# Potash deposits in the Devonian Prairie Evaporite, southwestern Manitoba

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## Potash Geology

#### I. Introduction

The Prairie Evaporite is a thick Denonian-aged evaporitic sequence dominantly consisting of halite and anhydrite. It includes four potash-bearing members, from oldest to youngest they are: the Esterhazy, White Bear, Belle Plain and Patience Lake members. Of these four members, only the Esterhazy and White Bear extend into Manitoba (Figure 1). The Esterhazy Member is the only potash bed in Manitoba with sufficient thickness and grade to sustain potentially economic underground potash mining. The ore grade and tonnages measured in Manitoba's Esterhazy Member are comparable to nearby, active, long-lived potash mines in Saskatchewan. Nearby mines include Potash Corporation of Saskatchewan's (PCS) Rocanville mine and The Mosaic Company's Esterhazy K1 and K2 mines

salt distribution

potash + salt distribution

eastern limit of the

0 10 20 30 40

wells that penetrate the

Russell-McAuley

potash area

Daly-Sinclair potash area

Figure 3: Map of southwestern Manitoba showing the

distribution of the salt and potash + salt, oil fields and wells

potash occurrence are shown, as are the northern (Russell

to the eastern limit of the salt and potash + salt distribution

deposit) and southern (St. Lazare deposit) blocks of the

4. Potash occurrences

14 to 21, ranges 27 to 29W1;

11, ranges 27 to 29W1; and

areas. (from Nicolas, 2015)

Prairie Evaporite (Figure 3):

indicates section with missing core.

that penetrate the Prairie Evaporite. The three mains areas of

Russell-McAuley area. The salt distribution edge is equivalent

The known area of potash occurrence in Manitoba can

1) the Russell-McAuley area, covering townships

2) the Daly-Sinclair area, covering townships 5 to

3) the Pierson area, occurring in township 1,

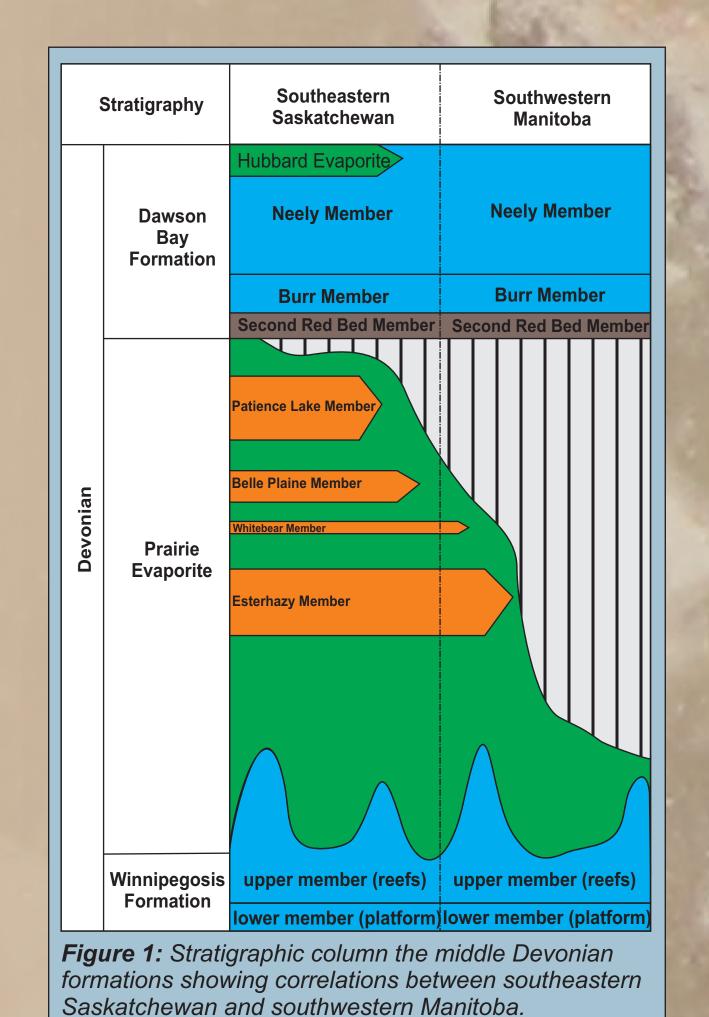
The only area that has been actively explored for

be subdivided into three subareas that are separated from

each other by broad areas with no potash occurrence in the

The known area of potash occurrence in Manitoba can be subdivided into three subareas that are separated from the others by broad areas with no potash occurrence in the Prairie Evaporite (Figure 3). These areas total approximately 2,247 km<sup>2</sup> of known, potentially mineable, potash occurrences.

Exploration for potash in Manitoba has been intermittent for many decades since potash exploration targeting the eastern extension of the prolific Saskatchewan deposits started in 1959. Drillhole and coring programs, supported by 2-D and 3-D seismic surveys, indicate that Manitoba has potentially economically mineable, sizable potash deposits with geological conditions similar to those in Saskatchewan.



potash is the Russell-McAuley area, where the Esterhazy Member is of sufficient thickness and grade to sustain potentially economic underground potash mining. The Daly-Sinclair and Pierson areas have not been explored due to the development of petroleum resources, which precludes the co-development of potash resources. Accordingly, there are no resource estimates for these areas. Russell-McAuley Potash Property

Figure 2: Geological map showing the eastern edge of the Prairie Evaporite salt dissolution front (red), and the eastern edge of the known potash area (yellow), drillholes that penetrate the Prairie Evaporite, and location of nearby potash mines in southeastern Saskatchewan.

Potash Mine Locations

Drillholes Penetrating Prairie Evaporite

Interpreted Eastern Potash Edge

---- Interpreted Eastern Salt Edge

Oil Fields

#### 2. Regional and Local Geology

In Manitoba, the Paleozoic-, Mesozoic- and Cenozoic-age strata form a basinward-thickening, southwesterly-sloping wedge, with the strata reaching a total thickness of 2.3 km in the extreme southestern corner of Manitoba (Figure 4). The sequences within this sedimentary package were deposited in two sedimentary basins, the Williston Basin and the Elk Point Basin, both of which are subbasins of the Western Canada Sedimentary Basin. The potash-bearing Devonian-age Prairie Evaporite was deposited within the Elk Point Basin (Figure 5). This formation overlies the carbonate rocks of the Winnipegosis Formation, and is overlain by the Second Red Bed Member at the base of the Dawson Bay Formation (Figure 1). The Prairie Evaporite consists mainly of thick halite beds, with minor anhydrite and four localized potash beds. Within the basin, the formation can exceed 210 m in thickness, and lies at depths of 200 to 2,700 m below surface.

The overlying Second Red Bed Member of the Dawson Bay Formation consists of grey, brown and red shales and argillaceous mudstones, which are overlain by limestone, dolomite and some interbedded anhydrite. The underlying Winnipegosis Formation consists of interbedded dolomite, dolomitic limestone and anhydrite. Reef structures within the Winnipegosis Formation have been identified by seismic surveys. These project up into the overlying Prairie Evaporite in a number of locations and are shown schematically in Figure 4 and 6.

In Saskatchewan, the upper 60 m of the Prairie Evaporite carries four groups of potash-bearing beds which occur at depths of 600 to 2,500 m below surface. From bottom to top, these are the Esterhazy, White Bear, Belle Plaine and Patience Lake members (Figure 1). Each member consists of sylvite-rich beds, up to 7 m thick, separated by halite beds. The potash members tend to thin from northwest to southeast and occur at shallower depths in the eastern part of the basin than in the centre (Figure 6). The Esterhazy and White Bear members are the only members present in Manitoba (Figure 1, 6 and 7).

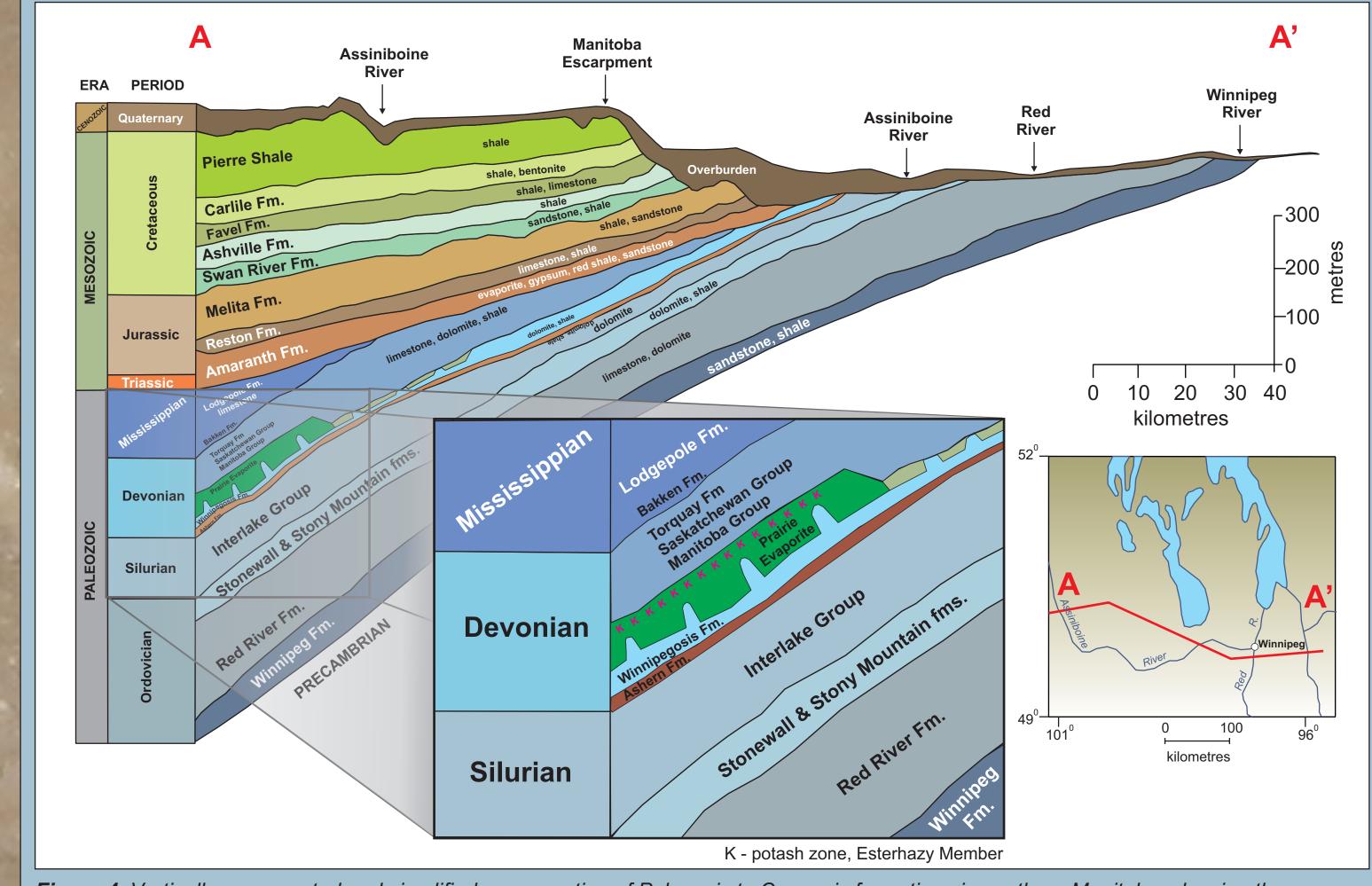
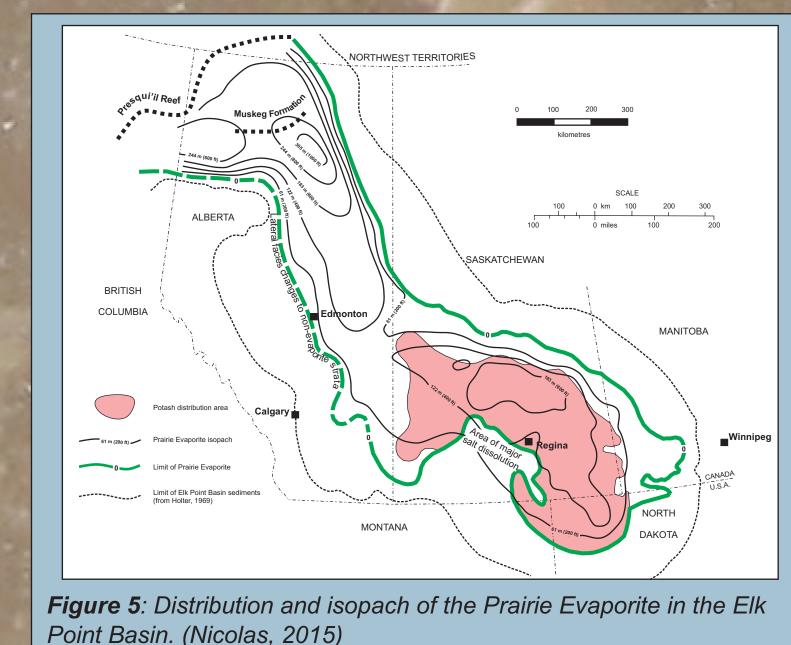
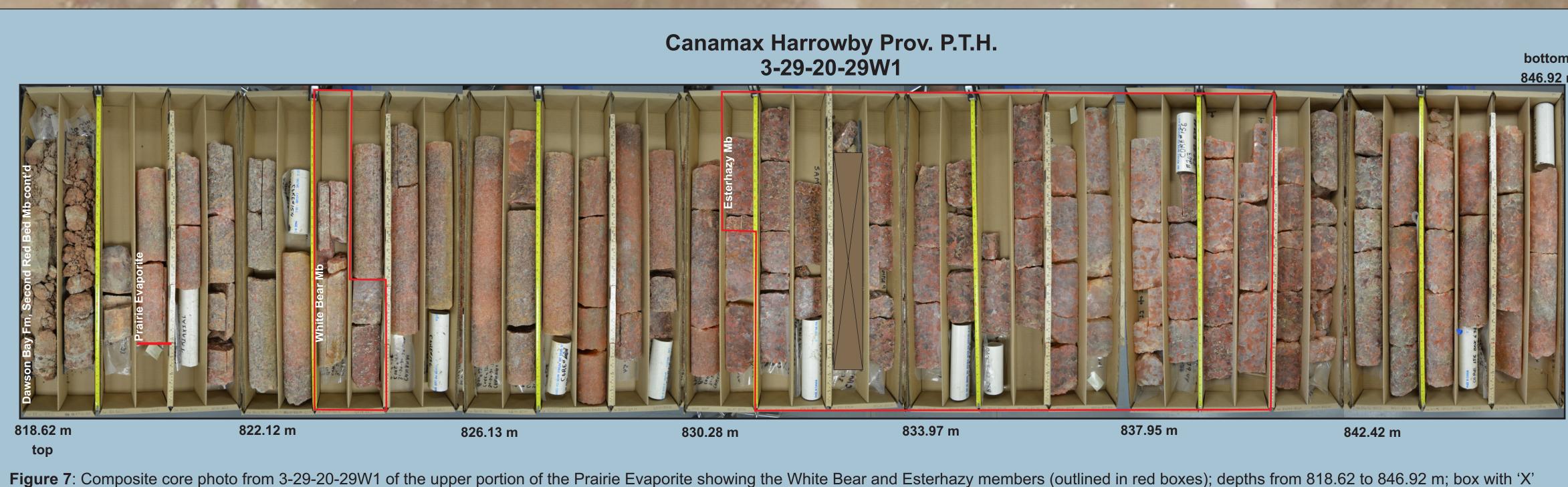


Figure 4: Vertically-exaggerated and simplified cross-section of Paleozoic to Cenozoic formations in southern Manitoba, showing the stratigraphy of the potash-bearing Prairie Evaporite, and underlying Winnipegosis and Ashern Formations. (Modified from Bamburak and



Saskatchewan ! E, WB, BP, PL Esterhazy, White Bear, Belle Plaine and Patience Lake members, respectively Figure 6: Idealized east-west section through the Prairie Evaporite and adjacent rock units. (Nicolas, 2015)



#### 3. Esterhazy Member

The Esterhazy Member is the most economic potash beds It consists of euhedral to subhedal halite crystals with large anhedral sylvite crystals and minor interstitial carnolite and clays (Figure 7 and 8).

The Esterhazy Member is intermittently present in a narrow, elongate strip in southwestern Manitoba, from Township 5 to 21, Ranges 27 to 29 W1 (Figure x). The Prairie Evaporite salt dissolution edge runs roughly north-south from Township 1 to 29, through Range 27 W1, and represents the maximum eastern extent of salt (and therefore potash) occurrence (Figure 9). The potash beds dips gently to the southwestern at depths ranging between approximately 800 m near Russell in the north to approximately 1,000 m near McAuley in the south. Over the area of known potash occurrence in Manitoba, the thickness of the Esterhazy Member averages 5.6 m.

The Esterhazy Member in Manitoba compares favourably in grade, size and mining conditions to deposits supporting producing mines in southeastern Saskatchewan. Potash grades, and the content of insoluble minerals and carnallite, appear to be comparable to those in the Esterhazy Member in southeastern Saskatchewan where it is mined at depths of over 1,000 m. The Esterhazy Member is mined at the operations of PCS at Rocanville and at Mosaic's operations at Esterhazy, just west of the MPC land holdings. It is the only potash bed of potentially economic significance in Manitoba.

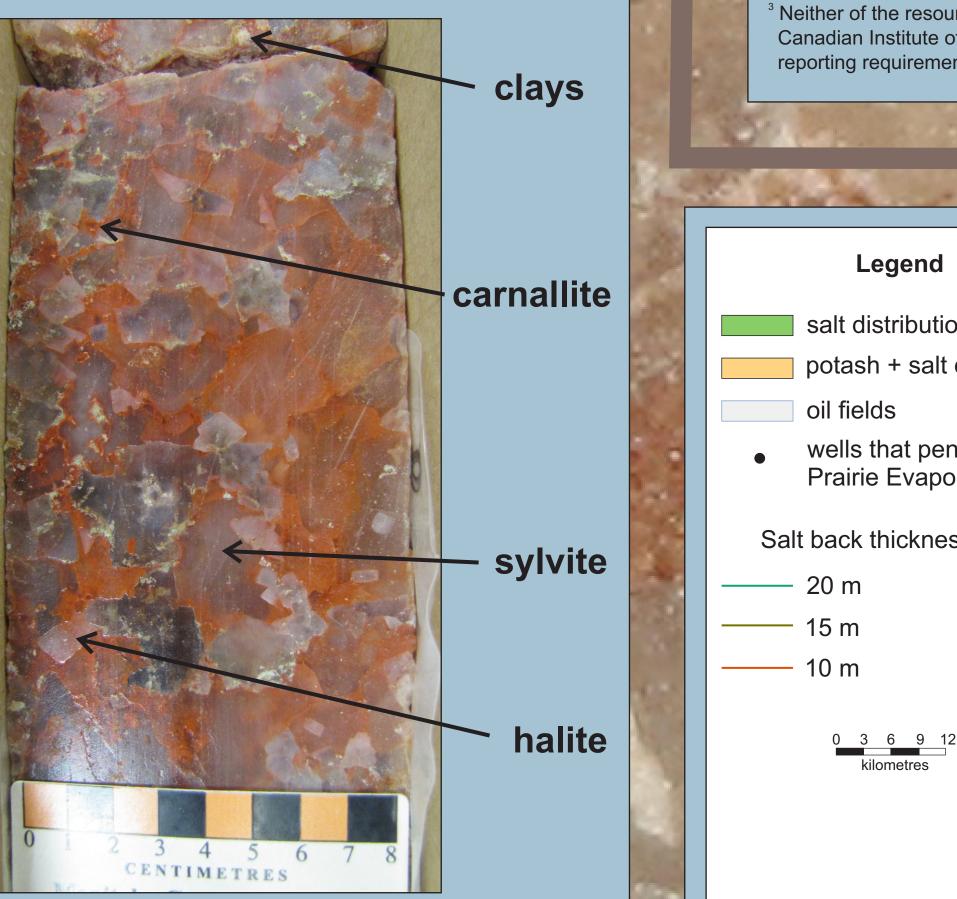


Figure 8: Core photograph of the Esterhazy Member, Prairie Evaporite, showing the potash ore zone of the St. Lazare deposit in 8-28-17-29W1; approximate depths are 915.3 to 916.03 m.

#### 5. Russell-McAuley Area

The potash deposits in the Russell-McAuley area are located between townships 14 and 21, ranges 27 and 29W1 (Figure 9), and are the most explored area for potash in the province. Within the project area, 41 potash/stratigraphic test drillholes penetrate the Prairie Evaporite, of which 30 have core through the potash beds. Additionally, there is a good cross-section of 2-D seismic lines and two 3-D seismic blocks. Depths to the top of the Prairie Evaporite in this area range from 785 to 1050 m. The isopach of the formation varies due to proximity to the dissolution edge but can measure up to 139 m thick (as measured by seismic in Assessment File 74426, Manitoba Mineral Resources, Winnipeg). The eastern dissolution edge in this area is well defined by 2-D seismic surveys

The deposits in the Russell-McAuley area are the only ootash deposits in Manitoba potentially amenable to conventional underground mining methods. Although the depth and grade of the deposits are comparable to those at Rocanville and Esterhazy in Saskatchewan, challenges to mine development include proximity of the area to the salt-dissolution edge; commensurate eastward decrease of the salt-back thickness (i.e., thickness of the salt between the top of the Esterhazy Member and the base of the Second Red Bed Member of the Dawson Bay Formation; Figure 9). Challenges that are not unique to Manitoba include geological anomalies, such as underlying Winnipegosis Formation reefs, salt-collapse structures and mineralogical impurities (insoluble minerals and carnallite). These challenges are demonstrated in Figure 10, where Winnipegosis reefs and a salt-collapse structure are easily imaged on seismic profiles.

From a potash-resource perspective, the Russell-McAuley area can be subdivided into two blocks: a northern block, referred to as the Russell deposit; and a southern block, referred to as the St. Lazare deposit (Figure 10). Both deposits are continuous into one another, the distinction between the two blocks simply reflects the extent of two long-standing potash dispositions held by competing companies.

### Potash Exploration

#### 6. Potash Resource

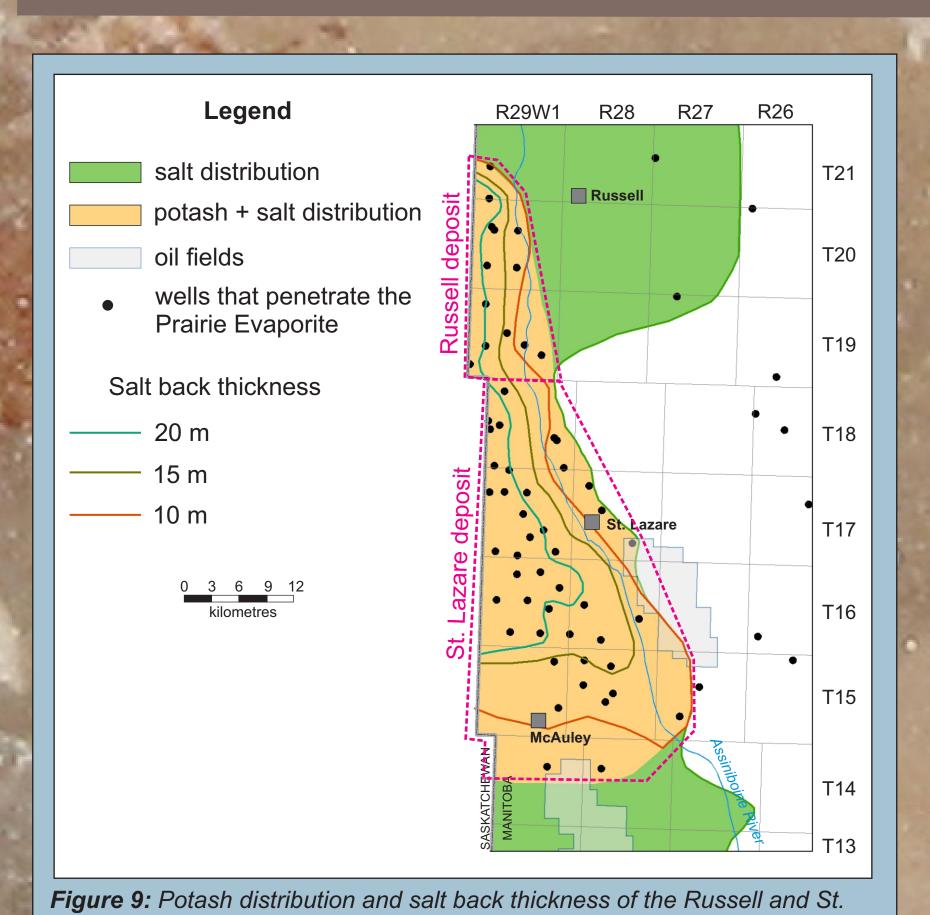
Formal mineral resource estimates have been prepared for the Russell deposit, most recently in 2009. A historical resource estimate for the St. Lazare deposit was prepared in 1983. **Table 1** summarizes the estimated resources for both the Russell and St. Lazare deposits. The estimated resources have not been combined since they were conducted at different periods using different parameters. The Russell-McAuley area has a robust resource potential for a long term, minimum 20 year, secure supply, at a rate of 2 Mt/y KCl, or higher.

 
 Table 1: Mineral resource estimates for the Russell and McAuley areas in
 southwestern Manitoba.

Area	Million tonnes <sup>3</sup>	Average grade (% K₂O)
Russell deposit <sup>1</sup>	392	22.5
St. Lazare deposit <sup>2</sup>	650	20.9

<sup>1</sup>BHP Billiton reports from ADM Consulting Ltd. and AMEC Americas Ltd. (2009) <sup>2</sup>Bannatyne (1983), 16% cut off grade

<sup>3</sup> Neither of the resource estimates has been reported using the definition standards of the Canadian Institute of Mining, Metallurgy and Petroleum and, therefore, do not meet the reporting requirements of Canadian National Instrument 43-101.



Lazare deposits in the Russell-McAuley area.

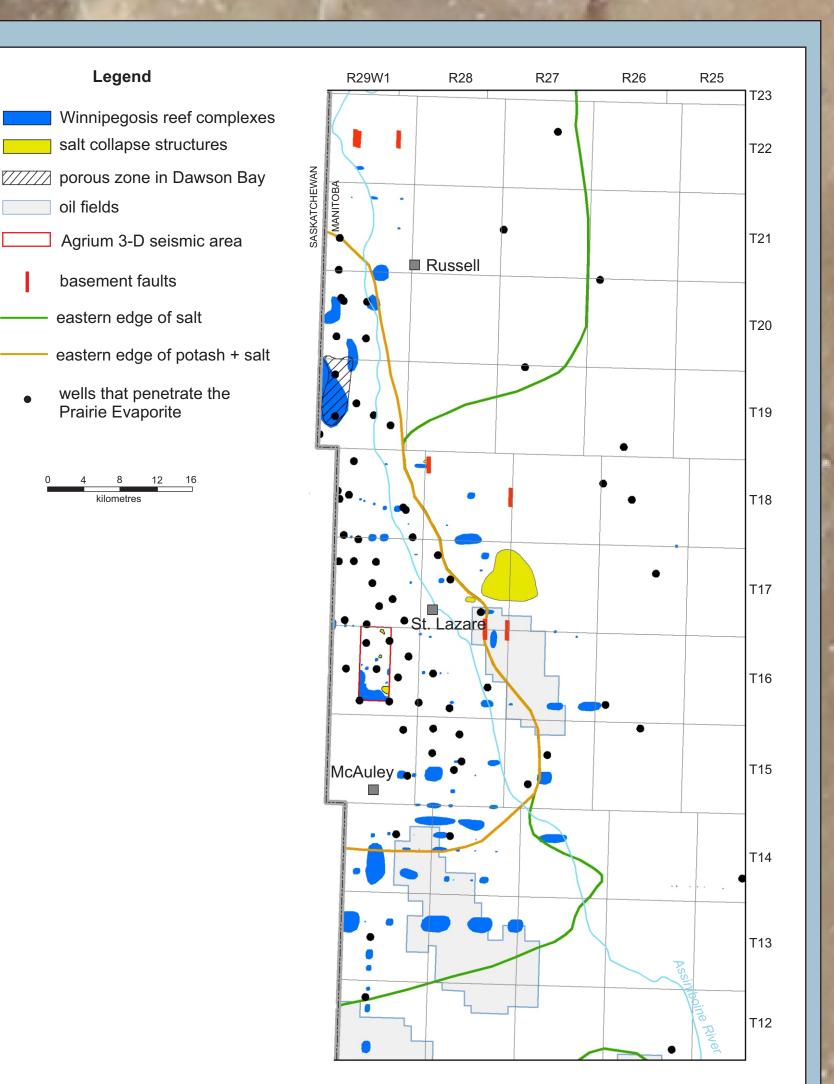


Figure 10: Compilation map of showing the location and size of Winnipegosis reefs and collapse structures and basement faults, as identified by 2-D and 3-D seismic surveys. Information compiled from assessment file 74426 and Gendzwill (unpublished report, 1986).

#### 7. Exploration History

The discovery of potash in Manitoba was in an oil well drilled in 1951 at 15-18-10-27W1. This discovery led to exploration programs by Sylvite of Canada and its predecessor companies resulting in a total of 10 holes drilled during several exploration programs between 1956 and 1966 between townships 17 and 19, range 29W1, in the northern portion of the St. Lazare deposit and southern extent of the Russell deposit.

The most extensive exploration campaign was conducted by Prairie Potash which drilled 15 holes between August 1964 and March 1966 and were focused in the St. Lazare deposit. Amax and Canamax focused exclusively on the Russell deposit, where eight holes were drilled between 1980 and 1986. Agrium held an exploration lease from 2005 to 2010 over the entire St. Lazare deposit. Western Potash drilled 9 exploratory wells in the perifery of the Russell-McAuley deposit in 2008.

In 2013, the crown potash area was amalgamated and is currently held by Manitoba Potash Corporation (MPC) (Figure 11). The MPC property has a combined exploration database for 40 holes that penetrate the Prairie Evaporite Formation, with additional data available for a number of other holes, both within and outside the property. There is also 2-D and 3-D seismic data available for certain areas in and around the Property.

In January 2015, MPC, assisted and advised by Micon International Limited and Manitoba Mineral Resources, initiated the divestiture process to sell MPC and its assets in the Russell-McAuley area. The phased divestiture process for MPC is ongoing. Micon has received a number of Expressions of Interest from interested parties, which will be assessed taking into consideration criteria such as industrial experience, capability, financial capacity, proposed exploration and resource evaluation, project development and marketing strategy and expected contribution to the economy of the province of Manitoba.

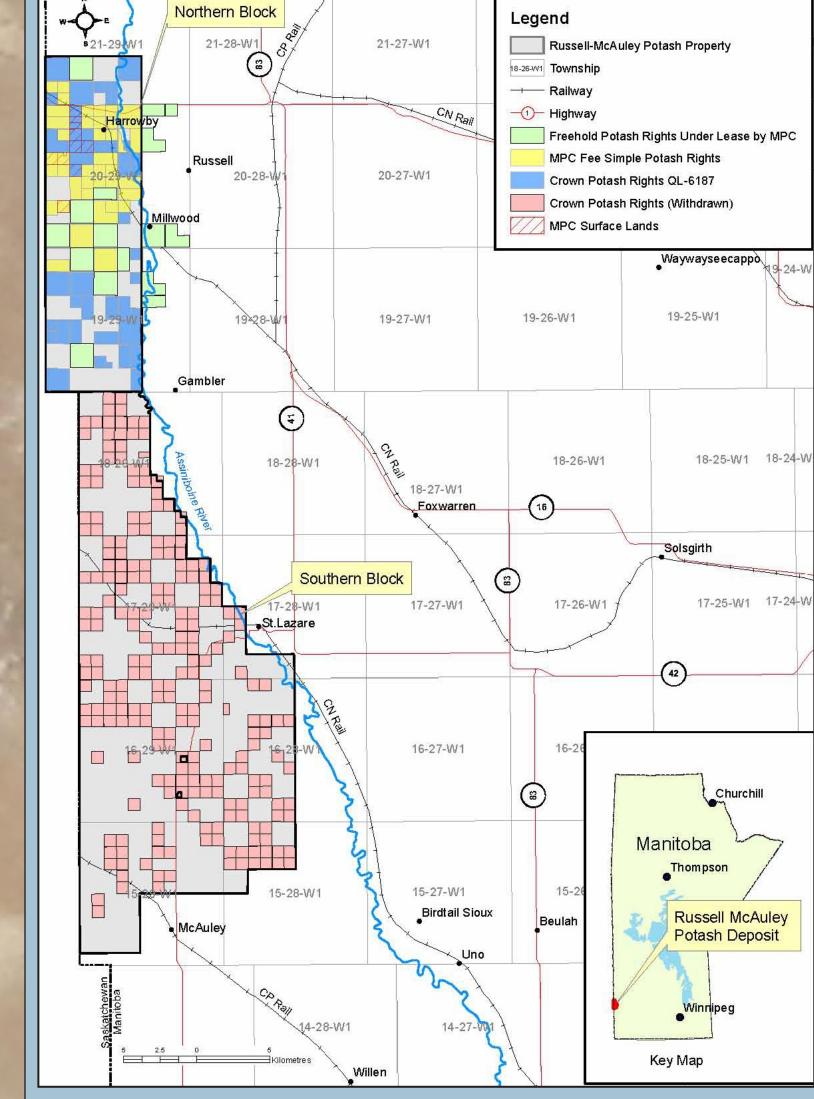


Figure 11: MPC property in the Russell-McAuley area, southwestern

#### Table 2: Detailed chronology of potash exploration in Manitoba.

Year	Deposit	Company	Details
1951	-	Imperial Oil	Discovery of potash at 15-18-10-27W1 near Virden.
1956-1966	St. Lazare	Sylvite of Canada S.A.M. Explorations Ltd. Francana Oil & Gas Ltd. Tombill Mines Ltd.	Sylvite and its predecessor companies Francana, S.A.M. and Tombill, drilled 10 exploration holes between Twp 17-19, Rge 29W1.
1964-1966	St. Lazare	Prairie Potash Mines Ltd.	South of the Sylvite area, Prairie Potash (owned by Canadian Nickel Co. Ltd. and Consolidated Faraday) drilled 15 holes. They conducted feasibility studies but the lease was allowed to lapse in 1977.
1968	St. Lazare	Sylvite of Canada	Sylvite let the exploration permit lapse in Manitoba to develop Saskatchewan mine (at Rocanville).
1980-1982	St. Lazare	IMC Ltd.	International Minerals & Chemical Corporation (Canada) Ltd. (IMC), predecessor to Mosaic, explored for potash south of the Sylvite program area. IMC dropped the program in 1982.
1980-1985	Russell	Amax Minerals Ltd. Canamax Resources Inc.	Amax was issued a 5-year permit in the Russell deposit (i.e. northern block), predecessor to Canamax; 8 exploration holes were drilled by the end of 1983.
1985	Russell	Canamax Resources Inc.	Canamax has Kilborn Ltd. undertake a preliminary engineering and economic evaluation of the Russell area deposit.
1986	Russell	Canamax Recources Inc. MPC	Canamax and the Government of Manitoba established Manitoba Potash Corporation (MPC); owed 51% by Canamax and 49% by Government of Manitoba. Kilborn prepared a technical feasibility study on the Russell deposit and completed it in October 1987.
1989	Russell	EMC Potamine Potash Mining Company of Canada Inc.	Entreprise Minière et Chimique (EMC) bought the Canamax interest in MPC. EMC established Potamine for its interest in MPC.
1995	Russell	Potamine	Potamine (though Gemmes and MDPA Ingénierie) carried out a critical review of the Kilborn feasibility study and ran a 3-D seismic study of the area.
1997	Russell	EMC	EMC in unwilling to proceed with the Russell project due to flooding in its Clover Hill potash mine in New Brunswick.
2006	Russell	Potamine BHP Billiton MPC	Potamine's interest in MPC is acquired by BHP Billiton. North Rim Exploration Ltd. prepared a mineral resource estimate for the Russell deposit (northern block). AMEC America's Limited prepares a high level conceptual development study on the Russell project.
2005-2010	St. Lazare	Agrium Inc.	Agrium Inc. gets a 5-year 45,000 hectare potash exploration permit (QP-154) in the St. Lazare area. Agrium cancels their Manitoba permit in favour of other projects.
2009	Russell	ADM Consulting Inc.	ADM Consulting Inc. completes a resource estimate for the Russell deposit.
2007-2009	St. Lazare	Western Potash	Western Potash Corp. held three potash exploration permits adjacent to the eastern and southern boundaries of the northern and southern blocks (referred to as their Russell-Miniota property). They drilled 9 exploration holes. Western Potash cancels their permits to focus on its Milestone potash solution mining project in Saskatchewan.
2012	Russell	BHP Billiton MPC	BHP Billiton relinquished its interest in MPC to the MPC, to focus on large-scale Jansen project in Saskatchewan.
2013	St.Lazare & Russell	MPC	MPC acquires the southern block crown land (previous Agrium permit area). MPC now controls all the crown potash lands in the north and south block (Russell and St. Lazare deposits).
2015	St.Lazare &	MPC	MPC begins divestiture process to sells the company and its assets.

### References

Manitoba Mineral Resources, Manitoba Geological Survey, p. 97-105.

ADM Consulting Limited. 2009: Review of material relating to the resource estimate for the Manitoba potash prospect; report prepared for AMEC Americas

AMEC Americas Limited. 2009: BHP Billiton Russell Project – High Level Development Scenario; report prepared for BHP Billiton. Bamburak, J. D. and Nicolas, M. P. B. 2009: Revisions of the Cretaceous stratigraphic nomenclature of southwest Manitoba (parts of NTS 62F, G, H, J, K, N,

O, 63 C, F); in Report of Activities 2009, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 183-192. Bannatyne, B.B. 1983: Devonian Potash Deposits in Manitoba; Manitoba Energy and Mines, Open File Report OF83-3, 27 p. Nicolas, M.P.B. 2015: Potash deposits in the Devonian Prairie Evaporite, southwestern Manitoba (parts of NTS 62F and K); in Report of Activities 2015,



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