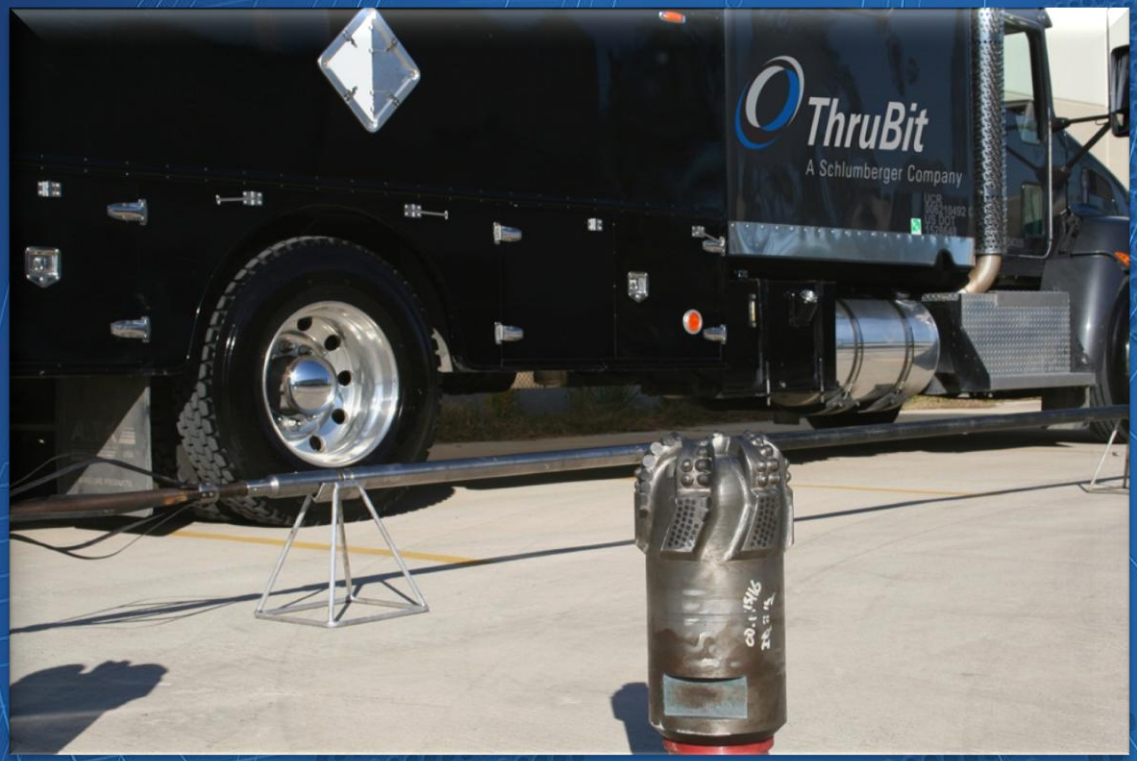
An Alternative Method of Obtaining Open Hole Logs in Horizontal Wells - Examples from the Mississippian

Mississippian and Arbuckle Workshop – October 31, 2012



Rick Reischman
ThruBit – Houston, TX

www.thrubit.com

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*

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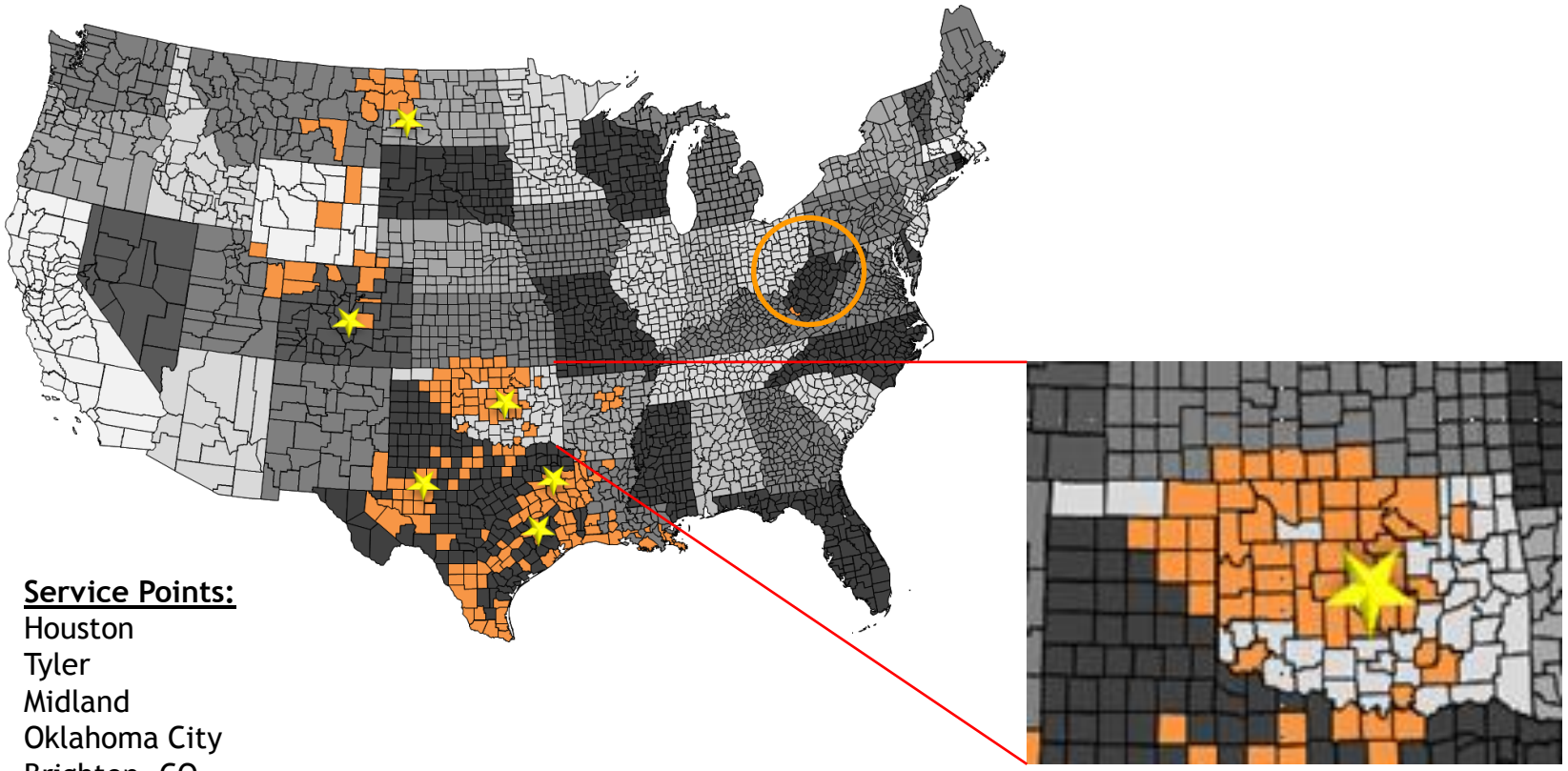
ThruBit Areas worked



Service Points:
Houston
Tyler
Midland
Oklahoma City
Brighton, CO

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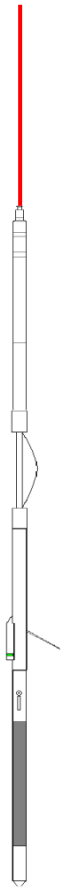
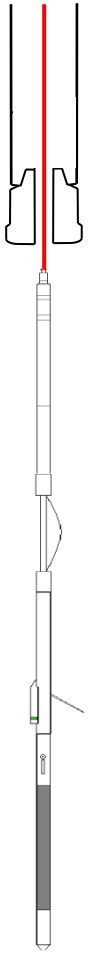
Four Levels of Deployment /Acquisition

1. Wireline Open Hole
Real Time



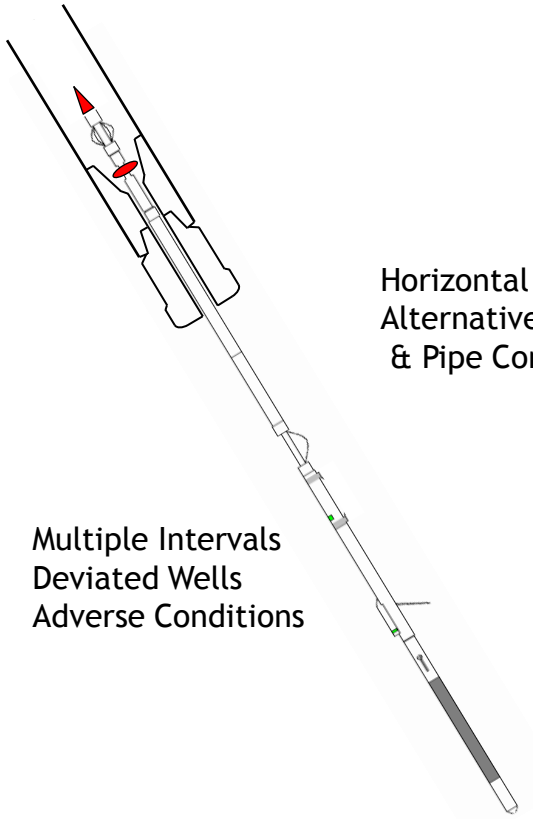
First Attempts
Slim Holes
Sticking conditions

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

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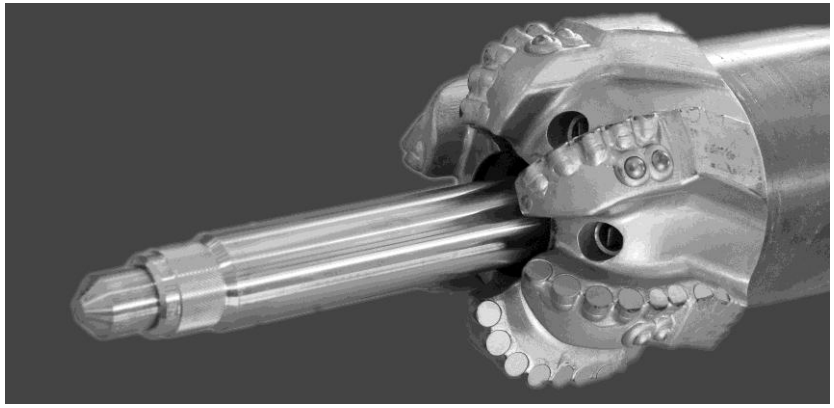
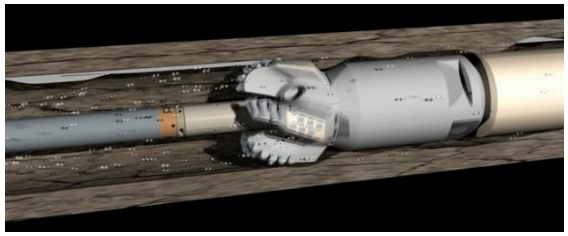
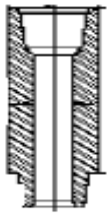
BHA Components



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.

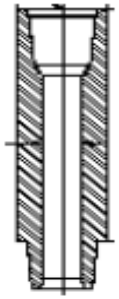




4 1/2" XH (Box)

X-over

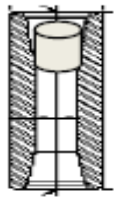
4 1/2" IF (Pin)



4 1/2" IF (Box)

Flapper (Optional)

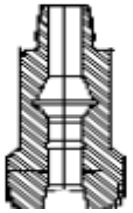
4 1/2" IF (Pin)



4 1/2" IF (Box)

Bit Sub

4 1/2" Reg (Box)



4 1/2" Reg (Pin)

Bit

8 1/2" or TB Reamer

2 1/2” (2 3/8” drift) Pass through diameter required through all tubulars

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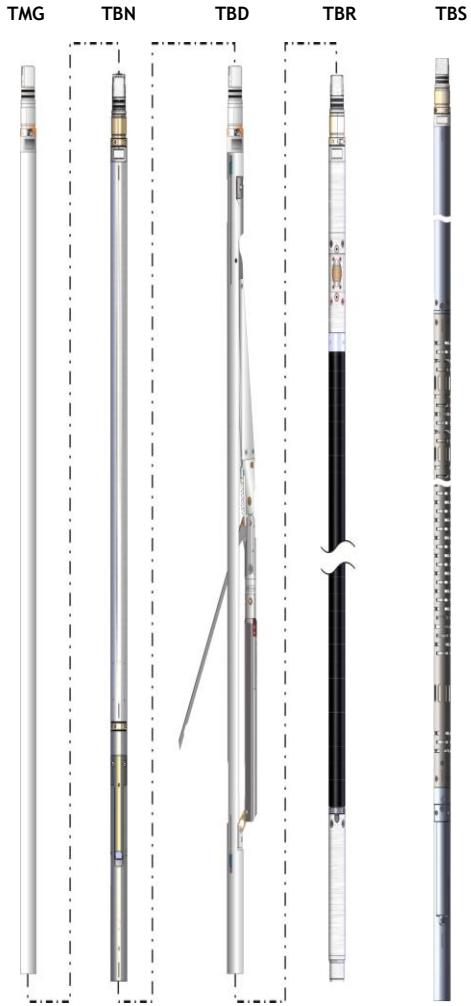
SureLog™ Logging Tools

(Memory or Real Time)



- 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)

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

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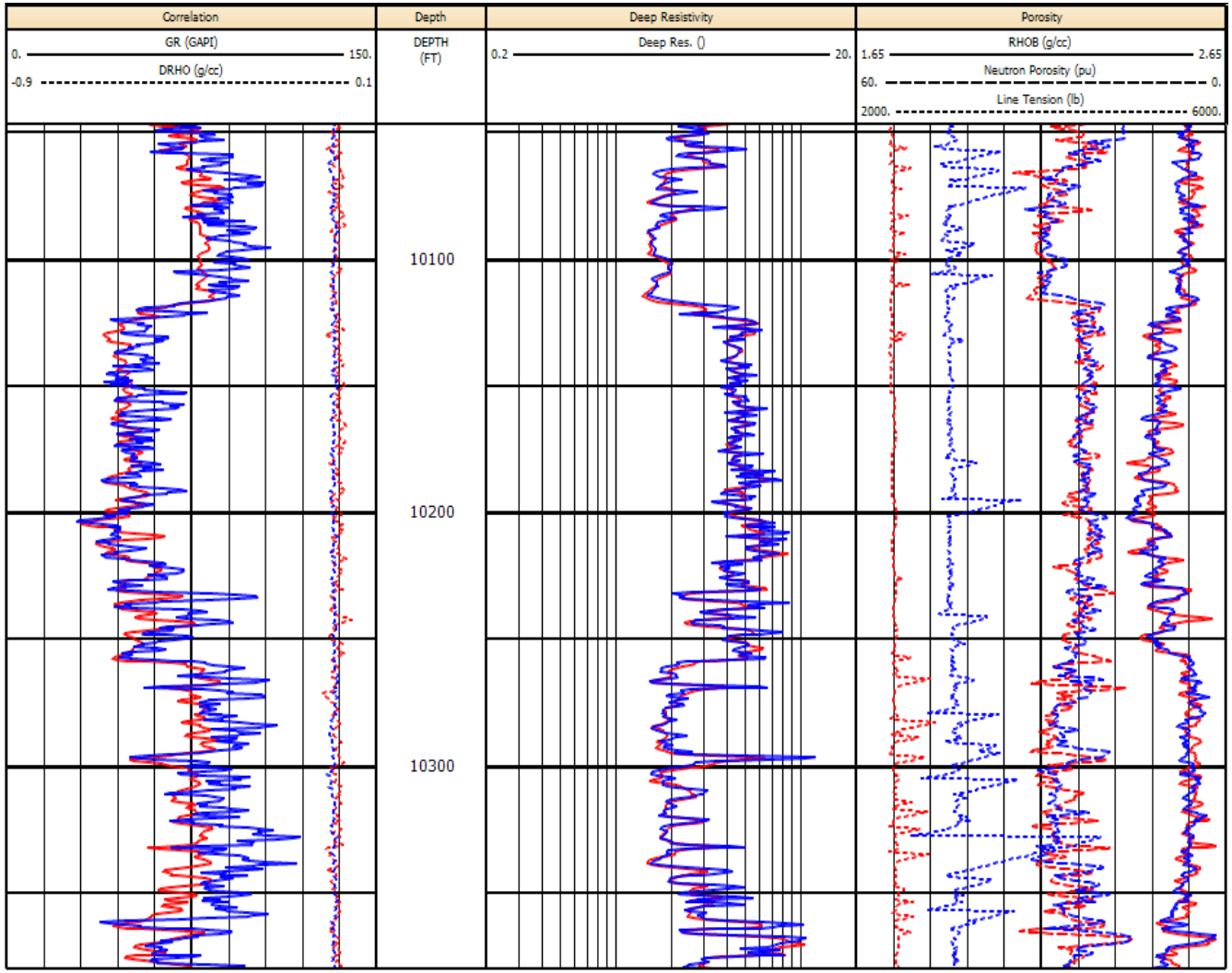
SureLog™/Q-String Comparison – South Texas Vertical Well



Level 1 Conveyance

Conditions:

- BS=6”
- OBM/16.8 ppg
- No Conditioning between runs
- Real Time Wireline

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Horizontal Memory Logging Video

Level 4 Conveyance

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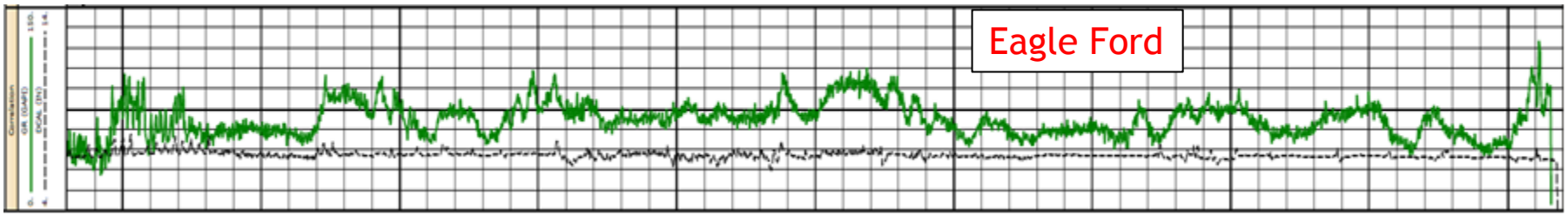
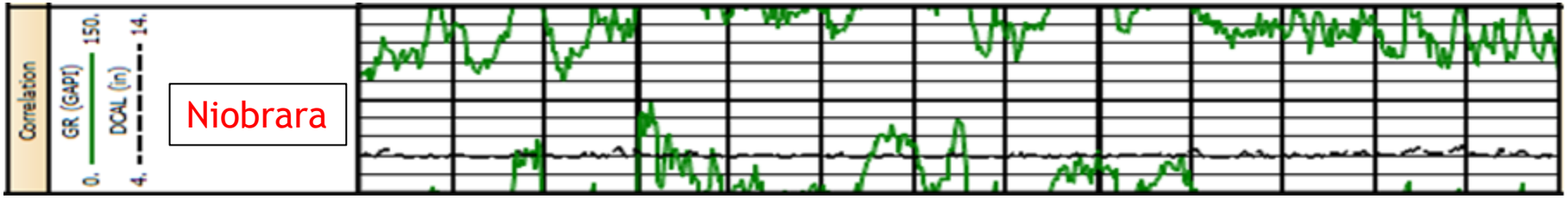
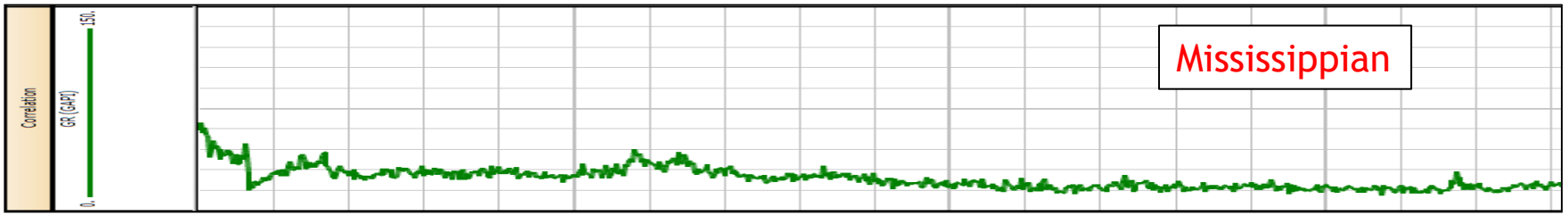
Typical Horizontal Well Logs







Questions:
In zone or Out of zone? Porosity/sweet spots? Naturally Fractured?
Ideal placement of stages/perfs ?

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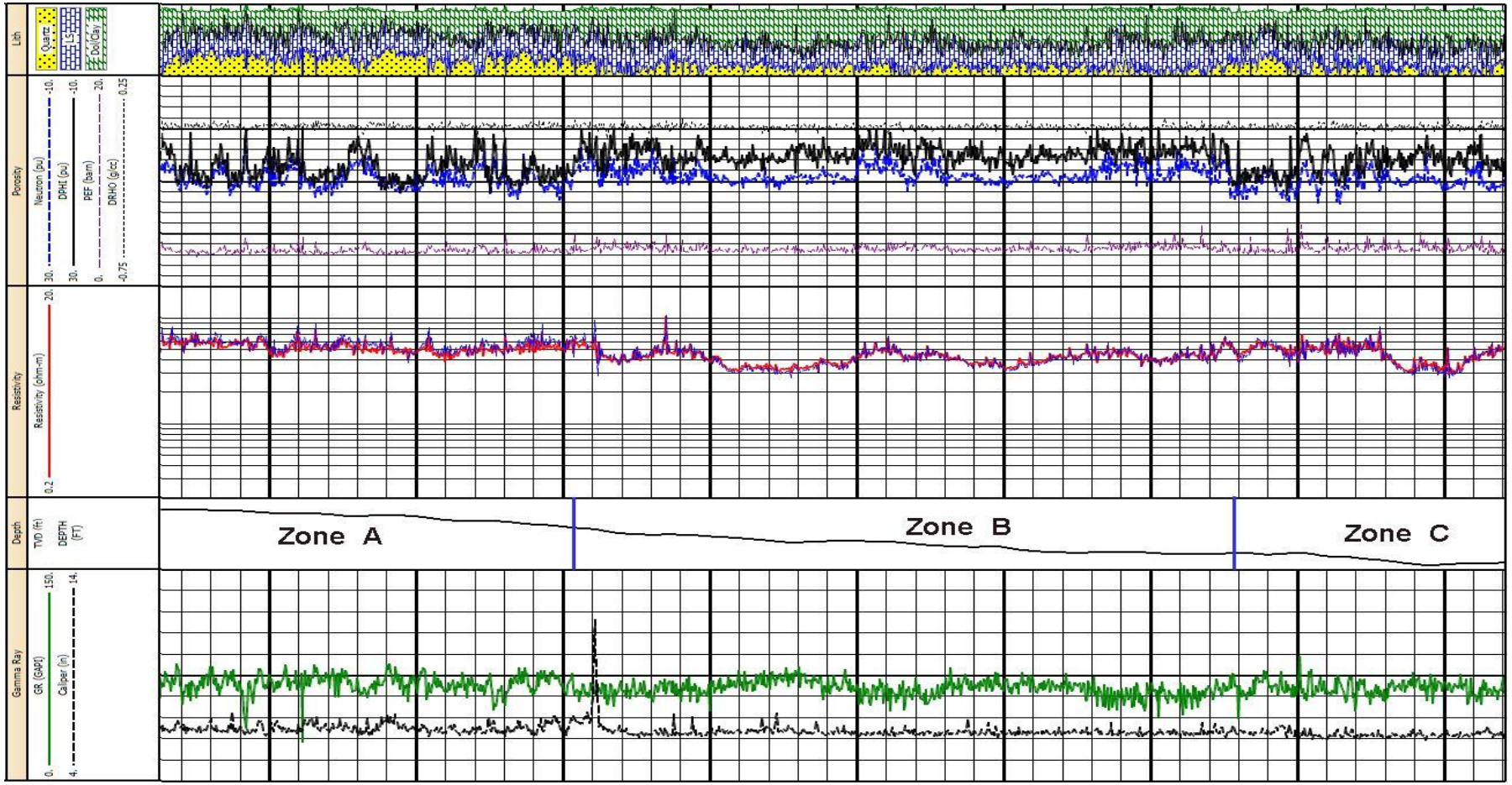
Bakken - North Dakota horizontal well

Depth Scale: 200'/division



- Caliper data – hole enlargements
- Variations in Porosity and Lithology
- GR is of little use for zone delineation

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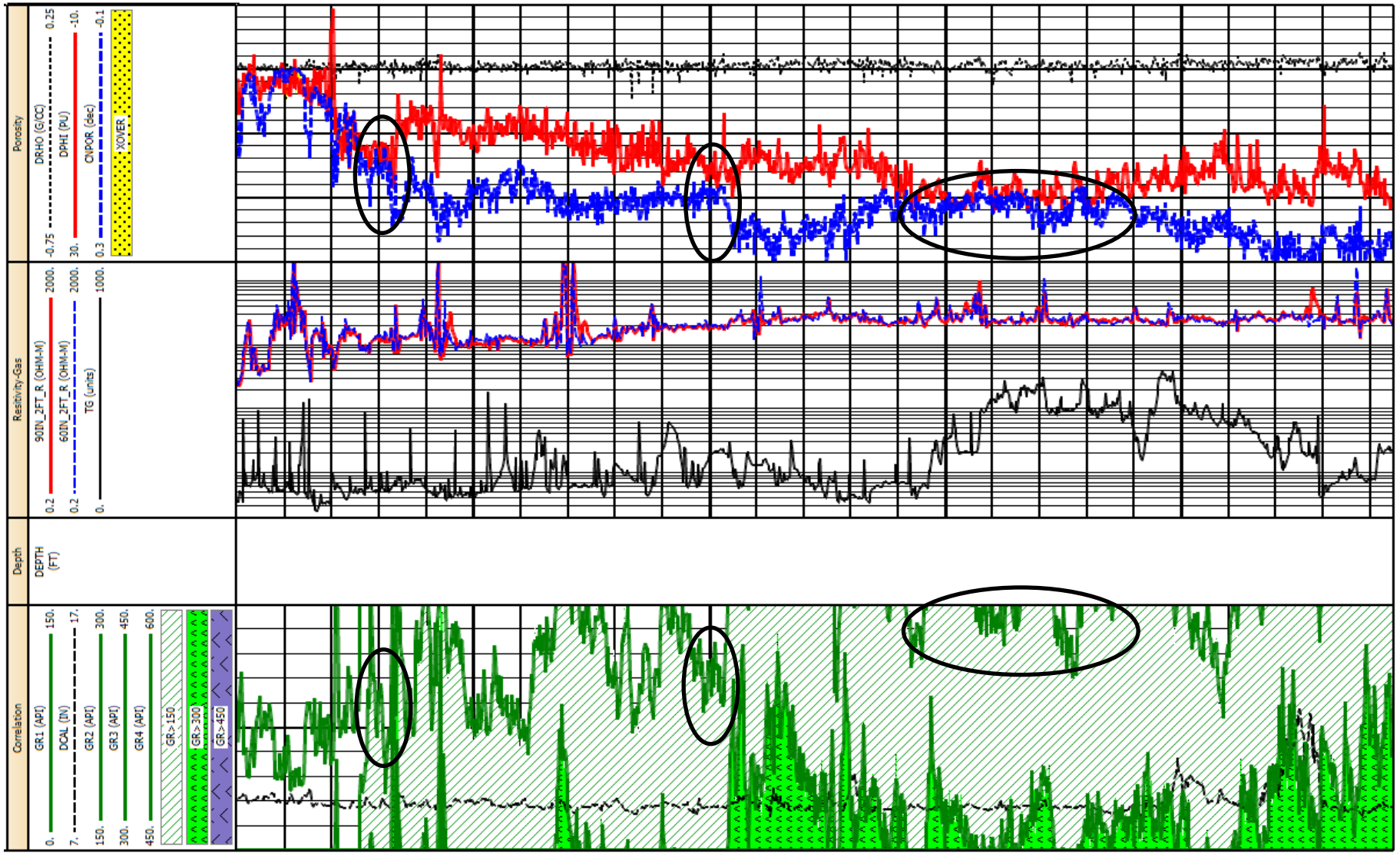
Oklahoma Woodford Shale Example

Horizontal well: 100'/division



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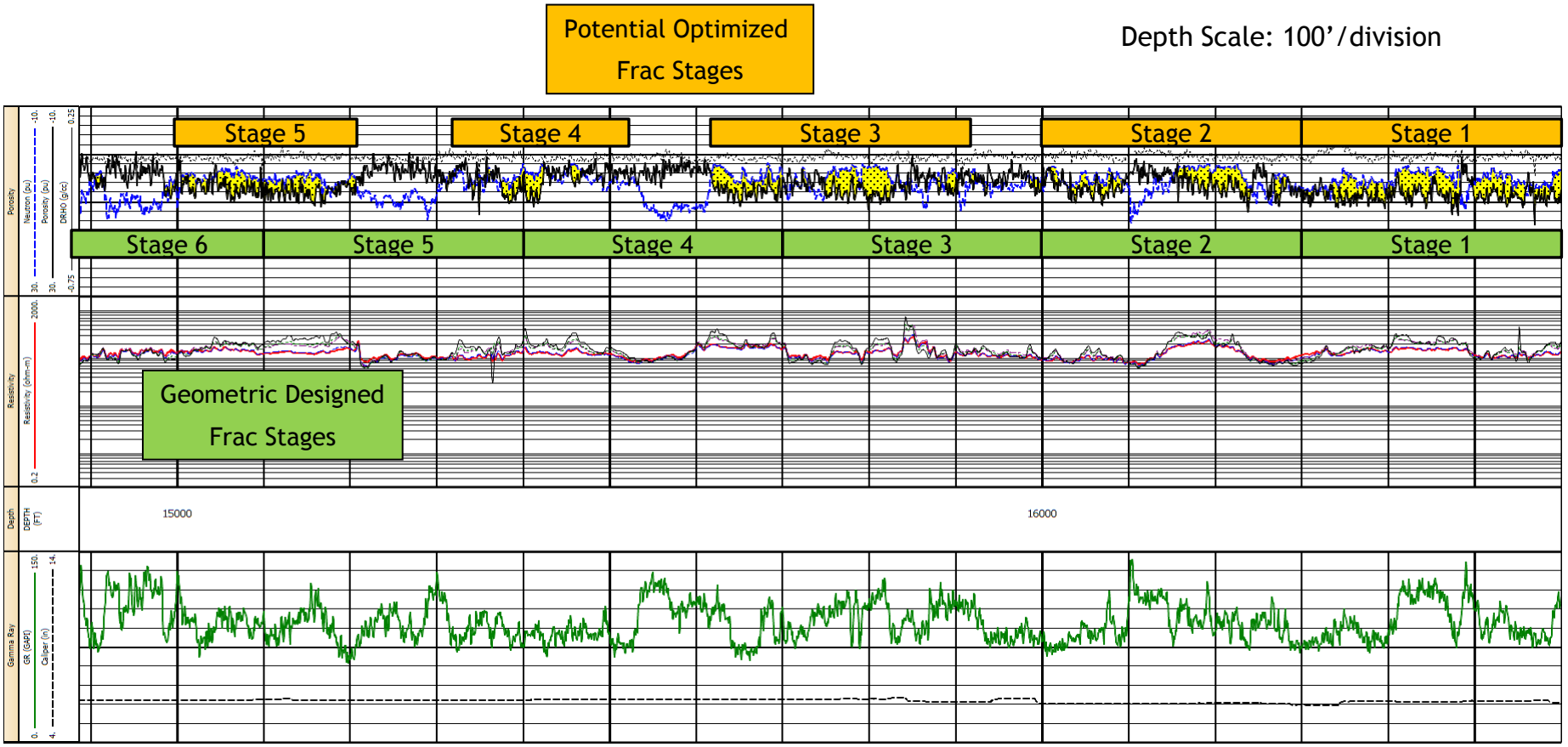
Granite Wash - TX Panhandle horizontal well



- Significant stratigraphic changes.
- Log data has a significant impact on completion design.
- GR is of little use for correlation or zone delineation

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Mississippian Example 1 – Western Oklahoma

Depth Scale: 100’/major division

- Limited Gamma Ray response throughout the lateral
- Variations in Porosity will influence completion design

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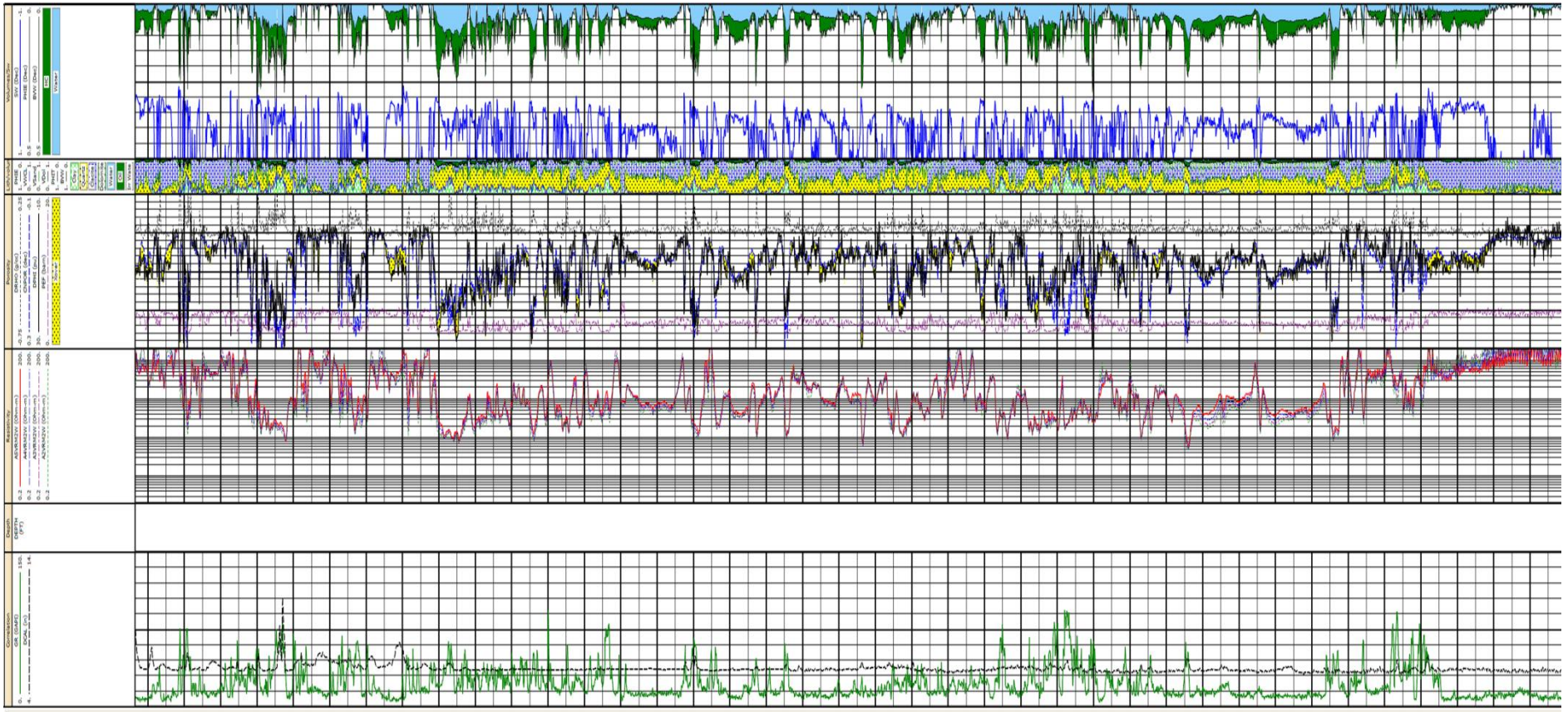
Mississippian Example 2 – Western Oklahoma

Depth Scale: 100’/major division



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

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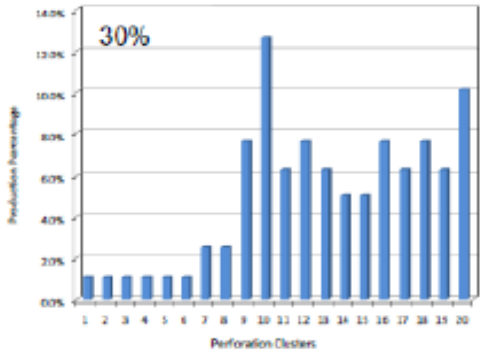
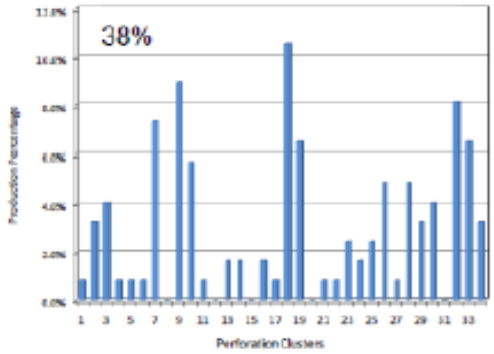
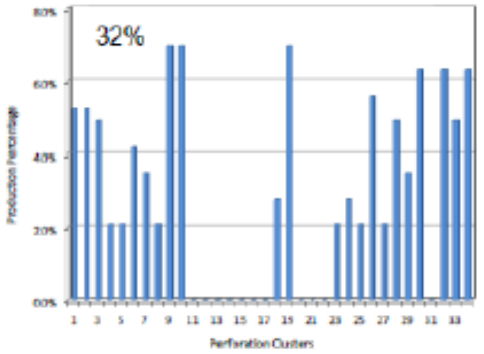
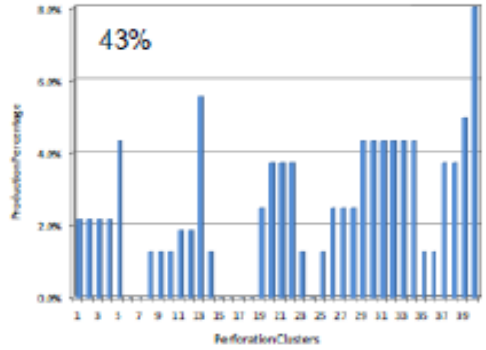
Production Logs from the Eagle Ford

Determine flow contribution by stage and cluster.



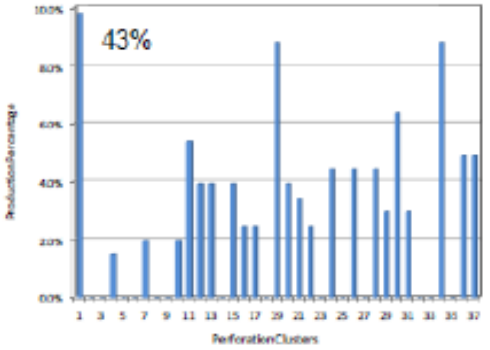






Eagle Ford Production Log Examples

- 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!

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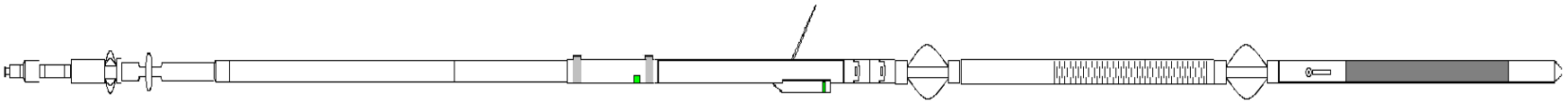
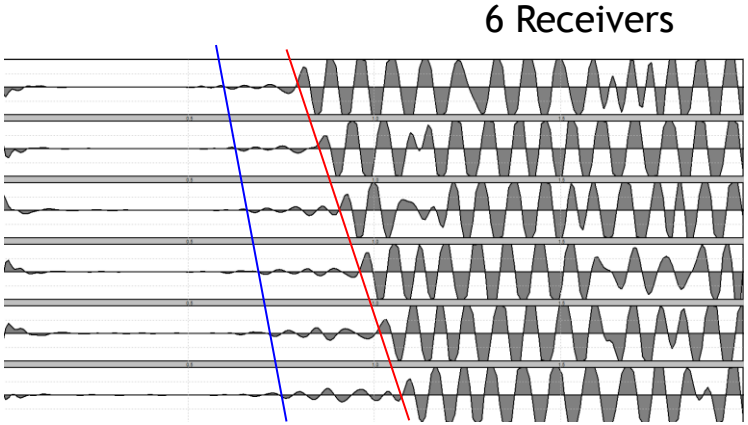
Sonic Applications



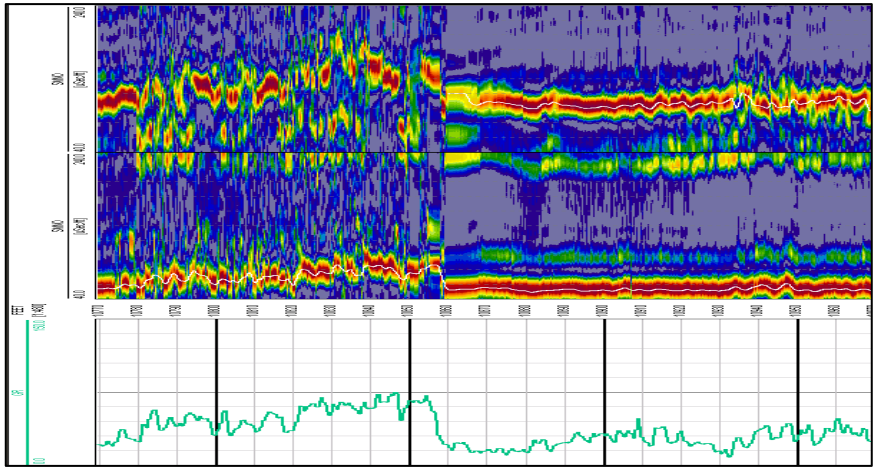
SureLog™ - Memory Quad combo Toolstring

- 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

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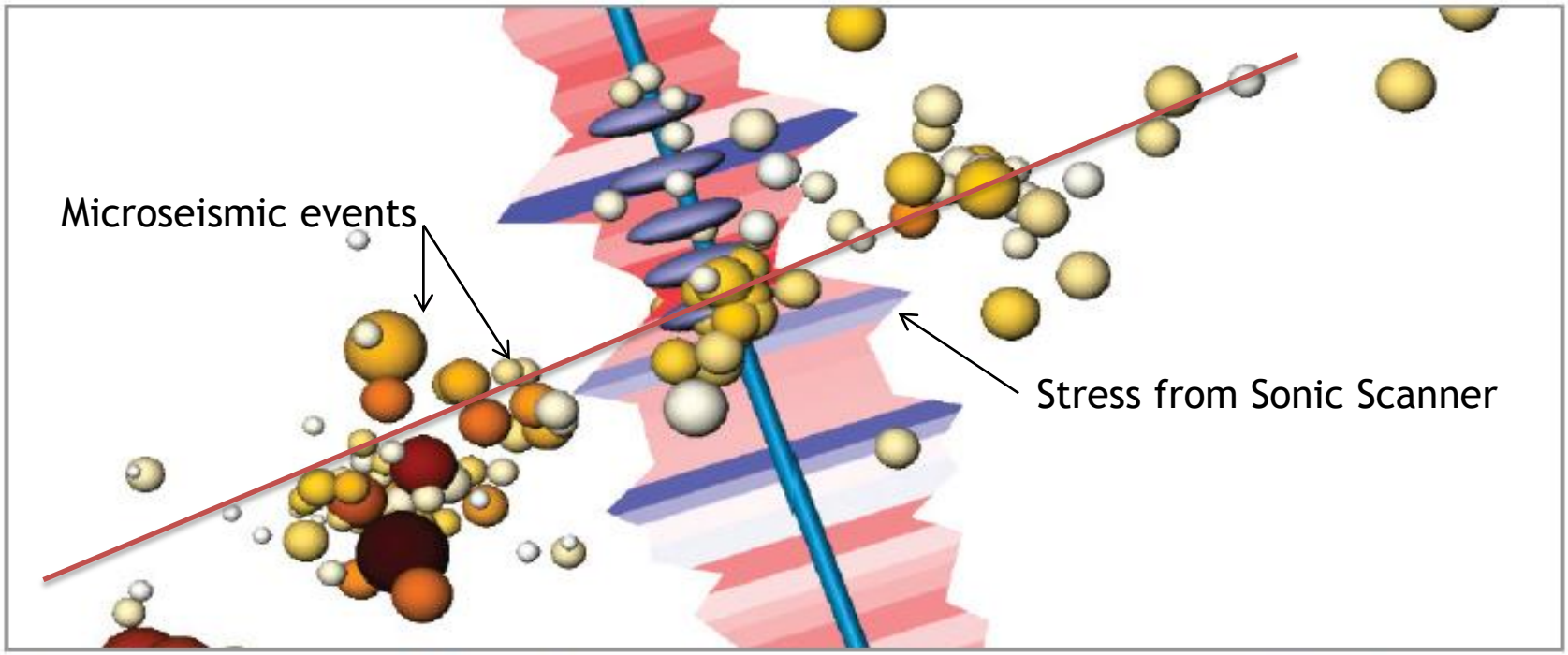
Predicting Frac Geometry using Borehole Stress Data



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).

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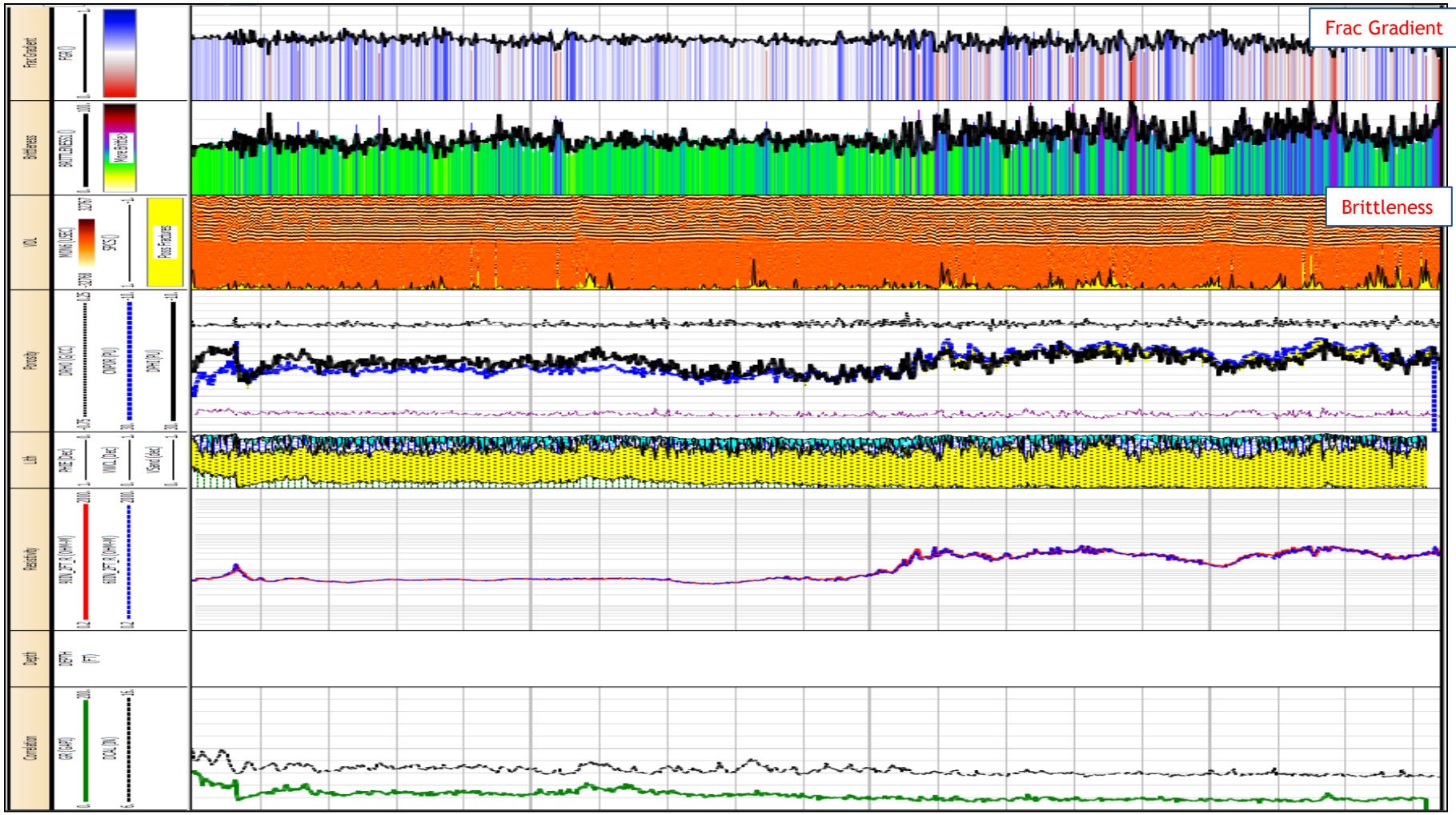
Geo-Frac™ – Stress Profiling

Mississippian – Southern Kansas

Horizontal well: 100'/division



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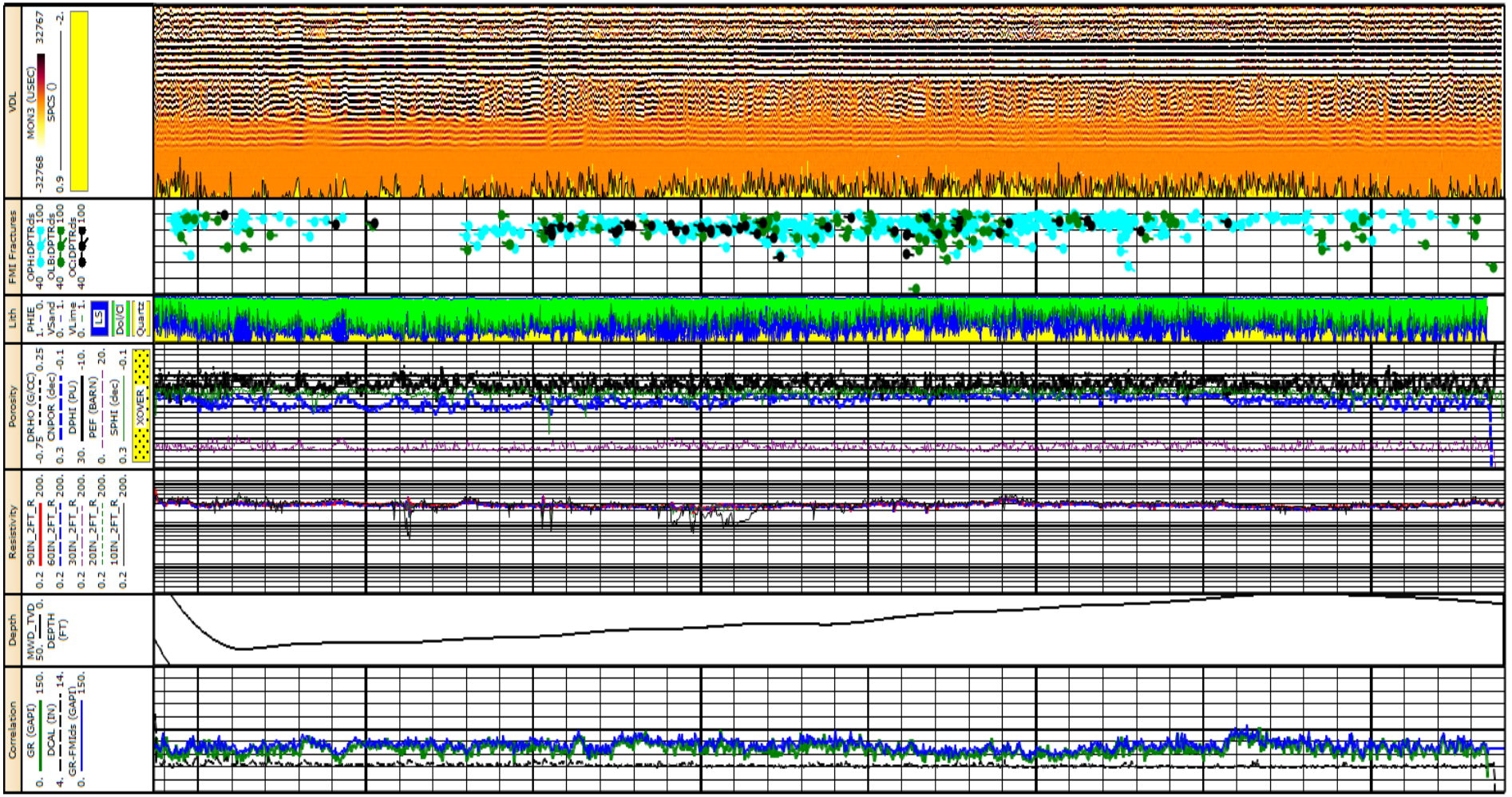
Qualitative Fracture Identification – Sonic VDL vs Image Interpretation

Black=Open Continuous, Green=Open Lith Bound, Aqua=Open Partially healed



Mid Continent Shelf Carbonate

Depth Scale=100’/division

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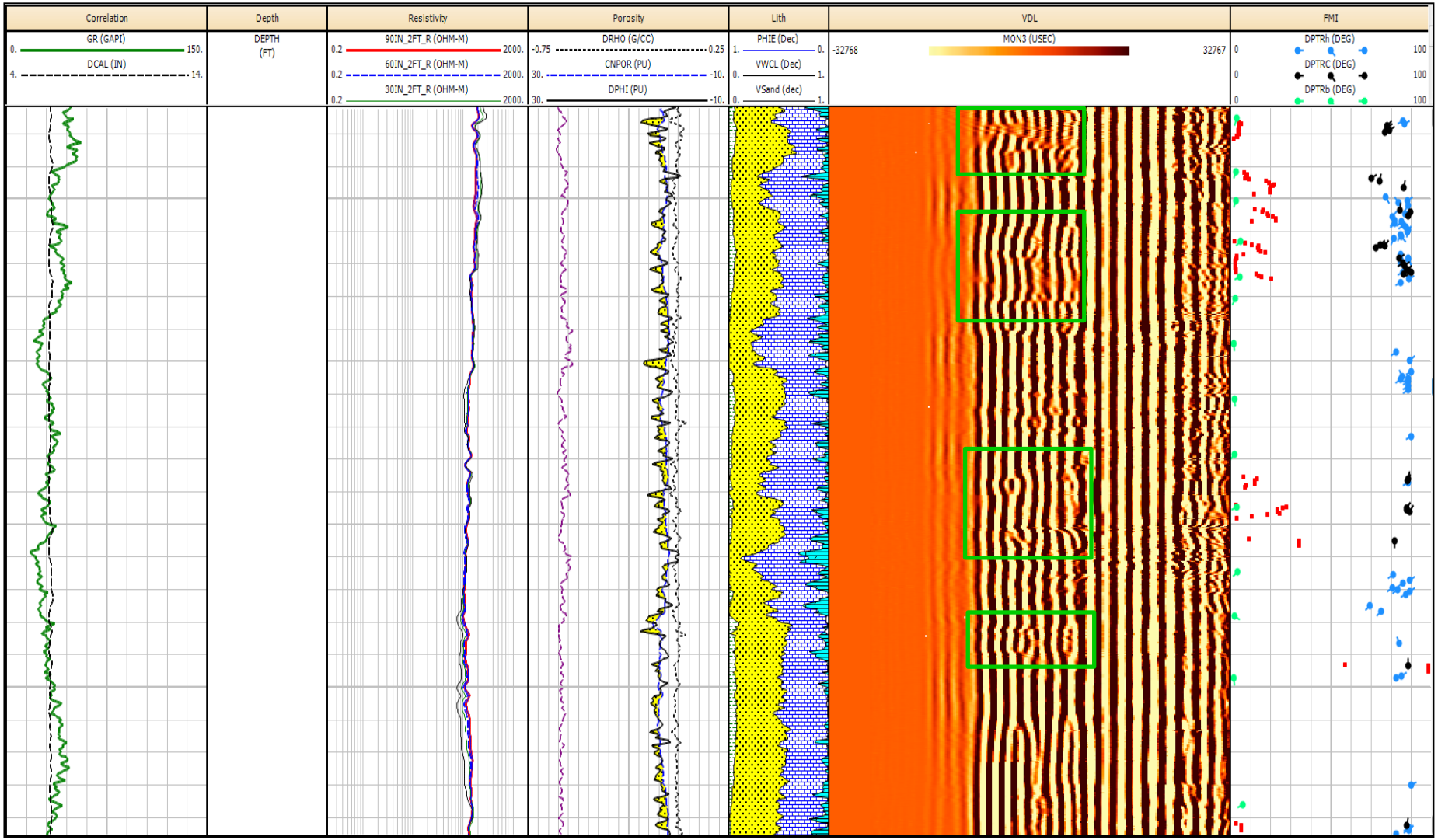
Sonic VDL in the Mississippian – N. Central Oklahoma *horizontal well*



- **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

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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.

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Questions