Marathon’s Bakken Well Vertical Seismic Profile and Tiltmeter Fracture Stimulation Monitoring

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September 20, 2007
Marathon After a Year in the Williston Basin

- Production Office Opened in Dickinson
  - New Building Opening by November

- Operating Safely While Building Infrastructure, Increasing Staff and Industry Ramp Up

- Six Rigs Running Including 5 H&P New Rig Start Ups

- Rigs are Concentrated in Dunn County
  - Marathon Operated Over 20 wells in 6 Project Areas
  - Participants in Several Other Outside Operated Wells

- Approach
  - Work with North Dakota
  - Technology Application in all Facets
Today - Update of Completed NDIC Petroleum Research Council Grant Work

- G-10-C: Vertical Seismic Profiling Test of a Seismic Fault and Fracture Detection in the Bakken Formation
- G-10-B: Surface Tiltmeter Study of a Bakken Fracture Stimulation
- Both Acquired in Marathon Klatt 31-14H, Dunn County During 2007
- Results Out to Public in June 2008

Acknowledgement

- North Dakota Petroleum Council Encouragement
- NDIC - Karlene Fine
VSP- Vertical Seismic Profile

- Purpose – Acquire VSP to tie to seismic for Bakken evaluation
- Plan – Acquire zero offset and two additional offsets along well path
- Contractor – Baker Atlas
- Cost - $240 M for survey
  - Two days of rig time
  - On budget
- Execution – Completed without difficulty
- Status – Processing and incorporating into data sets
- Marathon Contributors – Chuck Meeder, Geophysics and Erin Wanner, Land
Klatt Well Near 2D line and on 3D Survey

Near Bakken Time Slice

KLATT 31 – 14H

146N 95W
VSP Layout

Marathon Oil Company
Klatt #31-14H
660' FNL & 1917' FEL
NW1/4NE1/4 Section 14
T 146 N, R 95 W, 5th P.M.
Dunn County, ND

Marathon Oil Klatt #31-14H

Legend
Existing Roads
Proposed Roads

Map "B"
Quad Access Route

VSP source points
Bottom Hole Location

Dawsey & Wayne Klatt,
LaDonna M. Klatt Life Estate
= 831 ft. = 2442 rods
Proposed Access Road
(in June 19)

Scale 1"=2000'
Job Details

2 source points
200 ft south of well head
about 5,000 – 10,000 ft out the lateral

Sensor locations

- 50 ft interval from 10,900 to 2,500 ft 169 levels
- 500 ft interval from 2,000 to 500 ft 3 levels

- Zero Offset VSP to provide a tie to the seismic and to give better parameters on attenuation and velocity
- 5000 ft offset VSP to image first 2500 ft of lateral
- 10600 ft offset VSP to image lateral section from 2500 ft to 5000 ft
VSP data suggests that Bakken interval is at 2240 ms TWT at Klatt well location.
Tiltmeter – Fracture Stimulation Mapping

- **Purpose** – Map trends of fracture stimulation in a North Dakota Bakken horizontal
- **Plan** – Monitor tilt in earth with highly sensitive levels as fracture stimulation is pumped
- **Contractor** - Pinnacle
- **Cost** - $300 M for survey
- **Execution** – Initial stimulation interrupted due to mechanical failure. Second stimulation pumped recently with tiltmeters still in place
- **Status** – Processing second stimulation
- **Marathon Contributors** – Ken Dunek, Completions and Erin Wanner, Land
Comparison Technology – Tiltmeter And Surface Microseismic Mapping

• An array of highly sensitive levels or radial pattern of geophones
• Tiltmeter/Surface Microseismic will show
  • Orientation
  • Order of treating
• Cost $250-$350K

Comparison Technology – Monitor Well Microseismic

• Listen to completion from a single point monitor well
• Higher resolution in map and vertical
• Low area coverage
• Cost $500K-$1500K+
Principles of Fracture Mapping

- Tiltmeters are Essentially Deformation Gauges
- Tiltmeters are Highly Sensitive Levels that can measure in the Nano-radians

Hydraulic fracture induces a characteristic deformation pattern

Induced tilt reflects the geometry and orientation of created hydraulic fracture

Courtesy of Pinnacle, Inc.
5500 Series Pinnacle Tiltmeter

Installation

Manual Data Download Configuration

Automatic (Radio) Data Download Configuration

Courtesy of Pinnacle, Inc.

Pipe can be cut-off lower to ground if needed.
Note: Frac lengths and dips are not drawn to scale in this plan view.
Fracture Stimulation Job Results

- Stimulation ended with about 1/3 pumped because of mechanical difficulties
- Second job pumped and monitored September 5
Fracture Stimulation
Pumping Schedule

End 1st 40 min time step
End of Job
After 1st 40 Minutes
Klatt 31-14H

After Full Treatment
Klatt 31-14H

Best-fit theoretical deformation visualization
Conclusions

• Both grant projects will accomplish their goals to employ technology toward the Bakken Play for better understanding of the area around the Klatt well and its completion.

• Both are deemed successful in acquiring useful data

• Both were performed at projected costs, efficiently and safely

• Data release will be in June 2008