

PROSPECT SASKATCHEWAN

The Hummingbird Bakken Pool

A model for salt-solution induced multi-zone structural oil traps

SUMMARY

Southeast Saskatchewan's Hummingbird pool can be used as a model for finding additional conventional Bakken Formation oil. There are underexplored areas north and west of the Hummingbird pool exhibiting the same geological history and characteristics that formed the oil traps in the Hummingbird pool. Because of the similarities, it is likely these areas still have oil traps available for exploration and discovery.

INTRODUCTION

Saskatchewan has been successfully producing light oil from the Bakken Formation since 1956 (Figure 1A). There have been 22.5 million m³ of oil produced at a current rate of over 10 347 m³/day as of December 2013. The number of wells producing from southeastern Saskatchewan's Bakken Formation has risen from just 75 wells (2004) to 2,802 wells (2013). This has primarily been a result of favourable economics and the implementation of horizontal wells combined with multi-stage fracturing to access oil from the extremely low permeability (<1 mD) reservoir rocks of the Viewfield pool and to a lesser degree the Roche Percee and Ryerson pools (Figure 2) (Kohlruss *et al.*, 2012).

Production still comes from several older (1956-2005) wells that form discrete conventional pools (Roncott, Hummingbird, Ceylon, Rocanville, and Welwyn) that were drilled and produced as vertical wells (Figure 2) (Kohlruss *et al.*, 2012). These conventional pools (>1 mD) can be used as models for exploring for further prospects. In particular, the Hummingbird pool (Figure 1B) can be used as a model to explore for new conventional Bakken Formation, Ratcliffe Beds, and Birdbear Formation targets and possibly other formations that have yet to be proven producers.

BAKKEN FORMATION STRATIGRAPHY

The Bakken Formation is subdivided into three members. The Lower and Upper members are black organic-rich shales, while the Middle Member is comprised of dolomitic siltstones and calcite-cemented fine-grained

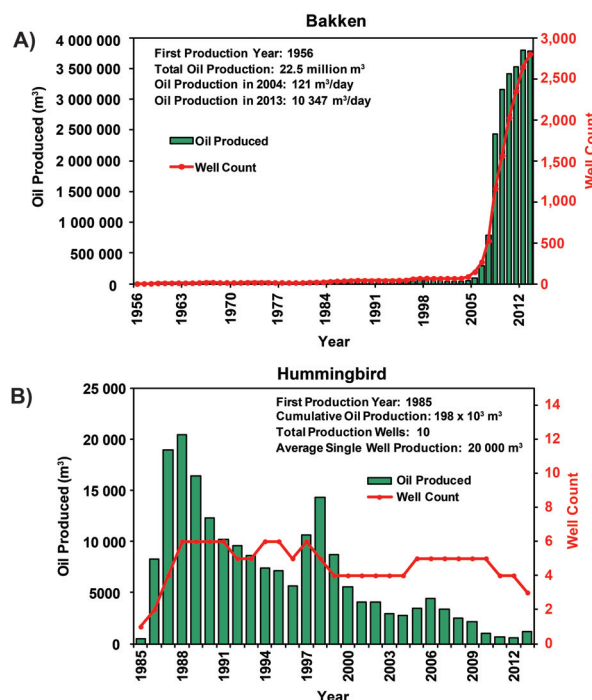


Figure 1 – A) Bakken Formation oil production and number of producing wells in southeast Saskatchewan from 1956 to year end 2013. B) Bakken oil production and producing wells in the Hummingbird pool. The average single well production is approximately 20 000 m³.

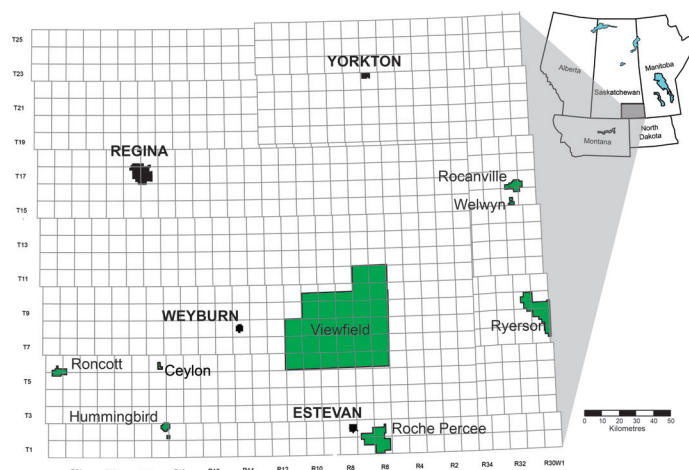


Figure 2 – Map illustrating the location of all the Bakken Formation oil pools in southeast Saskatchewan. Viewfield, Ryerson, and Roche Percee pools have been developed since 2005.

sandstones (Christopher, 1961). The Middle Member has been further divided into Units A, B, and C (Kreis *et al.*, 2006; Kohlruss and Nickel, 2009, 2013; Nickel and Kohlruss, 2011). Unit A is a bioturbated dolomitic siltstone coarsening upward to a dolomitic very fine grained quartz sandstone (Figure 3). Unit A has extremely low permeability (>1 mD) and is the main reservoir of the Viewfield pool (Figure 2). Unit B is a calcite-cemented, very fine to fine-grained quartz sandstone and, when Unit B is present, directly overlies Unit A. Unit B has higher permeability and porosity than Unit A and is the primary reservoir unit for the Roncott, Hummingbird, Ceylon, Rocanville, and Welwyn pools (Figure 2). Unit C is a highly bioturbated dolomitic siltstone that is not a known reservoir in southeastern Saskatchewan (Kohlruss *et al.*, 2012).

THE HUMMINGBIRD STRUCTURE

The Hummingbird structure is located 70 km south-southwest of the city of Weyburn (Figure 2). The structure is a steep-sided dome covering an area four

sections in size (Smith and Pullen, 1967). There has been light, 40° API (825 kg/m³) oil produced from the Bakken Hummingbird pools since 1985, totaling 198 000 m³ with an average single well production of 20 000 m³ (Figure 1B). In comparison, an average oil well from the Viewfield pool produces 13 000 m³ of oil cumulatively, but at a much higher cost since they are drilled horizontally and multi-stage fractured (Kohlruss *et al.*, 2013). This and the potential for multi-zone production (Ratcliffe, Bakken, or Birdbear) (Figure 4) makes Hummingbird-style structures very prospective.

The Hummingbird structure resulted from multi-stage salt solution and collapse (Figures 5 and 6) that created an anomalously thick section of Devonian and Mississippian stratigraphy (Smith and Pullen, 1967). Local dissolution of the Middle Devonian Prairie Evaporite during Late Devonian and Early Mississippian time created accommodation space and subsequent thickening (during their periods of deposition) of the Middle Devonian Souris River Formation, the Late Devonian Duperow Formation, and the Early Mississippian–Late Devonian Bakken Formation (Figure 5A). Complete dissolution of the Prairie Evaporite between the Mississippian and Cretaceous periods caused strata above the thickened Bakken, Duperow, and Souris River formations to collapse and drape over the respective popped-up structures (Figure 5B). This created multiple stacked structural oil traps (Figures 5 and 6) (Smith and Pullen, 1967; Holter, 1969).

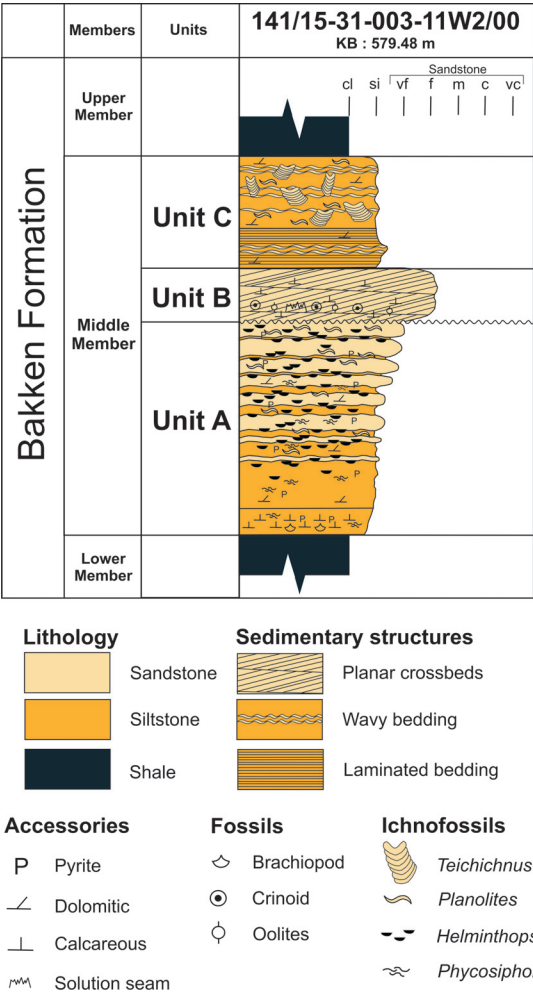


Figure 3 – Internal stratigraphy of the Bakken Formation (type well 141/15-31-003-11W2/00, Lic# 81D003) (Kohlruss and Nickel, 2013).

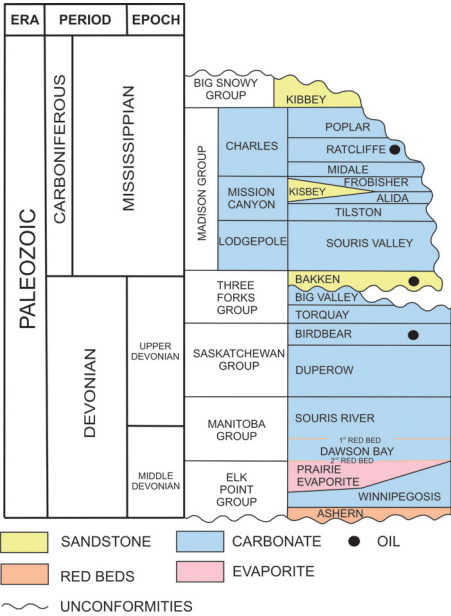


Figure 4 – Devonian to Jurassic stratigraphy of the study area. Birdbear and Bakken formations and the Ratcliffe Beds are all productive in the Hummingbird pools (modified from Saskatchewan Ministry of the Economy, 2011).

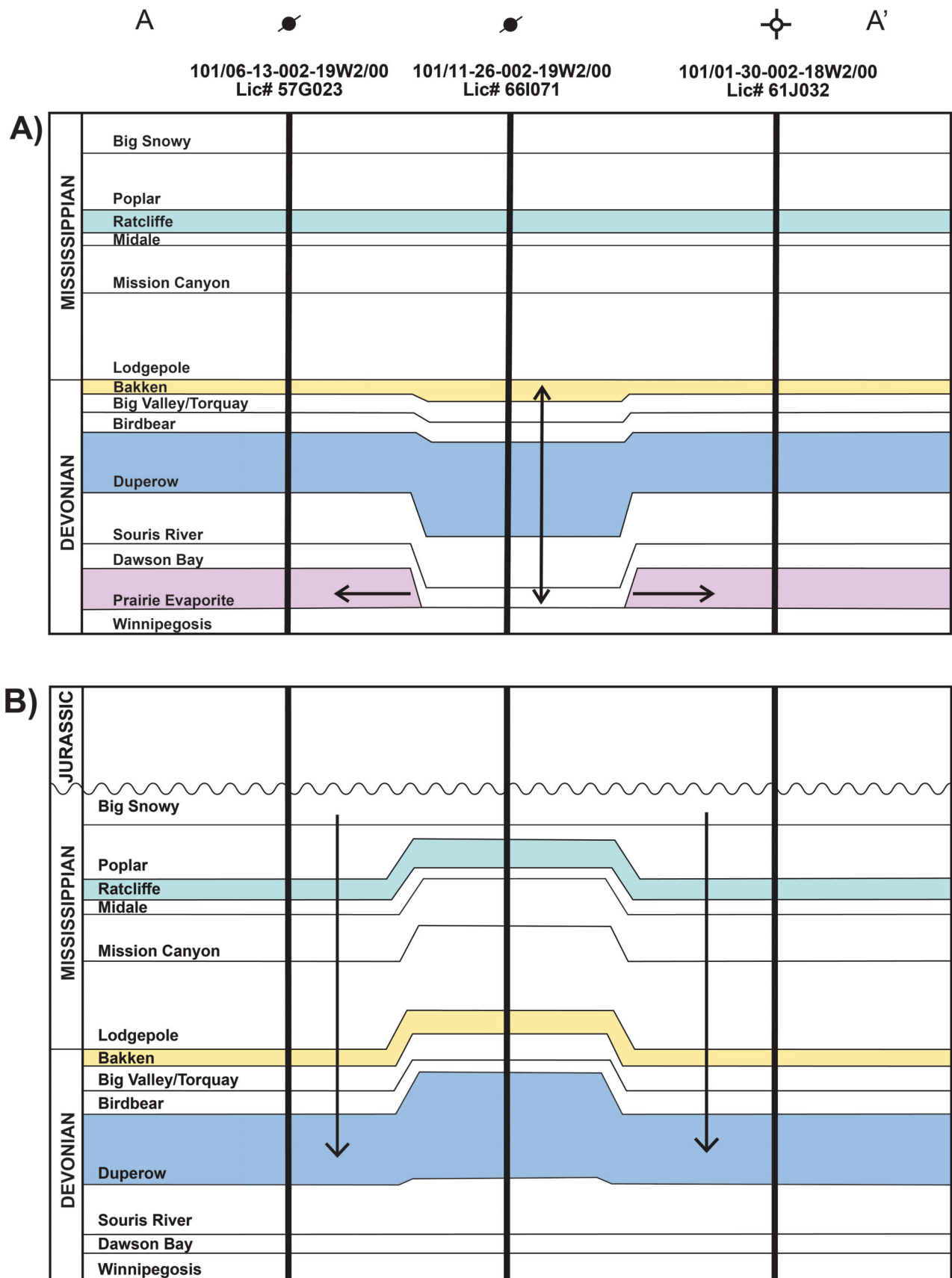


Figure 5 – Schematic cross-section A-A' (location shown on Figure 6) illustrating the multi-stage Prairie Evaporite solution events of the Hummingbird structure. A) Increased accommodation space created by Prairie Evaporite salt removal during Souris River, Duperow, and Bakken deposition, resulted in thickening of these beds. B) Complete removal of the Prairie Evaporite during Jurassic and Cretaceous time caused all the beds above the thickened Souris River, Duperow, and Bakken to “drape” over the “thicks” creating structural traps (modified from Smith and Pullen, 1967).

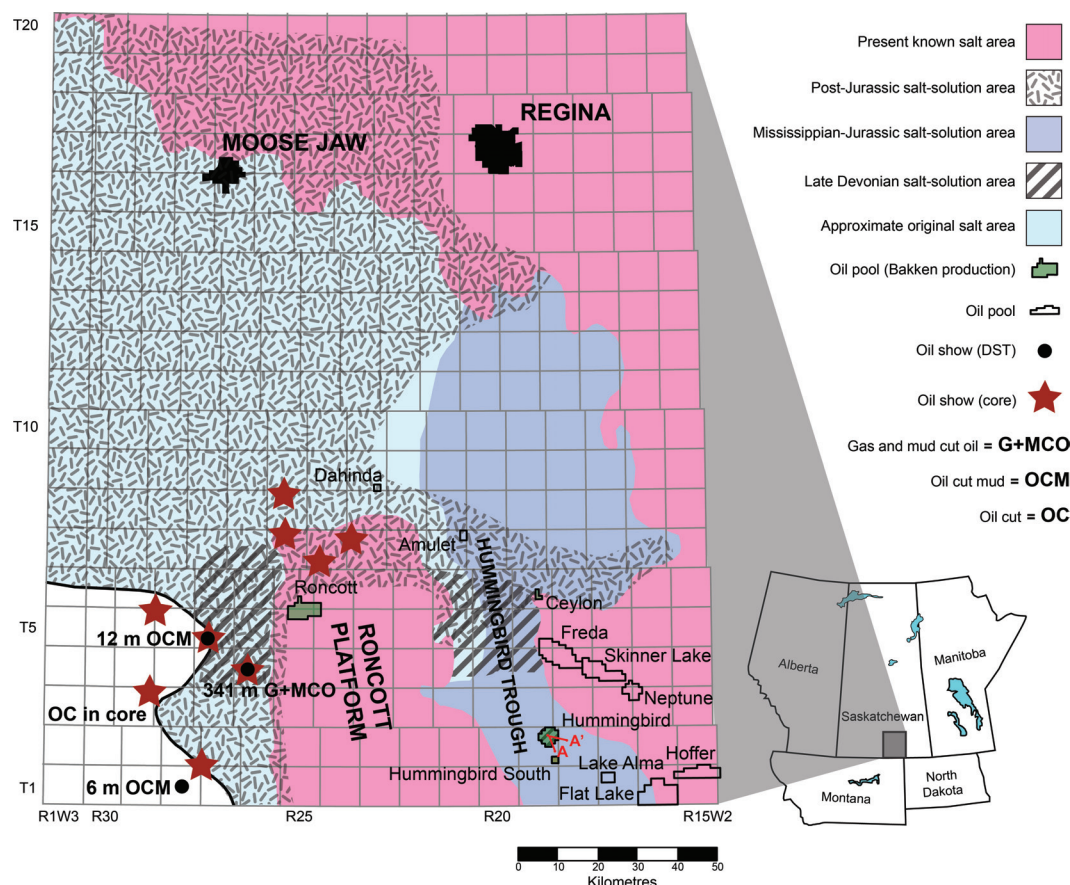


Figure 6 – Map illustrating locations and timing of major Prairie Evaporite solution events (modified from Holter, 1969). Note location of oil shows from drill-stem tests (DST) west of the Runcott Platform (residual salt high) and oil shows in cores. Cross-section A-A' (Figure 5) is also located on this map.

ECONOMIC POTENTIAL

New Bakken prospects are becoming increasingly difficult to locate. Fortunately, opportunities for conventional plays similar to the Hummingbird structure may still exist in areas just west and north of the Runcott Platform. Here, structural targets with multi-zone opportunities are worth investigating since the Prairie Evaporite salt has been subjected to multi-stage solutioning (Figure 6). Oil shows in cores and drill-stem tests west of the Runcott platform indicate oil migration has occurred through this area and if Hummingbird-like structures are present, oil will be trapped.

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