BAKKEN OIL RESOURCE PLAY
WILLISTON BASIN (US)
OVERVIEW AND HISTORICAL PERSPECTIVE
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July 28, 2010
The largest oil reserves for a continuous oil accumulation in the lower 48 states.

- Play covers an estimated 15,000 square miles.
- Recoverable reserves are estimated at 4.2 billion barrels (USGS).
- 1,946 horizontal Bakken wells have been completed since 1/2000.
- 196 million BO have been produced from wells completed since 1/2000.
- Daily production is approximately 200,000 BO.
- Current rig count at 135.
- Bakken has been completed during 4 distinct episodes since 1953, each driven by an advance in drilling or completion technology.
• CRI is a leading Bakken player.

• Largest leaseholder in the Bakken play with about 807,000 net acres.

• CRI 2010 capital budget is $1.3 billion, about 70% will be spent on the Bakken play.

• Currently operate 19 rigs.

• CRI will participate in over 200 Bakken wells during 2010, about 60% will be operated.
STAGE 1
ANTELOPE FIELD, ND
VERTICAL COMPLETIONS

STAGE 2
ELKHORN RANCH/BICENTENNIAL COMPLEX, ND
VERTICAL AND HORIZONTAL COMPLETIONS

STAGE 3
ELM COULEE FIELD, MT
HORIZONTAL COMPLETIONS WITH OPEN HOLE FRACS

STAGE 4
ND BAKKEN HORIZONTAL COMPLETIONS WITH LINERED AND STAGED FRACS

CUM 250 MMBO
DAILY RATE 200 MBO
2,000 WELLS PRODUCING
Symmetrical cratonic basin

Bakken play active at depths of 8,500’ – 12,000’

Geothermal gradient ranges from 1.8 – 2.0 degrees F/100 feet

Predominantly Laramide structures.

Onset of hydrocarbon generation - Laramide

Key structural factors:
- Vertical uplift and faulting
- Regional shear zones
- Salt dissolution in underlying Devonian
GENERAL GEOLOGY - STRATIGRAPHY

OBRIGEWITCH A-1
CITIES SERV O&G CORP
TWP: 146 N - Range: 97 W - Sec. 33

Density/Neutron
Resistivity

6% 100 OHM-M

Lodgepole Formation
Target Zones
Upper Bakken Shale
Middle Bakken Member
Lower Bakken Shale
Three Forks Formation
Productive wells are coincident with areas of thermal maturity.

Productive wells are located from Bakken pinch out to Bakken depocenter.

Hydrocarbon generation causes fracture generation via overpressuring.

HI = S₂/TOC
**General Geology – Cross-Section**

- **Upper Shale**
  - Highly organic (up to 20% TOC).
  - Brittle due to high silica content.
  - Max 28’ thick.

- **Middle Member**
  - Varies from dolomite, sand, shaley lime and shale across the basin.
  - Porosity is low.
  - Max 87’ thick.

- **Lower Shale**
  - Similar to Upper Shale.
  - Max 55’ thick.
 Basin-centered oil resource play.

 Hydrocarbon system is charged by thermally mature and high TOC Bakken shale members.

 Hydrocarbon system is overpressured.

 Target zones include Middle Bakken member and Three Forks formations.

 Storage and deliverability are controlled by matrix porosity and k, tectonic fractures and fractures related to oil generation.
HISTORICAL PERSPECTIVE

AREAS:
1) Antelope Field
2) Bicentennial – Elkhorn Fields
3) Elm Coulee Field
4) North Dakota Anticline

TOPICS ADDRESSED:
- Activity date
- Geologic overview
- Drilling and completion methods
- Results
- Conclusions
CASE HISTORY (1) – ANTELOPE FIELD

General data:
- Discovery date: 1953
- 59 Vertical wells
- Production from Sanish/Three Forks and Bakken interval
- Cum Field: 18 MMBOE
- Cum average well: 1.4 MMBOE, 4-5% porosity
- Spacing: > 40 acres
- Predominantly no frac
- Volumetric problem with Sanish Sand

Conclusions:
- Matrix storage & deliverability in Three Forks and Bakken
- Strong tectonic fracture enhancement
A living laboratory for vertical/horizontal wells and new/old technology


- 84 Vertical wells
- Average vertical well EUR 111 MBO
- 176 Horizontal wells
- Average “old” horizontal well 144 MBO
- Best horizontal well 605 MBOE
- GOR’s reflect tank-like behavior
- No frac’s on horizontal wells
- Short lateral horizontals, 2200’
- Middle Bakken member not present in numerous wellbores
- Interference between wells in less than 18 months

Conclusions:
- Three Forks matrix and tectonic fracture play
- Middle Bakken not required for production
CASE HISTORY (3) – ELM COULEE

General Data:
- 6/2000 to present
- 640 wells, 550 sq. mi. area
- 107 MMBOE produced
- Best wells have EUR’s of 500-1000 MBOE
- Dolomite shoreline facies, porosity 5-10 %, permeability up to 0.3 md
- Single, dual and triple laterals on 640’s and 1280’s
- Open hole fracture stimulation

Conclusions:
- Primarily a matrix driven play
- Minor tectonic fracture influence
General Data:

- 2004 to present
- Estimate 750 wells completed
- 2400 sq. mi. area, 125 miles from north to south
- Vertical displacement of over 500 feet on Nesson Anticline
- Middle Bakken and Three Forks are targets
- Middle Bakken member has a highly variable lithology
- Porosity for both reservoirs averages 5-6%, permeabilities average in the 0.1’s md.
- Dual reservoir model is substantially proven
- Currently determining optimum spacing
- Drilled first as dual laterals on 1280’s, then dual lateral coplanars and currently single lateral 1280’s
- Initially open hole fracs, linered fracs, and now linered-staged fracs
- EUR’s and IP’s have approximately doubled as a result of changes in frac technology

Conclusion:

- The ND anticline play is successful due to fracture enhanced porosity and advancements in drilling and completion technology
Typical CLR Horizontal Well Configuration

**Drilling**
- 1,280 acre spacing
- 10,000’ avg. TVD
- ~9,000’ single leg lateral
- 23 days to drill

**Completion**
- Currently using 24 stage fracs with some wells treated with as many as 30 stages
- Isolated with swell packers and plugs
- 40,000 bbls of x-link gel
- 2,000,000 pounds of proppant
- Treating pressures 6,000-8,000 psi @ 40 bbls / minute
- Complete 6-8 stages per day

**INDUSTRY TREND IS TOWARD MORE STAGES**
Williston Basin (US) Bakken play is a basin-centered oil resource play.

Geology can high-grade opportunities within the play.

Each area has required a leap forward in drilling and fracture stimulation practices to optimize production.

With respect to drilling and completion practices, necessity has been the mother of invention.

Early entry into the play and staying power through the determination of best methods are critical to success.