Abstract

The Upper and Lower Bakken shales are the source beds for the Bakken Petroleum System of the Williston Basin. Reservoirs for this system include the shales, the lower Lodgepole, Middle Bakken silty dolostones, and Three Forks silty dolostones. The Upper shale was a drilling target in the late 1970s through the early 1990s in southwest part of the basin in North Dakota (termed the depositional limit play or Billings Nose play). The discovery of the giant Elm Coulee Field changed drilling strategies to focus on the Middle Bakken dolostone member. As this play extended into North Dakota, drilling success was also encountered in the upper Three Forks dolostones. The Upper Bakken shale has recently been targeted with horizontal drilling and multistage fracture stimulations along the southwest edge of Elm Coulee Field where the Middle Member pinches out. In this area wells are drilling into the Upper shale and then completed with multistage fracture stimulations. The fracture stimulations extend into the adjacent Lodgepole and Three Forks formations. So in essence, these new wells target multiple pays. Factors thought to be important in this Upper shale play include: orientation of horizontal laterals, bed thickness, natural fractures, shale mineralogy, abnormal pressure, and TOC content. This play is a similar to the previous depositional limit play in North Dakota except the wells are completed with multistage fracture stimulations. Exploration success in the Upper Bakken shales suggests that future drilling should also target the Lower Bakken shales.
ABSTRACT

The Upper and Lower Bakken shales are the source beds for the Bakken Petroleum System of the Williston Basin. Reservoirs for this system include the shales, the lower Lodgepole, Middle Bakken silty dolostones, Pronghorn dolostones, and Three Forks silty dolostones. The Upper Shale was a drilling target in the late 1970s through the early 1990s in southwest part of the basin in North Dakota (termed the depositional limit play or Billings Nose play). The discovery of the giant Elm Coulee Field in Montana changed drilling strategies to focus on the Middle Bakken dolomite member. As this play extended into North Dakota, drilling success was also encountered in the upper Three Forks dolostones.

The Upper Bakken Shale has recently been targeted with horizontal drilling and multistage fracture stimulations along the southwest edge of Elm Coulee Field where the Middle Member pinches out. In this area wells are drilling into the Upper Shale and then completed with multistage hydraulic fracture stimulations. The fracture stimulations extend into the adjacent Lodgepole and Three Forks formations. So in essence, these new wells target multiple pays. Factors thought to be important in this Upper Shale play include: orientation of horizontal laterals, bed thickness, natural fractures, shale mineralogy, abnormal pressure, and TOC content. This play is a similar to the previous depositional limit play in North Dakota except the wells are completed with multistage fracture stimulations.

Exploration success in the Upper Bakken shales suggests that future drilling should also target the Lower Bakken Shale.

Figure 5. Isopach total Bakken, Billings Nose area. Wells shown are Bakken, Three Forks producers only.

Isopach Upper Bakken Shale. Wells shown are Bakken, Three Forks producers only.

Cross-section Billings Nose area. Note dramatic pinchout of Bakken to the southwest. Note also thickening of False Bakken in this area. The 21-9 and BN 1 wells show resistivity separation in the Upper Bakken Shale suggesting the presence of fractures.

Cross-section Elm Coulee. Shaded area on resistivity track is where MSFL is less than LLD curve resistivity. This is an indication of matrix and/or fracture permeability. Shaded areas on resistivity logs indicate mud filtrate invasion caused by salt based mud and the presence of fracture or matrix permeability.
**Upper Bakken Shale Resource Play, Williston Basin**

**Bakken Fractures**
- Regional
- Tectonic
- Diagenetic (expulsion)

"mineralization on fracture surfaces is absent" Carlisle et al., 1992

**LOG RESPONSES**

**MERIDIAN OIL INC**
MDI
T143N R102W S11

- False Bakken
- Scalloped Bakken Shale
- Lower Bakken Shale
- Prosham
- Three Forks

Pfs: 10490-10506
IP: 217 BOPD; 178 MCFD
CUM: 199 MBO
258 MMCF

Separation between MSFL and LLD can indicate fracture permeability (invasion)

"Separation between neutron and density porosity curves can indicate the presence or absence of fractures" Carlisle et al., 1992

**Conceptual Burial History of Unit – Volume of Oil - Source**

**Non-Tectonic Fractures**

**HC Generation - Upper Bakken Shale**

From LeFever

**Carus Fee 21**
Sec. 19-147N-96W

Overpressures generated by HC generation

Stereonet plot of poles to fractures, Bakken Shale. Note "bedding plane fractures"

"microfractures occur in all Bakken units" Carlisle et al., 1992

Kreis, Costa, Osadetz, 2006
Calcite-lined horizontal fracture networks.

Horner plot for Shapiro 21-9 (Sec. 9, T142N, R102W). The Horner plot yields a pressure gradient of 0.7 PSI/ft. B. Delta P and delta T plot with derivative analysis. The derivative plot suggests the presence of fractures. See Figure 7 for Shapiro log.

Structure top Bakken.

Log response for Bakken and Three Forks intervals from Elm Coulee.

Cross section indicating fractures, Upper Bakken Shale and matrix permeability in Middle Bakken, from Elm Coulee.

Hydrogen Index map for lower Bakken shales.

Hydrogen Index map for upper Bakken shales.

Isopach Lower Bakken Shale.

Isopach Total Bakken.

Isopach Middle Bakken.

Isopach Net Middle Bakken.

Isopach Total Upper Bakken Shale.

Isopach Upper Bakken Shale.

Isopach Net Upper Bakken Shale.

Isopach TOC Upper Bakken Shale.

Isopach Net Upper Bakken Shale.
Expulsion fractures noted in the Upper Bakken Shale.


Sonic, gamma ray, and dynamic elastic moduli for Vaira well. Note response in Upper Bakken Shale, along with drilling and completion technologies.

REFERENCES CITED


