Abstract

The upper Three Forks is evolving into a significant resource play in the Williston Basin. Although Three Forks production was established in Antelope Field in 1953, the play has re-emerged because of the horizontal drilling and multi-stage fracturing technologies. The upper Three Forks can be subdivided into three main facies: a) massive to chaotic bedded dolostone; b) interbedded dolostone with green mudstones; c) bioturbated dolostone to sandstone. The bioturbated sandstone and dolostone is referred to as the Sanish. The units represent an overall transgressive sequence ranging from upper intertidal/supratidal to subtidal.

The upper Three Forks has poor reservoir quality with low porosities (generally less than 8%) and low permeabilities (less than 0.1 md). The reservoirs require fracture stimulation to produce economically. Sweet-spot areas are related to favorable facies development, natural fractures, and mature Bakken source rocks. The main source rock for the Three Forks is the lower Bakken shale. Where the lower and middle Bakken members thin in the southern part of the Williston basin, the primary source rock becomes the upper Bakken shale. The Three Forks is overpressured and overpressuring is related to hydrocarbon generation.

The upper Three Forks does not appear to be in communication with the overlying middle Bakken reservoirs where the lower Bakken shales are sufficiently thick to form a barrier between the producing units. The Three Forks resource potential is estimated to be 2 billion barrels of recoverable oil.

Selected References


**Website**

Petroleum Potential of the Upper Three Forks Formation, Williston Basin, USA

Stephen A. Sonnenberg\textsuperscript{1}
Alan Gantyno \textsuperscript{1,2}
Rick Sarg\textsuperscript{1}

\textsuperscript{1}Colorado School of Mines
\textsuperscript{2}Exxon, Indonesia
Three Forks Isopach
Contour Interval: 50 ft
RMAG Atlas-1972
NDIC (2010) estimated ultimate production
Bakken Petroleum System:
Bakken: 2.1 Billion barrels
Three Forks: 1.9 Billion barrels

USGS Estimate (2008)
Bakken Petroleum System:
3.6 Billion barrels

Modified from Webster, 1984
Bakken Petroleum System Basics

• Upper & lower black shales
  ➢ ‘World Class’ Source Rocks
    ▪ Hard, siliceous, pyritic, fissile, organic rich
    ▪ TOC’s as high as 40 wt% (average 11%)
    ▪ High OM indicates anoxic conditions (amorphous-sapropelic OM)
    ▪ HC Generation: 10 to 400 B bbl oil
• Middle member (target of horizontal drilling)
  ➢ Dolomitic siltstone to a silty dolomite
  ➢ Low porosity and permeability
• Upper Three Forks dolostones (target of horizontal drilling)
  ➢ Low porosity and permeability
• Abnormal pressure and hydrocarbon generation (> 0.5 psi/ft)

Modified from LeFever, 2005
Bakken Petroleum System

Reservoirs:
- Middle Bakken & Three Forks

Source Beds:
- Upper & Lower Bakken Shales
6-10% Porosity
< 0.1 md Permeability
Structure
Three Forks
50 Miles
Pan American Pet. W. Starr No. 1
SwSe Sec. 21-T152N-R94W
KB 2145 TD 12460

Pfs: 10528-10556; well swabbed in; sand-oil squeeze; break down pressure 4900 psi;

IP: 541 BOPD; GOR 770 cu ft / bbl; 44° API

Completed: Dec. 6, 1953

Carlson and Anderson, 1959
Isopach
Upper Three Forks
Deadwood Canyon 43-28 – Sanish Field
Bakken / Three Forks Fractures

- Tectonic\structural
- Regional Fractures
- Hydrocarbon generation
Source Beds for Three Forks

Depositional/Erosional limits:
- Lower Bakken Shale
- Middle Bakken
- Upper Bakken Shale
- Three Forks
High Paleogeothermal Gradient Area

Limit Lower Bakken Shale
Lower Bakken Res
Limit Middle Bakken
Upper Bakken Res
Limit Upper Bakken Shale

Structure Bakken Formation

Resistivities Bakken Shales

50 miles
Three Forks IPs
> 500 BOPD

10 Miles
Deepening-upwards
Shallowing-upwards

Lower Intertidal
Intertidal
Intertidal
Supratidal

3rd Order Cycle
4th Order Cycles

Lower
Middle
Upper

Three Forks
Nisku/Birdbear
Lodgepole
False Bakken
Scallion
Upper Bakken Shale

After Gantyno, 2010
Summary

• Unconventional tight oil resource plays are ‘changing the game’
• Three Forks potential is enormous
• It all starts with good to excellent source beds
• Source beds mature over large areal extent
• Natural fracturing enhances tight reservoirs
• Horizontal drilling and fracture stimulation technology important in tight oil plays
Bakken/Three Forks Tight Oil Resource Play

Bakken Research Consortium
Steve Sonnenberg
ssonnenb@mines.edu