt. B, p. 114.

Log of Pembina Valley Well No. 1—Continued

Formations	Depth in feet	Description
Palæozoic (probably Devonian)	810	Red and pistachio-coloured shale with some coarse sand
	812	White and pink shale with coarse sand
	820	Bright brick-red shale
	830	Light grey shale
	840	Pink shale
	850-60	Terra-cotta and green shale
	912	Fine, white, calcareous sand
	990—1,020	Medium grey shale
	1,030	Dark buff to terra-cotta shale
	1,040	Very light grey and dark buff to terra-cotta shale
	1,070	Light grey and brownish red shale

The Boyne beds grade into the Morden beds so that they cannot be separated in well samples, but the former are characterized by a fauna of calcareous foraminifera. The Assiniboine beds also grade into the Keld beds. The base of the Keld is arbitrarily placed at the base of the bentonite layers in accordance with Kirk's classification, though the calcareous shale in the upper part of the Ashville is more typical of the Keld and the characteristic foraminifera occur in the lower part of the Ashville only.

The Deloraine well is reported to be 1,943 feet deep, the lower 121 feet having been in the Basal beds.[1] Only samples from 1,070 feet to 1,800 feet are available for study, but these represent the greater part of the formations passed through in Pembina Valley well No. 1.

Partial Log of Deloraine Well

Formations	Depth in feet	Description
Boyne and Morden beds	1,075 to 1,460	Calcareous shales; non-calcareous near the base. Foraminifera in the upper samples only
Assiniboine and Keld beds	1,470 to 1,580	Speckled calcareous shales. Pelagic foraminifera
Ashville beds........	1,585 to 1,800+	Dark grey, non-calcareous shales. Arenaceous foraminifera

The thicknesses of the formations at different places are shown in the following table. The sections at Pembina mountain and at Riding mountain (Vermilion River beds) are as given by Kirk.[2]

Localities	Thickness of formations (feet)				Total thickness
	Boyne and Morden	Assiniboine and Keld	Ashville	Basal beds	
Pembina valley, well No. 1......	385	190+	90	50	715+
Deloraine well..................	385	110	215+	121	816+
Pembina mountain..............	340	160	100-150	90	670-740
Riding mountain................	250-300	160-165	170	19-90	599-725

The table shows that the formations comprising the lower part of the marine Cretaceous rocks in southern Manitoba vary considerably in thickness over long distances. In limited areas the variation is small and if series like the Morden and Boyne beds are taken together the stratigraphic thickness is fairly uniform.

[1]Tyrrell, J. B.: Geol. Surv., Canada, Ann. Rept., N.S., vol. VI, pt. A, p. 2 (1895).
[2]Kirk, S. R.: Geol. Surv., Canada, Sum. Rept. 1929, pt. B, p. 114.

DEEP BORINGS IN THE PRAIRIE PROVINCES

By W. A. Johnston
(Chief, Division of Pleistocene Geology, Water Supply, and Borings)

The importance of obtaining dependable supplies of water, and the increasing necessity for providing information as to the probability of obtaining water from underground sources as the population of Canada increases both in numbers and density have led to the formation of the Division of Pleistocene Geology, Water Supply, and Borings. In the Prairie Provinces during 1930 the necessity for obtaining additional water supplies was emphasized by the very dry seasons that some parts of that area have recently experienced. The work of the Borings Division being so closely related to that of the new division it was considered advisable to include it in the newly formed division. The work which the Borings Division has been carrying on for over 20 years, involving the collection of samples and records from wells drilled for oil, gas, and water, will continue unaltered.

The necessity for the collecting of records of wells drilled for water is readily seen when the conditions prevailing in the Prairie Provinces are considered. It is an area almost entirely drift covered, supporting a large farming population, and data as to sources of water supply are generally only obtainable as a result of well-drilling operations. The rather irregular distribution in the drift of the sand and gravel deposits from which water is obtained also makes well records of particular value. The division is specially organized and operated to deal with the work of the collection of samples and records and it is hoped that drillers and owners of water wells will co-operate in the collection of data of this nature. The assistance and advice of the field officers of the Geological Survey are always available in the interpretation of the stratigraphic records.

A report on water conditions at Moose Jaw is given elsewhere. With the exception of Regina district, nothing of special interest seems to have transpired elsewhere in connexion with drilling for water. Thanks are due to the Layne Canadian Water Supply Company for information as to water wells drilled by them, to Messrs. McPherson and Thom of Regina for similar information in Balcarres district, and to the Clark Drilling Company of Wolseley, Saskatchewan, for information as to wells sunk. The Canadian National railways forwarded records and samples from a large number of wells drilled for them in connexion with branch lines built in the west. Mr. S. Toye forwarded the results of some drilling in the gypsum deposits in Manitoba, on lot 74 one mile from Charleswood, Manitoba. Mr. J. W. D. Farrell, of the Regina Waterworks Department, forwarded logs of wells drilled in Regina district. Mr. H. J. McLean of the Calgary Power Company and Dr. J. A. Allan of the University of Alberta forwarded information on drilling done in connexion with the Ghost River dam of the Calgary Power Company. Mr. F. J. Malkinson, secretary of the town of Fairview, Alberta, forwarded information as to water conditions in that area. The names of individual drillers who co-operated will be found in the tabulated list of shallow wells which follows. That the interest in the oil and gas possibilities of the Prairie Provinces was maintained during 1930 is shown by the number of samples received—28,859, only 207 less than in 1929. The arrangement by which samples were forwarded from the Calgary office of the Supervisory Engineer of the

Department of the Interior was continued during 1929, and much information relative to well logs, oil, gas, and water analyses, etc., was also received from that office.

In Manitoba work on the well at Dauphin was continued during 1930 and a deep test is being put down near Pembina by the Pembina Valley Gas and Oil Corporation. Neither well has obtained commercial production to date.

In Saskatchewan further drilling was done in Eden Valley, Pike Lake, Simpson, and Riverhurst districts. Tests are also going down near Biggar and at Pilot Butte near Regina.

In Alberta, Turner valley continued to be the centre of interest, many new wells coming in and a large production of high-grade naphtha and crude oil resulting. This remarkable field made by far the largest contribution to the oil and gas production of Canada during 1930. Considerable interest was shown and some development took place in the Red Coulée, Irma-Wainwright, and Ribstone fields. In Pincher Creek area, southwestern Alberta, the Alberta Gas and Fuel Company and the Weymarn interests continued drilling. Many other wells were put down at various points. Of the new areas tested those at Spring Coulée, Paintearth creek, and Keho lake have not been completed, and the well at Duvernay has been abandoned. Some drilling was done for gas in Medicine Hat area. The second deep test in Cypress Hills area was put down to 3,900 feet. Many other test holes, both shallow and deep, were put down in other areas.

The system of bottling samples was continued during 1930 and several thousands were so treated. The laboratory work by Mr. F. J. Fraser on samples brought in from the field by Mr. F. H. McLearn was continued, about 200 being examined and many permanent slides of the heavy minerals made. Samples from the diamond drill cores obtained from the well drilled near Ralph, Saskatchewan, many years back, were re-examined.

The first of the three well logs presented on following pages, provides information as to conditions at depth in an area in which no deep drilling seems to have been done. The success of this Experimental Station well extends the previously known area of the artesian water basin of southern Alberta about 20 miles to the east. A notable feature is that the water flows at an elevation of 3,050 feet, which is about 50 feet higher than that of any other flowing wells in the basin as reported by Dowling,[1] and this height is only about 150 feet below the elevation of the intake beds on Milk river 50 miles to the west. Probably the gas coming with the water causes the water to rise higher than it otherwise would. Unfortunately, the water has a high mineral content, as it has in other outlying parts of the artesian basin. A partial analysis by the Division of Chemistry of the Dominion Experimental Farms, Ottawa, showed a mineral content of 1,494 parts per million, consisting chiefly of sodium bicarbonate, 986 parts per million, and sodium chloride, 283 parts per million. The presence of large amounts of sodium bicarbonate in the water renders it unsuitable for irrigation, but it is a usable water for stock. Flow is 6 G.P.M.; temperature 54·5 degrees F.; a little gas.

The second well log provides information as to the nature of the basal Ordovician limestones and the underlying Winnipeg sandstone in the district west of lake Winnipeg.

[1]Dowling, D. B.: "Investigation of Artesian Water, Coal, Petroleum, and Natural Gas in Alberta"; Geol. Surv., Canada, Sum. Rept. 1922, pt. B, pp. 110-114.

The third well log provides detailed information on a section of limestone, probably Palæozoic in age, nearly 1,000 feet thick in the Ribstone field in Alberta in an area in which these limestones are buried beneath over 2,000 feet of sediments and where the nearest outcrop of these limestones is about 175 miles distant.

Log of Well, Dominion Range Experimental Station, Sec. 15, Tp. 2, Range 4, W. 4th Mer.

Depth (in feet)	—	Rate of effervescence with acid Cold	Notes
10	Sand, light brownish grey	0	Medium grained
20	" " "	2	Medium to coarse grained
30–60	Clay, " "	1	Considerable sand
70	" medium grey	1	
80	Shale, " "	1	
85–110	Sandstone, " "	1	Fine grained
120	Shale, " "	1	Considerable sand
130–140	" " "	1	
150–160	Sandstone, " "	1	Fine to medium grained
170–190	Shale, " "	1	Considerable sandstone
200–220	" " "	1	
230	" " "	1	" "
240	Sandstone, " "	1	Fine to medium grained
250	Sandy shale, " "	1	
260–290	Sandstone, " "	1	" "
300–310	Shaly sandstone, " "	1	
320	Sandy shale, " "	1	
330–370	Sandstone, " "	1	" "
380	Shale, very dark grey	1	Plant remains
390	" " "	1	Coal fragments
400–440	" dark grey	1	"
450–470	" "	1	Very few coal fragments
480–630	" brown-grey	1	" "
640–670	" dark brown-grey	1	" "
680–710	" " "	1	
720	" " "	1	Coal fragments
730–750	" " "	1	
760–780	" medium grey	1	White shell fragments
790–830	" "	1	
840	" "	2	A few coarse sandstone fragments. White shell fragments
850	" "	1	
860	" "	1	A few coal fragments
870–920	" "	1	
930	" "	1	Iridescent shell fragments
940	" "	1	
950–960	" "	1	A few coal fragments
970	" "	1	
980	" "	1	Shell fragment
990	" "	1	Iridescent shell fragments
1,000	Shaly sandstone, medium grey	1	Fine grained
1,010–1,020	Sandy shale, "	1	
1,030	Sandstone, "	1	Fine to medium grained
1,040–1,130	" "	1	" " a little shale
1,136	" "	1	Medium to coarse grained

Percentage of coal in unwashed sample from depths noted: 380 feet, 5 per cent; 390 feet, 45 per cent; 400 feet, 5 per cent; 410 feet, 3 per cent; 420 feet, 4 per cent; 430 feet, 15 per cent; 440 feet, 2·5 per cent; 660 feet, less than 1 per cent.

Disintegration tests on samples. from depths noted, with screening through 270-mesh sieve, gave amounts on screen of: 620 feet, 12·5 per cent; 630 feet, 8 per cent; 640 feet, 6·5 per cent; 650 feet, 6·3 per cent; 660 feet, 5 per cent; foraminifera found at 650 feet and 660 feet and iridescent shell fragments at 660 feet.

Log of R. J. McGuckin No. 1 Test Well, Southwest Part Tp. 33, Range 1, W. 1st Mer.

Depth (in feet)	—	Rate of effervescence with acid: Cold	Rate of effervescence with acid: Hot	Notes
8– 20	Limestone, brown-grey........	4	6	
20– 30	" light grey.........	6	6	
30– 60	" "	4	6	
60– 70	Dolomite "	2	6	
70–142	Limestone "	4	6	
142–165	Shale, medium grey...........	0	0	
165–178	Sandstone, brown-grey........	0	0	Medium to coarse grained, fairly well rounded, some etched grains
180–232	" light grey.........	0	0	" " "

This log does not show the base of the Winnipeg sandstone, but hole No. 3 records a thickness of 112 feet which would make the lower contact in well No. 1 about 250 feet.

Log of Ribstone Oils No. 2 Well, Ls. 5, Sec. 25, Tp. 46, Range 1, W. 4th Mer.

Depth (in feet)	—	Rate of effervescence with acid: Cold	Rate of effervescence with acid: Hot	Notes
30– 60	Clay, brown.................	2	......	
70– 90	" brown-grey............	1	......	With pebbles
100	" brown.................	2	......	
110	" brown-grey............	1	......	
120- 180	" "	2	......	"
190- 200	" grey...................	1	......	"
210- 250	Shale, "	0	......	"
260	Sandstone, grey...............	1	......	Medium grained
270	" "	4	......	" "
280	" brown-grey.........	4	......	Fine grained
290	" grey................	4	......	"
300	Sandy shale, grey............	3	......	
310	Sandstone, grey...............	3	......	"
320- 350	Sandy shale, brown-grey......	0	......	
360- 500	Shale, grey.....................	......	......	Somewhat sandy
510- 600	" "	......	......	A few sandy partings
610- 620	" "	......	......	Trace of bentonite
630- 820	" "	......	......	Pearly shell fragments at 680 feet
830- 850	" "	......	......	Some ironstone
860- 960	" "	......	......	At 890 feet trace of very fine sandstone and fragments of Baculites (?)
970- 980	" "	......	......	Ironstone at 970 feet
990-1,060	" "	......	......	Trace of bentonite at 990 feet
1,070-1,100	" dark grey............	......	......	Shell fragments
1,110-1,150	" grey..................	......	......	
1,160-1,290	" dark grey............	......	......	Shell fragments. Bentonite 1,260-1,270 feet
1,300-1,450	" "	......	......	Fissile, shell fragments, traces bentonite
1,460-1,540	" "	......	......	Thin, sandy partings
1,550	" "	......	......	Ironstone
1,560	" "	......	......	Fish tooth
1,570-1,650	" "	......	......	Trace fine-grained sandstone at 1,650 feet
1,660	" "	......	......	A little medium-grained sandstone

Log of Ribstone Oils No. 2 Well—Continued

Depth (in feet)	—	Rate of effervescence with acid: Cold	Rate of effervescence with acid: Hot	Notes
1,670	Shale, dark grey.............	......	......	A little sandstone
1,680-1,700	" "	......	......	Traces of sandy partings 1,690 feet
1,710	" "	......	......	Bentonite
1,720-1,739	" "	1	......	A few black chert pebbles at 1,733 feet
1,740-1,743	" brown-grey...........	1	......	
1,750	Sandy shale, dark grey.......	1	......	
1,753	Sandstone, grey..............	1	......	Medium grained, much shale, fibrous calcite
1,754	Shale, grey..................	1	......	Pebbles, coal
1,760	Sandstone, brown-grey........	0	......	Fine grained, pebbles
1,764-1,775	" "	0	......	" " pyrite at 1,765 and 1,775 feet
1,779	" "	0	......	Fine grained, pebbles, coal fragments
1,785-1,798	" medium grey......	0	......	Fine to medium grained
1,802-1,835	" "	0	......	Medium grained, little coal at 1,802, 1,835 feet
1,840	" "	0	......	Medium grained, pebbles, pyrite
1,845-1,852	" brown-grey........	0	......	"
1,859-1,900	" medium grey......	1	......	Fine to medium grained. A little coal at 1,889 feet
1,906	Coal, black..................	0	......	
1,908-1,932	Sandstone, medium grey......	0	......	Fine to medium grained. Salt water at 1,903 feet
1,940	Shale, very dark grey.........	0	......	
1,946	Sandstone, medium grey......	0	......	Fine to medium grained
1,956	" "	0	......	Medium grained. Salt water at 1,953 feet
1,970	Sandy shale, brown-grey......	1	......	Coarse sand and pebbles
1,983	Shale, dark grey.............	0	......	Sandy. A little coal
1,995	" brown-grey............	1	......	"
2,005-2,020	" dark grey..............	0	......	
2,023	Sandstone, brown-grey........	0	......	Medium grained. Salt water and oil
2,029	" medium grey......	0	......	" " much shale
2,033	Shale, dark grey.............	1	......	Pyrite
2,038	Sandstone, medium grey......	1	......	Medium grained. Considerable shale
2,045-2,057	" "	0	......	Fine to medium grained. Considerable shaly towards top and at 2,051 feet
2,058	Sandy shale "	0	......	
2,065	Shale, dark grey.............	1	......	Considerable sandstone
2,069	" "	4	......	" "
2,075	Sandstone, medium grey......	3	......	Fine to medium grained. Considerable shale
2,090-2,100	" "	2	......	" " "
2,105	Pyrite, brown-grey...........	0	......	Some shale and sandstone
2,113	Sandstone, medium grey......	1	......	Fine to medium grained, considerable shale
2,116	Shale, dark grey.............	0	......	
2,119	Sandstone, medium grey......	1	......	" " "
2,127-2,133	" brown-grey........	1	......	" " "
2,137	Shale, dark grey.............	1	......	
2,145-2,173	Sandstone, medium grey......	0	......	" " "
2,178	" "	0	......	Medium to coarse grained
2,186	" "	0	......	Coarse grained
2,191-2,192	Conglomerate, grey and dark grey........................	0	......	

Log of Ribstone Oils No. 2 Well—Continued

Depth (in feet)	—	Rate of effervescence with acid: Cold	Rate of effervescence with acid: Hot	—	Insoluble residue after HCl	Precipitate with barium chloride
2,197–2,216	Conglomerate, medium grey	0	......	....	....	....
2,229	Sandstone, medium grey	0	......	Coarse grained........	....	....
2,237	" "	0	......	Medium grained......	....	....
2,250	" "	0	......	Some coarse grains..	....	....
2,260	Conglomerate, medium grey	0	......	....	....	....
2,270–2,271	" "	3	......	Limestone fragments.	....	....
2,275	Conglomerate, brown-grey	3	4	Much limestone, well-rounded sand grains	....	0
2,279	" "	2	3	Considerable shale	....	0
2,286	Limestone, brown-grey	3	4	Considerable shale and sandstone	....	0
2,292–2,298	" "	4	5	Very little residue....	....	0
2,306–2,312	Sandstone, brown-grey	3	4	Grains well rounded. Considerable limestone	....	0
2,320–2,330	Limestone, brown-grey	3	4	Well-rounded sand grains	....	0
2,340–2,351	" "	5	6	Shaly residue.........	....	0
2,360	" "	5	6	....	....	0
2,371	Dolomite, brown-grey	3	5	....	....	0
2,376–2,387	Limestone, brown-grey	4	5	....	....	0
2,398	" "	3	4	Dolomitic, residue very low	....	0
2,411–2,429	" "	4	6	....	....	0
2,444	" "	3	4	Dolomitic............	....	0
2,465–2,548	" "	4	5	....	Very little....	0
2,560–2,574	Dolomite, brown-grey	1	5	....	"	0
2,586–2,593	Limestone, brown-grey	4	6	....	"	0
2,600–2,610	" "	3	5	Dolomitic............	"	0
2,620	Dolomite, medium grey	1	5	....	Bulky clay...	0
2,633–2,683	Limestone, medium grey	5	6	....	"	0
2,692	Limestone, brown-grey	5	6	....	"	0
2,701–2,732	Limestone, medium grey	5	6	....	"	0
2,744–2,763	Limestone, brown-grey	5	6	....	Small clay....	0
2,775	Limestone, brown...	3	4	Bituminous. Dolomitic	Medium......	0
2,784	Limestone, dark brown	4	4	Free oil, quartz grains	Considerable.	0
2,790	Limestone, brown...	5	6	....	Medium......	0
2,793	Limestone, medium grey	5	6	....	"	0
2,795	" "	5	6	....	Bulky.........	0
2,800–2,805	Limestone, brown-grey	5	6	....	Small.........	0
2,805–2,830	" "	6	7	....	Very little....	0
2,835–2,850	" "	5	6	....	"	Trace
2,855	" "	5	6	....	"	Present
2,860–2,870	" "	5	6	....	"	Trace
2,875	Limestone, medium grey	5	6	....	Very little....	0
2,880–2,890	" "	6	7	....	Bulky clay...	0

Log of Ribstone Oils No. 2 Well—Continued

Depth (in feet)	—	Rate of effervescence with acid: Cold	Rate of effervescence with acid: Hot	—	Insoluble residue after HCl	Precipitate with barium chloride
2,895	Limestone, medium grey	6	7		Very little....	0
2,900–2,905	Limestone, brown-grey	5	6		"	Present
2,910–2,915	Dolomite, brown-grey	2	7		"	"
2,920–2,930	Limestone, medium grey	5	7		"	"
2,935	Dolomite, medium grey	3	7		"	"
2,940	Limestone, medium grey	4	7		"	"
2,945–2,950	Dolomite, medium grey	3	6		"	"
2,955–2,960	Limestone, brown-grey	5	7		"	"
2,965	Dolomite, brown-grey	3	7		"	"
2,970	Limestone, brown-grey	5	6		"	"
2,975	Dolomite, brown-grey	3	6		"	"
2,980	Limestone, brown-grey	4	6		"	"
2,985	" "	6	7		"	"
2,990–2,995	" "	4	6		"	"
3,000	Missing....	....	....		"	"
3,005–3,010	Limestone, brown-grey	5	6		"	"
3,015	Dolomite, brown-grey	2	7		Considerable.	"
3,020–3,025	" "	3	6		Very little....	"
3,030	Limestone, brown-grey	6	7		"	"
3,035	Dolomite, brown-grey	3	6		"	"
3,040	Limestone, brown-grey	5	6	Salt present..........	"	"
3,050	Dolomite, brown-	2	6	"	"	"
3,055	" "	2	6		"	"
3,060	" "	3	6		"	"
3,065	Limestone, brown-grey	5	6		"	"
3,070–3,075	Dolomite, brown-grey	3	6		"	"
3,080–3,085	Limestone, brown-grey	6	7		"	"
3,090–3,095	" "	5	6	Trace of salt at 3,095 feet	"	Absent
3,100	" "	5	6		Considerable.	"
3,105–3,130	" "	5	6		Very little....	"
3,135–3,165	" "	6	7		"	Trace 3,145
3,170	" "	6	7		Bulky argillaceous	Absent
3,175–3,185	Limestone, medium grey	6	7		Very little ...	"
3,190–3,195	" "	6	7	Coarse sand grains....	Considerable.	"
3,200–3,220	" "	6	7		Very little....	"
3,230	" "	6	7		Bulky argillaceous	"

Water at 120 feet, 140 feet, 301 feet; salt water at 1,743 feet, 1,953 feet, 2,023 feet; sulphur water at 2,166–2,170 feet.

Gas, trace, at 275 feet; gas shows, at 1,372 to 1,392 and 1,462 feet; gas, at 1,600 feet and 1,740 to 1,743 feet. Oil show at 2,023 feet.

Summary:

	Feet
Ribstone Creek-Lea Park contact (?)	140
Sandstone in Lea Park	250–320
Base of Upper Cretaceous	1,739
Top of limestone	2,275

An analysis made by E. A. Thompson, of the Mines Branch, Dept. of Mines, of the brine found at 3,010 feet, follows:

Specific gravity at 60 degrees F	1·194
Solid matter in 100 cc.	26·98
Percentage of solid matter to weight of brine	22·59

Composition of Solid Matter

	Per cent
Sodium chloride	43·62
Potassium chloride	2·48
Calcium chloride	40·36
Magnesium chloride	12·97
Calcium sulphate	0·21
Calcium carbonate	0·30
	99·94

Composition of Brine per Barrel (35 Imperial gallons)

26·98 grs. of solid matter in 100 cc.
2,698 lbs. of solid matter in 1,000 Imperial gallons
2·698 lbs. of solid matter in 1 Imperial gallon
94·43 lbs. of solid matter in 1 barrel of 35 Imperial gallons

Pounds of Salt Constituent Recoverable from One Barrel of 35 Imperial Gallons

	Pounds
Sodium chloride	41·19
Potassium chloride	2·34
Calcium chloride	36·11
Magnesium chloride	12·25
Calcium sulphate	0·20
Calcium carbonate	0·28
	94·37

Deep Wells ((Samples and Logs Received During the Year)

Location					Description			Remarks
Ls.	Sec.	Tp.	Range	Mer.	Year drilled	Depth in feet covered by records	Number of samples received	
								BURDETT
15	14	9	12	4th.....	1930	2,070	245	C.N.W. L. H. and P. Company, Burdett No. 40
								CANYON CREEK
16	29	22	6	5th	1930	2,820	233	Moose Oils Limited No. 1
								CARBON
7	18	29	22	4th.....	1930	660	64	Carbon Exploration Company, Ltd., No. 1
								CHAMPION
9	9	16	23	4th.....	1930	2,740	61	Champion No. 1, Hudson Bay Marland Oil Company
								CYPRESS HILLS
4	30	7	3	4th	1930	4,070	405	Eagle Butte Co. No. 2
								DAUPHIN
......	14	24	20	1st	1930	1,256	34	Dauphin Oil Co. No. 1

DEAD HORSE COULÉE								
6	21	1	11	4th	1930	2,907	87	Ranger Oil and Gas Co. No. 2
DUVERNAY								
5	34	55	12	4th.....	1930	2,410	226	Alberta Pacific Consolidated Oils, Ltd., Duvernay No. 1
EDEN VALLEY								
14	35	28	8	3rd.....	1930	1,400	56	Eden Valley Oils Ltd. No. 1
ELBOW WELL								
11	35	22	5	5th.....	1930	3,041	116	Elbow Oils Ltd. No. 1
EYREMORE								
1	26	17	18	4th.....	1930	980	94	Hudson Bay Marland Oil Co., Eyremore No. 1
1	26	17	18	4th.....	1930	5,590	431	" " " " 1S
GHOST RIVER								
1	19	27	6	5th.....	1930	2,930	62	Atlantic Keystone No. 1
HERRON								
3	24	22	6	5th.....	1930	3,255	275	Herron Petroleum No. 1

Deep Wells (Samples and Logs Received During the Year)—Continued

Location					Description			Remarks
Ls.	Sec.	Tp.	Range	Mer.	Year drilled	Depth in feet covered by records	Number of samples received	
								HIGH RIVER
6	34	18	29	4th.....	1930	143	10	High River Oilfields Ltd. No. 1
16	13	20	28	4th.....	1930	3,990	60	Ranchmen's Oil and Gas Co. Ltd. No. 1
								HIGHWOOD
8	35	18	3	5th.....	1930	2,260	241	Northwest Calgary and Edmonton No. 2
8	35	18	3	5th.....	1930	3,310	172	" " " 1
8	1	18	3	5th.....	1930	4,010	418	Hudson Bay Marland Oil Co., Highwood No. 1
11	7	17	2	5th.....	1930	3,872	558	Western Alberta No. 1
4	28	18	3	5th.....	1930	740	47	Warner Oils Ltd. No. 2
3	28	18	3	5th.....	1930	2,770	278	" " No. 3
								KEHO LAKE
2	17	11	22	4th.....	1930	2,130	209	Hudson Bay Marland Oil Co., Keho Lake No. 1
								KINSELLA
3	29	48	10	4th.....	1930	2,080	1	J. P. McDonald No. 1
								LETHBRIDGE
4	23	8	22	4th.....	1930	350	80	Lethbridge Petroleum No. 3
3	4	8	22	4th.....	1930	358	78	" " No. 2
1	23	8	22	4th.....	1930	350	70	" " No. 1

								MEDICINE HAT
4	33	12	5	4th.....	1930	925	96	Medicine Hat Brick and Tile Company No. 1
4	33	12	5	4th.....	1930	1,025	11	" " " No. 2
								MILK RIVER
9	9	8	15	4th.....	1930	4,346	141	Commonwealth Petroleum Ltd., Milk River No. 1
								MOOSE MOUNTAIN
9	34	23	5	5th.....	1930	4,090	48	Signal Hill No. 2
								MORLEY RESERVE
......	....	....	Morley reserve....		1930	1,588	7	Norcon No. 1
								NEW BLACK DIAMOND
5	35	19	3	5th.....	1930	3,690	32	Outwest Petroleum No. 1
1	3	20	3	5th.....	1930	3,910	33	New Black Diamond, Weymarn No. 1
								NEW VALLEY
4	6	21	2	5th.....	1930	2,210	2	New Valley Oil Ltd. No. 1
								PAINTEARTH CREEK
5	27	39	14	4th.....	1930	1,840	173	Hudson Bay Marland Oil Company, Paintearth Creek No. 1
								PEACE RIVER
7	36	83	12	5th.....	1930	230	19	Four X Oils Co. Ltd. No. 1

Deep Wells (Samples and Logs Received During the Year)—Continued

Location					Description			Remarks
Ls.	Sec.	Tp.	Range	Mer.	Year drilled	Depth in feet covered by records	Number of samples received	
								PIKE LAKE
8	13	34	7	3rd.....	1930	3,170	83	Pike Lake Oil and Gas Development and Exploration Co. Ltd. No. 1
								PINCHER CREEK
5	7	6	1	5th.....	1930	2,250	230	Weymarn Petroleums, Pincher Creek No. 2
16	34	3	30	4th.....	1930	2,710	265	Alberta Gas and Fuel Co., Yarrow No. 1
								REDCLIFF
13	9	13	6	4th.....	1930	700	71	Redcliff Premier Brick Co. No. 1
								RED COULÉE
7	19	2	17	4th.....	1930	1,970	193	Dalco Oil and Gas Co. No. 2
4	11	1	16	4th.....	1930	2,640	275	" " No. 1
4	4	2	12	4th.....	1930	3,500	127	Capital Oil and Natural Gas Co. Ltd. No. 1A
3	21	1	16	4th.....	1930	2,750	267	" " " No. 1
4	17	1	16	4th.....	1930	2,680	230	Celtic Oils Ltd. No. 1
10	3	1	16	4th.....	1930	2,732	280	Commonwealth Petroleum, Ltd.,Red Coulée No. 1
15	7	1	16	4th.....	1930	1,360	133	Dixie Oil Co. No. 1A
2	4	1	16	4th	1930	2,500	211	Alberta Pacific Consolidated, Red Coulée No. 1
4	10	1	16	4th.....	1930	1,140	110	Devonshire Oil Co. Ltd. No. 1
1	2	1	17	4th.....	1930	1,570	113	Ko-Top Oils Ltd. No. 1
8	3	1	16	4th.....	1930	2,442	295	Southern Alberta Exploration Co. No. 1
3	4	1	16	4th.....	1930	2,507	255	Taylor Oil and Gas Syndicate No. 1
3	4	1	16	4th.....	1930	2,478	252	Vanalta, Milk River No. 2

RIBSTONE

4	16	45	1	4th.....	1930	1,885	193	Meridian Oils Ltd. No. 3.
4	16	45	1	4th.....	1930	1,803	187	" " No. 2
......	10	46	2	4th.....	1930	2,260	242	Oxville Oil and Gas Co. No. 1
14	9	45	1	4th.....	1930	2,545	182	Imperial Ribstone Oils Ltd. No. 2

RICKERT

2	28	19	4	5th.....	1930	2,239	30	Paramount Oils Ltd. No. 1

SIMPSON

2	9	29	25	2nd.....	1930	2,410	29	Simpson Oil Co., Roycroft No. 1

SKIFF

9	36	6	15	4th.....	1930	3,090	206	Dauntless Oils Ltd. No. 1
13	29	5	14	4th.....	1930	3,040	81	Devenish Petroleums Ltd. No. 1
13	29	5	14	4th.....	1930	2,000	172	" " No. 4

SPRING COULÉE

11	15	4	23	4th.....	1930	3,978	376	Alberta Pacific Consolidated Ltd., Spring Coulée No. 1

SUFFIELD

15	4	17	8	4th.....	1930	3,520	44	Ontario-Alberta Oil and Development Co. Ltd. No. 1

Deep Wells (Samples and Logs Received During the Year)—Continued

Location					Description			Remarks
Ls.	Sec.	Tp.	Range	Mer.	Year drilled	Depth in feet covered by records	Number of samples received	
								TABER
8	25	6	16	4th.....	1930	73	7	Cole Hunter, Taber Test No. 1
......	34	9	16	4th.....	1930	91	10	" " No. 2
2	9	10	17	4th.....	1930	97	19	" " No. 3
......	24	9	17	4th.....	1930	130	10	Majestic Mines, Test Hole No. 1
......	24	9	17	4th.....	1930	95	6	" " No. 2
......	24	9	17	4th.....	1930	96	10	" " No. 3
3	11	10	17	4th.....	1930	3,317	331	Taber No. 1
								TURNER VALLEY
16	19	19	2	5th.....	1930	6,020	373	Advance No. 5A
5	20	19	2	5th.....	1930	5,795	111	Alberta Pacific Consolidated No. 1
5	20	19	2	5th.....	1930	5,837	190	" " No. 2
16	22	20	3	5th.....	1930	3,570	201	Anaconda No. 1
13	20	19	2	5th.....	1930	5,870	177	Baltac No. 1, Northwest Co. Ltd.
6	12	20	3	5th.....	1930	5,148	17	British Dominion Oil and Development Co. Ltd. No. 2
6	12	20	3	5th.....	1930	3,870	406	" " " No. 3
2	1	20	3	5th.....	1930	5,850	44	Calmont Oils Ltd. No. 1
11	20	19	2	5th.....	1930	4,927	105	" No. 2
11	20	19	2	5th.....	1930	5,045	151	" No. 4
11	20	19	2	5th.....	19 0	5,415	397	" No. 7
11	20	19	2	5th.....	1930	1,580	128	" No. 8
11	20	19	2	5th.....	1930	1,310	113	" No. 10
11	20	19	2	5th.....	1930	450	40	" No. 11
12	34	20	3	5th.....	1930	3,170	19	Dalfin Oils Ltd. No. 1
9	30	19	2	5th.....	1930	5,003	114	Dalhousie Oils Ltd. No. 7
2	24	20	3	5th.....	1930	5,300	109	Dome Oils Ltd. No. 1
16	36	19	3	5th.....	1930	3,920	377	" No. 2
5	16	19	2	5th.....	1930	4,410	8	East Crest No. 1
4	16	19	2	5th.....	1930	3,203	136	" No. 2
4	16	19	2	5th.....	1930	4,577	457	" No. 2A

8	1	20	3	5th.....	1930	4,940	8	Foothills No. 2
16	8	19	2	5th.....	1930	6,040	57	" No. 3
4	3	21	3	5th.....	1930	4,800	189	Freehold No. 1
8	20	19	2	5th.....	1930	4,395	75	" No. 2
8	20	19	2	5th.....	1930	140	14	" No. 3
10	1	20	3	5th.....	1930	5,370	152	Freeman Lundy No. 1
10	20	19	2	5th.....	1930	5,076	129	Hargal Oils Ltd. No. 1
7	20	19	2	5th.....	1930	4,480	127	Home Oils Ltd. No. 5
2	20	19	2	5th.....	1930	4,680	465	" No. 6
1	20	19	2	5th.....	1930	2,260	218	" No. 7
5	16	19	2	5th.....	1930	4,795	144	Homestead Oils Ltd. No. 1
14	12	20	3	5th.....	1930	3,680	3	Illinois-Alberta No. 2
10	9	21	3	5th.....	1930	4,750	167	Invaders No. 1
11	17	19	2	5th.....	1930	5,460	154	Lowery Petroleum No. 1
11	17	19	2	5th.....	1930	4,000	390	" " No. 2
10	17	19	2	5th.....	1930	6,240	48	Mayland No. 1
8	17	19	2	5th.....	1930	4,892	174	" No. 2
2	17	19	2	5th.....	1930	6,173	265	" No. 3
16	17	19	2	5th.....	1930	1,160	122	" No. 4
15	1	20	3	5th.....	1930	5,040	433	McLeod No. 5
13	4	19	2	5th.....	1930	5,360	145	Mercury Oils Ltd. No. 1
11	4	19	2	5th.....	1930	5,420	200	" No. 2
2	4	19	2	5th.....	1930	5,270	135	" No. 3 (Sunlight No. 1)
2	4	19	2	5th.....	1930	4,590	400	" No. 5
2	4	19	2	5th.....	1930	1,880	176	" No. 7
13	27	18	2	5th.....	1930	4,860	52	Merland No. 1
9	1	20	3	5th.....	1930	4,140	50	Midfield No. 1
4	31	19	2	5th.....	1930	2,135	36	Mid-Royal No. 1
14	4	19	2	5th.....	1930	4,767	262	Mill City No. 1
14	4	19	2	5th.....	1930	5,065	42	" No. 1A
11	4	19	2	5th.....	1930	5,585	147	Miracle No. 1
8	22	20	3	5th.....	1930	5,890	55	Model Oils Ltd. No. 1
14	12	20	3	5th.....	1930	5,585	14	New McDougall-Segur No. 2
14	12	20	3	5th.....	1930	5,420	192	" No. 3
14	12	20	3	5th.....	1930	5,010	225	" No. 4
6	20	19	2	5th.....	1930	5,420	524	Northwest Associated No. 2
9	1	20	3	5th.....	1930	5,037	150	Okalta Oils Ltd. No. 2
9	1	20	3	5th.....	1930	4,140	132	" No. 3
8	1	20	3	5th.....	1930	890	66	Ranger No. 1
16	1	20	3	5th.....	1930	1,910	3	Regent No. 2
16	1	20	3	5th.....	1930	2,280	23	" No. 3
......	35	20	3	5th.....	1930	4,680	519	Richfield No. 1
10	12	20	3	5th.....	1930	4,020	151	Royalite No. 11
13	13	20	3	5th.....	1930	5,416	39	" No. 12
2	12	20	3	5th.....	1930	6,150	85	" No. 16
5	6	20	2	5th.....	1930	5,020	29	" No. 19

Deep Wells (Samples and Logs Received During the Year)—Continued

Location					Description			Remarks
Ls.	Sec.	Tp.	Range	Mer.	Year drilled	Depth in feet covered by records	Number of samples received	
								TURNER VALLEY—*Continued*
7	12	20	3	5th.....	1930	5,160	196	Royalite No. 20
13	13	19	2	5th.....	1930	5,320	101	" No. 23
3	29	19	2	5th.....	1930	5,240	503	" No. 24
11	31	19	2	5th.....	1930	4,030	364	" No. 25
15	8	20	2	5th.....	1930	5,850	127	Sentinel Oils Ltd. No. 1
16	1	20	3	5th.....	1930	6,180	338	Sioux City Oils No. 1
3	9	19	2	5th.....	1930	4,170	355	Southern Lowery No. 1
3	9	19	2	5th.....	1930	4,085	114	" No. 2
15	8	19	2	5th.....	1930	370	31	Southwest Petroleums No. 2
6	24	20	3	5th.....	1930	3,240	298	Spooner Oils Ltd. No. 3
14	13	20	3	5th.....	1930	5,290	517	" No. 4
9	5	19	2	5th.....	1930	2,250	31	Spray Oils Ltd. No. 1
15	33	18	2	5th.....	1930	6,525	237	Sterling Pacific No. 1
7	31	19	2	5th.....	1930	4,720	265	Structure Oils Ltd. No. 1
2	27	20	3	5th.....	1930	4,040	110	Turner Basin Oils Ltd. No. 1
5	34	20	3	5th.....	1930	2,970	26	Vanalta, Turner Valley No. 1
1	20	19	2	5th.....	1930	4,910	107	Wellington No. 1
11	12	20	3	5th.....	1930	4,960	159	Widney Oils Ltd. No. 1
								TWIN DOME
10	16	21	28	4th.....	1930	1,250	59	Twin Dome Oils Ltd. No. 1
								VERA
13	14	41	24	3rd.....	1930	1,850	142	Unity Valley Oils Ltd. No. 3

VIKING

6	7	49	12	4th.....	1930	2,140	211	Viking No. 16
1	31	48	12	4th.....	1930	2,190	217	" No. 17
8	17	49	12	4th.....	1930	2,118	204	" No. 18

WAINWRIGHT

16	36	44	7	4th.....	1930	2,690	37	Admiral Oils Ltd. No. 1
1	10	45	7	4th.....	1930	2,183	190	Beaument Oils No. 1
15	19	45	6	4th.....	1930	2,080	186	Edalta Oils Ltd. No. 1
12	6	45	7	4th.....	1930	323	19	Lloyd's Petroleum No. 1
1	24	45	8	4th.....	1930	1,777	198	Maple Leaf No. 2
8	20	45	6	4th.....	1930	2,232	62	Onalta Oils Ltd. No. 1
6	30	45	6	4th.....	1930	2,252	223	Wainwright Petroleum No. 1

WAITE VALLEY

8	33	19	3	5th.....	1930	3,060	226	Angus Oils Ltd. No. 1
2	35	20	4	5th.....	1930	3,700	153	Brock Petroleum No. 1
11	21	19	3	5th.....	1930	3,070	233	Calgary Development and Producers Co. No. 1
5	21	21	4	5th.....	1930	240	22	Cotton Belt Mines No. 1
4	18	20	3	5th.....	1930	1,400	56	Gibraltar No. 1
2	6	20	3	5th.....	1930	4,270	217	Innerfold Oils Ltd. No. 1
16	27	19	3	5th.....	1930	550	5	Roselite No. 1

WILDCAT HILLS

2	9	27	5	5th.....	1930	2,100	50	Frontier Oils Ltd. No. 1

Shallow Wells (Logs Received During the Year)

Owner	Ls.	Sec.	Tp.	Range	Mer.	At or near	Depth covered by records	Depth to bed-rock	Depth from surface to water	Driller	Remarks
							Ft. Ins.	Feet	Ft. Ins.		
Davidson, W. P.	SE. ¼	23	5	7	E.P.M.	Marchand	154		147	Friesen, C. K.	
Can. Pac. ry	SE. ¼	19	3	18	W.P.M.	Ninga	42		17	McCauley, J.	Water hard
Can. Nat. rys.	SE. ¼	7	45	3	2nd		136		6	Rahrick and Mainville	Rises to 6 feet from surface
Gienn, Ervin	NW. ¼	30	2	4	"	Hirsch	360		320	Price, A.	Water soft
Can. Nat. rys.		20	34	4	"	Sturgis	26		14	Buckoly, E.	Water in sand and gravel
" "	NW. ¼	30	34	4	"	Hinchcliffe jct.	27		17	"	All coarse sand below soil
" "		6	42	4	"	Kakwa	374		234	Rahrick and Mainville	Water salty, a little gas at 273 feet
Schopp, M.		3	3	5	"	Hirsch	360		260		
Can. Nat. rys.	NW. ¼	23	35	5	"	Lady Lake	35		23	Buckoly, E.	
" "		4	36	5	"	Hinchcliffe	36		27	Buckoly, E.	
" "	NE. ¼	9	37	5	"	Endeavour	35		23	Buckoly, E.	
" "	NE. ¼	4	38	5	"	Usherville	57		40	Buckoly, E.	
" "	NE. ¼	4	38	5	"	Usherville	52			Buckoly, E.	
" "		15	39	5	"	Tallpines	27		16	Buckoly, E.	
" "			40	5	"		340			Rahrick and Mainville	Dry
Mandt, C. P.	NE. ¼	36	2	6	"	Bienfait	208			Price, A.	
Can. Nat. rys.	SW. ¼	9	42	9	"	Copeau	31		16	Buckoly, E.	
" "	SW. ¼	9	42	9	"	Copeau	50		30	Buckoly, E.	
Wolseley town		11	17	10	"	Wolseley	63		15	Byass, D.	Gravel bands in clay
Can. Nat. rys.	SW. ¼	16	42	10	"	Chelan	26		14	Buckoly, E.	
" "	SW. ¼	16	42	10	"	Chelan	27		19	Buckoly, E.	
" "	NE. ¼	4	43	11	"	Steen	34		22	Buckoly, E.	
Indian Affairs Department	Okanese reserve					Balcarres	130			McPherson and Thom	
Indian Affairs Department	Little Black Bear reserve					Balcarres	200			McPherson and Thom	
Indian Affairs Department	Little Black Bear reserve					Balcarres	200		120	McPherson and Thom	
Indian Affairs Department	Okanese reserve					Balcarres	100		20	McPherson and Thom	

Indian Affairs Department	Okanese reserve........................					Balcarres.......	226		....	....		McPherson and Thom	Clay throughout
Indian Affairs Department	Peepeekisis reserve.....................					Balcarres.......	167		....	....		McPherson and Thom	Good supply
Scott, J. G.......	....	21	17	12	2nd	Sintaluta........	186		....	96		Clark, W. E....	
Osley, Hammond and Nanton	....	16	17	12	"	Sintaluta........	159	6	....	69	6	Clark, W. E....	Water contains iron
Can. Nat. rys....	SW. ¼	19	42	12	"	Zénon Park.....	121	6	....	87	6	Can. Well Supply Co.	Water below hard ledge
" "	NW. ¼	14	43	12	"	Bjorkdale.......	45	0	....	35	0	Buckoly, E.....	
" "	NW. ¼	14	43	12	"	Bjorkdale.......	26		....	17		Buckoly, E.....	
" "	NE. ¼	6	45	12	"	Crooked River..	25	6	....	9	6	Buckoly, E.....	
" "	SW. ¼	19	47	12	"	Zénon Park.....	121	6	108	99	6	Kech, H. J.....	Water salty in black shale
Schroeder, J. P...	....	31	14	13	"	Odessa..........	200		....	....		Dempsey, S....	
" "	SW. ¼	31	14	13	"	Odessa..........	105		....	20		Dempsey, S. ...	Water hard
Can. Nat. rys....	NE. ¼	22	46	13	"	New Osgoode...	301	5	....	....		Can. Well Supply Co.	A little water at 80 feet
Muscouequan School	NW. ¼	14	27	15	"	Lestock.........	146		....	116		Dempsey, S....	
Rattray, G. T....	SW. ¼	19	20	18	"	Tehner.........	275		....	165		Hay, T.........	
Crystal Brewing Co., Ltd.	....	19	17	19	"	Regina..........	265		....	205		McPherson and Thom	Water in sand and gravel 248-262 feet
Regina waterworks	SW. ¼	31	19	19	"	Regina..........	176		....	117		....	
Regina waterworks	SW. ¼	31	19	19	"	Regina..........	90		....	....		....	
Regina waterworks	NW. ¼	32	19	19	"	Regina..........	163		....	26		....	
Smuts town.......	NE. ¼	8	40	1	3rd	Smuts..........	259		....	80		Rahrick and Mainville	
Aberdeen town...	SW. ¼	13	39	2	"	Aberdeen.......	232		....	75		Rahrick and Mainville	
Can. Nat. rys....	SE. ¼	19	49	3	"	Shellbrook......	31		....	10	6	Buckoly, E.....	Water sand 26-31 feet
" "	SW. ¼	21	49	4	"	Cameo..........	70		....	58		Buckoly, E.....	
" "	SW. ¼	29	49	5	"	Ordale..........	45		....	35		Buckoly, E.....	
" "	SW. ¼	29	49	5	"	Ordale..........	45		....	21		Buckoly, E.....	
" "	NW. ¼	5	50	6	"	Mount Nebo....	34		....	8	6	Buckoly, E.....	All sand and gravel
" "	NW. ¼	5	50	6	"	Mount Nebo....	30		....	12		Buckoly, E.....	All sand and gravel
" "	SW. ¼	11	50	8	"	Shell Lake......	40		....	35		Buckoly, E.....	Water in coarse gravel
" "	SE. ¼	11	50	8	"	Shell Lake......	42	4	....	28	4	Buckoly, E.....	Entirley in sand and gravel
" "	SW. ¼	22	50	9	"	Amiens.........	68		....	16		Buckoly, E.....	
" "	SW. ¼	22	50	9	"	Amiens.........	178	6	....	58	6	Buckoly, E.....	
" "	NW. ¼	25	50	10	"	Mildred.........	42		....	24		Buckoly, E.....	
Greenhorn, A.....	SE. ¼	6	30	11	"	....	500		....	405		Fortier, C......	Very soft water

Shallow Wells (Logs Received During the Year)—Continued

Owner	Ls.	Sec.	Tp.	Range	Mer.	At or near	Depth covered by records	Depth to bed-rock	Depth from surface to water	Driller	Remarks
							Ft. Ins.	Feet	Ft. Ins.		
Can. Nat. rys.	SE. ¼	2	51	11	3rd	Spiritwood	61 6	....	51 6	Buckoly, E.	
" "	SE. ¼	2	51	11	"	Spiritwood	45	....	10 6	Buckoly, E.	
Head, Mrs. A.	SW. ¼	19	28	12	"	Sovereign	300	....	240	Dom. Well Drillers	Used for stock
Turner, L. B.	NW. ¼	31	28	12	"	Sovereign	266	....	66	Dom. Well Drillers	Water laxative
Sprott, W. J.	SW. ¼	26	28	13	"	Sovereign	441	....	361	Dom. Well Drillers	
Greer, J. V.	SW. ¼	6	30	12	"	Sovereign	300	....	220	Robins, J. M.	Water hard
Can. Nat. rys.	SW. ¼	11	51	12	"	Bapaume	44 9	....	35 9	Buckoly, E.	Water in gravel
Bailey, H.	NE. ¼	3	29	13	"	Sovereign	294	....	70	Elliott, R.	Water hard and tastes of iron
Piercy, B. F.	SE. ¼	33	29	13	"	Sovereign	272	....	....	Robins, J. M.	Water alkaline
Thurston, J. J.	NE. ¼	17	29	13	"	Sovereign	360	....	270	Fortier, C.	Water soft, alkaline, contains iron
Miller, J. S.	NW. ¼	16	29	13	"	Sovereign	490	....	80	Fortier, C.	Water soft
Thornton, G. W.	NW. ¼	21	29	13	"	Sovereign	198	....	98	Elliott, R.	Water contains iron
McCauley, W. C.	NE. ¼	10	29	13	"	Sovereign	426	....	70	Dom. Drilling Co.	Very good supply
Millsop, J.	NE. ¼	9	29	13	"	Sovereign	240	....	150	Robins, J. M.	
Lampman, B.	SW. ¼	22	29	13	"	Sovereign	320	....	240	Fortier, C.	
Can. Nat. rys.	SE. ¼	2	51	13	"	Belbutte	50 6	....	41 6	Buckoly, E.	
" "	SE. ¼	2	51	13	"	Belbutte	50 6	....	40 6	Buckoly, E.	
Biggar town	SE. ¼	6	36	14	"	Biggar	167	....	87	Layne Can. Water Supply Co.	Water medium hard
Can. Nat. rys.	SW. ¼	12	50	15	"	Medstead	56	....	17	Buckoly, E.	
" "	SE. ¼	11	50	15	"	Medstead	55	....	41	Buckoly, E.	
" "	SE. ¼	11	50	15	"	Medstead	61	....	47	Buckoly, E.	Water in coarse sand and gravel
Bracken village	SE. ¼	4	3	16	"	Bracken	100	....	60	Hannah, P.	Water too alkaline for use
" "	SE. ¼	4	3	16	"	Bracken	608	....	200	Bengston, S.	Water soft with some soda

Can. Nat. rys....	NW. ¼	18	50	18	3rd	Berentin........	72	....	60	Buckoly, E.....	Hole dry until shot with dynamite
Anderson, E. W. .	NW. ¼	20	29	2	4th	Sibbald.........	280	....	20	Oszust, J........	
Dom. Range Experimental Station............	NE. ¼	15	2	4	"	Manyberries....	1,133	....	....	Colbert, J.......	*See* log on page 76
Carlson, A........	NW. ¼	25	1	4	"	Onefour.........	26	....	20	....	
Wetherelt, J......	SE. ¼	27	1	4	"	Onefour.........	134	....	50	Mr. Williams...	
Lindsay, A.......	SE. ¼	25	1	4	"	Onefour.........	21	19 6	5	....	Water soft Sandstone at 19½, large supply
Chisholm, F.F.O.	SE. ¼	28	1	4	"	Wrentham......	105	....	25	Mr. Edwards...	Soft with a little water in quicksand below 65 feet of hardpan
McBain, J........	NE. ¼	32	1	4	"	....	60	....	....	....	Alkaline water at 15 feet; sand at 56 feet; clayey gravel above sand Lower water good
"	NE. ¼	32	1	4	"	....	30	....	....	....	
Cross, S..........	NE. ¼	35	1	4	"	....	17	....	12	....	Entirely in drift
Experimental Station	SE. ¼	9	2	4	"	Manyberries....	119	....	....	Ronnes, H......	
White, W. W......	NW. ¼	29	29	4	"	Oyen...........	180	....	....	Oszust, J........	
Can. Nat. rys....	NW. ¼	22	55	4	"	Heinsburg......	85	....	45	Barker, F.......	Water hard. Contains iron. Entirely in drift
" "	SW. ¼	22	55	4	"	Heinsburg......	300	50	....	Barker, F.......	Dry. Black shale 50-300 feet
" "	SW. ¼	22	55	4	"	Heinsburg......	55	....	20	Barker, F.......	Entirely in drift. Blue clay below water sand, water hard
" "	....	10	56	4	"	Heinsburg......	70	....	35	Barker, F.......	Water soft. In sand 58-66 feet
" "	SW. ¼	22	55	4	"	Heinsburg......	300	85	....	Barker, F.......	Dry sand 14-85 feet
Heath school.....	....	23	44	5	"	Heath..........	360	....	....	Schieck, T.....	Entirely in drift. Water soft
Reid, R. B.......	....	6	45	5	"	Wainwright....	221 6	218	95	Schieck, T.....	Water soft. Nine barrels per hour

Shallow Wells (Logs Received During the Year)—Continued

Owner	Ls.	Sec.	Tp.	Range	Mer.	At or near	Depth covered by records	Depth to bed-rock	Depth from surface to water	Driller	Remarks
							Ft. Ins.	Ft. Ins.	Ft. Ins.		
Can. Nat. rys....	....	34	56	5	4 th	Lindbergh......	135	....	95	Barker, F.......	Soft water in gravel 127-130 feet; white clay 1-8 feet; quick sand 18-95 feet; clay 95-127 feet
" "	NW. ½	34	56	5	"	Lindbergh......	178	....	168	Barker, F.......	Hard water in sand 168-174 feet
Vesey, E. A......	NW. ¼	8	60	8	"	Beacon House, Glendon	200	....	....	Salls, J. A......	Coal fragments at about 200 feet
Indian Affairs Department	....	11	58	10	"	St. Paul de Metis	461	....	....	Douglas, J. G...	Rock at 430 feet; water, soft, 300-400 feet; very hard at higher levels
Fletcher, J. R....	NW. ½	22	8	14	"	Purple Springs..	876	....	....	Fortune, J	A little gas with the water at 865 feet, water flows
Can. Pac. ry......	....	28	19	25	"	Herronton......	285	....	....	....	Rock at 260 feet; water sand 98-130 feet
Giroux Bros......	....	32	77	19	5th	McLennan......	682	....	602	Weaver, R. H..	Rock 280 feet; very soft 360-460 feet (bentonitic?) water at 670 feet, soft, contains soda
Gilbert, C........	5	34	81	1	6th	Whitelaw.......	85	....	....	Hyslop, J. A....	Clay with streaks of gravel, gas
"	5	34	81	1	"	Whitelaw.......	85	....	....	Hyslop, J. A....	Water alkaline, but potable. Driller reports small, clean gravel below clay
Featherston, W.E.	....	9	81	3	"	Waterhole......	601	120	....	Weaver, R. H..	Sandstone 120-240 feet; hard shale below. Driller reports crevices in both sandstone and shale; well dry; "breathing" well

Fairview village..	....	34	81	3	"	Fairview........	387	....	....	Weaver and Co.	Water at 387 feet
Liberty, W........	NW. ¼	32	70	11	"	Rio Grande.....	125	....	....	Foster, C.......	Water soft
Swanson, E........	....	9	71	10	"	Halcourt........	120	....	112	Foster, C.......	Water hard
Cleland, B. O.....	NW. ¼	8	71	10	"	Halcourt........	214	....	10	Oszust, J........	Water now soft, was hard for a while
Lossing, C. F.....	NE. ¼	36	71	10	"	Beaverlodge....	80	....	20	Mr. Mefstead	Water hard
Stone, G..........	SW. ¼	3	72	10	"	Beaverlodge....	66	50	1	Foster, C.......	Water soft, good supply
Hodges, V. C.....	SW. ¼	15	72	10	"	Beaverlodge....	110	100	....	Foster, C.......	Water slightly hard
Cunningham, R. A.	SW. ¼	27	72	10	"	Beaverlodge....	150	145	141	Foster, C.......	Water soft
Wright, G.........	....	1	72	10	"	Beaverlodge....	140	....	45	Foster, C.......	Water hard, good supply
Lay, H. R.........	NW. ¼	15	72	10	"	Beaverlodge....	150	....	125	Oszust, J........	Water soft in gravel; quicksand at about 100 feet
Cook, J...........	NE. ¼	35	70	12	"	Rio Grande.....	160	100	130	Foster, C.......	Water very soft
Cariboo school...	NW. ¼	28	70	12	"	Rio Grande.....	118	20	....	Oszust, J........	Water soft, good supply
O'Connell, D.....	SW. ¼	1	71	12	"	Rio Grande.....	122	70	....	....	Water soft
Pack, G. W.......	SE. ¼	21	72	21	"	Beaverlodge....	140	....	133	Foster, C.......	Water fairly soft

OTHER FIELD WORK

Geological

G. S. Hume. Mr. Hume geologically mapped part of Jumpingpound 1-mile quadrangle (latitudes 51° 00′ to 51° 15′, longitudes 114° 00′ to 114° 30′) and part of Calgary Southwest 1-mile quadrangle (latitudes 50° 45′ to 51° 00′, longitudes 114° 00′ to 114° 30′), Alberta.

W. A. Johnston. Mr. Johnston continued the investigation of the surface geology, including the soils, of Regina 8-mile map-area (latitudes 49° to 52°, longitudes 102° to 109°), Saskatchewan. He also investigated and mapped a block of seventy townships in southeastern Alberta and southwestern Saskatchewan; this work was done in co-operation with the Manyberries station of the Department of Agriculture.

P. S. Warren. Mr. Warren completed the study and mapping of the geology of the northern part of Regina 8-mile map-area (latitudes 49° to 52°, longitudes 102° to 109°), Saskatchewan.

S. R. Kirk. Mr. Kirk continued the study and mapping of the geology of the western part of Winnipeg 8-mile map-area (latitudes 49° to 52°, longitudes 95° to 102°).

Topographical

W. H. Miller. Mr. Miller continued the topographical survey of Nordegg 1-mile quadrangle (latitudes 52° 15′ to 52° 30′, longitudes 116° 00′ to 116° 30′), Alberta.

J. W. Spence. Mr. Spence completed the topographical survey of Wildcat Hills 1-mile quadrangle (latitudes 51° 15′ to 51° 30′, longitudes 114° 30′ to 115° 00′), Alberta.

J. A. Macdonald. Mr. Macdonald made a detailed topographical survey (field scale 800 feet to 1 inch) of the coal-mining area at Hillcrest, Alberta.

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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 four parts, A, B, C, and D. A review of the work of the Geological Survey for the year forms part of the Annual Report of the Department of Mines.