Saskatchewan Ministry of Energy and Resources

PROSPECT SASKATCHEWAN

Bakken and Torquay Light Oil

New Potential in Southeastern Saskatchewan

INTRODUCTION

Shales of the Upper Devonian to Lower Misssissippian Bakken Formation in the Williston Basin have generated and expelled at least 16 billion m^3 of oil (100 billion of barrels), of which only a small fraction has been identified in, or produced from, Williston Basin reservoirs. Recently, horizontal drilling and large sand-fracture completions have resulted in significant production of Bakken oil in Richland County, Montana. Detailed examination of Bakken cores, geophysical logs, and production data in southeastern Saskatchewan indicates that similar exploitation potential exists using horizontal completions, identifying by-passed pay, and finding additional oil in siltstones and sandstones of the Middle Member of the Bakken Formation. Weathered and brecciated dolostones of the Torquay Formation in southeastern Saskatchewan also exhibit high and relatively untested, potential for oil production.

To date, most Bakken production in Saskatchewan has been from siltstones and sandstones of the Middle Member. During the late 1980s to early 1990s, however, additional production in North Dakota was obtained from overlying and underlying Bakken shale members. More recently in Richland County eastern Montana, horizontal drilling has proved to be a successful method for exploiting Bakken oil from sandstones, siltstones, and limestones of the Middle Member. Common practice in this area is to drill one or two laterals that are subsequently subjected to sand-fractured completions using as much as 450 000 kg (1,000,000 lbs) of sand. The economic success of this play has spurred a renewed interest in land acquisition and exploration of the Bakken eastward and northward into North Dakota, and into the Estevan area of southeastern Saskatchewan. In the last 19 months, Bakken oil production in southeastern Saskatchewan jumped from approx. 3000 m^3/mo (July 2003) to approx. 5700 m^3/mo (February 2005) during which the number of producing wells rose from 62 to 81.

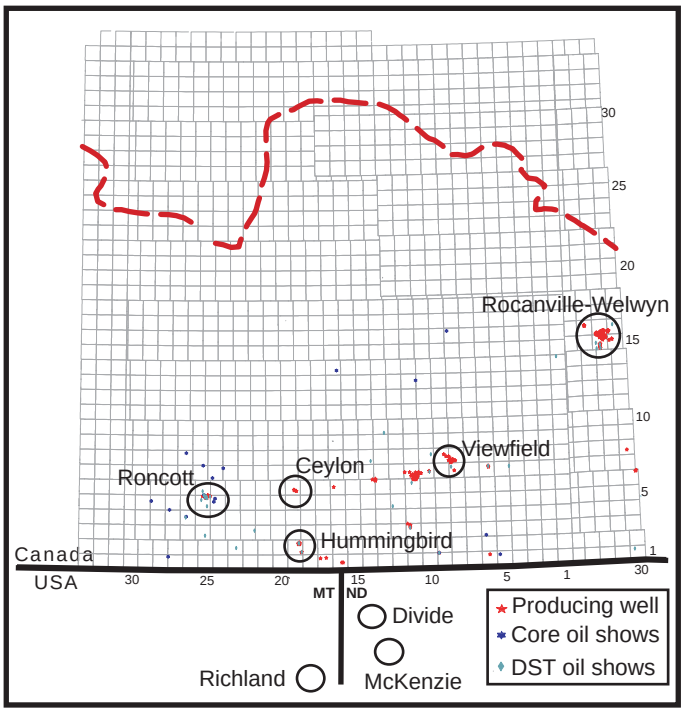

Figure 1 - Areas of Bakken production in Saskatchewan, North Dakota and Montana; also shown are core-based oil shows and DST shows. Red line indicates Bakken zero-edge.

oil m3	gas x1000 m3	water m3	Month	Prod. Wells
3044.9	25.7	6867	2003-07	62
3035.4	20.9	6106.2	2003-08	61
2913.4	13.5	6101.8	2003-09	60
2915.6	24.7	6383.4	2003-10	61
3208.5	33.4	6719.7	2003-11	61
3204.4	23.5	7971	2003-12	62
3123.1	20.2	7343.2	2004-01	60
2987.6	19.7	7153.5	2004-02	61
3337.7	19	7998.5	2004-03	62
3233.8	19.6	7946.9	2004-04	62
3010.8	21.1	8126.1	2004-05	64
3045	21.4	7738.6	2004-06	63
3273.2	22.6	8327.7	2004-07	66
4259.3	74.1	12239.5	2004-08	68
4182.3	72.7	13518.3	2004-09	73
4820.9	259.2	15195.1	2004-10	74
5349	284.6	14296.1	2004-11	76
5706.1	214.5	16378.3	2004-12	78
5681.4	173.7	16043.2	2005-01	81

Table 1 - From July 2003 to January 2005 Bakken production in southeastern Saskatchewan.

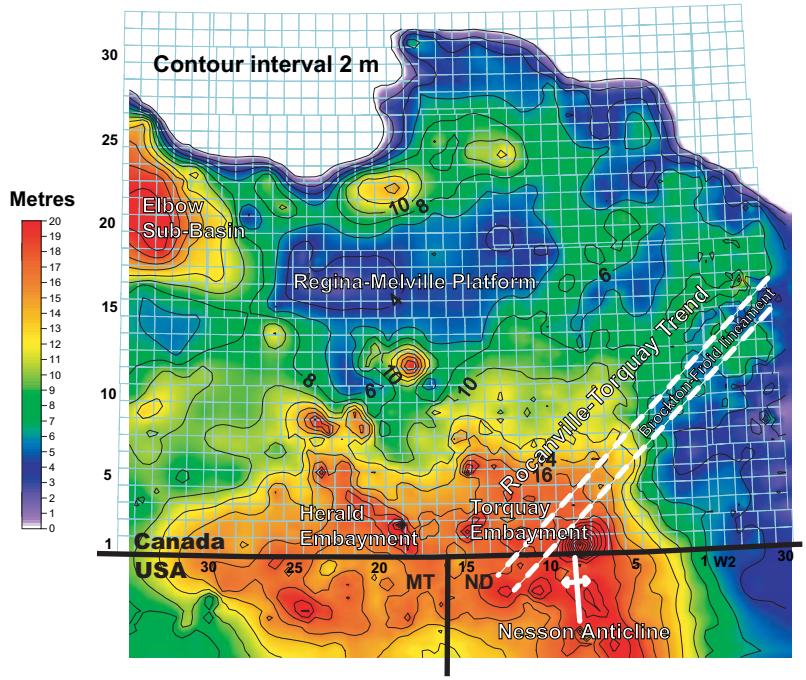

Figure 2 - Isopach map of the Middle Member of the Bakken Formation.

BAKKEN REGIONAL GEOLOGY

Sandstones and siltstones of the Middle Member of the Bakken Formation become increasingly thick towards the Member's depositional centre in northwestern North Dakota and northeastern Montana. In Saskatchewan, the Middle Member reaches a regional thickness of about 25 m, but, above areas of known salt dissolution, it attains thicknesses of up to 44 m. Anomalous thickening is also observed in shales of the Lower Member at these locales. Christopher (1961) recognized the relation between underlying Devonian salt dissolution and thick Bakken trends and named two thick areas in the south the Torquay and Herald embayments (Figure 2), and a thick region along the western margin, the Elbow Sub-Basin – a feature related to contemporaneous dissolution of the underlying Prairie Evaporite Formation. Relatively thin Middle Bakken occurs in the vicinity of the Regina-Melville Platform (T18-R23W2) and in the extreme southeast portion of the map, which is discussed later relative to its significance to the Torquay Formation play. A noteworthy feature of the isopach map of the Middle Member is a zone of thickness that extends southwestern from the Rocanville Pool to the Torquay Embayment. This northeast-southeast trend is coincident with the Rocanville-Torquay trend, named also by Christopher (1961), about which he stated "…this trend consists of a band of northeasterly aligned furrows into which the study beds are downwarped." He noted that salt sinks in the Rocanville, Wapella, and Kisbey pools, and oil shows and oil production in Bakken and older strata were aligned along this trend. Recent examination of cores and geophysical logs suggests that sandstones developed along this trend are potential migration conduits for Bakken-sourced oil into the Rocanville region.

RESISTIVITY ANOMALY

In places, the Upper and Lower Member shales of the Bakken Formation show very high resistivity values (Figures 3 and 4) that are attributed to the presence of oil which has replaced conductive pore waters. With continued oil replacement, oil saturation increases to produce progressively higher formation resistivity values. Other rock characteristics such as mineralogy, porosity, tortuosity, and the salinity of water within

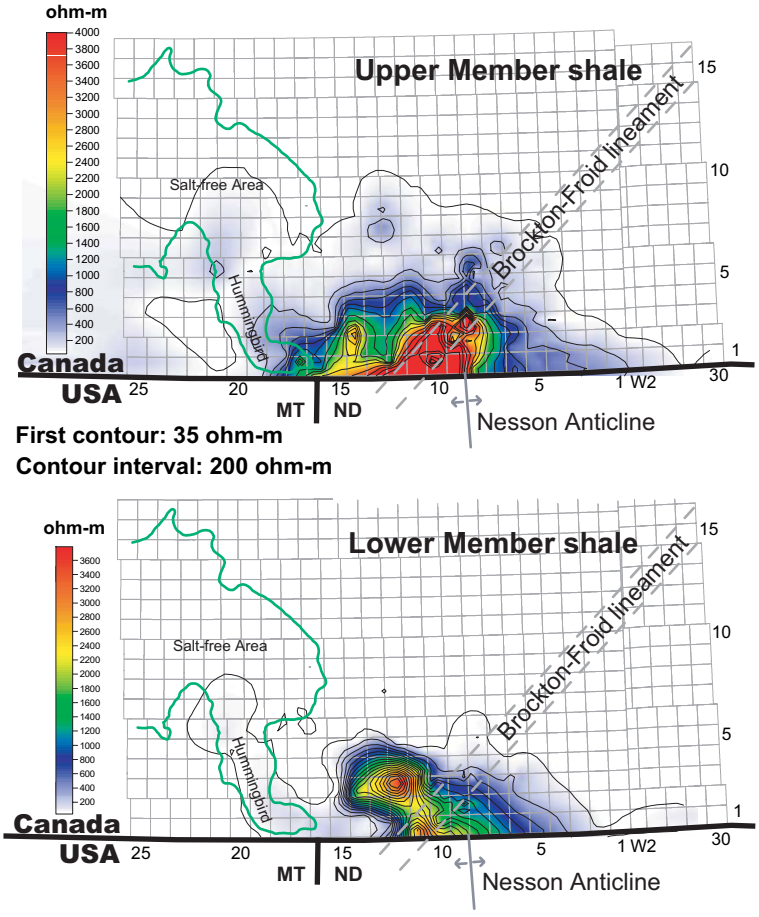

Figure 3 - Maps indicating distribution of anomalous resistivity values in the uppper Shale Member (upper map) and Lower Shale Member (lower map) of the Bakken Formation.

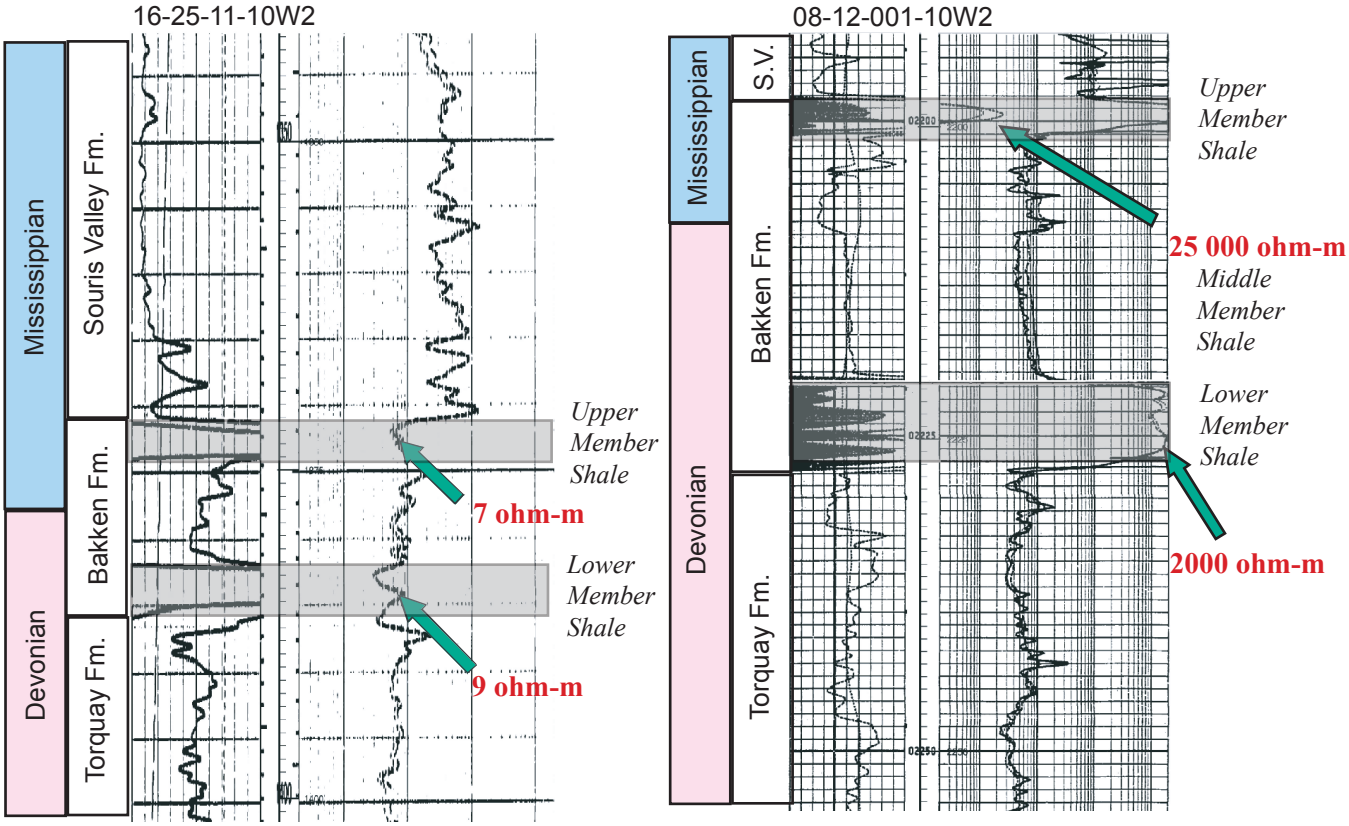

Figure 4 - Resistivity logs showing normal (left) and anomalous (right) readings in the Upper and Lower Bakken Member shales.

pore volume also contribute to the resistivity log response of the shale, but these parameters are apparently secondary to the presence of oil in the shales themselves. Although resistivity values do not distinguish whether oil has been generated *in situ* within the shales at a given location or has migrated into or within the shales, extensive Bakken core research by Schmoker and Hester (1990) has indicated that a resistivity value of greater than 35 ohms coincides with the onset of observable oil generation within Bakken shale. Resistivity values for Upper and Lower Member shales were mapped in southeastern Saskatchewan (Figure 3) using only deep-reading laterologs and without applying borehole or environmental corrections. Areas having resistivity values in excess of 35 ohms in the Upper Member shale oversteps that of the Lower Member shale.

Pool	SG (g/cm^3)	°API
Ceylon	0.825	40.0
Hummingbird	0.825	40.0
Hummingbird South	0.825	40.0
Rocanville	0.843	36.3
Roncott	0.823	40.4
Welwyn	0.888	27.8
Welwyn South	0.841	36.7

Table 2 - Specific gravity of oils from selected Bakken pools in southeastern Saskatchewan.

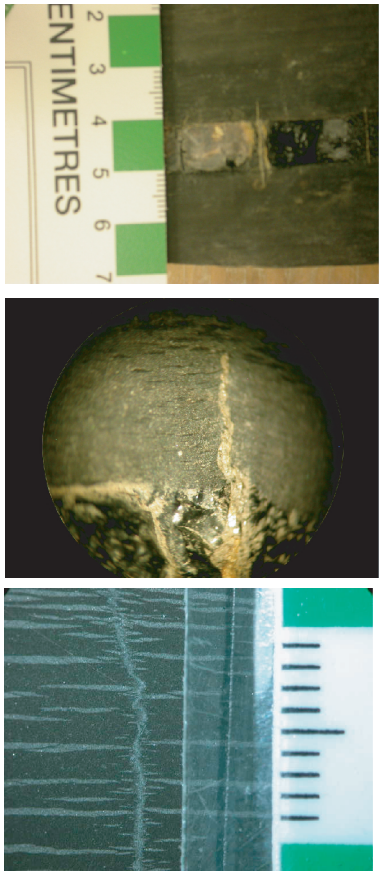

Figure 5 - Photographs of Lower Bakken shale displaying microfracturing generated by oil expulsion in 13-31-6-13W2 (top and middle) and 12-27-1-6W2 (bottom) wells. Note the bituminous-coaly material (vitrinite?) in the top photograph.

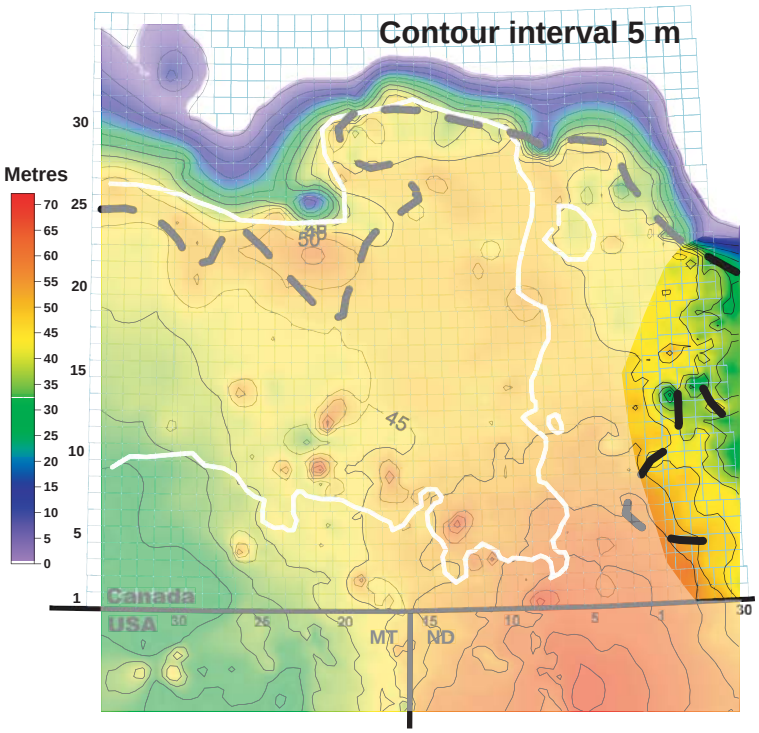

Figure 6 - Isopach map of the Torquay Formation. Also shown are the Lower Bakken zero edge (dashed line), and approximated Big Valley Formation zero edge (white line). Highlighted area along eastern edge shows region of depositional and erosional thinning in the Torquay and Bakken formations.

TORQUAY REGIONAL GEOLOGY

The Torquay Formation in the eastern highlighted area (Figure 6) shows depositional or erosional thinning in a region interpreted to have been uplifted prior to deposition of the Bakken Formation. Significant to this play is that weathering in the uplifted area prior to Bakken deposition has enhanced reservoir characteristics of the Torquay Formation where it immediately underlies the regional unconformity. Primary development of reservoir conditions in this area were also enhanced due to the shallower depositional setting for the sediments that now host the oil. For example, well developed ripple-bedded dolarenite is common in Torquay Formation cores from the Rocanville Pool area (*e.g.*, 8-5-16-31W1). Another critical element to this accumulation is the onlapping relationship of the overlying porous and permeable sandstones of the Middle Member of the Bakken Formation. Thinning and onlap of Bakken sediments are recognized throughout the eastern portion of Saskatchewan. The Lower Member shale is absent in this area so that oil-saturated sandstones of the Middle Member are in direct contact with reservoir quality-rocks of the underlying Torquay Formation. The Torquay rocks are interpreted to have been charged with light Bakken-sourced oil that migrated from hydrocarbon kitchens to the south and west.

The Torquay Formation in the inferred area of uplift exhibits reservoir-quality brecciated dolostones that show moderate to good porosity on sonic, density, and neutron logs. Streaming, milky white fluorescent cuts from dolostones have been observed in cores from 1-30W1 to 22-1W2. Resistivity logs also indicate the presence of hydrocarbons in wells from this area. Production has been attempted from three wells, 8-35-6-30W1, 12-36-6-30W1, and 13-10-8-30W1; the first two of which were vertical completions and have each produced approximately 3180 m^3 (20,000 bbls) of oil in three years. In this area, the Bakken Middle Member sandstone is generally less than 3 m thick, whereas geophysical logs and core from the Torquay Formation indicate that approximately 9 m thick porous intervals are oil-saturated from the unconformity down to the top of a well developed oxidized, reddish brown siltstone-mudstone.

SUMMARY

Analogs:
For Bakken production: Richland County, Montana; McKenzie and Divide Counties, North Dakota.

For Torquay production: Sinclair and Daly pools, Manitoba.

Trap:
Stratigraphic; subtle structure.

Seal:
Bakken Shale.

Characteristics:
Bakken reservoirs generally respond unconventionally to resistivity readings, have low permeabilities of 1 to 20 mD, and porosity values that range from 5 to 20%.

Source:
Bakken Shales.

References

Christopher, J.E. (1961): Transitional Devonian-Mississippian Formations of Southern Saskatchewan: Sask. Dep. Miner. Resour., Rep. 66, 103p.

Schmoker, J.W. and Hester, T.C. (1990): Formation resistivity as an indicator of oil generation-Bakken Formation of North Dakota and Woodford Shale of Oklahoma; The Log Analyst, January-February 1990, 9p.

Download documents and other information related to hydrocarbon resources of Saskatchewan at: http://www.er.gov.sk.ca/subsurfacelab.