ERD DEVELOPMENT IN THE SHELF PLAY
WESTERN ANADARKO BASIN

How to maintain drilling efficiency, while increasing well design complexity

Ben Sellers
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OUTLINE

• Background Information
  – Western Anadarko Basin (WAB) Geology
  – FourPoint Energy’s (FPE) Shelf Timeline Overview

• Well Plan Design Progression (2016 – Present)
  – Well Plan Design Changes (5k -10k Laterals)
  – Execution (DvD and Operational and BHA Design Changes)
  – Performance Highlight

• Present and Future Considerations
Anadarko Basin

Paleo-Geography and Tectonic Setting

Modified from Blakey (2005) and Ambrose & Hentz (2011)
Play Activity
Granite Wash and Shelf Sandstones
Motivation to Pivot Drilling Ops. to the Shelf

• **Adapting to Market Conditions**
  – Went from a 6 Rig Program (4 Wash, 2 Shelf) to ultimately a 4 Rig Program (1 Wash, 3 Shelf).

• **Two main drivers:**
  – Commodity Prices (Oil vs. Gas)
  – Senate Bill 867
    • Signed in under “Oklahoma Energy Jobs Act of 2017”
    • Passed 05-31-2017
    • Major significance to FPE came in the approval to drill two section laterals in non-shale (conventional) sources
In the Beginning… (Initial Well Design)

- **Initial CLVD Well Design:**
  - Drill Vertical to KOP
  - Medium Radius Curves
  - Single Section Laterals
  - Drilling wells for lease retention and/or delineation

- **Simple Well Design Allowed:**
  - Refinement of Fluids Program
  - BHA Selection
    - Bits
    - Motors
    - Stabilization
  - Single Run PDC Curves
  - Gain Consistency in Drilling DvD
Vertical (Intermediate)

- **8 3⁄4” Bit Selection**
  - Bit designed competent enough for a single run, however aggressive enough to maximize ROP through varying lithology
  - Managed Parameters
  - Shaped Cutters (i.e. Axe Blade)
  - 6 to 5 Blade PDCs

- **Mud Motor Selection**
  - Started at 0.242 RPG
  - Experimented w/higher RPG (7 ¼” MM)
  - Went back to a 0.242 RPG after DBRing bits

Curve (Production)

- **6 1/8” Bit Selection**
  - Initial PDC runs yielded variable DLS
  - Kymera Trials to key in on single run
  - Went back to PDC when motor config. was figured out

- **Mud Motor Selection**
  - Key Finding was going from a Regular BTB to a Short BTB with Superhawk bearing assembly ~39 inches (Next Slide)
• **Gaining Consistency in the Curve Section**
  
  – **Goal:** Execute Curve Section of the Well Plan with a Single BHA
  
  – **Experimentation Phase:**
    
    - Well Plans built curves on 10 – 16°/100 ft. (12 & 14’s Standard; Increased BUR for decrease in Curve MD)
    
    - Initial BHA Design utilized RBTB 4 ¾ - 5” MM (ABH & FBH f/2 – 3° with & without NBS)
    
    - Observed a significant variance in motor build rate potential throughout the curve and from well to well (geographical loc.)
  
  – **Lessons Learned:**
2017 Well Design Progression

What challenges were introduced from the design changes over 2017?

- Intermediate Tangent Work
  - Slot Placement
  - SSE or Pad Off-Section
  - Re-occupy Pad
- Anti-Collision Concerns
- Trials Begin to Extend Lateral Length F/5k – 7.5k
How FPE Initially Met Complexity w/Efficiency

8 ¾” Tangent Work
- Significant Step-Outs (1–2k ft.)
  - Before executing model tangent placement in ERA
    - ERA results indicated to keep DLS low in build/drop =<2º/100 ft. (hold angle was not a key component)
    - The KOP1 point should be as low in the 8 ¾” section as possible (Due to increased T&D impact from high DLS uphole)
  - Couple ERA Model results with real-world drilling tendencies to develop final solution

6 1/8” Lateral (Production) – Dealing with an Extra 2.5k FT.
- T&D Impact
  - Again Model the Extra 2.5k ft. of lateral in ERA
  - Increase PUSO collection frequency on the first few 7.5k ft. wells to have a higher density dataset
- Surface & Downhole Tool Utilization
  - ERA currently doesn't model the effects of vibratory/oscillator tools, therefore FPE trialed many different types and configurations of downhole vibratory tools and ensured each shelf rig had an top drive oscillator system
Making the Tangent Execution Seamless, let the Rock work for you.

- **Goal:** Almost every well from here on out will have a significant step-out (=>1,000 ft. displacement). Find the most efficient route to that displacement.
- **Experimentation Phase:**
  - Initial BHA Design utilized 6 ¾” MM (FBH f/1.25 – 1.83° w/SS)
  - Tried all sorts and sizes of stabilized assemblies (Nortrak, RR, NBS, RBS)
  - Brought learnings from the Granite Wash intermediates and they applied nicely to the shelf. (Even with the two differing in hole sizes)
- **Lessons Learned:**
  - **Formation Trends Uphole:**
    - Primary Control: Geology/Formations
    - Secondary Control: Drillstring/BHA Design
    - Minor Control: Mechanical Drilling Parameters (i.e. RPM, GPM, WOB)
  - Continue to refine: As more data is collected well to well by our FPE DDs, a more robust dataset aids in setting up predictive well planning for the tangent section.
  - **Take Home Message:** Understand real world execution is different than the simplicity of a well plan.
    - Plan DLS limits lower than the actual model limit
    - Plan sliding for build/hold/drop sections in sections with high ROP or easy steering. Very intuitive, but how often do we see this executed?
2018 Well Design Progression

(Left Plot) 08-24-17: 7.5 K Lateral, Re-Occupy Pad = Up-Hole Tangent

(Right Plot) 08-28-18: Double Section Lateral, Large Tangent to Hit Slot Positions, Change lateral slot position after first section

Design Changes F/2017 - 2018

- Change from lease retention to development mode drilling
- Multi-Well Pads
  - Slot Density/Placement
  - SSE/Reoccupy
- 10K Laterals
  - Up-dip
  - Down-Dip
- Allows for batch drilling
  - Surface – KOP (Wells A – C)
  - KOP – TD (Wells C – A)
From 5k to 7.5k to 10k Seamlessly

Curve (Production)
- Push Curve Assembly into the Lateral
  - Setup the curve assembly where it can be taken out into the lateral without elevated risk
  - More on this subject on the following slide

Lateral (Production)
- T&D of the last 2.5k on a 10k lateral
  - Modeled SO values always fail within the last 2.5k of the lateral. Where within that 2.5k depends on tangent, up/down-dip lateral and real world execution.
- Stabilization
  - The current dataset indicates that a strong overall building trend is expressed in the lateral (very few exceptions that have been attributed to geological control – i.e. hard streaks). Design lateral BHAs to neutralize the building trend.
- Drilling Windows
  - FPE Geo’s initially were very strict on the +/- 3 ft. above/below Geo. CL windows. As production result came in on wells with a higher % steered out of the drilling window, it was shown that economics could not justify the tight drilling windows. So we currently steer off of +/- 5 ft. and sometimes open those up towards TD. Heavily utilize continuous INC and sometimes BINC.
2018 Performance Highlight

- Transitioning from a dedicated curve assembly to pushing out in the lateral further with our curve assembly.
  - **Goal:** After landing the curve drill as far as possible, while maintaining >800 ft./day.
  - **Experimentation Phase:**
    - Initial BHA Design utilized SBTB 4 ¾” MM (FBH f/1.5 – 2.12º w/SS)
    - Tried both slick and lateral stabilized assemblies
    - Fixed the bit type to a 6 1/8” 6-Blade PDC (Similar bit as we predominantly run in the lateral)
  - **Lessons Learned:**
    - Initial success: First attempt drilled the curve and ~2k ft. of the lateral (On 7.5k Lateral).
    - Continue to refine: Decrease FBH angle to 1.83 deg. for the ability to increase RPMs for hole cleaning and longevity of motor components.
    - Most recent data point: Curve and ~6.5k of the lateral @ >1k/day.
Current Well Design Progression

Current Design Adjustments
- A summation of all the previous years adjustments. Back to gaining consistency.
  - Multi-Well Pad
  - Uphole Tangent
  - 10k Lateral
  - Updip Lateral
  - “S-Turn” in the lateral

(Left Plot) 07-17-18: Double Section Lateral, Large Tangent to Hit Slot Positions, Some minor 3-D at the base of the curve

(Right Plot) 10-28-18: Double Section Lateral, Large Tangent to Hit Slot Positions, Change lateral slot position after first section
Present Benchmark

Applying and Successfully Executing all Discussed Techniques

- Continue to gather data and refine processes

Lateral (Production)

- How to Efficiently Drill that Last 2.5k is the current challenge.
PRESENT AND FUTURE DIRECTIONS
• Current Path Forward
  – Push the Bit:
    • Advantages
      – Actual results have been the better of the RSS Systems
    • Disadvantages
      – Results have tended to be area specific (Pad Wear, Wash, LCM tolerances)
      – Requires specific execution of certain hole sections (Primarily the curve section)
  – Point the Bit:
    • Advantages
      – In theory the mechanical means of displacement is better suited for isolated areas of the Cleveland Play
    • Disadvantages
      – If ran non-motor assist (i.e., Well Guide), pipe wear becomes a concern due to excessive surface RPMs
      – Requires specific execution of certain hole sections (Primarily the curve section)
Future Considerations

Some Other Future Considerations

- MWD Advancements (Mud Pulse to EM Telemetry)
  - Reduce Mud Costs from Forgoing MP Telemetry (Fluids Program is no longer limited by MWD constraints)
  - Limit Unnecessary Trips due to Pack-Off Events
- Longer Curve/Lateral Runs (Roller Cutter Tech)
  - Curve/Lat. Runs are Tripped for PR Primarily
    - Solution: Eliminate the Shoulder Wear on the Cutters Causing the ROP Decline
**4½” Casing: Tension Snapshot at 17,083 ft**

Sensitivity to Friction Factor

- Well: Brady 2029 19-26 1HB (P1)
- Field: Granite Wash
- Operator: FourPoint Energy
- Location: Ellis County

**4½” Liner: Tension Snapshot at 19,315 ft**

Sensitivity to Friction Factor

- Well: Tubb 24X6X195
- Field: The Shelf - WAB
- Operator: FourPoint Energy
- Location: Ellis County
Western Anadarko Granite Wash and Shelf Sandstone plays

- Targeted plays cover 4.5 MM acres with active horizontal targets from 7,500’ – 15,500’
- Over 5,000 Hz wells drilled to date
- Thousands of potential drilling locations on FourPoint’s land position.
- Oily shelf Ss plays and liquids-rich upper GW drilling activity increasing over the past 6 months
- Exposure to significant natural gas resource in lower Granite Wash

Note: Granite Wash spans from the Lower Permian to the Pennsylvanian in age. Areas marked with an oil, gas or liquids symbol represent zones present in the Western Anadarko Basin.
Figure 3. Major structural features in southwestern Oklahoma. Compiled from Ham and others (1964) and Harlton (1951, 1963, and 1972).
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