2009 AADE Mid Continent Chapter Symposium
Northeast US Operations
January 14, 2009

Agenda

• Overview of Eastern US
• Geology
• Operations
• Lesson’s Learned

Donald Rumsfeld at a Defense Department Briefing on February 12, 2002:

“There are known knowns. There are things we know that we know. There are known
unknowns. That is to say, there are things that we now know we don’t know. But there are
also unknown unknowns. There are things we do not know we don’t know.”
Chesapeake and Shale Plays

- Overview

Location of CHK Properties

- CHK OKC headquarters
- CHK Eastern Division Headquarters
- CHK/CNR field offices
- CHK operated rigs (145)
- CHK non-operated rigs (91)
- Mississippian & Devonian black shales
- Thrust Belt

Scale: 1 inch = 275 miles
Appalachian Basin Statistics

- First oil in U.S. – 1859 drake discovery, Venango County, Pennsylvania @ 70 feet in Devonian Sandstone. 1823 first gas discovery made in Fredonia, NY.
- Basin area: 185,000 square miles (118.4 mm ac) across 9 states and southern Ontario
- Appalachian Basin = 2/3 size of Texas, 3x state of Oklahoma
- Cumulative production 42 Tcf (7 Bboe) + 3 billion bbls oil = 10 Bboe produced
- 257,000 wells in PI, 500,000+ total in basin?
- Gas production approximately 2.0 Bcf/d, approximately 4% of U.S. production
- New plays are emerging in deeper sections of basin, in unconventional tight gas shales (source rocks), sandstones, and hydrothermal dolomites.
- 3-D seismic will reinvent the basin...
- Marcellus Shale (31 MM ac.) is “Looming Giant” that will dwarf the Barnett Shale (2.7 MM ac.)!

Early USGS Map of Devonian Shale Extents

Extent of Devonian Shale in Eastern U.S. – Section A-A’ (Oliver and others, 1967)
Marcellus Shale Play Section

- Geology Review

Appalachian Basin Petroleum Systems

USGS -30 Plays Identified

- Alleghenian Orogeny
- Acadian Orogeny
- Taconic Orogeny
Shale Basins

Early Mississippian ~360 MYA
**PHASE ONE – Initial Collision**
- African Plate Overrides and Depresses NA Plate
- Generating a very Deep, Anoxic, Sediment Starved Basin
  - Termed a Proximal Trough and associated Peripheral Bulge

**PHASE TWO – Collision ends and NA Plate rebounds.**
- Deep, Anoxic, Sediment Starved Basin shallows and both Bulge and Trough migrate westward.

**PHASE THREE – Erosion of highlands rapidly fills shallowing basin.**
- Trough and Bulge features migrate further west

**OK – But What Does This Mean?**

- **Barnett Shale**
  - High Gas Yields – High Success Rates
  - May be the largest natural gas field developed in the U.S.
  - Development of new technologies in horizontal drilling and hydraulic fracturing

- **Barnett Shale and Marcellus Shale**
  - Although separated by 30 MY in time, both were generated by a similar depositional system and tectonic setting
  - Both were the initial sediments deposited in a very deep, sediment starved, anoxic trough that formed in response to an impinging tectonic plate

- **Marcellus Shale**
  - Deep water depths – maximum preservation on organic material and higher maturity
  - Minimal Bioturbation resulting in maximum preservation of silt laminae and increased lateral permeability
Operations and Production Section

- Operations

Eastern US Areas of Interest
Marcellus Footprint and Drill Depth Map

Marcellus Footprint
31 MM acres

966 data points
11 core sites

Black River Wellbore Schematic

Drilling Procedure
Hydrothermal Fractured Dolomite Formation

- Drill 17 1/2” Surface hole on air
- Set 13 3/8” casing and cement to surface
- Drill 12 1/4” hole on air – Evaluate hole conditions
- Set 9 5/8” casing and cement – if required
- Drill 8 3/4” on air to KOP and switch to brine based mud
- Drill from KOP and build angle at 12° per 100’ to top of Black River Formation
- Set 7” casing and cement
- Drill horizontal leg from 1,500’ to 4,000’
- Total drill days = 30 days
Drilling Program

Possible Problems:
- Shallow Gas Potential
- Salt Sections in 12-1/4” Hole
- Very Unstable Vernon Shale in 12-1/4” Hole
- If these problems are minimized then by-pass the 9-5/8” casing
- Fluid requirements for the Salt and Vernon shale must be maintained while building to horizontal
- Lost circulation / returns while drilling fractured Dolomite formation

CHK Marcellus Wells Drilled to Date

- Re-entered 6 well bores to test Marcellus beginning July 2006
- Initial vertical Marcellus test well spud March 2007
- Drilled 19 vertical Marcellus wells
- Cored 6 vertical test wells thru Marcellus (analyzed 11 Marcellus cores)
- Initial Horizontal well spud August 2007
- Drilled 15 horizontal wells – all successful
- 19 vertical and re-entry Marcellus wells on line
- 6 Horizontal Marcellus wells on line
Drilling Procedure

Storage Fields

- Drill 17 ½" Surface hole on air
- Set 13 3/8" casing and cement to surface
- Drill 12 ¼" hole on air to storage zones and then switch to brine based mud
- Continue 12 ¼" hole to below storage zones
- Set 9 5/8" casing and cement to above storage zones
- Drill 8 1/2" on air to KOP and switch to brine based mud
- Build angle at 12° per 100'
- Drill horizontal leg from 3,000' to 5,000'
- Total drill days = 25 days

Drilling Procedure

- Drill 12 ¼" hole on air
- Set 9 5/8" casing and cement
- Drill 8 3/4" on air to KOP and switch to brine based mud
- Build angle at 12° per 100'
- Drill horizontal leg from 3,000' to 5,000'
- Total drill days = 21 days
Possible Problems:
- Lost Circulation Zones below the 9-5/8” casing
- Directional / Targeting issues in areas without 3D Seismic
- Pad Drilling / Anticollision
- Marcellus Shale Stability
- Hole Cleaning in Extended Reach Horizontals

Drilling Program Opportunities

Efficiencies expected from:
- Pad drilling – expect up to 6 laterals per Pad
- Learning curve efficiencies
- Reduce days & costs with repeatable program
- Water based mud in laterals
- Reduce motor/MWD inefficiencies
- Increased vendor competition
- Economies of scale

Coach Red Beaulieu: “That’s kinda like my old man told me one time, Lynn. The only thing better than a crawfish dinner, is five crawfish dinners.”

The Waterboy
Drilling Procedure

- Drill 12 3/4" hole on air
- Set 9 5/8" casing and cement
- Drill 8 3/4" on air to KOP
- Set 7" casing and cement
- Build angle at 10° per 100'
- Drill horizontal leg from 2,500' to 4,000'
- Total drill days = 15 days
- Run 4-1/2" Isolation String for completion
Drilling Program

Possible Problems:
• Water flow below the 9-5/8” casing – instability
• Dry Air Drilling Horizontal Sections – Tool Reliability
• Lower Huron Shale Stability
• Flaring Gas while drilling on air
• Tripping with Gas pressure

Lesson's Learned

1. The Geologic Model works
   • Not all acreage will be prospective
   • Establish core drilling areas for focus as new rigs arrive
2. The Rock Rules
   • Adapting drilling and completion techniques to various areas
3. People are the key
   • Strong Supports Teams are required (Contractors, Service Providers, Transportation)
   • Resources from Barnett, Fayetteville, Woodford, and Haynesville
4. Understand the full process and time requirements
   • Sourcing different water supplies
   • Sourcing different water disposal outlets
   • Changing service requirements
   • Fit-for-purpose rig designs
5. Education process for landowners, local and township governments, state government, local and state regulators