PROVINCE OF MANITOBA

DEPARTMENT OF MINES AND NATURAL RESOURCES

MINES BRANCH

PUBLICATION 49-1

THE STRATIGRAPHY OF MANITOBA WITH REFERENCE TO OIL AND NATURAL GAS POSSIBILITIES

BY

Lillian B. Kerr

WINNIPEG, 1949

Errata:

Throughout this publication all references to the Commonwealth #2 well should be deleted. The location of this well is incorrect; the correct location is believed to be 1, S. 6, Sec. 25, T. 2, R. 6, W. Principal Mer. which is within a mile of the Commonwealth Levisay No. 2 well. The original data is no longer available and therefore the most reliable log of the Commonwealth Levisay No. 2 well should be considered representative of the section in this area.

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THE STRATIGRAPHY OF MANITOBA

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INTRODUCTION

During the past two years a growing interest has been shown in Manitoba as a possible source of petroleum and natural gas. The geological section in Manitoba includes appreciable thicknesses of Cretaceous, Devonian and Ordovician rocks; formations of the same ages in other parts of North America are known to be hospitable to oil accumulations. Deep drilling in parts of southeastern Saskatchewan and adjacent areas of North Dakota has indicated the presence of Mississippian and Triassic formations which may extend into Manitoba in the form of "sedimentary wedges". This report has been prepared for the purpose of gathering together all the data that are available on exploration undertaken in this field in the past, and to describe the occurrences of gas and oil shows which have been encountered. In addition to a brief history of exploration and the description of oil and gas occurrences, a section of this bulletin will be devoted to the post-Cambrian stratigraphy of the southern part of the province, and mention will be made of local structures which have been investigated. Also included is a schedule of wells listing all wells drilled in the province for which information is available, and descriptive logs of selected deep wells. A map shows the location of the wells listed in the Schedule of Wells, and correlation charts indicate the relation of the geological section in Manitoba to that in North Dakota.

The most favourable portions of the province from the point of view of potential petroleum and natural gas production have been explored only to a limited degree; very few deep wells have been drilled and of these not more than three or four were properly tested. A well drilled in 1949 in the vicinity of Lyleton is the first deep well drilled in the southwestern part of the province. As geological and geophysical exploration of this territory is presently being conducted under competent and experienced direction, it is probable that more drilling of deep test wells will be undertaken within the next few years to explore the possibilities of petroleum and natural gas production. Such wells, when drilled, will add greatly to our knowledge of the subsurface geology of the province and the information presented herein may soon become obsolete. However, certain conclusions regarding regional features may be reached from information available from Manitoba wells, when this information is studied in relation to deep wells in Saskatchewan and North Dakota.

This report will be concerned chiefly with the south-western part of Manitoba, with brief references to wells in North Dakota and Saskatchewan.

HISTORY OF EXPLORATION

The first drilling in Manitoba was done in 1873 when a Geological Survey of Canada party under the direction of W. B. Waud (1874, pp. 12-16)[1] drilled a series of holes for the three-fold purpose of geological exploration, investigation of ground water supply, and exploration for accessible beds of coal and other useful minerals in proximity to the proposed course of the Canadian Pacific railway. Three holes were drilled[2]; the deepest was seventy feet, and none penetrated below the glacial drift. A second attempt was made the following summer (Selwyn, 1876, pp. 2-3); a party from the Geological Survey of Canada resumed work on Rat Creek and also carried out operations in the vicinity of Fort Ellice on the Assiniboine River and on the Swan River near Fort Pelly, with a view to ascertaining the eastern limit of the Cretaceous coal-bearing rocks and investigating the possibility of locating artesian wells which would supply water suitable for domestic use. This drilling was continued to a depth of 210 feet; the hole penetrated eighty-eight feet of surficial deposits, forty-two feet of Palaeozoic, probably Devonian, limestone, and eighty feet of "grey rock", belonging to the Precambrian basement. In 1880, a party under the direction of Dr. A. R. C. Selwyn (1881, pp. 2A-9A) drilled four holes along the Souris River valley between Roche Percée in Saskatchewan and Turtle Mountain in Manitoba in search of the Tertiary lignite which is exposed near Roche Percée; none was encountered although the holes were from 155 to 295 feet deep.

The first exploration for petroleum was undertaken in 1887 (Tyrrell, 1891, p. 102). In April of that year a Manitoba charter was granted to the Manitoba Oil Company. A percussion drill was hauled north from Strathclair to the west bank of the Vermilion River in tp. 23, rge. 20, W. Principal mer., a distance of over forty miles. The first well had been drilled to a depth of 292 feet when a mechanical failure delayed the work until the following year.

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[1] References are listed on page 131

[2] (1) On the north bank of the Assiniboine River within the present city limits of Winnipeg - 31 feet deep (2) SE¼, sec. 31, tp. 15, rge. 2, W. Principal mer. - 25 feet deep (3) On Rat Creek, 66 miles west of the present city of Winnipeg.

In 1888, the drill was moved a short distance down the valley and a second hole was drilled to a depth of 743 feet.

Most of the wells drilled in the province prior to 1900 were drilled in search of water, and the geological information they afforded was merely a by-product. Notable among these were the Rosenfeld, Deloraine and Morden wells, drilled in the towns bearing the same names. The Rosenfeld well was drilled sometime prior to 1886 by the Canadian Pacific Railway Company to a total depth of 1037 feet. In 1888, the Town of Deloraine drilled a water well to a depth of 1943 feet and in 1889-90 the Town of Morden drilled a 600-foot well.

In the interval from 1900 to 1930, charters were granted to several companies interested in oil and gas exploration. Many of these charters were surrendered or cancelled with no wells having been drilled; a record of the wells which were drilled can be found in Schedule of Wells in the latter part of this publication.

The 1930's saw a renewed interest in oil and gas exploration, and several wells were drilled into the Palaeozoic formations. Notable among these were the Dauphin well, the Commonwealth Manitou No. 2 well and the Lisgar well. The Canadian Industries Limited well drilled near Neepawa for the recovery of salt brine was also of value for the geological information obtained. The Manitoba and Saskatchewan Oil and Gas Development Syndicate was formed in 1943. This syndicate has drilled two wells to the Palaeozoic to date. The first was the Portage la Prairie No. 1 drilled in 1944 and the other, the Gilbert Plains No. 1 drilled the following year. These wells are at present standing suspended at depths of 1540 feet and 1370 feet respectively, awaiting completion. The most recent drilling was done near Neepawa by the Langford Oil Syndicate which drilled the Langford No. 1 well to the Precambrian basement in 1947, and near Lyleton by the Souris Valley Oil Company which drilled the Gordon White No. 1 well to a depth of 5160 feet in 1949.

STRATIGRAPHY

The following descriptions of the geological formations of Manitoba are based primarily on well cuttings. The writer has examined all the cuttings available from Manitoba wells, but for the wells from which no samples were available, reference has been made to published logs. In cases where descriptions of outcrops give a more complete picture of the formation under discussion, reference is made to the field work of members of the Geological Survey of Canada and of other geologists.

The sedimentary rocks underlying Manitoba range in age from Ordovician to Paleocene; they have a total thickness of several thousand feet in the southwestern part of the province and gradually thin towards the northeast where the Precambrian shield is exposed. In general, the strata have a very gentle dip to the southwest, with the result that they outcrop progressively from west to east from the Cretaceous escarpment to the Precambrian shield.

Throughout this section of the report, several figures are included, which show the formations from the Ordovician to the Jurassic as they appear in well sections. In each figure, the bottom of the formation has been taken as the base line so that thicknesses and lithology may be compared easily.

PALAEOZOIC STRATIGRAPHY

Cambrian Period

To date, no sediments of Cambrian age have been identified in Manitoba. More than 219 feet of rocks of Cambrian age are found in the Northern Pacific No. 1 well in Fallon County, Montana (Laird, 1944), just beyond the North Dakota boundary, and it is believed that this formation extends into the western part of North Dakota. A well drilled near Ogema, Saskatchewan, penetrated 800 feet of sandstone, possibly Cambrian, and Cambrian beds are known to occur across southern Alberta. As the formation thins in an easterly direction across Montana and the Canadian prairies, it has probably pinched out somewhere to the west of Manitoba.

Wallace (1925, p. 16) suggested that the basal sandstone beds are correlative with the Ordovician St. Peter's Sandstone of Minnesota. Formerly correlation of the sandstone with the Potsdam Sandstone of late Cambrian times had been suggested though not on the bases of any paleontological data. Some geologists at the present time would correlate the sandstone with the Deadwood formation of North Dakota which is believed to be Cambrian in age. The northeasterly extent of the Cambrian seas will not be known until more deep wells are drilled in the marginal area.

Ordovician Period

The Ordovician seas extended over a much greater area than those of the Cambrian period; sediments of Ordovician age are believed to underlie all of southern Manitoba west of the Precambrian shield. Wallace (1925, p. 20) describes sediments of Ordovician age exposed in the Hudson's Bay region, leading to the belief that there was a continuous sea "from Hudson's Bay to southern Manitoba and probably to Wyoming and Colorado" during Ordovician time. The thickness of the Ordovician section is 1970 feet in the Emma L. Semling No. 1 well in Oliver County, North Dakota, 1590 feet in the Northern Pacific No. 1 well (Montana) 1200+ feet in the Norcanols Parry No. 1 well in Saskatchewan and 500-700 feet in Manitoba wells. The Ordovician sediments thin toward the southern Alberta plains and do not extend to the foothills. In most of the sections studied the Ordovician rocks can be divided into three formations which will be discussed in turn.

Winnipeg Formation

The oldest Ordovician rocks in Manitoba belong to the Winnipeg formation, and where found rest on the Precambrian basement. This formation is a sequence of shale and sandstone beds, having a thickness of 605 feet in the Northern Pacific No. 1 well (Montana), 520 feet in the Emma L. Semling No. 1 well (North Dakota), and 100-200 feet in Manitoba wells, except at Mafeking where 42 feet of sand alone make up the Winnipeg formation. The usual sequence is a relatively thin bed of colorless mostly unconsolidated sand, composed of rounded grains, overlain by a dark-green, splintery, in places slightly calcareous shale. The sand seems to thicken to the north to the exclusion of the shale, as the Winnipegosis No. 4 well penetrated about equal thicknesses of each and, as previously stated, the Mafeking well showed 42 feet of sand and no shale. The Langford No. 1 well failed to encounter any sand resting on the Precambrian basement. It is quite possible that some of the variations in the thickness of the sandstone are due to irregularities in the Precambrian surface on which it was laid down. A possible Cambrian age of the basal sandstone of the Winnipeg formation was discussed above.

Red River Formation

The Red River formation occupies the middle part of the Ordovician section; it is by far the thickest of the three formations in Manitoba. The thickness decreases from 830 feet in the Emma L. Semling No. 1 well (North Dakota), and 590 feet in the Northern Pacific No. 1 well (Montana), to 542 feet in Commonwealth Manitou No. 2, 480 feet in Portage la Prairie No. 1, 495 feet in Stony Mountain No. 1, and 340 feet in Winnipegosis No. 4. The

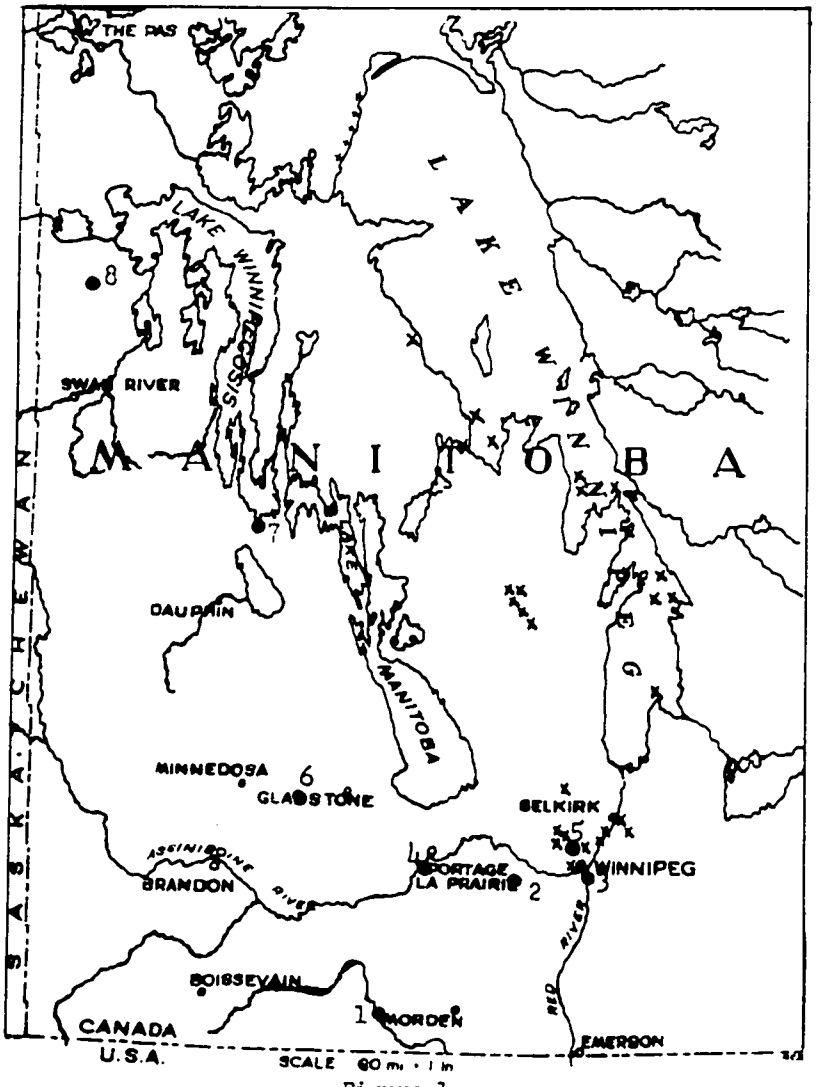

Figure 1

Map of Manitoba showing location of wells which penetrate Ordovician beds and location of outcrops of Ordovician strata. Well-sites are marked by large dots and outcrops by small crosses.

1. Commonwealth Manitou #2, 2. Commonwealth Pete #2, 3. Wells in vicinity of Winnipeg, 4. Portage la Prairie #1, 5. Stony Mountain, 6. Langford #1, 7. Winnipegosis #4, 8. Mafeking #3

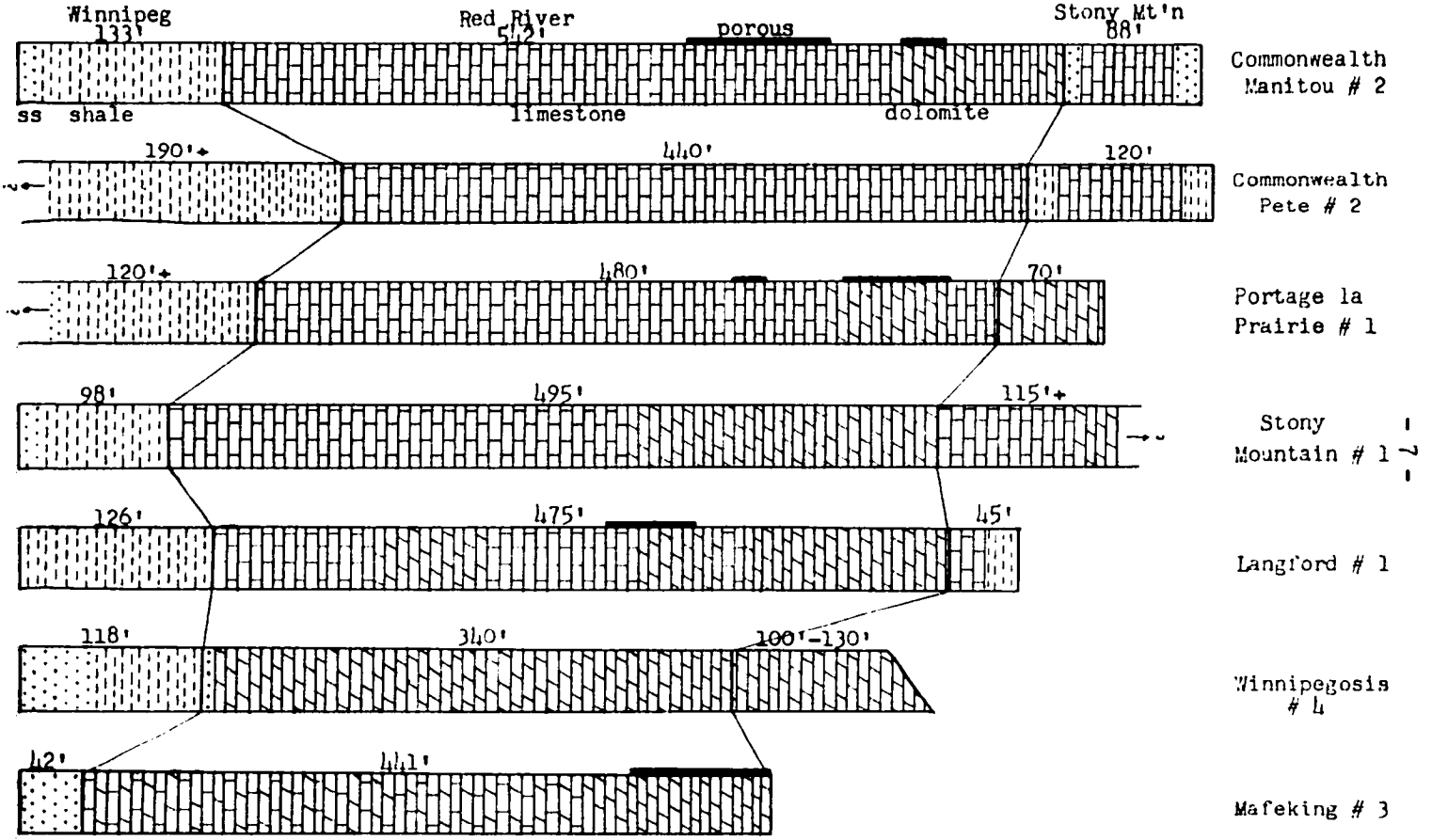

Figure 2
The Ordovician in Well Sections

formation consists chiefly of light-grey or buff and cream limestones in the southern part of the province. A band of light-coloured dolomite lies near the top of the section in the Commonwealth Manitou No. 2 and Portage la Prairie No. 1 wells. To the northwest, the dolomite content increases; the Langford No. 1 well encountered a thick bed of dolomite nearer to the base of the section, and in the Langford No. 1 and Stony Mountain No. 1 wells the whole upper section is dolomite; the Winnipegosis No. 4 section is almost entirely dolomite and the Mafeking No. 3 well penetrated dolomite and dolomitic limestone. Some porous beds in the Red River formation are seen in cuttings from the Commonwealth Manitou No. 2, Portage la Prairie No. 1 and Langford No 1 well.

The Red River formation as seen in outcrops is divisible into three members, the Lower Mottled or Dog Head, the Cat Head, and the Upper Mottled or Selkirk. According to Wallace (1925, pp. 17-18), the Dog Head is a buff-coloured limestone with darker brown spots; the Cat Head is a more dolomitic limestone with an abundance of chert nodules flattened along the bedding planes and most abundant near the base; the top beds are porous, honeycombed dolomites. The Selkirk consists of a light-grey limestone with darker patches, buff or blue in colour, which Wallace believed to be due to dolomitization. All three members contain abundant macro-fossils. To date it has not been possible to distinguish between the three members in well cuttings.

Stony Mountain Formation

The upper series of Ordovician sediments has a considerable thickness in the Northern Pacific No. 1 (Montana) and Emma L. Semling No. 1 (North Dakota) wells; 455 feet of these beds are found in the former well and 620 feet in the latter. The section in Manitoba is considerably thinner, being less than 130 feet thick in all the wells that penetrated it. The Stony Mountain section is a series of limestones and dolomites chiefly pink and/or grey in color. The Commonwealth Manitou No. 2 well has a sand bed at the top and another at the base of the formation; these beds have not been encountered in other wells although some sand is present in the limestones in the Commonwealth Pete No. 2 well.

From outcrops the Stony Mountain formation can be divided into four members as described by Okulitch (1943, pp. 60-64). In ascending order these are Stony Mountain Shale, Penitentiary, Gunton, and Birse. The lowest member is red shale interbedded with thin bands of hard, reddish, or dark-grey limestone and is highly fossiliferous. The Penitentiary member consists of soft and crumbly dolomite, buff to yellowish in colour with a little greenish-yellow and purple. The Gunton is composed of dense, hard, massive dolomite, buff in color with some red or maroon-coloured bands; some of the beds appear to be porous, possibly due to the weathering-out of small fossils. The upper member consists of white to light-buff dolomite or dolomitic limestone which weathers to a buff or ivory colour; weathering-out of fossils has

made the uppermost beds porous.[1] The information obtained from wells studied to date has not been sufficient to distinguish between these members.

Silurian Period

Stonewall Formation

Unlike the formations underlying it, the Stonewall appears to have the greatest thickness in the central part of the area under consideration and to thin towards the south and north. There are no known Silurian sediments in North Dakota with the possible exception of some in the extreme northeast corner of the state. The Commonwealth Manitou No. 2 well penetrated 400 feet of Stonewall beds, the Commonwealth Pete No. 2 well 430 feet, the Portage la Prairie No. 1 well 495 feet and the Langford No. 1 well 605 feet. From the Langford No. 1 well northward, the section becomes thinner; the Winnipegosis No. 4 well showed a thickness of 510 feet for the Stonewall, and the Mafeking No. 3 well 240 feet. Silurian sediments extend into southern Saskatchewan but do not extend as far west as southern Alberta.

The Stonewall formation is composed essentially of pink cream and buff-grey dolomites[2]. A bed of limestone can be traced through the Commonwealth Manitou No. 2, the Portage la Prairie No. 1, the Langford No. 1 and the Dauphin wells. This bed is 20 feet thick in the Commonwealth Manitou No. 2 well, 30 feet in the Portage la Prairie No. 1 and Langford No. 1 wells and 40 feet in the Dauphin well. The Commonwealth Manitou No. 2 and Portage la Prairie No. 1 wells intersect a second limestone bed some 60 feet below the first, but this bed is not recognized in cuttings from wells to the north. The top of the Stonewall formation in Manitoba is placed at the top of a red calcareous shale bed 10 to 20 feet thick, except in the Commonwealth Manitou No. 2 well where 20 feet of dolomite overlie the shale. In the Neepawa No. 2 well, the Langford No. 1 well and the Dauphin well, a bed of anhydrite 20 to 50 feet thick is encountered not far below the red shale. Zones of porosity were encountered in the Silurian dolomites in the Commonwealth Manitou No. 2, the Portage la Prairie No. 1 and the Langford No. 1 wells.

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[1] On the basis of lithology alone E. M. Kindle and S. R. Kirk considered the beds included in the Birse to be Silurian.

[2] The Commonwealth Pete No. 2 section is described as limestone; however this is a driller's description and it is probable that the rock was actually dolomite.

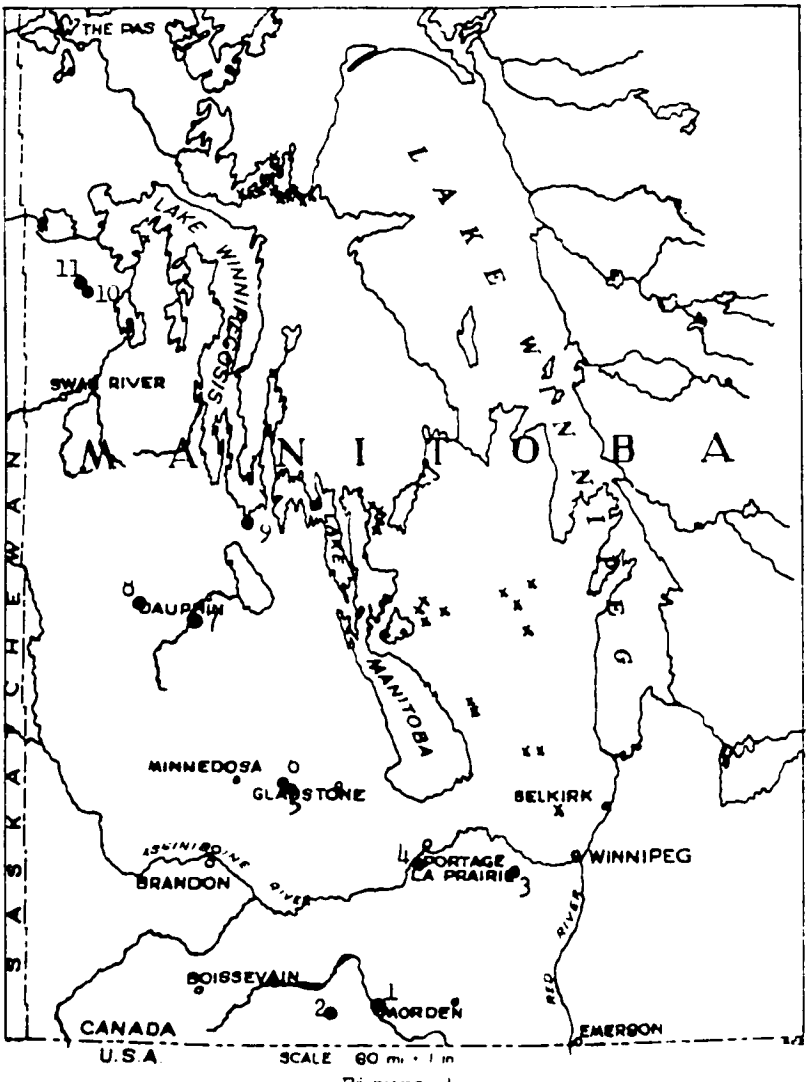

Figure 3

Map of Manitoba showing location of wells which penetrate Silurian beds and location of outcrops of Silurian strata. Well-sites are marked by large dots and outcrops by small crosses.

1. Commonwealth Manitou #2, 2. Pilot Mound, 3. Commonwealth Pete #2, 4. Portage la Prairie #1, 5. Langford #1, 6. Neepawa Salt #2, 7. Dauphin, 8. Gilbert Plains #1, 9. Winnipegosis #4, 10. Northern Manitoba Oil #3, 11. Mafeking #3.

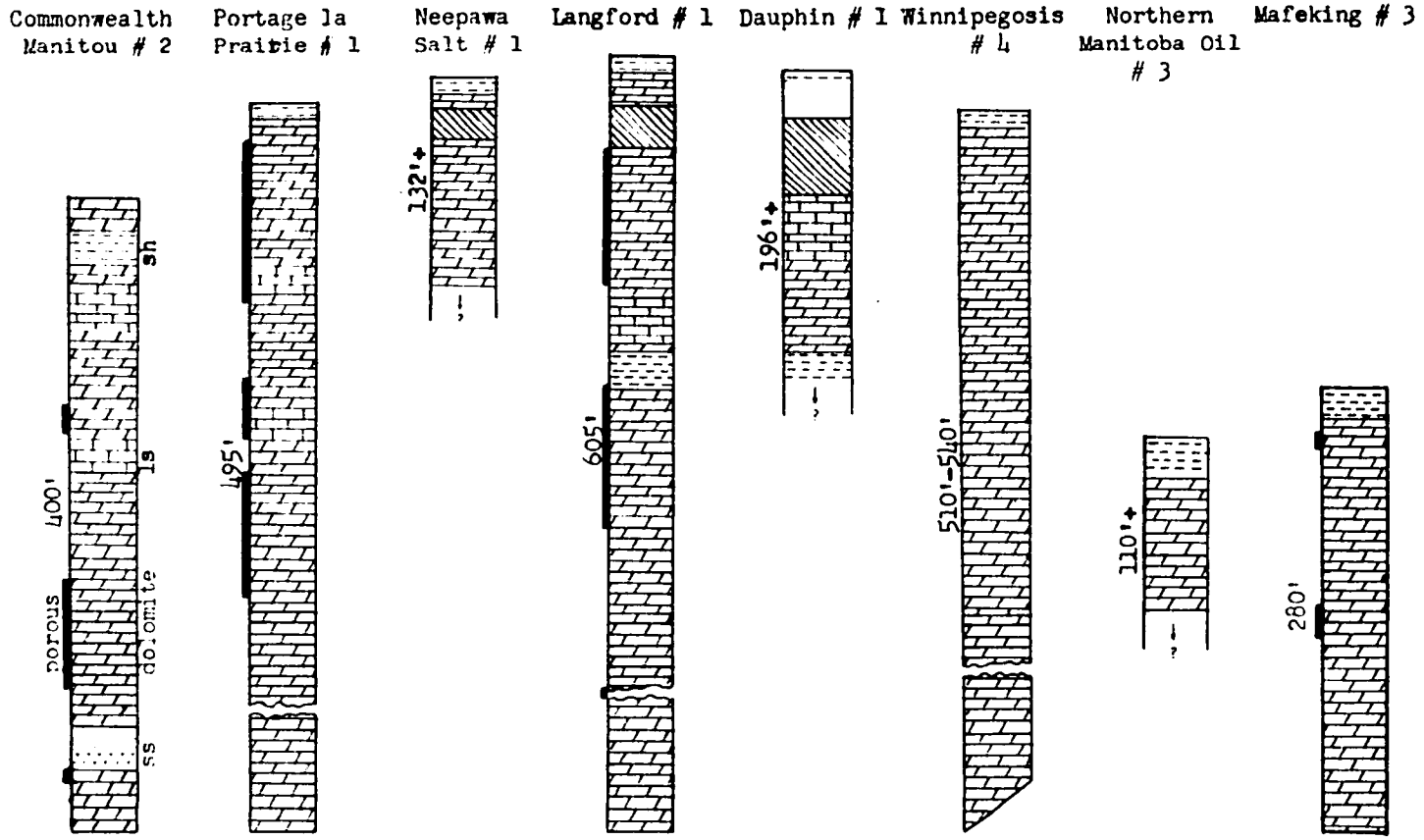

Figure 4

The Silurian in Well Sections

From the exposures in the quarry at Stonewall, Manitoba, E. M. Kindle named the Stonewall formation (1914, pp. 247-251). From a study of the quarry and other outcrops, he divided the formation into an upper cream or light-grey dolomite and a lower buff and pink dolomite separated by some 50 feet of white gypsum. At the town of Gypsumville, Manitoba, the gypsum is reported to be 150 feet thick and underlain by a considerable thickness of red clay-shale (Wallace, 1925, pp. 22-23). Wallace states that gypsum and red clay were found in drilling at Arnaud, St. Elizabeth, Dominion City, and Rathwell, but further deep drilling and investigation will be required to determine whether the beds encountered were Silurian or part of the Amaranth formation. It appears that conditions favouring deposition of red shale and gypsum were present only in the northeastern part of the area, and it is probable that at the same time as the deposition of gypsum and shale beds in the northeast, dolomites were being laid down to the west.

Rocks of Silurian age are exposed along the Nelson River in the Hudson's Bay region (Savage and Van Tuyl, 1919, pp. 345-346) and it would appear that a continuous sea extended from Hudson's Bay to southern Manitoba during at least part of Silurian time.

Devonian Period

The thickness and lithology of the Devonian rocks in Manitoba vary so greatly that it is difficult to describe the rocks of this period from a study of well cuttings. It seems apparent that parts of the Devonian section are missing in some wells. In the Commonwealth Manitou No. 2 well only 50 feet of sediments have been assigned to the Devonian. The upper 30 feet of limestone of this section is similar to the limestone found some 260 feet below the top of the Devonian in the Neepawa No. 2 well. The same limestone appears near the top of the Devonian section in the Dauphin well. As the Neepawa section includes over 250 feet of dolomite and anhydrite which are absent from the Commonwealth Manitou No. 2 and Dauphin wells, it is apparent that a considerable unconformity exists at the top of the Devonian. On the other hand, the Neepawa No. 2 well has 80 feet and the Dauphin well 500 feet of Devonian sediments below the limestones correlative with those of the Commonwealth Manitou No. 2 well. Wickenden (1934, p. 166) suggests that the lowest Devonian beds are also missing in the Winnipegosos No. 4 well. This would point to an unconformity at the base of the Devonian as well as at the top. The Devonian has a much greater thickness to the south and west; it is given as 1400± feet in southern Saskatchewan, 1800± in the southern Alberta plains, and 2875± feet in the southern Alberta foothills (Hume, 1947, p. 196). The thickness in the Kamp No. 1 well (North Dakota) is 600+ feet and in the Emma L. Semling No. 1 (North Dakota) well it is 470 feet.

The limestones and dolomites belonging to the Devonian are generally buff or cream in colour, but pinkish sections are present

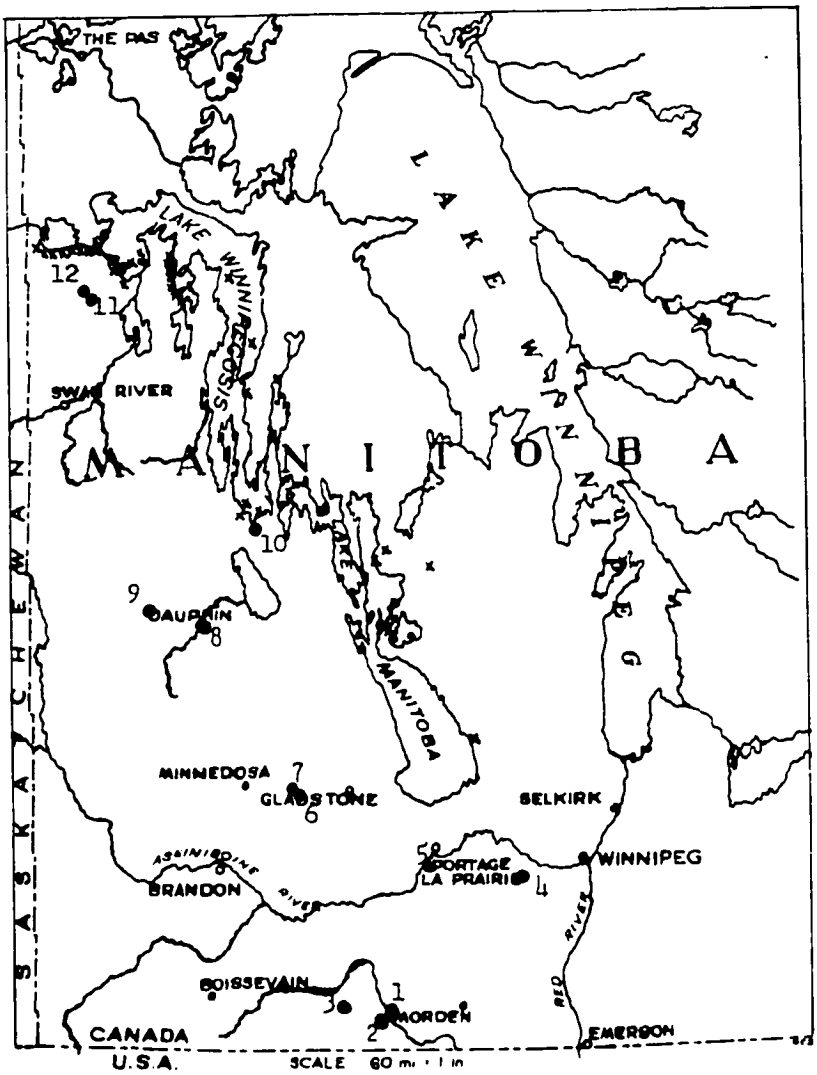

Figure 5

Map of Manitoba showing location of wells which penetrate Devonian beds and location of outcrops of Devonian strata. Well-sites are marked by large dots and outcrops by small crosses.

1. Commonwealth Manitou #2, 2. Lisgar, 3. Pilot Mound, 4. Commonwealth Pete #2, 5. Portage la Prairie #1, 6. Langford #1, 7. Neepawa Salt #2, 8. Dauphin, 9. Gilbert Plains #1, 10. Winnipegosis #4, 11. Northern Manitoba Oil #3, 12. Mafeking #3.

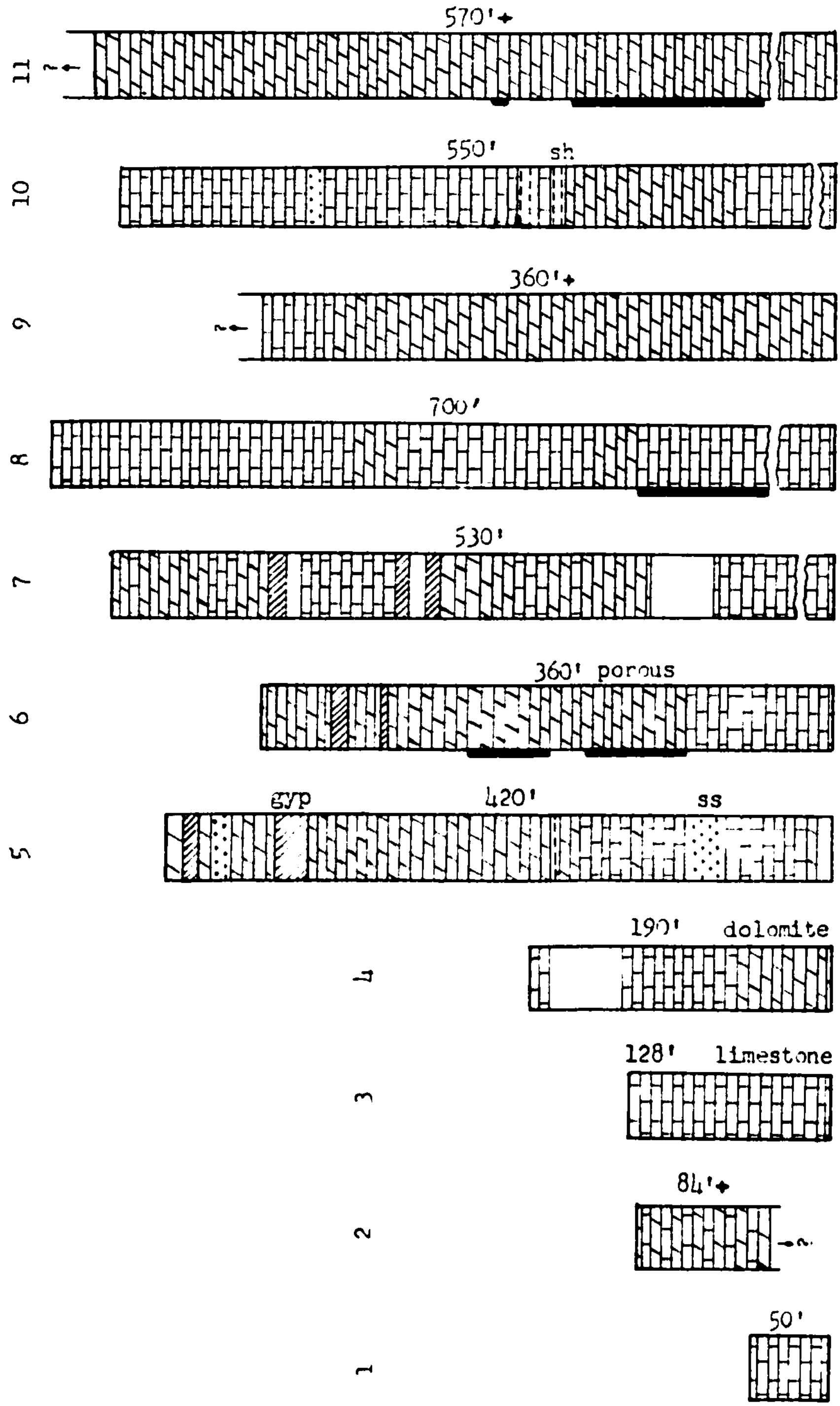

Figure 6

The Devonian in Well Sections

in some wells. The Neepawa No. 2 well and the Dauphin well intersected some gypsum beds in the Devonian. The Devonian beds penetrated in the Mafeking No. 3 well are unlike those found in any of the other Manitoba wells, the limestone being chiefly greenish and white in colour. Apparently the sequence of Devonian sediments varies a great deal over relatively short distances and it would seem that conditions of deposition were very changeable. It is also possible that there may be one or more disconformities within the Devonian itself. Porous zones were observed in the cuttings from the Langford No. 1, Gilbert Plains No. 1, and Mafeking No. 3 wells.

Wallace (1925, pp. 24-27) describes the Devonian in outcrops on the shores of Lakes Manitoba and Winnipegosis. He found it possible to divide the Devonian sediments into three formations: the Elm Point, Winnipegosan, and Manitoban, in ascending order. The Elm Point he described as a light-grey to dark-brown mottled limestone with argillaceous phases, arenaceous in its upper beds. The Winnipegosan is a porous light-grey or cream dolomite; there is a bed of red shale at the base and red argillaceous dolomite or shale at the top, which grades into the overlying Manitoban formation. The Manitoban limestone is similar to that of the Elm Point formation, being a mottled greyish-brown; an argillaceous limestone some 20 feet thick is found at the base of the formation and a thin bed of sandstone marks the top.

Mississippian Period

Rocks of Mississippian age have a considerable thickness in North Dakota and other parts of the Great Plains area. The Kamp No. 1

The Devonian in well sections, Figure 6

1. Commonwealth Manitou #2
2. Lisgar
3. Pilot Mound
4. Portage la Prairie #1
5. Neepawa Salt #2
6. Langford #1
7. Dauphin
8. Gilbert Plains #1
9. Winnipegosis #4
10. Northern Manitoba Oil #3
11. Mafeking #3

well in Williams County, North Dakota penetrated 3165 feet of Mississippian sediments of which 251 feet were Amsden, 1344 feet were Big Snowy, 1460 feet Madison, and 110 feet Kinderhook[1]. The Emma L. Semling No. 1 well (North Dakota) intersected 1790 feet of Mississippian sediments, divided into 90 feet of Amsden, 910 feet of Big Snowy, 760 feet of Madison, and 30 feet of Kinderhook.[1] Mississippian sediments in southern Saskatchewan are 1350± feet thick, in the southern Alberta plains 1100± feet thick, and in the southern Alberta foothills 2800± feet thick (Hume, 1947, p. 196). No Mississippian sediments have so far been positively identified in Manitoba but it is probable that at least some of the Mississippian formations extend into the southwestern part of the province. A well drilled recently near Lyleton, intersected 900 feet of beds resting on Devonian strata and believed to belong to the Madison formation. A part of the section overlying the Madison may also be Mississippian but these beds have not been definitely correlated.

Pennsylvanian and Permian Periods

As Pennsylvanian and Permian sediments are found only in the southwestern corner of North Dakota, it is most unlikely that any deposits were laid down in Manitoba during these two periods.

MESOZOIC STRATIGRAPHY

Triassic Period

The Triassic period is represented in the southern Great Plains area by the Spearfish formation. This formation is 895 feet thick in the Northern Pacific No. 1 well (Montana), 885 feet thick in the Kamp No. 1 well (North Dakota), and 220 feet in the Emma L. Semling No. 1 well (North Dakota). The formation consists of red to brown shales and red argillaceous sandstones and evaporites. It has not been definitely established that the Triassic is represented in Manitoba. The Amaranth formation is very similar in lithology to the Spearfish to the southwest, and it is possible that the Amaranth is Triassic in age. No diagnostic fossils have been found in the Amaranth: therefore the correlation cannot be made with any degree of certainty.

Amaranth Formation

Red calcareous shale, red frosted sandstone and much gypsum

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[1] For detailed lithology, see the Descriptive Logs given in the last part of this publication.

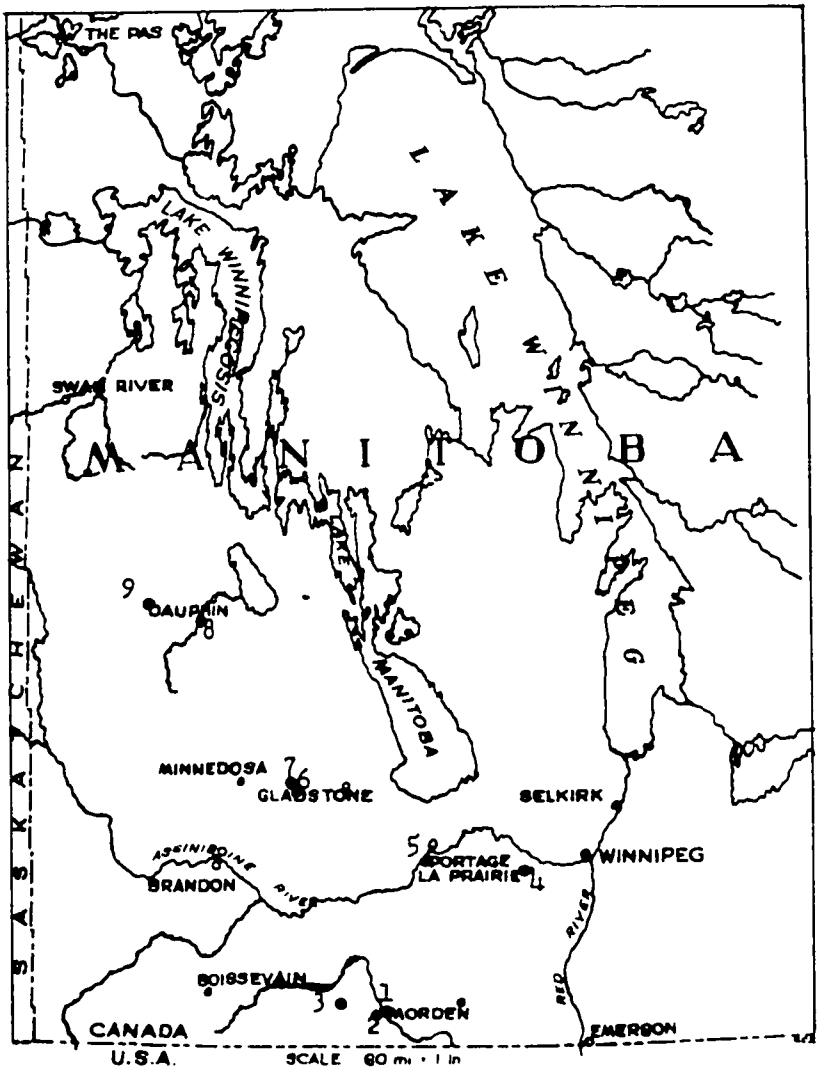

Figure 7

Map of Manitoba showing location of wells which penetrate Amaranth beds. Well-sites are marked by large dots.
1. Commonwealth Manitou #2, 2. Lisgar, 3. Pilot Mound, 4. Commonwealth Pete #2, 5. Portage la Prairie #1, 6. Langford #1, 7. Neepawa Salt #2, 8. Dauphin, 9. Gilbert Plains #1.

constitute the Amaranth formation in Manitoba. A bed of sandstone is found at the base of the formation in most wells, and the shales above it are frequently sandy. Small amounts of green and grey shales were found in the cuttings from some of the wells, suggesting narrow bands of these shales interbedded with the red. The gypsum is white and occurs in beds of apparently varying thickness. The Commonwealth Manitou No. 2 well, the Neepawa No. 2 well and the Dauphin well show a 20-foot bed of limestone at the top of the formation. The thickness of the formation is fairly uniform as seen in well samples; it is from 190 to 220 feet thick in the wells so far studied.

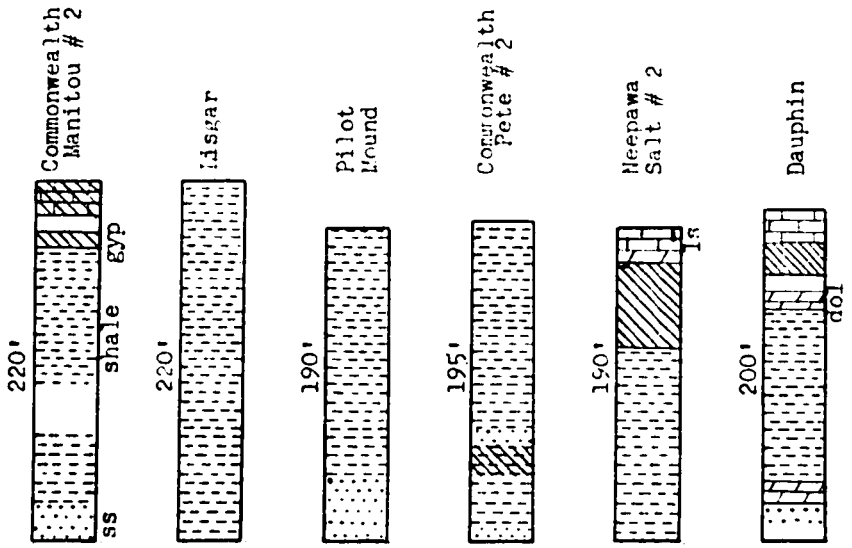

Figure 8

The Amaranth in Well Sections

Jurassic Period

Jurassic beds of considerable thickness occur in the section of the Great Plains which lies southwest of Manitoba. The Kamp No. 1 well (North Dakota) penetrated 965 feet of Jurassic sediments and the Emma L. Semling No. 1 well (North Dakota), 710 feet. Beds of Jurassic age have been encountered in several Manitoba wells. These beds are from 425 to 480 feet thick in the southern section as shown by the Commonwealth Manitou No. 2 and Pilot Mound wells. Towards the north, in the vicinity of Neepawa, the Jurassic has

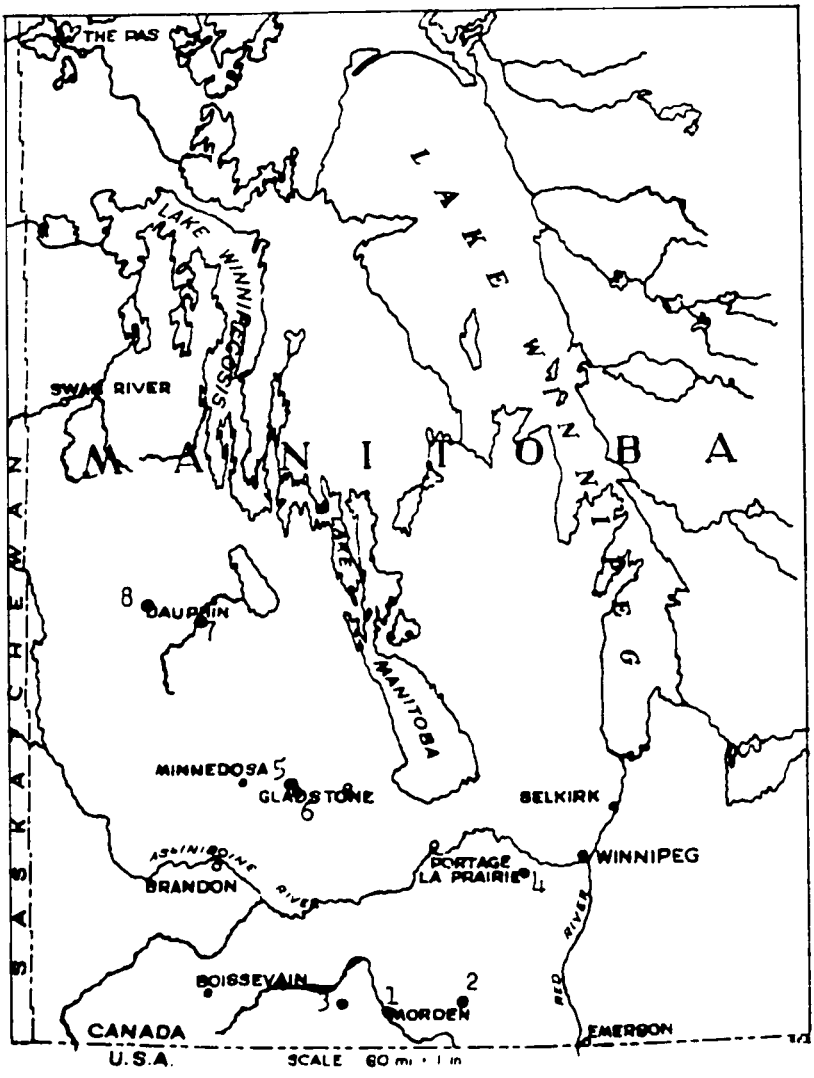

Figure 9

Map of Manitoba showing location of wells which penetrate Jurassic beds. Well-sites are marked by large dots. 1. Commonwealth Manitou #'s 1 and 2 and Lisgar, 2. Morden, 3. Pilot Mound, 4. Commonwealth Pete #2, 5. Neepawa Salt #'s 1 and 2, 6. Langford #1, 7. Dauphin, 8. Gilbert Plains #1.

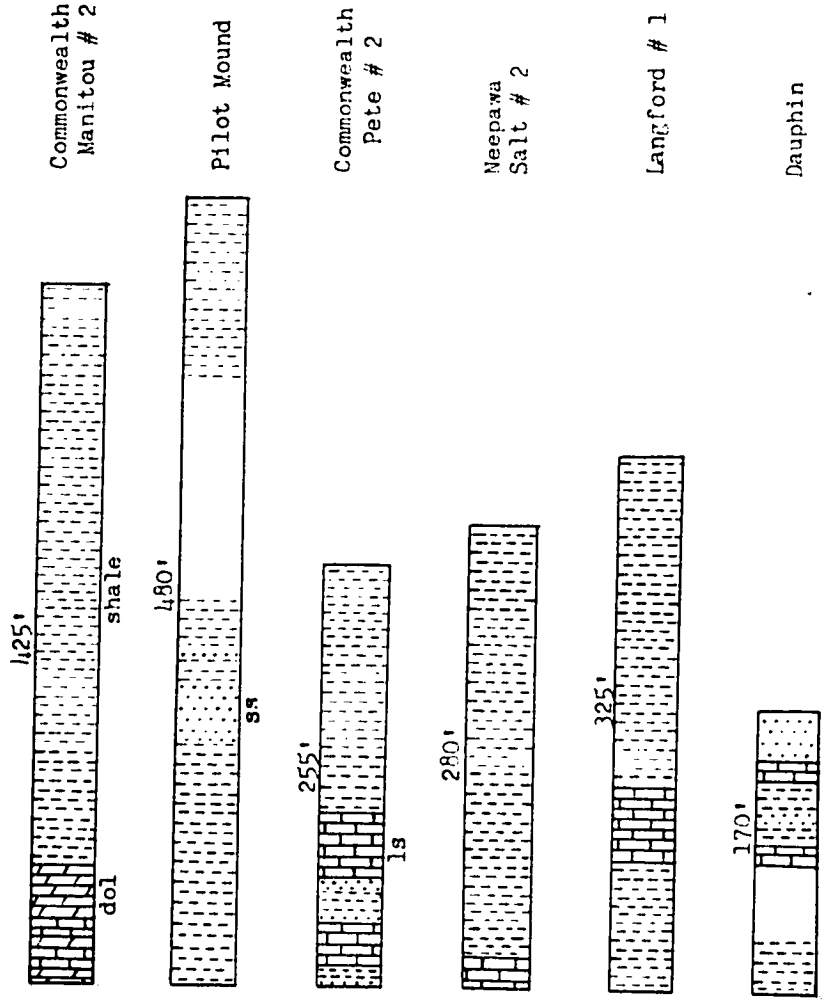

Figure 10

The Jurassic in Well sections

thinned to about 300 feet, and in the Dauphin well it is only 170 feet thick. The northern extent of Jurassic deposits is not known. No Jurassic sediments were recognized in the samples from the Northern Manitoba Oil No. 3 well in sec. 33, tp. 42, rge 26, W. Principal mer. and it is probable that the Jurassic

has pinched out south of this location.

The Jurassic of the northern United States can be divided into two formations. The lower, Sundance, is described by Laird (1944) as a series of glauconitic sandstone, green shale, sandstone, and shaly limestone with gypsum. The upper Morrison consists of grey and green shale and shaly sandstone. The earliest Jurassic beds in the southern part of Manitoba, as seen in Commonwealth Manitoba No. 2 samples are calcareous marine shales, grey, greenish, and red in colour. Below these shales is a limestone and dolomite section believed by Wickenden (1945, p.9) to be erosion debris from the top of the Amaranth. Resting on the marine shales is a 70-foot section of non-marine variegated shales. Wickenden found ostracods and chara fruit in the samples from this interval, and he believed them to be similar to those found in the Morrison formation in South Dakota and Wyoming. Overlying the non-marine shales is a thicker section of shale, mostly grey with a little red and greenish-grey which contains abundant shell fragments and crinoid stem fragments, denoting marine origin. The Neepawa No. 2 well, about eighty miles northwest of Manitou, disclosed a similar, though thinner section of Jurassic beds. Wickenden's log of the Neepawa well (1945, p. 10) describes an upper and lower marine member separated by a 30-foot non-marine member. The lower marine shales are grey, buff, and brownish red; the non-marine shales are chiefly medium- to light-grey; and the upper shales are medium-grey to brownish. A 20-foot band of light grey limestone forms the base of the formation in this well as in the Commonwealth Manitou No. 2 well. About 65 miles farther to the northwest, the Dauphin well was drilled. It showed only 10 feet of the upper marine shales, 30 feet of the middle non-marine shales, and 130 feet of the lower marine member. Hence, all three members become thinner towards the north, but the most marked decrease in thickness is in the upper marine shale.

As far as is known there are no Jurassic outcrops in the province.

Cretaceous Period

Swan River Group

The oldest Cretaceous rocks in Manitoba are a variable series of shales, sandstones, and some seams of low grade coal, collectively termed the Swan River group. The section is less than 100 feet thick in well cuttings from southern part of the province, but it thickens towards the north. A diamond drill hole on Thunder Hill penetrated most of the Swan River beds, which have a thickness there of over 330 feet and are chiefly sands and sandstones (Wickenden, 1945, p. 13). The excessive thickness in the north is probably due in part to the coarseness of the non-marine sediments in contrast with the finer-grained partly marine

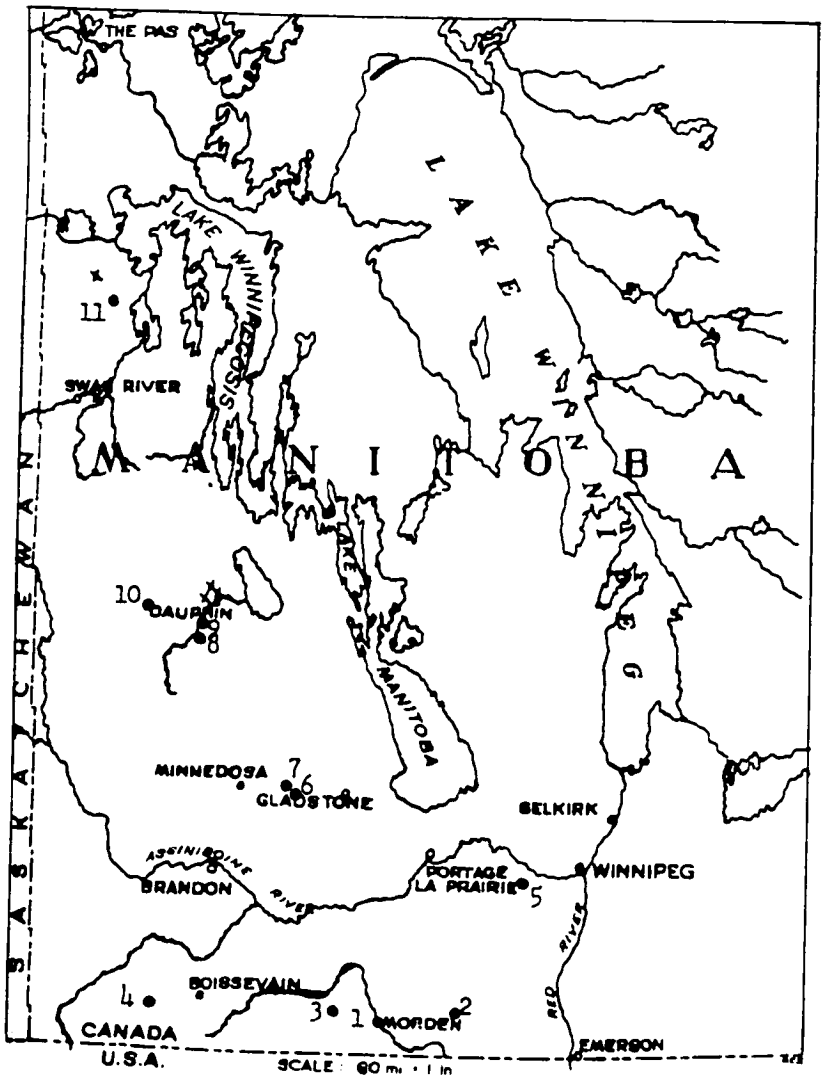

Figure 11

Map of Manitoba showing location of wells which penetrate Swan River beds and location of outcrops of Swan River strata. Well-sites are marked by large dots and outcrops by small crosses.

1. Commonwealth Manitou #'s 1, 2, & 3 and Lisgar, 2. Morden, 3. Pilot Mound, 4. Deloraine, 5. Commonwealth Pete #2, 6. Langford #1, 7. Neepawa Salt #2, 8. Vermilion River #2, 9. Dauphin, 10. Gilbert Plains #1, 11. Northern Manitoba Oil #3.

beds in the south. Some of the sands may be continental Jurassic deposits, but as no fossils have been found, there is no way of determining the contact between the Jurassic and the Cretaceous. The Commonwealth Manitou No. 2 well penetrated 30 feet of rounded-quartz sand and 20 feet of grey shale. The Neepawa section is 75 feet thick, being made up of 17 feet of sand and 58 feet of grey shale.

The most southerly exposure of the Swan River beds is in sec. 27, tp. 25, rge. 29, W. Principal mer. In outcrop the Swan River group is seen as sands and loose sandstones, mostly white, in places slightly glauconitic. The best exposures, according to Wickenden, are in the vicinity of Swan River, where sand, soft sandstone, and a little grey shale and clay constitute the formation.

The sands of the Swan River group carry water in many localities. In some places the water is suitable for domestic use; in other places it is too saline.

Ashville Formation

The Ashville formation has a thickness of 100 to 200 feet in the wells studied. It thickens towards the west, being 205 feet in the Deloraine well (Tyrrell, 1891, p. 93), 125 feet in the Commonwealth Manitou No. 2 well and 105 feet at Morden (Tyrrell, 1891, p. 98). In the Neepawa No. 2 well, 135 feet of sediments are placed in the Ashville formation (Wickenden, 1945, p. 69), and the Vermilion River No. 2 well penetrated 178 feet of Ashville, (Tyrrell, 1891, p. 103).

In the southern part of the province the formation is a medium- to dark-grey non-calcareous somewhat fissile shale. The Neepawa No. 2 well intersected some limestone bands and sand and silt beds near the top of the formation. This upper limestone phase is exposed in the vicinity of Kelwood, Norgate, and McCreary (Kirk, 1930, p. 118), and seems to be developed in this area only, disappearing towards the north and south. Limestone bands are seen near the top of the Ashville in outcrops on Valley River, Vermilion River, and Favel River, but, according to Wickenden (1945, p. 19), it is doubtful if these are the same beds as those in the Kelwood area to the south. Two diamond drill holes on Thunder Hill passed through 420 feet and 480 feet respectively of Ashville beds having a dip of 10 to 60 degrees as shown in the cores. A well-defined sandy zone was encountered about the middle of the formation in these drill-holes. Wickenden believes that the great thickness is due to the pushing action of the continental glacier, (1945, p. 55). A well drilled in 1939 by Canadian Industries Limited revealed a repetition of beds, including glacial drift, which suggested that Thunder Hill is made up in part of large masses of shale belong-

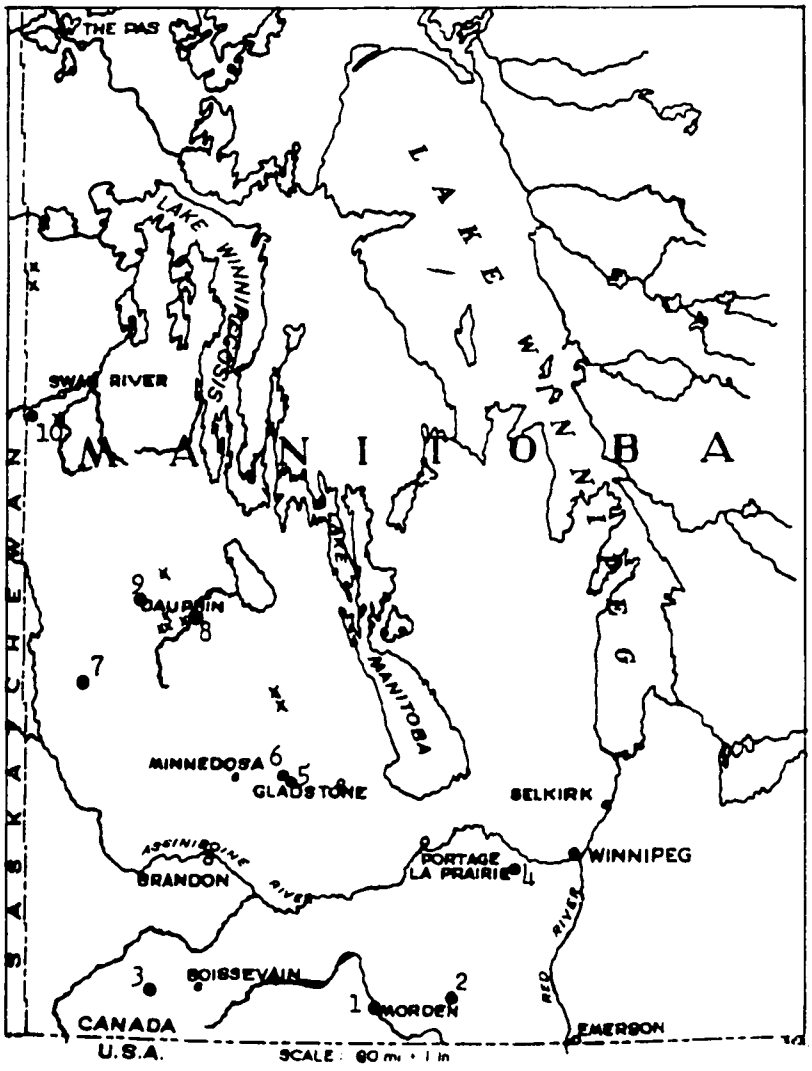

Figure 12

Map of Manitoba showing location of wells which penetrate Ashville beds and location of outcrops of Ashville strata. Well-sites are marked by large dots and outcrops by small crosses.

1. Commonwealth Manitou #'s 1, 2, & 3 and Lisgar,
2. Morden, 3. Deloraine, 4. Commonwealth Pete #2,
5. Langford #1, 6. Neepawa Salt #2, 7. Cleland #1,
8. Vermilion River #2, 9. Gilbert Plains #1,
10. Thunder Hill #1.

ing to the Ashville and Favel formations, that were picked up by glaciers and deposited on this site. During transportation the shales were crumpled and folded to some extent. Therefore, the thickness of the Ashville is much greater in this well than it is in undisturbed sections elsewhere (Wickenden, 1945, pp. 75-76). It had previously been suggested that the great thickness was due to the swelling of bentonite in the shale.

In exposures in the Swan River district narrow bands of bentonite occur just below the top of the Ashville, but these bands do not seem to be continuous over any appreciable area and cannot be used for correlation of outcrops. North of Swan River, in the Porcupine Mountain area, the formation, as seen in outcrops, comprises an upper dark-grey shale immediately below the Favel and a lower dark-grey shale, separated by a sandy horizon. A well drilled in l.s. 1, sec. 31, tp. 44, rge. 2, W. 2nd. mer. penetrated a dark-grey shale and a sandy zone and from fossil evidence, this sandy zone appears to be the same zone as the one encountered in the Thunder Hill drill-holes (Wickenden, 1945, p. 21).

In summary, the Ashville in the southern section, as revealed in Commonwealth Manitou No. 2 well cuttings, is a formation of dark-grey shale; in the central or Neepawa section it is dark-grey shale with lime and sandy beds near the top; in the northern section it consists of two shale members, with an intermediate sand member.

Favel Formation

Resting on the dark-grey shale of the Ashville is the speckled shale of the Favel formation. The Favel is 170 feet thick in the Commonwealth Manitou No. 2 well, 140 feet in the Deloraine well, 160+ feet in the Fleming well[1] and 100 feet in the Ventures Kamsack No. 7 well.[2]

The Favel formation consists of a grey shale speckled with white calcareous material. These specks were regarded as fossil fragments by some investigators but the possibility of their being calcite is now being considered. The origin of the specks is not yet known. The presence of limestone in well cuttings from the upper part of the formation in the Commonwealth Manitou No. 2 and Deloraine wells is an indication of limestone beds, probably several narrow ones, interbedded with the shale. In exposures, a band of grey impure limestone can be distinguished near the middle of the formation; this limestone was the marker which Kirk used to mark the contact between his Keld and Assiniboine beds (1930, p. 120); in well cuttings it cannot be distinguished from calcare-

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1 Location - sec. 14, tp. 12, rge. 30, W. Principal mer. (Saskatchewan).

2 Location - l.s. 14, sec. 23, tp. 29, rge. 32, W. Principal mer. (Saskatchewan).

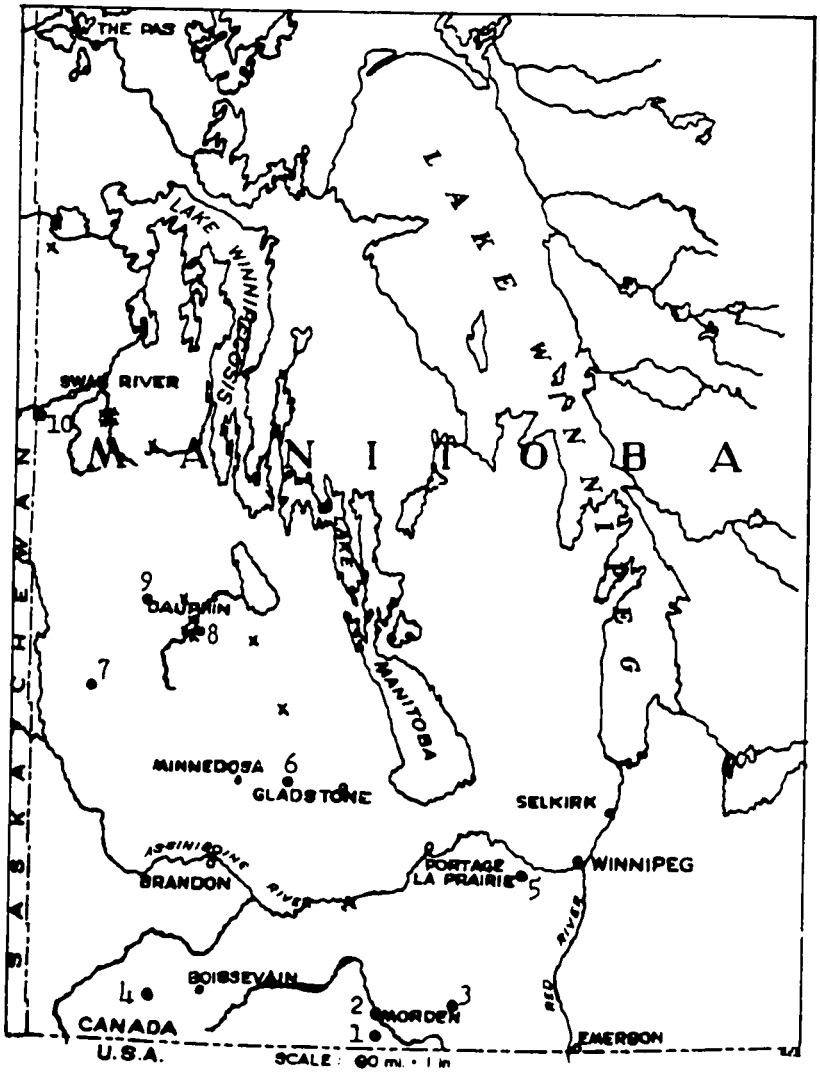

Figure 13

Map of Manitoba showing location of wells which penetrate Favel beds and location of outcrops of Favel strata. Well-sites are marked by large dots and outcrops by small crosses.

1. Snowflake, 2. Commonwealth Manitou #'s 1, 2, & 3 and Lisgar, 3. Morden, 4. Deloraine, 5. Commonwealth Pete #2, 6. Neepawa Salt #2, 7. Cleland #1, 8. Vermilion River #2, 9. Gilbert Plains #1, 10. Thunder Hill #1.

ous shale and it is, therefore, impossible to draw the contact between the Keld and Assiniboine members in well sections. Wickenden examined and measured many outcrops of the Favel and from his descriptions (1945, pp. 24-31), it can be seen that the formation has numerous bands of limestone and bentonite, commonly rather narrow, in almost all its exposures. However, except for the marker bed at the top of the Keld, it is not possible to correlate these narrow bands from one outcrop to another. It seems likely, therefore, that both the bentonite and the limestone deposits are in the form of lenses and stringers rather than continuous beds.

Vermilion River Formation

The Vermilion River formation was divided into three members by Kirk (1930, p. 114). These will be discussed in turn.

Morden member: The beds which overlie the speckled shale of the Favel are dark-grey non-calcareous shales and clays, termed Morden by Kirk. The lithology cannot be distinguished from that of the Ashville formation. The Morden member thins towards the north and is thickest in the southwest, being 180 feet in the Deloraine well, 120 feet in the Commonwealth Manitou No. 2 well and 30 to 40 feet in Ventures Kamsack No. 7 well (Saskatchewan).

In exposures in the southern part of the province near the town of Morden the lowest member of the Vermilion River formation is seen as dark-grey non-calcareous shale with large ellipsoidal septarian concretions. The Morden/Boyne contact is placed at the top of a 10-foot interval of fine sand and silt beds interbedded with the shale (Tovell, 1948, p. 3). The sand is almost pure quartz, uncemented, and occurs in very thin bands. Tovell found small calcareous concretions about 20 feet from the top of the Morden in the Pembina Valley sections. Outcrops of the Morden are usually streaked with melanterite.

Wickenden describes the Morden in outcrops of the northern area, Vermilion River and beyond, as a dark-grey shale. The contact with the Boyne is difficult to place owing to the absence of the silt beds and the less calcareous nature of the overlying Boyne member.

Boyne member: The middle member of the Vermilion River formation is made up predominantly of grey calcareous shale, although, as mentioned above, the shale is less calcareous in the northern areas. According to Wickenden, the calcareous shales are somewhat petroliferous. Much of the Boyne shale contains white specks so that the appearance of the member is similar to that of the Favel formation.[1] Tovell (1948, p. 4) and Wickenden (1945, p. 41)

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[1] X-ray studies on the Boyne shales at the University of Toronto indicate that the white specks are calcite.

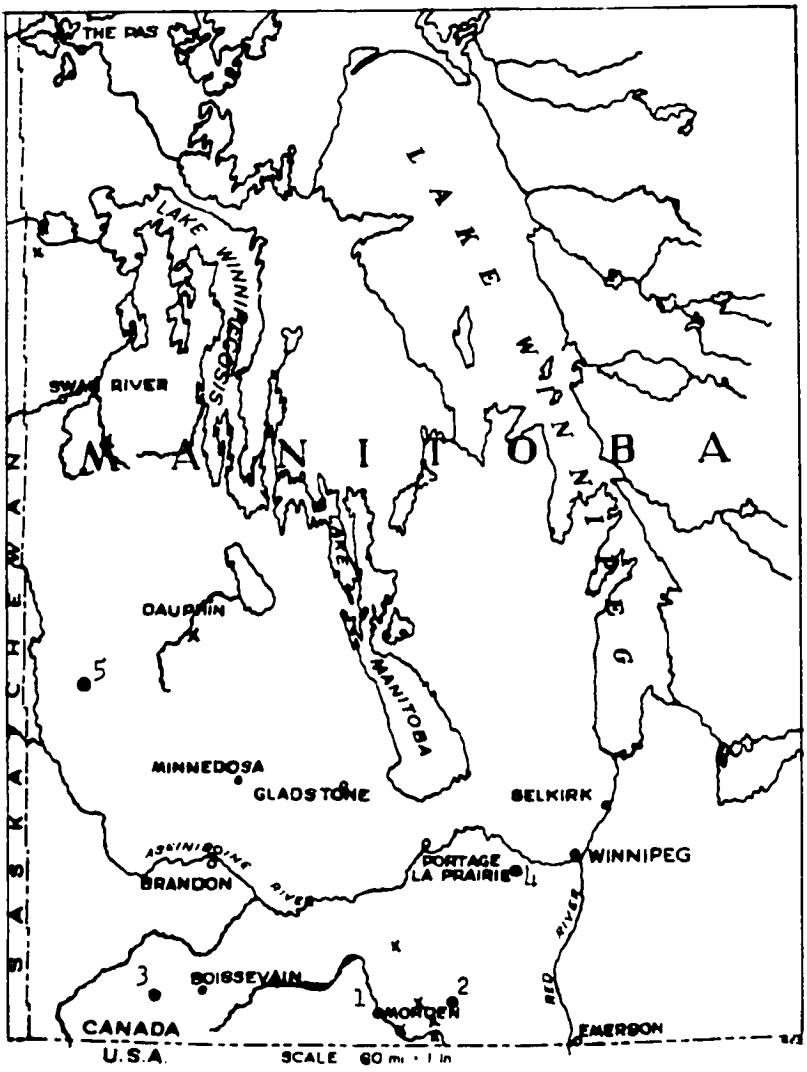

Figure 14

Map of Manitoba showing location of wells which penetrate Vermilion River beds and location of outcrops of Vermilion River strata. Well-sites are marked by large dots and outcrops by small crosses.
1. Commonwealth Manitou #'s 1, 2, & 3 and Lisgar,
2. Morden, 3. Deloraine, 4. Commonwealth Pete #2,
5. Cleland #1.

record the presence of many narrow bentonite bands, most of which cannot be correlated for any distance; there is, however, a group of three beds 0.1 to 0.5 feet thick, occurring 114 feet below the top of the Boyne which could be used for correlation throughout much of the Pembina Valley area.

The Boyne beds are thicker in the south than in the north. In the Deloraine well the Boyne member is 200 feet thick, in outcrops in SW¼, sec. 4, tp. 1, rge. 6, W. Principal mer. Wickenden found it to be 145-150 feet thick (1945, p. 35), and in the vicinity of Leary, in tp. 6, rge. 8, W. Principal mer., it is only 115 feet thick. It is difficult to mark the contacts between the members in wells in the northern part of the area, but in the Piwei No. 1 well[1], the entire formation is only 110 feet thick, and still farther north in Northern Royalties No. 1 well[2], the Vermilion River formation is 75 feet thick. In outcrops along the Etomami River near Bertwell (Saskatchewan), the Boyne member has a thickness of about 40 feet.

The Boyne/Pembina contact is placed at the bottom of that part of the section which contains considerable bentonite, whether or not the underlying beds are calcareous.

Pembina member: The Pembina member is somewhat thinner than the Boyne, being not more than 100 feet. Wickenden describes in detail a section in sec. 27, tp. 1, rge. 8, W. Principal mer. which includes 76 feet of Pembina beds, and he has estimated that the total thickness of the member is about 80 feet in that area. About 12 miles to the northwest, the Pembina appears to be 60 feet thick in the Commonwealth No. 1 well; however, the samples from this well are not absolutely reliable. In his log of the Deloraine well, Tyrrell records 25 feet of grey shale which is apparently Pembina (1891, p. 93). The Fleming well (Saskatchewan) penetrated 100 feet of Pembina beds according to the log prepared by Wickenden (1945, p. 68). An outcrop on Vermilion River in sec. 22, tp. 23, rge. 20, W. Principal mer. shows a thickness of 85 feet, and farther to the north in the Kakwa No. 5 well[3], the Pembina is 50 feet thick (Wickenden, 1945, p. 80). Wickenden suggests that the variations in the thickness of the Pembina member may be due to an unconformable contact with the overlying Riding Mountain formation or to thickening of the Boyne or Morden members at the expense of the Pembina.

Lithologically, the Pembina member is a very dark-grey or black non-calcareous carbonaceous shale containing numerous bentonite bands in the lower part of the section. Tovell observed

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1 Location - Sec. 34, tp. 39, rge. 5, W. 2nd mer. (Saskatchewan).

2 Location - Sec. 27, tp. 40, rge. 5, W. 2nd mer. (Saskatchewan).

3 Location - Sec. 31, tp. 41, rge. 4, W. 2nd mer. (Saskatchewan).

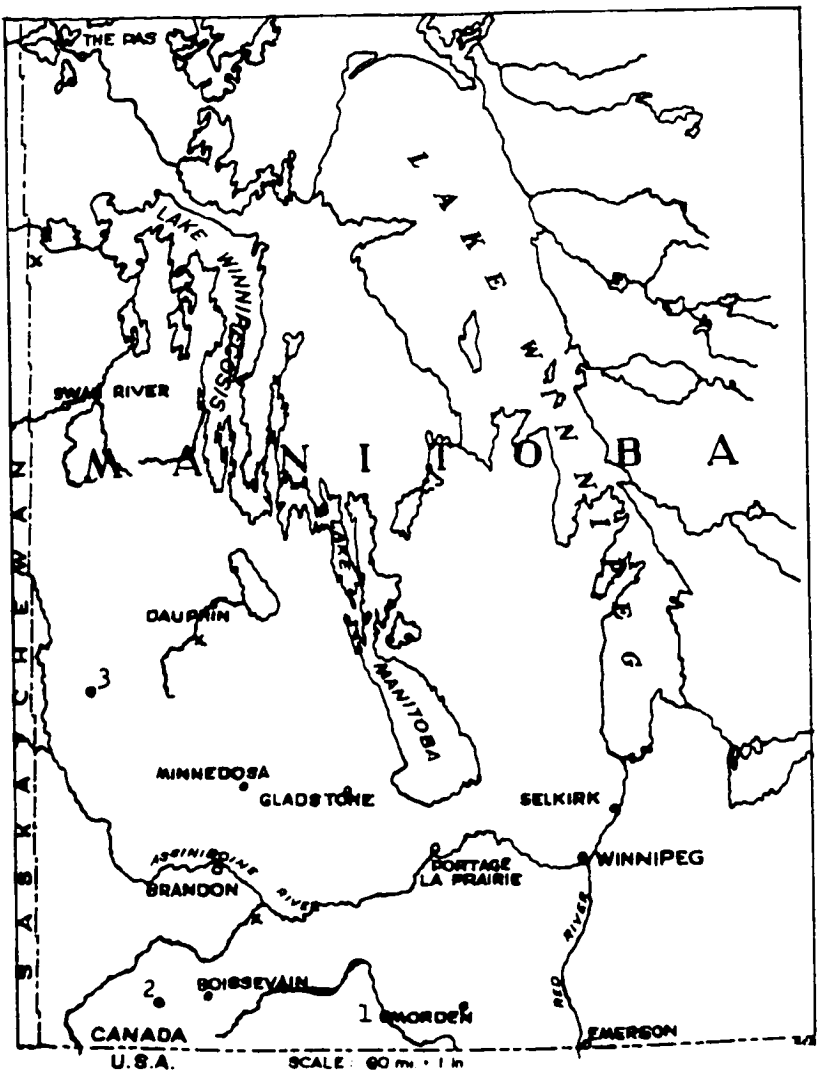

Figure 15

Map of Manitoba showing location of wells which penetrate Riding Mountain beds and location of outcrops of Riding Mountain strata. Well-sites are marked by large dots and outcrops by small crosses.
1. Commonwealth Manitou #'s 1 & 3 and Lisgar, 2. Deloraine, 3. Cleland #1.

fish scales in the upper organic shales (1948, p. 4).

Riding Mountain Formation

The Riding Mountain formation was first described by Tyrrell who divided it into the Millwood and Odanah members. Kirk noted that the contact was not stratigraphic, and further work has pointed to the probability that the two phases are complementary. The thickness of the formation is about 1100 feet in southwestern Manitoba as estimated from the thickness in the Deloraine and Fleming (Saskatchewan) wells. To the north, much of the upper Riding Mountain is missing.

The lower or Millwood phase of the Riding Mountain formation is composed of soft greenish clay which slumps badly, forming only poor outcrops. The Millwood grades upward into the light-grey hard siliceous shales of the Odanah phase. In places the hard shales are interbedded with soft bentonitic shale, especially near the base of the section. Tovell observed that the Odanah shales showed purple staining and that purple-stained concretions are fairly common throughout the unit in the Pembina River area (1948, p. 6).

Boissevain Formation[1]

The Boissevain formation was not encountered in any well in Manitoba, and the description given here is made on the basis of outcrops.

The Boissevain sands are exposed on the flanks of Turtle Mountain. From the elevations of the highest and lowest beds exposed, the thickness of the formation is estimated at 100 feet; no complete sections have been discovered. The Boissevain is composed of greenish-grey sandstone which weathers to a yellow to rusty colour. Some of the more firmly-cemented parts of the sandstone are used for building stone.

CENOZOIC STRATIGRAPHY

Paleocene Epoch

Turtle Mountain Formation

The thickness of the Turtle Mountain formation is not known owing to the scarcity of outcrops.

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[1] The Boissevain formation is Cretaceous and/or Tertiary in age; no diagnostic fossils have been identified.

The formation is comprised of a series of shale, sandstone and lignite beds; a few fossil plant remains occur in the fine white or yellowish sands and sandstones.

TERMINOLOGY AND CORRELATION[1] OF FORMATIONS

An attempt is made in the succeeding paragraphs to make general correlations between the Manitoba formations and those in North Dakota, southern Saskatchewan and southern Alberta. Brief mention is made of the formation names used by Tyrrell and Wallace and their associates and the relation of these names to those in current use.

In 1898, D. B. Dowling (1901, p. 35) used the names Winnipeg, Trenton and Stony Mountain, for the three formations of the Ordovician; the Trenton he divided into the Lower Mottled, Cat Head, and Upper Mottled members. He suggested the possibility of the Stony Mountain and the Winnipeg formations being equivalent to the Utica Group and Black River formation respectively, of Minnesota. In 1925, Wallace (1925, p. 16) suggested that the upper shales of the Winnipeg formation were correlative with the Black River shales and that the underlying sandstones could be correlated with the St. Peter's sandstone of the Chazy formation in Minnesota. The terms Upper Mottled and Lower Mottled are now frequently replaced by Selkirk and Dog Head respectively. The nomenclature in current use for the Ordovician formations in Manitoba is Winnipeg, Red River, and Stony Mountain, whereas the formations are known as Lower Whitewood, Upper Whitewood, and Big Horn in North Dakota and Montana.

The only formation of Silurian age in Manitoba was called Niagara by Tyrrell (1891, p. 200E). However, the Silurian of Manitoba is unlike the New York Niagara both faunally and lithologically, and the formation was renamed Stonewall by Kindle from the exposures in the vicinity of the town of Stonewall (1914, p. 249).

The Devonian of Manitoba is divided into the Elm Point, Winnipegosan and Manitoban formations. These three names are also in use in North Dakota. In addition, a fourth formation at the top of the Devonian is recognized and termed Amaranth by some geologists south of the International Boundary; it should be noted that this formation is not correlative with the Amaranth formation of Manitoba.

The age of the Amaranth formation in Manitoba is at present doubtful. Until recently, all that was known was that it lay between known Devonian and known Jurassic beds. A deep well recently drilled near Lyleton penetrated some Madison limestone

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[1] "Correlation" is used here in the sense of time or age equivalence.

below the Amaranth. Hence, the formation is late Mississippian or younger. In lithology it resembles the Spearfish formation of Triassic age, found in North Dakota, but the possibility of an Upper Mississippian or Jurassic age must not be overlooked.

The regional correlation of Cretaceous rocks presents the greatest difficulty. In recent literature, the oldest Cretaceous rocks in the province are collectively called the Swan River group in preference to the term Dakota which had been applied by Tyrrell and Wallace to these beds; the "true" Dakota formation of North Dakota is Upper Cretaceous in age. The Swan River group appears to be the time equivalent of the Lakota formation in North Dakota, with some of the lower beds in the northern areas possibly being Jurassic in age.

The name Ashville was originally suggested by Kirk in 1929 for the beds previously called Benton by Tyrrell and Wallace. This formation represents only the lower part of the formation currently known as Benton in the western United States as the upper part of the Ashville may be considered correlative with the Graneros member of the Benton (Kirk, 1930, p. 117). The Manitoba equivalent of the Dakota formation of North Dakota appears to be included in the Ashville formation. McLearn found a few poorly preserved macrofossils in the upper beds of the Ashville and suggested that this part of the formation might be correlated with the Dunvegan formation in Alberta (1937, p. 113). The microfauna of the upper Ashville can be correlated with that of the lower part of the Alberta formation in southern Saskatchewan (Fraser, et al, 1935, p. 16). The lower part of the Ashville appears to be Lower Cretaceous in age. Wickenden found that the microfauna of the lower Ashville related that part of the formation to the Shaftesbury formation of the Peace River district (1945, p. 23). McLearn (1945, p. 5) presented further evidence in support of a Lower Cretaceous age for the lower Ashville. From the lithology it appears that the lower Ashville is correlative with the Fuson formation in North Dakota and the uppermost Lower Cretaceous beds in southern Saskatchewan.

The Favel formation is the Manitoba extension of the widespread "second white specks". It was divided into two members by Kirk, the Keld and the Assiniboine. Fossil evidence points to the correlation of the Keld with the Greenhorn member of the Benton in the United States, although the Greenhorn is essentially a limestone (Kirk, 1930, p. 119). Kirk tentatively correlated the Assiniboine beds (the upper Favel) with at least part of the Carlile member of the Benton (1930, p. 123), although the scarcity of fossil evidence makes age relationships difficult to determine. On the basis of fossils, Wickenden has correlated the Favel with the Lower Alberta formation in the southern foothills, the Blackstone formation in the northern foothills, and the Kaskapau formation in the northern Alberta plains (1945, p. 33). The Favel extends into southern Saskatchewan as the middle part of the Alberta formation. The early reports of Tyrrell and Wallace refer to the Favel beds as Niobrara but these are not the same

beds as those which are currently termed Niobrara south of the International Boundary and which correlate with the Manitoba Morden and Boyne beds.

The Vermilion River beds, named by Kirk, are the lower part of the Millwood series of Tyrrell's section. The lowest member, the Morden, lies just below the "first white specks" and, therefore, it is the age equivalent of the lower part of the Niobrara formation in North Dakota and the uppermost beds of the Alberta formation in southern Saskatchewan. The Boyne beds or "first white specks" are correlative with the Wapiabi formation of the foothills, the upper Niobrara in North Dakota (Wickenden, 1945, p. 42), and all or part of the Lea Park formation in southern Saskatchewan (Fraser, et al. 1935, p. 17). The uppermost, or Pembina, member occupies the position in the section corresponding to the basal Pierre in North Dakota, the Milk River formation in the southern Alberta plains, the lower part of the Belly River formation in the southern Alberta foothills (Hume, 1947, p. 196) and in southern Saskatchewan (Fraser, et al, 1935, p. 21). In Alberta and North Dakota, the Upper Cretaceous sediments are divided into the Colorado and Montana groups. If this grouping were extended into Manitoba, the break would come between the two upper members of the Vermilion River formation. In this respect it might be noted that Tovell (1948, p. 5), suggested that the Pembina beds are more closely related to the overlying Riding Mountain beds than to the Boyne beds beneath, in the Pembina River area at least.

The Riding Mountain formation appears to correspond to formations from upper Lea Park to Bearpaw in the northern Alberta plains and from upper Belly River to Bearpaw in the southern Alberta plains and southern Saskatchewan. It is apparently correlative with the Upper Pierre shales of the western states. The Riding Mountain beds were included in the Pierre of Tyrrell's report, being the upper portion of his Millwood and his Odanah members.

The Boissevain sandstone carries no diagnostic fossils and may include some beds of Cenozoic age at the top. According to Hume, (1947, p. 196), it has no equivalents in Alberta, but is related to the Frenchman formation in southern Saskatchewan. Wickenden (1945, p. 50) implies that there is a similarity between part of the Boissevain and the Whitemud formation of southern Saskatchewan. The Eastend formation which is below the Whitemud in Saskatchewan is not believed to have an equivalent in Manitoba. The Boissevain may be the equivalent of the Fox Hills and/or the Hell Creek formations in North Dakota.

The Turtle Mountain formation of Paleocene age is the time equivalent of the Ravenscrag formation of southern Saskatchewan and the Paskapoo formation of the southern Alberta foothills. The Paleocene epoch is represented in North Dakota by the Fort Union formation.

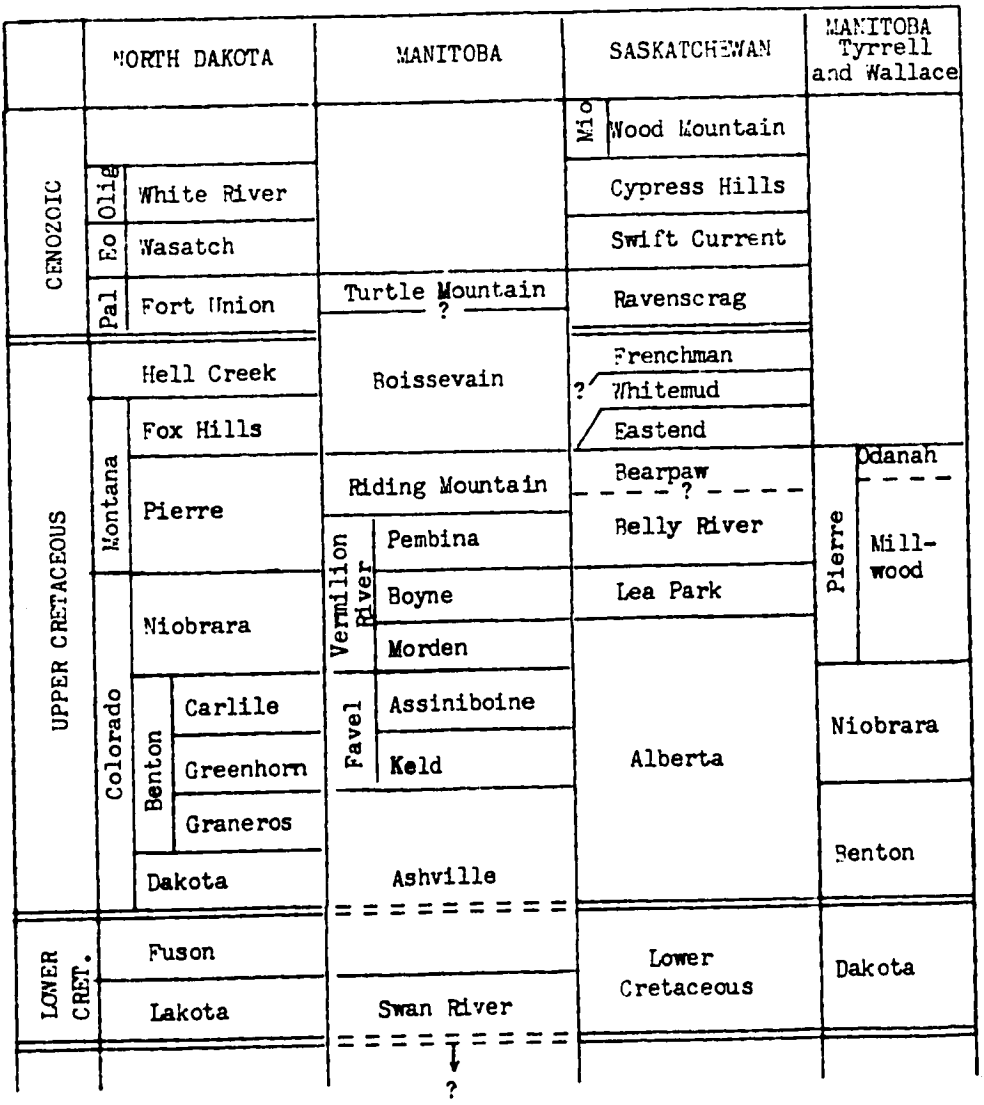

Figure 16

Correlation of post-Jurassic formations of North Dakota, Manitoba, and southern Saskatchewan

ORIGIN AND OCCURRENCE OF PETROLEUM AND NATURAL GAS

THEORY OF ORIGIN

In the relatively short lifetime of the science of petroleum geology, numerous theories have been offered to explain the presence of petroleum and natural gas in rocks. The most popular of these theories at the present time is based on the idea that petroleum and related substances originated from the organic remains of plant and animal life that flourished in ancient geological time. The presence in crude oils of a wide variety of microscopic objects such as diatoms, foraminifera, insect scales, petrified wood and chlorophyll porphyrins suggests that a great variety of organic materials may be the parent substances of petroleum. The differences in the nature of crude oil found in rocks of different ages or in different localities may be due, in part, to the differences which existed in the original organic materials. The manner in which the parent substances were converted into petroleum is still not known but it is probable that the action of multitudes of bacteria upon the material when it was first laid down, the pressure of later sediments, and the higher temperatures found at depth in the earth all contributed to the chemical actions which finally resulted in the formation of petroleum. The contribution of radioactivity in the earth to the formation of petroleum is being studied at present.

PRINCIPLES GOVERNING ACCUMULATION OF PETROLEUM

Successful exploration for oil in various parts of the world has shown that several geological features are necessary for the formation of oil pools. The major prerequisites are as follows: (1) a source rock containing the organic material necessary for the formation of oil and gas, (2) a porous horizon through which the petroleum can migrate and in which it can accumulate, (3) an impervious layer above the porous horizon to prevent the oil from seeping upward from the reservoir beds and (4) some structural feature which will prevent the lateral escape of oil and gas.

Source rocks are chiefly shales, deposited at or near sea-level, commonly along swampy shores and deltas where there was abundant vegetation; however, some organic limestones may contain the material necessary for the formation of petroleum. The usual reservoir rocks are sandstones or porous limestones and dolomites that have sufficient intergranular space to allow migration and accumulation of fluids. Clay and shale are impervious and are the most common sediments making up the "impervious layer" in oil traps.

Numerous structural features are favourable to the accumulation of oil and gas, and some of these will be discussed briefly. The classic structures are anticlines and domes which have the shape of an inverted trough and an inverted bowl respectively. These "deformational traps" are illustrated in Figures 17 and 17a.

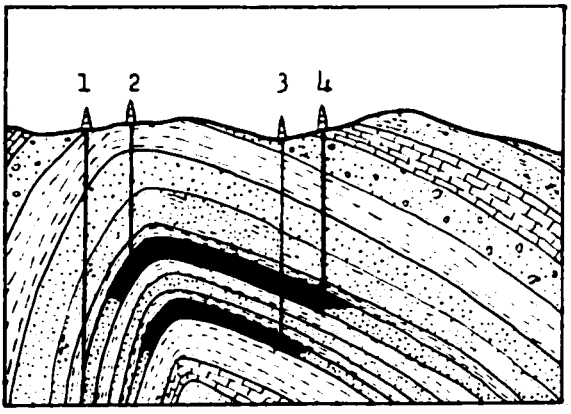

Figure - 17
(After L. C. Uren)

Simple asymmetric anticline with oil-bearing strata (shown in solid black) reached by three wells (Nos. 2, 3, and 4).

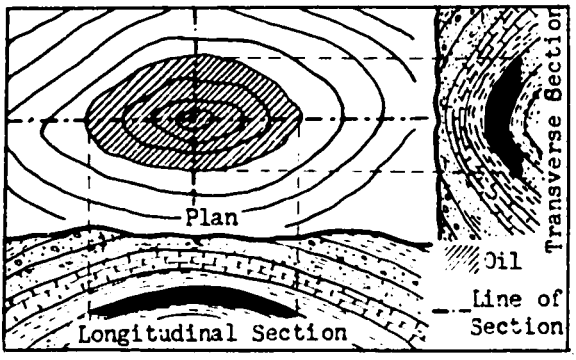

Figure - 17a
(After L. C. Uren).

Dome structure illustrated in plan and vertical sections; an oil-bearing stratum (shown in solid black) is depicted in the vertical sections and the area underlain by it is shown on the plan.

Sand lenses constitute a type of oil-bearing structure that is encountered in places and that does not involve any folding or warping of the strata. The accompanying figure shows the relationship of these lenses to the enclosing beds. Littoral sands laid

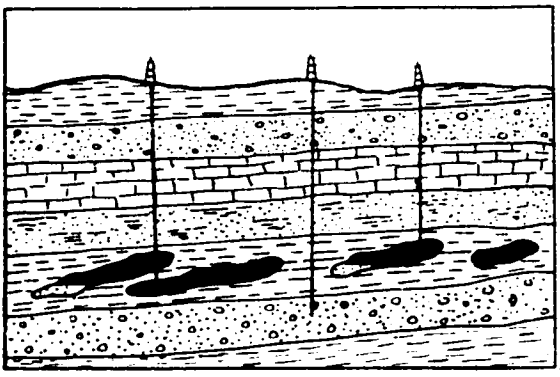

Figure - 18
(After L. C. Uren)

Lenticular deposits. Lenses of coarse sand in oil-bearing shales serve as local centres of concentration.

down along the margin of some ancient sea. if covered by a sufficient thickness of overlying beds, provide a structure similar in nature to sand lenses, but greater in extent.

Another type of oil-bearing reservoir known as a "stratigraphic trap" may exist at an erosional unconformity; that is, a series of beds overlying the eroded upsloped ends of an earlier series having a greater dip. Oil may accumulate in the upper part

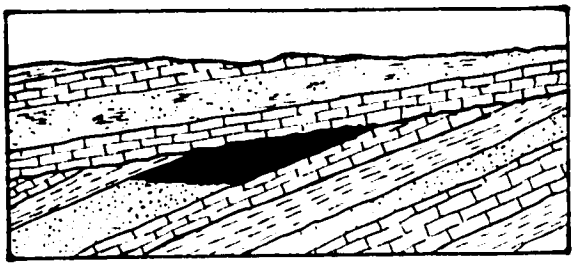

Figure - 19
(After Longwell, Knopf and Flint)

Stratigraphic trap showing the occurrence of oil (solid black) in sandstone below an angular unconformity.

of the dipping porous beds and be trapped there if the overlying unconformable beds are impervious. A similar situation arises where sediments laid down on a sea floor have thinned towards the shore and eventually pinched out entirely. If, sometime later, another sea covered the pinch-out area, the sediments deposited in it might become the required impervious layer. The result is the same in each case - a wedge-shaped stratum from which accumulated petroleum or gas could not escape.

The Norman Wells and Leduc fields exemplify yet another type of oil reservoir - the buried coral reef. Corals grow in clear warm shallow salt water, and as the organisms die, their calcium carbonate skeltons are left and gradually build up to form a reef. As the colonies expand and build upward, the dead base is gradually covered by the growth of new generations and by broken reef debris, the whole deposit being gradually cemented into a white spongy limestone. It is conceivable that the reef may serve as both a source and reservoir rock, the oil possibly being formed from the organic parts of the animals and accumulating in the natural pore spaces of the reef.

PROSPECTS OF RESERVOIR STRUCTURES IN MANITOBA

Of the several types of oil traps described above, some are more likely to be encountered in Manitoba than others. The sediments of Manitoba have suffered very little deformation; they are relatively flat-lying and the possibility of finding anticlines or similar structures is not great. The Cretaceous beds of Manitoba contain oil-bearing shales which are potential source rocks for oil and gas. Such shales have been shown to be capable of yielding on distillation as much as ten gallons of petroleum products per ton. Shales of this character, if folded, might give rise to accumulations of oil and gas. Unfortunately, however, the beds are, as a rule, essentially horizontal and undisturbed. An oil occurrence in unfolded beds is depicted in Figure 18. It is possible for an oil accumulation to occur in sand lenses in the Cretaceous shales of this province, but unless there were an oil seepage, no surface indication of such an occurrence would exist, and the only means of discovery would be geophysical prospecting and drilling.

In Saskatchewan, the Palaeozoic rocks are overlain by beds of Jurassic age. These beds extend eastwards into Manitoba but are not found exposed on the surface. If their disappearance is due to non-deposition rather than to erosion, littoral sand deposits might be expected along the shoreline of the sea in which the Jurassic beds were laid down. Provided the structures were suitable, such sands might serve as reservoir beds for gas and oil, and it is possible that the irregularities of the eroded surface of the underlying Palaeozoic beds may, in some localities, provide structures capable of trapping gas and oil. The sand deposits

would give no surface indication of their presence and the only method of learning of their existence or extent would be by geophysical prospecting and deep drilling.

Since the discovery of Mississippian rocks in the southwestern corner of the province, the existence of a stratigraphic trap has become highly possible. The recent well near Lyleton penetrated about 900 feet of Madison limestone. No such deposits have been recognized in the Commonwealth Manitou No. 2 well which is located about 110 miles to the east, so that thinning of the beds must be fairly rapid, whether it was caused by erosion or non-deposition.

Wallace observed some interesting dome-like features in the Devonian exposures in the Bell River area south of Dawson Bay, Lake Winnipegosis (1925, p. 27). He found no evidence that they were coral reefs but as no other explanation of the features has been offered, the possibility of an organic origin should not be overlooked. During the field season of 1949, a Manitoba Geological Survey party under A. D. Baillie recognized reef structures in the Devonian and Silurian outcrops east of Lake Manitoba. The reefs occur in the upper Silurian beds and in the Winnipegosan formation of the Devonian. Some measuring 50 feet by 150 feet were examined, and other larger domes and ridges in the area are probably a reflection of reefs at some depth below the surface. Some of the reefs are of coral origin and others appear to be algal; most have high porosity. These particular reefs are of no value as reservoirs owing to their proximity to the surface but it is probable that others may lie buried beneath later sediments to the south.

It appears that the most promising prospects for finding oil and gas in Manitoba lie in the discovery of sand lenses in the shales, littoral sands, stratigraphic traps, or coral reefs.

OCCURRENCE OF PETROLIFEROUS SHALES

The occurrence, in Manitoba, of petroliferous shales has been described by several observers, most notable of these being Ells (1923, pp. 34-41) and Wallace and Greer (1927, pp. 73-75).

Ells reports that the soft greenish and grey shales from the Benton (Ashville)[1] to the Niobrara (Boyne)[1] have been darkened by the presence of hydrocarbons and iron sulphides. He found that many of the shales, when freshly broken, emitted a marked odor of petroleum which passed off on exposure. When disintegrated by the drilling tools, in the presence of water, the shale forms an emulsion of a dark-green colour, which gives off a faint odor of petroleum, and after standing, exhibits a thin film of crude oil

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[1] See section on Terminology

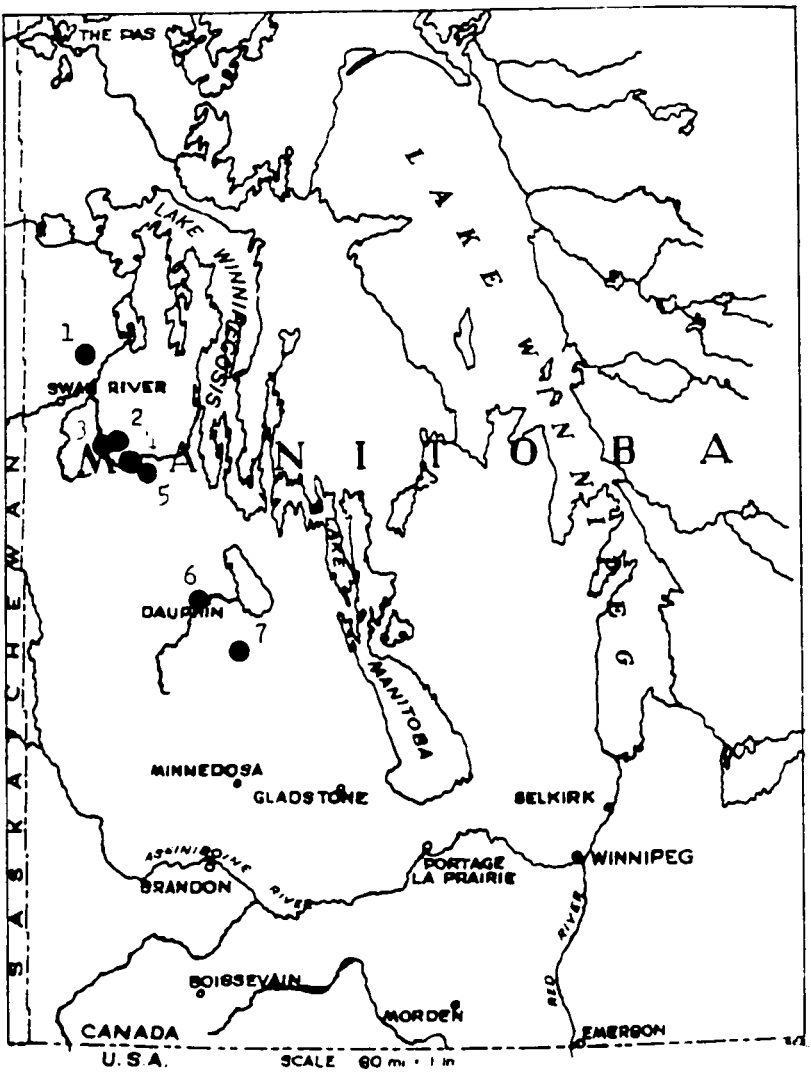

Figure 20

Map of Manitoba showing localities from which samples of petroliferous shales were collected by S.C. Ells, 1921.

on the surface. The Niobrara (Boyne) formation is the most highly fossiliferous and, therefore, is the best horizon for the occurrence of oil shales. The Cretaceous beds of Manitoba are almost horizontal, the dip being very slight towards the southwest. Any compression or folding of the beds which might have taken place would, in all probability, have resulted in the formation of gas and petroleum. None of the shales will ignite by means of a match, but the Niobrara (Boyne) shales will commonly ignite when placed on an open fire. The Pierre (Pembina and Riding Mountain)[1] shales ignite but rarely, and the Benton (Ashville) shales show no evidence of being combustible. Ells' sampling was confined, therefore, to the Niobrara (Boyne).

Localities from which shale samples were taken are shown on the accompanying map. The results obtained from distillation are given in the following table (Ells, 1923, p. 40):

Locality	Imp. gals. crude pet. per ton	Sp. gr. of crude pet. at 60° F.	Imp. gals. water per ton
1. Birch river 31-39-26W	0	-----	42.7
2. Favel river 30-35-25W	6.2	0.972	12.1
3. (Loc. 26-35-26W	6.8	0.984	7.0
(Loc. 26-35-26W	5.9	0.965	15.2
4. Sclater river 15-34-23W	4.8 - 7.5	0.966 - 0.968	9.2 - 18.7
5. Pine river 6-33-22W	3.3	0.969	4.5
6. Vermilion river 12-24-20W	1.1 - 5.1	0.952	8.1 - 22.0
7. Ochre river 29-22-17W	4.0 - 5.3	0.955	14.6 - 15.2

This content of petroleum is much too low to be commercial; even in Utah, Colorado and Montana, where production of 35 to 40 gallons of petroleum per ton of shale may be obtained, operating costs of mining and distillation are too high to allow commercial production. The shales are of interest at present chiefly as an indication that source rocks do exist, and that accumulations are possible if there should be suitable structures.

OCCURRENCE OF NATURAL GAS

Shows of natural gas have been reported in the drillers' logs of some of the deep wells of the province[2], but none of these occurrences have been of sufficient importance to be of commercial interest. However, in a few areas in the southern part of the province gas from shallow wells has been sufficient for lighting and some heating of farm houses. The gas appears to occur in pockets in the Favel and Riding Mountain shales. The greatest pressure measured was 45 pounds. The most extensive field is the Waskada-Melita district; this field is probably related to the Bottineau gas field south of the International Boundary. Wallace and Greer (1927,

[1] See section on Terminology
[2] See Schedule of Wells

pp. 71-73) described these occurrences at some length.

Waskada Area

Four shallow wells, drilled about 1921, in the vicinity of Waskada, yielded gas. Three of these were in the town and the fourth on sec. 8. tp. 2, rge. 25, W. Principal mer. Pressures of about 14 pounds were recorded. In 1947, two of the town wells were still producing. In that year, another well was drilled in the town, and gas sufficient for the top of a gas stove was obtained.

The gas is almost odorless and dry. It occurs in the upper Riding Mountain (Odanah) beds at a depth of 180 to 240 feet. Tovell[1] believed porosity to be from a fractured or preglacially weathered zone.

Melita Area

On the farm of J. B. Elliott (SW¼, sec. 10, tp. 2, rge. 27, W. Principal mer.), twelve miles south of Melita, a well was drilled for gas on the east bank of South Antler Creek about 1906. The well was 212 feet deep, and gas was encountered some distance above that depth. It was in sufficient quantity for a cook stove and a five-burner lamp in the farmhouse for over twenty years. At one time the pressure was measured at 19 pounds.

Natural escape of gas was visible at several places on South Antler Creek in this vicinity about 1927.

At Melita, natural gas was used for lighting purposes in the engine room of a grist mill (now dismantled) some 45 years ago.

Miami Area

Gas is reported to have been encountered in August, 1912, at a depth of 120 feet in a well being drilled for water, three miles west of Miami.

Hartney Area

At a depth of 190 to 210 feet gas was encountered in a well being drilled for water on the farm of Robert Hall (NW¼, sec. 14, tp. 6, rge. 22, W. Principal mer.). The well was capped, and

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[1] Personal communication, September, 1947

when the gas pressure was measured it registered 48 pounds but was reduced to 35 pounds on permitting the gas to escape for several minutes. After five hours, the pressure had increased to 45 pounds. This is the greatest pressure which had been recorded up to 1927. Dr. Shipley of the University of Manitoba made the following report on a sample of gas from this well: (Wallace and Greer, 1927, p. 72).

	Per cent
Combustible, mostly methane, but a small percentage of a heavier hydrocarbon	75.4
Carbon dioxide	0.0
Oxygen	4.0
Hydrogen	0.0
Residual non-combustible	20.6

Practically 80% of the gas is of value for light or heat, the remainder being of no value. If the pressure can be maintained, the gas could be of value for cooking, and probably for heating purposes.

Rathwell Area

Gas was found five miles south-southeast of Rathwell at the farm of Frank Bosc ($SW\frac{1}{4}$, sec. 21, tp. 7, rge. 8, W. Principal mer.) where a well was sunk to a depth of 210 feet. The flow of gas was sufficient for one light in the kitchen for several years. The gas in both the Treherne and Rathwell areas seems to come from the band of carbonaceous shale overlying the hard limestone band of the Favel formation which can be seen in outcrops on the Assiniboine River northwest of Treherne ($NE\frac{1}{4}$, sec. 36, tp. 8, rge. 11, W. Principal mer.)

Treherne Area

A well on the farm of E. C. Haskell ($NE\frac{1}{4}$, sec. 28, tp. 7, rge. 10, W. Principal mer.), located approximately three miles southwest of Treherne, was sunk to a depth of 250 feet and encountered gas at 150 feet. Up to 1927 gas from this well had been used for fifteen years for kitchen and dining room lighting and, occasionally, in a small gas heater for cooking.

Virden Area

Natural gas was reported to have been struck while drilling for water for the Virden hospital in 1932. The well is about one quarter mile north of the Canadian Pacific railway station and about thirty feet northwest of the hospital building, ($NW\frac{1}{4}$, sec. 23, tp. 10, rge. 26, W. Principal mer.).

When gas was struck the pressure was sufficient to blow sand and tools up to the head block of the derrick, a height of about sixty feet. The well was cased and capped and a steam guage registered 25 pounds pressure. Pressure gradually diminished and water eventually rose in the hole, shutting off the gas. As far as is known no use was made of the gas.

A sand strata about forty feet thick, classified as dune sand, rests on the Riding Mountain shale and appears to act as a reservoir for the gas which has migrated from the shale and is trapped under an impervious layer of clay.

Other Occurrences

In other areas in the province small flows of natural gas have been encountered during drilling operations. These flows have usually spent themselves within a few hours of being tapped and can now be detected only with difficulty or not at all. One such occurrence was near the town of Steinbach where at a depth of 80 feet, in glacial gravels, a pocket of marsh gas was trapped; it flowed for less than two days.

TOPOGRAPHIC FEATURES OF THE CRETACEOUS IN MANITOBA

The eastern limit of the Cretaceous rocks of Manitoba is marked by a steep escarpment which has been eroded and dissected to form a series of hills which rise 500 to 1000 feet above the Manitoba Lowland to the east. From south to north, these hills are named Pembina Mountains, Riding Mountain, Duck Mountain, Porcupine Mountain, and Pasquia Hills, and their somewhat flattened tops form the level of the second prairie steppe. It should be remembered that these hills are purely the result of erosion and are in no way the surface expression of subsurface folds or domes.

A dome-shaped structure near the town of Pilot Mound has aroused the interest of oil-seekers in the past. The shale beds on the flanks of the mound all have steep dips and, at first glance, it would appear that the strata had been pushed up from beneath to form a dome. However, a close study reveals that the irregular dips are due to slumping of the beds which were probably pushed up in the first place by the action of the continental glacier. The presence of glacial erratics on the top of the mound clearly indicates that the mound itself has been overridden by a continental ice sheet, and so, deformation of the surface shale beds would of necessity have resulted. Drilling revealed that there was, in reality, no "structure" below the surface beds.

Another domed structure within the Cretaceous beds occurs at Thunder Hill in the Swan River Valley, on the Manitoba-Saskatchewan boundary. Kirk (1930, pp. 132-133) has stated that the strata on Thunder Hill are 300 to 400 feet higher in elevation than the corresponding strata in the surrounding area. He writes as follows: "It appears to be necessary to postulate a direct and very much localized uplift, but the cause of such uplift can only be guessed at." Two holes were drilled in this structure in 1934 and the interpretation of drilling results suggests that, whereas the upper beds are domed up, the Swan River beds lie at the normal elevation, indicating that the folding is superficial. Much bentonite was encountered in the drilling, and the suggestion has been offered that expansion of bentonite through absorption of water was the direct cause of the uplift. The well drilled a few years later by Canadian Industries Limited revealed that the hill is made of displaced shales of the Favel and Ashville formations with intermediate layers of glacial material. It seems, therefore, that Thunder Hill, like Pilot Mound, is the result of glacial action.

DEEP DRILLING OPERATIONS

In the following pages, an account is given of most of the deep drilling done in the province. The operations are discussed according to area, beginning in the south. Wells having about the same latitude are described in order from east to west.

1. PEMBINA RIVER AREA

The wells discussed below are located within 16 miles of the International Boundary and are distributed from Rosenfeld to Pilot Mound, a distance of some sixty miles. The greater part of the drilling was done in the vicinity of the Pembina River valley.

Rosenfeld

A hole was drilled by the Canadian Pacific Railway Company at Rosenfeld station sometime prior to 1886. An ordinary percussion drill was used and the hole reached a depth of 1037 feet. The well penetrated 143 feet of surficial deposits and 892 feet of Ordovician formations; it bottomed in what the driller described as "granite". Small flows of brine were encountered at depths of 265 feet and 800 feet, and in the interval 875 to 925 feet the brine produced a flowing well.

Morden

The town of Morden drilled a well in search of water in 1889-90. It was located about 150 yards northwest of the railway station. The hole penetrated shale and sand of the Upper Cretaceous and Swan River formations and bottomed in Jurassic beds. The total depth was 601 feet; salt water was encountered at a depth of 324 feet. The location has since been built over.

Snowflake

A shallow well was drilled near the town of Snowflake sometime prior to 1919. A depth of 323 feet was reached. The hole penetrated 62 feet of overburden and 238 feet of oily-looking shale of the Favel formation (Dowling, Slipper and McLearn, 1919, p. 35).

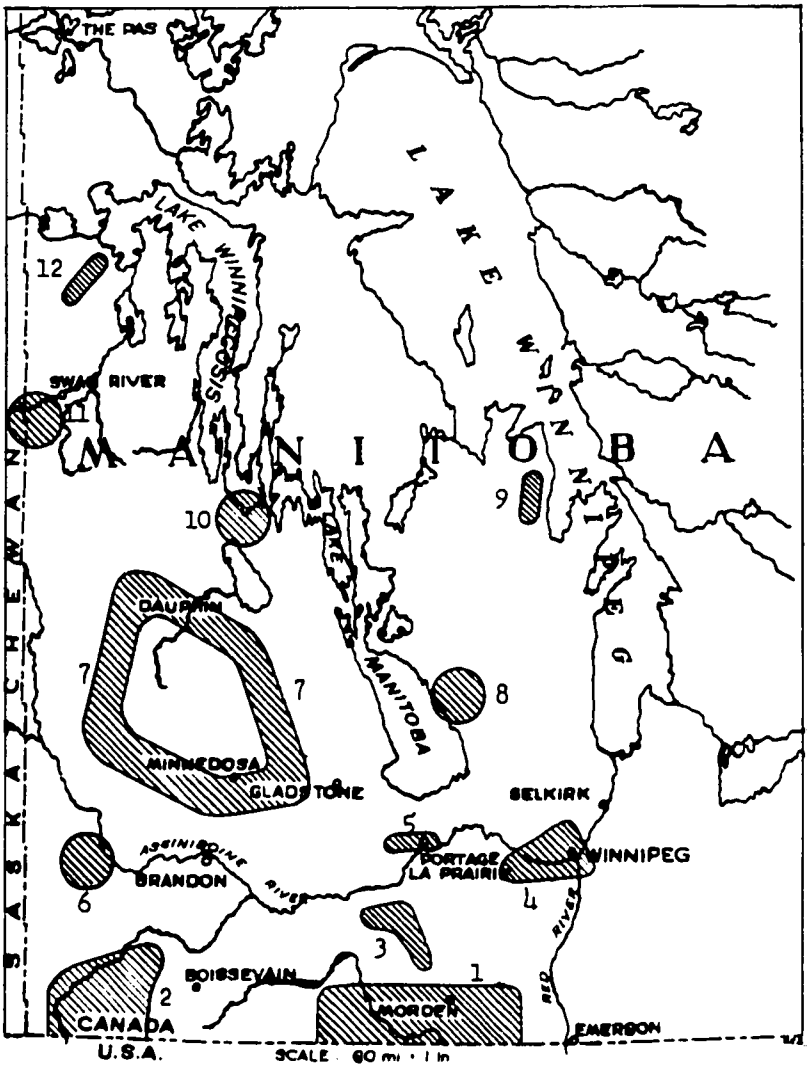

Figure 21

Map of Manitoba showing areas where drilling has been carried on.

1. Pembina River area
2. Southwestern Manitoba
3. Treherne-Miami area
4. Winnipeg area
5. Portage la Prairie area
6. Virden area
7. Riding Mountain area
8. Lundar area
9. Lake St. George area
10. Winnipegosis area
11. Thunder Hill area
12. Mafeking area

Manitou

In 1934, Croyden Developments Limited drilled three test holes near a point about eleven miles south of Manitou. This company was later taken over by Natural Gas Utilities of Canada Limited. The holes were drilled on the supposed surface expression of underlying structure to depths of 300, 700 and 750 feet. No indication of interesting structure was found and no oil or gas was encountered.

The Commonwealth Petroleums Limited sank two wells on the same section, approximately seven miles south of the town of Manitou. These are known as Commonwealth Manitou No. 1, drilled in 1915-16, and Commonwealth Manitou No. 3, drilled in 1930-31. The Manitou No. 1 well bottomed in the Jurassic at a depth of 1200 feet. Petroliferous shale of the Favel formation was encountered at 507 feet. Gas was also encountered but the depth of this occurrence is not known. The Commonwealth Manitou No. 3 well had a total depth of 1120 feet; small showings of gas were reported.

The Commonwealth Manitou No. 2 well, located roughly six miles south of Manitou, was drilled in 1931-32 by Commonwealth Petroleums Limited for Pembina Valley Gas and Oil Company Limited. The hole reached a depth of 2639 feet and furnished an excellent stratigraphic section from the Upper Cretaceous to the Precambrian.

Purves

Drilling operations were carried on intermittently during the years 1934 to 1938 by the Lisgar Oil and Gas Company Limited at a point approximately two miles east of Purves and six miles west of the Pembina River. The hole reached a depth of 1904 feet, encountering the top of the Palaeozoic beds at approximately 1500 feet. The drillers reported several minor shows of gas and oil.

Pilot Mound

In 1938-39, Bates Petroleum Limited drilled a well on the west flank of the mound which is located about two miles northwest of the town of Pilot Mound. The well intersected a considerable thickness of Upper Cretaceous beds, the Swan River group of the Lower Cretaceous, 480 feet of Jurassic beds, the Amaranth formation, Devonian rocks, and bottomed in Silurian strata. Distillation tests on the samples from the well gave no indication of oil or gas.

2. SOUTHWESTERN MANITOBA

The area described in this section extends from Hartney southwest to Coulter.

Hartney

A 210-foot well was drilled in 1926 on a farm about three miles northeast of the town of Hartney. Gas was encountered at a depth of 190-210 feet.

Deloraine

The Deloraine well, begun in 1888, was the first exploration undertaken in the southern Manitoba area. The well was drilled by W. Ward for the town of Deloraine and is located about 100 yards north of the railway station, on a level alluvial plain which stretches northwards from the base of the Turtle Mountain to the Souris River. It was begun for the purpose of finding an adequate supply of water; as the geology was of little interest at the time, no samples were kept for the first 975 feet. Intermittent samples were taken below that depth as drilling was carried on with the aid of the Geological Survey of Canada. A percussion drill, supported by jointed rods and worked by a small stationary engine was used, and the cuttings were raised with an ordinary sand pump. The well is cased to the bottom with iron tubing. The hole penetrated over 1600 feet of Upper Cretaceous beds and bottomed in the Swan River sandstone at a depth of 1943 feet. A small amount of water was encountered at 150 feet, and a greater flow of salt water was encountered at a depth of 1800 feet, in the Swan River beds.

Waskada

There have been at least five small gas wells in the vicinity of Waskada. Four of these were drilled in 1911 and were in active use in 1927; in 1948, only two of the four were still flowing, these in the town itself. The fifth well was drilled in 1947 to a depth of 250 feet; gas was encountered at 180 feet.

Coulter

A gas well was drilled in 1906-7 about one mile northwest of the village of Coulter to a depth of 1009 feet. A small flow of gas was encountered at an unknown depth.

3. TREHERNE-MIAMI AREA

Most of the wells drilled in this area have been shallow gas wells.

Miami

Three miles west of the town of Miami, a well was drilled to an unknown depth in search of water. Gas was encountered at a depth of 120 feet but the quantity is not known.

Rathwell

A gas well was drilled to a depth of 210 feet on a farm about five miles southeast of Rathwell. Gas occurred at a depth of 170 feet.

The Province of Manitoba drilled a well a short distance south of the town of Rathwell sometime prior to 1913. The total depth was 1885 feet. Little is known of the geology of the well, but the well is believed to have penetrated formations from the Ashville to the Precambrian.

Treherne

A well was drilled in 1911 on a farm about four miles southwest of Treherne. Nothing is known of the formations penetrated. The total depth was 250 feet and gas occurred at a depth of 150 feet.

4. WINNIPEG AREA

Winnipeg

Several water wells have been drilled in the vicinity of Winnipeg and St. Boniface. A number of 5-inch and 12-inch wells have been sunk on the Swift Canadian Company's property in St. Boniface. The only one of these from which samples have been examined was 400 feet in depth and penetrated part of the Red River formation. Dr. R. T. D. Wickenden examined the samples and reported that the contact between the Selkirk and Cat Head members of the formation was probably at a depth of 140 feet.

D. J. Coyle drilled a water well for the DeLuxe Theatre in North Winnipeg to a depth of 400 feet. The rocks penetrated are

believed to be part of the Red River formation of the Ordovician.

A 240-foot well was drilled in search of water at St. Andrews about 1938. The samples taken indicate that the formations penetrated were the Red River and the upper part of the Winnipeg of Ordovician age.

A water well was drilled for the Riedle Brewery in 1946, on the Brewery's property at Stadacona street and Talbot avenue. The depth was 300 feet and the hole penetrated creamy-buff dolomite and limestone. Some porosity was noted at depths of 190-200 feet and 250-300 feet.

The Pelissier Brewery had a water well drilled on their property at Osborne street and Mulvey avenue in Winnipeg in 1946. It reached a depth of 350 feet and penetrated buff or cream dolomite with bands of dolomitic limestone and limy dolomite. Porous zones were noted at depths of 170-240 feet and 320-350 feet.

Starbuck

A well known as Commonwealth Pete No. 2 was drilled during the 1930's a short distance west of the town of Starbuck, by the Pembina Valley Gas and Oil Company Limited. The total depth was 2650 feet and the hole penetrated formations from Vermilion River to the Winnipeg. Several small oil and gas shows were reported in the driller's log.

Lilyfield

A well was drilled at the village of Lilyfield, about four and one-half miles southwest of Story Mountain by the Stony Mountain Oil and Gas Company in 1922. The well began in the lower beds of the Stony Mountain formation, penetrated the Red River and Winnipeg formations and reached the Precambrian at a depth of 708 feet. The hole continued in Precambrian granite to a total depth of 1010 feet. No indications of oil or gas were found.

5. PORTAGE LA PRAIRIE AREA

Portage la Prairie

The Coutts Portage la Prairie No. 1 well was drilled in 1944-45 by the Manitoba and Saskatchewan Oil and Gas Development Syndicate. The driller was D. J. Coyle of Winnipeg; a rotary rig was used. The hole began in the Amaranth formation and bottomed in the Winnipeg formation at a total depth of 1540 feet. Some porous zones were encountered but no shows of oil or gas were

reported.

Willowbend Creek

In 1874, a hole was bored for the Geological Survey of Canada to a depth of 210 feet at a location 66 miles west of Fort Garry, as Winnipeg was then known. This was on the bank of Willowbend Creek, then called Rat Creek in tp. 11, rge. 9, W. Principal mer. The drilling was done "to ascertain where the eastern limit of the Cretaceous coal-bearing rocks is, and at the same time whether artesian wells affording good water can be made upon the prairies where surface water is either very scarce or for the most part too saline for domestic purposes". (Selwyn, 1876, pp. 2-3). The well was reported to have penetrated limestone of Silurian or Devonian age and grey rock of uncertain age.

6. VIRDEN AREA

In 1932, a well was drilled for water on the property of the General Hospital at Virden. At a depth of about 140 feet, a flow of gas was encountered, which had sufficient pressure to blow sand and tools up the head block of the derrick. The gas was shut off and the well was deepened in search of water. A second well was put down near by to test the gas flow but the initial pressure of about twenty-five pounds decreased to almost zero and no use was made of the gas.

7. RIDING MOUNTAIN AREA

Localities where drilling has been done in the Riding Mountain area are discussed according to their distribution around the flank of the mountain starting on the south flank at Neepawa and proceeding in a clockwise direction.

Neepawa

The Neepawa No. 1 well was drilled in the interval 1910-13 to a depth of 1798 feet. The well began in the Cretaceous shales and bottomed 970 feet below the top of the Palaeozoic. Brine flows occurred at depths of 550 feet, 1185 feet, and 1460 feet. In 1931 this well was taken over by the Neepawa Salt Company Limited which in 1935 became a subsidiary of Canadian Industries Limited. The Neepawa No. 2 well was commenced in 1935 and attained a depth of 1492 feet. Flows of salt water were encountered at 1162 feet and at 1445 feet. Production of salt commenced in 1932 and has increased

from 508 tons in that year to 26,339 tons in 1945. Early analysis of the brine indicated that it contained more than 17 per cent of dissolved salts, analysis of which has been given as follows: (Wallace and Greer, 1927, p. 92)

	Per cent
Sodium chloride	91.4
Potassium chloride	0.016
Calcium chloride	4.06
Magnesium chloride	2.32
Magnesium bromide	0.055
Calcium sulphate	2.06
Iron and Aluminium	traces
Magnesium iodide	0.0081
	99.9191

Some bitumen or heavy oil was encountered in the Neepawa No. 2 well at a depth of 1400 feet.

In the autumn of 1947, the Langford Oil Syndicate drilled a well a few miles east of the salt wells. A rotary rig was used and the well reached a depth of 2509 feet. The hole started in the Upper Cretaceous and bottomed in the Precambrian. Samples from the upper part of the well were poor, but samples from the Amaranth and older formations were good. Flows of salt water were encountered but no gas or oil shows were reported.

Rapid City

At Rapid City and in the area southward to Levine and northward to Minnedosa, a limited amount of exploration has been made for oil. A few shallow holes were drilled in the valley of the Minnedosa River southwest of Minnedosa but details regarding this and other drilling in the area are not known.

A well known as the Rapid City well was drilled immediately east of the Canadian Pacific railway station at Rapid City. Total depth of the hole was 755 feet and the beds at that depth were reported to be the limestone horizon of the Niobrara (Favel).

Solsgirth

A well was drilled in the town of Solsgirth by the Manitoba and Northern Railway Company sometime prior to 1886. The hole was drilled to a depth of 360 feet; the upper 292 feet was glacial deposits and the lower 68 feet was grey clay of the Riding Mountain formation or possibly glacial silt.

Birdtail

The Waywasecapow Oil Syndicate (incorporated in 1939 as the Waywasecapow Oil Company Limited) commenced drilling on the Cleland No. 1 well a short distance east of Birdtail station in 1936. This location is near the south flank and the west end of Riding Mountain. In June, 1939, the hole had reached a depth of about 1200 feet and soon after this the tools were lost in the hole. A second hole, Cleland No. 2, was begun about sixty feet south of the first, but at a depth of 928 feet the tools froze in the hole. The operator reported a show of oil at a depth of 1129 feet in the Cleland No. 1 well. Cleland No. 3 is presently being drilled close to the site of the first two wells.

Grandview

Grandview Oils Limited drilled six miles north of Grandview in 1926-27. Two shallow holes were put down which apparently did little more than penetrate the glacial drift. Oil was reported in one of these holes, but this report was subsequently found to be incorrect.

Gilbert Plains

The Coutts Gilbert Plains No. 1 well was drilled in 1945-46 by D. J. Coyle for A. R. Coutts of the Manitoba and Saskatchewan Oil and Gas Development Syndicate to a depth of 1370 feet. Samples taken indicate that the well started in the Favel formation and bottomed in the Silurian strata. There were no indications of oil or gas.

Dauphin

The Dauphin Oil Syndicate drilled a well about eight miles southwest of Dauphin in 1929-30. A standard cable-tool rig was used and the hole attained a depth of 1256 feet. The formations penetrated range from Lower Cretaceous to Devonian. Light shows of gas and oil were reported in this well.

Vermilion River

The Vermilion River rises on the north flank of Riding Mountain and flows roughly northeast, into Lake Dauphin. Drilling was done near the river approximately twelve miles south-southwest

of the town of Dauphin as early as 1887, when the Manitoba Oil Company hauled a percussion drill north from Strathclair and drilled two holes during the summers of 1887 and 1888. The first hole reached a depth of 292 feet. The second hole, known as the Vermilion River well reached a depth of 743 feet in Upper and Lower Cretaceous shales and underlying Devonian limestones.

In 1921, the Agassiz Oil Development Company drilled a hole to a depth of 320 feet at a nearby location. Neither this nor the earlier drilling gave any indication of oil or gas.

Ochre River

Three wells were drilled near Ochre River and approximately ten miles south of Ochre River station in the years 1921 to 1927. Situated on the northeast flank of Riding Mountain, the wells were started several hundred feet above the base of the Upper Cretaceous. The first drilling was done by Lindsay and Thompson on l.s. 12, sec. 30, tp. 22. rge. 17, W. Principal mer. The hole was drilled to 540 feet and left standing. Drilling operations were taken over by Mack Oil Company in 1927 and continued to a depth of 920 feet. Shows of gas were reported.

The Holmes well was drilled in 1926-27 on legal subdivision 10 of the same section to a depth of 1487 feet. No data are available on this well.

Riding Mountain

A well was drilled one mile west of Riding Mountain station sometime prior to 1914. Cretaceous shale and sand were penetrated to a depth of 351 feet.

8. LUNDAR AREA

Two shallow wells were drilled in 1921 by Martin and Rothwell near Rabbit Point on the east shore of Lake Manitoba, some eight miles west of Lundar station. The drilling was done to test a Devonian dome structure. The deepest hole was 267 feet.

A 98-foot hole was drilled by H. A. Jukes in 1926 at a location two and one-half miles northeast of Rabbit Point. No data are available.

George Mann drilled a hole one mile southeast of Lundar in 1921. The hole was abandoned at an unknown depth. No data are available.

9. LAKE ST. GEORGE AREA

Three test holes were put down in the vicinity of Lake St. George by R. J. McGuckin in 1928. Lake St. George lies some six miles west of Fisher Bay, Lake Winnipeg. Two holes were drilled on tp. 31, rge. 1, E. Principal mer. near the south end of the lake to depths of 232 feet and 258 feet. The third hole was drilled to the north of the lake on tp. 33, rge. 1, E. Principal mer. to a depth of 141 feet. The holes started in Ordovician limestone and although the results are not known, it seems probable that they penetrated to the base of the Palaeozoic.

10. WINNIPEGOSIS AREA

A typical Devonian dome structure, similar to those described by Wallace (1925, p. 27), southeast of the town of Winnipegosis was investigated in 1920-21 by the Manitoba Government. Operations were conducted near the south shore of Lake Winnipegosis, immediately south of Snake Island. After abandoning three shallow holes, a deep hole was drilled which penetrated the Palaeozoic limestone. The Palaeozoic section was found to be 1458 feet thick at this point; the well started in the Devonian and reached the Precambrian. No indications of oil or gas were found.

11. THUNDER HILL AREA

An apparent dome structure at Thunder Hill in the Swan River valley has been described above.[1] Two diamond drill holes were drilled in 1933-34 to investigate this structure by John Drybrough of Winnipeg. It was found that the sandstones of the Swan River group apparently lie at their normal elevation and, hence, the doming of the overlying beds is probably superficial. The first hole was drilled to a depth of 429 feet and penetrated part of the Ashville formation; the second hole was drilled to 638 feet and passed through parts of the Favel and Ashville formations. The holes were drilled primarily in search of salt; there were no indications of oil or gas.

In 1937, Canadian Industries Limited drilled a diamond drill hole near the Thunder Hill No. 2 well, to a depth of 1152 feet. The beds were found to be repeated with layers of glacial drift between. This would indicate that the hill is the result of glacial action.

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[1] See section on Topographic Features of the Cretaceous

12. MAFEKING AREA

The Mafeking area lies on the east flank of Porcupine Mountain. Activity was confined to the area between Steeprock River to the north, Bell River to the south, the first terrace of the mountain to the west, and a line approximately one mile east of the railway to the east. Eight holes were drilled, one by core drill, todepths of from 235 to 1630 feet. The holes were started in either the Swan River sand or the lower part of the Ashville shale, entered the Palaeozoic limestones, and at least one, Mafeking No. 3, reached the underlying Precambrian granite.

Three holes were drilled by E. Doherty and associates. Two of these, located on Steeprock River one mile below and one and one-quarter miles above the railway crossing were drilled to depths of 235 feet and 807 feet respectively. The third hole, located one mile west of the town of Mafeking, was drilled by core drill to a depth of 1630 feet; this hole is known as the Mafeking No. 3 well.

Three holes were drilled by Northern Manitoba Oil Company Limited on sec. 33, tp. 42, rge. 26, W. Principal mer., where a branch of the Bell River cuts through the foothill scarp. Hole No. 1 was shallow, but holes No. 2 and No. 3 reached depths of 996 and 1380 feet respectively.

On the south branch of the Bell River, approximately seven miles south of Mafeking, two holes were drilled by Porcupine Mountain Oil and Gas Company, Limited. Hole No. 1 reached a depth of 350 feet, hole No. 2 a depth of 977 feet.

A small showing of gas is reported to have been encountered in hole No. 2 drilled by the Porcupine Mountain Oil and Gas Company Limited. No other indications of oil or gas were found by drilling in the Mafeking area.

SCHEDULE OF WELLS[1]

In the following pages, a list is given of all wells drilled in Manitoba of which the Manitoba Mines Branch has a record. For some, the data on file is very scant but it is presented here to give as complete a picture as possible.

The information on which most of the logs have been based has been supplied by the companies and drillers that have drilled the wells; the Mines Branch can not vouch for the accuracy of this information.

Following is a list of abbreviations of formation names used throughout:

Drift	Glacial drift and topsoil
Rec	Recent
Pleis	Pleistocene
Cret	Cretaceous
RM	Riding Mountain
VR	Vermilion River
Pem	Pembina member
Boyne	Boyne member
Mor	Morden member
Fav	Favel
Ash	Ashville
SR	Swan River group
Jur	Jurassic
Am	Amaranth
Pal	Palaeozoic
Dev	Devonian
Sil	Silurian
Ord	Ordovician
SM	Stony Mountain
RR	Red River
Wpg	Winnipeg
Prec	Precambrian

DEEP WELLS

(1) SNOWFLAKE
Location - 35-1-9 WPM Elevation - 1290'
Total Depth - 323'
Drilled prior to 1918
Contact Drift/Fav @ 62'
Reported oily shales 73-311 feet

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[1] The numbering of wells in this section has been altered from that used in the Schedule of Wells previously issued separately.

(2) COMMONWEALTH MANITOU No. 1
Location - l.s. 2, 23-2-9 WPM Elevation - 1301.7'
Total Depth - 1200'
Commenced 1915, suspended at 925' in 1916, resumed drilling 1931, abandoned in 1932
Contacts: RM/VR-Pem @ 20', VR-Pem/VR-Boyne @ 80', VR-Boyne/VR-Mor @ 300', VR-Mor/Fav @ 425', Fav/Ash @ 640', Ash/SR @ 740', SR/Jur @ 800'
Petroliferous shale at 507'; gas show at 714'(?)

(3) COMMONWEALTH MANITOU No. 2
Location - l.s. 8, 26-2-9 WPM Elevation - 1270'
Total Depth - 2639'
Drilled 1931-1932
Drilled by Commonwealth Petroleums for Pembina Valley Oil & Gas Co. Ltd.
Drilling rig: standard cable tool
Contacts: Drift/VR-Boyne @ 100-140', VR-Boyne/VR-Mor @ 290', VR-Mor/Fav @ 410', Fav/Ash @ 580', Ash/SR @ 705', SR/Jur @ 755', Jur/Am @ 1180' Am/Dev @ 1400', Dev/Sil @ 1450', Sil/Ord-SM @ 1850', Ord-SM/Ord-RR @ 1938', Ord-RR/Ord-Wpg @ 2480', Ord/Prec @2613'
Porous zones at 1580-1600, 1700-1770, 1820-1830, 2017-2045, 2390-2480
Shows of gas were reported at 280-310, 540-570 and 670-690; shows of oil were reported at 280-310, 1510-1530, 1810-1850, 1890-1920. (This information was reported by Granville G. Howard as having been obtained from the Supt. of Mining Engineers of the Dept. of Interior)

(4) COMMONWEALTH MANITOU No. 3
Location - SE¼, 23-2-9 WPM Elevation - 1270'
Total Depth - 925'
Drilled in 1907
Drilling rig: standard cable tool
Contacts: RM/VR @ 425', VR/Fav- ?, Fav/Ash @ 610', Ash/SR @ 716'
Show of gas and blue film of oil at 925'. Reported by G. G. Howard that gas was still escaping from this hole in 1935

(5) LISGAR
Location - NE¼, 13-2-10 WPM Elevation - 1589.8'
Total Depth - 1904'
Drilled from July, 1934 to August, 1939
Drilled by Lisgar Oil and Gas Co.
Drilling rig: standard cable tool to 1400, then rotary
Casing: 10" to 96', 6-8" to 311', 6" to 1107'
Contacts: RM/VR @ 400', VR/Fav @ 690', Fav/Ash @ 830', Ash/SR @ 950', SR/Jur @ 1120', Jur/Am @ 1600', Am/Dev @ 1820'
Porous zone at 1250-1260

Water shows at 180' (small), 940' (slightly salty, rose to 500-600')
Gas shows at 450-480, 810, 950, 1180-1240, and 1513 (wet)
Oil shows at 230, 260, 300, 400-420, 440, 450-480, 580, 610, 810, 830, 930; 950, 1110, 1130, 1190, 1390-1408

(6) ROSENFELD
Location - l.s. 4, 9-3-1 WPM Elevation - 770'
Total Depth - 1037'
Drilled by Canadian Pacific Railway Co.
Drilling rig: percussion drill
Top of well is near base of Swan River formation; most of beds penetrated are Palaeozoic
Water (salt) 265'(small), 800'(small), 875-925'(strong)

(7) MORDEN
Location - 5-3-5 WPM Elevation - 990'
Total Depth - 601'
Drilled in 1889-1890
Drilled by Town of Morden
Contacts: Drift/VR @ 15', VR/Fav @ 94', Fav/Ash @ 215', Ash/SR @ 320', SR/Jur @ 412'
Porous zone (narrow) at 500'
Salty water at 324'

(8) PILOT MOUND (Coal Gate #1) Elevation - 1557.1'
Location - SW¼, 20-3-11 WPM
Total Depth - 2010'
Commenced drilling, October, 1937, suspended December, 1937 at 624', hole deepened to 2010' in 1938
Drilled by Gates Petroleum Ltd.
Drilling rig: standard cable tool
Casing: 12" to 90', 10" to 356.5'
Contacts: SR/Jur @ 1163', Jur/Am @ 1640', Am/Dev @ 1830', Dev/Sil @ 1958'
Water at 50' rose to 30' in hole
Blue gas show 103-125

(9) DELORAINE
Location - SE¼, 10-3-23 WPM Elevation - 1644'
Total Depth - 1943'
Drilled 1888-1892
Drilled by Town of Deloraine
Contacts: Pleis/Cret @ 94', RM/VR-Pem @ 1050', VR-Pem/VR-Boyne @ 1075', VR-Boyne/VR-Mor @ 1275', VR-Mor/Fav @ 1455', Fav/Ash @ 1595', Ash/SR @ 1800
Water at 150 feet and salt water at 1800'

(10) RATHWELL
Location - 7-8-8 WPM Elevation - 1071'
Total Depth - 1885'
Drilled prior to 1913
Drilled by Province of Manitoba
Contacts: top SR @ 427'; Top Pal @ 700'

(11) COMMONWEALTH PETE No. 2
Location - l.s. 6, 26-9-2 WPM Elevation - 1300' approx.
Total Depth - 2650'
Drilled after 1931
Drilled by Pembina Valley Gas and Oil Co. Ltd
Casing: 15" to 91', 12½" to 122' (pulled and replaced by 15"), 15" to 132, 12½" in lime band at 634', 10" at 750', 8" at 897, 6-5/8" at 1300', 4 3/4" at 1900' (pulled and replaced by 6" from 1913'
Contacts: Drift/VR @ 130', VR/Fav @ 570', Fav/Ash @ 670', Ash/SR @ 850', SR/Jur @ 960', Jur/Am @ 1215', Am/Dev @ 1410', Dev/Sil @ 1470', Sil/Ord-SM @ 1900', Ord-SM/Ord-RR @ 2020', Ord-RR/Ord-Wpg @ 2460'
Water shows: 10-20 (fresh), 30-40 (strong, fresh), 110-120 (fresh), 480-490 (small, salty), 715 (saline), 860-870 (small, saline), 900 (small, saline), 1970-1980 (small, saline), 2190-2200 (small), 2240
Gas shows: 200-300, 560 -570 (small), 660-670, and 690-700
Oil shows: 280-300, 340-350, 530-570, 1510-1530 (colors on rock), 1810-1820, 1830-1850, 1890-1900 (colors), 1900--1920

(12) RIEDLE BREWERY
Location - Stadacona & Talbot Ave. Wpg. Elevation - 760'
Total Depth - 300'
Drilled in 1946 for water
Rock is crystalline brown dolomite and limestone
Porous zones: 190-200, 250-300

(13) PELISSIERS BREWERY
Location - Osborne & Mulvey Ave., Winnipeg; Elevation - 762'
Total Depth - 350'
Drilled in 1946 for water
Rock is buff or cream dolomite with band of dolomitic limestone and limy dolomite
Porous zones: 170-240, 320-350

(14) DELUXE THEATRE
Location: 1525 Main St., Winnipeg Elevation - 760'
Total Depth - 400'
Drilled by D. J. Coyle, Winnipeg
Formation: Red River formation of Ordovician

(15) SWIFT CANADIAN
Location - Lot 310, Reg. Plan #433, St. Boniface
Elevation - 760' approx.
Total Depth - 400'
Formation - Red River of Ordovician; contact between Selkirk and Cat Head members of this formation at 250'

(16) PORTAGE LA PRAIRIE No. 1
Location - SW¼, 9-12-7 WPM Elevation - 850' approx.
Total Depth - 1540'
Drilled in 1944-1945, well suspended, standing
Drilled by D. J. Coyle for A. R. Coutts (Manitoba & Saskatchewan Oil and Gas Development Syndicate)
Drilling rig: rotary
Contacts: Drift/Am @ 100', Am/Dev @ 170-190
Dev/Sil @ 375', Sil/Ord-SM @ 870, Ord-SM/Ord-RR @ 940', Ord-RR/Ord-Wpg @ 1420'
Porous zones: 400-480, 490-500, 550-570, 580-590, 610-690, 970-1040, 1090-1110

(17) STONY MOUNTAIN No. 1
Location - SE¼, 29-12-2 EPM Elevation - 800' approx.
Total Depth - 1009'
Drilled in 1922
Drilled by Stony Mountain Oil and Gas Co. Ltd.
Contact: Drift/Ord-SM @ 2', Ord-SM/Ord-RR @ 115', Ord-RR/Ord-Wpg @ 610', Ord/Prec @ 708'

(18) C. H. SINCLAIR
Location - Lot 165, St. Andrews, Manitoba. Elevation - 750' approx.
Total Depth - 240'
Contact: Drift/Ord-RR @ 20'

(19) RAPID CITY
Location - 20-13-19 WPM Elevation - 1584'
Total Depth - 755'
Formation at 755' - "Niobrara" (Favel)

(20) NEEPAWA No. 1
Location - 33-14-15 WPM Elevation - 1222.1'
Total Depth - 1798'
Drilled 1910-1913
Drilled by ?; well taken over by Neepawa Salt Co. in 1931
Contacts: Drift/Cret @ 40', Cret/Jur @ 450', Jur/Pal @ 830'
Well produced brine

(21) NEEPAWA No. 2
Location - l.s. 9, 33-14-15 WPM Elevation - 1205.7'
Total Depth - 1492'
Drilled August, 1935 to February, 1936
Drilled by Neepawa Salt Co. Ltd.
Drilling rig: standard cable tool
Casing: 12½" to 156'3", 10" to 991'8", 8¼" to 1401'4"
Contacts: Fav/Ash @ 260', Ash/SR @ 395', SR/Jur @ 470', Jur/Am @ 750', Am/Dev @ 940', Dev/Sil @ 1360'
Salt water flows at 1162' and 1445'; well started producing brine in 1936
Some bitumen or heavy oil at 1400'

(22) LANGFORD No. 1
Location - l.s. 5, 29-14-14 WPM — Elevation (Grd.) - 1139.5'
Total Depth - 2519' — Elevation (D.F.) - 1141.9'
Drilled September to November, 1947
Drilled by Langford Oil Syndicate
Drilling rig: rotary
Casing: 7" to 200' (pulled) 7" to 323'(cemented with 70 sacks cement)
Contacts: Ash /SR @ 340', SR/Jur @ 425', Jur/Am @ 750', Am/Dev @ 895', Dev/Sil @ 1255', Sil/Ord-SM @ 1860', Ord-SM/Ord-RR @ 1905', Ord-RR/Ord-Npg @ 2380', Ord/Prec @2506'
Porous zones: 550-555, 570-575, 1025-1075, 1100-1160, 1280-1285, 1315-1320, 1325-1335, 1345-1355, 1360-1400, 1465-1555, 1670-1730, 2070-2095, 2100-2125
Salt water at 540', 1130', 1430', 1930'

(23) SOLSGIRTH
Location - N½, 30-17-25 WPM — Elevation - 1757'
Total Depth - 360'
Drilled prior to 1886
Drilled by Manitoba & Northwestern Railway Co.
Contacts: Drift/RM @ 292' or sediments all glacial drift and silt

(24) RIDING MOUNTAIN
Location - 9-18-15 WPM — Elevation - 1214'
Total Depth - 351'
Drilled prior to 1914'
Penetrated Cretaceous shale and sand

(25) CLELAND No. 1
Location - 22-20-25 WPM — Elevation - 1810'
Total Depth 1209'
Drilled 1936 to 1939; second hole started June, 1939
Drilled by Waywasecapow Oil Co.
Contacts: Drift/RM @ 104', RM/VR @ 575', VR/Fav @ 800', Fav/ Ash @ 1005'

(26) OCHRE RIVER (Mack Oil)
Location - l.s. 12, 30-22-17 WPM — Elevation - 1150' approx.
Total Depth - 920'
Drilled 1921-1927
Drilled to 540' by Lindsay & Thompson, abandoned; taken over by Mack Oil in 1927 and completed
Porous zone: 480-517'

(27) VERMILION RIVER No. 1
Location - ?-23-20 WPM Elevation - 1300' approx.
Total Depth - 292'
Drilled 1887
Drilled by Manitoba Oil Co.
Drilling rig: percussion drill

(28) VERMILION RIVER No. 2
Location - ?-23-20 WPM Elevation - 1300' approx.
Total Depth - 743'
Drilled 1888
Drilled by Manitoba Oil Co.
Drilling rig: percussion drill
Contacts: Fav/Ash @ 223', Ash/SR @ 401, SR/Dev (?) @ 420'

(29) DAUPHIN
Location - SE¼, 14-24-20 WPM Elevation - 1100' approx.
Total Depth - 1256'
Drilled 1929-1930
Drilled by Dauphin Oil Syndicate
Drilling rig: standard cable tool
Contacts: SR/Jur @ 160', Jur/Am @ 330', Am/Dev @ 530',
Dev/Sil @ 1060'

(30) GILBERT PLAINS No. 1
Location - l.s. 10, 9-25-22 WPM Elevation - 1315'
Total Depth - 1370'
Drilled October, 1945 to August, 1946
Drilled by D. J. Coyle for A. R. Coutts (Manitoba and Saskatchewan Oil and Gas Development Syndicate)
Drilling rig: rotary
Contacts: Drift/Fav @ 130', Fav/Ash @ 210', Am/Dev @ 640'
Dev/Sil @ 1340'
Porous zone: 1010-1290'

(31) WINNIPEGOSIS No. 4
Location - l.s. 7, 29-30-17 WPM Elevation - 840' approx.
Total Depth - 1473'
Drilled 1920-1921
Contacts: Dev/Sil @ 360', Sil/Ord-SM @ 870-900, Ord-SM/
Ord-RR @ 1000', Ord-RR/Ord-Wpg @ 1340, Ord/Prec @ 1458

(32) THUNDER HILL No. 1
Location - l.s. 16, 19-35-29 WPM Elevation - 1390'
Total Depth - 430'
Drilled December,1933 to January, 1934
Drilled by Boyle Bros Ltd., Vancouver for John Drybrough
Drilled by diamond drill
Cased to 270'
Formation - Ashville

(33) THUNDER HILL No. 2
Location - l.s. 15, 23-35-30 WPM Elevation - 1657'
Total Depth - 638'
Drilled January, 1934 to February, 1934
Drilled by Boyles Bros. Vancouver for John Drybrough
Drilled by diamond drill
Cased to 420'
Contact: Fav/ Ash @ 450'

(34) THUNDER HILL (C.I.L.)
Location - l.s. 1, 25-35-30 WPM Elevation - 1670' approx.
Total Depth - 1152'
Drilled about 1937
Drilled by Canadian Industries Ltd.
Drilled by diamond drill
Contacts: Ash/Drift @ 218', Drift/Fav @ 225-262', Fav/Drift @ 291', Drift/Ash @ 340', Ash/SR @ 820'

(35) WELLS NEAR MAFEKING (?)
Location - l.s. 2, 3-42-26 WPM Elevation - 1063'
Total Depth - 350' and 977'
Drilled in 1923
Drilled by Porcupine Mountain Oil and Gas Co. Ltd.
Deeper hole gave small show of gas at unknown depth

(36) NORTHERN MANITOBA OIL No. 3
Location - 33-42-26 WPM Elevation - ?
Total Depth - 1380'
Drilled 1923 to 1925
Drilled by H. Johnson (Northern Manitoba Oil Co.)
Contacts: Drift/SR @ 10', SR/Dev @ 110', Dev/Sil @ 660'

(37) MAFEKING No. 3
Location - l.s. 12, 2-43-26 WPM Elevation - 1140'
Total Depth - 1630'
Drilled 192?
Drilled by Longyear Co. for Reid & Cathcart (Winnipeg Grain Exchange) or E. Doherty and Associates
Drilled by diamond drill
Contacts: Dev/Sil @ 800', Sil/Ord-RR @ 1080', Ord-RR/Ord-Wpg @ 1520', Ord/Prec @ 1562'
Porous zones: 480-490, 530-650, 830-840, 940-960, 1080-1170

GAS WELLS

(38) Location NE¼, 5-2-25 WPM (town of Waskada)
Elevation - 1550' Three wells - average depth was 240'
Drilled about 1911
Gas occurs in Riding Mountain shale at depths of 190-240'
Two wells still flowing in 1947
Gas pressure - about 14 pounds

(39) Location 5-2-25 WPM
Elevation - 1550' Total depth - 250'
Drilled 1947 on farm of O. S. Young
Cased through drift to 90' where Odanah beds of the Riding Mountain were encountered
Gas occurred at 180'
Gas pressure - 14 pounds

(40) Location 8-2-25 WPM
Elevation - 1550' Total depth - about 250'
Drilled about 1911 on farm of T. Wright
Gas occurs in Riding Mountain shale at depth of 190-240'
Gas pressure - about 14 pounds

(41) Location SW¼ 10-2-27 WPM (Sourisford gas well)
Elevation - 800' Total depth - 1009'
Drilled 1906-1907
Drilled on farm of J. B. Elliott
Gas occurred at an unknown depth
Gas pressure - 19 pounds

(42) Location 11-5-7 WPM
Drilled in 1912 for water
Gas encountered at a depth of 120'

(43) Location NW¼, 14-6-22 WPM
Elevation - 1480' Total depth - 210'
Drilled in 1926 on farm of Robert Hall
Gas encountered at 190-210'
Initial pressure of 48 pounds, decreased to 35 pounds after several hours

(44) Location SW¼, 21-7-8 WPM
Elevation - 1140' Total depth -210'
Drilled in 1919 on farm of Frank Bosc
Gas occurred at 170', evidently in a carbonaceous shale horizon of Favel formation
Sufficient gas to light farmhouse kitchen

(45) Location NE¼, 28-7-10 WPM
Elevation - 1265' Total depth 250'
Drilled in 1911 on farm of E. C. Haskell
Gas occured at depth of 150'
Sufficient gas was provided for kitchen and dining room lighting and occasionally a small gas heater for cooking for over fifteen years

(46) Location NW¼, 23-10-26 WPM
Elevation - 1450' approx. Total depth - 250'
Drilled in 1932 at Virden General Hospital
Top Riding Mountain about 200'
Gas encountered at 140' in sand strata
Gas pressure - 25 pounds

TEST HOLES

(47) Location - Township 11, range 9, WPM
Elevation - ? Total depth - 210'
Drilled in 1874 by Geological Survey of Canada "to ascertain where the eastern limit of Cretaceous coal bearing rocks is, and at the same time whether artesian wells affording good water can be made upon the prairies where surface water is either very scarce, or for the most part too saline for domestic purposes."
Hole reported to have penetrated limestones of Silurian or Devonian age and grey rock of uncertain age

(48) Location l.s. 4, 23-43-26 WPM
Elevation - ? Total depth - 807'
Drilled in 1925-1926 by E. Doherty and Associates
Drilled for geological information
No indication of oil or gas

(49) Location l.s. 5, 25-43-26 WPM
Elevation - ? Total depth - 235'
Drilled in 1925 by E. Doherty and Associates
Drilled for geological information
No indication of oil or gas

DESCRIPTIVE LOGS

On the following pages, the descriptive logs of those wells which appear on the correlation charts and those from which samples are filed in the Manitoba Mines Branch Stratigraphy Laboratory are presented in full. The logs were prepared by the writer unless otherwise indicated.

COMMONWEALTH MANITOU NO. 1

Location - l.s. 2, sec. 23, tp. 2, rge. 9, W. Principal mer.
Elevation - 1301.7 feet

DEPTH IN FEET	LITHOLOGY AND REMARKS
0 - 20	Shale, dark brownish-grey non-calcareous, hard; black carbonaceous spots on shale abundant
	UPPER CRETACEOUS
	Vermilion River Formation
20 - 300	Shale, soft, medium grey, calcareous; pyrite and bentonite rare
300 - 340	Shale, soft, grey, calcareous as above; angular colorless quartz fairly common
340 - 385	Shale, grey, soft, calcareous as above
385 - 405	Shale, grey, soft, slightly calcareous
405 - 425	Shale, grey, soft, calcareous
	Favel Formation
425 - 545	Shale, grey, soft, very calcareous, much has white specks; Inoceramus prisms common in some samples
545 - 565	Shale, white specks abundant
565 - 585	Shale, grey, soft, calcareous, few specks; some Inoceramus prisms and bentonite
585 - 590	Shale, grey, soft, calcareous, few specks
590 - 620	Shale, grey, soft, calcareous, slightly speckled
620 - 640	Shale as above; bluish bentonite very abundant
	UPPER AND LOWER CRETACEOUS
	Ashville Formation
640 - 660	Shale, grey, soft, rather silty, less calcareous than above
660 - 670	Shale, grey, soft, somewhat calcareous
670 - 680	Shale, grey, silty, calcareous

680 - 700	Shale, dark-grey, non-calcareous 690-700 some white bentonite
700 - 710	Shale, grey, silty, non-calcareous; a little white bentonite
710 - 740	Shale, grey, silty; a little loose siltstone

LOWER CRETACEOUS

Swan River Group

740 - 750	Sandstone, colorless to light-grey, fine- to medium-grained; abundance of Inoceramus prisms, some cemented in sandstone
750 - 780	Sand, colorless, medium- and coarse-grained quartz
780 - 790	No sample
790 - 800	Sand as above

JURASSIC

800 - 810	Shale, pale-green and red-buff, soft
810 - 812	Shale, pinkish-white and salmon-pink, very soft; some hard red ferruginous nodules; sub-angular quartz very abundant
812 - 820	Shale, brilliant-orange-red, very soft
820 - 830	Shale, pale-pink, pale-green and brown
830 - 850	Shale, pale-green, calcareous; a little red shale
850 - 870	Shale, pale-grey-green and red, calcareous
870 - 880	Shale as above; a little quartz
880 - 890	No sample
890 - 900	Shale, medium-greenish-grey, soft, calcareous
900 - 910	Sandstone, light-greenish-grey, calcareous, argillaceous
910 - 912	Sand, fine-grained sub-rounded quartz
912 - 930	No samples
930 - 950	Shale, greenish-grey and brick-red, soft, calcareous; sub-rounded quartz quite common
950 - 980	No samples
980 - 990	Shale, light-grey, very calcareous
990 - 1000	No sample
1000 - 1020	Shale, greenish-grey and brick-red, calcareous
1020 - 1030	Shale, buff, very soft, slightly calcareous
1030 - 1040	Shale, white and light-red-brown, soft
1040 - 1050	Shale, brick-red and a little light-green, calcareous
1050 - 1060	No sample
1060 - 1100	Shale, red and very pale-green, calcareous
1100 - 1110	Shale, light reddish-buff and pale-green
1110 - 1130	Shale as above and much red shale
1130 - 1140	Shale, light-red-buff and a little green, calcareous

1140 - 1150	Shale, white, soft, calcareous
1150 - 1190	Shale, red-buff and light-green, calcareous
1190 - 1200	Shale, pale-greenish-grey and a little light-red-buff, very calcareous

COMMONWEALTH MANITOU NO. 2

Location - l.s. 8, sec. 26, tp. 2, rge. 9, W. Principal mer.
Elevation - 1270 feet

DEPTH IN FEET	LITHOLOGY AND REMARKS
	GLACIAL DRIFT
0 - 10	Grey and buff rounded pebbles of dolomite
10 - 20	Grey, buff and pink rounded and angular pebbles
20 - 30	Grey calcareous shale with some pebbles
30 - 60	No samples
60 - 70	Grey shale with fragments of limestone, quartz, etc.
70 - 80	Sand, colorless, pink and yellow, angular; much hard grey shale and some pebbles
80 - 90	Mostly hard grey shale with some clear rounded quartz and other pebbles
90 - 100	Pebbles of very hard grey shale; much angular quartz and some chert
100 - 140	No samples
	UPPER CRETACEOUS
	Vermilion River Formation
	Boyne Member
140 - 180	Shale, grey, calcareous, a few white specks
180 - 200	No samples
200 - 240	Shale, grey, hard, slightly micaceous, some white specks
240 - 280	Shale, grey, hard, calcareous, white specks; very fine white gypsum
280 - 290	Shale, grey, hard, white specks rare; some very fine gypsum
	Morden Member
290 - 300	Shale, medium- and dark-grey; a little pyrite
300 - 320	No samples
320 - 330	Shale, grey, hard, calcareous; a few brown specks
330 - 340	Shale, medium-grey, calcareous

340 - 350	Shale, grey, calcareous
350 - 370	Shale, medium-grey, only slightly calcareous
370 - 400	Shale, dark-grey, non-calcareous
400 - 410	Shale, medium-grey, calcareous; brown carbonaceous specks rare

Favel Formation

410 - 420	Shale, light-grey, calcareous, white specks rare
420 - 450	Shale, grey, calcareous, some white specks
450 - 460	Limestone, grey, crystalline; abundant Inoceramus prisms; some shell fragments
460 - 490	Shale, grey, calcareous, many white specks 480-490 Inoceramus prisms
490 - 580	Shale, grey, calcareous, white specks 570-580 Inoceramus prisms

UPPER AND LOWER CRETACEOUS

Ashville Formation

580 - 590	Shale, dark-grey, calcareous
590 - 600	Shale, grey, less calcareous
600 - 610	Shale, grey, calcareous; white bentonite common
610 - 620	Shale, grey, slightly calcareous; a little bentonite
620 - 630	Shale, grey, non-calcareous
630 - 640	Shale, grey; bentonite very abundant; some impure limestone; shell fragments
640 - 650	Shale, grey; some Inoceramus prisms; shell fragments rare
650 - 660	Shale, grey; considerable Inoceramus prisms
660 - 670	Shale, grey
670 - 700	No samples
700 - 705	Shale, grey; few rounded quartz grains

LOWER CRETACEOUS

Swan River Group

705 - 735	Sand, colorless, sub-angular quartz; some shale
735 - 755	Shale, grey, very sandy

JURASSIC

755 - 760	Shale, very light-greenish-grey, calcareous; a little dark shale with white streaks; a few rounded quartz grains
760 - 764	Shale, light-greenish-grey, slightly calcareous
764 - 770	Shale, light-grey and red-buff, slightly calcareous

770 - 780	Shale, red, brown and light-greenish-grey, calcareous; rounded quartz rare
780 - 790	Shale, light-greenish-grey, calcareous with a few light-red-buff streaks
790 - 800	Shale, red-brown, calcareous, and very slightly calcareous light-greenish-grey shale
800 - 810	Shale, light-greenish-grey, calcareous
810 - 820	Shale, greenish-grey, calcareous
820 - 830	Shale, medium-grey and darker greenish-grey, hard, slightly calcareous
830 - 855	Shale, grey, slightly calcareous
855 - 860	Shale, grey and some pinkish-buff, calcareous
860 - 870	Shale, dark-greenish-grey and a little calcareous brownish-yellow
870 - 872	Shale, grey; pieces of very fine sandstone with pyrite and a little yellow dolomite (caving)
872 - 880	Shale, brick-red, slightly calcareous and a little light-greenish-grey
880 - 890	Shale, grey and a little red, hard, calcareous, rather sandy
890 - 895	Shale, reddish-brown, slightly calcareous; some grey shale
895 - 900	Sand, very fine
900 - 901	Shale, greenish-grey and reddish-buff; a little sand
901 - 940	Shale, medium to dark-grey, calcareous
940 - 950	Shale, grey; a few shell fragments and fragments of Pentacrinus
950 - 960	Shale, grey, calcareous; abundant shell fragments and a little limestone
960 - 970	Shale, grey, calcareous; shell fragments and crinoid buttons
970 - 1060	Shale, light-green, brick-red, grey, etc.; white gypsum 1000-1010 and 1030-1040
1060 - 1070	Shale, greenish-grey, red and buff, calcareous; some gypsum; some fossils
1070 - 1090	Shale, red, buff, greenish and lavender, calcareous; some gypsum
1090 - 1110	Shale, very light-grey, calcareous; some grey and red shale
1110 - 1120	Dolomite, cream, dense, some sandy; some gypsum; a little red and green shale
1120 - 1130	Dolomite, cream, dense; some white gypsum
1130 - 1140	Dolomite, white; some pale-green calcareous shale; some gypsum
1140 - 1150	Limestone, greyish-cream, dense, soft
1150 - 1160	Dolomite, light-grey; very fine-grained quartz quite common; some sandy, buff, calcareous shale; abundant gypsum
1160 - 1170	Limestone, light-buff; some grey and greenish shale

1170 - 1180	Dolomite, light-cream; some green and grey shale
	TRIASSIC (?)
	Amaranth Formation
1180 - 1200	Limestone, grey; much gypsum; some grey, buff, and greenish, calcareous shales
1200 - 1210	No sample
1210 - 1220	Gypsum, white and cream; some shale and a little limestone
1220 - 1230	Shale, red, calcareous, and grey; much gypsum
1230 - 1240	No sample
1240 - 1280	Shale, red, and white, crystalline gypsum; some greenish-grey shale 1260-1270 less gypsum 1270-1280 more green shale
1280 - 1300	Shale, red and green; some white gypsum
1300 - 1330	No samples
1330 - 1380	Shale, red and a little green, hard; a little white gypsum and brown sandstone
1380 - 1400	Sandstone, brick-red, shaly, calcareous, and red shale; some rounded and frosted quartz; gypsum rare
	DEVONIAN
1400 - 1430	Limestone, pinkish-cream, granular; a little red calcareous shale, green shale and frosted quartz
1430 - 1450	Limestone, light buff, some pink
	SILURIAN
1450 - 1470	Dolomite, purple, red and grey, hard; green shale and gypsum rare
1470 - 1490	Shale, red, calcareous; some white gypsum
1490 - 1500	Dolomite, cream and pink, finely-crystalline; some gypsum
1500 - 1520	Limestone, light cream, pink and light green, slightly dolomitic; red shale and gypsum rare
1520 - 1530	Limestone, lavender crystalline, and white massive; buff and green shale, slightly calcareous
1530 - 1540	Dolomite, white and pink, crystalline; lavender and green shale
1540 - 1550	Dolomite, pink and cream, crystalline; some purple speckled calcareous shale; grey shale and gypsum rare
1550 - 1560	Dolomite, cream, white and pink, crystalline; green-brown and lavender shale; white crystalline and massive limestone
1560 - 1570	Dolomite, pink, crystalline; white compact lime-

	stone; some calcareous lavender shale, colorless quartz and calcite
1570 - 1580	Limestone, white and cream; some pink crystalline dolomite
1580 - 1600	Dolomite, white and light pink, massive, and dark pink, crystalline
1600 - 1620	Limestone, white, finely-crystalline; some brown, green and lavender shale 1610-1620 abundant calcite
1620 - 1640	Dolomite, pink, crystalline; white, finely-crystalline dolomitic limestone rare
1640 - 1650	Dolomite, pinkish-cream, massive, and cream, finely-crystalline; gypsum and red shale
1650 - 1660	Dolomite, light-pink and cream; lavender and green shale; gypsum rare
1660 - 1670	Dolomite, cream, massive, and pinkish-buff and buff dolomite; some colored shale and gypsum
1670 - 1680	Dolomite, buff, finely-crystalline, and white and pink crystalline; red shale and gypsum
1680 - 1685	Dolomite, buff, pink and white, crystalline; red shale rare
1685 - 1690	Dolomite, buff and pink, crystalline, and white, massive
1690 - 1695	Dolomite, buff and pink, crystalline; colored shales and gypsum
1695 - 1700	Dolomite, pink and buff, crystalline; abundant colored shales and some gypsum
1700 - 1705	Dolomite, white, massive; a little colored shale
1705 - 1740	Dolomite, white, massive; some colored shale
1740 - 1750	No sample
1750 - 1780	Dolomite, white, massive; some colored shale
1780 - 1790	Dolomite, white and buff, massive
1790 - 1800	Shale, red, green and lavender, calcareous; much rounded quartz and some gypsum
1800 - 1810	Sandstone, pink, very fine-grained, slightly calcareous
1810 - 1820	Dolomite, light-cream and pink, finely-crystalline
1820 - 1830	Dolomite, white and light-pink, crystalline; olive-green shale rare
1830 - 1840	Dolomite, pink; rounded white quartz
1840 - 1850	Dolomite, pink and white, crystalline; a little rounded quartz

ORDOVICIAN

Stony Mountain Formation

1850 - 1870	Sand, pink and light-cream; some white and pink, crystalline dolomite
1870 - 1910	Limestone, pink and cream; abundant fine sand
1910 - 1933	Limestone, dark-grey, mainly fossil fragments;

	pink and white dolomite and some red shale
1933 - 1935	Sand; fragments of dark-grey and light-grey limestone; red shale and white gypsum
1935 - 1938	No sample

Red River Formation

1938 - 1960	Dolomite, cream to light-buff; fossil plants rare; some dark-grey limestone
1960 - 1980	Limestone, light-brown and light-grey, crystalline
1980 - 2000	Limestone, light-buff; abundant colorless sand; some dark-grey limestone and gypsum
2000 - 2045	Dolomite, buff, massive; light-grey limestone, non-fossiliferous
2045 - 2055	Dolomite, light-buff, crystalline, fine-grained; some rounded quartz and white gypsum
2055 - 2060	Limestone, cream, massive, slightly dolomitic; a few pieces of buff, crystalline dolomite; some grey shale
2060 - 2080	Limestone, buff, crystalline 2070-2080 rounded quartz abundant
2080 - 2090	Limestone, light-cream, massive; some dark-brown shale
2090 - 2100	Limestone, cream, crystalline; some white gypsum and quartz
2100 - 2105	Limestone, cream, massive; some brown shale and gypsum
2105 - 2120	Limestone, cream, massive and crystalline; grey and pink shale; some gypsum
2120 - 2130	Limestone, dark-cream, crystalline and sandy; brown shale rare; some crinoid buttons
2130 - 2140	No sample
2140 - 2145	Limestone, cream, massive; a little rounded quartz and grey shale
2145 - 2157	Limestone, cream, massive; some grey shale, colorless rounded quartz and gypsum
2157 - 2172	Limestone, cream, massive; some pink and brown shale
2172 - 2185	Limestone, light-cream, massive; crinoid buttons rare; some gypsum
2185 - 2237	Limestone, dark-cream, massive 2222-2237 crinoid buttons
2237 - 2245	Limestone, light-cream, massive; some gypsum
2245 - 2288	Limestone, light-cream, massive; some rounded quartz
2288 - 2300	Limestone, light-grey and buff, massive; a little red calcareous shale; some fossil fragments
2300 - 2310	Limestone, light-brown and grey, crystalline; quartz and gypsum
2310 - 2320	No sample
2320 - 2330	Limestone, light-cream and grey; some grey shale

2330 - 2340	No sample
2340 - 2350	Limestone, light-cream, massive
2350 - 2360	Limestone, light-buff and a little grey, massive
2360 - 2390	No samples
2390 - 2400	Limestone, cream, porous; crinoid stems rare
2400 - 2430	No samples
2430 - 2480	Samples mostly calcareous drilling mud; formation probably limestone

Winnipeg Formation

2480 - 2490	Shale, green, hard, slightly calcareous
2490 - 2530	Shale, green, very slightly calcareous
2530 - 2570	Shale, green, very slightly calcareous, hard
2570 - 2580	Shale, dark-olive-green, non-calcareous, and green, very slightly calcareous shale; pyrite and quartz rare
2580 - 2600	Shale, bluish-green, soft, very slightly calcareous
2600 - 2602	Sand, colorless, composed of rounded quartz; some green shale
2602 - 2610	Sand, colorless and yellow, composed of rounded quartz; some light-green shale
2610 - 2613	Shale, green, non-calcareous; some red shale and colorless angular quartz

PRECAMBRIAN

2613 - 2616	Quartzite, rusty; angular quartz and biotite
2616 - 2618	Very much rusted decomposed rock; much biotite
2618 - 2626	Small rounded flakes of biotite; rusty quartz
2626 - 2634	Rusty quartzite, some fragments of angular quartz
2634 - 2636	No sample
2636 - 2638	Rusty quartzite; some biotite
2638 - 2638.6	Rusty mafic material and rusty quartzite
2638.6 - 2639	Rusty quartzite

MORDEN WELL

Location - sec. 5, tp. 3, rge. 5, W. Principal mer.
Elevation - 990 feet
Log prepared by J. B. Tyrrell (1891, p. 98); revision by L. B. Kerr.

DEPTH IN FEET	LITHOLOGY AND REMARKS
	RECENT
0 - 8	Light sandy soil
8 - 11	Quicksand

11 - 12	Quicksand, red
12 - 15	Fine gravel, red

UPPER CRETACEOUS

Till

15 - 25	Clay, lead-colored, with pebbles
25 - 27.5	Limestone, a boulder with fine scratches
27.5 - 31	Small boulders and shale

Vermilion River Formation

Pembina Member

31 - 55	Shale, dark grey

Boyne and Morden Members

55 - 55.5	Hard streak
55.5 - 60	Shale, dark grey
60 - 62	Hard streak
62 - 68	Shale, dark grey
68 - 69	Hard streak
69 - 80	Shale, dark-grey
80 - 81	Hard streak, mixture of stones and shale
81 - 85	Shale, dark-grey
85 - 86	Shale, black, very gritty
86 - 93	Shale, dark-grey
93 - 94	Shale, black, hard and gritty

Favel Formation

94 - 215	Shale, grey, calcareous

UPPER AND LOWER CRETACEOUS

Ashville Formation

215 - 250	Shale, dark-grey
250 - 253	Soapstone
253 - 320	Shale, dark-grey

LOWER CRETACEOUS

Swan River Group

320 - 324	Sand, white, with water
324 - 378	Sand, white; particles of coal
378 - 380	Shale, white
380 - 390	Shale, grey, soft

390 - 400	Shale, black
400 - 412	Shale, grey, with sandstone
	JURASSIC
412 - 500	Shale, red and grey
500	Limestone, porous
500 - 600	Shale, red and grey

DELORAINE WELL

Location - SE¼, sec. 10, tp. 3, rge. 23, W. Principal mer.
Elevation - 1644 feet
Log prepared by J. B. Tyrrell (1891, p. 93); revision by L. B. Kerr.

DEPTH IN FEET	LITHOLOGY AND REMARKS
	PLEISTOCENE
0 - 3	Black soil
3 - 33.5	Clay, with some small pebbles
33.5 - 90	Clay, blue, hard, with pebbles
90 - 94	Sand, black, fine; gravel
	UPPER CRETACEOUS
	Riding Mountain Formation
94 - 150	Shale, light-blue-grey
150 - 150.5	Sand, black, with water
150.5 - 386	Shale, blue
386 - 787	Soapstone, with thin layers of limestone rock
787 - 975	Clay, blue, with round boulders
975 - 1050	Shale, dark-blue-grey
	Vermilion River Formation
	Pembina Member
1050 - 1075	Shale, grey
	Boyne Member
1075 - 1275	Shale, mottled-grey, calcareous
	Morden Member
1275 - 1410	Shale, dark, non-calcareous or slightly calcare-

	ous
	Favel Formation
1410 - 1595	Shale, grey, calcareous
	UPPER AND LOWER CRETACEOUS
	Ashville Formation
1595 - 1790	Shale, dark, non-calcareous
	LOWER CRETACEOUS
	Swan River Group
1790 -	No information is available on the lower part of the well; it continued to a depth of 1943 feet and appeared to be still in the Swan River sands.

COMMONWEALTH PETE NO. 2

Location - l.s. 6, sec. 26, tp. 9, rge. 2, W. Principal mer.
Elevation - 1300 feet (approximately)
Log received from the company which drilled the well

DEPTH IN FEET	LITHOLOGY AND REMARKS
	GLACIAL DRIFT
0 - 100	Shale-clay, limy pebbles gravel some sand at 40-50 feet
100 - 130	Gravel and shale wash
	UPPER CRETACEOUS
	Vermilion River Formation
130 - 300	Shale, dark
300 - 340	Shale, dark, soft
340 - 570	Shale, black, very oily; dark lime band at 453 feet; some iron pyrite at 460-470 feet; sandy at 480-490
	Favel Formation
570 - 610	Shale, black; some lime
610 - 620	Shale, black; iron pyrite

620 - 670	Shale, black; lime bands

UPPER AND LOWER CRETACEOUS

Ashville Formation

670 - 700	Shale, black; sandstone; lime
700 - 710	Shale, dark; coarse sand
710 - 720	Quicksand
720 - 730	Sandrock, white, very hard, fine-grained
730 - 740	Shale, dark, banded with hard sandstone
740 - 750	Shale, dark; iron pyrite; gypsum
750 - 760	Shale-sandstone, light-grey; iron pyrite
760 - 770	Shale, light-grey; some sandstone
770 - 780	Shale, green
780 - 790	Shale, brown-grey; red and grey lime
790 - 800	Shale, grey
800 - 810	Shale, green
810 - 820	Shale, brown; lime bands
820 - 840	Shale, dark, very soft and mucky
840 - 850	Shale, lighter

LOWER CRETACEOUS

Swan River Group

850 - 860	Shale, limy; sandstone; soft lime
860 - 870	Sandstone, fine-grained
870 - 880	Shale, green
880 - 890	Shale, black, sticky; lime bands; reddish-brown shale at 885 feet
890 - 900	Lime, grey, very hard; sandstone
900	Sand, white, very fine-grained
900 - 930	Shale, dark, sticky; lime bands and lime pebbles
930 - 950	Shale, light, limy
950 - 960	Shale-sandstone, brown; lime

JURASSIC

960 - 980	Shale, brown
980 - 990	Shale, green
990 - 1020	Shale, brown and green; narrow lime bands at 1000-1010 feet
1020 - 1030	Shale, brown and grey
1030 - 1050	Shale, light grey; lime bands
1050 - 1060	Shale, brown, green and grey; gypsum
1060 - 1090	Shale, variegated; gypsum and lime
1090 - 1110	Shale, light-grey, gypsum
1110 - 1150	Lime, hard; streaks of dark shale 1130-1150
1150 - 1160	Sand, brown, fine-grained
1160 - 1170	Shale, green; bands of gypsum

1170 - 1175	Sand, brown, fine-grained
1175 - 1200	Lime, hard
1200 - 1210	Shale, yellow; lime
1210 - 1215	Sand, soft; gypsum

TRIASSIC (?)

Amaranth Formation

1215 - 1340	Shale, brick-red; gypsum and lime; some sandstone at 1310-1340
1340 - 1350	Sand, yellow-brown
1350 - 1360	Shale, dark-red, sandy; gypsum
1360 - 1370	Shale, dark-red; gypsum
1370 - 1380	Shale, soft, reddish-brown
1380 - 1390	Shale, brown; sandstone
1390 - 1400	Sandstone, brown
1400 - 1410	Sand, brown, coarse-grained; lime bands

DEVONIAN

1410 - 1420	Shale, reddish-brown; sandstone, green shale and lime conglomerate
1420 - 1430	Shale, brown, soft; lime bands; gypsum
1430 - 1470	Lime, grey; streaks of bright red shale 1450-1470

SILURIAN

1470 - 1480	Shale, deep-red, soft, sticky
1480 - 1490	Red rock, hard; red lime pebbles
1490 - 1500	Lime, grey-brown-red, soft
1500 - 1510	Lime, grey and brown
1510 - 1520	Lime, grey, hard
1520 - 1530	Lime and conglomerate shale, all colors
1530 - 1540	Lime, pink, quartzitic, hard
1540 - 1550	Lime, pepper and salt, quartzite rock
1550 - 1560	Lime, pink and quartzitic
1560 - 1570	Lime, pink and grey, fine-grained
1570 - 1580	Lime, white and grey, fine-grained
1580 - 1590	Lime, pink; hard pink quartzite
1590 - 1600	Lime, pink
1600 - 1650	Lime, pink; quartzite
1650 - 1660	Lime, pinkish, crystalline
1660 - 1680	Sand, pinkish-grey; no lime
1680 - 1690	Sand, pink-brown, fine-grained
1690 - 1700	Sand, very fine-grained, colored; deep-red chalky shale
1700 - 1710	Sand, lighter-red, fine-grained; trace of lime
1710 - 1730	Lime, pink; streaks of chalk-white lime
1730 - 1750	Lime, pinkish and chalk-white
1750 - 1760	Lime, white
1760 - 1770	Lime, pinkish-white, softer than above

1770 - 1780	Lime, pinkish; narrow bands of chalky-white and red-chalky shale
1780 - 1790	Lime, pink, chalky
1790 - 1800	Shale, red, sandy; no lime
1800 - 1810	Shale, pinkish-red, fine-grained, sandy; some lime
1810 - 1820	Lime, pinkish, fine-grained, sandy
1820 - 1830	Lime, pink; fine-grained sand
1830 - 1840	Lime, grey
1840 - 1850	Sand, pink, fine-grained
1850 - 1860	Lime, deep-terracotta, chalky
1860 - 1880	Lime, reddish-brown and white; some fine-grained sand
1880 - 1890	Lime, reddish-brown, sandy
1890 - 1900	Sand, light-grey

ORDOVICIAN

Stony Mountain Formation

1900 - 1920	Shale, grey; some fine-grained lime
1920 - 1930	Lime, grey, shaly; fossil bed
1930 - 1940	Lime, white; fine sand base; some bluish shale
1940 - 1970	Lime, grey
1970 - 1980	Sand, white, fine-grained
1980 - 1990	Lime, grey, hard
1990 - 2000	Lime, grey
2000 - 2020	Shale, grey; little lime

Red River Formation

2020 - 2050	Lime, light-grey, pure
2050 - 2060	Lime, grey, fairly hard
2060 - 2100	Lime, grey, soft
2100 - 2160	Lime, light-grey, shaly, soft
2160 - 2190	Lime, lighter, chalky
2190 - 2200	Lime, darker; little very fine-grained round sand
2200 - 2240	Lime, lighter; harder 2210-2240
2240 - 2290	Lime, light-grey, shaly, soft; no sand
2290 - 2460	Lime, light-grey; fine-grained sand

Winnipeg Formation

2460 - 2470	Shale, green
2470 - 2480	Lime, light-grey
2480 - 2610	Shale, dark-green
2610 - 2640	No record

DELUXE THEATRE WELL

Location - 1525 Main Street, Winnipeg, Canada.
Elevation - 760 feet

DEPTH IN FEET	LITHOLOGY AND REMARKS
	ORDOVICIAN
	Red River Formation
0 - 90	No samples
90 - 100	Limestone, grey-buff, sandy; some quartz and black chert
100 - 150	Dolomitic limestone, light-grey-buff, slightly sugary
150 - 170	Dolomite, light-grey or white, soft
170 - 210	Limestone, white, finely-crystalline
210 - 250	Limestone, white; some fine-grained quartz
250 - 300	Limestone, very light-grey
300 - 320	Limestone, light-buff
320 - 330	Limestone as above and dolomitic limestone; a little quartz
330 - 370	Dolomitic limestone, light-buff; some calcite
370 - 400	Limestone, light-reddish-brown

STONY MOUNTAIN WELL

Location - SE¼, sec. 29, tp. 12, rge. 2, E. Principal mer.
Elevation - 800 feet
Log copied from Geological Survey of Canada Summary Report, 1929, Part B, p. 177; contacts picked by L. B. Kerr.

DEPTH IN FEET	LITHOLOGY AND REMARKS
	ORDOVICIAN
	Stony Mountain Formation
1 - 2	Sand, dark-grey, medium-grained
2 - 7	Dolomite, light-grey
7 - 15	No record
15 - 30	Dolomite, light-grey
30 - 115	Limestone, light-brown
	Red River Formation
115 - 130	Dolomite, light-brown

130 - 225	Dolomite, light-brown; very little red dolomite
225 - 250	Dolomite, light-brown
250 - 310	Dolomite, light-grey
310 - 415	Limestone, light-grey
415 - 510	Limestone, pink
510 - 560	Limestone, light-brown
560 - 565	Dolomite, light-brown
565 - 610	Limestone, light-brown
	Winnipeg Formation
610 - 650	Shale, green-grey
650 - 695	Shale, green
695 - 708	Sandstone, light-grey, coarse-grained, very many grains rounded and etched
	PRECAMBRIAN
708 - 740	Igneous rock, light-grey; much biotite
740 - 1010	Igneous rock, light-brown; much green shaly material; much biotite

PORTAGE LA PRAIRIE NO. 1

Location - l.s. 3, sec. 9, tp. 12, rge. 7, W. Principal mer.
Elevation - 850 feet (approximately)

DEPTH IN FEET	LITHOLOGY AND REMARKS
0 - 90	No samples
90 - 100	Drift - light-grey quartz sand and limestone pebbles
100 - 110	No sample
	TRIASSIC (?)
	Amaranth Formation
110 - 120	Shale, medium-grey, sandy
120 - 130	No sample
130 - 140	Sand, grey, argillaceous
140 - 150	Dolomitic limestone, white and brown; quartz grains common
150 - 160	Dolomitic limestone; quartz grains abundant
160 - 170	Sandstone, light-grey, loosely cemented with calcareous material
170 - 190	No samples

DEVONIAN

190 - 200	Limestone, light-grey; gypsum rare
200 - 250	No samples
250 - 290	Limestone, grey-buff, slightly dolomitic
290 - 320	Limestone, pinkish-buff, granular, crystalline
320 - 350	Dolomite, buff, crystalline
350 - 370	Dolomite, cream
370 - 380	Dolomite, pink and buff; specks of red shale, some porous

SILURIAN

380 - 390	Shale, red, calcareous
390 - 400	Dolomite, cream, some very porous
400 - 430	Dolomite, buff, crystalline, porous; some gypsum
430 - 480	Dolomite, light-grey-buff, crystalline, porous
480 - 490	Limestone, cream and pink, granular
490 - 500	Limestone, light-grey, granular
500 - 510	Dolomite, deep-rose and pinkish-grey, non-crystalline
510 - 520	Dolomite, cream and pinkish-buff
520 - 530	Dolomite, purplish-red, crystalline
530 - 550	Dolomite, reddish-brown and buff
550 - 570	Dolomite, light-colored, granular and crystalline
570 - 590	Limestone, white, dense and crystalline and some pink, somewhat porous
590 - 640	Dolomite, light-cream
640 - 650	Dolomite, cream; some purple shale
650 - 660	Dolomite, light-buff, soft
660 - 670	Dolomite, white and light pink
670 - 720	Dolomite, very light-buff, soft
720 - 810	Dolomite, white becoming slightly cream, chalky in appearance
810 - 840	Dolomite, light-pink, porous
840 - 870	Dolomite, cream

ORDOVICIAN

Stony Mountain Formation

870 - 920	Dolomite, reddish-buff to dark-brick-red, shaly
920 - 940	Dolomite, reddish-buff, shaly

Red River Formation

940 - 970	Limestone, light-buff; some granular dolomite at 950 feet
970 - 1000	Dolomite, greyish-buff
1000 - 1040	Dolomite, very light-grey
1040 - 1050	Dolomite, light-grey, granular and crystalline

1050 - 1060	Limestone, light-grey, crystalline
1060 - 1170	Limestone, light-buff and grey-buff, crystalline
1170 - 1190	Limestone as above; some dolomite
1190 - 1240	Limestone, light-buff; fossil fragments abundant
1240 - 1250	Limestone, light; dolomite abundant
1250 - 1280	Limestone, light-buff, soft
1280 - 1290	Limestone, light-grey
1290 - 1390	Limestone, almost white
1390 - 1420	Limestone, grey

Winnipeg Formation

1420 - 1450	Shale, brownish-green, calcareous
1450 - 1480	Shale, green, slightly calcareous
1480 - 1530	Shale, green, slightly calcareous; some iron stains
1530 - 1540	Sandstone, grey, quartz rounded; a little green shale

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LANGFORD NO. 1

Location - l.s. 5, sec. 29, tp. 14, rge. 14, W. Principal mer.
Elevation - 1139.5 feet

DEPTH IN FEET	LITHOLOGY AND REMARKS
	GLACIAL DRIFT
0 - 40	Clay, soft, sandy; fine lime fragments
40 - 80	Clay, soft, sandy; pebbles of limestone and chert
80 - 90	Sand, fine to coarse angular quartz; pebbles of limestone
90 - 100	Clay, sand and gravel
100 - 120	Clay, sandy; pebbles of limestone
120 - 130	Sand to gravel, clayey; pebbles of limestone
	UPPER AND LOWER CRETACEOUS
130 - 210	Shale, medium- and dark-grey; much sand and gravel
210 - 220	No sample
220 - 230	Sand, very fine quartz grains, colorless to yellow and pink
230 - 270	Shale, medium-grey and some dark-grey; some fine quartz
270 - 290	Shale, mostly light-grey, considerable darker-grey with small white specks 270-275 fine siltstone common

290 - 340	Shale, mostly light-grey; abundant fine, angular quartz 290-295 a little siltstone, some pyritized 295-315 a little dark speckled shale 315-340 some cream limestone 330-335 dark-speckled-shale; siltstone
	LOWER CRETACEOUS
	Swan River Group
340 - 360	Shale, dark-grey and some light-grey; very abundant quartz
360 - 370	Shale, dark- and medium-grey
370 - 390	Shale, dark-grey; much fine quartz sand 375-380 a little bluish-white bentonite
390 - 400	Shale, light- and dark-grey; considerable fine sand and pyrite
400 - 425	Shale, grey, fairly hard; sand and pyrite abundant 420-425 black coaly material fairly common
	JURASSIC
425 - 460	Shale, grey; considerable pyrite 425-430 a little black carbonaceous material 435-440 some loose siltstone 445-450 a little pyritized sandstone
460 - 470	Shale, grey; abundant pyrite 465-470 abundant white siltstone
470 - 495	Shale, grey, calcareous 480-490 pyrite fairly common
495 - 515	Shale, grey, brown, buff, soft to hard 500-505 fine quartz siltstone
515 - 520	Shale, dark-blue-grey and buff with brick-red spots; siltstone common
520 - 535	Shale, dark-grey and reddish, calcareous, silty
535 - 540	Shale, dark-grey; white sandstone rare; quartz abundant
540 - 555	Shale, dark-grey, splintery
555 - 560	Shale, a little lighter grey
560 - 570	Shale, dark-grey, splintery; quartz and pyrite rare
570 - 575	Shale, dark-grey, splintery; some silty shale with large quartz grains included
575 - 580	Limestone, buff, finely-crystalline; much dark-grey shale
580 - 585	Shale, dark-grey; much light-grey shale with some quartz grains
585 - 590	Shale, dark-grey, splintery; some chalky-white limestone

590 - 625	Shale, dark-grey, splintery; abundant porous calcareous sandstone and siltstone
625 - 670	Limestone, greyish-cream, massive; considerable dark-grey shale
670 - 685	Shale, dark-grey; some cream and greyish-white limestone
685 - 720	Shale, dark-grey; considerable gypsum in some samples
720 - 735	Shale, dark-grey and buff; gypsum common; some buff dolomite
735 - 750	Shale, dark- and light-grey and buff; some gypsum and anhydrite

TRIASSIC (?)

Amaranth Formation

750 - 815	Shales, dark- and light-grey, red, green, bluish-grey, and buff; some gypsum in some samples
815 - 895	Shale, red; considerable gypsum in some samples; some variegated shales as above 840-860 some buff argillaceous siltstone 860-895 red-buff silty shale, calcareous and somewhat porous appears in the sample 860-865 and increases in abundance until it becomes the chief constituent of sample 885-890

DEVONIAN

895 - 940	Dolomite, cream, massive; some white gypsum; some red and variegated shales (cavings) 910-920 some rose crystalline dolomite 920-930 considerable white anhydrite
940 - 950	Anhydrite, white
950 - 970	Dolomite, cream and pink, crystalline; considerable anhydrite in some samples
970 - 975	Anhydrite, greyish-white; some cream and pink dolomite as above
975 - 1025	Dolomite, buff and pink as above 980-985 much anhydrite 995-1000 some anhydrite 1015-1020 some anhydrite and grey sandstone
1025 - 1055	Dolomite, light-buff, finely-crystalline, finely-porous 1025-1030 a little anhydrite 1035-1040 a little light-grey limestone 1040-1050 a little anhydrite
1055 - 1100	Dolomite, cream to light-buff, some crystallinity, very fine porosity to 1075 feet 1060-1065 some of the dolomite is cavernous 1065-1100 a little anhydrite in some samples

1100 - 1160	Dolomite, buff, crystalline, partly porous and/or cavernous; a little anhydrite in some samples 1130-1160 dolomite is mostly porous and crystalline
1160 - 1255	Limestone, buff, massive; a little anhydrite in some samples 1245-1250 limestone is pinkish-buff in color

SILURIAN

1255 - 1265	Shale, medium-grey, silty; some limestone as above and a little gypsum
1265 - 1300	Dolomite, buff to pinkish-buff and pink 1280-1285 a little light-buff crystalline porous dolomite; some light-blue-grey limestone 1285-1300 considerable white anhydrite
1300 - 1305	Anhydrite, white; some dolomite as above
1305 - 1325	Dolomite, cream and light-buff 1315-1320 some cream and buff, crystalline, porous dolomite
1325 - 1335	Dolomite, finely-crystalline, porous
1335 - 1350	Dolomite, cream, massive to crystalline 1345-1350 a little porosity
1350 - 1355	Dolomite, cream, some crystalline and porous
1355 - 1360	Dolomite as above but less porosity; a little gypsum
1360 - 1380	Dolomite, buff, some pin-point porosity, some is cavernous
1380 - 1385	Dolomite, light-cream and buff, massive to finely-crystalline; a little brownish-white anhydrite
1385 - 1390	Dolomite, buff, crystalline, some porous; gypsum common
1390 - 1400	Dolomite, buff, mostly massive but a little crystalline and porous 1390-1395 gypsum common
1400 - 1430	Limestone, cream to light-buff, massive to crystalline; a little porosity in some samples
1430 - 1435	Dolomite, dark-rose, massive; some limestone as above
1435 - 1445	Dolomite, dense, buff to pink to dark-rose; a little is buff, crystalline dolomite
1445 - 1460	Shale, brick-red, calcareous; dolomite, cream to buff, some crystalline
1460 - 1465	Shale, brick-red, calcareous; some dense grey-buff dolomite
1465 - 1490	Dolomite, cream to greyish, crystalline 1475-1480 some of the dolomite is cavernous
1490 - 1525	Dolomite, light-cream to grey-cream, some finely-crystalline and finely-porous
1525 - 1555	Dolomite, cream, massive to crystalline, porous

1555 - 1580	Dolomite, white, massive
1580 - 1605	Dolomite, greyish-white, massive to crystalline, a few crystalline porous pieces
1605 - 1670	Dolomite, light-cream, massive to crystalline, some slightly porous
1670 - 1685	Dolomite, white to cream, non-crystalline, fairly porous and cavernous
1685 - 1730	Dolomite as above, some very porous, some quite compact 1725-1730 considerably less porosity
1730 - 1735	Dolomite, cream, massive, a little porosity; much dolomitic limestone, pinkish-buff, massive
1735 - 1760	Dolomite, creamy-white, massive 1735-1740 a little pink limestone as above
1760 - 1765	Dolomite, cream and light-pinkish-buff, massive
1765 - 1770	No sample
1770 - 1805	Dolomite, cream, massive to partly crystalline 1790-1800 pink crystalline dolomite common
1805 - 1820	Dolomite, cream, non-crystalline, a little porosity
1820 - 1835	Dolomite, cream, little or no porosity, some slightly crystalline
1835 - 1860	Dolomite, cream, crystalline, very little porosity

ORDOVICIAN

Stony Mountain Formation

1860 - 1880	Shale, light-grey, soft; a little gypsum and red shale; some dolomite as above
1880 - 1905	Limestone, blue-grey; some dolomite as above

Red River Formation

1905 - 1910	Dolomite, cream, crystalline
1910 - 1925	Dolomite as above; some finely-saccharoidal grey-cream dolomitic limestone 1920-1925 a little greyish-cream limestone
1925 - 1940	Dolomitic limestone, greyish-cream 1930-1940 some light-buff dolomite
1940 - 1955	Dolomite, greyish-cream; some dolomitic limestone, massive to sugary
1955 - 1965	Dolomite, cream, massive
1965 - 1975	Dolomitic limestone, cream, massive
1975 - 2020	Dolomite, cream to dark-cream, massive
2020 - 2025	Dolomite, grey-cream, massive
2025 - 2030	Dolomite, dark-cream to buff, massive
2030 - 2035	Dolomite, greyish-buff, massive
2035 - 2040	Dolomite, light-buff and greyish-buff, massive to crystalline
2040 - 2050	Limestone, light-buff and greyish-buff, massive
2050 - 2055	Limestone, light-buff, massive to finely-crystalline

2055 - 2060	Dolomite, grey-buff, crystalline
2060 - 2070	Dolomite, grey-buff, massive to crystalline
2070 - 2095	Dolomite, grey-buff, massive to finely-crystalline, a few pieces are cavernous and/or porous
2095 - 2100	Dolomite, cream
2100 - 2125	Limestone, creamy-white to buff, porous
2125 - 2135	Limestone, light-buff, finely-sugary; some soft cream, non-crystalline limestone
2135 - 2185	Limestone, cream, some dense and some sugary, fossiliferous 2165-2170 some greyish dolomite
2185 - 2200	Dolomitic limestone, greyish-buff, crystalline
2200 - 2205	Dolomite, grey-buff, finely-crystalline, some finely-porous
2205 - 2270	Dolomite, light-grey-buff, massive, grading to a grey color by 2235 feet 2205-2220 some is crystalline 2250-2270 some is finely-crystalline
2270 - 2275	No sample
2275 - 2285	Limestone, light-buff, massive to finely-crystalline
2285 - 2300	Limestone, cream to light-buff, massive to crystalline 2290-2295 a few pieces fossiliferous
2300 - 2380	Limestone, light-grey and light-buff, massive, becoming lighter in color after 2340 feet

Winnipeg Formation

2380 - 2390	Shale, dark-grey-green, splintery; some limestone
2390 - 2415	Shale, dark-green, splintery; some limestone
2415 - 2505	Shale, dark-green, splintery

PRECAMBRIAN

2505 - 2519	Iron formation

NEEPAWA NO. 2

Location - l.s. 9, sec. 33, tp. 14, rge. 15, W. Principal mer.
Elevation - 1205.7 feet
Log by R.T.D. Wickenden (1945, pp. 69-70)

DEPTH IN FEET	LITHOLOGY AND REMARKS
0 - 150	No samples
150 - 160	Drift material
160 - 230	No samples
	UPPER CRETACEOUS
	Favel Formation
230 - 260	Shale, medium- to dark-grey with white, calcareous specks; many foraminifera, mostly Globigerina cretacea; many Inoceramus prisms
	UPPER AND LOWER CRETACEOUS
	Ashville Formation
260 - 280	Sandstone, grey, fine-grained; some glauconite and fossil fish bones; some grey shale
280 - 290	Limestone, medium-grey
290 - 320	Shale, medium- to dark-grey
320 - 330	Sandstone, fine-grained, grey; fossil fish fragments
330 - 350	Shale, dark-grey; some sandstone as above
350 - 395	Shale, dark-grey
	LOWER CRETACEOUS
	Swan River Group
395 - 412	Sand, light-grey, all quartz
412 - 470	Shale, medium- to dark-grey; some sand
	JURASSIC
470 - 520	Shale, medium-grey; much pyrite at 500 to 520 feet; Jurassic foraminifera and fragments of dentaliums, echinoderms, and other marine fossils in samples from 490 to 520 feet
520 - 530	Shale, medium-grey and much light-grey; calcareous sandstone
530 - 540	Shale, medium-grey, slightly brownish; some calcareous sandstone, limestone, and numerous smooth grains of rusty yellow material, probably limo-

	nite; some fragments of fossils of marine origin
540 - 570	Shale, medium- to light-grey, and much calcareous sandstone and cream-colored limestone; few fossils; many smooth ostracods and chara fruit at 560 feet
570 - 580	Shale, buff-grey; some fragments of brownish-red shale
580 - 610	Shale, medium-grey; some cream-colored limestone; some calcareous sandstone; foraminifera and many fragments of marine fossils at 600 feet
610 - 620	Shale, buff; a little white limestone
620 - 630	Shale, brownish-red and grey, probably mottled or variegated if found in situ
630 - 640	Shale, yellowish-brown
640 - 650	Shale, grey and brownish-red; few foraminifera, but may not be in place
650 - 660	Shale, light-brown
660 - 680	Shale, grey and brown
680 - 690	Shale, light-brown and brownish-red; sample contains many fragments of rock from surface
690 - 720	Shale, greyish-buff
720 - 730	Shale, medium-grey; a little very light-buff, platy limestone, suggests algal origin
730 - 750	Limestone, light-grey with streaks and specks of black carbonaceous material

TRIASSIC (?)

Amaranth Formation

750 - 760	Limestone and calcareous sandstone, light-grey; much grey chert
760 - 770	Dolomite, buff; much contamination with overlying formations
770 - 790	Gypsum, white
790 - 820	Gypsum and anhydrite, white; some buff dolomite
820 - 850	Anhydrite, white; some white gypsum; some reddish-brown shale at 840-850 feet
850 - 860	Shale, bright-red, slightly sandy; some pinkish or buff-red shale; some gypsum and anhydrite
860 - 890	Shale, brick-red and light-grey, sandy; some white gypsum
890 - 900	Shale, red and grey; much sand, medium-grained, well-rounded with frosted surfaces; some gypsum and anhydrite
900 - 930	Shale, brick-red and light-grey; much gypsum and some anhydrite
930 - 940	Shale, dull-red and gypsum, white

DEVONIAN

940 - 950	Limestone, light-grey, porous; some gypsum and red shale inclusions

950 - 960	Dolomite, light-buff, with thin streaks of gypsum
960 - 970	Cypsum, pink and white
970 - 980	Dolomite, light-buff; some streaks of gypsum
980 - 990	Sand, white, medium-grained, well-rounded, some polished and some frosted grains
990 - 1010	Dolomite, light-buff, with reddish streaks; a little fine-grained sandstone
1010 - 1020	Dolomite, light-buff; many fragments show gypsum mixed with dolomite
1020 - 1040	Anhydrite, light-buff to cream; a little gypsum and dolomite
1040 - 1050	Dolomite, light-buff; some gypsum and anhydrite
1050 - 1060	Dolomite, light-buff, granular, fine-grained; some rose or purplish fine-grained sandstone
1060 - 1070	Dolomite, light-buff and rose-purplish shale with streaks of light-greenish-grey shale
1070 - 1080	Dolomite and sandstone; light-grey and buff dolomite; some rose shale and gypsum
1080 - 1090	Dolomite, buff, fine-grained; some anhydrite
1090 - 1130	Dolomite, light-buff, chalky; white anhydrite
1130 - 1160	Dolomite, pink and white, granular
1160 - 1170	Dolomite, buff, granular; some anhydrite
1170 - 1192	Dolomite, buff, very fine-grained; some anhydrite
1192 - 1197	Shale, greyish-brown; some buff dolomite
1197 - 1210	Dolomite, buff, granular
1210 - 1240	Limestone, buff; fossil fragments and ostracods
1240 - 1250	Dolomite, light-buff, granular
1250 - 1280	Limestone, buff and pinkish, somewhat granular; some fragments of fossils and ostracods, including a species of Octonaria
1280 - 1300	Sand, fine-grained, white, grains mostly sub-angular
1300 - 1310	Limestone, white; fine sand
1310 - 1320	Limestone, cream; a little white sand
1320 - 1330	Limestone, greyish-buff, finely-granular
1330 - 1340	Limestone, cream, slightly granular
1340 - 1350	Dolomite, buff, amorphous; limestone, buff, granular
1350 - 1360	No sample

SILURIAN

1360 - 1370	Shale, reddish-buff; some light-buff dolomite
1370 - 1380	Dolomite, pink, granular and crystalline
1380 - 1400	Dolomite, light-buff, very fine, granular; some gypsum; some fine sand may be from cavings
1400 - 1420	Dolomite, cream to white, granular
1420 - 1490	Dolomite, light-buff, granular

DAUPHIN WELL

Location - SE¼, sec. 14, tp. 24, rge. 20, W. Principal mer.
Elevation - 1100 feet (approximately)
Log by R. T. D. Wickenden (1945, pp. 71-72)

DEPTH IN FEET	LITHOLOGY AND REMARKS
0 - 10	Glacial drift
10 - 20	Shale, medium- to dark-grey
20 - 30	Mostly glacial drift
	UPPER AND LOWER CRETACEOUS
30 - 110	Shale, medium- to dark-grey (Ashville ?)
110 - 160	Shale, medium-grey; some glauconite (Ashville or Swan River ?)
	JURASSIC (?)
160 - 190	Sandstone, white, calcareous; much cream limestone; some smooth ostracods
	JURASSIC
190 - 200	Limestone, cream-colored; some light-grey shale
200 - 210	Shale, light-grey and brick-red
210 - 220	Shale, light-grey and brick-red; some pink and yellow limestone; some chara fruit
220 - 230	Sandstone and limestone, same as at 160-190 feet
230 - 240	Shale, brick-red; some pink, white and yellow limestone; many fossil chara fruit
240 - 250	Limestone; cream and white sandstone
250 - 300	Contaminated samples; material looks like weathered shale from Favel formation
300 - 310	Shale and limestone, grey
310 - 320	Shale, medium-to light-grey; some glauconite and fragments of shells
320 - 330	Shale, brownish-grey
	TRIASSIC (?)
	Amaranth Formation
330 - 350	Limestone, cream to white; much light-grey banded chert or chalcedony apparently filling vugs in limestone
350 - 360	Gypsum and anhydrite, white
360 - 370	Gypsum and anhydrite, white; some reddish-brown shale and buff dolomite
370 - 380	No sample

380 - 390	Dolomite, buff; some white gypsum and clear, crystalline quartz
390 - 410	Shale, reddish-buff
410 - 430	Shale, brick-red; a little gypsum
430 - 495	Shale, sandy, dull-brick-red; sand grains very fine; some white gypsum; a little light-grey and greenish-grey shale; some samples show more gypsum than others
495 - 510	Dolomite, light-buff; a little gypsum
510 - 520	Sandstone, rose, fine-grained, calcareous
520 - 530	No samples

DEVONIAN

530 - 540	Dolomite, rose-buff; a little gypsum
540 - 550	Limestone, light-rose to pink; some sandy fragments; fossil shell fragments (looks like that at 1400' in Commonwealth Manitou #2 and at 1250 to 1280 feet in Neepawa #2
550 - 570	Dolomite, light-buff, granular, fine-grained; some inclusions of gypsum
570 - 580	Limestone and dolomite, light-buff; some gypsum
580 - 590	Dolomite, light-buff, granular, medium-grained; a little gypsum
590 - 610	Limestone, rose, granular; a little buff dolomite
610 - 630	Dolomite, light-buff, and gypsum, white
630 - 640	Gypsum, white
640 - 650	No sample
650 - 680	Limestone, light-grey, finely-granular; few fragments of fossils
680 - 690	No sample
690 - 710	Limestone, light-grey and light-buff
710 - 720	Anhydrite and gypsum, bluish and white
720 - 730	No sample
730 - 740	Anhydrite and gypsum; bluish and white
740 - 760	Dolomite, light-buff; a little gypsum
760 - 780	Dolomite, cream to white; much anhydrite; a little pinkish-buff shale
780 - 790	Limestone, white and pink
790 - 800	Limestone or dolomite, rose
800 - 820	Dolomite, cream and pink
820 - 830	Limestone, cream and white
830 - 870	Dolomite, cream, somewhat crystalline; a little white gypsum at 860 feet
870 - 880	No sample
880 - 890	Poor sample; powdered calcareous material
890 - 910	No samples
910 - 920	Mixture of gypsum, anhydrite, limestone, and dolomite
920 - 940	Limestone, greyish-brown, granular
940 - 950	Limestone, greyish-brown, granular, light-grey, fine-grained

950 - 990	Limestone, light-grey; many fragments of fossils; ostracods include a species of Octonaria, a few attached species of foraminifera
990 - 1030	Limestone, light-buff
1030 - 1050	Limestone, light-grey
1050 - 1060	No sample

SILURIAN ?

1060 - 1070	Shale, red and light-greenish-grey, slightly calcareous
1070 - 1090	No samples
1090 - 1130	Anhydrite, white
1130 - 1140	Gypsum, white, with numerous fine streaks of brown lime
1140 - 1150	Limestone, brown, with much gypsum and anhydrite
1150 - 1170	Limestone (magnesian ?), buff, with dark-brown streaks (bitumen ?)
1170 - 1180	Limestone (?), badly stained with rust from bit
1180 - 1230	Dolomite, light-buff to cream, somewhat crystalline
1230 - 1240	Dolomite, white and pink, probably mottled
1240 - 1256	Shale, buff-red; some dolomite as in previous sample

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GILBERT PLAINS NO. 1

Location - l.s. 10, sec. 9, tp. 25, rge. 22, W. Principal mer.
Elevation - 1315 feet

DEPTH IN FEET	LITHOLOGY AND REMARKS
	GLACIAL DRIFT
0 - 90	No samples
90 - 100	Drift pebbles - quartz, limestone, etc.
100 - 110	Clay, brown-grey, soft, contains many pebbles
110 - 130	Dolomite pebbles, clay as above and drilling mud
	UPPER CRETACEOUS
	Favel Formation
130 - 140	Shale, dark-grey, white specks common
140 - 150	Clay and pebbles - probably mostly cavings
150 - 160	Shale, dark-grey with white specks
160 - 170	No sample
170 - 190	Shale, grey, some speckled, calcareous
190 - 200	Sample mostly cavings from drift

200 - 210	Shale, grey, some speckled, calcareous; some bluish-white bentonite

UPPER AND LOWER CRETACEOUS

Ashville Formation

210 - 230	Shale, dark-grey, non-calcareous; some bluish-white bentonite
230 - 280	Shale, dark-grey, non-calcareous; some bentonite
280 - 290	Shale, grey, slightly calcareous
290 - 470	No samples

TRIASSIC (?)

Amaranth Formation

470 - 480	Clay, red-buff, soft, calcareous; some gypsum
480 - 500	Clay-shale, red-buff, soft, calcareous; some light-grey calcareous shale
500 - 510	No sample
510 - 530	Limestone, pinkish-cream
530 - 540	Dolomite, cream, crystalline; a little gypsum
540 - 550	Limestone, pinkish-cream
550 - 570	Limestone, grey-buff
570 - 580	No sample
580 - 590	Dolomite, white and some buff; some gypsum
590 - 620	Dolomite, brown; considerable white gypsum
620 - 640	Dolomite, buff

DEVONIAN

640 - 650	Limestone, light-cream
650 - 690	Limestone, pinkish-cream
690 - 700	Limestone, light-cream
700 - 710	Limestone, cream
710 - 740	Limestone, pinkish-buff
740 - 750	Limestone, cream
750 - 760	Limestone, light-pinkish-cream
760 - 800	Limestone, dark-cream
800 - 810	Limestone, dark-pinkish-cream
810 - 820	Limestone, dark-pinkish-buff
820 - 830	Limestone, dark-pinkish-cream
830 - 850	Dolomite, reddish-brown, harder than limestone above
850 - 860	Dolomite, reddish-brown
860 - 870	Dolomite, pinkish-buff and light-grey
870 - 880	Limestone, grey-cream
880 - 890	Limestone, light-reddish-brown
890 - 900	Limestone, light-cream
900 - 980	Limestone, light-grey-cream
980 - 1010	Dolomite, light-cream, harder than limestone above

1010 - 1050	Limestone, light-grey-cream, porous
1050 - 1060	Limestone, light-cream, porous
1060 - 1070	Limestone, light-grey-cream, porous
1070 - 1090	Limestone, light-cream, porous
1090 - 1120	Limestone, light-grey-cream, porous
1120 - 1130	Dolomitic limestone, dark-grey-cream, porous
1130 - 1150	Limestone, light-grey-cream, porous
1150 - 1200	Limestone, grey-cream, porous
1200 - 1280	Limestone, light-grey-cream, porous
1280 - 1290	Limestone, grey-cream, porous
1290 - 1320	Dolomitic limestone, light-grey, a little harder than above
1320 - 1340	Limestone, light-grey-cream
	SILURIAN
1340 - 1360	Shale, reddish-buff and light-greenish-grey, calcareous
1360 - 1370	Shale as above only less greenish-grey shale

WINNIPEGOSIS NO. 4

Location - sec. 29, tp. 30, rge. 17, W. Principal mer.
Elevation - 840 feet (approximately)
Log by R. T. D. Wickenden (1934, p. 165B)

DEPTH IN FEET	LITHOLOGY AND REMARKS
0 - 25	No samples
	DEVONIAN
25 - 40	Limestone, medium-grey
40 - 50	Limestone, brownish-grey
50 - 60	Limestone, medium-grey
60 - 70	Limestone, brownish-grey
70 - 340	Dolomite, cream to white
340 - 360	Dolomite, grey to brown
	SILURIAN
360 - 370	Dolomite, reddish-brown and buff-red
370 - 380	Dolomite, buff
380 - 390	Dolomite, cream
390 - 420	Dolomite, dark-buff to grey
420 - 430	Dolomite, cream and reddish-brown
430 - 440	Dolomite, cream and pink
440 - 450	Dolomite, reddish-buff
450 - 460	Dolomite, cream

460 - 470	Dolomite, cream and rose
470 - 480	Dolomite, cream and light-pink
480 - 520	Dolomite, cream to grey
520 - 530	Dolomite, pink
530 - 870	Dolomite, cream to white
870 - 900	No samples

ORDOVICIAN

Stony Mountain Formation

900 - 1000	Dolomite, medium-grey

Red River Formation

1000 - 1075	Dolomite, cream
1075 - 1210	Dolomite, light-buff; some limestone
1210 - 1220	Dolomitic limestone, light-buff
1220 - 1260	Dolomite, buff; some limestone
1260 - 1270	Dolomitic limestone
1270 - 1330	Dolomite, buff; some limestone
1330 - 1340	Sandstone; a little dolomite

Winnipeg Formation

1340 - 1360	Shale, grey
1360 - 1365	Shale, brownish-grey
1365 - 1380	No samples
1380 - 1400	Shale, brownish-grey
1400 - 1410	Shale, greenish-grey
1410 - 1425	Sand, buff and brown; some grey shale
1425 - 1435	Sand, white, composed of coarse, well-rounded quartz
1436	Shale, greenish-grey
1437 - 1444	Sand, white, composed of coarse, well-rounded quartz
1444 - 1447	Clay (kaolin ?), light-greyish-green
1447 - 1450	Sandstone, very coarse quartz
1450 - 1458	Sand, medium-grained

PRECAMBRIAN

1458 - 1462	Clay, light-greenish-grey and quartz; some weathered Precambrian rock
1462 - 1468	Sand, medium-grained, buff with some brown, iron-stained fragments
1469	Weathered Precambrian rock, grey
1469 - 1473	Weathered Precambrian rock, brown

NORTHERN MANITOBA OIL NO. 3

Location - sec. 33, tp. 42, rge. 26, W. Principal mer.
Elevation - ?

DEPTH IN FEET	LITHOLOGY AND REMARKS
0 - 10	Drift, mostly rounded and sub-rounded quartz
	LOWER CRETACEOUS
	Swan River Group
10 - 20	Sand, green, fine-grained, glauconitic; some limestone and other pebbles
20 - 30	No sample
30 - 40	Sand, dark-greenish-grey, glauconitic, shaly
40 - 50	Shale, dark-grey, glauconitic, sandy
50 - 70	Shale, medium-grey; a little glauconite
70 - 100	Sand, light-grey quartz, very fine-grained
100 - 110	Shale, light-grey and a few reddish-brown pieces
	DEVONIAN
110 - 170	Limestone, light-buff, massive; some has honeycombed or "graphic" appearance
170 - 180	No sample
180 - 210	Limestone, grey-buff, massive; a little quartz and gypsum
210 - 220	Limestone, buff
220 - 230	Limestone, grey and a little brown, compact
230 - 240	Sand, colorless quartz; abundant cream limestone
240 - 250	Limestone, buff, finely-crystalline
250 - 260	Limestone, grey, finely-speckled and some buff as above
260 - 280	Limestone, grey, massive 270-280 many small grey ostracods
280 - 290	Limestone, grey; some crinoid buttons
290 - 300	Limestone, grey; some gypsum; crinoid buttons
300 - 310	Limestone, grey and brown
310 - 320	Limestone, very light-grey
320 - 330	Limestone, light-grey
330 - 340	Limestone, grey
340 - 350	Limestone, grey, massive; a little buff dolomite
350 - 360	Limestone, light-buff
360 - 370	Shale, red, calcareous
370 - 380	Limestone, grey-buff and a little red
380 - 390	Shale, buff, calcareous
390 - 410	Dolomite, buff, massive; a little quartz and limestone
410 - 420	Dolomite, buff
420 - 430	Dolomite, light-brown

430 - 440	Dolomite, light-brown; a little grey limestone
440 - 460	Dolomite, light-cream, finely-crystalline
460 - 480	Dolomite, white, finely-crystalline
480 - 490	Dolomite, white; some crystalline calcite
490 - 500	Dolomite, light-buff
500 - 510	Limestone, cream, granular, sandy
510 - 520	Limestone, light-buff and cream, crystalline and massive
520 - 550	Limestone, very fine-grained, sandy
550 - 570	Limestone, light-buff, crystalline and massive
570 - 590	Limestone, white and yellow, crystalline; dolomite common; sample very fossiliferous
590 - 600	Limestone, light-buff, non-fossiliferous, very sandy
600 - 610	Limestone, light-buff, compact
610 - 620	Limestone, light-buff, crystalline and compact; a little light-buff dolomite
620 - 650	Limestone, light-buff
650 - 660	Limestone, grey, argillaceous
	SILURIAN
660 - 680	Shale, red, calcareous
680 - 690	Dolomitic limestone, cream and red, compact
690 - 700	Dolomitic limestone, light-brown and white
700 - 710	Dolomitic limestone, cream
710 - 720	Dolomitic limestone, orange and white, massive to finely-crystalline
720 - 730	Dolomitic limestone, light-cream, massive to finely-crystalline
730 - 740	Dolomite, white
740 - 750	Dolomitic limestone, cream, finely-crystalline
750 - 760	Dolomitic limestone, light-buff, crystalline
760 - 770	Limestone, light-buff, massive and crystalline

MAFEKING NO. 3

Location - l.s. 12, sec. 2, tp. 43, rge. 26, W. Principal mer.
Elevation - 1140 feet
Log by R. T. D. Wickenden (1934, pp. 166-67B)

DEPTH IN FEET	LITHOLOGY AND REMARKS
0 - 230	No record
	DEVONIAN
230 - 300	Dolomite, cream
300 - 310	No sample

310 - 330	Dolomite, light-buff
330 - 340	Dolomite, medium-grey
350 - 370	Dolomite, dark-buff
370 - 380	Dolomite, reddish-brown; shale, reddish-brown
390 - 470	Dolomite, medium-grey, shaly
470 - 480	No sample
480 - 490	Dolomite, medium-grey to buff, porous
490 - 500	Dolomite, medium-grey
500 - 510	No sample
510 - 520	Dolomite, reddish-brown, shaly
520 - 530	Dolomite, medium-grey
530 - 540	Dolomite, white, very porous
540 - 550	Dolomite, light-buff, porous
550 - 640	Dolomite, light-buff
640 - 650	Dolomite, light-buff, very porous
650 - 690	Dolomite, cream
690 - 700	Dolomite, medium-grey
700 - 720	Dolomite, cream
720 - 730	Dolomite, brownish-grey, mottled
730 - 800	Dolomite, cream, slightly porous

SILURIAN

800 - 820	Dolomite, reddish-brown
820 - 830	Dolomite, cream
830 - 840	Dolomite, buff, porous
840 - 850	Dolomite, pink to rose
850 - 860	Dolomite, light-rose and buff
860 - 870	Dolomite, streaked rose and buff
870 - 890	Dolomite, light-greyish-buff, hard, compact
890 - 900	No sample
900 - 910	Dolomite, light-greyish-buff
910 - 920	Dolomite, white, compact, conchoidal fracture
920 - 930	Dolomite, light-greyish-buff, conchoidal fracture
930 - 940	Dolomite, cream, compact, conchoidal fracture
940 - 960	Dolomite, cream, porous
960 - 990	Dolomite, light-buff, nearly white, compact
990 - 1000	Dolomite, light-buff; many fine grains of sand embedded in matrix
1000 - 1080	Dolomite, light-buff

ORDOVICIAN

Red River Formation

1080 - 1170	Dolomite, light-buff but darker than above and somewhat mottled and streaked, porous
1170 - 1190	Dolomite, grey and light-buff
1190 - 1200	Dolomite, buff
1200 - 1220	Dolomite and limestone, cream
1220 - 1240	Dolomite, buff
1240 - 1250	Dolomite, buff and white

1250 - 1260	Dolomite and limestone, buff
1260 - 1280	Dolomite, light-buff
1280 - 1290	Dolomite, medium-grey
1290 - 1300	Dolomitic limestone, light-buff
1300 - 1330	Dolomite, buff and grey, mottled
1330 - 1340	No sample
1340 - 1350	Dolomite, buff and grey, mottled
1350 - 1520	Dolomite, buff and some mottled
	Winnipeg Formation
1520 - 1570	Sand, buff and grey
	PRECAMBRIAN
1570 - 1580	Granite, pink, foliated
1580 - 1590	Granite, dark-grey, foliated
1590 - 1600	Granite, pink, foliated
1600 - 1610	Granite, dark-grey, foliated
1610 - 1630	Granite, pink, foliated

KAMP NO. 1

Location - C NW¼ NE¼, sec. 3, tp. 154N, rge. 96W, Williams County, North Dakota
Elevation - surface 1918 feet; rotary table 1926 feet
Drilled by California Oil Company, 1937-38

DEPTH IN FEET	LITHOLOGY AND REMARKS
0 - 100	No samples
100 - 340	Shale, very black and shiny (carbonaceous), brittle; fine, light-buff, slightly porous, calcareous siltstone 220-240 almost entirely shale
340 - 400	Shale, light-colored, silty; some siltstone as above; a little black shale
400 - 500	No samples
500 - 700	Shale, light-grey, soft, silty; some fine-grained mottled calcareous sandstone
700 - 730	Sandstone, mottled, calcareous, shaly; much chert and silty shale
	CRETACEOUS
	Fox Hills Formation
730 - 860	Shale, light-colored, silty, fairly hard, with sandstone as above and chert; fine angular quartz

fairly common in lower part

Pierre Formation

860 - 870	Sandstone, coarse; much silty-sandy shale as above
870 - 880	Sand, coarse, quartz rounded to sub-angular; silty shale common
880 - 1020	Sandstone, medium-grained, shaly, and much loose quartz; light silty shale in varying amounts
1020 - 1060	Shale, light-grey-buff, soft
1060 - 1120	Shale as above with abundance of massive white limy material and some angular quartz
1120 - 1200	Shale, light-grey, silty; a little chert and quartz
1200 - 1220	Shale, silty as above; chert and quartz; a little carbonaceous shale - may be caving
1220 - 1230	Shale, light-grey, quite sandy; a little chert and carbonaceous shale
1230 - 3400	Shale, light-grey, fairly soft
	2040-2070 some carbonaceous shale or lignite
	2210-2290 some mottled limy sandstone
	2300-2320 considerable dense brown limestone
	2340-2370 a little brown limestone
	2410-2440 some mottled sandstone
	2500-2510 much dark-grey to black shale
	2850-2860 a little of the shale is glauconitic
	3070-3100 some grey-brown mottled limestone
3400 - 3420	Shale, dark-grey, a little silty
3420 - 3450	Shale, dark- and light-grey about equal; a little calcite and pyrite

Niobrara Formation
(Vermilion River - Boyne)

3450 - 3540	Shale, dark-grey to black, much is speckled, calcareous; calcite and pyrite quite common; some grey crystalline limestone to 3530 feet
3540 - 3580	Shale, dark-grey, only a small amount speckled; Inoceramus prisms common

(Vermilion River - Morden)

3580 - 3630	Shale, medium-grey, hard; small amount of sand
	3580-3600 some white bentonite
3630 - 3910	Shale, mostly a dark-grey, laminated to massive
	3655-3660 a little lignite; bentonite rare
	3675-3680 lignite quite common
	3700-3705 lignite quite common
	3860-3865 glauconitic sandstone common
	3895-3900 a little glauconitic sandstone
	3900-3905 a little bentonite

Benton Formation
(Favel)

3910 - 4020 Shale, light-grey increases in abundance with depth, some dark-grey
- 3915-3925 sandstone fairly common
- 3935-3955 considerable white siltstone
- 3950-3955 some speckled shale
- 4010-4015 some speckled shale

(Upper Ashville)

4020 - 4220 Shale, very dark-grey, somewhat laminated; a very small amount of glauconitic sandstone in some samples
- 4165-4180 no samples

Dakota Formation

4220 - 4360 Sandstone, white, some impure; some shale as above

4360 - 4395 Sand, much coarser quartz, grains rounded, some loose and some cemented, white to brown; some shale

Fuson Formation
(Lower Ashville)

4395 - 4465 Shale, dark-grey, laminated; a little sandstone, yellowish-brown
- 4415-4440 some cream shale
- 4440-4465 some soft medium-grey shale

4465 - 4508 Shale, dark-grey, laminated, and soft medium-grey; considerable white and grey very fine sandstone
- 4485-4490 yellowish-brown medium-grained sandstone fairly common
- 4490-4495 fine-grained white sandstone very abundant

4508 - 4525 Shale, light-grey, somewhat silty

4525 - 4541 No samples

4541 - 4550 Shale, light-brownish-grey, soft, and dark-grey, laminated; a little yellowish-brown sandstone

Lakota Formation
(Swan River)

4550 - 4645 Shale, dark-brownish-grey, laminated; minor white siltstone and some light-grey-buff shale
- 4615-4645 white sandstone very abundant in some samples

JURASSIC

Morrison Formation

4645 - 4665	Shale, dark-grey, laminated
4665 - 4675	Shale, dark-grey and dark-brown and some lighter colors, laminated
4675 - 4710	Shale, mostly light-grey-buff, massive, some dark, laminated
4710 - 4750	Shale, medium-grey, rather silty; a little massive grey limestone; a little greenish shale and some poorly laminated dark-grey shale
4750 - 4840	Shale, medium-grey and some slightly greenish; a little fine white sandstone 4770-4775 a little buff and pinkish-buff shale 4820-4825 white sandstone very common

Sundance Formation

4840 - 4850	Shale, grey and green; considerable fine-grained calcareous sandstone
4850 - 4890	Shale, grey, buff and green (amount of green shale increases with depth) 4865-4890 white calcareous sandstone common
4890 - 4915	Sandstone, white, fine-grained, calcareous; some shale, greenish-grey and dark-brownish-grey
4915 - 4920	Shale as above; sandstone common but no longer the major constituent
4920 - 4925	Shale, light-buff, silty and greyish-green, smooth; sandstone rare
4925 - 4940	No samples
4940 - 4970	Shale, buff and grey-green, splintery 4950-4955 a little white sandstone
4970 - 5035	Shale, almost all grey-green, splintery; grey and white sandstone rare 4985-4990 sandstone abundant 4990-5000 a little white sandstone
5035 - 5200	Shale, light-greyish-green, splintery, and some light-greyish-buff 5170-5200 some dark-red-brown limy shale
5200 - 5320	Shale, grey and a little greenish-grey and tan; some red-brown limy shale 5270-5325 some dark-cream to buff limestone 5280-5290 considerable light limy sandstone
5320 - 5360	Shale, variegated; a little very fine-grained white sandstone
5360 - 5410	Limestone, cream, massive; some shale as above
5410 - 5430	Shale, greyish-green and dark-grey; much limestone as above; red shale rare
5430 - 5465	Limestone, light-buff, massive; much green and grey shale
5465 - 5470	Shale, green and buff, mottled; much buff limestone

5470 - 5480	Limestone, dark-cream and buff, massive; green shale as above abundant
5480 - 5490	Shale, grey, green and black; a little limestone
5490 - 5505	Limestone, cream, massive; some shale, grey, brown and black
5505 - 5550	Shale, grey, green, brown, black and other colors; some buff limestone to 5520 feet 5525-5535 much red shale
5550 - 5565	Shale, variegated including much pink; white gypsum and cream limestone very common; pink shale and gypsum are closely associated
5565 - 5585	Limestone, cream; some gypsum; some grey, green and red shale
5585 - 5600	Shale, green and red; some limestone and gypsum

TRIASSIC

Spearfish Formation

5600 - 5620	Shale, bright-orange-red, calcareous; considerable grey-green and dark-grey shale
5620 - 5665	Shale, bright-orange-red, calcareous, some with included quartz grains; some dark shale 5625-5630 gypsum fairly common
5665 - 5765	Siltstone, red, finely-porous, and red shale; much grey-green and brown shale 5740-5765 mostly red siltstone
5765 - 5800	Shale, mostly light- and dark-grey, some red and brown 5795-5800 some red siltstone
5800 - 5845	Siltstone, red, slightly coarser than above; some red shale; dark-grey and dark-brown shale common
5845 - 5855	Shale, dark-grey and dark-reddish-brown; a little red siltstone
5855 - 5900	Sandstone, red, and red shale; much dark-grey and dark-red-brown shale 5870-5900 abundant black shale 5880-5900 some gypsum associated with red shale and sandstone
5900 - 5945	Shale, grey, black and dark-red-brown; some bright-red siltstone and shale
5945 - 5955	Shale, light-greyish-green, brown and red; some bright-red shale and siltstone
5955 - 5965	Shale, dark-grey to black, soft; a little bright-red and brown shale
5965 - 6018	Shale, bright-red, medium-grey, brown and black; considerable red siltstone 5975-5980 white gypsum common
6018 - 6020	Sandstone, red, calcareous, finely mottled with white gypsum
6020 - 6045	Shale, red, grey and black; some red sandstone and a little gypsum

6045 - 6050	Limestone, salmon-pink to bright-red, some quite porous; gypsum closely associated with the limestone; some black shale
6050 - 6090	Shale, medium-grey, black, brown and red
6090 - 6175	Shale, brick-red, some grey and black; gypsum rare 6120-6130 a little black shale 6140-6175 some porous red siltstone 6160-6175 much brown shale
6175 - 6195	Shale, light-grey and red
6195 - 6205	Shale, dark-grey to black, soft
6205 - 6220	Shale, black as above and red, silty, porous
6220 - 6290	Shale, red and black
6290 - 6300	Shale, black and a little red
6300 - 6375	Shale, red as above and some black 6330-6340 some anhydrite
6375 - 6400	Shale, black, dark-grey and red
6400 - 6485	Shale, red; some black and grey shale 6470-6485 anhydrite common

MISSISSIPPIAN

Amsden Formation

6485 - 6560	Dolomite, light-cream, massive; some red and black shale as above
6560 - 6565	Shale, red and some black
6565 - 6570	Shale, black; some dolomite and red shale
6570 - 6580	Shale, red; some black and grey shale
6580 - 6585	Shale, black and grey
6585 - 6590	Shale, red and some black; some dolomite
6590 - 6595	Shale, black, red and a little purple
6595 - 6600	Sand, purple, well-rounded grains; some purple shale; red shale abundant
6600 - 6640	Shale, red and purple; some rounded purple sand; trace of calcite
6640 - 6700	Shale, deep-maroon and lighter-purple shades, splintery; white to purple sandstone common
6700 - 6703	No sample
6703 - 6726	Shale, red and purple; purple sandstone common
6726 - 6736	Shale, light- and dark-purple and some red; sandstone rare

Big Snowy Group

Heath Member

6736 - 6746	Shale, black, splintery; some purple and red shale as above
6746 - 6760	No samples
6760 - 6820	Shale, black, splintery; light-grey splintery shale common to 6800 feet
6820 - 6835	Shale, black, splintery; light-grey shale common
6835 - 6860	Shale, medium-grey and greenish-grey

6860 - 6870	Shale, variegated
6870 - 6895	Shale, black, splintery; some light-green shale 6875-6880 light-grey dolomitic limestone fairly common
6895 - 6905	Dolomitic limestone, light-grey; considerable anhydrite

Otter Member

6905 - 6910	Shale, black and brownish-red, also yellow and green in small amounts
6910 - 6925	Shale, dark-grey to black; some light-grey limestone and anhydrite
6925 - 6930	Dolomite, light-grey, massive; considerable black splintery shale
6930 - 6940	Shale, variegated
6940 - 6965	Shale, brownish-grey and a little black 6945-6965 some anhydrite closely associated with the shale
6965 - 6985	Dolomitic limestone, light-grey; some anhydrite; some shale as above and a little green shale
6985 - 6995	Shale, variegated

Kibbey Member

6995 - 7000	Siltstone, very fine-grained, dark-pink to red; much colored shale
7000 - 7005	Shale, black, hard; a little buff dolomitic limestone; dark-pink siltstone rare
7005 - 7030	Shale, black, grey and a little colored; some massive dolomitic limestone; a little anhydrite
7030 - 7045	Shale, light-brown, somewhat mottled; a little colored shale as above 7040-7045 some pink and white sandstone
7045 - 7070	Sandstone, pink and white; much shale as above; some greenish-grey shale with dark specks 7055-7070 considerable dark-yellow and green shale
7070 - 7075	Shale, dark-greenish-grey, soft; a little sandstone as above
7075 - 7080	Dolomite, red, finely-crystalline; some black and colored shales
7080 - 7100	Shale, black and dark purple
7100 - 7105	Sandstone, fine, red and a little coarser, white; abundant black shale and some purple shale
7105 - 7155	Shale, light-red, silty; some red sandstone 7120-7140 sandstone much more abundant
7155 - 7175	Shale, variegated; some red sandstone as above and considerable white sandstone
7175 - 7185	Anhydrite, white; shale as above
7185 - 7220	Limestone, brown, mottled, massive, some quite porous; a little anhydrite to 7200 feet 7210-7215 fine grey limy sand abundant

7220 - 7230	Sandstone, grey, very fine, limy
7230 - 7275	Shale, pinkish-buff, sandy, hard; a little included anhydrite
	7230-7235 some limy sandstone
	7270-7275 some soft grey shale
7275 - 7300	Shale, grey, somewhat mottled, soft
	7280-7285 a little white medium-grained sandstone
	7285-7300 some variegated shales

Charles Member

7300 - 7320	Shale, brownish-red, limy; much white anhydrite
7320 - 7325	Shale, dark-grey and a little red; anhydrite as above
7325 - 7520	Shale, red, limy to 7350 feet; abundance of grey and white anhydrite; considerable dark-grey shale to 7360 feet
	7355-7360 light-green shale common
	7370-7380 some shale porous
	7510-7520 anhydrite very abundant
7520 - 7525	Sandstone, light-grey, very fine-grained, limy; much hard red shale as above
7525 - 7540	Anhydrite, grey-white; red shale abundant
7540 - 7555	Shale, red and grey; considerable anhydrite
7555 - 7565	Shale, red, and anhydrite
7565 - 7645	Shale, red, light-grey, black, etc.; anhydrite
	7625-7645 very abundant anhydrite
7645 - 7710	Anhydrite; shale as above
7710 - 7735	Limestone, brown, and anhydrite - some limestone fairly porous
7735 - 7745	Sandstone, light-grey, very fine-grained, some limestone and anhydrite
7745 - 7755	Limestone, light- to medium-brown, massive and oolitic, some is porous
7755 - 7780	Limestone as above; much anhydrite
7780 - 7805	Anhydrite, white to dark-cream; shale, red and grey, fairly common
7805 - 7820	Shale, dark- and light-grey, red and buff; anhydrite quite common
7820 - 7825	Shale, light-grey; anhydrite and limestone
7825 - 7840	Shale, very light-grey and some light-brownish-red; considerable anhydrite
7840 - 7850	Anhydrite; some shale as above
7850 - 7865	Shale, very light-grey, some red; considerable anhydrite
7865 - 7900	Limestone, massive, dark-brown, some is very porous; some anhydrite
7900 - 7920	Limestone, dark-brown, massive, a little is very porous
	7915-7920 a little light-grey dolomite

7920 - 7930	Dolomite, light-grey, massive
7930 - 7965	Anhydrite; some dolomite as above 7945-7965 some porous brown limestone 7960-7965 some light-red-brown shale
7965 - 7980	Dolomite, grey as above; much anhydrite and some brown limestone
7980 - 8020	Shale, light-grey 7990-8020 anhydrite fairly common
8020 - 8025	Dolomite, light-grey, massive
8025 - 8035	Limestone, brown; some dolomite 8030-8035 considerable anhydrite
8035 - 8055	Dolomite, grey, massive, and grey limestone, some anhydrite
8055 - 8080	Dolomite, light-grey-brown, massive; anhydrite common 8075-8080 some dark-brown limestone

Madison Formation

8080 - 8115	Limestone, dark-brown, somewhat mottled, massive 8100-8115 anhydrite, brown and white, common
8115 - 8130	Anhydrite, mostly dark-blue-grey; much limestone as above, some porous
8130 - 8170	Limestone, dark-brown, mottled, massive, some quite porous; white anhydrite common to 8140 feet 8155-8160 much of limestone is oolitic
8170 - 8220	Limestone, brown and very dark-brown, mottled, crystalline to massive, mostly very hard 8210-8215 a little dark-grey limestone
8220 - 8230	Limestone, light-brown, crystalline; a little anhydrite
8230 - 8240	Limestone, buff, massive
8240 - 8260	Limestone, light-brown, massive, a little porous; some dark limestone
8260 - 8275	Limestone, dark-brown, mottled, massive
8275 - 8285	Limestone, light-brown, massive
8285 - 8300	Limestone, dark-brown, some mottled, massive 8290-8300 a little porosity
8300 - 8530	Limestone, light- and dark-brown, mottled, massive to finely-crystalline
8530 - 8545	Limestone, light-grey-buff, somewhat mottled, non-crystalline; some darker-brown limestone
8545 - 8610	Limestone, light- and dark-brown, mottled crystalline 8600-8605 some dark-grey limestone
8610 - 8615	Limestone, brown-grey; abundance of variegated shale, probably caving
8615 - 8630	Shale, black, splintery; some limestone, dark-grey and brown
8630 - 8635	Limestone, dark-cream, non-crystalline; some black shale
8635 - 8650	Shale, variegated; some cream limestone

8650 - 8655	Limestone, cream and brown; some shale as above
8655 - 8685	Limestone, black, and some light-colored, crystalline
8685 - 8775	Limestone, very dark-brown-black, massive to finely-crystalline 8715-8720 a little anhydrite
8775 - 8780	Limestone, dark-cream or very light-buff, massive to finely-crystalline
8780 - 9205	Limestone, brown, brownish-grey and dark-grey grading into each other, crystalline 8990-9100 some very light-grey limestone 9180-9205 some light-grey limestone
9205 - 9375	Limestone, medium-grey, becoming darker with depth, non-crystalline to crystalline 9305-9310 much dense buff limestone
9375 - 9445	Limestone, brownish-grey, fairly dark, dense to crystalline
9445 - 9540	Limestone, dark-grey, dense and crystalline

Kinderhook Formation

9540 - 9565	Shale, black, flaky, carbonaceous; a little cream limestone
9565 - 9600	Limestone, mostly grey, finely-crystalline, and buff
9600 - 9635	Shale, black, carbonaceous 9625-9635 considerable crystalline limestone, light-grey
9635 - 9650	Dolomite, very pale-pinkish-cream, crystalline; much shale and limestone as above

DEVONIAN

Unit A

9650 - 9675	Limestone, grey and light-brown, mostly massive
9675 - 9720	Dolomite, light-grey, sugary
9720 - 9755	Limestone, very light-grey, crystalline 9725-9735 shale, light-greyish-green, somewhat calcareous; considerable crystalline limestone as above 9740-9755 some pink crystalline dolomite and a little anhydrite 9750-9755 some light-green calcareous shale
9755 - 9775	Dolomite, red-brown, crystalline; some light-green calcareous shale as above; a little anhydrite
9775 - 9785	Shale, very light-green; much light-grey crystalline dolomite
9785 - 9795	Dolomite, very light-grey, finely-crystalline
9795 - 9800	Dolomite, red-brown, crystalline; much green shale

9800 - 9810	Shale, light-green, calcareous; white anhydrite and some light dolomite
	Unit B
9810 - 9840	Limestone, brown, massive; some light, crystalline dolomite as above
9840 - 9875	Limestone, light-brown and cream, non-crystalline
9875 - 9920	Limestone, dark-brown, crystalline
9920 - 9975	Limestone, tan, light- and dark-brown, mostly non-crystalline to 9935 feet, then sugary 9945-9965 considerable dark-grey limestone 9960-9965 considerable light-grey, finely crystalline dolomite
9975 - 10015	Limestone, dark-brown, crystalline; some white anhydrite to 10003 feet
10015 - 10050	Limestone, medium- to dark-brown, some cream to 10030 feet, finely-crystalline 10035-10050 fine porosity in a little of the darker limestone
10050 - 10065	Limestone, crystalline, brown, medium-grained, some massive
10065 - 10075	Limestone, very dark-brown, massive 10070-10075 considerable anhydrite
10075 - 10095	Limestone, medium-brown, crystalline, medium-grained; considerable anhydrite
10095 - 10145	Limestone, medium-brown, crystalline and dark-brown, massive
	Unit C
10145 - 10265	Limestone, medium-brown, crystalline, pin-point porosity; some lighter-brown, non-crystalline dolomite to 10200; some of the limestone becomes more coarsely-crystalline and more porous below 10230 feet 10245-10250 considerable cream anhydrite 10260-10265 anhydrite
10265 - 10281	Limestone, light- and medium-brown, mostly massive; a little anhydrite

EMMA L. SEMLING NO. 1

Location - C SE¼, SE¼, sec. 18, tp. 141N, rge. 81W, Oliver County, North Dakota
Elevation - 2025 feet, ground; depths measured from top of rotary drive bushing at 2034 feet
Drilled by Carter Oil Company, 1942

DEPTH IN FEET	LITHOLOGY AND REMARKS
	TERTIARY
	Fort Union Formation
	Tongue River Member
18 - 30	Silt, dark- and light-grey, very fine, loosely-consolidated; some orange-red pieces
30 - 50	Siltstone, light-grey, somewhat porous, soft; some carbonized plant remains and lignite
50 - 70	Sandstone, light-buff, fine-grained, calcareous, finely-porous
70 - 90	Sandstone, buff, coarse-grained, calcareous, some loose quartz grains
90 - 110	Shale, black, bituminous; siltstone rare
110 - 130	Sandstone, red-buff, fine-grained, very porous; dark-grey siltstone; dark-grey shale rare
130 - 150	Sandstone, dark-grey and buff, very porous, shaly; loose angular quartz
150 - 170	Shale, red-buff and light-grey, sandy
170 - 210	Shale, light-grey, very sandy
	Cannonball Member
210 - 250	Shale, buff, soft, slightly sandy
250 - 270	Shale, grey, soft, silty; medium-grained, shaly sandstone common
270 - 550	Shale, grey, soft, silty 310-330 great abundance of grey shaly limestone - represents a thick bed 370-410 a little green limestone 410-430 great abundance of loose angular quartz 430-470 much limestone
	Ludlow Member
550 - 610	Shale, grey, soft, very sandy; considerable limestone
610 - 810	No samples

CRETACEOUS

Hell Creek Formation

810 - 870	Shale, grey-buff, very sandy, grading into grey-buff shaly sandstone
870 - 910	Shale, light-grey, silty

Fox Hills Formation

910 - 950	Shale, light-grey-buff, silty; white, fine-grained, calcareous sandstone increases downward
950 - 1010	Sandstone as above and loose quartz grains 990-1010 some green grains in sandstone
1010 - 1090	Shale, light-grey-buff, silty; sandstone as above 1060-1070 some chalky-white limestone 1070-1080 sandstone slightly glauconitic 1080-1090 more of calcareous glauconitic sandstone than above

Pierre Formation

1090 - 1100	Shale, light-grey; a little limestone
1100 - 1120	Shale, grey with a few pinkish-buff pieces, slightly bentonitic
1120 - 1130	Siltstone, light-grey, calcareous; some shale
1130 - 1140	Shale, light-grey, non-calcareous; some calcareous siltstone
1140 - 1170	Shale, light-grey
1170 - 1200	Shale, grey, micaceous
1200 - 1210	Shale, grey, micaceous; considerable green and yellow glauconite
1210 - 1220	Shale, light-grey; glauconite rare
1220 - 1270	Shale, grey, somewhat micaceous
1270 - 1280	Shale, grey; considerable white bentonite
1280 - 1290	Shale, grey; bentonite rare
1290 - 1300	Shale, grey; glauconite rare
1300 - 1310	Shale, grey; bentonite and pyrite rare
1310 - 1330	Shale, grey; a little bentonite
1330 - 1340	Shale, grey and buff
1340 - 1350	Shale, grey; a little white bentonite with biotite flakes
1350 - 1370	Shale, grey
1370 - 1380	Shale, grey and buff
1380 - 1400	Shale, grey; bentonite rare
1400 - 1410	Shale, grey, slightly micaceous
1410 - 1470	Shale, grey
1470 - 1510	Shale, light-grey
1510 - 1570	Shale, light- and medium-grey
1570 - 1620	Shale, light-grey
1620 - 2100	Shale, light- and medium-grey 1780-1790 glauconite and pyrite rare

1830-1850 a little brown shale
2030-2040 a little glauconite in shale
2070-2100 white and bluish bentonite fairly common

2100 - 2110 Shale, medium-grey; pyrite rare
2110 - 2120 Shale, grey, silty; a little white bentonite; Inoceramus prisms rare
2120 - 2130 Shale, light- and medium-grey; Inoceramus prisms rare
2130 - 2150 Shale, light- and medium-grey, silty, slightly micaceous; bentonite content increases downward
2150 - 2160 No sample
2160 - 2170 Shale, light-grey, silty; a few pieces of bentonite and brown siderite
2170 - 2180 Shale, light- and medium-grey; a little bentonite and siderite
2180 - 2200 Shale, light- and medium-grey, micaceous, some pyritic
2200 - 2210 Shale, light-grey; a little white bentonite and a few shell fragments
2210 - 2270 Shale, light- and medium-grey; a little white bentonite
2220-2270 a few pieces of siderite
2270 - 2280 Shale, light- and medium-grey; some pieces of brown and dark-red shale; shell fragments and bentonite rare
2280 - 2290 Shale, light- and dark-grey; some bluish-white and pink bentonite

Niobrara Formation

2290 - 2300 Shale, light- and medium-grey, very calcareous; bluish-white bentonite fairly common
2300 - 2340 Shale, medium- and dark-grey speckled, calcareous; bluish-white bentonite fairly common
2340 - 2350 Shale, medium- and dark-grey; very little bentonite
2350 - 2400 Shale, medium-grey, calcareous, speckled; a little bentonite
2400 - 2420 Shale, light-grey, speckled, calcareous; some white bentonite
2420 - 2470 Shale, light-grey; some white bentonite
2430-2440 a little more limestone and bentonite
2440-2470 some shale is pyritic
2470 - 2500 Shale, light- and medium-grey, speckled, calcareous; bentonite common

Benton Formation

2500 - 2530 Shale, light-grey, non-calcareous; white bentonite
2530 - 2540 Shale, light-grey, non-calcareous, some pyritized; glauconite and bentonite rare
2540 - 2560 Shale, light-grey; bentonite quite common; a little

	dark-brown limestone 2550-2560 some Inoceramus prisms
2560 - 2570	Shale, light-grey; bentonite and glauconite rare; a little limestone as above
2570 - 2600	Shale, light- and medium-grey; a little white bentonite and brown dolomite
2600 - 2610	Shale, light-grey; some white bentonite and a little brown limestone
2610 - 2640	Shale, light- and dark-grey; white bentonite and some pyrite
2640 - 2650	Shale, medium-grey
2650 - 2660	Shale, medium- and dark-grey, some pyritic; white bentonite fairly common
2660 - 2670	Shale, light- and medium-grey, a little pyritic; some white bentonite and brown limestone
2670 - 2680	Shale, medium- and dark-grey; a little bentonite
2680 - 2700	Shale, light- and medium-grey
2700 - 2710	Shale, medium- and dark-grey; glauconite, pyrite and Inoceramus prisms rare
2710 - 2720	Shale, medium- and dark-grey; some bentonite
2720 - 2740	Shale, medium-grey; pyrite and Inoceramus prisms rare
2740 - 2760	Shale, medium-grey; pyrite and bentonite rare
2760 - 2780	Shale, medium- and dark-grey; some pyrite, bentonite and Inoceramus prisms
2780 - 2790	Shale, medium- and dark-grey; some Inoceramus prisms and pink bentonite
2790 - 2800	Shale, medium- and dark-grey; Inoceramus prisms rare
2800 - 2810	Shale, light-grey; Inoceramus prisms rare
2810 - 2820	Shale, light-grey; some bentonite; pyrite and Inoceramus prisms rare
2820 - 2860	Shale, light-grey; Inoceramus prisms increase with depth 2850-2860 dark speckled shale rare
2860 - 2880	Shale, light- and dark-grey; much of the dark shale is speckled with white; crystalline calcite common; Inoceramus prisms rare
2880 - 2890	Inoceramus prisms and calcite; some shale as above; pyrite rare
2890 - 2960	Calcite and Inoceramus prisms are common but shale as above is chief constituent
2960 - 2970	Shale, dark-grey; calcite and Inoceramus prisms abundant
2970 - 2990	Shale, light-grey, a little speckled; calcite not so abundant; pyrite and reddish-brown dolomite rare
2990 - 3000	Shale, medium-grey; a little calcite and some Inoceramus prisms; red-brown dolomite rare
3000 - 3010	Shale, medium- and dark-grey; a little speckled shale; calcite and Inoceramus prisms rare

3010 - 3050	Shale, light- and medium-grey, a little speckled; calcite and Inoceramus prisms more common 3030-3040 white bentonite fairly common
3050 - 3070	Shale, light- and dark-grey; some Inoceramus prisms and pyrite
3070 - 3080	Shale, light-, medium- and dark-grey; some Inoceramus prisms; pyrite rare
3080 - 3090	Shale, light- and dark-grey; some Inoceramus prisms; speckled shale rare
3090 - 3100	Shale, mostly dark-grey, a few pieces pyritized; Inoceramus prisms fairly common
3100 - 3110	Shale, light- and medium-grey
3110 - 3150	Shale, medium- and dark-grey; some Inoceramus prisms
3150 - 3160	Shale, medium-grey; speckled shale rare
3160 - 3170	Shale, medium-grey; bentonite
3170 - 3190	Shale, dark-grey; some Inoceramus prisms
3190 - 3200	Shale, medium-grey; Inoceramus prisms very common
3200 - 3220	Shale, medium- and dark-grey; some Inoceramus prisms
3220 - 3230	Shale, medium-grey; some white bentonite
3230 - 3240	No sample
3240 - 3250	Shale, medium-grey
3270 - 3290	Shale, medium- and dark-grey; speckled shale rare; a little pyrite
3290 - 3300	Shale, light- and dark-grey; white bentonite and pyrite rare
3300 - 3320	Shale, dark-grey
3320 - 3340	Shale, medium- and dark-grey; bentonite and calcite rare
3340 - 3360	Shale, medium- and dark-grey; some Inoceramus prisms
3360 - 3380	Shale, medium- and dark-grey; a little white bentonite
3380 - 3390	Shale, medium- and dark-grey; Inoceramus prisms and pyrite rare
3390 - 3420	Shale, medium-grey; bluish-white bentonite rare
3420 - 3430	No sample
3430 - 3440	Shale, medium-grey
3440 - 3450	Shale, medium- and dark-grey; some Inoceramus prisms
3450 - 3460	Shale, medium-grey; white bentonite rare
3460 - 3470	Shale, medium- and dark-grey
3470 - 3500	Shale, medium-grey; fine-grained, calcareous siltstone fairly common 3480-3500 small round orange quartz pebbles abundant
3500 - 3510	Shale, medium-grey with some fine-grained siltstone and a little pale-pink bentonite
3510 - 3530	Shale, dark- and light-grey; a few orange pebbles as above
3530 - 3540	Shale, dark-grey; more white bentonite than above; a little white crystalline limestone

Dakota Formation

3540 - 3560	Shale, dark-grey; more white limestone than above; colorless and orange, rounded quartz grains very common
3560 - 3570	Shale, dark-grey; white limestone, some pyrite
3570 - 3580	Shale, light- and dark-grey; a little white limestone; yellow shale and Inoceramus prisms rare
3580 - 3590	Shale, dark-grey; rounded quartz grains quite common; a little limestone
3590 - 3600	Shale, medium-grey; a little colorless and orange quartz
3600 - 3610	Shale, medium-grey; some bentonite; colorless, calcareous sandstone rare
3610 - 3620	Shale, medium-grey; colorless and orange quartz fairly common

Fuson Formation

3620 - 3640	Shale, medium-grey; colorless, calcareous sandstone and pyrite rare; a little colorless and orange quartz
3640 - 3650	Shale, light- and dark-grey; colorless and orange quartz rare; bentonite and pyrite rare

Lakota Formation

3650 - 3670	Shale, medium-grey; rounded, colorless quartz very abundant; bentonite and pyrite rare

JURASSIC

Morrison Formation

3670 - 3680	Shale, medium- and very dark-grey; small amount of light-greenish-grey shale
3680 - 3690	Shale, dark-grey and a little greenish-grey; a little sandy, grey shale and considerable pinkish-white shale
3690 - 3700	Shale, very dark-grey

Sundance Formation

3700 - 3710	Shale, dark- and light-grey; considerable medium-grained, grey and green sandstone with calcareous cement
3710 - 3740	Shale, light- and medium-grey; glauconite in a few pieces of shale
3740 - 3745	Shale, medium- and dark-grey
3750 - 3780	Shale, light- and dark-grey; a little orange quartz
	3755-3775 no samples

3780 - 3790	No samples
3790 - 3795	Shale, very dark-grey
3800 - 3805	Shale, dark-grey; a little orange quartz
3805 - 3845	Shale, light- and dark-grey; orange quartz and white, calcareous siltstone in small amounts 3810-3830 a little pyrite 3840-3845 siltstone quite common
3850 - 3865	Shale, medium- and dark-grey; considerable calcareous, greenish-grey, splintery shale
3870 - 3875	Shale, very light- and dark-grey; orange quartz and calcareous siltstone rare; a little greenish shale as above
3875 - 3910	No samples
3910 - 3960	Shale, mostly greenish-grey, and some reddish-brown very shiny shale; a little pinkish limestone 3920-3930 white siltstone fairly common 3930-3960 white siltstone very abundant
3960 - 4000	Shale, light-green, and white siltstone; some of fragments show banding of these two; some light-brown shale 3990-4000 some dark-grey shale
4000 - 4050	Shale, light-greenish-grey and very dark-grey; white siltstone rare 4010-4020 pale-pink shale rare 4030-4040 some pale-pink shale 4040-4050 some coarse-grained sandstone - white calcareous matrix with colorless and brown calcareous rounded pebbles
4050 - 4070	Shale, light-grey, slightly greenish; light-grey to white siltstone fairly common
4070 - 4090	Shale, greenish-grey; much very light, silty shale; siltstone as above
4090 - 4130	Shale, light-greenish-grey and dark-grey; siltstone rare
4130 - 4190	Shale, light-greenish-grey and a little dark-grey; a little siltstone 4140-4150 in some pieces shale and siltstone are interbedded 4150-4170 red-brown limestone fairly common 4170-4180 cream limestone very common
4190 - 4200	Shale, dark-grey, greenish-grey and light-grey
4200 - 4300	Shale, medium- and dark-grey; cream limestone common 4210-4230 some light-greenish-grey shale 4220-4240 rose limestone rare 4250-4260 and 4270-4290 limestone more abundant
4300 - 4380	Shale, greenish-grey and dark-grey; some cream limestone 4320-4370 a little red-brown dolomite 4360-4380 a little bright-orange-red shale

TRIASSIC

Spearfish Formation

4380 - 4400	Shale, greenish-grey and dark-grey; much orange shale
4400 - 4410	Shale, light- and dark-grey and orange as above
4410 - 4420	Shale, red-orange, and red, calcareous, fine-grained sandstone; some light- and dark-grey shale
4420 - 4430	Shale, dark-grey, buff and red; red, calcareous siltstone
4430 - 4440	Shale, light-and dark-grey, buff and red, and fine-grained sandstone as above
4440 - 4470	Shale, red, light- and dark-grey; red, fine-grained sandstone 4460-4470 more sandstone than shale
4470 - 4480	Sandstone, red and light-grey shale
4480 - 4490	Sandstone, red and pale-pink; red and grey shale
4490 - 4500	Shale, grey and a little red; pink, sugary dolomite common
4500 - 4520	Shale, light- and dark-grey; considerable pale-pink crystalline dolomite; red sandstone and shale 4510-4520 more sandstone and less dolomite
4520 - 4560	Shale, light- and dark-grey; colorless, pink and red sandstone; red shale rare 4530-4550 some pinkish dolomite as above
4560 - 4570	Shale, dark- and light-grey and a little light-green; red shale very common; considerable white gypsum
4570 - 4580	Shale, light- and dark-grey and some red; less gypsum
4580 - 4600	Shale, light-grey and a little red 4590-4600 a little gypsum

MISSISSIPPIAN

Amsden Formation

4600 - 4630	Dolomite, pale-purple; red and grey shale; white gypsum fairly common
4630 - 4680	Shale, greenish-grey and red; considerable dolomite and gypsum 4660-4680 mostly shale
4680 - 4690	Shale, light-grey and red; gypsum rare

Big Snowy Formation

Heath Member

4690 - 4710	Shale, light-grey and red; small amount of black carbonaceous shale 4700-4710 more gypsum; some massive brown dolomite
4710 - 4760	Shale, black, carbonaceous; considerable red

shale and gypsum; some light-grey, calcareous shale
4730–4760 light-green shale content increases with depth

4760 - 4790 Shale, black, carbonaceous as above, also light-green and greenish-yellow shale; much cream limestone; red shale
4770-4780 some green shale blends into maroon

4790 - 4820 Shale, black, carbonaceous, with colored shales in small amounts; a little limestone

Otter Member

4820 - 4900 Shale, variegated

4900 - 4910 Shale, rose and grey predominating; considerable pale-green-grey and more green and yellow-green than above; a little gypsum

4910 - 4940 Shale, variegated

Kibbey Member

4940 - 4950 Shale, fewer colours; much cream limestone

4950 - 4980 Shale, grey, green and red; abundant white limestone
4970–4980 less limestone

4980 - 5030 Shale, red predominating, much grey and some pale-green
4990–5000 dark-purple shale

5030 - 5070 Shale, grey, red and other colours; considerable light-buff to colorless dolomite
5050–5070 some white limestone

Charles Member

5070 - 5090 Limestone, light-buff, massive; some shales as above
5080–5090 some of limestone is oolitic

5090 - 5120 Shales, variegated; limestone in small amounts; some gypsum
5110–5120 slightly more limestone, some of it oolitic

5120 - 5140 Shales, variegated; anhydrite common; limestone rare

5140 - 5170 Limestone, light-buff or cream, massive; much light-grey and variegated shale; gypsum fairly common

5170 - 5190 Shales, variegated; little limestone
5180–5190 anhydrite common

5190 - 5200 Limestone and very abundant anhydrite

5200 - 5220 Limestone, light-buff; anhydrite rare

5220 - 5240 Shales, variegated; a little limestone and more anhydrite than above

5240 - 5290 Shales, variegated; a little limestone; anhy-

drite abundant, white and some bluish
5250-5290 limestone quite abundant

5290 - 5300 Dolomite, cream and bluish-white; shale as above; anhydrite abundant

5300 - 5310 Mostly shales; little limestone or dolomite; anhydrite common

5310 - 5350 Cream dolomite and limestone; some shale; anhydrite not so common
5320-5340 some limestone very finely crystalline;

5350 - 5360 Limestone, cream and bluish; cream dolomite; some anhydrite

5360 - 5390 Dolomite, bluish-grey; some limestone; little anhydrite

5390 - 5400 Limestone, buff, crystalline; dolomite as above less abundant

5400 - 5410 Dolomite more abundant than limestone

5410 - 5420 Dolomite, cream; anhydrite common

5420 - 5430 Dolomite and anhydrite

5430 - 5460 Dolomite, bluish and cream; anhydrite
5440-5460 considerable buff limestone

5460 - 5560 Limestone, cream to light-buff, massive to crystalline, some a little porous

5560 - 5590 Limestone, light-buff, massive to crystalline
5580-5590 a little blue anhydrite

5590 - 5600 Anhydrite; abundant variegated shale (caving); limestone rare

Madison Formation

Mission Canyon Member

5600 - 5620 Limestone, buff, massive; anhydrite and shale as above

5620 - 5640 Limestone, buff, finely-crystalline, finely-porous

5640 - 5730 Limestone, cream, massive, much finely-porous
5660-5730 a little buff finely-crystalline
5680-5730 porosity steadily decreases

Lodgepole Member

5730 - 5780 Limestone, dark-grey-brown, crinoidal, and some as above; dark limestone is slightly porous

5780 - 5790 Limestone, grey, more massive than above

5790 - 5830 Limestone, grey and buff, crinoidal

5830 - 5870 Limestone, mostly grey, crystalline, and some as above

5870 - 5900 Limestone, grey and buff, crinoidal and crystalline

5900 - 6070 Limestone, grey, crystalline
5960-6070 amount of crystalline limestone increases steadily
6040-6070 much shale caving

6070 - 6080	No sample
6080 - 6090	Limestone, mostly massive, grey; some as above
6090 - 6110	Limestone, buff to grey
6110 - 6130	Limestone, grey, crystalline, and buff, massive
6130 - 6170	Limestone, grey, massive to crystalline, and buff as above; much shale
6170 - 6200	Limestone, grey, mostly dense
6200 - 6210	Limestone, grey
6210 - 6330	Limestone, grey-buff 6230-6240 some limestone quite shaly
6330 - 6350	Limestone, cream, finely-granular; a little massive grey limestone
6350 - 6360	Limestone, cream to light-buff, massive

Kinderhook Formation

6360 - 6370	Shale, black, carbonaceous; sample mostly limestone as above
6370 - 6390	Shale, black, carbonaceous; some limestone as above

DEVONIAN

Amaranth Formation

6390 - 6420	Red shale and red sandstone rare; sample mostly black shale as above
6420 - 6450	Dolomite, reddish-buff, finely-crystalline; much black shale

Manitoban Formation

6450 - 6470	Limestone, buff, crystalline; much shale; a little gypsum
6470 - 6530	Limestone, light-buff, granular and crystalline, some porous
6530 - 6550	Limestone, cream, massive, and some as above
6550 - 6580	Limestone, cream, very finely-crystalline, some finely-porous
6580 - 6650	Limestone, cream and buff, massive and finely-crystalline 6600-6610 some of crystalline pieces are porous

Winnipegosan Formation

6650 - 6660	Limestone, buff; grey dolomite; limestone has stringers of included anhydrite
6660 - 6690	Dolomite, buff to brown, medium crystallinity, quite porous; anhydrite rare
6690 - 6700	Limestone and dolomite, buff and brown, crystalline, less porosity
6700 - 6710	Limestone, light-grey non-crystalline; buff, crinoidal limestone rare

6710 - 6760	Limestone, cream and light-grey, massive 6740-6750 some limestone tending toward fine crystallinity
6760 - 6800	Limestone, cream, sugary 6790-6800 a little brown limestone
6800 - 6810	Limestone, cream to brown, a little coarser crystallinity than above, slight porosity in some pieces
6810 - 6820	Limestone, cream to brown-grey, finely crystalline, slightly porous
6820 - 6830	Limestone, mostly massive cream; a little cream to brown, finely-crystalline limestone
6830 - 6860	Limestone, cream to buff, massive

ORDOVICIAN

Stony Mountain Formation

Unit I

6860 - 6880	Limestone, cream and brown, massive; a little red and orange limestone
6880 - 6890	Limestone, cream to buff; considerable dark grey shale
6890 - 6930	Limestone, creamy-white, massive 6900-6910 grey and green shale rare 6920-6930 a little limestone tends toward crystallinity
6930 - 6950	Limestone, dense, buff to brown; a little shale 6940-6950 a little red, calcareous shale with buff streaks
6950 - 6990	Limestone, buff and brown, massive
6990 - 7020	Limestone, cream to buff, massive

Unit II

7020 - 7030	Limestone, buff and grey-buff, massive
7030 - 7040	Limestone, buff, massive
7040 - 7050	Limestone, buff, massive, sugary buff dolomite
7050 - 7060	No sample
7060 - 7070	Limestone and dolomite as above with the limestone predominating
7070 - 7130	Dolomite, light cream, massive
7130 - 7140	Dolomitic limestone, grey, very finely-crystalline; buff, finely-crystalline dolomite
7140 - 7170	Dolomitic limestone, grey-buff and buff, very finely-crystalline, pin-point porosity
7170 - 7180	Dolomite, as above except less porous; a little buff dolomite with large rounded quartz grains; green shale rare
7180 - 7190	Dolomite, cream and buff, finely-crystalline, finely-porous

Unit III

7190 - 7210	Dolomite, creamy-white, non-crystalline
7210 - 7260	Dolomite, white, non-crystalline to granular; green shale rare 7220-7260 a little porosity in dolomite
7260 - 7300	Dolomite, white, massive
7300 - 7330	Dolomite, white, massive 7300-7310 crystalline calcite fairly common 7310-7320 a few pieces porous
7330 - 7400	Dolomite, white, massive 7350-7360 considerable shale, grey and green
7400 - 7480	Dolomite, white, massive and finely sugary 7430-7470 some shale grey and red 7470-7480 some rose dolomite

Red River Formation

Unit I

7480 - 7500	Dolomite as above with considerable grey-tan limestone or dolomitic limestone (less dolomite near 7500 feet)
7500 - 7510	Sandstone, light-grey, fine-grained, calcareous; some creamy-white dolomite as above
7510 - 7530	Sandstone, light-grey to colorless, fine-grained; a few large grains included; a little dolomite (more large rounded grains toward 7530 feet)
7530 - 7540	Limestone, tan, crystalline; some sandstone
7540 - 7560	Dolomite, cream to buff, massive to crystalline 7550-7560 considerable light-grey limestone
7560 - 7590	Dolomitic limestone, cream, massive; some massive grey limestone
7590 - 7660	Limestone, grey, non-crystalline; some dolomite 7630-7660 limestone very smooth; bryozoans noted 7650-7660 some massive buff limestone

Unit II

7660 - 7680	Dolomitic limestone, buff and a little grey, massive limestone as above 7670-7680 light-green shale fairly common
7680 - 7690	Dolomitic limestone, massive, darker-buff than above; green shale as above; coarse sandstone rare
7690 - 7710	Dolomite, cream and dark-buff, massive; bryozoans noted; 7700-7710 anhydrite abundant - 15%
7710 - 7720	Dolomite, light-buff, massive; less anhydrite than above but still very common; green shale rare

7720 - 7730	Dolomite and anhydrite; a little of dolomite quite sandy
7730 - 7740	Dolomite, light-buff, massive ; very little anhydrite; some dark-grey and green shale
7740 - 7760	Limestone, buff, granular; dolomite as above; a little anhydrite 7750-7760 much more anhydrite

Unit III

7760 - 7770	Limestone, cream, fairly sugary; dolomite
7770 - 7820	Dolomite, cream, sugary; a little anhydrite and green shale 7810-7820 a little porosity
7820 - 7850	Dolomite, buff, finely-crystalline, fairly porous 7830-7850 less porosity

Unit IV

7850 - 7890	Limestone, cream, massive; much dolomite as above 7880-7890 brown crystalline dolomite and green calcareous shale rare
7890 - 7900	Limestone, cream, massive; a little green calcareous shale
7900 - 7970	Limestone, light-grey-buff, massive; a little green calcareous shale 7910-7920 a little crystalline buff dolomite
7970 - 8040	Limestone, cream, massive and crystalline; a little dolomitic limestone and green shale
8040 - 8180	Dolomitic limestone, buff, crystalline; limestone as above; green shale 8060-8070 bryozoan 8130-8140 dark-grey plicated shell fragment 8160-8170 more shale, some grey
8180 - 8310	Dolomitic limestone and limestone, cream to buff, massive; considerable shale, green and grey 8190-8310 less shale, now mostly green

Winnipeg Formation

8310 - 8350	Shale, green and black; considerable limestone
8350 - 8360	Shale, very dark-greenish-grey
8360 - 8430	Shale, dark-green, splintery; a little brown splintery shale
8430 - 8510	Shale, green splintery; much reddish-brown splintery shale 8460-8470 light-green sandstone rare 8480-8500 white medium-grained sandstone rare
8510 - 8520	Shale as above; considerable more medium- to coarse-grained, white sandstone
8520 - 8540	Shale as above; some white sandstone; large frosted rounded quartz grains quite common
8540 - 8550	Shale as above; sandstone rare
8550 - 8560	Shale, green splintery, a little brown shale; small amount of white sandstone, rather angular

8560 - 8580	Shale as above; some colorless to light-buff, crystalline dolomite (less abundant 8570-8580)
8580 - 8590	Shale as above; greyish-white, granular limestone fairly common
8590 - 8600	Shale as above
8600 - 8630	Shale as above; white sandstone and white limestone rare 8620-8630 more sandstone and very little limestone
8630 - 8650	Shale as above; some limestone and a little sandstone
8650 - 8660	Shale as above; some rather coarse white sandstone and white limestone
8660 - 8670	Shale as above; sandstone, somewhat conglomeratic
8670 - 8680	Shale as above; coarse-grained, white sandstone fairly common, a little is glauconitic; large frosted quartz grains fairly common
8680 - 8720	Shale as above; sandstone and frosted quartz less common 8710-8720 slightly more sandstone
8720 - 8740	Shale, very dark-green and brown; very little sandstone
8740 - 8760	Shale, dark, abundant fine- to medium-grained, white sandstone; a little limestone
8760 - 8780	Shale, very dark-green to black and some brown; small amount of sandstone and limestone
8780 - 8830	Shale as above; some glauconitic limestone and a little sandstone 8790-8830 more glauconitic limestone 8800-8830 some glauconitic sandstone

PRECAMBRIAN

8830 - 8850	Hard green glassy igneous material - amphibolite; much shale

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