Oil Satuations and Relevance to Oil Production in the Bakken

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The potential supply of North American natural gas is far bigger than was thought even a few years ago.

Likely surprising to many, America’s oil resources are also proving to be much larger than previously thought.

Natural gas and oil resources are needed even as efficiency reduces energy demand and alternatives become more economically available on a large scale.

Realizing the benefits of natural gas and oil depends on environmentally responsible development.
Cumulative Production in Mountrail County–Dunn County

Drilling Activity in the Bakken and Three Forks Formations of North Dakota, EERC 2011
Structure?

Modified from North Dakota Geologic Survey
Geologic Factors

Map Data from North Dakota Geologic Survey

• Overpressuring due to oil generation and expulsion into the middle Bakken from the diagenesis of the thick highly organic Bakken shales.

• The pressure gradient in the Parshall Field of 0.73 psi/ft is unusual, as compared to the west in the Sanish Field where the average pressure gradient is 0.55 psi/ft.

• Unusual that the location of the Parshall Field is a considerable distance into a thermally immature area of the Bakken Formation.

A multivariable trapping scenario.
The upper bound is the regionally thick impermeable Lodgepole Formation.
Lineaments trending NE/SW are thought to act as lateral seals, evidenced by significant pressure differences encountered during the drilling of horizontal wells.
The eastern updip boundary is the thermally immature upper Bakken shale. Immature kerogen-rich shale limits the migration of downdip fluids because of less matrix and fracture permeability.

Overpressuring

Saturation

Map of average water saturations from well logs produced by Simonson, 2010


6-month Cumulative Production, EERC 2011

Oil Saturation

Production Water Cut, Kriging

Core Saturations, co-kriging
Correlation

15 Month Average Water Cut versus Water Saturation

\[ y = 1.0441x^{1.6262} \]
\[ R = 0.6734 \]

Average Water Cut (vol/vol)

Water Saturation \((S_w)\)

<table>
<thead>
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<th>Archie Variable Statistics</th>
<th>a</th>
<th>m</th>
<th>n</th>
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</table>
Proxy to Oil Production

15-month production, Kriging

Core Saturations, co-kriging
Conclusions

- Formation saturation appears to be a relative predictor of cumulative production for the eastern boundary of the Bakken Formation.
- Predictive capability may be limited for the western portion of North Dakota in the Billings nose area, Divide, and Williams Counties.
- Data for wells in the Billings nose area includes production from the upper Bakken shale, and may not be directly attributable if the production was from the middle member including a multi-stage horizontal completion.
- Production in Williams County is largely attributed to the more aggressive implementation of multi-stage hydraulic fracturing, which is enabling higher production in areas of lower oil saturation.

\[ y = -1E+05 \ln(x) - 37395 \]

\[ R = 0.642 \]
Bakken Shale

Well #: 16721
Sampled: 10,399.2 - 10,399.6 ft
Interval
Well #: 16771
Sampled Interval: 10,396.7-10,397 ft
#12
Three Forks

Well #: 16771
Sampled: 10,417.8
Interval: 10,418.1 ft
#27
Middle Bakken

Well #: 16771
Interval: 10,339.5 - 10,340.2 ft
Sampled: #11
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