

Reservoir Characteristics of the Birdbear Formation in West-Central Saskatchewan

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Abstract

Although oil has been intermittently produced from the Birdbear Formation in west-central Saskatchewan since 1968, the recent application of horizontal technology resulted in a sharp increase of average per-well production from 1 m³/d in January 2008 to over 10 m³/d in May 2009. This success has sparked renewed interest in the Birdbear, resulting in re-evaluation of the formation's potential as an oil resource for the province.

In west-central Saskatchewan, Birdbear oil has been recovered along the subcrop of the Birdbear Formation (Tp. 39, Rge. 24W3 to 27W3) and in the area north of Kindersley (Tp. 30 to 32, Rge. 23W3 to 28W3). Log-to-core correlation of the Birdbear pay zones, core examination and thin-section study are being carried out to improve understanding of the reservoir's petrology and other characteristics. North-south and west-east trending cross sections have been constructed to correlate stratigraphic units in the upper member of the Birdbear Formation.

Introduction

The Birdbear Formation represents the last phase of upper Devonian carbonate sedimentation, and upper portion correlates with the Nisku Formation of the Alberta Basin. In Saskatchewan, hydrocarbons are produced from two widely separated areas, southeastern Saskatchewan and west central Saskatchewan. The Birdbear in the southeast has yielded totally about 1.1 x 10⁶ m³ of lighter oil, of which 86% are produced from Hummingbird and Kisbey pools that structural traps associated with multiple-stage salt solution and collapse (Smith and Pullen, 1967; Kent, 1998). Cumulative production of heavy oil from the Birdbear in the west-central area has been only 85 x 10³ m³ by June 2009. However, it is being revitalized by horizontal drilling technology. Regional mapping indicates that there are some significant variations in the thickness of the Birdbear throughout its extent in the province. Its maximum depositional thickness in the west central area is 60m (PTRC, 2006). By comparison, it is up to 70m in southeastern Saskatchewan (Targeted Geoscience Initiative II, 2008).

The distribution, origin and diagenesis of the different limestones, dolostones and anhydrites within the Birdbear Formation of southeastern Saskatchewan in the Williston Basin have been studied by Nichols (1970), who recognized it as a single, shoaling-upward, carbonate-evaporite couplet that forms a broad, pancake-like deposit. The basal two-thirds consist of open-marine to

intertidal, variably fossiliferous limestones and dolostones, whereas the upper third consists of interbedded calcarenite and anhydrite (Halabura, 1982, 1983; Kissling and Ehrets, 1984).

A detailed study of Birdbear Formation diagenesis in southwestern Saskatchewan has been carried out by Whittaker and Mountjoy, 1996. Organic geochemical analyses indicate that Birdbear oil was sourced in the Winnipegosis Formation (Osadetz et al., 1992). A more recent study has revealed a different unknown source rock for oil found in Birdbear Formation, suggesting a separate petroleum system may be operative in the Saskatchewan Group of the Canadian portion of the Williston Basin (Obermajer et al., 1999). Three types of hydrocarbon fluid inclusions trapped in cements have recorded two major hydrocarbon migration events and a southwest-to-northeast-trending oil-migration pathway (Stasiuk et al., 1998).

In west-central Saskatchewan, Kent (1968) sub-divided the Birdbear Formation into an upper and a lower member. The lower member is largely made up of argillaceous carbonate and the upper member contains both non-argillaceous and argillaceous dolostones. Further studies of the stratigraphy, depositional setting and diagenesis were made by Cisyk (1991). The success of recent wells drilled into the Birdbear Formation in west-central Saskatchewan has resulted in re-evaluating the formation, focusing on a) log, core and thin-section examinations of pay zones in the upper member to better understand the reservoir petrology and characterization, and b) constructing north-south and west-east trending cross sections to correlate stratigraphic units in the upper member.

Birdbear Formation Production History in West-Central Saskatchewan

The Upper Devonian Nisku Formation has been one of the major oil producers in Alberta for many years. In west-central Saskatchewan, only 13 production wells have produced from Birdbear Formation with a cumulative output of about 25,000 m³ of oil between 1968 and 2007. Production is mostly derived from two regions, the first defined by the subcrop of the Birdbear Formation (Tp. 39, Rge. 24W3 to 27W3), and the second located north of Kindersley (Tp. 30 to 32, Rge. 23W3 to 28W3). Over the 17-month period from January 2008 to May 2009, the number of producing wells in the Birdbear rose from 5 to 15, increasing the monthly production from 180 m³ (1100 bls) to 4500 m³ (28400 bls). This upswing in Birdbear drilling and production are shown in Figure 1.

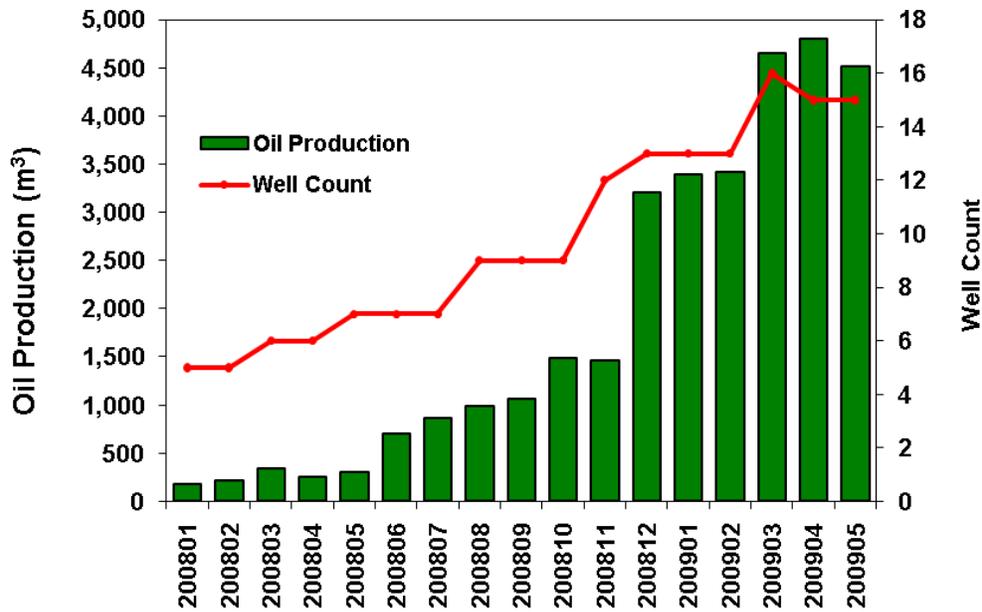


Figure 2. The Birdbear oil-production and well-count trends from January 2008 to May 2009 in west-central Saskatchewan.

Core Display

The productive layers of the upper member of the Birdbear Formation are the focus of this study. One representative core from each of the two production regions has been carefully selected for core examination.

Core 1: Well Rife et al Eureka 131/14-02-032-23W3

In 1985, this well was drilled through the Birdbear Formation to a depth of 950m. The upper member of the formation was cored from 890 to 926.25m. To 1991, the well had a cumulative oil production of 2800 m³ from two perforated intervals, the first from 900.5m to 903.5m, and the second from 910.5m to 913.5m. The oil has a heavy specific gravity: 1.003 (API 9.6°).

The reservoir rock is heavily oil-stained, light grey to dark brown dolomitic grainstone. Locally, fossil fragments are observed “floating” in the sediment. Interparticle, moldic, vuggy and fracture porosities are common, and may have been enhanced by dissolution. The vugs and fractures are, in places, partially filled by calcite crystals that may or may not be oil stained (Figure 2). The porosity of the reservoir rocks ranges from 11 to 27% with an average of 19%, and the permeability is as high as 2000 millidarcies.



Figure 2. Core photograph of heavy oil dolostone reservoir rock from the upper member of the Birdbear Formation at Rife et al Eureka 131/14-02-032-23W3. Note the intensity of oil stain and the excellent interparticle, fracture and vuggy porosities that are partially filled by oil-stained calcite crystals.

Core 2: Well Nuvista Mackin 111/12-04-039-27W3

In 1985, this well was drilled into the subcrop of the Birdbear Formation to a total depth of 785m. The top part of the Birdbear may be truncated by the sub-Cretaceous unconformity that the Birdbear is overlain by the Lower Cretaceous Mannville Group. The cores (742m to 760m) were taken from the upper member of the Birdbear Formation immediately below the unconformity. The well was perforated from 750 to 753m, and had a cumulative production of 1600 m³ of heavy oil (specific gravity: 0.985, API 12.2°) from 1985 to 1988.

The reservoir rock is heavily oil-stained, light grey to dark brown dolostone with interparticle, vuggy and open-fracture porosities that may have been enhanced by dissolution (Figure 3). Total porosity ranges from 10 to 24% with an average of 20% and permeability is up to 400 millidarcies. High-resistivity readings are not observed in the producing intervals of the Birdbear Formation because of the abundance of pyrite.



Figure 3. Core photography of heavily oil stained dolomite reservoir rock with excellent vuggy and fracture porosity from the upper member of the Birdbear Formation at Well Nuvista Mackin 111/12-04-039-27W3.

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