An Alternative Method of Obtaining Open Hole Logs in Horizontal Wells - Examples from the Mississippian

Mississippian and Arbuckle Workshop - October 31, 2012
Objective:
To obtain high quality open hole log data after drilling with minimal risk and cost in horizontal wells.

How:
Conveying a specially designed set of slim hole logging tools by pumping them down through drillpipe and a Portal™ bit to suspend sensors into open hole. Data is then acquired in memory as the pipe is tripped out.

Benefits:

• Reservoir delineation (Porosity, Lithology, Stress)
• Completion optimization
ThruBit Areas worked

Service Points:
Houston
Tyler
Midland
Oklahoma City
Brighton, CO
Four Levels of Deployment / Acquisition

1. Wireline Open Hole
   - Real Time
   - First Attempts
   - Slim Holes
   - Sticking conditions

2. Wireline thru Drillpipe and Bit
   - Real Time
   - Single Zones Near TD
   - Bypassing Ledges

3. Memory Logging
   - Difficult Wells
   - Multiple Intervals
   - Deviated Wells
   - Adverse Conditions

4. Memory Logging - Pump Assisted
   - Horizontal Wells
   - Horizontal Wells
   - Alternative to LWD & Pipe Conveyed
BHA Components

Portal™ Bit - Sizes 6” - 12 ¼”

- Deployment/retrieval of the logging string at any time.
- Rotation and Circulation can be maintained at all times.
- Lost circulation material can be added.

2 1/2” (2 3/8” drift) Pass through diameter required through all tubulars
SureLog™ Logging Tools

Operating Milestones:
Max MD > 24000’, Max Dog Leg = 31deg/100’  Max Inc = 103 deg  Max BHT=317

- Maximum Outer Diameter: 2 1/8”
- Minimum Hole Size: 4”
- Maximum Hole Size: 14”
- Temperature: 300° F
- Pressure: 15,000 psi

TBN - Thermal Neutron
TBD - Density, PEF, Caliper
TBR - Array Induction
TBS - Sonic  (monopole 6 receivers - compressional and shear)
SureLog™/Q-String Comparison - South Texas Vertical Well

Conditions:
- BS=6”
- OBM/16.8 ppg
- No Conditioning between runs
- Real Time Wireline
Typical Horizontal Well Logs

Questions:
In zone or Out of zone?  Porosity/sweet spots?  Naturally Fractured?
Ideal placement of stages/perfs?
• Caliper data - hole enlargements
• Variations in Porosity and Lithology
• GR is of little use for zone delineation
Oklahoma Woodford Shale Example

Horizontal well: 100’/division
Granite Wash - TX Panhandle horizontal well

- Significant stratigraphic changes.
- Log data has a significant impact on completion design.
- GR is of little use for correlation or zone delineation.
• Limited Gamma Ray response throughout the lateral
• Variations in Porosity will influence completion design
### Mississippian Example 2 - Western Oklahoma

- Gamma Ray does not clearly indicate porosity/lithology changes
- Variations in Porosity will influence completion design

![Graph: Mississippian Example 2 - Western Oklahoma](image)
Production Logs from the Eagle Ford

Determine flow contribution by stage and cluster.

Eagle Ford Production Log Examples
- 21% of the Perforation Cluster are “Not Contributing”.
- 30% to 43% of the Perforation Clusters are contributing less than 1% of total production.

Often entire stages are not contributing: 60% of production from 39% of stages.
What if all stages contributed equally, or we eliminated the poor stages? Cost/boe goes down!
Sonic Applications

- Compressional/Shear velocities
- Primary/Secondary Porosity
- Rock Properties Poisson’s ratio/Young’s Modulus
- Brittleness (SPE 115258)
- Qualitative fracture indications

Processed Results

Slowness Time
Coherence

Shear
Compressional
Microseismic monitoring clearly shows that the fracture initiates in the lowest-stress interval (in red), and treatments tend to understimulate higher-stress intervals (in pink and blue).
Geo-Frac™ - Stress Profiling
Mississippian - Southern Kansas

Horizontal well: 100’/division
Qualitative Fracture Identification - Sonic VDL vs Image Interpretation

Mid Continent Shelf Carbonate

Depth Scale=100’/division

Black=Open Continuous, Green=Open Lith Bound, Aqua=Open Partially healed
**Sonic VDL in the Mississippian - N. Central Oklahoma**

- Typical interval with open fractures. Note attenuation and discontinuities in the shear portion of the VDL.
- Healed fractures are not detected.

**Depth Scale: 10’/division**
Conclusions

• The SureLog™ tools, Portal™ bit, and deployment technique allow for the successful acquisition of open hole logs in horizontal wells at minimal risk.
  – Rapid retrieval of logging tools and sources if pipe becomes stuck
  – Full Circulation and rotation of pipe throughout the procedure
  – Wireline never exposed to open hole.

• Use of wireline enhances reliability.
  – Tools only deployed after bit is in position and well is deemed ready.
  – Down log recorded – continuous monitoring of sensors before being released
  – Down log can be used as a secondary depth reference

• Rig time and acquisition cost savings with less operational and LIH risk compared to LWD and other logging techniques.

• Porosity and sonic data can optimize the completion by allowing the zones of similar properties to be grouped, resulting in improved frac designs and maximized productivity.
Questions