Northern Oklahoma Woodford Shale Overview
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Brad Crowdis
Drilling Engineer
Woodford Shale Focus Area
Woodford Shale Horizontals
Challenges & Best Practices

• Multiple well pads
  – Shallow directional work, increased torque & drag
• Curve design
  – Smooth tangent for ESP placement
• Well design
  – What is the optimum design?
• Lateral performance
  – Best practices for optimum performance
• Lost circulation
  – What is the driving mechanism?
• Liner cementing
  – Best practices for successful jobs
Multiple Well Pads

• 4-5 wells per pad - 20 ft. spacing
  – 3-4 producers & 1 disposal

• Benefits
  – Cost savings, reduction of surface footprint and facilities

• Challenges
  – Directional work required on every well out from under surface
  – Significant nudge inclinations
  – Increased torque and drag
  – Limited artificial lift options
• All wells require 200’ md smooth tangent for ESP placement

• Two designs
  – Curve with tangent
    • 6-8°/100’ BUR curve with tangent at 60-70°
  – Tight radius curve
    • 16-20°/100’ BUR curve with tangent above KOP

• Both designs have challenges, still testing both designs...
Initial Well Design
No intermediate casing - Curve with tangent

- 12-1/4" hole
- 8-3/4" hole
- 9-5/8" 36#/ft set at 450'
- KOP @ 4500'
- 200' md tangent at 70°
- 6'/100' BUR to 90°
- EOC @ 6215' MD / 5667' TVD
- TD = 10500' MD / 5667' TVD
- 5-1/2" 17#/ft set at TD
Current Well Design
Intermediate casing - Tight radius curve
Performance
Woodford Horizontals

Transition to intermediate casing
Lateral Performance

- High performance, high speed, stabilized motors on 4” drill pipe
- Differential Pressure vs. ROP
- Reduced connection times
- Planned clean-up cycles
- Reduction of agitator usage
- Frequent communication with geologists and geosteerers
Lateral Performance
Differential Pressure vs. ROP
Lateral Performance
Connection times

Average ROP w/ connections vs. Instant ROP (fph)

- 5 min
- 10 min
- 15 min
- 20 min
- 25 min
- Actuals
Lost Circulation

• Lose at least 100 bbl. WBM on 75% of all WDFD laterals
• What is driving mechanism of lost circulation/seepage?
  – Faulting/natural fractures
  – ECDs > fracture gradient
• Lost circulation mitigation/treatment
  – Nitrogen units
  – Planned cleanup cycles
  – Minimize LCM treatments
  – “Dry” drill
Liner Cementing

- Liner hanger/packer selection
  - “Wash/ream to bottom” and/or “float”
- Centralization
  - 1 centralizer per joint
- Nitrified mud ahead of cement job
  - 1 gpm:1scfm ratio
- Increased excess from 20% to 30-50%
  - Relatively small additional volume
- Rotate liner while cementing
  - 15 to 25 rpms
Extended Reach Drilling (ERD)
Devon drilled horizontals
Extended Laterals

Challenges

• Provide twice the length of lateral for less than twice the cost of a standard length lateral

• Optimum well design
  – What is the optimum design?

• Hole cleaning
  – Lost circulation reduces efficiency

• Tool availability
  – Limited supply of specialty tools

• Torque and Drag
  – Conventional vs. Rotary Steerable
  – Getting casing to bottom
• Tested designs
  – 8-3/4” all the way = 5-1/2” long string
  – 8-3/4” curve, 6-1/8” lateral = 7” x 4-1/2” liner
  – 12-1/4” curve, 8-3/4” lateral = 9-5/8” x 5-1/2” long string
  – 9-7/8” to KOP, 8-3/4” curve, 6-1/2” lateral = 7-5/8” x 4-1/2” liner
  – There are a number of additional designs also worth considering...

• Challenges
  – Risk vs. Reward
  – ECDs in slim hole, accurate ECD modeling
  – What zones can be exposed? How long?
  – Additional drilling time for larger hole = additional days and cost
Extended Laterals
Days vs. Depth

[Graph showing days vs. depth for different lateral sizes]

NYSE: DVN
www.devonenergy.com
Extended Laterals
Torque & Drag

- Relatively high FFs
- Conventional vs. RSS
  - What is the limit?
- Running Casing
  - Long strings
    - Conventional
    - Rotate to bottom
    - Floating
  - Liner
    - Conventional
    - Rotate to bottom
    - Floating
- Lubricants
  - Cost vs. Benefit
Moving Forward

• Continuous improvement of current practices
• Define the boundaries of the play
  – Continue testing well design concepts for standard length laterals throughout the entire play
  – Utilize key learnings from standard length laterals and apply to extended laterals
• WellCon - Decision Support Center
  – 24/7 real-time monitoring center
Thank You