POF18-2000

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Geology, Reservoir Characteristics and Petroleum Potential of the MC-1 Member, Mission Canyon Formation, Southwestern Manitoba

By
C.D. Martiniuk, M.P.B. Nicolas
and J.N. Fox

Manitoba
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Cover:
Core photo of Lithofacies 6 showing peloidal packstone with fenestral porosity; cemented by anhydrite. Taken from the well at 9-12-3-28 WPM at a depth of 959.5 m below K.B.

Georeference:
NTS area(s): 62F

Keywords: lithofacies, MC-1 Member, Mission Canyon Formation, Mississippian, oil and gas fields, petroleum, petroleum exploration, production, reserves, southwestern Manitoba, stratigraphy

Suggested reference:
Martiniuk, C.D., Nicolas, M.P.B., and Fox, J.N. 2000: Geology, reservoir characteristics and petroleum potential of the MC-1 Member, Mission Canyon Formation, southwestern Manitoba; Manitoba Conservation, Petroleum and Energy Branch, Petroleum Open File Report POF18-2000, 62 p.

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Winnipeg, 2000

Conservation

Hon. Oscar Lathlin
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Deputy Minister

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INTRODUCTION

The Mississippian Mission Canyon Formation is conformably underlain by the carbonates of the Lodgepole Formation and conformably overlain by the evaporitic beds of the Charles Formation. It is subdivided in southwestern Manitoba into the MC-1, MC-2 and MC-3 members. The MC-1 is the lowermost member of the Mission Canyon Formation and consists generally of limestones and dolomitic limestones deposited in a shallow-water, shelf-type environment.

The MC-1 Member has produced in excess of 413.2 $10^3 m^3$ (2.6 million bbls.) of oil in Manitoba, mostly from bioclastic, lime wackestones and grainstones and dolomitic skeletal mudstones and wackestones. Oil entrapment within the MC-1 Member is related primarily to paleotopographic highs on the Mississippian erosional surface and also to stratigraphic and diagenetic factors.

Recent pool discoveries along the Manitoba extension of the MC-1 Member subcrop trend has stimulated renewed interest in the MC-1 Member in Manitoba. The majority of MC-1 production in Manitoba is derived from the Tilston Field, with minor production at Waskada and Pierson fields and smaller, recently developed pools at East Tilston, South Reston and South Pipestone. As of December 31, 1998, there were 73 non-confidential, non-abandoned wells within 12 MC-1 Member pools in southwestern Manitoba.

This study summarizes the stratigraphy of the MC-1 Member of the Mission Canyon Formation and describes the lithofacies identified in the study area (Fig. 1). Depositional environments and distribution of lithofacies are discussed. The main reservoir facies are described in terms of their hydrocarbon potential. The factors controlling oil accumulation in productive pools, including trapping mechanisms are assessed. The reservoir rock and fluid properties for seven of the largest non-abandoned MC-1 Member pools are reviewed in detail. Production and reserves data are also presented, including a comparison of the production performance of MC-1 Member vertical and horizontal producers.

Study Area

The study covers the regional extent of the MC-1 Member of the Mississippian, from Townships 1 to 7 and Ranges 22 to 29 WPM. It encompasses over 5200 km^2.

Non-confidential data available to December 31, 1998, from 216 wells that completely penetrate the MC-1 Member, including drill stem tests, were incorporated in the study. Available cores from 41 selected wells were examined and described (Fig. 2; Appendices I, II and III). Fifteen thin sections from selected wells were also studied.

Previous Work

Previous studies of the MC-1 Member of southwestern Manitoba were conducted in the Tilston Field and Waskada Field areas (Bell, 1986; Rodgers, 1986). Limited study has been made of the lithofacies of the MC-1 Member on a regional scale in southwestern Manitoba.

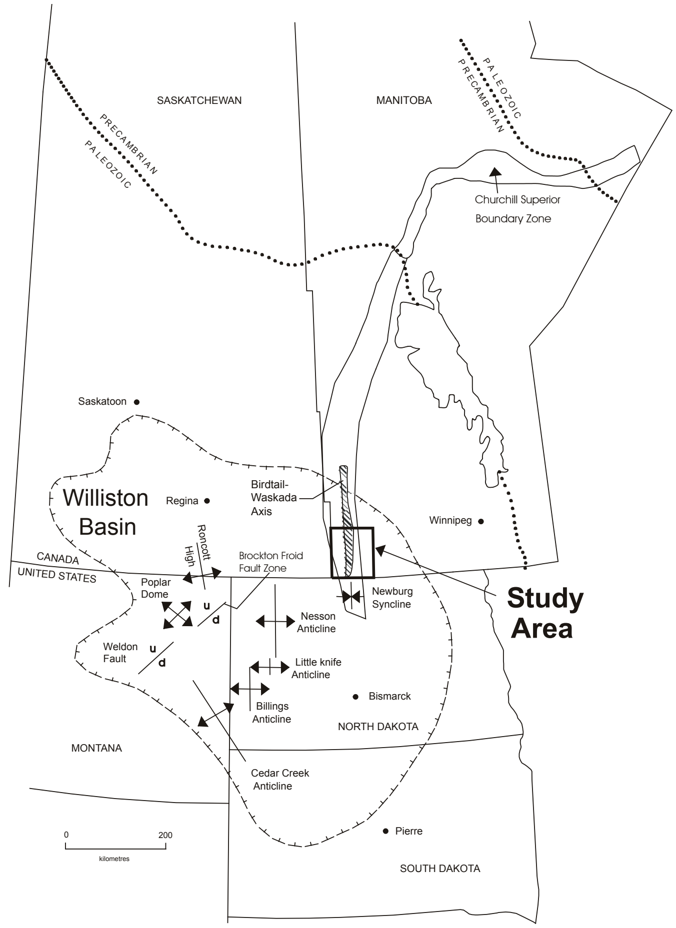


Figure 1: Map of the Williston Basin showing major structural features. Location of study area is shown.

Acknowledgements

The authors gratefully acknowledge the contributions and assistance of the staff of Manitoba Conservation, particularly the staff of the Petroleum and Energy Branch and the staff of the Rock Preparation Laboratory, Geological Survey, Manitoba Industry, Trade and Mines.

GEOLOGICAL SETTING

Southwestern Manitoba is situated along the northeastern flank of the Williston Basin. Rocks of Paleozoic, Mesozoic and Cenozoic age form a basinward thickening wedge of strata that reach a total thickness of 2300 m in the extreme southwestern corner of the province.

Paleozoic and Mesozoic strata are separated by a major angular unconformity representing one or more periods of erosion that occurred from late Mississippian to early Jurassic time. During that time period, Paleozoic strata in the northeastern portion of the basin were uplifted and differentially eroded, whereas strata in the southern part underwent relatively slight uplift (McCabe, 1959). Successively older Paleozoic strata were progressively truncated toward the basin margin. Deposition resumed during Mesozoic time when a thick sequence of Jurassic and Cretaceous strata were deposited on the eroded Paleozoic surface.

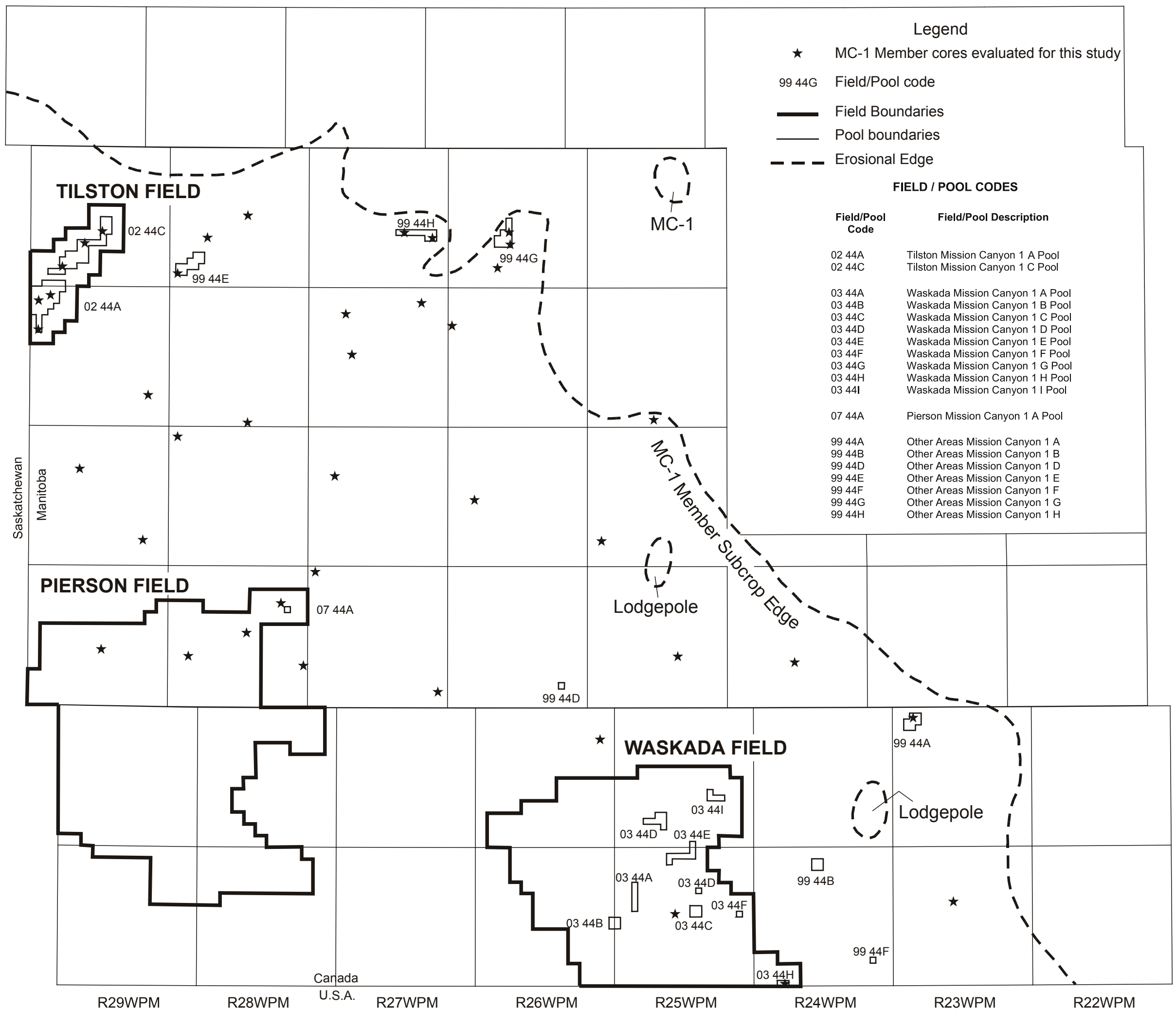


Figure 2: Map of study area showing MC-1 Member fields and pools, the MC-1 Member subcrop edge, and location of cores examined in this study.

GENERAL STRATIGRAPHY

The lower Mississippian in southwestern Manitoba is divided, in ascending order, into the Bakken Formation and the Lodgepole, Mission Canyon and Charles formations of the Madison Group.

The three formations of the Madison Group are conformable and exhibit a complex intertonguing relationship towards the northeastern margin of the Williston Basin in Manitoba. Recognition of facies changes and transitions between evaporites and carbonates of the sequence across the Williston Basin has led to the use of marker horizons to delineate informal units within the Madison Group on the northeast flank of the basin. In southwestern Manitoba, stratigraphic subdivisions of the Lodgepole, Mission Canyon and Charles formations sequences adhere to the "formation" system of nomenclature, rather than the marker-defined or "bed" system of nomenclature employed in other parts of the basin.

The Mission Canyon Formation consists predominantly of fragmental carbonates that conformably overlie the argillaceous carbonates of the Lodgepole Formation and conformably underlie the evaporitic beds of the Charles Formation.

The Mission Canyon and Charles formations in Manitoba, represent a complex sequence of interbedded carbonates and evaporites. Much of this sequence was removed during pre-Jurassic erosion and, as a result, only the lowermost part of this sequence is preserved. The Mission Canyon Formation subcrops along the northeastern portions of the study area, where it is unconformably overlain by the Jurassic Lower Amaranth (Red Beds) Formation.

In southwestern Manitoba, the Mission Canyon Formation is subdivided, in ascending order, into three members, MC-1, MC-2 and MC-3. The MC-1 Member consists of crinoidal-fragmental and oolitic limestones, dolomitic limestones and dolostones. The overlying MC-2 Member consists of evaporitic and shaly carbonates that straddle a thin interbed of dense to earthy, argillaceous dolostone, referred to as the MC-2 marker (McCabe, 1959). The MC-3 Member consists predominantly of fragmental limestones, along with some dolomitic limestones and dolostones.

The MC-1 Member and MC-2 Member are correlative to the Tilston Beds of southeastern Saskatchewan and the Tilston interval of north-central North Dakota. The MC-3 Member is equivalent to the Frobisher-Alida Beds of southeastern Saskatchewan and the Frobisher-Alida interval of north-central North Dakota (Fig. 3; Rodgers, 1986; LeFever *et al.*, 1991).

In the southwestern corner of the province, the MC-1 Member is overlain by the MC-2 Member of the Mission Canyon Formation. Beyond the MC-2 subcrop, the MC-1 is unconformably overlain by the Jurassic Lower Amaranth (Red Beds) Formation (Fig. 4).

LITHOFACIES AND ENVIRONMENT OF DEPOSITION

The lower Mississippian Madison Group represents one complete major sedimentary cycle of marine transgression and regression. The cycle commenced with the widespread deposition of the shales and siltstones of the Bakken Formation during the initial transgression of Mississippian seas. It reached its maximum transgression in Lodgepole time, with the deposition of a repetitive sequence of shales and oolitic-crinoidal limestones.

A transition from the deeper water, marine carbonate deposition of the Lodgepole Formation occurred during the Mission Canyon succession, representing a shift in the sedimentary cycle to an overall regressive phase of shallow-water, marine shelf deposition. During Mission Canyon time, the rate of subsidence decreased, reflecting an overall decrease in water depth of Mississippian seas, relatively stable tectonics, and a decrease, or lack of detrital input into the Williston Basin that was most pronounced along the shelf areas of Manitoba. The basin underwent cyclical fluctuations in sea level and minor periods of transgression and regression during Mission Canyon time, as represented by the development of carbonate-evaporite cycles. This resulted in the deposition of a repetitive sequence of barrier island/open marine shoreline buildup complexes with evaporites shoreward and marine environments basinward (McCabe, 1959).

During Charles Formation time, the basin became more restricted when evaporites and interbedded limestones and shales were deposited, marking the last stage of regression.

MC-1 Member

In Manitoba, the MC-1 and MC-2 members form the couplet of a minor period of trangression and regression in the Mission Canyon-Charles interval. The MC-1 Member represents the predominantly carbonate portion

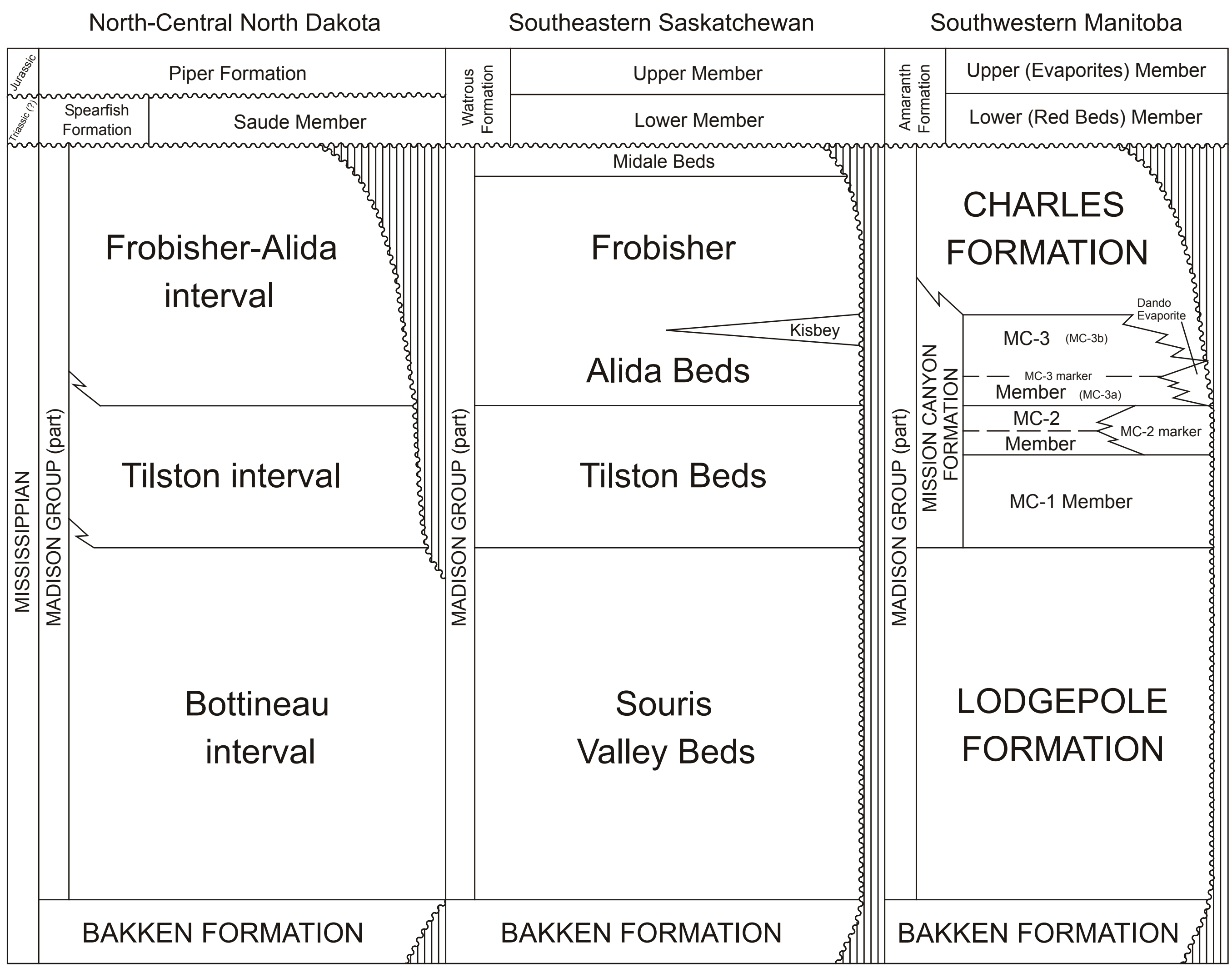


Figure 3: Stratigraphic correlation chart, north-central North Dakota, southwestern Saskatchewan and southwestern Manitoba.

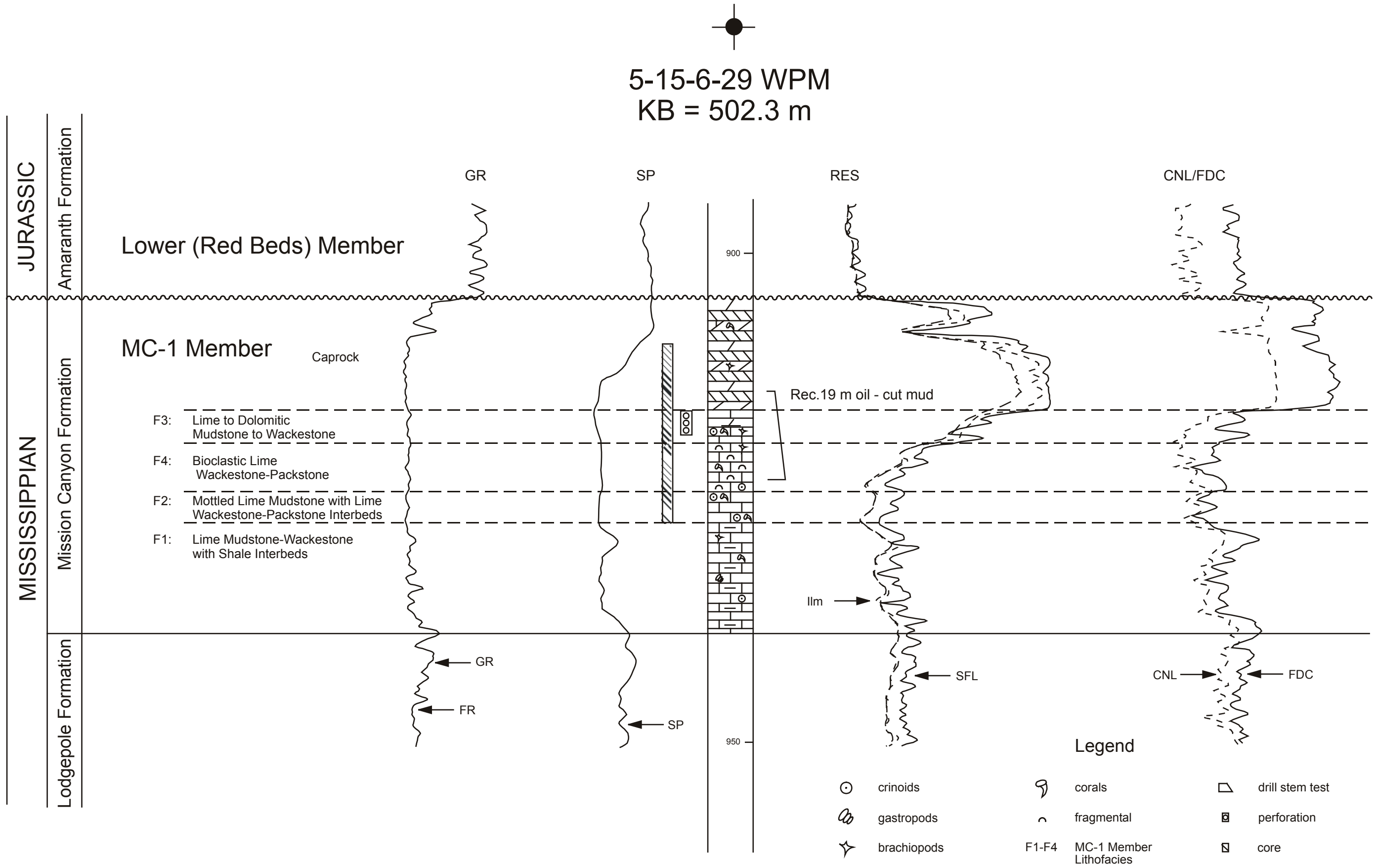


Figure 4: Reference log for the MC-1 Member, Mission Canyon Formation, southwestern Manitoba.

of a minor transgressive-regressive cycle. (Fig. 4; McCabe, 1959).

Eight lithofacies were identified in this study (Table 1). These include: (F1) Lithofacies 1 - Lime Mudstone-Wackestone with Shale Interbeds; (F2) Lithofacies 2 - Mottled Lime Mudstone with Lime Wackestone-Packstone Interbeds; (F3) Lithofacies 3 - Lime to Dolomitic Mudstone to Wackestone; (F4) Lithofacies 4 - Bioclastic Lime Wackestone-Packstone; (F5) Lithofacies 5 - Lime to Dolomitic Mudstone; (F6) Lithofacies 6 - Peloidal Lime Mudstone/Wackestone/Packstone; (F7) Lithofacies 7 - Oolitic Lime to Dolomitic Packstone; (F8) Lithofacies 8 - Interbedded Dolostone and Anhydrite; and the Alteration Zone (Caprock) - Anhydritic Dolostone. The "alteration zone" is not a depositionally related lithology, but rather, a diagenetic feature believed to be related to processes that occurred at the Mississippian erosional surface.

Composite lithofacies descriptions of the MC-1 Member are shown in Table 1. The regional fence diagram in Figure 5 shows the distribution of the various lithofacies of the MC-1 Member over the study area.

The following is a detailed description of the lithofacies of the MC-1 Member based on the data derived from the examination of available cores from 41 wells within the study area. Fifteen thin sections from selected wells were also studied.

The cores were selected based on recovery and location. Lithologic descriptions were based on Dunham's (1962) scheme. A list of available cores and formation tops for the MC-1 Member in southwestern Manitoba is shown in Appendix I. Select core descriptions of wells examined in this study are given in Appendix II.

Lithofacies 1: Lime Mudstone-Wackestone with Shale Interbeds

Lithofacies 1 occurs throughout the study area and represents the lowermost facies of the MC-1 Member. It directly overlies the Lodgepole Formation. The top of the facies coincides with a shaly SP and gamma ray well log response (Fig. 4) that is mappable throughout most of the study area, except along the southeastern erosional edge of the MC-1 Member (Fig. 5).

Lithofacies 1 consists of light brown, microsucrosic, lime mudstone-wackestone grading occasionally to wackestone-packstone, with grey-green calcareous, soft, fissile shale interbeds. The shale interbeds are massive to finely laminated or thinly bedded, have rare brachiopods, and range in thickness from 2 to 20 cm (Fig. 6). The facies is partly bioclastic. Fossils include solitary rugose corals, occasional crinoid stems, rare brachiopods and colonial corals (including *Syringoporid*) and trace gastropods. Occasional stylolitic partings, coated grains, rare chert nodules and disseminated pyrite are present. Anhydrite occurs as cement, fossil replacement and moldic infill, nodules and healing vertical fractures. Calcite and silica cement are also observed. Contact with the underlying Lodgepole Formation is sharp and is marked by occasional faint mottled hematitic staining. Visible pinpoint, intercrystalline and moldic porosity is trace to poor (<5%), grading

Table 1: Lithofacies of the MC-1 Member, Mission Canyon Formation, Southwestern Manitoba.

	Alteration Zone
CAPROCK: ANHYDRITIC DOLOSTONE **Dolostone:** light brown; finely crystalline; massive to mottled; faintly banded in places; crinoid stems, solitary rugose corals, occasional to rare brachiopods; trace colonial corals; occasional tripolitic chert nodules; rare chalky nodules; rare shale breccia near top; no visible porosity; occasional light patchy oil staining. **Anhydrite:** blue-grey to white; massive; occurs as infilling, replacement (in part as trace authigenic overgrowths), blebs, nodules, healing vertical fractures and rare wispy laminations. *Thickness: 0.5 to 9 m; averages 3.8 m*	**Alteration Zone**
OOLITIC LIME TO DOLOMITIC PACKSTONE Light brown; fine to medium crystalline; slightly dolomitic, grading in part to faintly mottled to massive dolostone; rarely laminated; oolitic, often grading from very oolitic to slightly oolitic with increased micrite matrix; occasional brachiopods; open vertical fractures; rare stylolitic partings; slightly chalky; anhydrite as blebs and nodules; calcite and anhydrite cement; poor to good (5-15%) visible interoolitic, vuggy and pinpoint porosity; faint patchy to even oil staining. *Thickness: 0.5 to 7.2 m; averages 3.9 m*	**F7**
PELOIDAL LIME MUDSTONE/WACKESTONE/PACKSTONE Light brown; fine to coarsely crystalline; calcareous to slightly dolomitic; rarely grades to grainstone; <u>peloidal</u>; thinly bedded to laminated; <u>occasional brachiopods, crinoids, solitary rugose corals</u>, rare bryozoans; open and healed vertical fractures; occasional stylolitic partings; anhydrite as blebs, wispy laminations, infill, replacement, and healing vertical fractures; calcite and anhydrite cement; poor to fair (5-10%) visible <u>fenestral</u>, pinpoint, vuggy and moldic porosity; occasional faint patchy oil staining. *Thickness: 0.5 to 8.8 m, averages 3.1 m* ***Secondary Reservoir Facies***	**F6**
LIME TO DOLOMITIC MUDSTONE Light brown; <u>microcrystalline</u>; massive to mottled to laminated; <u>predominantly non-fossiliferous</u>, trace brachiopods; open and anhydrite-healed vertical fractures; occasional stylolitic partings; occasional chalky nodules (2-5 cm) and coated grains; trace disseminated pyrite; anhydrite as wispy laminations, blebs, cement and infill; trace to poor (<5%) visible pinpoint and intercrystalline porosity; rare light patchy oil staining. *Thickness: 0.5 to 11.7 m, averages 3.4 m*	**F5**
BIOCLASTIC LIME WACKESTONE-PACKSTONE Medium to light brown, light grey; fine to medium crystalline; slightly dolomitic in part; occasionally grades to grainstone; occasional faint bedding; rare grey-green shale partings; <u>very fossiliferous</u>, large solitary rugose corals, colonial corals (*Syringoporid*), brachiopods, crinoids and gastropods; open and anhydrite-healed vertical fractures; occasional stylolitic partings; fragmental rare coated grains; occasional dark siliceous nodules (3-4 cm); anhydrite as white blebs and infill; calcite and anhydrite cement; fair to good (12-20%) pinpoint, vuggy, moldic, intercrystalline porosity in thin section; even to patch medium oil staining, often restricted to wackestone intervals. *Thickness: 1.4 to 12.8 m, averages 5.4 m* ***Primary Reservoir Facies***	**F4**
LIME TO DOLOMITIC MUDSTONE TO WACKESTONE Light brown to grey to buff; fine to medium crystalline; slightly dolomitic, grading to dolostone; massive to faintly bedded or <u>laminated to burrow mottled</u> throughout; rare green-grey shale partings; slightly peloidal in part; slightly fragmental; solitary rugose corals, crinoids, <u>occasional to rare brachiopods</u>, rare gastropods, bryozoans, and colonial corals (*Acrocyathus*); open and anhydrite-healed vertical fractures; occasional stylolitic partings; occasional zoned dolomite nodules; occasional light grey banded chert nodules (3-5 cm); rare chalky nodules; anhydrite blebs and nodules throughout; calcite and anhydrite cement; trace to poor (<5%) visible moldic and pinpoint porosity; patchy light oil staining. *Thickness: 0.7 to 13.9 m, averages 4.1 m* ***Primary Reservoir Facies***	**F3**
MOTTLED LIME MUDSTONE WITH LIME WACKESTONE-PACKSTONE INTERBEDS **Mottled Lime Mudstone:** light brown to grey; <u>very fine to finely crystalline</u>; slightly dolomitic; <u>burrow mottled</u>; massive to faintly bedded; rare grey-green shale partings; occasional crinoids; open and anhydrite-healed vertical fractures; occasional stylolitic partings; occasional chalky nodules (3-5 cm); rare coated grains and siliceous nodules; anhydrite as wispy laminations, blebs, infill and replacement; poor pinpoint porosity (<5%); occasional light oil staining. **Lime Wackestone-Packstone:** light brown to grey; <u>medium crystalline</u>; slightly dolomitic in places; rarely grades to grainstone; rarely mottled to occasionally bedded (10-20 cm thick); fragmental, fossils slightly deformed; crinoids, brachiopods, foraminifera, solitary rugose and colonial corals (*Acrocyathus*), rare gastropods and ostracods; occasional coated grains; rare white siliceous zoned nodules (3-7 cm); calcite and anhydrite cement; poor to good (5-20%) visible vuggy, moldic, pinpoint and intercrystalline porosity; medium to heavy patchy oil staining. *Thickness: 0.6 to 11.4 m, averages 4.9 m* ***Secondary Reservoir Facies***	**F2**
LIME MUDSTONE-WACKESTONE WITH SHALE INTERBEDS **Shale**: <u>grey-green</u>; <u>calcareous</u>; soft; <u>fissile</u>; occasionally massive to finely laminated or thinly bedded; 2-20 cm interbeds; rare brachiopods. **Lime Mudstone-Wackestone**: light brown; microsucrosic; occasionally grading to wackestone-packestone in part; bioclastic in part, including <u>solitary rugose corals, occasional crinoids</u>, rare brachiopods, rare colonial corals (*Syringoporid*) and trace gastropods; occasional stylolitic partings; occasional coated grains; rare chert nodules; rare disseminated pyrite; occasional faint hematitic staining; anhydrite as cement, moldic infill, fossil replacement, nodules, and healing vertical fractures; calcite and silica cement; trace to poor (<5%) visible pinpoint, intercrystalline and moldic porosity; rare patchy oil staining. *Thickness: 0.3 to 8.4 m, averages 4.1 m*	**F1**

Lithofacies of Local Occurrence

INTERBEDDED DOLOSTONE AND ANHYDRITE **Anhydrite**: 50% of interval; blue-grey; massive; occurs as blebs, replacement, fracture-fill and thin laminae. **Dolostone**: 50% of interval; light brown; fine to medium crystalline; dense; mottled; rare solitary rugose corals. *Thickness: 0.5 to 2.5 m*	**F8**

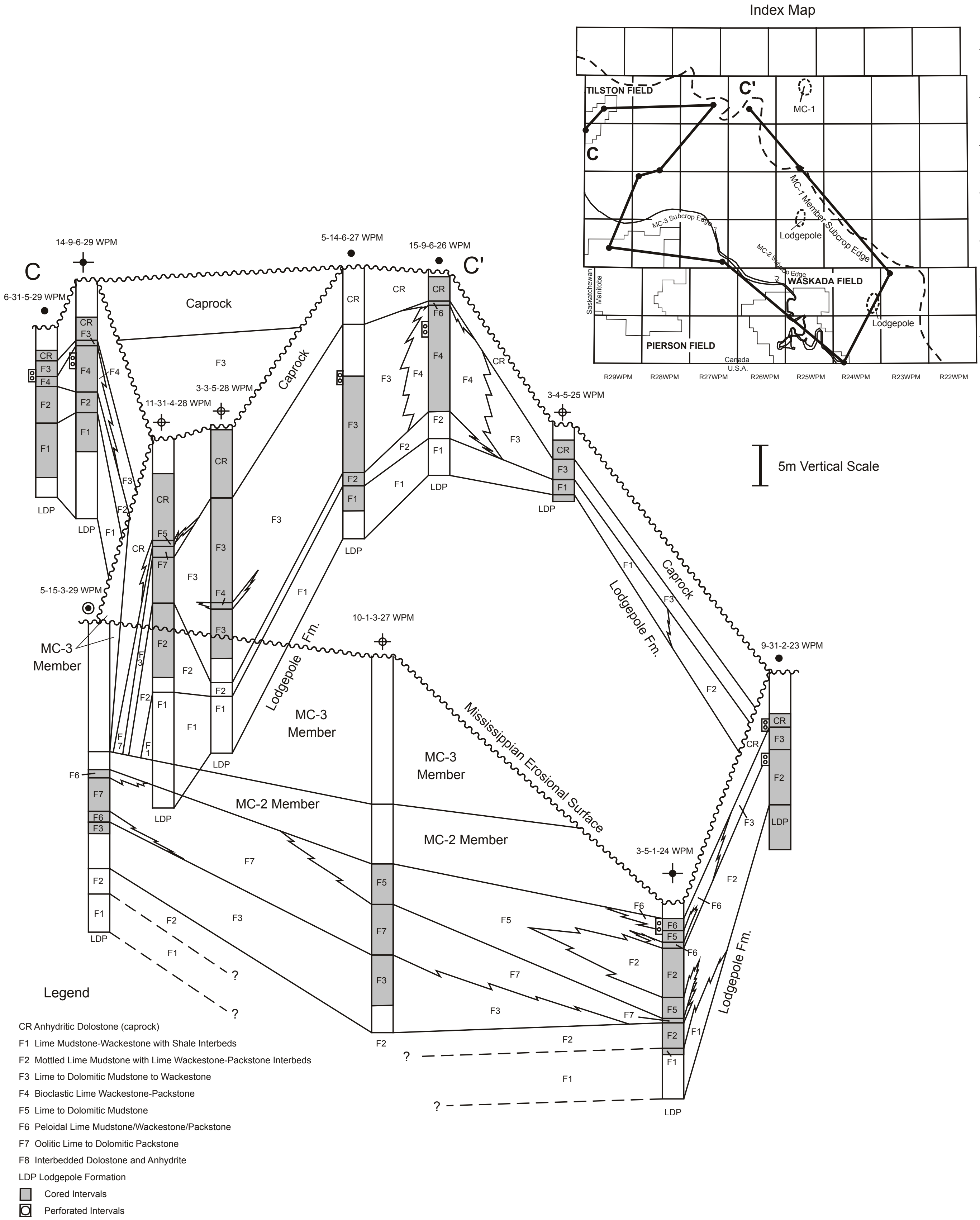


Figure 5: Fence diagram showing the distribution of lithofacies within the MC-1 Member in the study area.

Figure 6: Core photo of Lithofacies 1 showing mudstone with grey-green calcareous shale interbeds. Taken from the well at 6-31-5-29 WPM at a depth of 954.7 m below K.B.

from partly fair to good (10 to 20%) in thin section. Oil staining is rare. Thickness of Lithofacies 1 ranges from 0.3 to 8.4 m and averages 4.1 m.

Lithofacies 1 sedimentation represents the transition from deposition of the deeper-water carbonates of the Lodgepole Formation into the shallow-water, initial regressive phase of the Mission Canyon Formation. The abundance of carbonate muds and the presence of shale interbeds suggests deposition under low energy, subtidal, relatively quiet water conditions, below wave base (Fig. 7).

Lithofacies 2: Mottled Lime Mudstone with Lime Wackestone-Packstone Interbeds

Lithofacies 2 directly overlies Lithofacies 1. It is present throughout most of the study area, except along the erosional edge of the MC-1 Member in Township 5 and Range 25 WPM (Fig. 5). It is considered to be a secondary reservoir facies of the MC-1 Member.

Lithofacies 2 consists of a light brown to grey, very fine to finely crystalline burrow-mottled lime mudstone with medium crystalline, fragmental wackestone-packstone interbeds (Fig. 8). The mudstone is slightly dolomitic in part and massive to faintly bedded, with occasional stylolitic and rare grey-green shale partings. Fossils comprise occasional crinoids that have been infilled and replaced with anhydrite. Occasional chalky and siliceous nodules and rare coated grains are present. Anhydrite occurs as blebs, wispy laminations, and fossil infill and replacement. Vertical open and anhydrite-healed fractures are present. Visible pinpoint porosity is poor (<5%). There is light oil staining in places.

The fragmental lime wackestone-packstone interbeds grade rarely to grainstone. The interbeds are light brown to grey, slightly dolomitic in part, occasionally bedded and rarely faintly mottled. Thickness of the interbeds range from 10 to 20 cm. Fossils mainly include slightly deformed crinoid stems, brachiopods, foraminifera, solitary rugose and colonial corals (including *Acrocyathus*), with rare gastropods and ostracods. Occasional coated grains and rare, white siliceous zoned nodules (3 to 7 cm in diameter) are present. The lithofacies is cemented by calcite and anhydrite. Visible, small vuggy, moldic, pinpoint and intercrystalline porosity is present and ranges from poor to good (5 to 20%). Measured porosity from core analyses of producing wells averages 15.4%; measured permeability averages 8.5 md. Medium to heavy patchy oil staining occurs in the northern extent of the facies.

Thickness of Lithofacies 2 ranges from 0.6 to 11.4 m and averages 4.9 m.

The faunal assemblage, shale partings and burrow mottling indicate that Lithofacies 2 was deposited in a low energy, shallow marine to restricted, protected shelf/lagoonal setting (Fig. 7). Periodic minor fluctuations in sea level, wave action and winnowing of carbonate muds resulted in the deposition of fragmental, skeletal wackestone-packstone interbeds when the water level reached wave base (Lindsay and Roth, 1982).

Lithofacies 3: Lime to Dolomitic Mudstone to Wackestone

Lithofacies 3 is correlative throughout the study area. It overlies Lithofacies 2 in the southern portion of the area and is interfingered with Lithofacies 4 in the northern portion of the study area. It is locally absent south of Township 2 near the MC-1 Member erosional edge, as observed in the well at 3-5-1-24 WPM. In Townships 5 and 6, the facies is believed to have undergone diagenetic alteration at the erosional surface to form the caprock (Fig. 9a, b). The facies is productive and is considered to be a primary productive reservoir facies of the MC-1 Member.

Lithofacies 3 is a light brown to grey to buff, fine to medium crystalline, lime to dolomitic mudstone to wackestone (Fig. 10). It is commonly laminated to burrow mottled throughout, occasionally massive to faintly bedded and slightly fragmental. Fossils consist predominantly of solitary rugose corals and crinoid stems, with occasional to rare brachiopods, and rare colonial corals (including *Acrocyathus*), gastropods and bryozoans. The facies is slightly peloidal in part and contains rare green-grey shale partings. Occasional nodules of zoned dolomite, banded light grey chert nodules and rare chalky nodules are present. Anhydrite occurs as blebs and nodules. Occasional stylolitic partings are present. Open and anhydrite-healed vertical fractures are common. Visible moldic and pinpoint porosity is trace to poor (<5%). Measured porosity from core analysis of productive wells averages 15.9%; measured permeability averages 6.3 md. Light patchy oil staining is common, mainly along the northern portion of the study area. Thickness of the facies ranges from 0.7 to 13.9 m and averages 4.1 m.

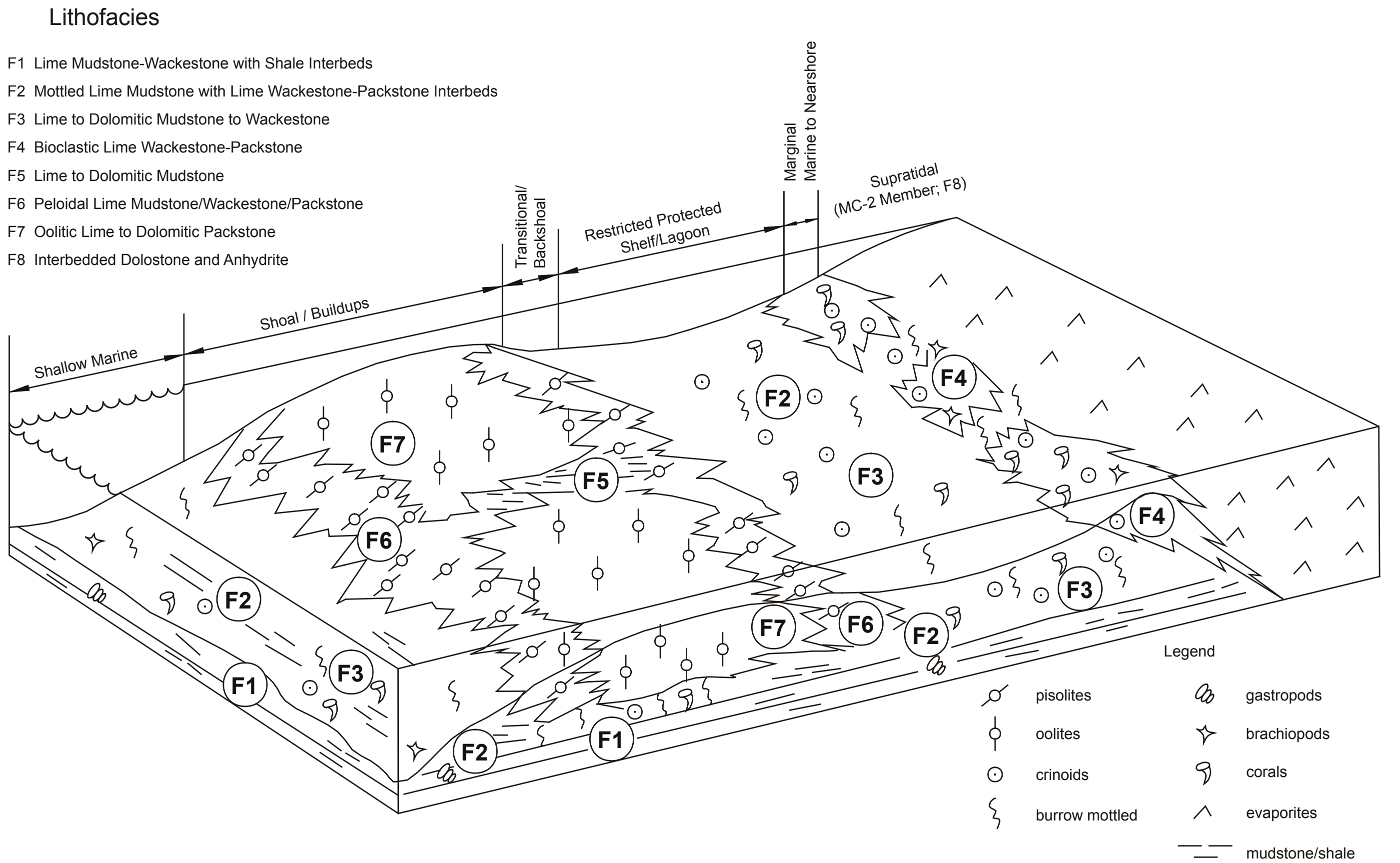


Figure 7: Simplified depositional model of the MC-1 Member, Mission Canyon Formation, southwestern Manitoba.

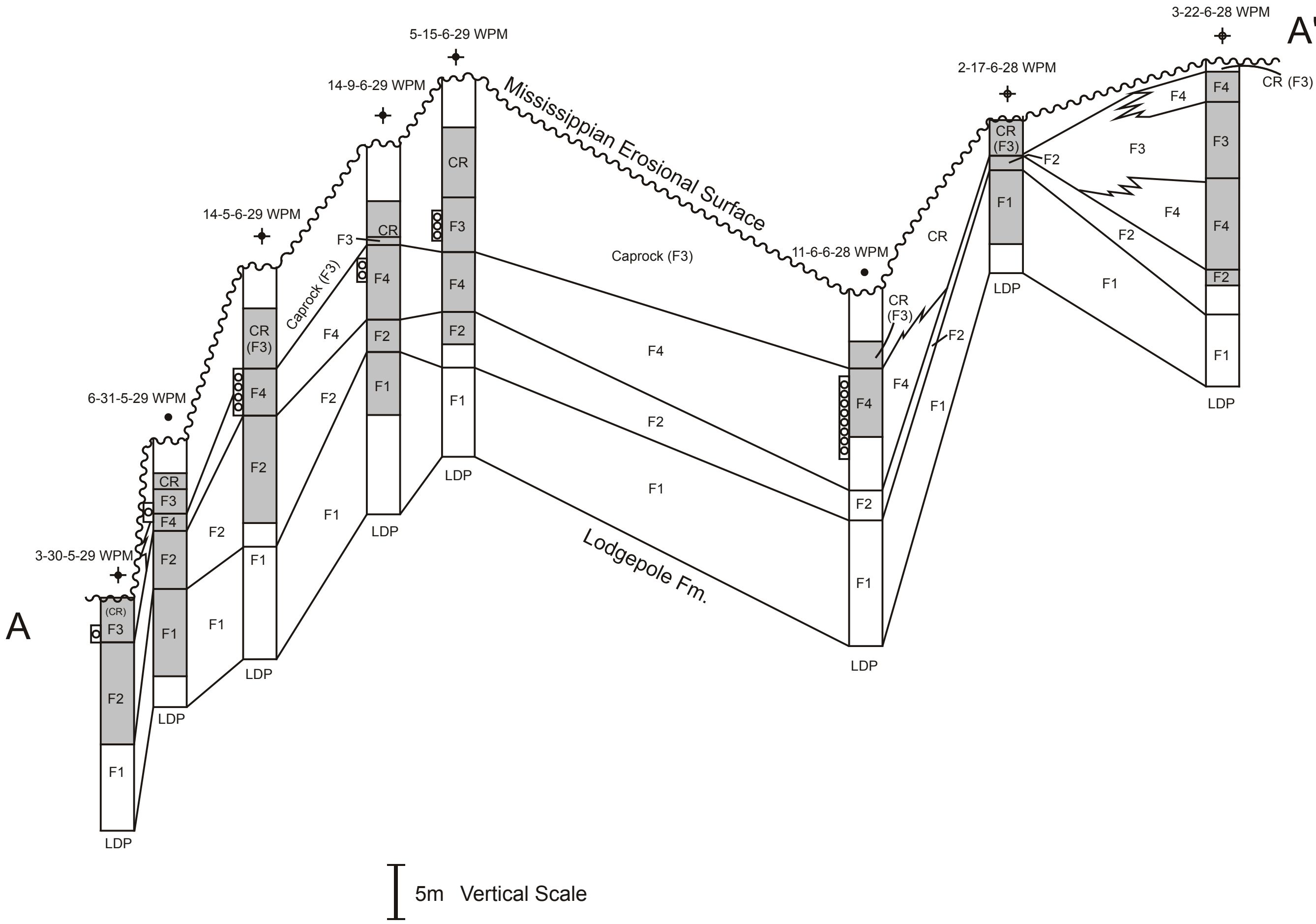
Figure 8: Core photo of Lithofacies 2 showing mudstone with wackestone-packstone interbeds. Fossils within the wackestone-packstone interbeds include brachiopods and crinoid stems. Taken from the well at 11-31-4-28 WPM at a depth of 942.7 m below K.B.

The argillaceous content, burrow mottling, laminated bedding and limited faunal assemblage suggests that Lithofacies 3 was deposited under low energy, shallow marine to restricted, protected shelf/lagoonal conditions (Fig. 7). Dolomitization of peloids has left vague ghost remnants of original pellets.

Lithofacies 4: Bioclastic Lime Wackestone-Packstone

Lithofacies 4 is the most productive primary reservoir facies of the MC-1 Member. It is confined to the northern portion of the study area, north of Township 4. The facies is generally underlain by Lithofacies 2 and is interfingered with Lithofacies 3 (Fig. 5, 9a, b).

Lithofacies 4 consists of medium to light brown to light grey, fine to medium crystalline, bioclastic lime wackestone-packstone that grades occasionally to grainstone. It is slightly dolomitic in part and occasionally faintly bedded. The facies is primarily fossiliferous and includes large, solitary rugose corals, colonial corals (including *Syringoporid*), brachiopods, gastropods and crinoid stems (Fig. 11). Fossil fragments, particularly crinoids, are compacted and slightly deformed. Occasional dark siliceous nodules (3 to 4 cm), stylolites and grey-green shale partings are present, along with rare, fragmented-coated grains. Anhydrite occurs as white blebs, infill and fossil replacement. Open and anhydrite-healed vertical fractures are common. In thin section, pinpoint, vuggy, moldic and intercrystalline porosity development is uneven and patchy, ranging from fair to good (12 to 20%). Calcite and anhydrite cement



Legend

CR Anhydritic Dolostone (caprock)

F1 Lime Mudstone-Wackestone with Shale Interbeds

F2 Mottled Lime Mudstone with Lime Wackestone-Packstone Interbeds

F3 Lime to Dolomitic Mudstone to Wackestone

F4 Bioclastic Lime Wackestone-Packstone

F5 Lime to Dolomitic Mudstone

F6 Peloidal Lime Mudstone/Wackestone/Packstone

F7 Oolitic Lime to Dolomitic Packstone

F8 Interbedded Dolostone and Anhydrite

LDP Lodgepole Formation

Cored Intervals

Perforated Intervals

Index Map

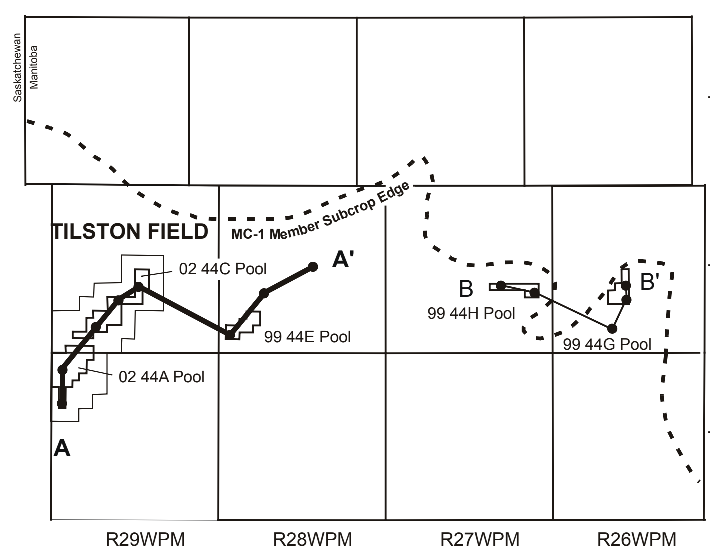
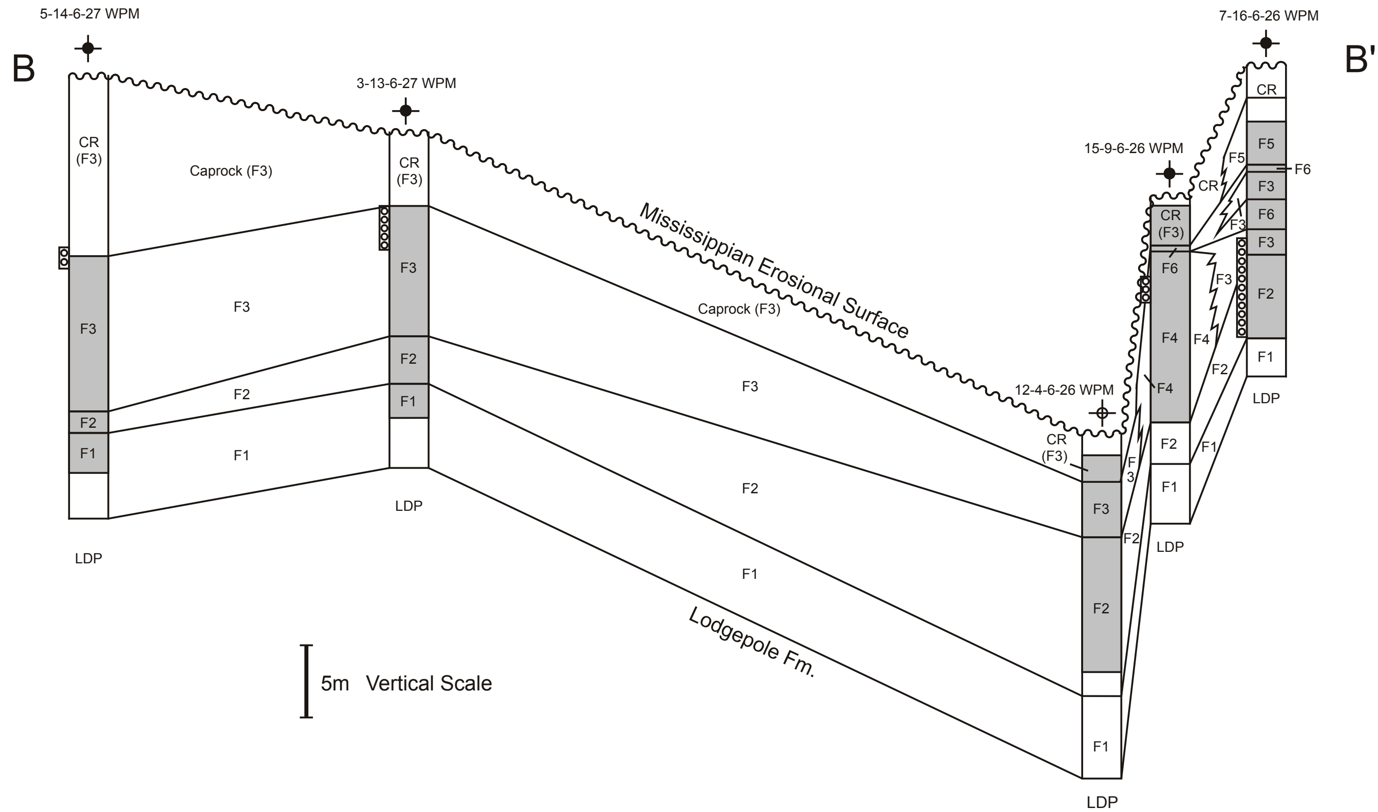


Figure 9a: Fence diagram showing lithofacies distribution in the MC-1 Member in the Tilston area.



Legend

- CR Anhydritic Dolostone (caprock)
- F1 Lime Mudstone-Wackestone with Shale Interbeds
- F2 Mottled Lime Mudstone with Lime Wackestone-Packstone Interbeds
- F3 Lime to Dolomitic Mudstone to Wackestone
- F4 Bioclastic Lime Wackestone-Packstone
- F5 Lime to Dolomitic Mudstone
- F6 Peloidal Lime Mudstone/Wackestone/Packstone
- F7 Oolitic Lime to Dolomitic Packstone
- F8 Interbedded Dolostone and Anhydrite
- LDP Lodgepole Formation
- Cored Intervals
- Perforated Intervals

Index Map

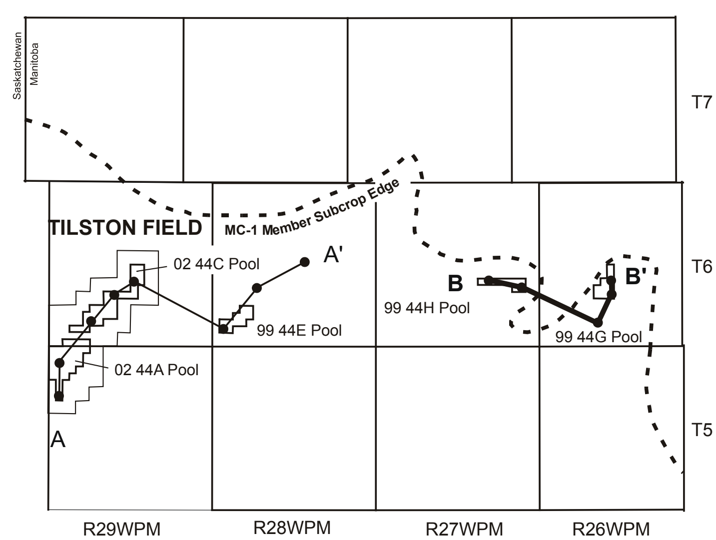


Figure 9b: Fence diagram showing lithofacies distribution in the MC-1 Member in the South Reston-Pipestone area.

Figure 10: Core photo of the faintly bedded mudstone to wackestone characteristic of Lithofacies 3. Solitary rugose corals are scattered throughout. Taken from the well at 9-12-3-28 WPM at a depth of 972.3 m below K.B.

the facies. Measured porosity from core analysis averages 15.7%; permeability averages 14.0 md. Even to patchy medium oil staining is common and often restricted to wackestone intervals. Thickness ranges from 1.4 to 12.8 m and averages 5.4 m.

The abundant faunal content of Lithofacies 4 may be indicative of the reworking and build-up of skeletal material in a marginal marine, nearshore setting (Fig. 7; Lindsay and Roth, 1982). Skeletal grains are typically mud supported, but patches of grainstone suggest winnowing of carbonate muds. The "build-ups" are often interfingered with the protected shelf deposits of Lithofacies 2 and 3.

Lithofacies 5: Lime to Dolomitic Mudstone

Lithofacies 5 is present in the southern portion of the study area, where it is interfingered with Lithofacies 2, 6 and 7 (Fig. 5). Although productive east of the Waskada Field area (Township 1, Range 24 WPM), it is generally considered to be a poor reservoir rock.

Lithofacies 5 consists of a light brown, microcrystalline, lime to dolomitic mudstone (Fig. 12). It is massive, mottled or laminated, and predominantly non-fossiliferous, with trace brachiopods. Occasional chalky nodules (2 to 5 cm), coated grains, stylolitic partings and trace-disseminated pyrite are present. Anhydrite occurs as wispy laminations, blebs, cement and infill. Open and anhydrite-healed vertical fractures are present. Visible pinpoint and intercrystalline porosity is trace to poor (<5%). Measured porosity from core analysis of productive wells averages 17.1%; measured permeability averages 23.3 md. Rare, light patchy oil staining is noted and confined to the southeastern extension of the facies. Thickness of this unit ranges from 0.5 to 11.7 m and averages 3.4 m.

The laminated or mottled nature of Lithofacies 5 suggests deposition in a low energy, sheltered location leeward or between the shoals represented by Lithofacies 6 and 7 (Fig. 7). The lack of faunal material may also suggest deposition under higher than normal salinity conditions.

Lithofacies 6: Peloidal Lime Mudstone/Wackestone/Packstone

Lithofacies 6 is present south of Township 5 along a northwest-southeast trending belt where it is interfingered with Lithofacies 2, 3, 5 and 7 (Fig. 5). It also occurs locally in Township 6, Range 26 WPM. Lithofacies 6 is considered to be a secondary reservoir facies.

Lithofacies 6 consists of a light brown, fine to coarsely crystalline, calcareous to slightly dolomitic, peloidal limestone grading from mudstone to wackestone to packstone (Fig. 13). It is thinly bedded to laminated with occasional stylolitic partings. Fossils include occasional brachiopods, crinoid stems, solitary rugose corals and rare bryozoans. Anhydrite occurs as blebs, wispy laminations, and fossil infill and replacement. Open and anhydrite-healed fractures are present. The lithofacies is cemented by calcite and anhydrite. Visible porosity is poor to fair (5 to 10%) with well-developed fenestral porosity dominating. Other porosity types include

Figure 11: Thin section photograph showing fossiliferous packstone to grainstone of Lithofacies 4 in plane polarized light. Thin section is made with blue epoxy and stained with alizarin red. Fossils include: crinoid ossicles (A), coral fragments (B), and brachiopods (C). Peloids and micritic envelopes are also present (dark patches). Minor calcite and dolomitic cement occur as infill intercrystalline porosity (shown in blue). Taken from well at 15-9-6-26 WPM at a depth of 766.0 m below K.B.

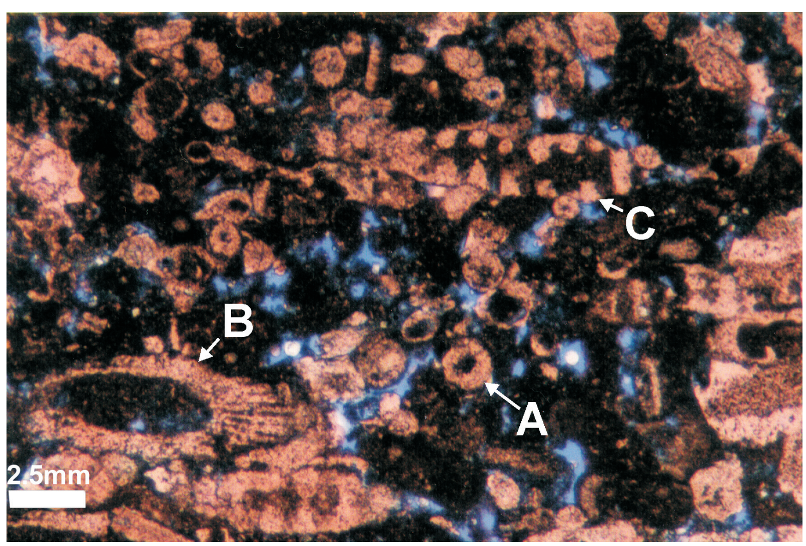


Figure 12: Core photo of Lithofacies 5 showing laminated dolomitic mudstone. Taken from well at 11-31-4-28 WPM at a depth of 931.0 m below K.B.

pinpoint, vuggy and moldic. Measured porosity from core analysis in productive wells averages 13.0%; measured permeability averages 13.5 md. Oil staining is occasional. Thickness ranges from 0.5 to 8.8 m and averages 3.1 m.

The peloidal-rich nature of Lithofacies 6 suggests deposition under low energy, shallow marine to transitional/backshoal conditions (Fig. 7). The facies is often

Figure 13: Core photo of Lithofacies 6 showing peloidal packstone with fenestral porosity; cemented by anhydrite. Taken from the well at 9-12-3-28 WPM at a depth of 959.5 m below K.B.

developed as a shoal flanking deposit associated with Lithofacies 7. It also occurs locally as a small, restricted and sheltered backshoal deposit in Township 6, Range 26 WPM, where it flanks Lithofacies 4.

Lithofacies 7: Oolitic Lime to Dolomitic Packstone

Lithofacies 7 occurs along a northwest-southeast trending belt south of Township 4 (Fig. 5).

It consists of light brown, fine to medium crystalline, slightly chalky, oolitic, limy to dolomitic packstone, grading in part to faintly mottled to massive dolostone. Laminations and stylolitic partings are rare. Fossils include occasional brachiopods. The lithofacies grades upwards in repetitive cycles from slightly oolitic and micritic, to very oolitic with little micritic matrix. Anhydrite occurs as blebs and nodules. Open vertical fractures are occasional. The lithofacies is cemented by calcite and anhydrite. Visible interoolitic, vuggy and pinpoint porosity is poor to good (5 to 15%). Faint even oil staining is noted in wells in Townships 4 and 5. Thickness ranges from 0.5 to 7.2 m and averages 3.9 m.

The oolitic packstones of Lithofacies 7 are indicative of sedimentation under conditions of higher energy, shallower water and higher than normal salinity. The graded bedding within Lithofacies 7 suggests periodic small-scale fluctuation and variation in energy conditions. The facies is deposited in association with Lithofacies 6 to form shoals or build-up complexes. Low energy, shallow marine and restricted, protected shelf/lagoonal deposits of Lithofacies 2 and 3 fringe these complexes (Fig. 7).

Lithofacies 8: Interbedded Dolostone and Anhydrite

Lithofacies 8 is a locally occurring facies identified in two of the wells examined in the study area (1-20-5-27 WPM and 13-17-4-26 WPM). The facies consists of 50% blue-grey anhydrite and 50% light brown dolostone. The anhydrite occurs as massive, blebs, thin laminae, replacement, and fracture-fill. The dolostone is light brown, fine to medium crystalline, dense and mottled with rare solitary rugose corals. Thickness of the lithofacies ranges from 0.5 to 2.5 m.

Lithofacies 8 is believed to represent a localized period of shallow-water restriction and resultant evaporite deposition.

Alteration Zone (Caprock): Anhydritic Dolostone

The caprock is a diagenetic feature associated with the Mississippian erosional surface and is present where the MC-1 Member subcrops. It acts as a top seal in producing areas, except at Pierson Field, where the MC-2 Member overlies the MC-1 Member. The alteration zone (caprock) consists of dense, blue-grey to white anhydrite that occurs in varying amounts, and light brown, finely crystalline dolostone. Occasional tripolitic chert nodules and rare chalky nodules are also present. It is massive to mottled and faintly banded in part. The top of the zone is rarely marked by a shale breccia. The dolostone contains fossils that are generally replaced by extensive anhydritization and dolomitization and include crinoid stems, solitary rugose corals, occasional to rare brachiopods and trace colonial corals. It displays no visible porosity and has occasional light, patchy oil staining. The anhydrite occurs as infill, replacement (in part as trace authigenic overgrowths), blebs, nodules, wispy laminations and healing vertical fractures. Thickness of the alteration zone ranges from 0.5 to 10 m and averages 3.8 m.

Dolomitization and anhydritization is believed to be related to the downward percolation of magnesium-rich and later, calcium-rich waters during the deposition of the overlying Jurassic Lower Amaranth (Red Beds) Formation, resulting in the alteration of the underlying Mississippian MC-1 Member limestones (McCabe, 1963).

ISOPACH

The distribution of the MC-1 Member throughout the study area is shown in Figure 14. The isopach shows a deposition pattern related to Williston Basin sedimentation, reflecting the decrease in the rate of subsidence and overall period of regression during Mission Canyon time. The MC-1 Member trends generally in an arcuate pattern, thinning from the southwest to the northeast (Fig. 14).

The MC-1 Member reaches a maximum thickness of 55 m in the southwestern corner of the province and averages 28 m in thickness. It thins generally to the northeast, towards the MC-1 Member erosional edge. Localized thins occur in Township 1, Range 28 WPM and Township 2, Range 26 WPM. In Township 2, Range 24 WPM and Townships 3 to 4, Range 25 WPM, local erosion has completely removed the MC-1 Member. In Township 6, Range 25 WPM, a small, erosional remnant or outlier of MC-1 Member is preserved.

The complex pattern of isopach thicks and thins at Waskada Field and immediately northward of the field

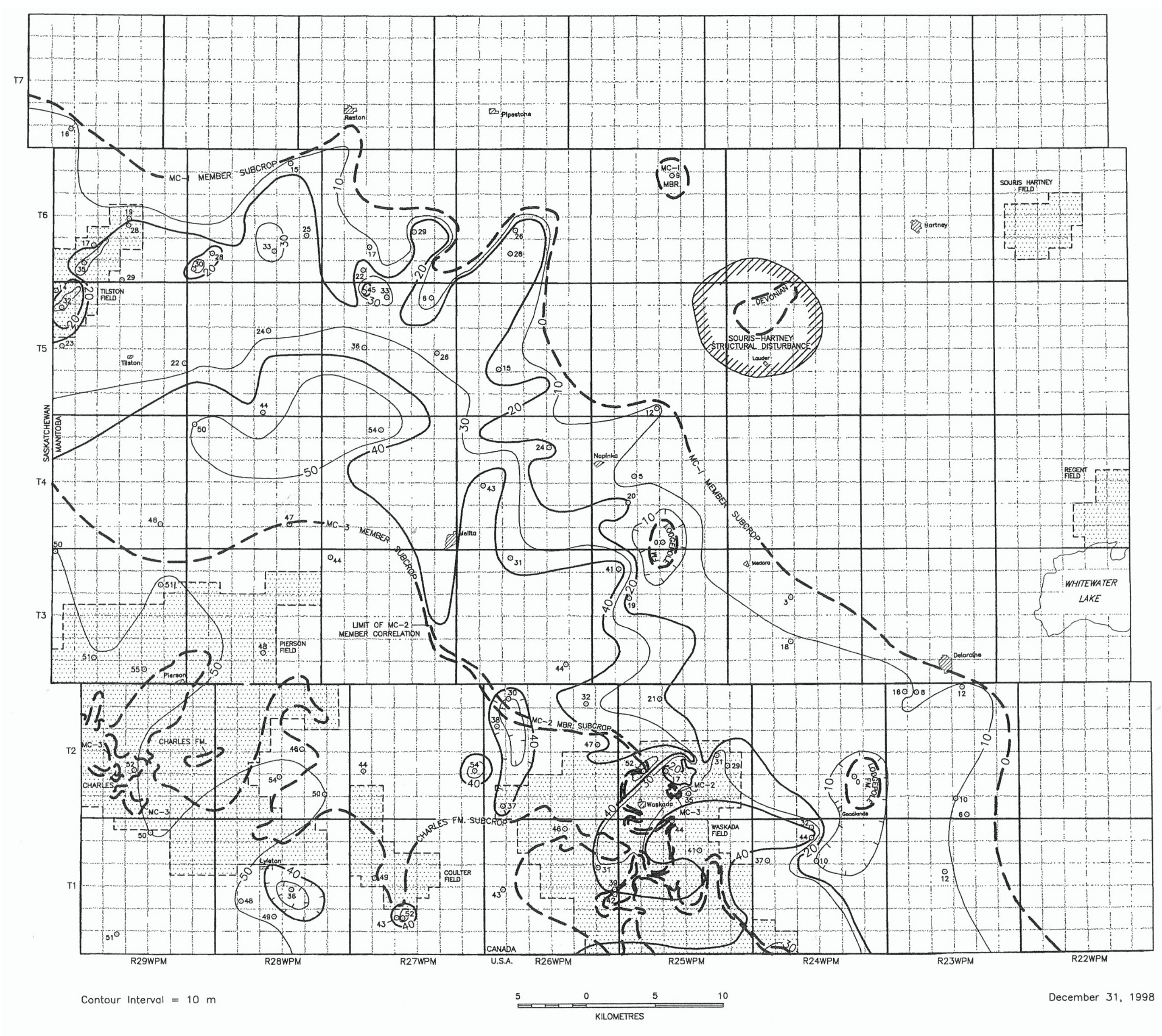


Figure 14: Isopach map of the Mission Canyon Formation, MC-1 Member, southwestern Manitoba.

are believed to be related to the multiple stage dissolution and collapse of the underlying Devonian Prairie Formation salt during MC-1 Member deposition.

STRUCTURE

In southwestern Manitoba, structure on the MC-1 Member and underlying Lodgepole Formation is fairly regular and follows the regional Paleozoic tilt to the southwest (Fig. 15, 16). Several features depart from the regional pattern. The Waskada Field (Townships 1 and 2; Ranges 25 and 26 WPM) is an area of complex structural anomalies. These anomalies may be a direct or indirect result of salt dissolution resulting from minor tectonic movement along the southern extension of the boundary zone between the Churchill and Superior provinces (termed the Birdtail-Waskada Axis). The axis coincides with the present solution edge of the Devonian Prairie Formation salt section. The structures have been important in controlling the accumulation of oil in Manitoba. The majority of southwestern Manitoba's oil reserves in Mississippian and Jurassic age strata are pooled in traps along the Birdtail-Waskada Axis (Fox *et al.*, 1999; Rodgers, 1986; McCabe, 1959, 1963, 1978).

Other notable features include the structural and "paleotopographic" highs on the MC-1 Member surface. Several of these features are coincident with structural expressions on the underlying Lodgepole Formation. A structural nose on the MC-1 Member extends along Range 27 WPM from Township 4 south to Township 1. It is coincident with a similar feature on the underlying Lodgepole Formation (Fig. 15, 16) and may also be related to movement along the Birdtail-Waskada Axis.

Several "paleotopographic highs" are observed on the top of the MC-1 Member beyond the subcrop edge of the MC-2 Member. These "highs" are most notable along or near the MC-1 Member erosional edge and are, in several areas, coincident with structural expressions on the underlying Lodgepole Formation. This is evidenced at Tilston Field (Townships 5 and 6; Range 29 WPM). A

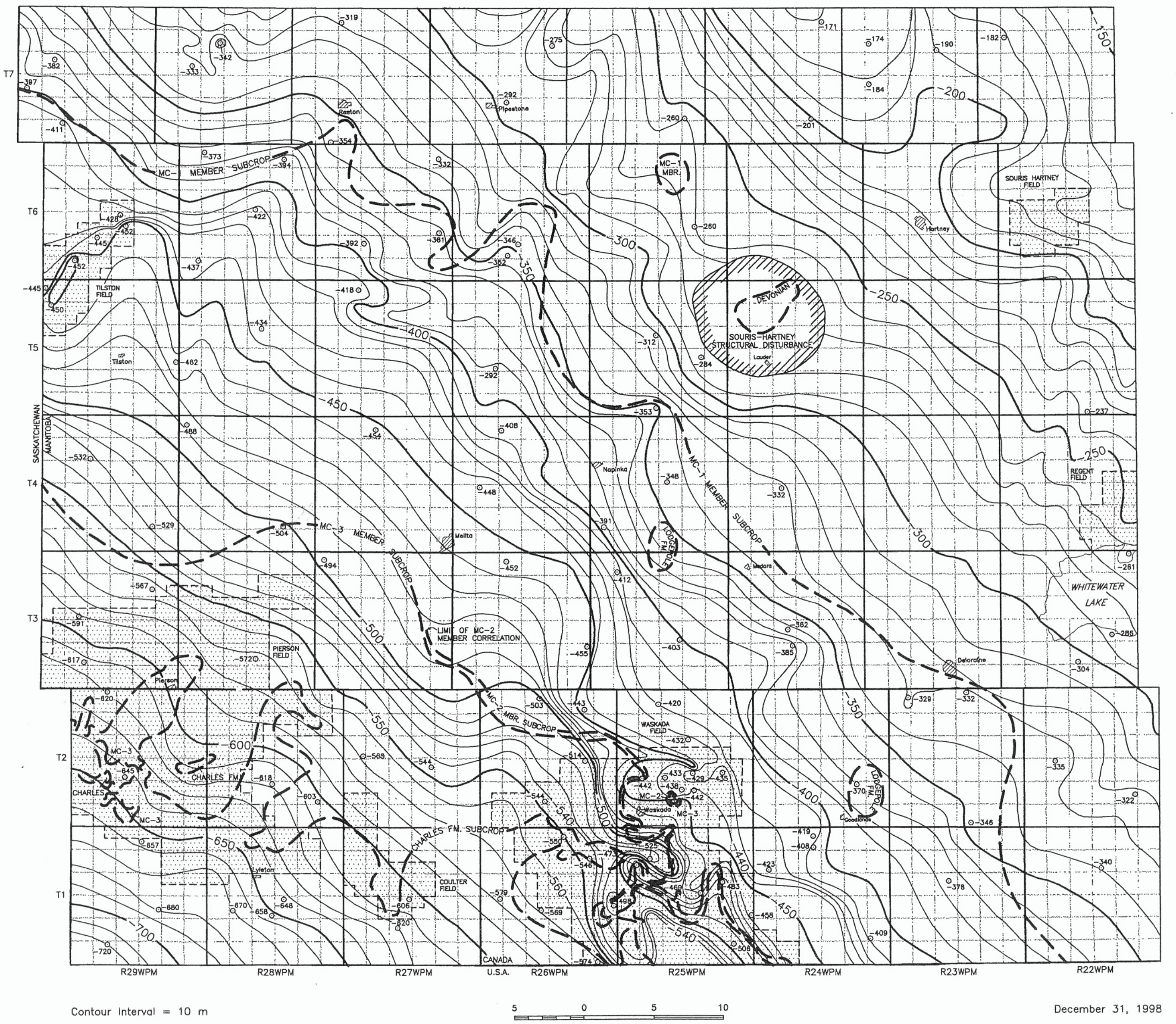


Figure 15: Structure on top of the Lodgepole Formation, southwestern Manitoba.

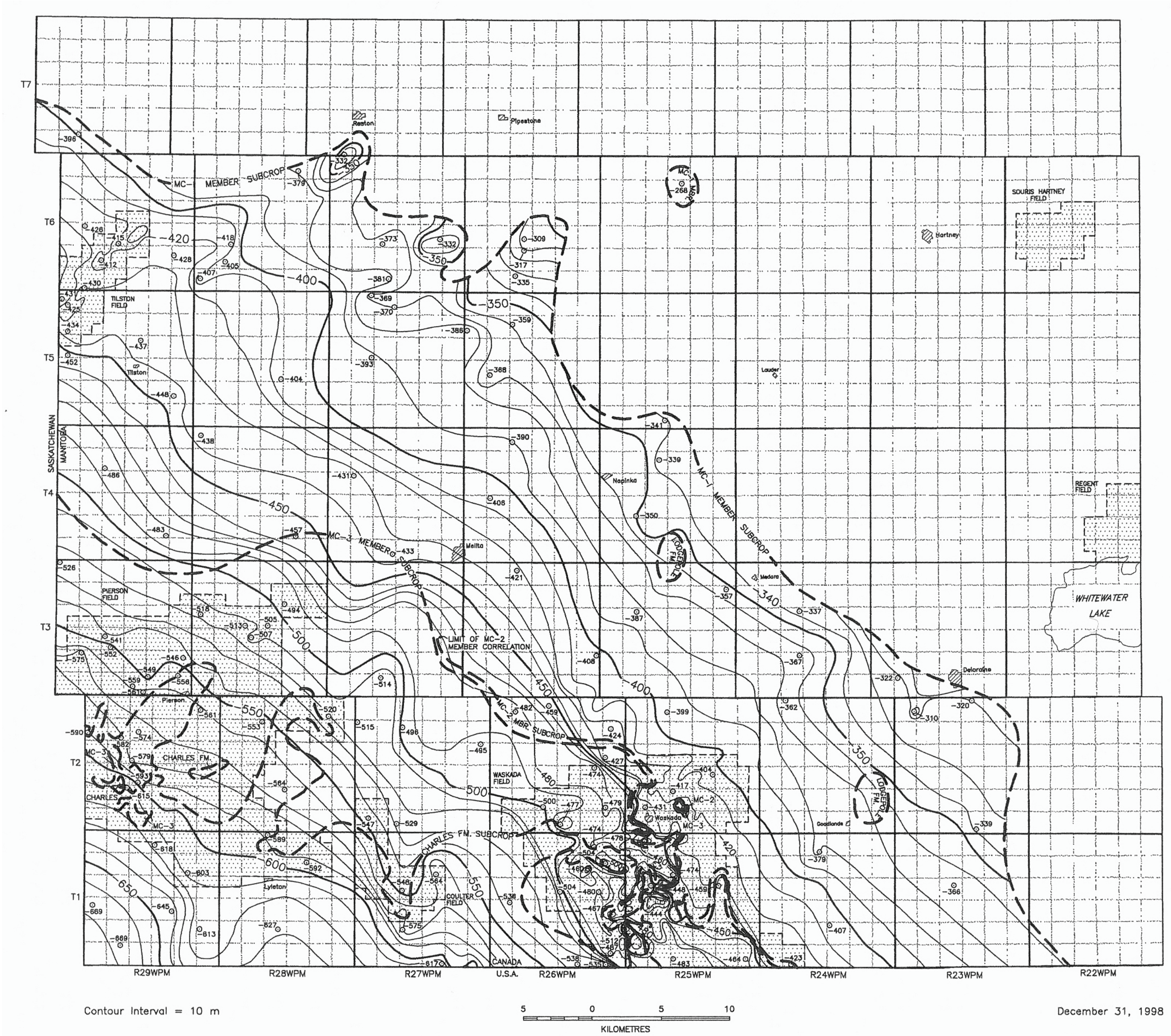


Figure 16: Structure on top of the Mission Canyon Formation, MC-1 Member, southwestern Manitoba.

southwest-plunging structural nose on top of the Lodgepole Formation at Tilston Field is also reflected on the overlying top of the MC-1 Member (Fig. 15, 16). The structural expression observed on top of the MC-1 Member at the Tilston MC-1 C and MC-1 A pools predate deposition on the overlying Jurassic Lower Amaranth (Red Beds) Formation. Localized thickening of the MC-1 Member is present at both pools (Fig. 14).

At the Other Areas MC-1 E Pool east of Tilston Field (Township 6, Range 28 WPM), a southwest-plunging structural nose on the top of the Lodgepole Formation and corresponding structure on the overlying MC-1 Member are also observed. The structure corresponds with the thickening of the MC-1 Member (Fig. 14, 15, 16). This structure is not reflected at the Jurassic Lower Amaranth (Red Beds) Formation surface, suggesting that, as in the Tilston area, structural deformation predated deposition of the Lower Amaranth Formation.

"Paleotopographic highs" on the MC-1 Member are also observed at the Other Areas MC-1 G and H Pools in the Pipestone area (Township 6, Ranges 26 and 27 WPM). Over 8 m of structural closure on the MC-1 Member is seen at the Other Areas MC-1 G Pool. These "highs" are associated with structural lows on the Lodgepole Formation and corresponding thickening of the MC-1 Member. It is suggested that these features represent the erosional remnants of the MC-1 Member deposited in erosional lows on the underlying Lodgepole Formation. A similar feature is also observed north of Pipestone, in Township 6, Range 27 WPM, where a structural low on the Lodgepole Formation is coincident with 18 m of structural closure on the overlying MC-1 Member (Fig. 15, 16).

A southwest-plunging structural nose on the Lodgepole Formation observed at the Other Areas MC-1 A Pool in the Deloraine area (Township 2; Range 23 WPM) corresponds to a structural nose on the overlying MC-1 Member and MC-1 isopach thin

(Fig. 14, 15, 16). The structural feature on the MC-1 Member is interpreted to be post-Mission Canyon Formation in age, resulting from the deposition and subsequent erosion of the MC-1 Member over a pre-existing Lodgepole "high".

RESERVOIR CHARACTERISTICS

Reservoir Description

Oil shows are recognized in all lithofacies identified in the study area, except within Lithofacies 8. This suggests that hydrocarbons migrated throughout most of the MC-1 Member, however, not all lithofacies within the MC-1 Member are productive or display reservoir potential. Two main productive reservoir facies are identified as primary reservoir facies in the study area; Lithofacies 3 (Lime to Dolomitic Mudstone to Wackestone) and Lithofacies 4 (Bioclastic Lime Wackestone-Packstone). Lithofacies 3 is present throughout most of the study area, while Lithofacies 4 is limited to the northern portion of the study area. Porosity and permeability within these lithofacies are variable and controlled primarily by lithofacies type and by secondary diagenesis. Reservoir potential also exists in Lithofacies 6 (Peloidal Lime Mudstone/Wackestone/Packstone) and Lithofacies 2 (Mottled Lime Mudstone with Lime Wackestone-Packstone Interbeds).

Micritization and the secondary diagenetic effects of cementation and dolomitization affect reservoir quality. Primary depositional fabric, particularly the content of micrite matrix, is a major factor in the determination of reservoir quality and potential of lithofacies within the study area. In lithofacies identified as primary and secondary reservoirs, higher micritic content was generally noted in non-producing wells, than in their producing equivalents.

Cementation is also a factor in reservoir development. In the non-reservoir facies, Lithofacies 1 and 7, porosity is occluded by extensive, early cementation by calcite, which occurs as overgrowths, and later cementation by blocky anhydrite and silica.

Selective and localized dolomitization is evident in the lithofacies identified in the study area. This has both enhanced and reduced porosity and permeability within the primary Lithofacies 3 and 4 and secondary reservoir Lithofacies 2 and 6.

The bioclastic lime wackestone-packstones of primary reservoir Lithofacies 4 are found along a belt in Townships 5 and 6, Ranges 26 to 29 WPM and are interpreted to have been deposited in a marginal marine, nearshore environment (Fig. 7). Lithofacies 4 generally displays good original skeletal porosity and permeability that may have been enhanced to a minor extent, by a later stage of dolomitization. The facies is less productive in the off-flank areas of skeletal "build-up" where the facies is interfingered with Lithofacies 2 and 3, and selective dolomitization and increased micritization has occluded porosity and permeability (Fig. 17).

Primary reservoir Lithofacies 3 and secondary reservoir Lithofacies 2 occur throughout most of the study area, however, are only productive along the MC-1 Member subcrop edge within "paleotopographic highs" (Fig. 5). These lithofacies are believed to have been deposited in a restricted, protected shelf/lagoonal environment. In general, the lime mudstones to wackestones of Lithofacies 3 are productive where dolomitization has enhanced porosity and permeability. There appears to be at least 3 stages of cementation and dolomitization within reservoir Lithofacies 3; an initial cementation stage (syn-depositional), a second, porosity/permeability enhancing dolomitization stage (post-depositional) and a third, dolomitization and anhydritization, post-Mississippian erosional stage forming the "caprock" (post-Jurassic Lower Amaranth (Red Beds) Formation deposition). Porosity and permeability within Lithofacies 2 is best developed in the more grainy, lime wackestone-packstone interbeds, than in the mudstone interbeds of the facies.

The peloidal lime mudstone/wackestone/packstone of secondary reservoir Lithofacies 6 is present along a belt covering Townships 1 to 3, Ranges 24 to 29 WPM (Fig. 5). It is interpreted to have been deposited in a transitional/backshoal setting as a shoal flanking deposit associated with the oolitic lime to dolomitic packstones of Lithofacies 7. Fenestral porosity within Lithofacies 6 is localized and interfingered with Lithofacies 7 and the

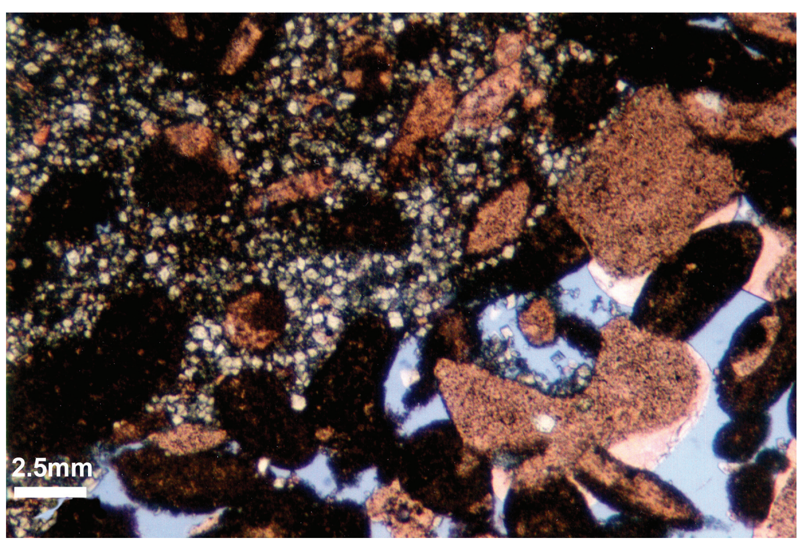


Figure 17: Thin section photograph in plane polarized light showing selective dolomitization in a wackestone-packstone interbed of Lithofacies 2. Thin section is made with blue epoxy and is stained with alizarin red. Porosity and permeability is occluded by the development of small dolomite rhombohedrons. Syntaxial calcite overgrowths occur on peloids and crinoid fragments, also contributing to porosity reduction. Taken from well at 5-30-5-26 WPM at a depth of 2743 ft. (836.1 m) below K.B.

more impermeable lime mudstones of Lithofacies 5. The primary porosity and permeability of Lithofacies 6 appears generally to have been occluded by a later stage of dolomitization and anhydritization. This later stage of secondary diagenesis also appears to have greatly reduced the porosity and permeability of the oolitic lime to dolomitic packstones of non-reservoir Lithofacies 7.

Minor secondary reservoir potential also exists locally within Lithofacies 5 in Townships 1 to 3, Ranges 24 WPM, where the mudstone facies has been dolomitized and porosity and permeability has been enhanced.

Trapping Mechanisms

Regional oil entrapment within the MC-1 Member in southwestern Manitoba is attributed to a combination of controlling factors which have been identified within the study area. These include:

(1) Primary lithostratigraphic factors
  - regional reservoir facies distribution and variation

(2) Stratigraphic factors
  - truncation of the MC-1 Member at the Mississippian erosional surface within "paleotopographic highs"

(3) Variation in reservoir quality
  - diagenetic influences; porosity and permeability variation

(4) Salt dissolution/collapse features
  - dissolution of Devonian Prairie Evaporite salt

(5) Distribution of caprock ("alteration zone")

The majority of MC-1 Member oil production is trapped stratigraphically. Trapping is controlled by the regional distribution of reservoir facies and variations in reservoir quality, porosity and permeability. Structure also plays a minor role in oil entrapment. Throughout the study area, the MC-1 Member has been anhydritized and dolomitized near the Paleozoic erosion surface to form a caprock ("alteration zone"). The thickness of this caprock is related to the overall thickness of the overlying Jurassic Lower Amaranth (Red Beds) Formation, which acts as a secondary seal to the reservoir. Generally, the caprock and the overlying Lower Amaranth (Red Beds) thicken off the flanks of Mississippian erosional "highs" ("paleotopographic highs").

Oil is trapped within primary lithostratigraphic-truncation type traps at Tilston and East Tilston. The pools at Tilston and East Tilston are developed on minor structures on the underlying Lodgepole Formation in association with localized thickening of the MC-1 Member. At Tilston Field, Lithofacies 3 and 4 are trapped stratigraphically within a "paleotopographic high" at the Mississippian erosion surface. Lithofacies 4, the primary reservoir, is thicker and better developed in the northeastern portion of the field within the MC-1 C Pool . It thins towards the MC-1 A Pool at the southwestern end of the field. Lithofacies 3 is believed to have been partially anhydritized and dolomitized at the Mississippian erosion surface to form an impermeable "alteration zone" that acts as caprock.

Entrapment is similar at East Tilston (Township 6, Range 28 WPM), where oil is trapped stratigraphically within a "paleotopographic high" in combination with a lateral pinchout of Lithofacies 4 into the less porous and permeable Lithofacies 3. The "alteration zone" caps the pool (Fig. 18, in pocket).

Stratigraphic-diagenetic trapping is believed to be the major factor in oil accumulation at Reston-Pipestone. The pools are coincident with MC-1 Member isopach thicks deposited within erosional lows on the underlying Lodgepole Formation. Oil is trapped within "paleotopographic highs" along the MC-1 Member subcrop edge and are capped by the "alteration zone" (Fig. 19, in pocket). Porosity and permeability of reservoirs within these pools has been locally enhanced by dolomitization. At the Other Areas MC-1 G Pool (Township 6, Range 26 WPM), Lithofacies 4 is the dominant reservoir, where present. Towards the MC-1 Member subcrop edge within this pool, where porosity and permeability has been locally enhanced, Lithofacies 2 and 3 are the secondary reservoirs. Within the Other Areas MC-1 H Pool (Township 6, Range 27 WPM), only Lithofacies 3 is present and is productive.

In the Deloraine area (Township 2, Range 23 WPM), oil entrapment is related to the updip truncation of the lime wackestone-packstone interbeds of Lithofacies 2 and the dolomitic mudstone to wackestones of Lithofacies 3, in association with an overall thinning of the MC-1 Member. Oil is trapped within a "paleotopographic high" on the Mississippian erosional surface and is capped by the "alteration zone".

The MC-1 Pools at the Waskada Field area are controlled by a combination of stratigraphic-structural trapping related to the multistage salt dissolution and collapse of the underlying Devonian Prairie Formation. The reservoir facies is primarily restricted to Lithofacies 6 (Rodgers, 1986).

Source Beds and Migration

Production from the Mission Canyon Formation is derived from the Lodgepole-Family C oil-source system. Family C oils are considered to be sourced from bituminous carbonates within the Mississippian Lodgepole Formation (Osadetz *et al*., 1992; Osadetz and Snowden, 1995). These oils are characterized by long distance, lateral migration from the centre of the Williston Basin, and area of thermal maturity. Large reserves of Family C oils in Manitoba indicate the excellent hydraulic characteristics of the northeast flank of the basin.

The MC-1 Member subcrop edge extends northwestward into Saskatchewan, and southeastward into North Dakota. Several oil pools have developed along the subcrop edge in Saskatchewan, such as the Parkman Field. Production in Saskatchewan along this trend is from both the Upper Souris Valley Beds and the Tilston Beds. Reservoir potential exists within the correlative Tilston Interval in North Dakota along the subcrop edge, however, there is no current production (Christensen *et al*., 1994).

Reservoir Rock and Fluid Properties

Twenty MC-1 Member pools have been discovered in Manitoba. In this study, seven of the largest non-abandoned MC-1 Member pools are reviewed in detail. The seven pools account for 90% of cumulative MC-1 Member production and 92% of MC-1 Member recoverable reserves. The pools are located along the MC-1 Member subcrop edge between Deloraine in Township 2, Range 23 WPM and Tilston in Township 6, Range 29 WPM (Fig. 2). The reservoir rock and fluid properties for the seven pools are listed in Table 2.

The pools range from 64.8 to 340.2 ha in size. The productive areas are generally limited updip by facies changes and downdip by an oil/water contact. The two largest pools are located in the Tilston Field, which accounts for 79.6% of current and 72.7% of cumulative MC-1 Member production.

Original oil-in-place (OOIP) estimates for the pools have been determined volumetrically using wellbore parameters. In some of the newly discovered pools, the Other Areas MC-1 E, G and H pools, there is limited vertical well control. Companies have used 3D seismic to delineate pool boundaries and horizontal wells to develop the pools. The lack of well control has impacted on the accuracy of the volumetric oil-in-place estimates.

Net pay for the pools was determined from core and logs using the following net pay cut-offs: permeability - 1 md; porosity - 9% (with some variation between pools); and water saturation - 60%. The average pool net pay ranges from 5.2 to 10.3 m. There was a wide variation in porosity within the productive facies in the pools examined. Average pool porosity ranges from 14.1 to 17.5%, with intervals of higher porosity, in excess of 25%, encountered in most wells.

The average water saturation in the pools examined ranged from 36.2 to 46.6%. The salinity of the produced water from the pools is between 47 860 and 72 802 mg/l (total dissolved solids), with the exception of the Other Areas MC-1 A Pool where the salinity is between 134 500 to 162 724 mg/l. The total dissolved solids in the A Pool may be a function of the thinning effects of overlying Jurassic Lower Amaranth (Red Beds) Formation and downward percolation of Jurassic Upper Amaranth (Evaporite) Formation dissolved salts.

Relative permeability data available for a number of the MC-1 Member pools examined reveals a wide variation in the irreducible water saturation (Swi) both within and between pools (Tundra Oil and Gas, 1993, 1996; Rigel Oil and Gas, 1998). Figure 20 is a plot of the variation in Swi as a function of core permeability for the various samples analyzed. In the Other Areas MC-1 G Pool, a range of samples of different rock types and characteristics such as grain size and texture were analyzed. The Swi for the samples varied dramatically with permeability, from 6.7% to 77.1%, as illustrated in Figure 20. Swi for the Tilston MC-1 C Pool and Other Areas MC-1 A Pool, determined from core stacks, was 23.1% and 29.7%, respectively. From the Swi versus core permeability plot, Swi equals 56% at 1 md, which corresponds well with the net pay cut-offs used in this study.

The density of crude oil from the pools examined

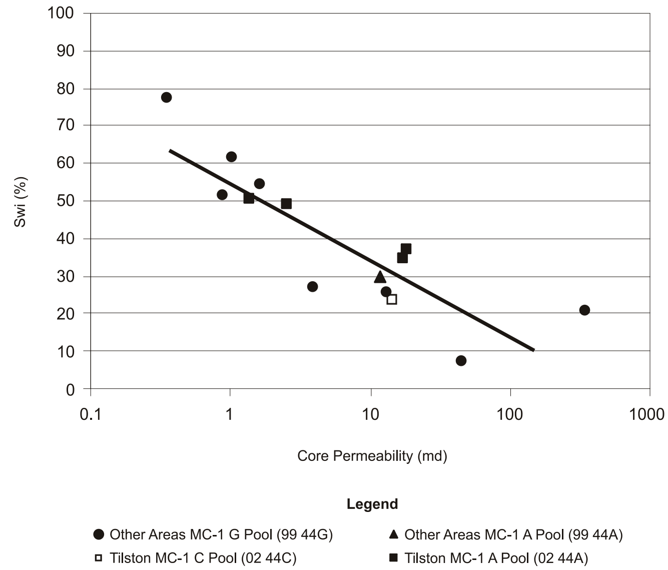


Figure 20: Irreducible water saturation of MC-1 Member pools, southwestern Manitoba.

varies from 25.2 to 35.4° API. No pressure-volume-temperature (PVT) data is available for the MC-1 Member pools in Manitoba. A formation volume factor of 1.05 m^3/m^3 was therefore used for the MC-1 Member based on PVT analysis from the Lodgepole Formation which has crude oil of similar properties to that of the MC-1 Member.

Original oil-in-place determined for the seven pools ranges from 286.2 to 1591.6 10^3m^3 and totalled 5487.8 10^3m^3. The average hydrocarbon pore volume ranges from 0.44 to 0.9 m^3/m^2, which equates to oil-in-place ranging from 71.2 to 145.8 $10^3/m^3$ per legal subdivision (16.2 ha). The largest pools are the Tilston MC-1 A and C Pools with oil-in-place of 1591.6 and 1054.1 10^3m^3, respectively. The other MC-1 Member pools examined may prove to contain considerably more oil-in-place than currently estimated, when completely developed.

MC-1 Member Production and Reserves

In December 1998, there were 31 MC-1 Member wells producing from eight oil pools in southwestern Manitoba. Average daily oil production from the MC-1 Member in December 1998 was 121.1 m^3/d, representing approximately 7.3% of the province's daily oil production. Cumulative MC-1 Member oil production to December 31, 1998 was 413.2 10^3m^3. Table 3 lists the MC-1 Member pools in Manitoba, their pool status, average daily oil production, cumulative oil production, and oil reserves as of December 31, 1998.

The MC-1 Member discovery well in Manitoba was drilled in 1952 at 5-32-5-29 WPM in the Tilston Field. Figure 21 shows a historical plot of MC-1 Member production versus time, highlighting significant events. Between 1952 and 1981, only four MC-1 Member pools were discovered. During this period, the Tilston MC-1 A Pool accounted for over 90% of MC-1 Member oil production. Between 1981 and 1985, nine MC-1 Member pools were discovered. In October 1984, MC-1 Member

Table 2: Reservoir Rock and Fluid Properties of the MC-1 Member, Mission Canyon Formation, Southwestern Manitoba.

Pool (Field/Pool Code)	Area (ha)	Net Pay (m)	Porosity (%)	Water Saturation (%)	Shrinkage (m^3/m^3)	Original Oil-in-Place (10^3 m^3)	Average Well Depth (m)	Initial Reservoir Pressure (kPa)	Oil Density (°API)	Water Salinity (TDS) (mg/l)
Tilston MC-1 A Pool (02 44A)	340.2	6.5	14.1	46.4	0.952	1591.6	945	9260	32.9 to 33.8	64 490 to 72 802
Tilston MC-1 C (South) Pool (02 44C)	211.0	6.0	16.1	45.7	0.952	1054.1	936	8900	35.4	63 764
Tilston MC-1 D (North) Pool (02 44D)[1]	64.8	5.9	16.9	44.6	0.952	338.0	912	8835	35.4	63 764
Other Areas MC-1 A Pool (99 44A)	64.8	5.2	16.8	46.6	0.952	286.2	825	8058	34.4 to 37.0	134 500 to 162 724
Other Areas MC-1 E Pool (99 44E)	72.1	5.8	17.5	36.2	0.952	444.7	906	8746	30.6	
Other Areas MC-1 G Pool (99 44G)	119.2	9.4	15.8	42.8	0.952	961.3	760	7814	25.2 to 32.1	47 860 to 55 519
Other Areas MC-1 H Pool (99 44H)	90.6	10.3	16.4	44.3	0.952	811.8	793	7824	27.3	62 070 to 65 900
					Total OOIP	5487.8				

[1] Formerly part of the Tilston MC-1 C Pool (02 44C). Now the Tilston MC-1 D Pool (02 44D). Also referred to as the "North Pool" in this study.

Table 3: Pool Production and Reserves of the MC-1 Member, Mission Canyon Formation, Southwestern Manitoba.

Pool (Field/Pool Code)	Discovery Year	No. of Active Wells	Daily Production (Dec-98) Oil (m^3)	Daily Production (Dec-98) WOR (m^3/m^3)	Cumulative Oil Production[1] ($10^3/m^3$)	Pool Status	Proved Developed[1] Reserves (10^3m^3)	Remaining Proved[1] Reserves (10^3m^3)	Recovery Factor Current[1] (%)	Recovery Factor Ultimate (%)
Tilston MC-1 A Pool (02 44A)	1952	10	5.3	13.8	120.0	Active	128.9	8.9	7.5	8.1
Tilston MC-1 C (South) Pool (02 44C)	1983	9	52.7	9.2	156.3	Active	201.0	44.7	14.8	19.1
Tilston MC-1 D (North) Pool (02 44D)[2]	1984	4	38.4	1.5	37.3	Active	57.3	20.0	11.0	17.0
Waskada MC-1 A Pool (03 44A)	1956	0	0.0	0.0	1.9	Abandoned	1.9	0.0		
Waskada MC-1 B Pool (03 44B)	1952	0	0.0	0.0	16.0	Abandoned	16.0	0.0		
Waskada MC-1 C Pool (03 44C)	1968	0	0.0	0.0	1.4	Abandoned	1.4	0.0		
Waskada MC-1 D Pool (03 44D)	1982	1	1.0	9.7	10.4	Active	10.7	0.3		
Waskada MC-1 E Pool (03 44E)	1982	0	0.0	0.0	1.5	Inactive	1.5	0.0		
Waskada MC-1 F Pool (03 44F)	1983	0	0.0	0.0	0.2	Abandoned	0.2	0.0		
Waskada MC-1 G Pool (03 44G)	1982	0	0.0	0.0	3.7	Abandoned	3.7	0.0		
Waskada MC-1 H Pool (03 44H)	1985	0	0.0	0.0	0.0	Abandoned	0.0	0.0		
Waskada MC-1 I Pool (03 44I)	1990	0	0.0	0.0	0.2	Inactive	0.2	0.0		
Pierson MC-1 A Pool (07 44A)	1984	0	0.0	0.0	0.1	Abandoned	0.1	0.0		
Other Areas MC-1 A Pool (99 44A)	1981	2	1.9	48.4	16.6	Active	20.2	3.6	5.8	7.1
Other Areas MC-1 B Pool (99 44B)	1965	0	0.0	0.0	6.0	Active	6.1	0.1		
Other Areas MC-1 D Pool (99 44D)	1985	0	0.0	0.0	0.4	Abandoned	0.4	0.0		
Other Areas MC-1 E Pool (99 44E)	1994	1	0.7	19.0	9.0	Active	9.5	0.5	2.0	2.1
Other Areas MC-1 F Pool (99 44F)	1996	0	0.0	0.0	0.5	Inactive	0.5	0.0		
Other Areas MC-1 G Pool (99 44G)	1996	2	7.0	1.0	15.8	Active	19.7	3.9	1.6	2.0
Other Areas MC-1 H Pool (99 44G)	1996	2	14.1	0.6	15.9	Active	24.3	8.4	2.0	3.0
Total		31	121.1	6.1	413.2		503.6	90.4		

[1] Production and reserves to December 31, 1998

[2] Formerly part of the Tilston MC-1 C Pool (02 44C). Now the Tilston MC-1D Pool (02 44D). Also referred to as the "North Pool" in this study.

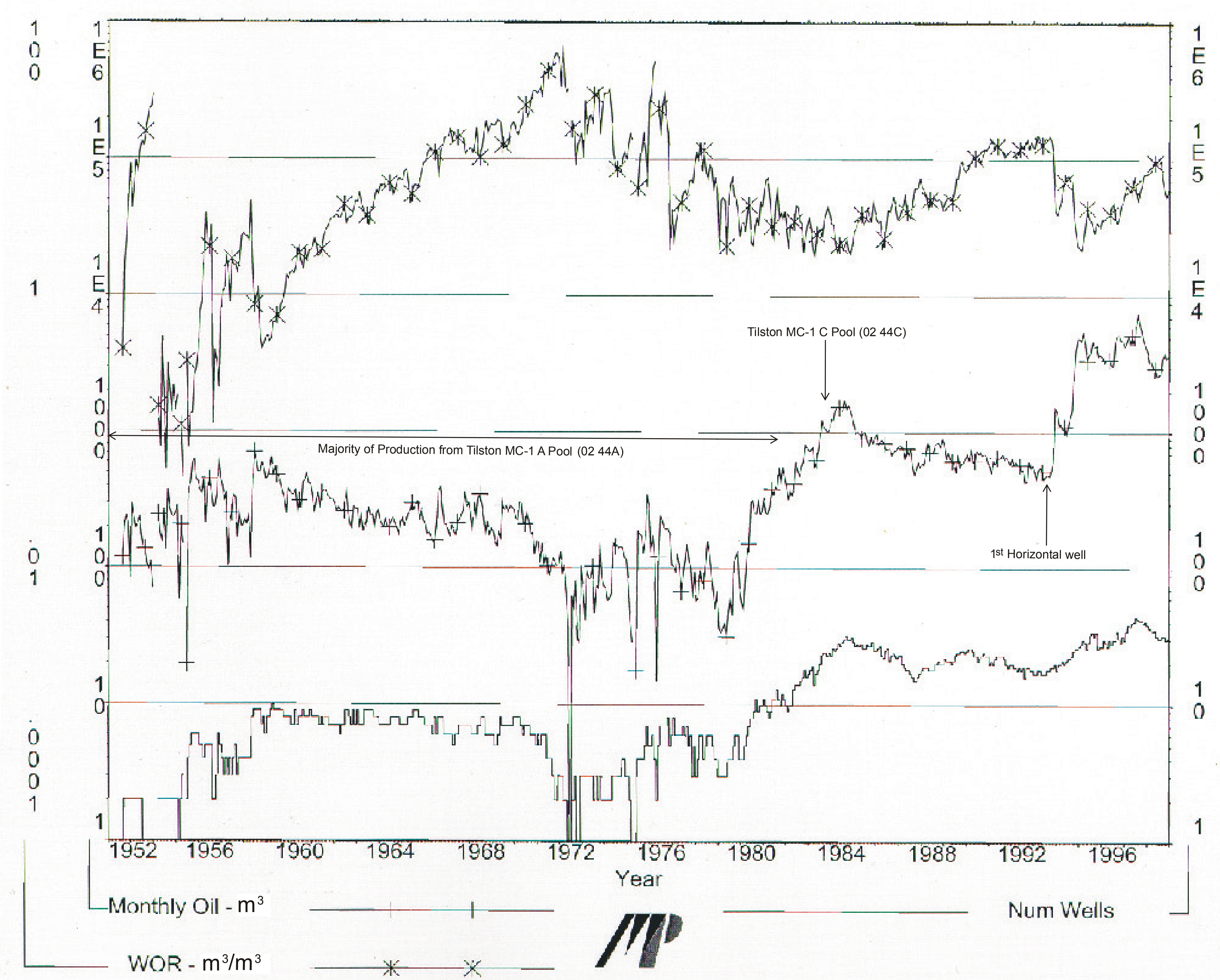


Figure 21: Production history of MC-1 Member pools, southwestern Manitoba.

oil production peaked to 1583 m^3/month. The key discovery during this period was the Tilston MC-1 C Pool, the most prolific MC-1 Member pool in Manitoba. Since 1985, another six MC-1 Member pools have been discovered, which has increased MC-1 Member oil production dramatically. In August 1997, MC-1 Member oil production peaked at 7492 m^3/month with 43 wells on production. Since then, MC-1 Member production has declined by 57%, due in part to the high initial decline rates associated with horizontal wells and to the low oil prices experienced during 1998.

The most significant development with respect to MC-1 Member production was horizontal drilling. The first horizontal well in the MC-1 Member was drilled in the Tilston MC-1 C Pool in late 1993. In December 1998, 17 horizontal producers accounted for over 90% of MC-1 Member oil production. In five years, horizontal wells have produced 190.6 10^3m^3 of oil from the MC-1 Member, almost 50% of the cumulative oil production. In December 1998, horizontal wells produced at an average rate of 6.5 m^3/d of oil, 9.3 times the average vertical well rate.

Normalized production plots were generated to compare the performance of vertical and horizontal MC-1 Member oil producers (Fig. 22). The plot shows the average horizontal well has an initial (first year) production rate of 15.9 m^3/d of oil, compared to 2.6 m^3/d for the average vertical well. The average horizontal well recovers 20 300 m^3 of oil, compared to 8500 m^3 of oil for a vertical well. Despite an initial decline rate of 50% per year, the average horizontal well recovers 8500 m^3 in 20 months, compared to 15 years for the average vertical well.

The seven pools examined in this study have strong water drives and are subject to water coning which is exacerbated by vertical fracturing. In pools where there is some pressure history, there has been negligible pressure depletion. Initial reservoir pressures vary with pool depth and range from 7814 to 9260 kPa (Table 2). In order to maximize recovery from MC-1 Member pools, operators must be able to economically handle large volumes of water.

Table 3 shows the proved developed and remaining proved reserves for all MC-1 Member pools as of December 31, 1998. The proved developed reserves are 503.6 10^3m^3 of oil, 92% of which are in the seven pools reviewed in this study. Remaining proved MC-1 Member oil reserves total 90.4 10^3m^3 and represent approximately 2.2% of the province's remaining oil reserves.

In the pools examined, the ultimate recovery factor ranges from 2.0% OOIP to 19.1% OOIP. Individual well recoveries vary substantially within the pools, with wells located near the crest of the structure exhibiting higher recoveries. The pools in the Tilston Field have the highest estimated recoveries, 8.1 to 19.1% OOIP, reflecting their maturity and intensive development. In addition to vertical well development on 16 ha spacing, the Tilston pools have been drilled horizontally down to a closer interwell spacing. In the case of the C Pool, the horizontal interwell spacing is 80 m. On the other hand, the newly discovered Other Areas MC-1 E, G and H Pools have low ultimate recoveries, 2.0 to 3.0% OOIP. These low recoveries are indicative of the early stage of pool development. Additional development drilling, where economically feasible, will increase pool recovery.

Waterflood core studies (Tundra Oil and Gas, 1993, 1996) have been conducted in the Tilston MC-1 C Pool and Other Areas MC-1 A Pool. Based on initial and end-point oil saturations (C Pool – So_r = 27.1% and A Pool – So_r = 36.8%), the pools had a waterflood

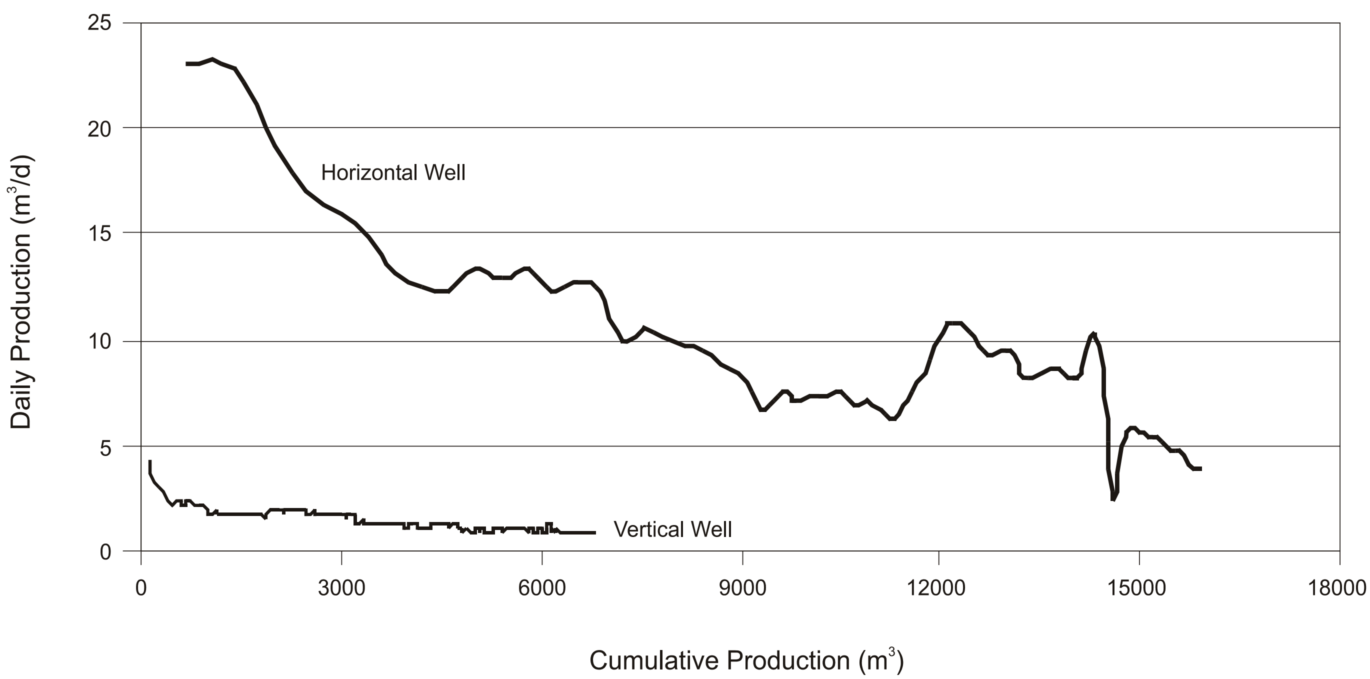


Figure 22: Comparison of vertical and horizontal well performance, MC-1 Member, southwestern Manitoba.

displacement efficiency of 47.7 to 64.8% OOIP. Waterflooding has not been attempted in any of the Tilston pools in Manitoba, although water disposal into the MC-1 Member in the Tilston MC-1 A Pool appears to have had a beneficial impact on recovery at offsetting wells.

MC-1 Member Individual Pool Review

The following is a review of seven MC-1 Member pools in the study area; the Tilston MC-1 A and C Pools and the Other Areas A, E, G and H Pools. For the purpose of this study, the Tilston MC-1 C Pool has been divided into the South Pool (C Pool) and North Pool (unofficially designated D Pool).

Rock and reservoir fluid properties for the pools are listed in Table 2 and production and reserves data is listed in Table 3.

Tilston MC-1 A Pool (02 44A)

The Tilston MC-1 A Pool was discovered in 1952 with the drilling of the well at 5-32-5-29 WPM (Fig. 23). The pool is located adjacent to the Manitoba-Saskatchewan border. It was developed in three phases. Between 1952 and 1958, 11 producers were drilled. From 1979 to 1984, another 12 producers were drilled including 4 re-drills, extending the pool southward into Section 30, Township 5, Range 29 WPM. From 1994 to 1995, two vertical wells and four horizontal wells were drilled.

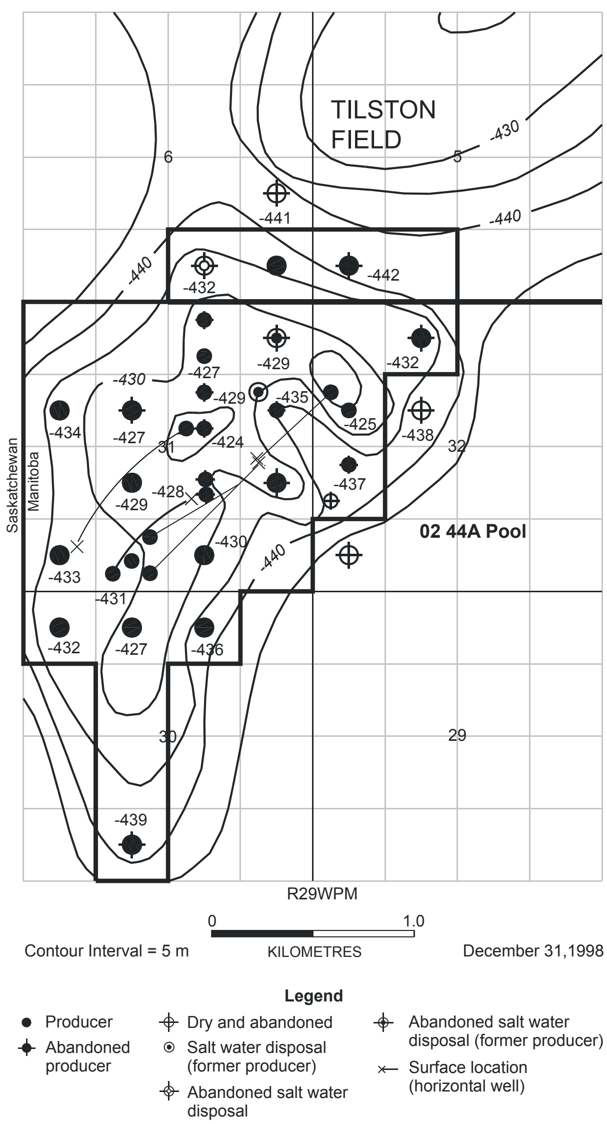


Figure 23: Structure on top of the MC-1 Member porosity, Tilston MC-1 A Pool (02 44A), southwestern Manitoba.

In December 1998, there were six vertical and four horizontal wells producing from the pool and an additonal four wells were shut-in. Oil production from the pool averaged 5.3 m^3/d at a water-oil ratio (WOR) of 13.8 m^3/m^3. Cumulative oil production from the A Pool to December 31, 1998 was 120.0 10^3m^3, with the majority of production from wells in the east-half of Section 31, Township 5, Range 29 WPM. These wells are located near the crest of the pool (Fig. 23) and appear to have benefited from water disposal into the MC-1 Member at 9-31-5-29 WPM and 16-31-5-29 WPM.

The estimated OOIP in the A Pool is 1591.6 10^3m^3. The pool is subject to a strong water drive, which has been augmented by water disposal into the producing zone. The limited reservoir pressure data for the pool shows a 3.7% decline in reservoir pressure from a discovery pressure of 9260 kPa in 1952, to 8916 kPa in 1994. The estimated current and ultimate recovery factors for the pool are 7.5% and 8.1% OOIP, respectively. Ultimate and remaining recoverable oil reserves as of December 31, 1998 are 128.9 10^3m^3 and 8.9 10^3m^3, respectively.

Four horizontal wells have been drilled in the A Pool. A review of sample descriptions for the wells indicate the horizontal sections were drilled in Lithofacies 2, 3 and 4 and encountered good to excellent reservoir within each facies. Production from the horizontal wells is characterized by high water-cuts (95% in December 1998) and correspondingly low oil rates. Two of the four horizontal wells lost circulation during drilling and may have encountered large open fractures. Packers were set in these wells, isolating the intervals of lost circulation. Despite initial oil production rates in excess of 20 m^3/d, the horizontal wells are only estimated to recover 4500 m^3 of oil on average. Poor horizontal well performance may also be attributed to the higher oil recovery in the areas where the wells were drilled; horizontal wells were drilled in an area where the original vertical wells had recovered an average of 12.5% OOIP or 8867.8 m^3/well of oil.

Tilston MC-1 C Pool (02 44C)

The Tilston MC-1 C Pool was discovered in 1983 with the drilling of the well at 12-9-6-29 WPM, 0.4 km north of the A Pool. Geological and engineering evidence in this study indicates that the C Pool should be divided into two separate pools, which for the purpose of this study will be referred to as the North Pool (D Pool) and South Pool (C Pool) as shown in Figure 24. The North and South pools have distinctly different oil/water contacts and are separated by a dry hole at 2-16-6-29 WPM. The oil/water in the North Pool is at -420.6 m subsea, almost 10 m higher than the oil/water

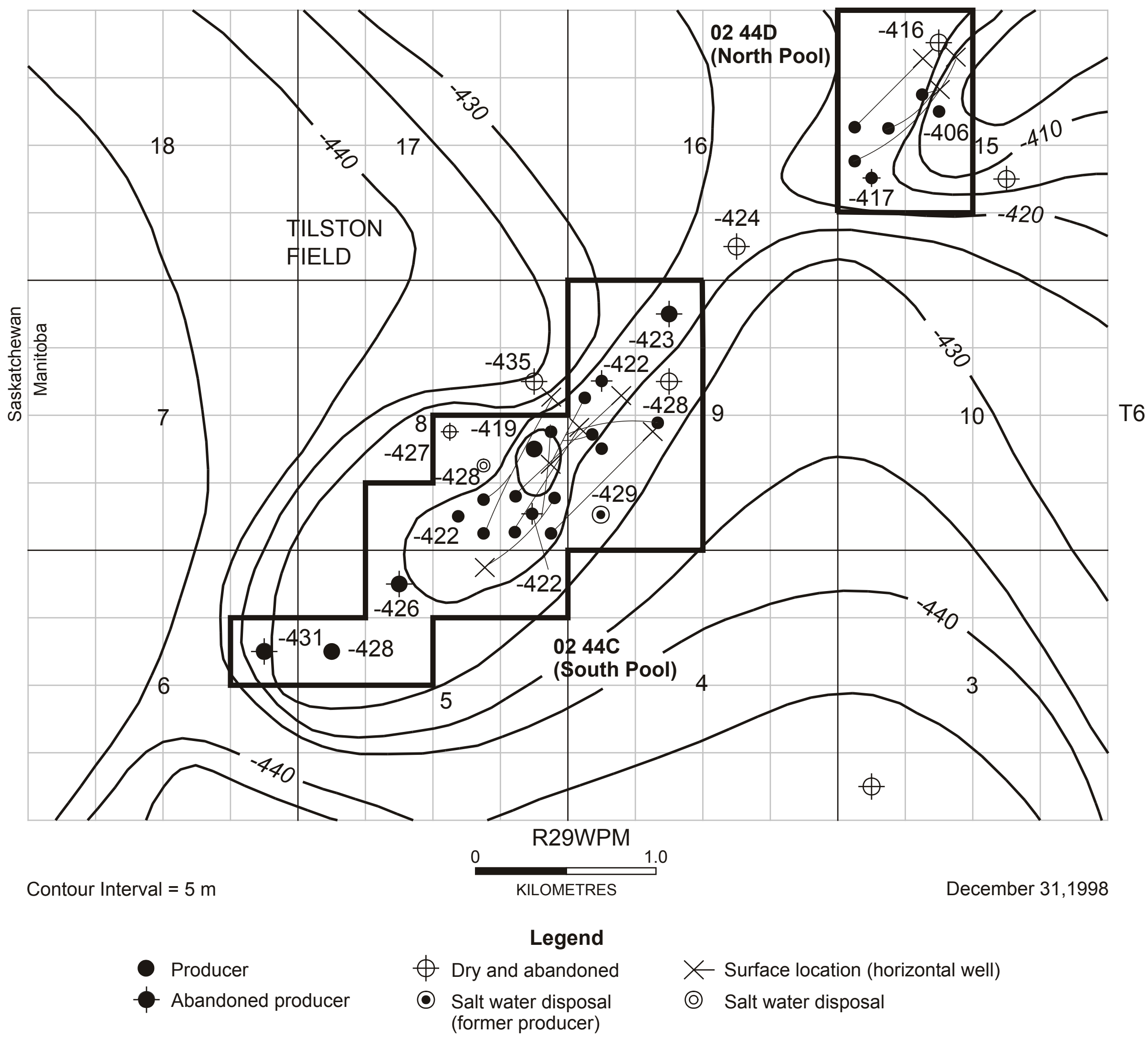


Figure 24: Structure on top of the MC-1 Member porosity, Tilston MC-1 C Pool (02 44C), southwestern Manitoba.

contact in the South Pool, which is at -430.0 m subsea.

The South Pool is the most prolific MC-1 Member pool in Manitoba. It was initially developed with the drilling of nine vertical wells during 1983 to 1984, mainly in Sections 8 and 9, Township 6, Range 29 WPM. Horizontal drilling has had a dramatic impact on recovery from the South Pool. The South Pool has a strong water drive. Water coning has restricted the area drained by vertical wells in the pool to an average of 4 ha. In 1993, prior to the drilling of the first horizontal well in the pool, ultimate oil recovery from the vertical wells on 16 ha spacing was estimated at 4.8% OOIP. Reduced 8 ha spacing was considered as an option to increase recovery. The estimated ultimate recovery from the pool increased to 19.1% OOIP with the drilling of six horizontal wells in the South Pool.

In December 1998, the six horizontal wells accounted for 95% of the daily pool oil production of 52.7 m^3/d and 74% of the cumulative pool oil production of 156.3 10^3m^3. The horizontal wells drilled in the pool have targeted Lithofacies 4 and are located near the top of porosity to maximize stand-off from the oil/water contact. The result has been a significant reduction in water coning when compared to vertical wells in the pool. Figure 25 is a log-log plot of water-oil ratio (WOR) versus cumulative oil production for both vertical and horizontal wells. The producing WOR for horizontal wells is less than the oil producing WOR for vertical wells over the total range of cumulative oil production. After the production of 41.0 10^3m^3, the cumulative WOR for vertical wells was 4.6 m^3/m^3, compared with a cumulative horizontal well WOR of 3.0 m^3/m^3, after 114.0 10^3m^3 of production.

Horizontal wells in the South Pool are among the most productive MC-1 Member horizontal wells. The average daily oil production rate for horizontal wells in the pool during the first 12 months on production is 26.2 m^3/d, compared to an average of 4.8 m^3/d for the best five vertical wells. The estimated average oil recovery for horizontal wells in the South Pool is 26.2 10^3m^3, with the well at A1-8-6-29 WPM estimated to recover over 45.0 10^3m^3.

The North Pool was discovered in 1984 with the drilling of 5-15-6-29 WPM. The well was abandoned in 1990 after producing only 315.7 m^3 of oil. The potential of the North Pool was not realized until 1994, when the well at 11-15-6-29 WPM was drilled. The North Pool is considerably smaller than the South Pool, covering only a

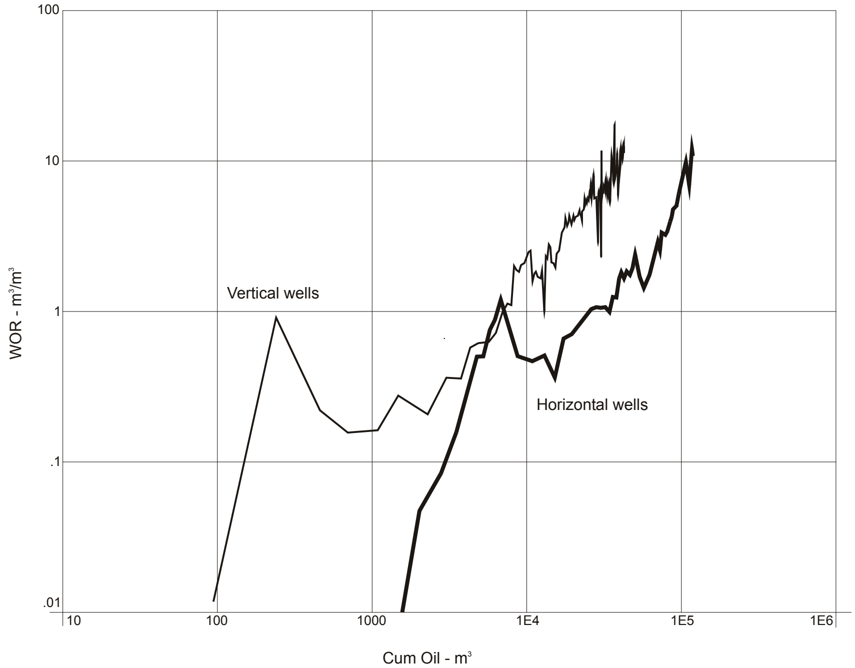


Figure 25: Comparison of water coning between vertical and horizontal wells, Tilston MC-1 C Pool (02 44C), southwestern Manitoba.

quarter section in areal extent. In December 1998, there were three horizontal wells and one vertical well on production. Oil production from the pool averaged 38.4 m^3/d at a WOR of 1.5 m^3/m^3. Cumulative oil production from the North Pool to December 31, 1998 was 37.3 10^3m^3, 82% of which was produced by the horizontal wells.

Volumetric OOIP for the North Pool is 338.0 10^3m^3. The ultimate and remaining recoverable oil reserves for the pool are 57.3 10^3m^3 and 20.0 10^3m^3, respectively. The pool ultimate recovery factor of 17.0% OOIP, is the second highest for MC-1 Member pools.

Other Areas MC-1 A Pool (99 44A)

The Other Areas MC-1 A Pool (Fig. 26) was discovered in 1981. It was shut-in and almost abandoned in 1986, and subsequently reactivated in 1988. In December 1998, there were three wells producing in the pool. Average oil production from the pool was 1.9 m^3/d at a WOR of 48.4 m^3/m^3. Cumulative oil production from the pool as of December 31, 1998 was 16.6 10^3 m^3.

The estimated volumetric original oil-in-place is 286.2 10^3m^3. The predicted ultimate recovery for this strong water drive pool in reserves is 7.1 % OOIP or 20.2 10^3m^3, an average recovery of almost 7000 m^3 per well. Remaining recoverable oil reserves are estimated at 3.6 10^3m^3.

The A Pool is located at the subcrop edge of the MC-1 Member (Fig. 26). A review of the completion history of wells in the A Pool indicates the Lodgepole Formation underlying the pool is productive at 8-31-2-23 WPM. The Lodgepole Formation produced 788 m^3 of oil at 8-31-2-23 WPM before a bridge plug was set and the well was completed uphole in the MC-1 Member. The final producing rate from the Lodgepole Formation was 3.3 m^3/d of oil at a WOR of 3.9 m^3/m^3. A confidential deeper pool wildcat was drilled adjacent to the A Pool in 1998, at 5-32-2-23 WPM.

Other Areas MC-1 E Pool (99 44E)

The Other Areas MC-1 E Pool, located 10 km east of the Tilston Field in Township 6, Range 28 WPM, was discovered in 1994 (Fig. 27). In December 1998, there was one well producing in the pool and three shut-in producers. Oil production averaged 0.7 m^3/d at a WOR of 19.0 m^3/m^3. Cumulative oil production from the pool, as of December 31, 1998, was 9.0 10^3m^3, with the majority of production from the horizontal well at 6-8-6-28 WPM.

Volumetric original oil-in-place for the E Pool is 444.7 10^3m^3 of oil. Estimated ultimate recoverable oil reserves for the pool are 9.5 10^3m^3, with remaining reserves of 500 m^3. Under current operating conditions, the recovery factor for this strong water drive pool is an extremely low, 2.1% OOIP. Given favourable oil prices, recovery from this pool can be improved by increasing reservoir withdrawals. Producing water-cuts of 97% or greater may be necessary to achieve a significant level of oil production.

Other Areas MC-1 G Pool (99 44G)

The Other Areas MC-1 G Pool was discovered in 1996 (Fig. 28). A total of seven wells, two vertical and five horizontal, have been drilled in the pool. Another two horizontal wells were cased and completed downdip of the MC-1 G Pool in Section 9, Township 6, Range 26 WPM. Despite good oil shows in samples, both wells produced only water. In December 1998, pool oil production averaged 7.0 m^3/d at a WOR of 1.0 m^3/m^3, with only two wells on production. Oil production has declined from a peak of 109.9 m^3/d in August 1997, with most of the production derived from the horizontal well at

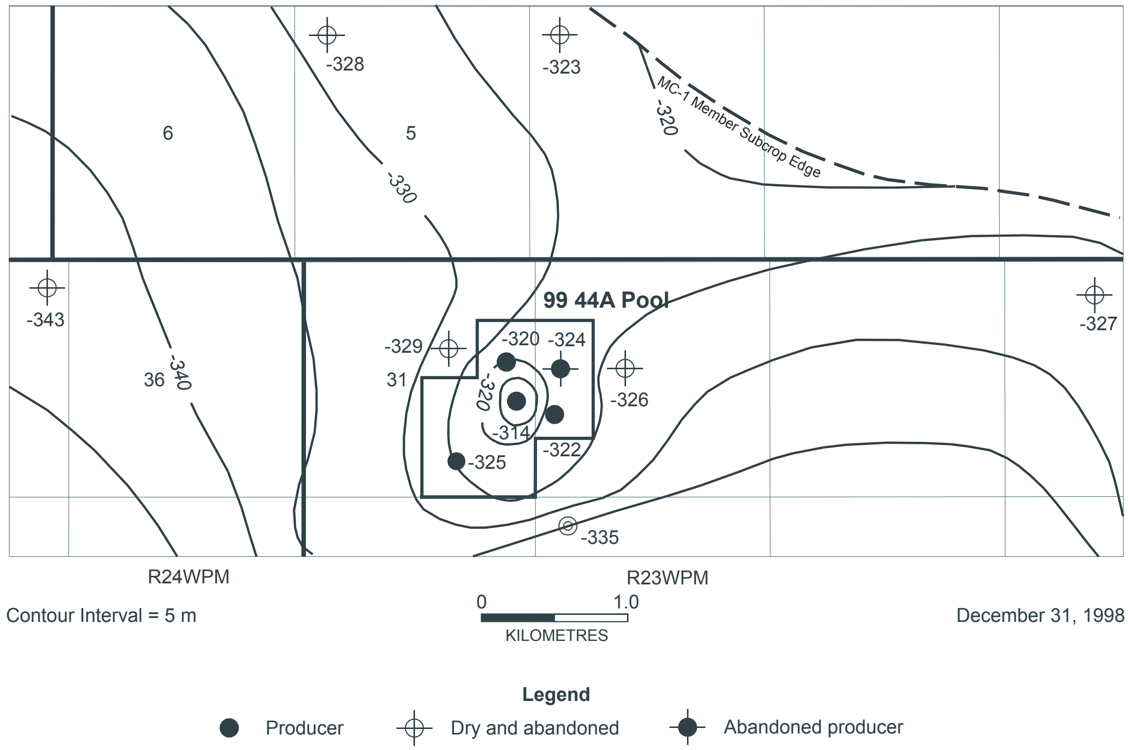


Figure 26: Structure on top of the MC-1 Member porosity, Other Areas MC-1 A Pool (99 44A), southwestern Manitoba.

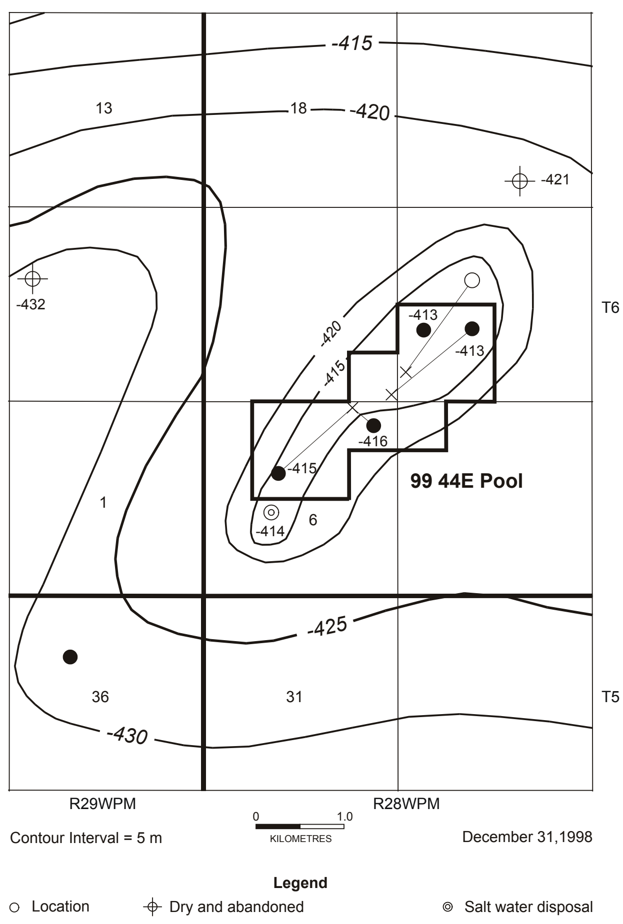


Figure 27: Structure on top of the MC-1 Member porosity, Other Areas MC-1 E Pool (99 44E), southwestern Manitoba.

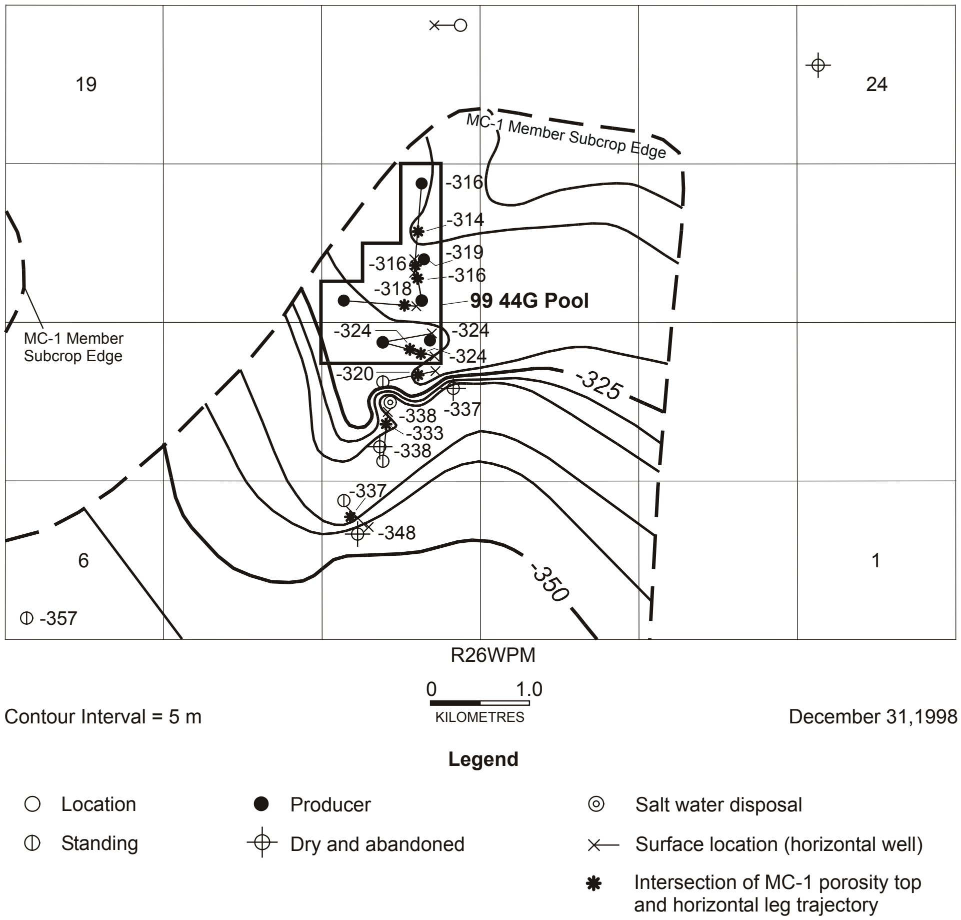


Figure 28: Structure on top of the MC-1 Member porosity, Other Areas MC-1 G Pool (99 44G), southwestern Manitoba.

14-9-6-29 WPM. The well averaged 38.8 m^3/d of oil during its first six months on production. Cumulative oil production from the MC-1 G Pool is 15.8 10^3m^3, with the horizontal wells accounting for 95% of the pool's cumulative oil production.

A petrographic and reservoir quality study of select wells in and adjacent to the G Pool indicated a significant difference in lithology across the pool with variations in grain size, dolomitization, and amount of anhydrite, gypsum and calcite cement (Rigel Oil and Gas, 1998). In general, the study concluded that pervasive dolomitization enhanced reservoir quality, whereas selective dolomitization reduced reservoir quality.

Volumetric original oil-in-place for developed spacing units in the MC-1 G Pool is 961.3 10^3m^3. The total proven recoverable reserves for the MC-1 G Pool, under current operating conditions, is 19.7 10^3m^3 or 2.0% OOIP. Reactivation of the five shut-in wells in the pool would have a positive impact on ultimate recovery. There are potential development drilling locations in the north half of the pool, if economic rates can be obtained from these wells.

Other Areas MC-1 H Pool (99 44H)

The Other Areas MC-1 H Pool was discovered in 1996. The pool contains two shut-in vertical producers located 2.0 km apart from two horizontal producers at 3-13-6-27 WPM and 5-14-6-27 WPM (Fig. 29). In December 1998, oil production from the two horizontal wells totalled 14.1 m^3/d, at an uncharacteristically low WOR of 0.6 m^3/m^3. Cumulative oil production from the MC-1 H Pool is 15.9 10^3m^3, with the horizontal wells accounting for 73% of the pool's cumulative oil production.

Volumetric original oil-in-place for developed spacing units in the MC-1 H Pool is 811.8 10^3m^3. Estimated ultimate recoverable oil reserves for the MC-1 H Pool, under current operating conditions, is 24.3 10^3m^3 or 3.0% OOIP. The two vertical wells had a combined oil production of 5.7 m^3/d when they were shut-in in May 1998 to eliminate high costs associated with trucking produced fluids. Favourable oil prices could lead to the reactivation of these wells.

REGIONAL EXPLORATION AND DEVELOPMENT POTENTIAL

Potential exists for exploration and new discoveries in the MC-1 Member of the Mission Canyon Formation in southwestern Manitoba. The MC-1 Member, with its favorable reservoir characteristics, porosity and permeability variation, lateral and vertical lithofacies variation and impermeable caprock ("alteration zone"), make it an ideal candidate for stratigraphic type hydrocarbon plays.

Recent interest in the hydrocarbon potential of the MC-1 Member has resulted in new discoveries and

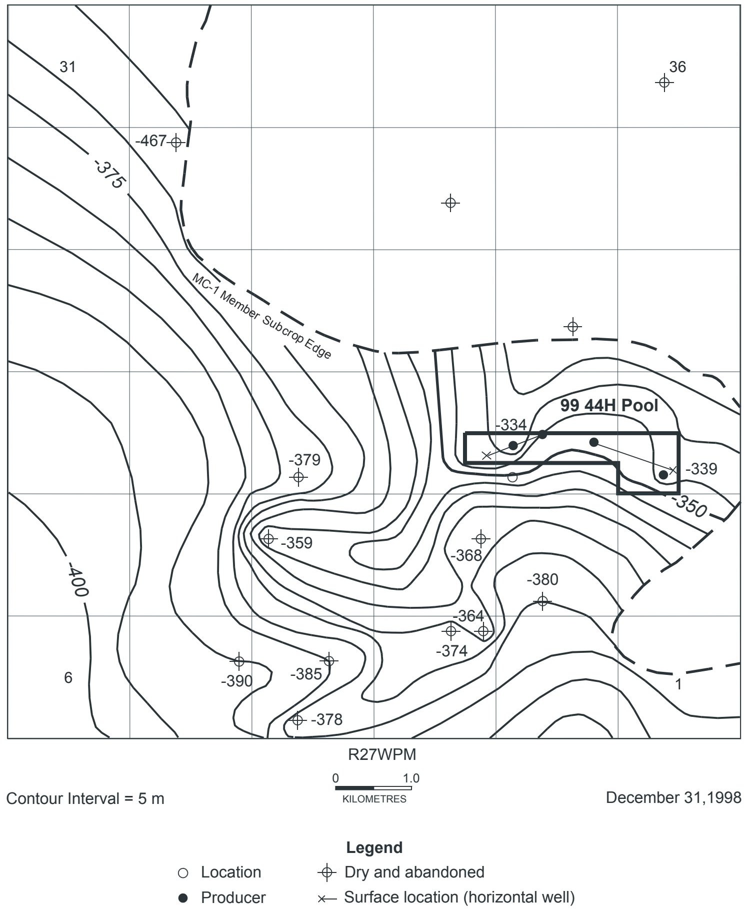


Figure 29: Structure on top of the MC-1 Member porosity, Other Areas MC-1 H Pool (99 44H), southwestern Manitoba.

development of existing oil pools along the MC-1 Member subcrop edge. Exploration for primary lithostratigraphic-truncation type traps may be directed towards the northern limits of the MC-1 Member, in areas where Lithofacies 4 (Bioclastic Lime Wackestone-Packstone) is present. Stratigraphic trapping within "paleotopographic highs" at the Mississippian erosion surface may exist where locally enhanced porous and permeable zones of Lithofacies 4 are pinched out against more micritic and dolomite-cemented zones within Lithofacies 3.

Future exploration potential may also exist within "paleotopographic highs" developed along the MC-1 Member subcrop edge from Pipestone south through Deloraine to the United States border. Potential for stratigraphic-diagenetic trapping may exist where locally enhanced porous and permeable zones within Lithofacies 3 are pinched out against tighter, anhydrite or dolomite-cemented zones within adjacent mud-rich lithofacies.

Primary lithostratigraphic-truncation type trapping may also occur within Lithofacies 2 (Mottled Lime Mudstone with Lime Wackestone-Packstone Interbeds) where porous and permeable lime wackestone-packstone interbeds are pinched out against tighter, lime mudstone interbeds.

Exploration potential may also occur in the southern portion of the study area, where Lithofacies 6 (Peloidal Lime Mudstone/Wackestone/Packstone) is present. Stratigraphic-diagenetic trapping may exist where local porosity and permeability enhanced zones within Lithofacies 6 are pinched out against tighter lithofacies.

Delineation of the limits and extent of established MC-1 Member oil pools may also provide future potential. Development opportunities may exist at the Other Areas MC-1 E Pool east of Tilston and the Other Areas MC-1 H and G Pools at Reston-Pipestone, all of which are currently defined by limited well control. South of the Other Areas H Pool, a number of wells drilled downdip of the pool had oil recoveries on DST (Appendix III). Potential also exists to the north, between existing producers and the postulated subcrop edge at 7-23-6-27 WPM where no wells have been drilled.

There are potential drilling locations in the Other Areas MC-1 A Pool at 1-31-2-23 WPM and 7-31-2-23 WPM (Fig. 26). A number of step-out locations also exist within the MC-1 A Pool towards the MC-1 Member subcrop edge. The use of 3D seismic would reduce the risk associated with any development drilling in these proposed locations.

CONCLUSIONS

The Mississippian Mission Canyon Formation conformably overlies the carbonates of the Lodgepole Formation and underlies the evaporitic beds of the Charles Formation. The Mission Canyon Formation in southwestern Manitoba is subdivided, in ascending order, into three members, the MC-1, MC-2 and MC-3. The MC-1 Member is the lowermost member of the Mission Canyon Formation and consists generally of crinoidal-fragmental and oolitic limestones, dolomitic limestones and dolostones.

The MC-1 Member represents an overall regressive phase of shallow-water marine shelf deposition. Combined with the evaporites of the overlying MC-2 Member, the MC-1 Member represents a cycle of deposition from shallow marine to shoal/buildups to transitional/backshoal to restricted, protective shelf/lagoonal to marginal marine, nearshore to supratidal.

Eight lithofacies were identified in this study. These include: (F1) Lithofacies 1 - Lime Mudstone-Wackestone with Shale Interbeds; (F2) Lithofacies 2 - Mottled Lime Mudstone with Lime Wackestone-Packstone Interbeds; (F3) Lithofacies 3 - Lime to Dolomitic Mudstone to Wackestone; (F4) Lithofacies 4 - Bioclastic Lime Wackestone-Packstone; (F5) Lithofacies 5 - Lime to Dolomitic Mudstone; (F6) Lithofacies 6 - Peloidal Lime Mudstone/Wackestone/Packstone; (F7) Lithofacies 7 - Oolitic Lime to Dolomitic Packstone; (F8) Lithofacies 8 - Interbedded Dolostone and Anhydrite; and the Alteration Zone (Caprock) - Anhydritic Dolostone. The "alteration zone" is not a depositionally related lithology, but rather, a diagenetic feature believed to be related to processes that occurred at the Mississippian erosional surface.

Generally, the MC-1 Member isopach shows a depositional pattern related to Williston Basin sedimentation, trending generally in an arcuate pattern (Fig. 14). The MC-1 Member thins generally to the northeast, towards the erosional edge, with anomalous thins and thicks occurring locally. Maximum thickness of the MC-1 Member reaches 55 m in the extreme southwest corner of Manitoba and averages 28 m. The structure on top of the MC-1 Member is fairly regular and follows the regional Paleozoic dip to the southwest. Notable structural features at Waskada Field and north of the field are associated with the Churchill-Superior crustal boundary zone (Birdtail-Waskada Axis). Several "paleotopographic highs" at the Mississippian erosional surface occur along the MC-1 Member subcrop edge.

Oil shows have been identified in all the facies in the study area, except within Lithofacies 8, suggesting that hydrocarbons have migrated throughout most of the MC-1 Member. However, not all lithofacies are productive or display reservoir potential. Primary depositional fabric, micritization and diagenesis (cementation, dolomitization and anhydritization) all play a role in the determination of reservoir potential. Lithofacies 3 and 4 are identified as primary reservoirs. Lithofacies 2 and 6 are identified as secondary reservoirs.

Trapping mechanisms within the MC-1 Member are attributed to a combination of controlling factors: (1) primary lithostratigraphic factors; (2) stratigraphic factors; (3) variation in reservoir quality; (4) salt dissolution/collapse features; and (5) distribution of the caprock ("alteration zone"). The majority of the MC-1 Member production is trapped stratigraphically.

Twenty MC-1 Member pools have been discovered in Manitoba. The productive areal extent of the pools is generally controlled updip by facies changes and downdip by underlying water. The pools are subject to strong water drives. Producing wells have exhibited water coning which is exacerbated by vertical fracturing. Original oil-in-place for the most productive MC-1 Member pools ranges from 286.2 10^3m^3 to 1591.6 10^3m^3 of oil.

Geological and engineering evidence in this study suggests that the Tilston MC-1 C Pool is composed of two separate pools. As a result, it is recommended that the Tilston MC-1 C pool be divided into a south pool (Tilston MC-1 C Pool - 02 44C) and a newly designated north pool (Tilston MC-1 D Pool - 02 44D).

There is a wide range in ultimate oil recovery from the MC-1 Member pools in Manitoba. Older, established pools at Tilston Field have oil recoveries as high as 19.1% OOIP, while recently discovered pools that have not been fully developed have low ultimate oil recoveries ranging from 2 to 3% OOIP. In order to properly exploit MC-1 Member pools, operators must be prepared to handle large volumes of water economically.

Horizontal drilling has been very successful in the MC-1 Member in southwestern Manitoba. Horizontal wells currently account for over 90% of MC-1 Member oil production. The average MC-1 Member horizontal well has an initial oil production rate (first year) of 15.9 m^3/d and estimated recoverable oil reserves of 20 300 m^3.

Future exploration should be directed towards the delineation of "paleotopographic highs" developed along the MC-1 Member subcrop edge. This is an area of sparse current well control and offers excellent exploration opportunities. Potential exploration targets also exist within stratigraphic-diagenetic traps in the southern portion of the study area.

RECOMMENDATIONS

This report presents a regional overview of the geology, reservoir charactersitics and petroleum potential of the MC-1 Member of the Mission Canyon Formation in southwestern Manitoba. The information and interpretation presented in this report provide the basic framework for future studies of the MC-1 Member in Manitoba.

The following recommendations are proposed for future study:

(1) Detailed petrographic examination of the lithofacies of the MC-1 Member through thin section petrograhy, scanning electron microscopy and x-ray diffraction analysis;

(2) Detailed analysis of the reservoir characteristics of the lithofacies of the MC-1 Member with respect to porosity/permeability and diagenesis;

(3) Paleontological evaluation of the lithofacies of the MC-1 Member to determine an in-depth depositional history; and,

(4) Pressure-Volume-Temperature (PVT) analysis of MC-1 Member crude oil to determine bubble point pressures and solution gas-oil ratios (GOR).

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Appendix I: List of Formation Tops and Available Cores, MC-1 Member, Mission Canyon Formation, Southwestern Manitoba (to December 31, 1998).

	Licence #	Location (WPM)	MC-1 Top	Cored Interval	Recovery of MC-1 Core
*	1082	10-21-001-23	3352.94 ft.	3354.95-3404.95 ft.	37.40 ft.
			(1021.99 m)	(1022.60-1037.84 m)	11.40
	3956	09-01-001-24	957.00 m	956.00-974.00 m	17.00
**	2755	03-05-001-24	912.00 m	914.00-932.00 m	20.00
	4624	13-10-001-24	927.00 m	912.00-930.00 m	3.00
	4322	12-11-001-24	927.30 m	928.00-942.00 m	14.00
	4575	04-12-001-24	940.00 m	942.00-960.00 m	18.00
	4625	10-14-001-24	920.00 m	920.00-938.00 m	18.00
	1861	01-28-001-24	2919.98 ft.	2914.99-2955.28 ft.	35.37 ft..
			(890.02 m)	(888.50-900.78 m)	(10.78 m)
	2044	02-33-001-24	2807.97 ft.	2862.96-2901.97 ft.	39.01 ft.
			(855.88 m)	(872.64-884.53 m)	(11.89 m)
	2081	08-33-001-24	2877.95 ft.	2874.97-2901.97 ft.	24.70 ft.
			(877.21 m)	(876.30-884.53 m)	(7.53 m)
	3395	10-33-001-24	881.50 m	880.00-898.00 m	16.00 m
	2854	06-08-001-25	932.00 m	925.00-943.00 m	11.00 m
	2773	01-13-001-25	901.00 m	895.00-913.00 m	12.00 m
	893	10-14-001-25	3015.06 ft.	3006.95-3036.97 ft.	21.92 ft.
			(919.00 m)	(916.53-925.68 m)	(6.68 m)
	2383	12-14-001-25	3018.34 ft.	2981.95-3041.96 ft.	23.62 ft.
			(920.00 m)	908.91-927.20 m	(7.20 m)
	2330	16-15-001-25	2978.97 ft.	2965.97-3025.95 ft.	46.98 ft.
			(908.00 m)	(904.04-922.32 m)	(14.32 m)
	2486	11-16-001-25	3024.90 ft.	3015.97-3059.97 ft.	35.07 ft.
			(922.00 m)	(919.28-932.69 m)	(10.69 m)
	2962	08-17-001-25	919.00 m	905.00-923.00 m	4.00 m
	2945	04-18-001-25	945.00 m	930.00-948.00 m	3.00 m
	853	13-18-001-25	3015.06 ft.	3017.98-3077.95 ft.	62.89 ft.
			(919.00 m)	(919.89-938.17 m)	(19.17 m)
	2621	13-18-001-25	3021.62 ft.	3039.66-3080.67 ft.	59.06 ft.
			(921.00 m)	(926.50-939.00 m)	(18.00 m)
	3705	09-19-001-25	920.50 m	921.00-939.00 m	18.00 m
	2444	10-19-001-25	3028.18 ft.	3028.97-3068.96 ft.	40.78 ft.
			(923.00 m)	(923.24-935.43 m)	(12.43 m)
	2840	07-20-001-25	926.00 m	915.00-933.00 m	7.00 m
*	2299	02-22-001-25	2982.25 ft.	2999.96-3049.96 ft.	67.72 ft.
			(909.00 m)	(914.40-929.64 m)	(20.64 m)
	2919	03-22-001-25	911.00 m	900.00-918.00 m	7.00 m
	3192	05-22-001-25	912.00 m	910.00-928.00 m	16.00 m
	2312	10-23-001-25	2959.28 ft.	2935.96-3000.95 ft.	41.67 ft.
			(902.00 m)	(894.89-914.70 m)	(12.70 m)
	2302	14-23-001-25	3005.21 ft.	2965.97-3025.95 ft.	20.73 ft.
			(916.00 m)	(904.04-922.32 m)	(6.32 m)
	4723	14-24-001-25	891.00 m	891.00-909.00 m	18.00 m
	3062	02-27-001-25	902.00 m	892.00-910.00 m	8.00 m
	2970	12-27-001-25	909.00 m	904.00-915.00 m	6.00 m
	2972	10-28-001-25	908.00 m	896.00-914.00 m	6.00 m

Appendix I (Continued)

	Licence #	Location (WPM)	MC-1 Top	Cored Interval	Recovery of MC-1 Core
	1183	01-30-001-25	3005.21 ft. (916.00 m)	3009.97-3059.97 ft. (917.45-932.69 m)	54.76 ft. (16.69 m)
	252	03-32-001-25	2998.65 ft. (914.00 m)	2987.96-3049.96 ft. (910.74-929.64 m)	51.31 ft. (15.64 m)
	2843	14-32-001-25	910.00 m	902.00-914.00 m	4.00 m
	2892	06-33-001-25	906.00 m	898.00-916.00 m	10.00 m
	3260	11-33-001-25	909.50 m	907.00-916.00 m	6.00 m
	2542	14-33-001-25	2969.12 ft. (905.00 m)	2969.98-3029.95 ft. (905.26-923.54 m)	59.97 ft. (18.28 m)
	2343	04-35-001-25	2959.28 ft. (902.00 m)	2963.97-3007.97 ft. (903.43-916.84 m)	48.69 ft. (14.84 m)
	2869	10-01-001-26	960.00 m	947.00-965.00 m	5.00 m
	184	09-13-001-26	3018.34 ft. (920.00 m)	3012.96-3100.95 ft. (918.36-945.18 m)	82.61 ft. (25.18 m)
	256	16-13-001-26	3031.46 ft. (924.00 m)	3023.98-3129.95 ft. (921.72-954.02 m)	98.49 ft. (30.02 m)
	2045	02-03-002-23	3240.97 ft. (987.86 m)	3242.97-3292.97 ft. (988.47-1003.71 m)	19.98 ft. (6.09 m)
	2775	13-03-002-23	953.00 m	952.00-966.50 m	10.00 m
	4084	02-31-002-23	825.00 m	827.00-845.00 m	12.00 m
	2706	08-31-002-23	812.00 m	813.00-827.00 m	15.00 m
**	3140	09-31-002-23	815.20 m	820.00-838.00 m	18.00 m
	1580	10-31-002-23	2699.97 ft. (822.96 m)	2699.97-3058.03 ft. (822.96-932.10 m)	29.86 ft. (9.10 m)
	3379	11-32-002-23	826.50 m	829.00-847.00 m	9.00 m
	2339	14-34-002-23	2705.97 ft. (824.79 m)	2734.97-2 769.98 ft. (833.63-844.30 m)	11.91 ft. (3.63 m)
	3993	15-11-002-24	867.10 m	873.00-891.00 m	3.00 m
	4724	13-32-002-24	844.00 m	847.00-860.00 m	8.00 m
	4078	07-04-002-25	898.00 m	894.00-912.00 m	14.00 m
	3629	13-04-002-25	895.00 m	880.00-898.00 m	3.00 m
	3679	04-05-002-25	909.00 m	894.00-912.00 m	3.00 m
	3536	10-07-002-25	900.00 m	887.00-905.00 m	5.00 m
	4065	05-10-002-25	890.00 m	875.00-893.00 m	3.00 m
	4164	07-10-002-25	892.00 m	877.00-895.00 m	3.00 m
	4029	13-10-002-25	893.00 m	871.00-899.00 m	6.00 m
	3631	14-10-002-25	889.00 m	874.00-892.00 m	3.00 m
	4140	15-10-002-25	888.00 m	873.00-891.00 m	3.00 m
	4142	16-10-002-25	884.00 m	869.00-887.00 m	3.00 m
	2874	10-12-002-25	880.00 m	865.00-883.00 m	3.00 m
	2875	04-13-002-25	874.00 m	869.00-887.00 m	13.00 m
	2853	04-15-002-25	892.00 m	878.00-896.00 m	4.00 m
	3735	05-15-002-25	885.00 m	882.00-900.00 m	15.00 m
	2803	08-32-002-25	877.00 m	870.00-888.00 m	11.00 m
	2766	05-24-002-26	900.00 m	894.00-912.00 m	12.00 m
*	2908	11-25-002-26	898.00 m	902.00-920.00 m	18.00 m
	254	03-14-002-27	3129.88 ft. (954.00 m)	3129.95-3168.96 ft. (954.02-965.91 m)	39.07 ft. (11.91 m)
	2453	09-15-002-27	3129.88 ft. (954.00 m)	3149.57-3208.62 ft. (960.00-978.00 m)	59.05 ft. (18.00 m)
	2096	15-27-002-27	3064.27 ft. (934.00 m)	3027.95-3077.95 ft. (922.93-938.17 m)	13.68 ft. (4.17 m)

Appendix I (Continued)

	Licence #	Location (WPM)	MC-1 Top	Cored Interval	Recovery of MC-1 Core
	1410	13-30-002-27	3188.94 ft. (972.00 m)	3166.96-3216.96 ft. (965.30-980.54 m)	28.02 ft. (8.54 m)
	1962	13-04-003-23	2685.96 ft. (818.69 m)	2684.97-2744.98 ft. (818.39-836.68 m)	58.00 ft. (17.68 m)
	2052	13-05-003-23	2687.96 ft. (819.30 m)	2687.96-2747.97 ft. (819.30-837.59 m)	31.82 ft. (9.70 m)
*	1403	16-09-003-24	2757.97 ft. (840.64 m)	2743.96-2804.95 ft. (836.37-854.96 m)	45.80 ft. (13.96 m)
	2701	17-21-003-24	818.00 m	820.00-835.00 m	3.00 m
*	299	01-15-003-25	2797.96 ft. (852.83 m)	2784.97-2863.97 ft. (848.87-872.95 m)	65.45 ft. (19.95 m)
	1835	15-25-003-25	2728.97 ft. (831.80 m)	2729.95-2789.96 ft. (832.10-850.39 m)	22.64 ft. (6.90 m)
**	3393	10-01-003-27	940.00 m	944.00-962.00 m	18.00 m
	4581	04-06-003-27	954.00 m	948.00-977.00 m	23.00 m
*	4578	11-31-003-27	915.50 m	921.00-939.00 m	18.00 m
*	3904	09-12-003-28	955.00 m	941.00-974.40 m	19.40 m
	4319	11-15-003-28	979.00 m	965.00-983.00 m	4.00 m
	3401	13-15-003-28	978.00 m	964.00-982.00 m	4.00 m
	1566	04-16-003-28	3264.40 ft. (995.00 m)	3239.95-3289.95 ft. (987.55-1002.79 m)	25.56 ft. (7.79 m)
	3182	16-16-003-28	976.50 m	966.50-980.00 m	3.00 m
*	2111	01-18-003-28	3280.80 ft. (1000.00 m)	3256.95-3306.95 ft. (992.73-1007.97 m)	26.15 ft. (7.97 m)
	2109	09-18-003-28	3264.40 ft. (995.00 m)	3243.96-3283.95 ft. (988.77-1000.96 m)	19.55 ft. (5.96 m)
*	3280	03-22-003-28	975.00 m	974.00-986.00 m	11.00 m
	3279	04-22-003-28	978.00 m	969.00-987.00 m	9.00 m
	3222	04-25-003-28	948.00 m	941.00-959.00 m	11.00 m
	3243	08-25-003-28	940.00 m	933.00-951.00 m	11.00 m
*	3276	08-26-003-28	948.00 m	944.00-962.00 m	14.00 m
	846	02-27-003-28	3175.81 ft. (968.00 m)	3171.98-3186.97 ft. (966.83-971.40 m)	11.15 ft. (3.40 m)
	745	04-29-003-28	3215.18 ft. (980.00 m)	3199.96-3241.96 ft. (975.36-988.16 m)	26.77 ft. (8.16 m)
*	582	05-15-003-29	3369.38 ft. (1027.00 m)	3343.96-3393.95 ft. (1019.25-1034.49 m)	24.57ft. (7.49 m)
	1868	08-21-003-29	3343.14 ft. (1019.00 m)	3331.95-3358.95 ft. (1015.59-1023.82 m)	15.81 ft. (4.82 m)
	1298	13-31-003-29	3359.54 ft. (1024.00 m)	3326.96-3376.96 ft. (1014.07-1029.31 m)	17.42 ft. (5.31 m)
*	1420	02-07-004-25	2717.98 ft. (828.45 m)	2722.97-2762.96 ft. (829.97-842.16 m)	40.98 ft. (12.49 m)
	2683	02-17-004-25	805.00 m	817.00-827.00 m	8.00 m
	218	08-20-004-25	2634.97 ft. (803.15 m)	2639.96-2654.95 ft. (804.67-809.24 m)	19.68 ft. (6.00 m)
	2039	03-22-004-25	2603.97 ft. (793.70 m)	2604.96-2659.97 ft. (794.00-810.77 m)	55.02 ft. (16.77 m)
*	777	13-17-004-26	2799.83 ft. (853.40 m)	2802.95-2872.96 ft. (854.35-875.69 m)	74.44 ft. (22.69 m)
	2237	10-22-004-26	2680.09 ft. (816.90 m)	2682.97-2742.98 ft. (817.78-836.07 m)	53.21 ft. (16.22 m)
	1850	05-33-004-26	2740.12 ft. (835.20 m)	2752.95-2802.95 ft. (839.11-854.35 m)	45.57 ft. (13.89 m)

Appendix I (Continued)

	Licence #	Location (WPM)	MC-1 Top	Cored Interval	Recovery of MC-1 Core
*	265	13-20-004-27	2919.91 ft. (890.00 m)	2922.96-2987.99 ft. (890.93-910.75 m)	68.08 ft. (20.75 m)
	4579	07-33-004-27	854.00 m	856.00-874.00 m	10.00 m
**	4569	11-31-004-28	917.00 m	922.00-949.00 m	27.00 m
*	360	01-11-004-29	3160.07 ft. (963.20 m)	3155.97-3224.96 ft. (961.95-982.98 m)	65.55 ft. (19.98 m)
*	1140	04-28-004-29	3209.93 ft. (978.40 m)	3214.95-3239.95 ft. (979.93-987.55 m)	25.98 ft. (7.92 m)
**	4746	08-04-005-25	786.00 m	788.00-803.00 m	10.00 m
	1421	01-17-005-26	2690.26 ft. (820.00 m)	2689.96-2714.96 ft. (819.91-827.53 m)	24.70 ft. (7.53 m)
	1617	12-28-005-26	2624.64 ft. (800.00 m)	2613.98-2653.97 ft. (796.75-808.94 m)	29.33 ft. (8.94 m)
*	2172	05-30-005-26	2716.50 ft. (828.00 m)	2721.98-2781.95 ft. (829.67-847.95 m)	59.97 ft. (18.28 m)
	1839	13-13-005-27	2736.19 ft. (834.00 m)	2736.97-2786.97 ft. (834.24-849.48 m)	50.00 ft. (15.24 m)
**	1838	01-20-005-27	2775.56 ft. (846.00 m)	2777.95-2877.95 ft. (846.73-877.21 m)	100.00 ft. (30.48 m)
*	1849	15-29-005-27	2746.03 ft. (837.00 m)	2754.95-2814.96 ft. (839.72-858.01 m)	59.97 ft. (18.28 m)
	497	05-31-005-27	2841.17 ft. (866.00 m)	2823.98-2868.96 ft. (860.76-874.47 m)	27.79 ft. (8.47 m)
	2049	09-32-005-27	2732.91 ft. (833.00 m)	2739.96-2789.96 ft. (835.15-850.39 m)	57.05 ft. (17.39 m)
	2063	16-32-005-27	2719.78 ft. (829.00 m)	2729.95-2789.96 ft. (832.10-850.39 m)	39.04 ft. (11.90 m)
	2925	08-33-005-27	824.00 m	837.00-855.00 m	18.00 m
*	1886	08-35-005-27	2696.82 ft. (822.00 m)	2699.97-2752.95 ft. (822.96-839.11 m)	39.50 ft. (12.04 m)
*	507	03-03-005-28	2939.60 ft. (896.00 m)	2940.97-3040.97 ft. (896.42-926.90 m)	100.00 ft. (30.48 m)
	4567	01-15-005-28	876.00 m	883.00-901.00 m	18.00 m
	633	15-22-005-28	2877.26 ft. (877.00 m)	2916.96-2930.97 ft. (889.10-893.37 m)	53.71 ft. (16.37 m)
*	1134	05-12-005-29	3051.14 ft. (930.00 m)	3052.95-3096.98 ft. (930.55-943.97 m)	101.93 ft. (31.07 m)
	940	03-19-005-29	3149.57 ft. (960.00 m)	3152.95-3170.96 ft. (961.03-966.52 m)	17.95 ft. (5.47 m)
	4225	15-22-005-29	935.00 m	939.00-957.00 m	18.00 m
*	3025	03-30-005-29	947.00 m	945.00-962.00 m	15.00 m
	3415	13-30-005-29	940.00 m	943.00-961.00 m	18.00 m
	2615	02-31-005-29	930.00 m	933.50-948.50 m	15.00 m
**	2845	06-31-005-29	941.00 m	944.00-962.00 m	18.00 m
	1285	07-31-005-29	3070.83 ft. (936.00 m)	3084.97-3134.97 ft. (940.31-955.55 m)	50.00 ft. (15.24 m)
	908	08-31-005-29	3054.42 ft. (931.00 m)	3096.98-3108.95 ft. (943.97-947.62 m)	11.97 ft. (3.65 m)
*	402	09-31-005-29	3097.08 ft. (944.00 m)	3085.95-3111.97 ft. (940.61-948.54 m)	14.89 ft. (4.54 m)
	1299	10-31-005-29	3064.27 ft. (934.00 m)	3084.97-3134.97 ft. (940.31-955.55 m)	50.00 ft. (15.24 m)
	181	05-32-005-29	3097.08 ft. (944.00 m)	3079.95-3145.96 ft. (938.78-958.90 m)	48.88 ft. (14.90 m)

Appendix I (Continued)

	Licence #	Location (WPM)	MC-1 Top	Cored Interval	Recovery of MC-1 Core
	433	11-32-005-29	3090.51 ft. (942.00 m)	3086.97-3148.98 ft. (940.92-959.82 m)	58.46 ft. (17.82 m)
	365	12-32-005-29	3041.96 ft. (927.20 m)	3086.97-3105.97 ft. (940.92-946.71 m)	23.98 ft. (7.31 m)
*	4732	12-04-006-26	776.00 m	777.00-795.00 m	18.00 m
	4668	03-09-006-26	765.00 m	768.00-786.00 m	18.00 m
	4773	09-09-006-26	761.50 m	762.80-780.80 m	18.00 m
**	4669	15-09-006-26	754.00 m	755.00-773.00 m	18.00 m
*	4597	09-09-006-26	746.50 m	752.00-770.00 m	18.00 m
	4665	04-06-006-26	794.00 m	802.00-820.00 m	18.00 m
	2140	16-03-006-27	2667.29 ft. (813.00 m)	2669.98-2729.95 ft. (813.82-832.10 m)	61.61 ft. (18.78 m)
	3090	03-04-006-27	829.00 m	834.00-852.00 m	18.00 m
	1874	06-05-006-27	2723.06 ft. (830.00 m)	2779.95-2837.96 ft. (847.34-865.02 m)	59.05 ft. (18.00 m)
**	4596	03-13-006-27	780.00 m	786.00-804.00 m	18.00 m
*	4651	05-14-006-27	784.00 m	792.00-810.00 m	18.00 m
	3406	03-16-006-27	830.00 m	834.00-852.00 m	18.00 m
*	4516	11-06-006-28	896.00 m	900.00-908.00 m	8.00 m
	3150	03-13-006-28	853.00 m	852.00-870.00 m	17.00 m
*	518	02-17-006-28	2936.32 ft. (895.00 m)	2920.96-2969.98 ft. (890.32-905.26 m)	33.66 ft. (10.26 m)
*	3354	03-22-006-28	872.00 m	873.00-891.00 m	18.00 m
	415	04-03-006-29	3067.55 ft. (935.00 m)	3023.98-3043.96 ft. (921.72-927.81 m)	46.42 ft. (14.15 m)
	1696	04-05-006-29	3070.83 ft. (936.00 m)	3076.96-3126.96 ft. (937.87-953.11 m)	50.00 ft. (15.24 m)
*	3358	14-05-006-29	925.00 m	929.00-947.00 m	18.00 m
	1522	01-06-006-29	3060.99 ft. (933.00 m)	3067.97-3089.96 ft. (935.13-941.83 m)	21.98 ft. (6.70 m)
	1478	02-06-006-29	3084.94 ft. (940.30 m)	3094.98-3129.95 ft. (943.36-954.02 m)	34.97 ft. (10.66 m)
	2588	08-06-006-29	3093.79 ft. (943.00 m)	3091.96-3141.96 ft. (942.44-957.68 m)	48.16 ft. (14.68 m)
	2143	07-08-006-29	3070.83 ft. (936.00 m)	3069.98-3129.95 ft. (935.74-954.02 m)	59.12 ft. (18.02 m)
	3169	05-09-006-29	924.00 m	927.00-941.00 m	14.00 m
*	3334	14-09-006-29	921.00 m	926.00-944.00 m	18.00 m
*	3337	05-15-006-29	905.00 m	909.00-927.00 m	18.00 m
	485	07-15-006-29	3018.34 ft. (920.00 m)	2999.96-3051.96 ft. (914.40-930.25 m)	59.05 ft. (18.00 m)
	4475	11-15-006-29	901.00 m	907.00-925.00 m	18.00 m
	1978	13-17-006-29	3100.36 ft. (945.00 m)	3109.97-3149.96 ft. (947.93-960.12 m)	39.99 ft. (12.19 m)
**	4010	03-22-006-29	913.50 m	916.00-934.00 m	18.00 m

Total : 171 cores

*** Cores examined in this study**
**** Select descriptions of cores examined in this study shown in Appendix II**

Appendix II: Select Core Descriptions, MC-1 Member, Mission Canyon Formation, Southwestern Manitoba.

Enron et al. S. Goodlands
03-05-001-24 WPM
KB: 489.3 m

Cored Interval: **914.00-932.00 m**

Perforated Interval: **914.00-916.00 m**

Interval (m)	Thickness (m)	Description
914.00-915.57	1.57	Wackestone-Packstone: light brown; peloidal; occasional brachiopods, crinoids and solitary rugose corals; calcite and anhydrite cement; poor to fair pinpoint and fenestral porosity; faint patchy oil staining.
915.57-917.11	1.54	Dolostone: light brown; microsucrosic; massive; poor pinpoint and intercrystalline porosity; even oil staining.
917.11-917.96	0.85	Wackestone-Packstone: light brown; peloidal; wispy laminated throughout; anhydrite occurs as blebs and infill; poor to fair interparticle and pinpoint porosity.
917.96-924.58	6.62	Mudstone with Wackestone-Packstone interbeds: Mudstone: light brown; massive; occasional wispy anhydrite laminations; occasional large solitary rugose corals; rare peloids; anhydrite-healed vertical fractures; occasional stylolitic partings; very poor pinpoint and intercrystalline porosity. Wackestone-Packstone interbeds (0.3-0.6 m thick): light brown; fine to medium crystalline; peloidal in part; occasional small solitary rugose corals, brachiopods and crinoids; anhydrite-healed vertical fractures; stylolitic partings; calcareous nodules replaced with anhydrite; occasional chalky nodules; calcite cement; poor to fair pinpoint and intercrystalline porosity; interbeds occur at 918.76 m, 919.96 m and 921.96 m.
924.58-927.48	2.90	Mudstone: light brown; massive; occasional wispy anhydrite laminations; anhydrite-healed vertical fractures; occasional stylolitic partings; very poor pinpoint and intercrystalline porosity.
927.48-927.96	0.48	Packstone-Grainstone: light brown; oolitic; occasional brachiopods; stylolitic; fair to good interparticle porosity; faint patchy oil staining.
927.96-931.38	3.42	Mudstone-Wackestone with Wackestone-Packstone interbeds: Mudstone-Wackestone: light brown; faint fossil remnants replaced with anhydrite; occasional wispy anhydrite laminations; poor pinpoint and intercrystalline porosity. Wackestone-Packstone interbeds: light brown; brachiopods, solitary rugose corals; anhydrite as fossil replacement; stylolitic in part; occasional coated grains; interbeds occur at 924.76 m, 930.26 m and 930.56 m.
931.38-932.00	0.62	Mudstone-Wackestone with Shale laminae and interbeds: Mudstone-Wackestone: light brown; occasionally grades to wackestone-packstone; occasional crinoids, solitary rugose corals and coated grains; anhydrite as cement and fossil replacement; trace pinpoint and intercrystalline porosity. Shale laminae and interbeds (3.0-15.0 cm thick): grey-green; massive; soft; calcareous.

Appendix II (Continued)

Roxy-Andex *et al* Deloraine
09-31-002-23 WPM
KB: 501.8 m

Cored Interval: **820.00-838.25 m**

Perforated Intervals: **821.00-823.00 m**
825.00-827.00 m

Interval (m)	Thickness (m)	Description
820.00-821.92	1.92	Anhydritic Dolostone: dolomite (60% of interval), anhydrite (40% of interval); occasional tripolitic chert nodules; faint oil staining near base. *Dolostone*: light brown; massive; dense; finely crystalline; occasional brachiopods and crinoids. *Anhydrite*: blue-grey to white; massive; dense; occurs as infill and replacement and vertical fracture fill.
821.92-823.77	1.85	Mudstone-Wackestone: light brown-grey; slightly dolomitic in part; slightly mottled; occasionally wavy bedded in part; brachiopods and crinoids; open vertical fractures; anhydrite occurs as nodules, infill and replacement; rare siliceous nodules; poor pinpoint and moldic porosity; patchy oil staining throughout.
823.77-824.88	1.11	Mudstone: light grey; mottled; occasionally wavy laminated; shale parting at 924.23 m; poor intercrystalline and pinpoint porosity; patchy light oil staining throughout.
824.88-828.78	3.90	Mudstone with Wackestone interbeds: *Mudstone:* light brown-grey; massive; occasionally wavy laminated; non-fossiliferous; occasional siliceous nodules; poor pinpoint and intercrystalline porosity; light even oil staining. *Wackestone interbeds:* light brown-grey; fragmental; brachiopods, crinoids, solitary rugose corals and gastropods; anhydrite-healed and open vertical fractures; anhydrite as replacement and infill; light patchy oil staining.
828.78-831.78	3.00	Mudstone-Wackestone: light brown-grey; occasionally faintly bedded; crinoids, brachiopods and occasional solitary rugose corals occur in thin interbeds; open vertical fractures; occasional stylolitic partings; large anhydrite nodules throughout; fair pinpoint, interparticle and vuggy porosity; medium to heavy patchy oil staining.
831.78-832.40	0.62	Mudstone-Wackestone: light brown-grey; faint crinoid ghosts; peloidal packstone interbeds (5.0-11.0 cm thick) occur at 931.78 m and 932.28 m; poor to good vuggy, pinpoint and moldic porosity; light patchy oil staining throughout.

Lodgepole Formation (832.40 m)
(well log depth: 831.50 m)

832.40-838.25	5.85	Mudstone with Wackestone-Packstone interbeds: light brown; fragmental; crinoids and brachiopods; trace pinpoint and moldic porosity.

Appendix II (Continued)

Resman Jorex *et al* S. Melita
10-01-003-27 WPM
KB: 458.0 m

Cored Interval: 942.93-962.00 m

Interval (m)	Thickness (m)	Description
942.93-944.00	1.07	Anhydritic Dolostone: dolostone (50% of interval), anhydrite (50% of interval). *Dolostone*: light brown; mottled near top; finely bedded near base; fair intercrystalline porosity. *Anhydrite*: blue-grey; massive; dense; occurs as blebs, infill and replacement.
944.00-946.80	2.80	Lime Mudstone: buff; finely crystalline; massive; stylolitic; poor vuggy and intercrystalline porosity.
946.80-949.30	2.50	Lime Mudstone: light brown; slightly chalky in part; occasional brachiopods; anhydrite-healed vertical fractures; rare disseminated pyrite; trace pinpoint and vuggy porosity.
949.30-953.64	4.34	Wackestone-Packstone: light brown to buff; oolitic, oolites are very fine grained, oolite concentration increases upwards in section; grades in part to packestone; open vertical fractures; calcite cement; fair pinpoint and interoolitic porosity.
953.64-955.74	2.10	Wackestone: light brown to buff; oolitic, oolites are very fine grained; finely crystalline; calcite cement; trace pinpoint porosity.
955.74-956.14	0.40	Wackestone to Packstone: light brown; oolitic; occasional disseminated pyrite; anhydrite blebs; calcite cement; trace pinpoint and interoolitic porosity.
956.14-959.19	3.05	Mudstone: light brown; very finely crystalline; occasional solitary rugose corals, rare gastropods and brachiopods; blue-grey anhydrite occurs as blebs, infill and replacement; very poor pinpoint, intercrystalline and moldic porosity.
959.19-962.00	2.81	Wackestone: light brown; slightly fragmental or oolitic; occasional brachiopods; anhydrite-healed vertical fractures; stylolitic; poor pinpoint porosity.

Appendix II (Continued)

Trinity West Melita
11-31-004-28 WPM
KB: 479.5 m

Cored Interval: 922.00-949.00 m

Interval (m)	Thickness (m)	Description
922.00-931.00	9.00	Anhydritic Dolostone: dolostone (50% of interval), anhydrite (50% of interval). *Dolostone*: light brown; massive; finely crystalline; dense. *Anhydrite*: blue-grey; massive; dense; finely crystalline; occurs as vertical fracture fill.
931.00-931.60	0.60	Dolostone: light brown; finely laminated, increasingly mottled towards base; non-fossiliferous; anhydrite laminations; poor pinpoint porosity.
931.60-932.60	1.00	Dolostone: light grey to light brown; mottled; "spongy texture" in part (remnant ghosts of oolites?); limy towards base; non-fossiliferous; poor pinpoint porosity.
932.60-933.16	0.56	Mudstone: buff; massive; occasional beds with "spongy texture", as above; non-fossiliferous; occasional irregular calcite blebs; very poor pinpoint and vuggy porosity.
933.16-934.52	1.36	Mudstone-Wackestone: light brown; massive to slightly oolitic(?); occasional brachiopods and crinoids; stylolitic partings near base; anhydrite as replacement; poor pinpoint porosity.
934.52-939.35	4.83	Mudstone: light brown; faintly mottled throughout; occasional crinoid, brachiopod and rare bryozoan fragments occur throughout; open and anhydrite-healed vertical fractures; anhydrite as infill and replacement; very poor pinpoint porosity.
939.35-943.01	3.66	Wackestone-Packstone: light brown; occasional mudstone interbeds (1.0-3.0 cm thick); abundant brachiopods throughout and occasional crinoids; anhydrite as replacement and large white to grey nodules; poor to fair pinpoint and intramoldic porosity.
943.01-949.00	5.99	Wackestone to Packstone: light brown; faintly laminated and mottled in part; brachiopods throughout, occasional small crinoids and rare solitary rugose corals; occasional stylolitic partings; brown anhydrite as infill and replacement; sparry calcite in vugs; poor pinpoint, intramoldic, intercrystalline and vuggy porosity.

Appendix II (Continued)

Rigel West Lauder
08-04-005-25 WPM
KB: 445.25 m

Cored Interval: **788.00-803.00 m**

Interval (m)	Thickness (m)	Description
788.00-790.47	2.47	Anhydritic Dolostone: dolostone (50% of interval); anhydrite (50% of interval). *Dolostone*: light brown; finely crystalline; dense; occasional solitary rugose corals and crinoids; slightly calcareous at base. *Anhydrite*: blue-grey, brown; massive; dense; occurs as blebs, occurs as fracture fill and replacement.
790.47-792.10	1.63	Dolostone: light brown; faintly mottled and wavy bedded; occasional grey-green shale laminae; mudstone-wackestone original fabric; occasional crinoids and brachiopods; occasional siliceous nodules (2.0-5.0 cm diameter) at base; anhydrite as replacement; very poor pinpoint porosity.
792.10-793.20	1.10	Mudstone: light brown; banded and mottled throughout; grades in part to wackestone; crinoids and solitary rugose corals; occasional stylolitic partings; occasional siliceous nodules; occasional hematitic staining; anhydrite as nodules, blebs, replacement and infill; very poor pinpoint porosity.
793.20-795.36	2.16	Mudstone with Wackestone interbeds: *Mudstone:* grey-green; shaly laminations; rare solitary rugose corals; occasional stylolitic partings; calcareous; very poor pinpoint porosity. *Wackestone interbeds*: light brown; occasional solitary rugose corals, crinoids and brachiopods; anhydrite as replacement and blebs; poor pinpoint porosity.

Lodgepole (795.36 m)
(well log depth: 798.30 m)

Interval (m)	Thickness (m)	Description
795.36-797.96	2.60	Dolostone: light brown, earthy red in upper 0.70 m of interval; finely laminated towards base; non-fossiliferous; mudstone original fabric; occasional siliceous nodules (< 6 cm diameter); anhydrite as replacement and vertical fracture fill.
797.96-803.00	5.04	Mudstone with Wackestone-Packstone interbeds: not described.

Appendix II (Continued)

B. A. Gervin Broomhill
01-20-005-27 WPM
KB: 1487 ft. (453.24 m)

Cored Interval: **2778.00-2878.00 ft. (846.73-877.21 m)**

Interval (ft)	Thickness (ft)	Description
2778.00-2780.25 (846.73-847.42 m)	2.25 (0.69 m)	Anhydritic Dolostone: dolostone (80% of interval), anhydrite (20% of interval). *Dolostone*: light brown; massive; finely crystalline; dense. *Anhydrite*: blue-grey; massive; occurs as infill and replacement.
2780.25-2790.25 (847.42-850.47 m)	10.00 (3.05 m)	Dolostone: light brown; massive to bedded in part; dense; microsucrosic; hairline fractures; mudstone original fabric; non-fossiliferous; very poor pinpoint porosity.
2790.25-2816.75 (850.47-858.55 m)	26.50 (8.08 m)	Dolostone: light brown to grey; mottled near top, faintly bedded throughout; mudstone original fabric; non-fossiliferous; occasional chalky interclasts (0.5-3.0 in.; 5.0-7.0 cm diameter); very poor pinpoint porosity.
2816.75-2818.67 (858.55-859.13 m)	1.92 (0.58 m)	Dolostone: light grey to brown; massive, faintly mottled in part; bedded at top of interval; mudstone original fabric; very poor pinpoint porosity.
2818.67-2823.67 (859.13-860.65 m)	5.00 (1.52 m)	Dolostone: light brown to grey; finely crystalline; brachiopods, crinoids and rare solitary rugose corals; dark interstitial material; anhydrite as infill and replacement; very poor pinpoint and intercrystalline porosity.
2823.67-2828.19 (860.65-862.03 m)	4.52 (1.38 m)	Dolostone: light brown to light grey to occasionally pink; wispy anhydrite laminations; solitary rugose corals, crinoids and brachiopods; very poor porosity.
2828.19-2829.83 (862.03-862.53 m)	1.64 (0.50 m)	Anhydritic Dolostone: dolostone (50% of interval), anhydrite (50% of interval). *Dolostone*: light brown; mottled; dense; occasional solitary rugose coral. *Anhydrite*: blue-grey; dense; occurs as massive beds (0.5-3.0 in.; 1.0-7.0 cm thick) and replacement.
2829.83-2846.17 (862.53-867.51 m)	16.34 (4.98 m)	Wackestone-Packstone: light brown to light grey; solitary rugose corals, brachiopods and crinoids more abundant near base; occasional stylolitic partings; white anhydrite as blebs and fossil replacement; fair pinpoint, vuggy and intercrystalline porosity; patchy oil staining.
2846.17-2853.17 (867.51-869.65 m)	7.00 (2.14 m)	Mudstone-Wackestone: light brown to buff; finely crystalline; brachiopods and solitary rugose corals; anhydrite occurs as blebs and replacement; very poor pinpoint and intercrystalline porosity.
2853.17-2855.40 (869.65-870.33 m)	2.23 (0.68 m)	Packstone: light brown to buff; fragmental; solitary rugose corals, crinoids and occasional brachiopods and colonial corals (*Acrocyathus*); base marked by stylolitic parting; anhydrite occurs as replacement and cement; fair pinpoint, moldic and intercrystalline porosity.
2855.40-2870.25 (870.33-874.85 m)	14.85 (4.52 m)	Mudstone-Wackestone: light brown; finely laminated in part; mud content increases towards base; solitary rugose corals, crinoids, occasional colonial corals (*Syringoporid*) and brachiopods; occasional stylolitic partings; anhydrite as replacement; calcite cement; poor pinpoint, moldic and intercrystalline porosity.

B. A. Gervin Broomhill
01-20-005-27 WPM
KB: 1487 ft. (453.24 m)

Cored Interval: (cont'd) **2778.00-2878.00 ft. (846.73-877.21 m)**

Interval (ft)	Thickness (ft)	Description
2870.25-2871.57 (874.85-875.25 m)	1.32 (0.40 m)	Packstone: light brown; crinoids and solitary rugose corals throughout, occasional brachiopods; occasional stylolitic partings; anhydrite as fossil replacement and cement; calcite cement; poor to fair pinpoint, moldic and vuggy porosity.
2871.57-2875.40 (875.25-876.42 m)	3.83 (1.17 m)	Mudstone: light brown; occasionally grades to wackestone-packstone; occasional grey-green shale interbeds; crinoids and solitary rugose corals; anhydrite as cement and vertical fracture fill; fair pinpoint, vuggy and moldic porosity.
2875.40-2878.00 (876.42-877.21 m)	2.60 (0.79 m)	MISSING CORE

Appendix II (Continued)

Renaissance Tilston
06-31-005-29 WPM
KB: 515.6 m

Cored Interval: **944.00-962.00 m**

Perforated Interval: **946.50-948.00 m**

Interval (m)	Thickness (m)	Description
944.00-945.25	1.25	Anhydritic Dolostone: brown; medium crystalline; limy in part; brachiopods, crinoids and occasional solitary rugose corals; open and healed vertical fractures; anhydrite as massive, infill and replacement; very poor intercrystalline porosity; light patchy oil staining.
945.25-947.33	2.08	Mudstone-Wackestone: light brown to buff; medium crystalline in part; dolomitic near top of interval; crinoids, brachiopods and solitary rugose corals; very poor pinpoint porosity; light patchy oil staining.
947.33-948.73	1.40	Wackestone to Packstone: light grey to buff; occasional grey-green shale partings near base; abundant crinoid fragments, occasional solitary rugose corals and brachiopods; calcite-healed vertical fractures; good pinpoint and vuggy porosity; light even oil staining.
948.73-953.67	4.94	Wackestone with Packstone interbeds : *Wackestone*: light brown to buff; finely crystalline in part; crinoids, solitary rugose corals and brachiopods; anhydrite-healed and open vertical fractures; occasional stylolitic partings; disseminated pyrite near base; fair pinpoint and vuggy porosity; patchy oil staining. *Packstone interbeds (0.2-0.3 cm thick)*: light grey to light brown; fragmental; abundant crinoids, solitary rugose corals and brachiopods; good intercrystalline, vuggy and intermoldic porosity.
953.67-955.36	1.69	Mudstone to Wackestone: light brown; occasional grey-green shale interbeds (1.0-2.0 cm thick) and laminae; occasional solitary rugose corals; very poor pinpoint porosity.
955.36-961.06	5.7	Mudstone-Wackestone: light brown; finely crystalline; occasional buff dolostone interbeds (dense; deformed bedding; open and healed vertical fractures); occasional grey-green shale interbeds (calcareous; fissile; deformed bedding; trace brachiopods); crinoids, brachiopods and solitary rugose corals; open vertical fractures; occasional stylolitic partings; fair intramoldic and vuggy porosity; light patchy oil staining.
961.06-962.00	0.94	MISSING CORE

Appendix II (Continued)

Rigel South Pipestone Prov.
15-09-006-26 WPM
KB: 437.40 m

Cored Interval: **755.00-773.00 m**

Perforated Interval: **761.00-763.00 m**

Interval (m)	Thickness (m)	Description
755.00-758.30	3.30	Anhydritic Dolostone: dolostone (75% of interval), anhydrite (25% of interval). *Dolostone*: light brown with occasional hematitic staining; slightly mottled; dense; finely crystalline; faint remnants of peloids, brachiopods and occasional solitary rugose corals; light patchy oil staining. *Anhydrite*: grey; massive; dense; occurs as infill, replacement, thin beds and laminae.
758.30-758.76	0.46	Packstone-Grainstone: medium brown; peloidal, peloids are deformed; solitary rugose corals, brachiopods and crinoids; anhydrite as cement and replacement; poor to fair pinpoint, moldic and intercrystalline porosity; medium patchy oil staining.
758.76-763.70	4.94	Packstone-Grainstone: light brown; medium crystalline; crinoids, brachiopods and occasional solitary rugose corals; occasional stylolitic partings; anhydrite-healed vertical fractures; anhydrite as wavy laminae and replacement; fair to good pinpoint, intercrystalline, moldic and vuggy porosity; medium patchy oil staining.
763.70-764.90	1.20	Dolostone: light brown; finely crystalline; packstone original fabric; non-fossiliferous; anhydrite as infill, wispy laminae and replacement; very poor pinpoint and intercrystalline porosity; patchy oil staining.
764.90-771.60	6.70	Packstone to Grainstone: light brown; faintly mottled throughout; finely crystalline, coarsely crystalline in part; abundant crinoids, solitary rugose corals and occasional brachiopods; open and anhydrite-healed vertical fractures; occasional stylolitic partings; anhydrite as blebs, laminae and replacement; fair pinpoint, intercrystalline, moldic and vuggy porosity; medium patchy oil staining.
771.60-773.00	1.40	MISSING CORE

Appendix II (Continued)

CANNAT South Reston
03-13-006-27 WPM
KB: 446.66 m

Cored Interval: **786.50-804.00 m**

Perforated Interval: **786.50-790.00 m**

Interval (m)	Thickness (m)	Description
786.50-797.13	10.63	Wackestone: light brown; occasional thin shaly laminations; solitary rugose corals, crinoids, brachiopods and rare bryozoans; stylolitic partings; poor vuggy, pinpoint and intercrystalline porosity; heavy patchy oil staining throughout.
797.13-798.43	1.30	Mudstone: light grey; occasional grainstone beds; green-grey shaly laminations throughout; open vertical fracture at base; good pinpoint and intercrystalline porosity; patchy oil staining restricted to grainstone beds.
798.43-799.73	1.30	Wackestone: light brown; grades near top and base to grainstone; brachiopods; open vertical fractures; fair vuggy and intercrystalline porosity in wackestone and good pinpoint, intercrystalline and fenestral porosity where graded to grainstone; heavy patchy to even oil staining.
799.73-801.85	2.12	Wackestone: light grey-brown; occasionally grades to packstone; wavy bedded; solitary rugose corals, brachiopods and crinoids; dolomitic interbed (3.0-4.0 cm thick); anhydrite as replacement; fair intercrystalline, pinpoint, intramoldic, vuggy and fenestral porosity; patchy oil staining.
801.85-804.00	2.15	Packstone with Shale partings: *Packstone:* light grey-brown; abundant crinoids; fair pinpoint and vuggy porosity; patchy heavy oil staining. *Shale partings:* grey-green; calcareous; massive; fissile.

Renaissance et al. C. Linklater HZNTL
11-06-006-28 WPM
KB: 489.10 m

Cored Interval: **900.00-908.00 m**

Perforated Interval: **903.00-910.00 m**

Interval (m)	Thickness (m)	Description
900.00-902.20	2.20	Dolomitic Anhydrite: anhydrite (80% of interval), dolostone (20% of interval); dense; rare brachiopods.
902.20-908.00	5.80	Wackestone-Packstone: medium brown; grades towards base to wackestone; solitary rugose corals, brachiopods and occasional crinoids; open and anhydrite-healed vertical fractures; poor to fair intercrystalline, vuggy, moldic and pinpoint porosity; patchy oil staining throughout.

Appendix II (Continued)

Saskoil Jecco S. Linklator Prov.
03-22-006-28 WPM
KB: 483.30 m

Cored Interval: 873.00-891.00 m

Interval (m)	Thickness (m)	Description
873.00-874.40	1.40	Wackestone: light brown; fragmental; crinoids, brachiopods, solitary rugose corals; occasional dark siliceous nodules; anhydrite as infill and replacement; poor pinpoint and vuggy porosity; patchy oil staining throughout.
874.40-875.20	0.80	Anhydritic Dolostone: dolomite (60% of interval), anhydrite (40% of interval); light brown; finely crystalline; crinoids and brachiopods; anhydrite-healed hairline horizontal fractures; anhydrite as blebs and infill; very poor porosity.
875.20-875.42	0.22	Wackestone-Packstone: light brown to grey; fragmental bioclastic; faintly thinly bedded; brachiopods and crinoids; poor porosity.
875.42-877.42	2.00	Dolostone: light brown to grey; faintly mottled; finely crystalline; rare brachiopods; hairline vertical fractures; occasional anhydrite inclusions; poor pinpoint porosity; patchy oil staining.
877.42-881.97	4.55	Dolostone: light brown to buff; slightly calcareous in part; occasional thin dolomitic shale breaks; brachiopods and crinoids; anhydrite-healed vertical fractures; occasional stylolitic partings; anhydrite as replacement and infill; very poor porosity.
881.97-890.30	8.33	Wackestone to Packstone: light brown to grey; solitary rugose corals, crinoids, brachiopods; anhydrite-healed hairline vertical fractures; occasional stylolitic partings; occasional black carbonaceous(?) flecks; anhydrite as infill and replacement; poor pinpoint intramoldic and vuggy porosity; patchy oil staining.
890.30-891.00	0.70	Mudstone: light brown; very finely crystalline; large solitary rugose corals and large brachiopods; anhydrite-healed vertical fractures; very poor pinpoint porosity; patchy heavy oil staining.

Appendix II (Continued)

Tundra et al. Tilston
14-09-006-29 WPM
KB: 508.10 m

Cored Interval: **926.00-944.00 m**

Perforated Interval: **931.00-933.00 m**

Interval (m)	Thickness (m)	Description
926.00-929.00	3.00	Dolomitic Anhydrite: anhydrite (60% of interval), dolostone (40% of interval); light brown to buff, light grey; dense; solitary rugose corals, very small brachiopods, crinoids; light grey anhydrite as infill, stringers and massive.
929.00-929.70	0.70	Wackestone: light brown; solitary rugose corals, crinoids and rare, small brachiopods; very poor pinpoint porosity; heavy patchy oil staining.
929.70-936.40	6.70	Packstone: light brown; fragmental; abundant crinoids and small solitary rugose corals throughout, occasional brachiopods and colonial corals (*Syringoporid*); anhydrite-healed thin horizontal fractures; fair pinpoint, intramoldic and vuggy porosity; patchy oil staining.
936.40-939.40	3.00	Wackestone to Packstone: light brown to buff; crinoids, brachiopods and rare solitary rugose corals; occasional stylolitic partings; fair pinpoint and intramoldic porosity; light patchy oil staining throughout.
939.40-942.27	2.87	Mudstone: light brown to buff; grades near base to wackestone; occasional grey-green shale laminae; occasional brachiopods and solitary rugose corals and rare gastropods; occasional stylolitic partings; occasional disseminated pyrite; poor pinpoint porosity.
942.27-944.00	1.73	Wackestone with Shale interbeds: *Wackestone*: light brown; occasional colonial corals (*Acrocyathus*), brachiopods, solitary rugose corals and crinoids; poor pinpoint porosity. *Shale interbeds (up to 2 cm thick and as laminae):* grey-green; calcareous; non-fossiliferous.

Appendix III: List of Drill Stem Tests and Results, MC-1 Member, Mission Canyon Formation, Southwestern Manitoba (to December 31, 1998).

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
10-21-001-23 WPM	1082		D&A	3353 ft. (1022.0 m)	3351-3386 ft. (1021.4-1032.1 m) REC: 720 ft. (219 m) salt water, and 180 ft. (55 m) slightly oil flecked mud.	914.0-916.0 m
03-05-001-24 WPM	2755	03 44G	ABD OIL Producer	912.0 m	913.0-917.0 m REC: 116 m gas cut oil, and 11 m gas cut mud.	912.0-914.0 m
04-05-001-24 WPM	2943	03 44G	ABD OIL Producer	910.2 m	911.0-914.5 m REC: 36 m gassy oil cut mud, 95 m gassy oil, 2 m salt water, and 9 m gassy oil cut mud.	917.0-918.0 m
11-06-001-24 WPM	3703		ABD OIL Producer	902.7 m	906.0-909.0 m REC: 47 m salt water and gas cut mud,47 m mud, 76 m gassy oil cut mud, and 61 m mud.	906.0-907.2 m
04-12-001-24 WPM	4575	99 44F	OIL Producer	940.0 m	941.0-948.0 m REC: 20 m oil cut mud.	941.5-946.0 m

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
10-14-001-24 WPM	4625		OIL Producer	920.0 m	922.5-926.0 m REC: 19 m salt water, 29 m oil cut mud, and 28 oil cut water cut mud.	
01-28-001-24 WPM	1861	99 44	Salt Water Disposal	2920 ft. (890.0 m)	2925-2942 ft. (891.5-896.7 m) REC: 15 ft. (5 m) mud, and 113 ft. (34 m) slightly oil flecked salt water cut mud.	
02-33-001-24 WPM	2044	99 44B	OIL Producer	2808 ft. (855.9 m)	2860-2888 ft. (871.7-880.3 m) REC: 30 ft. (9 m) mud, 68 ft. (21 m) gas cut mud, and 200 ft. (61 m) gas cut oil flecked mud. 2890-2911 ft. (880.9-887.3 m) REC: 138 ft. (42 m) clean salt water, 243 ft. (74 m) gas cut oil cut salt water, and 180 ft. (55 m) gassy mud.	2863-2866 ft. (872.6-873.6 m) 2871-2873 ft. (875.1-875.7 m) 2875-2877 ft. (876.3-876.9 m) 2879-2880 ft. (877.5-877.8 m) 2871-2873 ft. (875.1-875.7 m) 2880-2884 ft. (877.8-879.0 m) 2864-2886 ft. (872.9-873.7 m) 2863-2873 ft. (872.6-875.7 m)
08-33-001-24 WPM	2081	99 44B	OIL Producer	2878 ft. (877.2 m)	2873-2885 ft. (875.7-879.3 m) REC: 45 ft. (14 m) oil cut mud. 2885-2895 ft. (879.3-882.4 m) REC: 215 ft. (66 m) gas cut mud cut oil, and 5 ft. (2 m) salt water. 2895-2902 ft. (882.4-884.5 m) REC: 321 ft. (98 m) gassy mud cut oil, and 20 ft. (6 m) salt water.	2885-2887 ft. (879.3-880.0 m)

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
11-16-001-25 WPM	2486		D&A	3025 ft. (922.0 m)	3032-3046 ft. (924.2-928.4 m) REC: 15 ft. (5 m) oil, and 575 ft (175 m) salt water.	
13-18-001-25 WPM	853	03 44B	ABD OIL Producer	3015 ft. (919.0 m)	3061-3078 ft. (933.0-938.2 m) REC: 1200 ft. (366 m) gassy oil, 260 ft (79 m) mud cut oil, 100 ft. (30 m) salt water, and 60 ft. (18 m) gassy oil cut mud.	3048-3051 ft. (929.0-930.0 m) 3061-3065 ft. (933.0-934.2 m)
02-22-001-25 WPM	2299	03 44C	ABD OIL Producer	2982 ft. (909.0 m)	2986-3000 ft. (910.1-914.4 m) REC: 310 ft. (94 m) heavy gassy oil, 60 ft. (18 m) mud, and 240 ft. (73 m) gassy oil flecked mud. 2990-3025 ft. (911.4-922.0 m) REC: 620 ft. (189 m) gassy oil cut water, 530 ft. (162 m) salt water, 60 ft. (18 m) mud, and 260 ft. (79 m) gassy oil flecked mud.	
02-27-001-25 WPM	3062	03 44F	ABD OIL Producer	902.0 m	903.0-908.0 m REC: 26 m gassy oil, and 10 m gassy oily mud.	902.0-904.0 m 905.0-906.0 m

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
01-30-001-25 WPM	1183	03 44A	ABD OIL Producer	3005 ft. (916.0 m)	3014-3035 ft. (918.7-925.1 m) REC: 300 ft. (91 m) clean oil, 300 ft. (91 m) salt water, and 30 ft. (9 m) mud. 3016-3029 ft. (919.3-923.2 m) REC: 155 ft. (47 m) clean oil, 90 ft. (27m) salt water, and 40 ft. (12 m) oil flecked mud.	
09-13-001-26 WPM	184	03 44B	ABD OIL Producer	3018 ft. (920.0 m)	3000-3034 ft. (914.4-924.8 m) REC: 60 ft. (18 m) gas cut oil cut mud. 3033-3063 ft. (924.5-933.6 m) REC: 300 ft. (91 m) gas cut oil, 100 ft. (31 m) gas cut oil & salt water, and 200 ft. (61 m) gas cut oil cut mud. 3061-3101 ft. (933.0-945.2 m) REC: 300 ft. (91 m) mud cut water, 1300 ft. (396 m) slightly oil flecked salt water, and 1000 ft. (305 m) water cut mud.	3028-3034 ft. (922.9-924.7 m) 3034-3040 ft. (924.8-926.6 m)
A9-13-001-26 WPM	2635	03 44B	OIL Producer	920.0 m	924.0-932.1 m REC: 58 m heavily gas cut oil cut mud, and 18 m gas cut water cut mud.	927.0-930.0 m

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
16-13-001-26 WPM	256		D&A	3031 ft. (924.0 m)	3021-3046 ft. (920.8-928.4 m) REC: 95 ft. (29 m) slightly gassy oil cut mud. 3045-3080 ft. (928.1-938.8 m) REC: 570 ft. (174 m) oil, 120 ft. (37 m) water, and 60 ft. (18 m) mud.	
16-13-001-26 WPM	2636	03 44B	ABD OIL Producer	924.0 m	922.0-934.0 m REC: 58 m gassy mud cut oil, 93 m oil cut gassy mud.	921.0-926.0 m 926.0-934.0 m 927.0-927.5 m
13-03-002-23 WPM	2775		D&A	953.0 m	953.0-957.0 m REC: 20 m oil cut mud.	
02-31-002-23 WPM	4084	99 44A	OIL Producer	825.0 m	818.0-834.0 m REC: 191 m gassy oil, and 75 m salt water.	829.3-831.0 m
08-31-002-23 WPM	2706	99 44A	OIL Producer	812.0 m	811.0-827.0 m REC: 56 m gassy oil flecked mud, and 57 m gassy oil cut mud.	829.5-832.0 m 821.5-824.0 m 812.0-815.5 m 816.5-818.5 m
09-31-002-23 WPM	3140	99 44A	ABD OIL Producer	815.2 m	820.0-830.0 m REC: 47 m mud cut oil, 179 m frothy oil, and 19 m dirty muddy water.	821.0-823.0 m 825.0-827.0 m

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
10-31-002-23 WPM	1580		D&A	2700 ft. (823.0 m)	2715-2730 ft. (827.5-832.1 m) REC: 30 ft. (9 m) muddy salt water, and 55 ft. (17 m) gassy oil cut mud.	
11-32-002-23 WPM	3379		D&A	826.5 m	830.0-837.0 m REC: 24 m muddy water, and 3 m slightly oil cut mud.	
12-32-002-23 WPM	2995	99 44A	ABD OIL Producer	822.0 m	825.0-833.0 m REC: 143 m gassy oil & mud, 73 m salt water & mud, and 36 m gassy oil cut mud.	
15-11-002-24 WPM	3993		D&A	867.1 m	870.0-875.0 m REC: 9 m oil, and 110 m salt water.	
10-12-002-25 WPM	2874		D&A	880.00 m	881.0-886.5 m REC: 140 m slightly oil cut salt water.	
13-08-002-25 WPM	3347		Water Injector	894.0 m	897.5-902.5 m REC: 2 m oil, and 24 m slightly oil flecked muddy salt water.	
04-13-002-25 WPM	2875		D&A	874.0 m	880.0-884.0 m REC: 18 m slightly oil cut water, 211 m salt water, and 36 m water cut gassy oil cut mud.	

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
11-14-002-25 WPM	4234		D&A	880.0 m	882.0-885.0 m REC: 19 m gassy mud cut oil, 36 m salt water, and 19 m gassy oil cut mud.	
02-35-002-26 WPM	2764		D&A	880.0 m	885.0-892.0 m REC: 57 m oil cut salt water, 122 m salt water, and 29 m gassy oil cut mud.	
13-04-003-23 WPM	1962		D&A	2686 ft. (818.7 m)	2686-2779 ft. (818.7-847.0 m) REC: 1490 ft. (454 m) gassy mud cut oil flecked salt water, and 930 ft. (284 m) gassy oily salt water.	
16-02-003-26 WPM	3666	99 44D	ABD OIL Producer	878.5 m	881.0-887.0 m REC: 16 m oil, and 15 m oily mud.	885.5-887.0 m 881.0-882.0 m 883.5-884.5 m 880.5-882.5 m
04-22-003-28 WPM	3279	07 43B	OIL Producer	978.0 m	966.0-979.5 m REC: 28 m gassy oil cut mud.	
04-25-003-28 WPM	3222	07 44A	ABD OIL Producer	948.0 m	946.0-952.0 m REC: 20 m oil, and 40 m oil cut mud.	948.0-949.8 m 952.0-952.3 m 948.3-949.3 m

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
11-21-003-29 WPM	3445		D&A	1014.0 m	1013.0-1020.0 m REC: 290 m gassy oil, 300 m water, and 10 m gassy oil cut water.	1015.2-1017.0 m
01-11-004-29 WPM	360		D&A	3160 ft. (963.2 m)	3157-3225 ft. (962.3-983.0 m) REC: 120 ft. (37 m) muddy salt water, 30 ft. (9 m) mud, and 120 ft. (37 m) slightly oil flecked mud.	
09-32-005-27 WPM	2049		D&A	2733 ft. (833.0 m)	2754-2785 ft. (839.4-848.9 m) REC: 175 ft. (53 m) slightly oil flecked mud. 2754-2795 ft. (839.4-851.9 m) REC: 473 ft. (144 m) oil flecked salt water, and 210 ft. (64 m) mud.	
10-29-005-29 WPM	4543		D&A	941.5 m	943.0-950.0 m REC: 9 m gassy oil, and 170 m gassy oily salt water.	
03-30-005-29 WPM	3025	02 44A	ABD OIL Producer	947.0 m	950.0-954.5 m REC: 2 m oil, 18 m salt water, 2 m mud, and 1 m gassy mud.	952.0-953.5 m
15-30-005-29 WPM	3057	02 44A	OIL Producer	940.0 m	945.0-951.0 m REC: 1 m slightly oil flecked mud, and 8 m mud.	947.0-949.0 m

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
03-31-005-29 WPM	2844	02 44A	OIL Producer	935.0 m	940.0-948.0 m REC: 235 m gassy oil, and 60 m gassy oil cut mud.	944.5-946.0 m
08-31-005-29 WPM	908	02 44A	ABD OIL Producer	3054 ft. (931.0 m)	3096-3107 ft. (943.7-947.0 m) REC: 325 ft. (99 m) oil, 180 ft. (55 m) mud cut oil, and 5 ft. (2 m) salt water.	3103-3107 ft. (945.8-947.0 m) 3077-3087 ft. (937.9-940.9 m)
09-31-005-29 WPM	402	02 44A	ABD OIL Producer	3097 ft. (944.0 m)	3090-3100 ft. (941.8-944.9 m) REC: 15 ft. (5 m) mud. 3100-3110 ft. (944.9-947.9 m) REC: 1470 ft. (448 m) clean gassy oil, and 90 ft. (27 m) heavy oil cut mud.	3109-3112 ft. (947.6-948.5 m) 3107-3112 ft. (947.0-948.5 m)
11-31-005-29 WPM	1668	02 44A	ABD OIL Producer	3074 ft. (937.0 m)	3090-3100 ft. (941.8-944.9 m) REC: 20 ft. (6 m) gas cut oily mud. 3096-3106 ft. (943.7-946.7 m) REC: 65 ft. (20 m) gassy oil cut mud.	3094-3108 ft. (943.1-947.3 m)

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
05-32-005-29 WPM	181	02 44A	ABD OIL Producer	3097 ft. (944.0 m)	3090-3108 ft. (941.8-947.3 m) REC: 1600 ft. (488 m) mud cut oil, 550 ft. (168 m) mud cut water, and 350 ft. (107 m) oil cut mud. 3090-3113 ft. (941.8-948.8 m) REC: 2400 ft. (732 m) mud cut oil; 200 ft. (61 m) water, and 500 ft. (152 m) oil cut water cut mud. 3121-3131 ft. (951.3-954.3 m) REC: 100 ft. (31 m) slightly oil cut mud, and 250 ft. (76 m) gas cut mud.	3110-3122 ft. (947.9-951.6 m) 3108-3112 ft. (947.3-948.5 m)
12-32-005-29 WPM	365	02 44A	OIL Producer	3042 ft. (927.2 m)	3089-3111 ft. (941.5-948.2 m) REC: 1480 ft. (451 m) clean oil, and 930 ft. (283 m) salt water. 3044-3111 ft. (927.8-948.2 m) REC: 1000 ft. (305 m) clean oil, 200 ft. (61 m) oil emulsion, and 750 ft. (229 m) oily mud.	3067-3100 ft. (934.8-944.9 m) 3068-3072 ft. (935.1-936.3 m) 3070-3074 ft. (935.7-937.0 m)
14-32-005-29 WPM	4156	02 44A	ABD OIL Producer	935.0 m	937.0-943.5 m REC: 386 m gassy oil, and 347 m salt water. 937.0-940.5 m REC: 24 m gassy oil, 15 m mud cut oil, and 6 m oil cut mud.	938.5-940.0 m

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
04-06-006-26 WPM	4665		Standing	794.0 m	801.0-807.0 m REC: 1 m mud, 10 m oil cut mud, 30 m oil flecked mud, and 32 m oil flecked mud.	801.0-805.0 m
03-09-006-26 WPM	4668		D&A	765.0 m	776.0-792.0 m REC: 40 m muddy water, 137 m water, and 40 m slightly oil flecked mud. 770.0-778.5 m REC: 2 m water, 9 m oil flecked mud, 9 m oil cut mud, and 10 m slightly oil flecked mud.	
15-09-006-26 WPM	4669	99 44G	OIL Producer	754.0 m	759.0-764.5 m REC: 17 m gassy oil, and 100 m gassy oil flecked mud.	761.0-763.0 m
03-04-006-27 WPM	3090		D&A	829.0 m	839.0-844.0 m REC: 38 m salt water, 9 m oil cut mud, and 18 m salt water cut mud.	
10-04-006-27 WPM	2368		D&A	2746 ft. (837.0 m)	2750-2768 ft. (838.2-843.7 m) REC: 100 ft. (30 m) oil flecked watery mud.	
09-05-006-27 WPM	1874		D&A	2773 ft. (845.2 m)	2781-2797 ft. (847.6-852.5 m) REC: 80 ft. (24 m) muddy salt water, and 10 ft. (3 m) oil flecked mud.	

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
12-09-006-27 WPM	3155		D&A	2736 ft. (834.0 m)	2744-2772 ft. (836.4-845.0 m) REC: 272 ft. (83 m) slightly frothy oil cut mud.	2746-2749 ft. (837.0-838.0 m) 2753-2766 ft. (839.0-843.0 m) 2779-2779 ft. (847.0-847.0 m)
16-06-006-28 WPM	4433	99 44	OIL Producer	898.0 m	904.5-907.5 m REC: 92 m gassy mud cut oil, 36 m salt water, and 19 m oil cut mud.	905.0-908.0 m 904.8-906.3 m
05-08-006-28 WPM	4535	99 44	OIL Producer	892.0 m	902.3-906.5 m REC: 340 m oil, and 360 m salt water. 895.0-902.3 m REC: 60 m oil, and 20 m mud cut oil.	896.5-901.0 m
08-10-006-28 WPM	4568		D&A	870.0 m	879.0-883.0 m REC: 1 m oil, 53 m salt water, and 9 m mud.	
03-13-006-28 WPM	3150		D&A	853.0 m	854.0-862.5 m REC: 34 m slightly oil cut mud.	860.5-861.5 m 855.8-856.5 m
04-05-006-29 WPM	1696	02 44A	ABD OIL Producer	3071 ft. (936.0 m)	3081-3127 ft. (939.1-953.1 m) REC: 1200 ft. (366 m) oily salt water, and 600 ft. (183 m) mud. 3081-3104 ft. (939.1-946.1 m) REC: 60 ft. (18 m) clean oil, 540 ft. (165 m) gassy muddy oil, and 60 ft. (18 m) salt water.	3081-3086 ft. (939.0-940.6 m) 3081-3084 ft. (939.0-940.0 m)

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
01-06-006-29 WPM	1522	02 44A	OIL Producer	3061 ft. (933.0 m)	3068-3096 ft. (935.1-943.7 m) REC: 1650 ft. (503 m) clean oil, and 90 ft. (27 m) muddy oil.	
08-06-006-29 WPM	2588	02 44C	D&A	3094 ft. (943.0 m)	3090-3122 ft. (941.8-951.6 m) REC: 100 ft. (30 m) slightly oil cut mud.	
09-06-006-29 WPM	3396	02 44C	ABD OIL Producer	933.0 m	938.0-944.0 m REC: 55 m oil, 55 m muddy salt water, and 190 m oil cut mud.	939.0-940.0 m
07-08-006-29 WPM	2143		D&A	3071 ft. (936.0 m)	3070-3130 ft. (935.7-954.0 m) REC: 350 ft. (107 m) slightly watery oil flecked mud. 3078-3088 ft. (938.2-941.2 m) REC: 16 ft. (5 m) oil flecked mud, and 60 ft. (18 m) oil cut mud.	
05-09-006-29 WPM	3169	02 44C	OIL Producer	924.0 m	932.0-940.0 m REC: 52 m gas cut oil, 18 m frothy water, and 126 m oil cut mud.	934.0-937.0 m
12-09-006-29 WPM	3074		ABD OIL Producer	925.5 m	934.0-938.8 m REC: 38 m slightly mud cut oil, 15 m muddy water, and 107 m frothy oil cut mud.	935.0-937.5 m

Appendix III (Continued)

Location (WPM)	Licence #	Field/Pool Code	Well Status	MC-1 Top Depth	Drill Stem Test Interval and Results	MC-1 Perforated Interval
05-15-006-29 WPM	3337	02 44C	ABD OIL Producer	905.0 m	914.0-923.0 m REC: 19 m oily mud.	916.0-918.5 m
11-15-006-29 WPM	4475	02 44C	OIL Producer	901.0 m	904.0-911.0 m REC: 65 m gassy oil, 56 m frothy mud cut oil, and 18 m oil cut muddy water. 911.0-915.5 m REC: 65 m gassy oil, 65 m frothy mud cut oil, 16 m mud cut oil, and 18 m water.	907.0-910.5 m
14-15-006-29 WPM	4540		D&A	907.0 m	917.0-922.0 m REC: 58 m slightly oil cut salt water, 114 m slightly oil cut salt water, and 676 m salt water.	

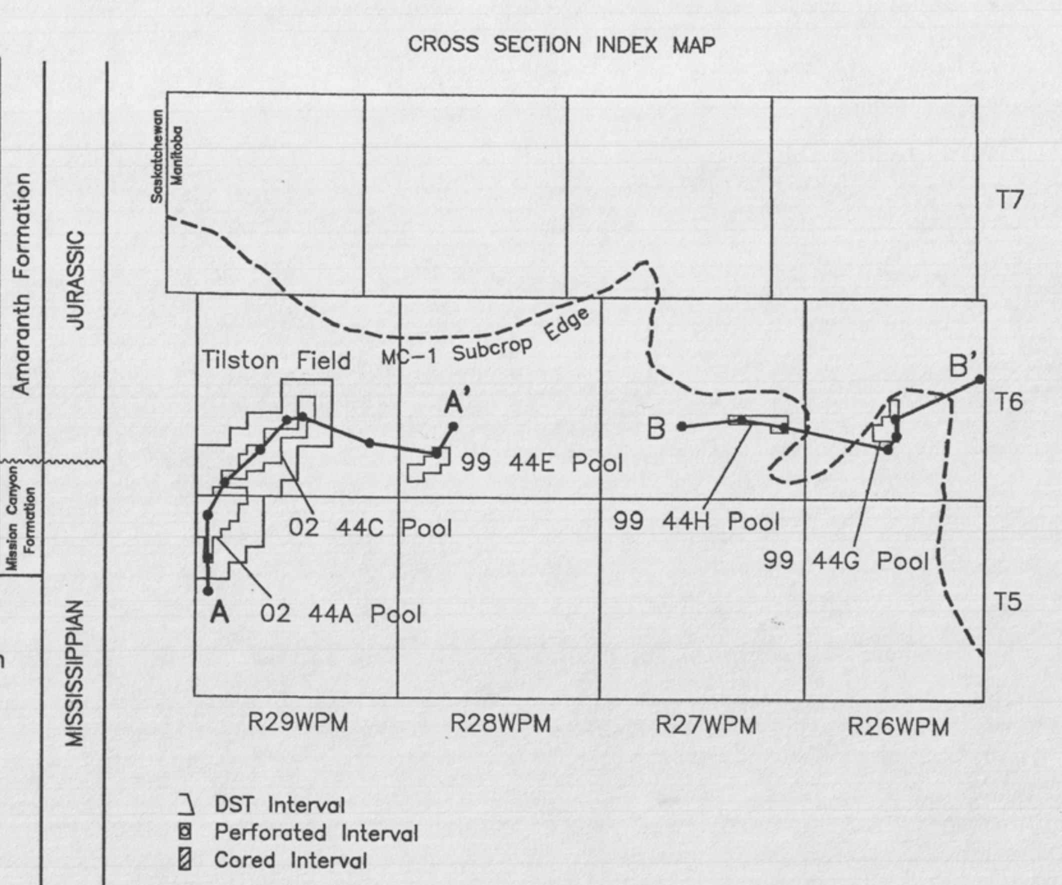

FIGURE 18:

STRUCTURAL CROSS SECTION A – A'

GEOLOGY, RESERVOIR CHARACTERISTICS, AND PETROLEUM POTENTIAL OF THE MC-1 MEMBER, MISSION CANYON FORMATION, SOUTHWESTERN MANITOBA.
Geology by : M.P.B. Nicolas and C.D. Martiniuk
Date: December 31, 1998

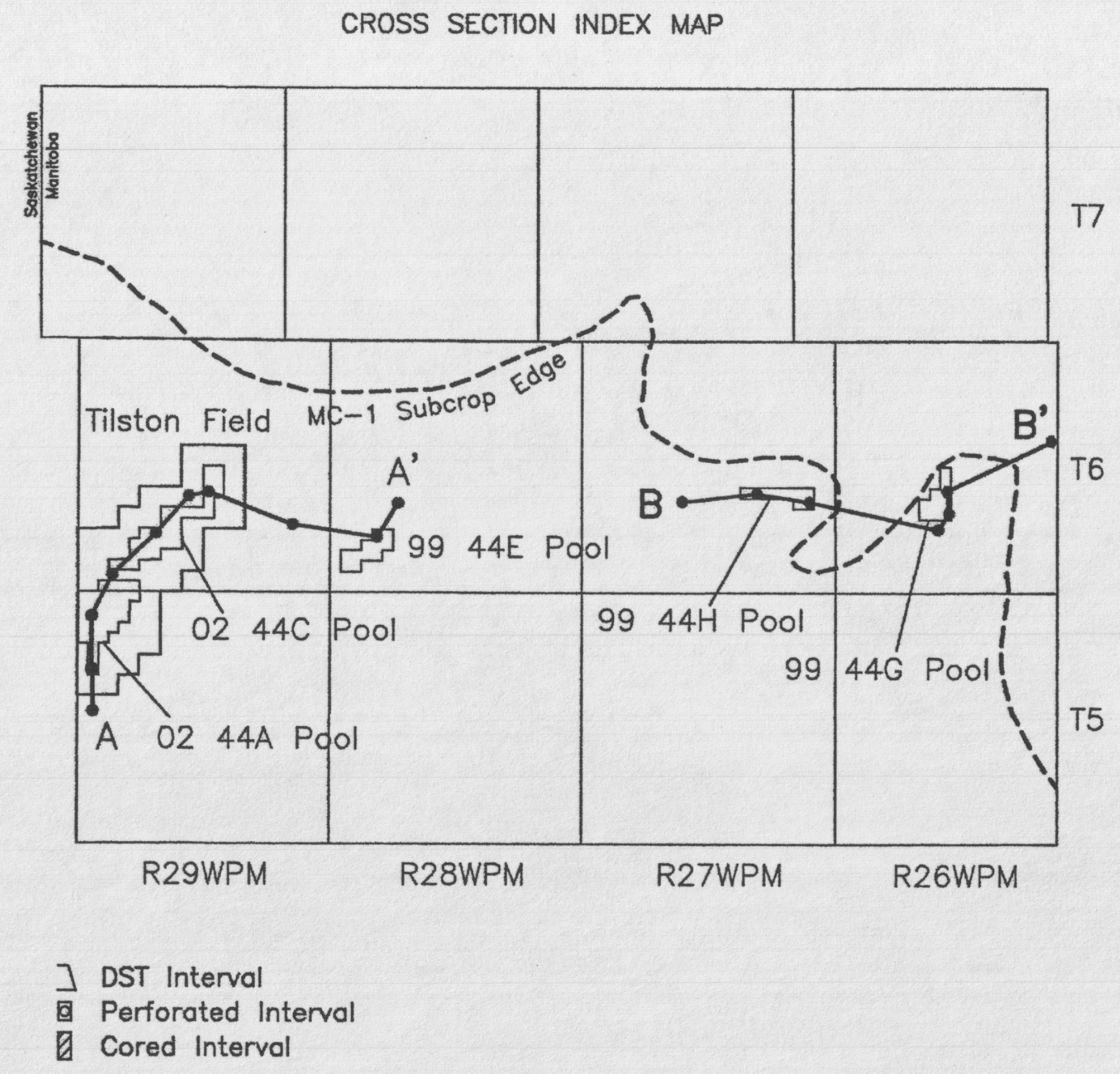

FIGURE 19:

STRUCTURAL CROSS SECTION B – B'

GEOLOGY, RESERVOIR CHARACTERISTICS, AND PETROLEUM POTENTIAL OF THE MC-1 MEMBER, MISSION CANYON FORMATION, SOUTHWESTERN MANITOBA.
Geology by: M.P.B. Nicolas and C.D. Martiniuk
Date: December 31, 1998