Understanding Saskatchewan's Middle Bakken Oil Trapping Mechanisms

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Introduction

The Upper Devonian-Lower Mississippian Bakken Formation of southeast Saskatchewan has become an extremely important producer in North America. This has primarily been a result of engineering and technology developments in both horizontal well drilling and ever improving multistage fracturing processes. The understanding of the Middle Bakken Member's stratigraphic architecture and the character of its various trapping mechanisms has also contributed significantly to the development of the play.

Stratigraphy

In southeast Saskatchewan, the Bakken Formation overlies the Torquay and Big Valley Formations. Together the Torquay, Big Valley and Bakken Formations comprise the Three Forks Group (Christopher, 1961). The Bakken Formation ranges from zero to 30m in thickness throughout the study area, with local anomalously thick sections reaching 70m as a result of discrete salt collapse features (Kreis *et al*, 2006). Generally, the Bakken Formation is comprised of a mixed carbonate-clastic sequence (Middle Bakken Member) "sandwiched" between two black organic rich shales (Upper and Lower Bakken Members).

The Middle Member has been subdivided into a lowermost Unit A, middle Unit B and uppermost Unit C. The distribution and relationship of these units has become critical to development of the Bakken oil resource (Christopher, 1961, Kreis *et al*, 2006, Kohlruss and Nickel, 2009).

Unit A conformably overlies the Lower Bakken Shale and is mainly a massive grey to greenish grey argillaceous dolomitic siltstone to silty dolostone. It is also characterized by abundant bioturbation including, but not limited to *Helminthopsis* and *Phycosyphon*. Unit A gradually coarsens upward to become a silty sandstone at its top where the majority of hydrocarbon production is likely from.

Unit B sharply overlies Unit A and is a fine-grained calcite-cemented sandstone ranging from massively bedded at the base, to high angle planer cross-bedded, to laminated at the top.

Unit C is the uppermost portion of the Middle Bakken and is recognized by laminated argillaceous dolomitic siltstone to very fine grained sandstone. Bioturbation and soft sediment deformation is very prevalent within Unit C and can readily be identified in core.

Trapping

The need for horizontal drilling and multistage fracturing to recover oil from southeast Saskatchewan's Viewfield area is one of the keys to understanding the trap itself. Utilizing conventional vertical well technology is not sufficient to recover oil from the extremely low permeability reservoir rock of Unit A (predominantly less than 1.0 mD). Fortunately, the extremely low permeability, independent of high porosity, impedes oil from being completely flushed by formation waters. The same attribute which makes the oil difficult to recover contributes to the trapping mechanism. The combinations of low permeability, reduced buoyancy drive and facies pinch-out all contribute to an expansive area of trapped oil over the Viewfield area. And, despite secondary migration, the Viewfield Bakken play has been described as a resource and/or unconventional play due to its extreme low permeability, expansive nature and apparent lack of structural trap.

Counter to conventional thought, high permeability and corresponding high porosity in the Middle Member is often detrimental to Bakken oil exploration success. This unfavorable scenario is typically observed in the Unit B sandstone where permeability and porosity increase and decrease dependently. The Unit B sandstone is predominantly water-wet because of this relationship and is rarely reservoir except in discrete areas like Hummingbird, Roncott and Rocanville. In these locations, the coincidence of higher permeability and porosity along with structural closures resulted in trapped oil. Subsequently these areas are characterized by production by typical conventional methods.

It is important to consider permeability when exploring for further Bakken oil since not all Bakken rocks are created equal and therefore require specific exploration strategies.

Summary

The Bakken Middle Member of southeast Saskatchewan has been divided into three distinct Units; The Unit A, B and C. These have been mapped to show their extent and stratigraphic relationship. Unit A is the primary reservoir and producing unit for the Viewfield area and its extreme low permeability is one of the major keys to the trapping mechanism in the Viewfield area. Without low permeability, the rocks would likely be water-wet and non-reservoir. Outside of Viewfield, oil has been identified and produced from the Unit B, but as a conventional play where structure, along with higher permeability and porosity, must all coincide for success.

References

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