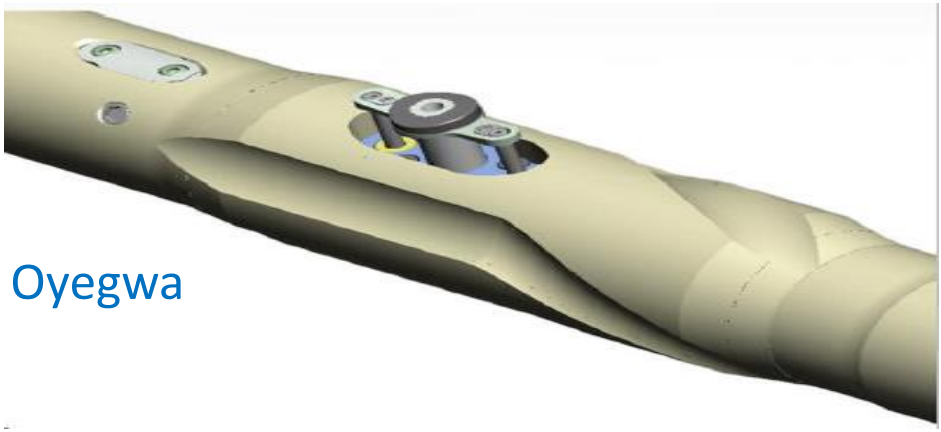
# NAPE
# May 2017 Technical Meeting

# Logging-While-Drilling (LWD) Pressure Data Acquisition, Interpretation & Challenges:

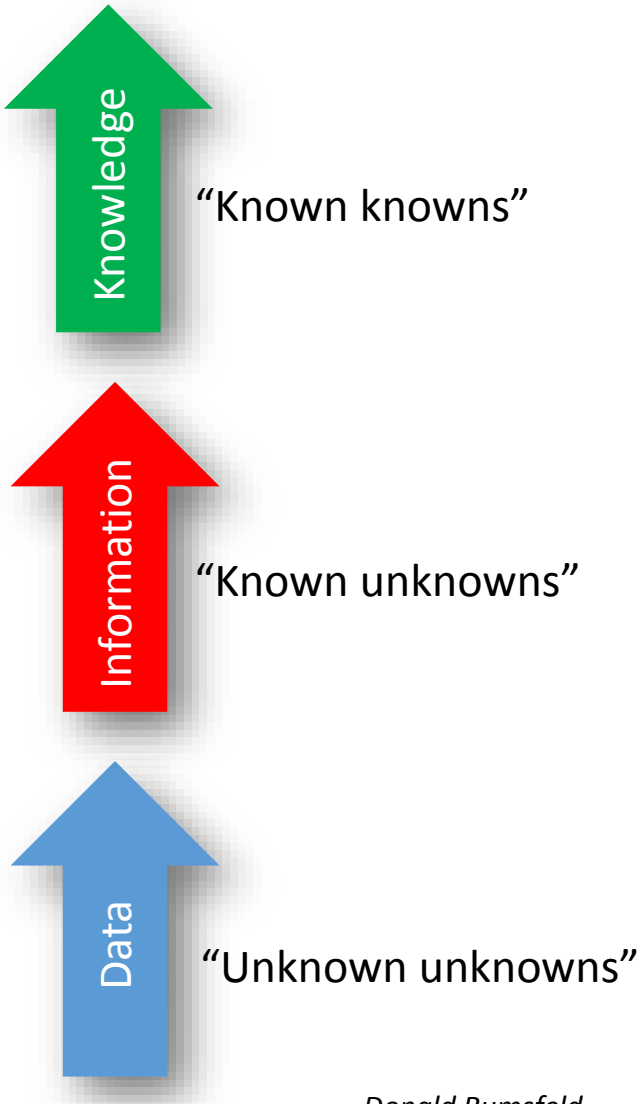
*Okan Field Example*



Presenter: A.D. Oyegwa

# Presentation Outline

- **Field Introduction**
- **Background Information**
- **Acquisition Challenges**
- **Experiment**
- **Results**
- **Lessons Learned**
- **Recommendations**




*……Donald Rumsfeld*

# Okan Field Location and Geology

- 1st NNPC/Chevron JV Offshore Asset
- OML 90, Western area of the Niger Delta
- 25’ water depth
- 18 km offshore Escravos, Nigeria
- Over 50 years of production
- Over 130 wells drilled to date
- Multiple stacked reservoirs

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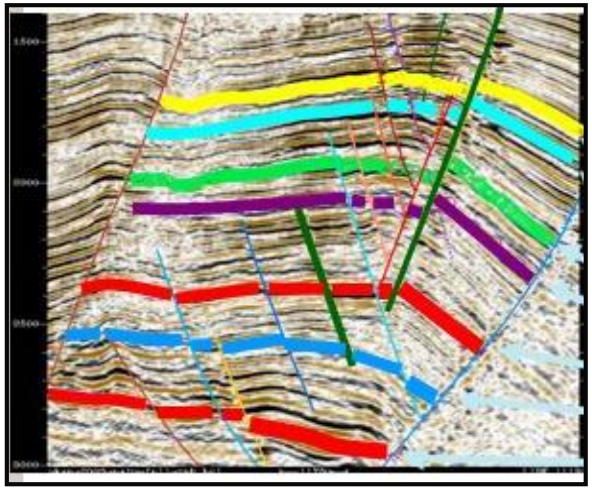
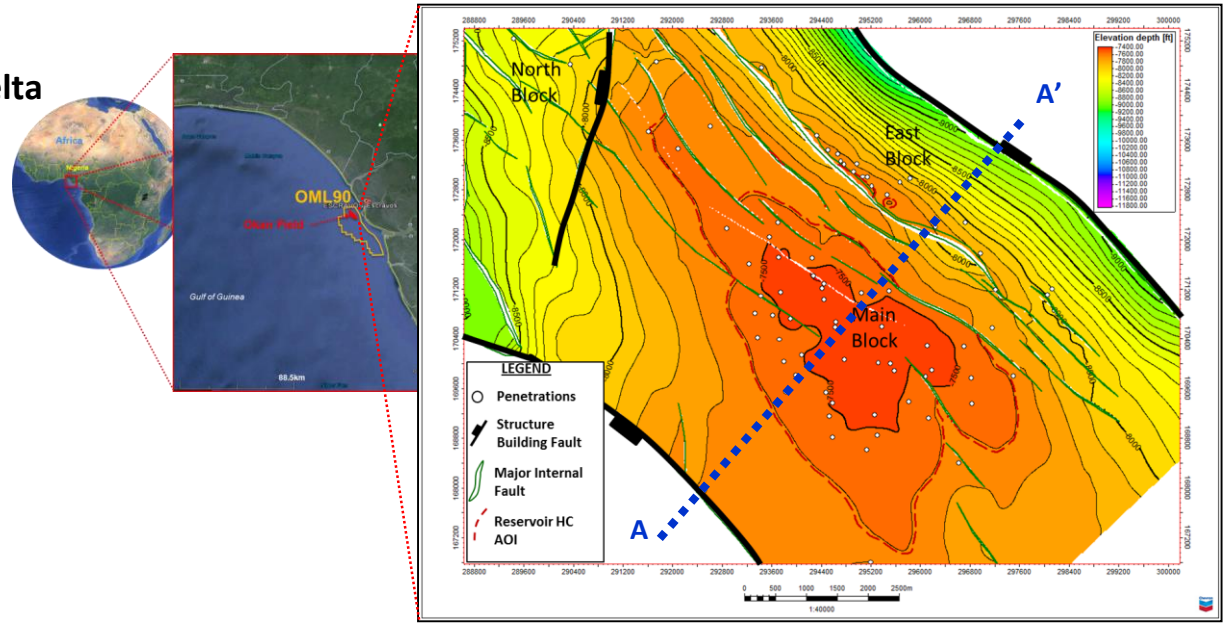


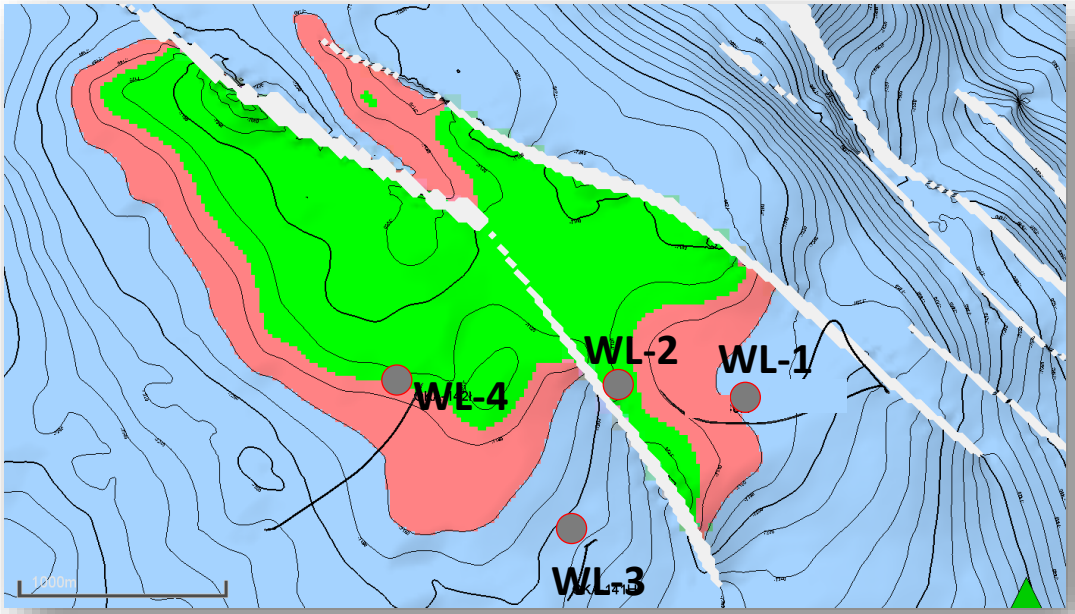



- Elongate NW-SE trending anticline, bound on the NE & SW by major structure-building faults
- Structurally complex with crestal collapse faults, variably synthetic and antithetic in throw.
- Three major fault blocks: Okan Main, North & Block E
- Key reservoir management uncertainties affecting recovery are compartmentalization and variations in fluid contacts

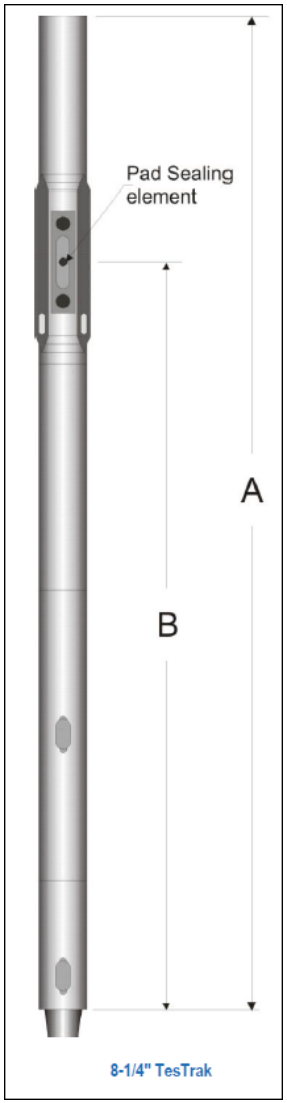
# Background Information

- Pressure data acquired in 3 wells
- Objectives
  **Fluid Contacts**
  **Reservoir communication**
  **Fluid Typing**
- Acquisition success rate: ~86%
- A number of reservoirs with interesting information

**Reservoir Map**



# LWD Tool & Acquisition Operations




Baker Hughes ©

Formation pressure while-drilling service

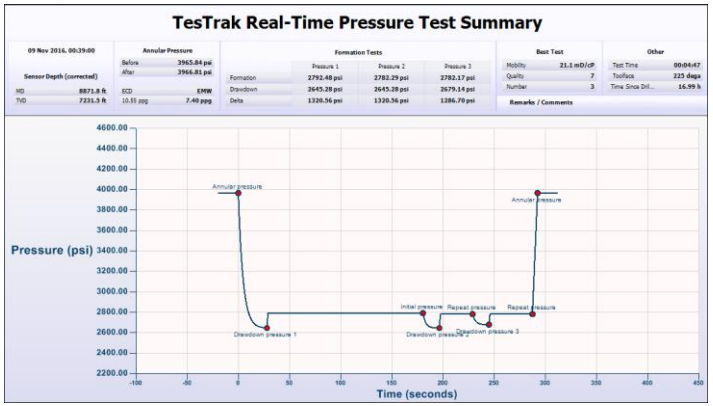
## Applications

- Onshore and offshore drilling: all well types and formation types
- Drilling hazard mitigation
- Reservoir characterization

## Features

- SmarTest™ intelligent testing
- SmartPad™ closed-loop sealing
- Real-time pore pressure measurements
- Real-time gradient analysis to identify fluids and contacts
- Real-time formation mobility

| | |
|---|---|
| Tool size | 4¾-in. (121 mm)<br>6¾-in. (171 mm)<br>8¼-in. (210 mm) |
| Hole size* | 5¾-in. to 17½-in. (146 mm to 445 mm) |

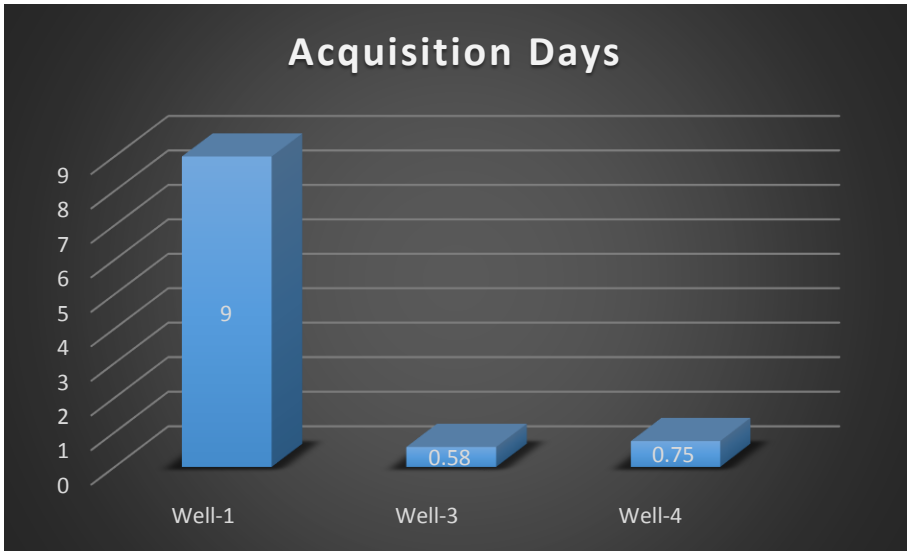


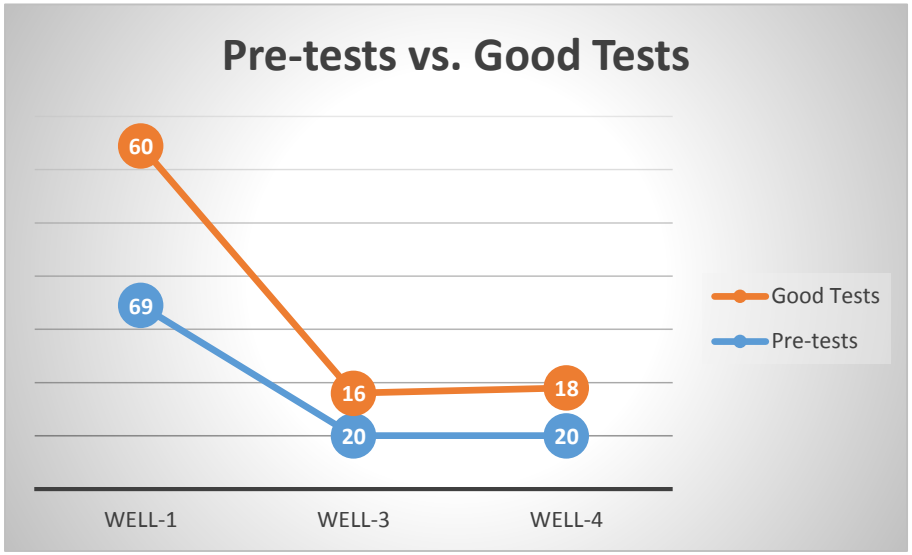

- Data acquired in 6” and 8-1/2” hole sizes
- Data monitored and qc’ed at office location

# Acquisition Challenges

- Telemetry issues related to mud pumps and Bi-directional Communication and Power Module (BCPM)
- Plugged probes/tight tests
- High Rate of Penetration (ROP) over reservoir sections
- Depleted reservoirs
- Time constraints for elaborate real time interpretation

# Acquisition Duration and Success Rates



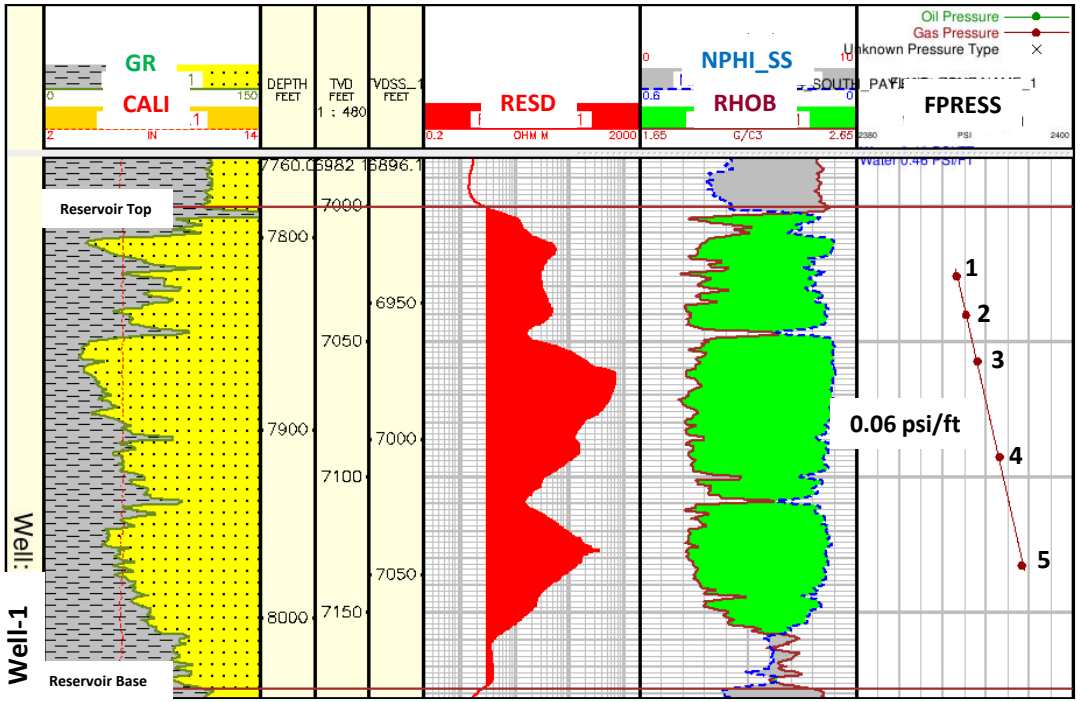




- Variable experience in the acquisition process
- For the 3 wells, the acquisition time ranges from 0.58 days to ~ 9 days
- Well-1 duration was due to tool failures and number of pre-test stations

- Success rates:
  - Well 1: 87%
  - Well 3: 81%
  - Well 4: 90%

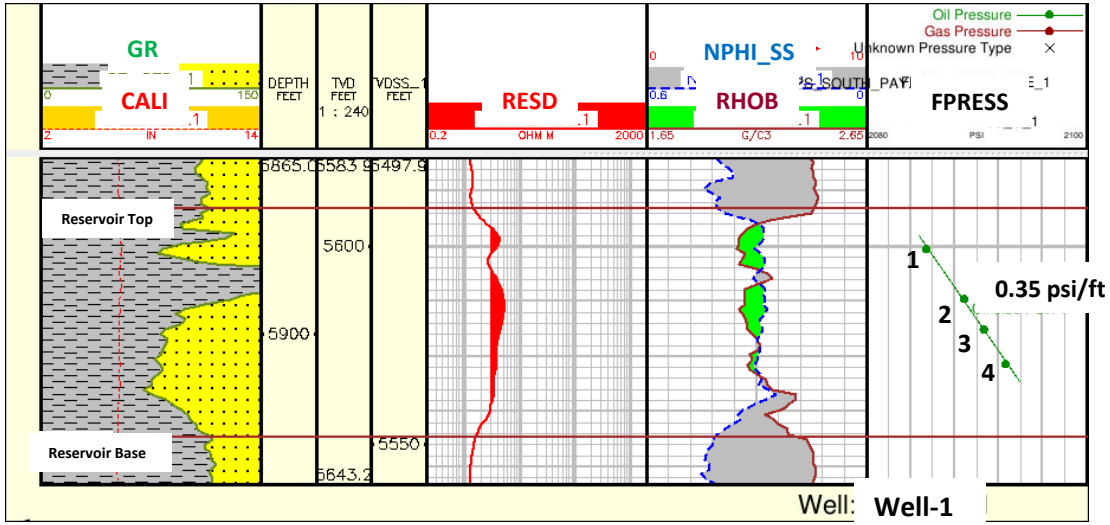
# Experiment

# Fluid Typing vis-à-vis Number of Pressure Points




| Example 1 | | |
|---|---|---|
| **Points** | **Psi/ft** | **Fluid** |
| All | 0.06 | Gas |
| 1&2 | 0.06 | Gas |
| 2&3 | 0.06 | Gas |
| 3&4 | 0.06 | Gas |
| 4&5 | 0.05 | Gas |
| 1&5 | 0.06 | Gas |

- Accuracy of fluid gradients are influenced by the number of points
- Two (2) good points are sufficient to differentiate between gas and liquid

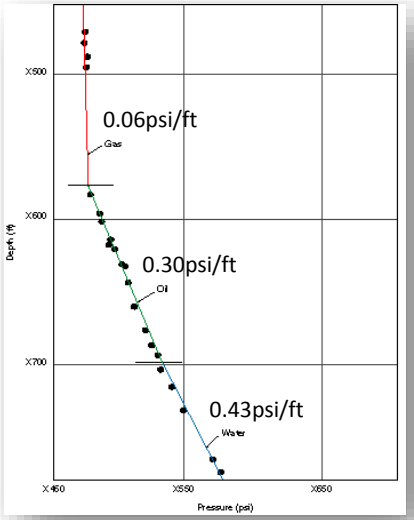



| Example 2 | | |
|---|---|---|
| **Points** | **Psi/ft** | **Fluid** |
| All | 0.35 | Oil |
| 1&2 | 0.38 | Oil |
| 2&3 | 0.32 | Oil |
| 3&4 | 0.32 | Oil |
| 1&4 | 0.35 | Oil |
| 2&4 | 0.32 | Oil |

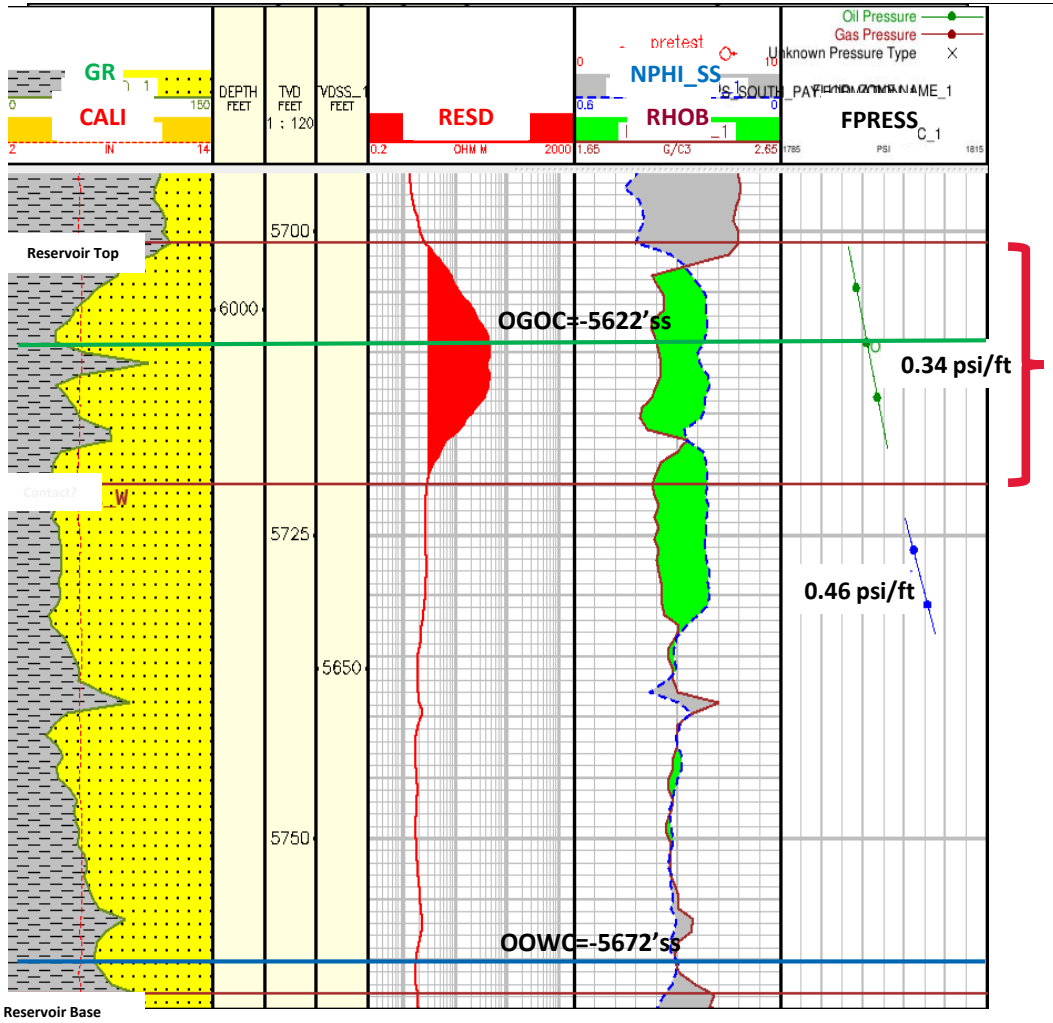
# Results

# Results

- Gas effects
- Compartmentalization
- Pressure regimes and variable fluid contacts
- Fluid typing
- Facies identification

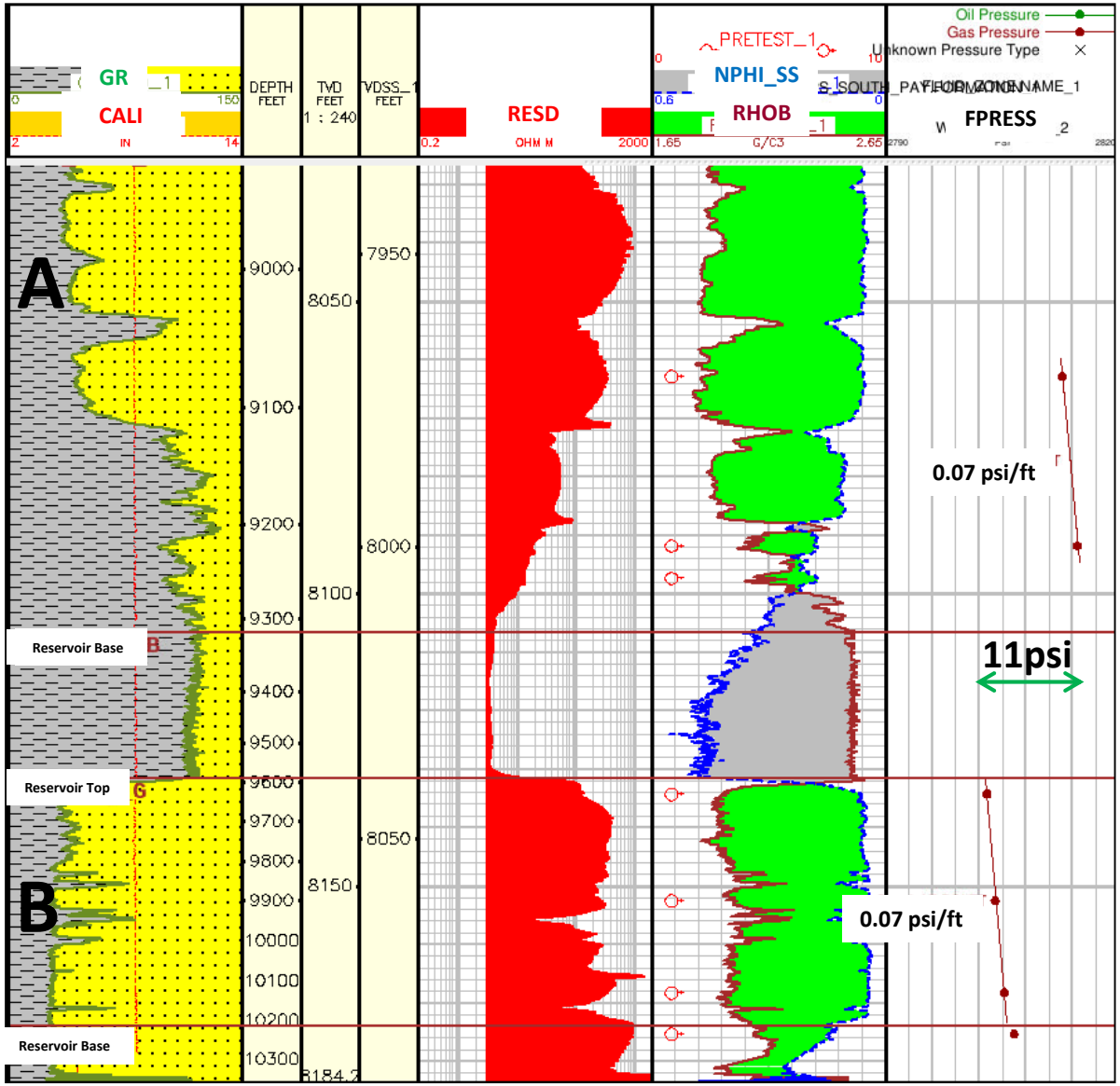


# Residual Gas



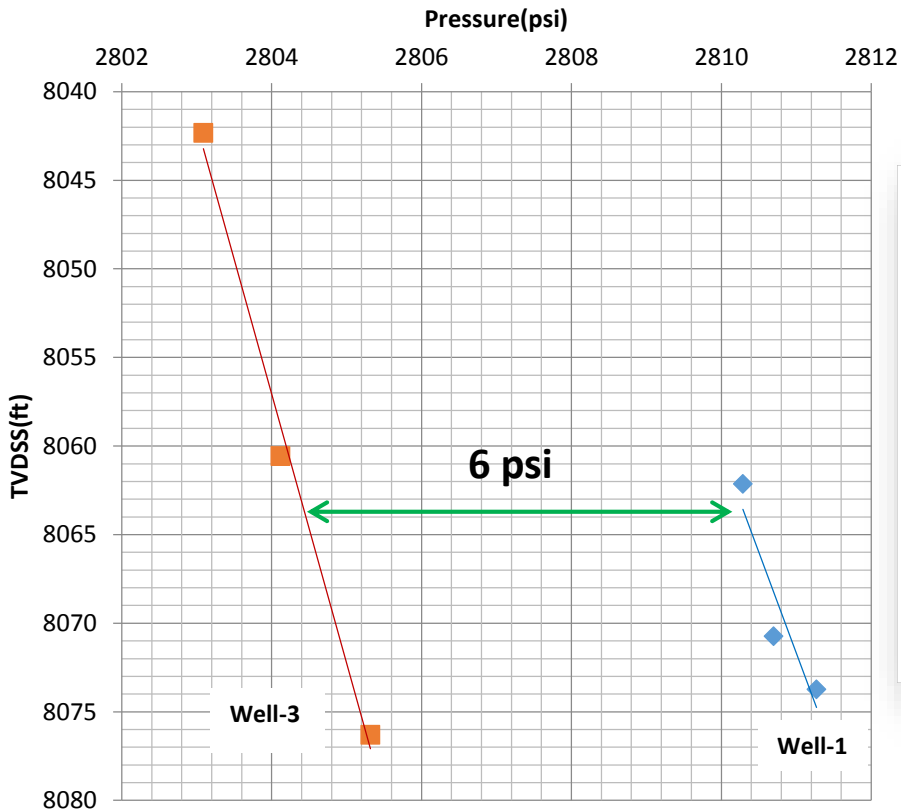

- Resistivity log suggests hydrocarbon water contact within sand
- Porosity logs suggests very light hydrocarbon beyond that suggested by resistivity
- Pressure profile confirms current fluid type and fluid contact depths
- Logs show imprints of reservoir production history

# Vertical Compartmentalization

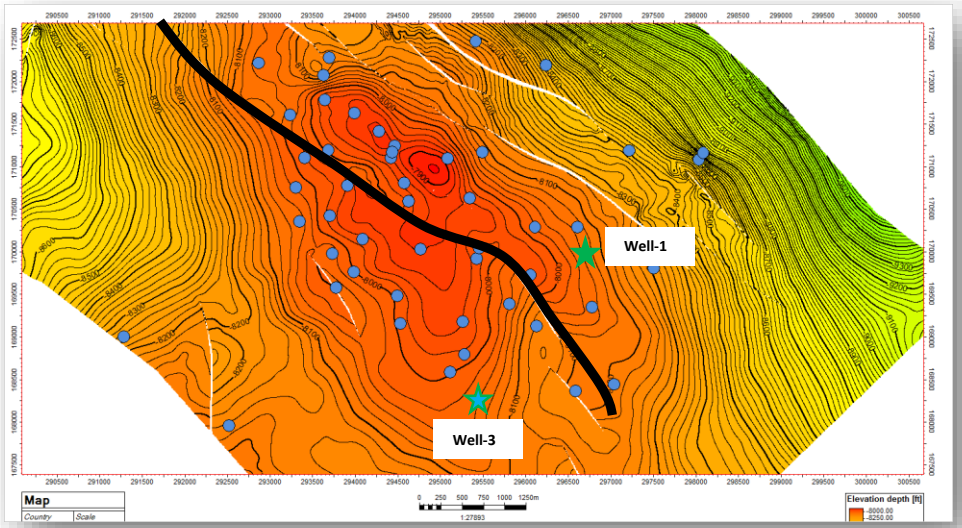



- Based on scanty pressure data and well logs correlation, reservoirs A and B were considered connected
- Recent pressure data now shows that the sands are separate.

# Variable Fluid Contact

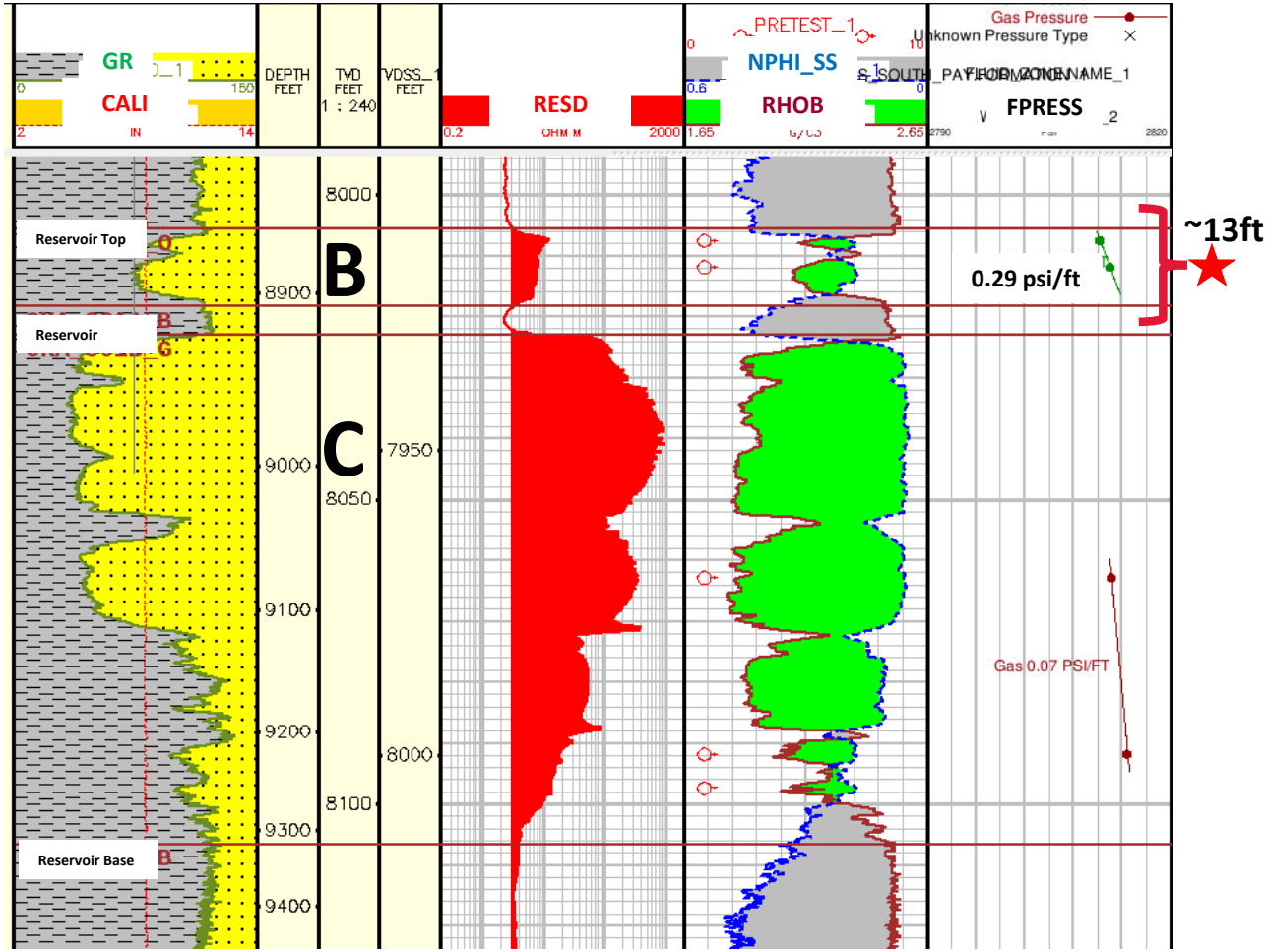



## C Reservoir Top Structure Map



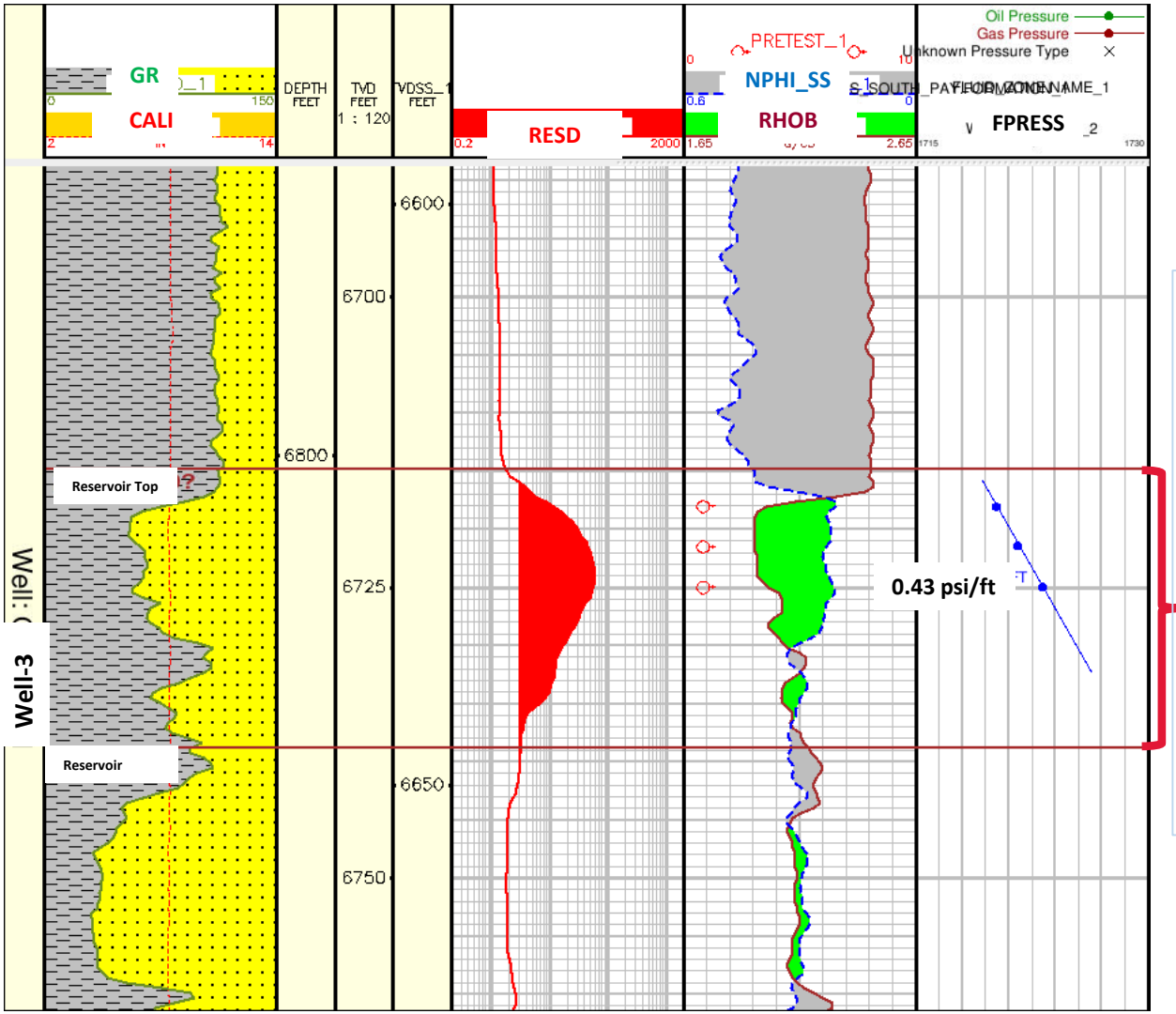

- Pressure difference likely responsible for observed fluid contact difference across faults

# New Fluid Type Interpretation



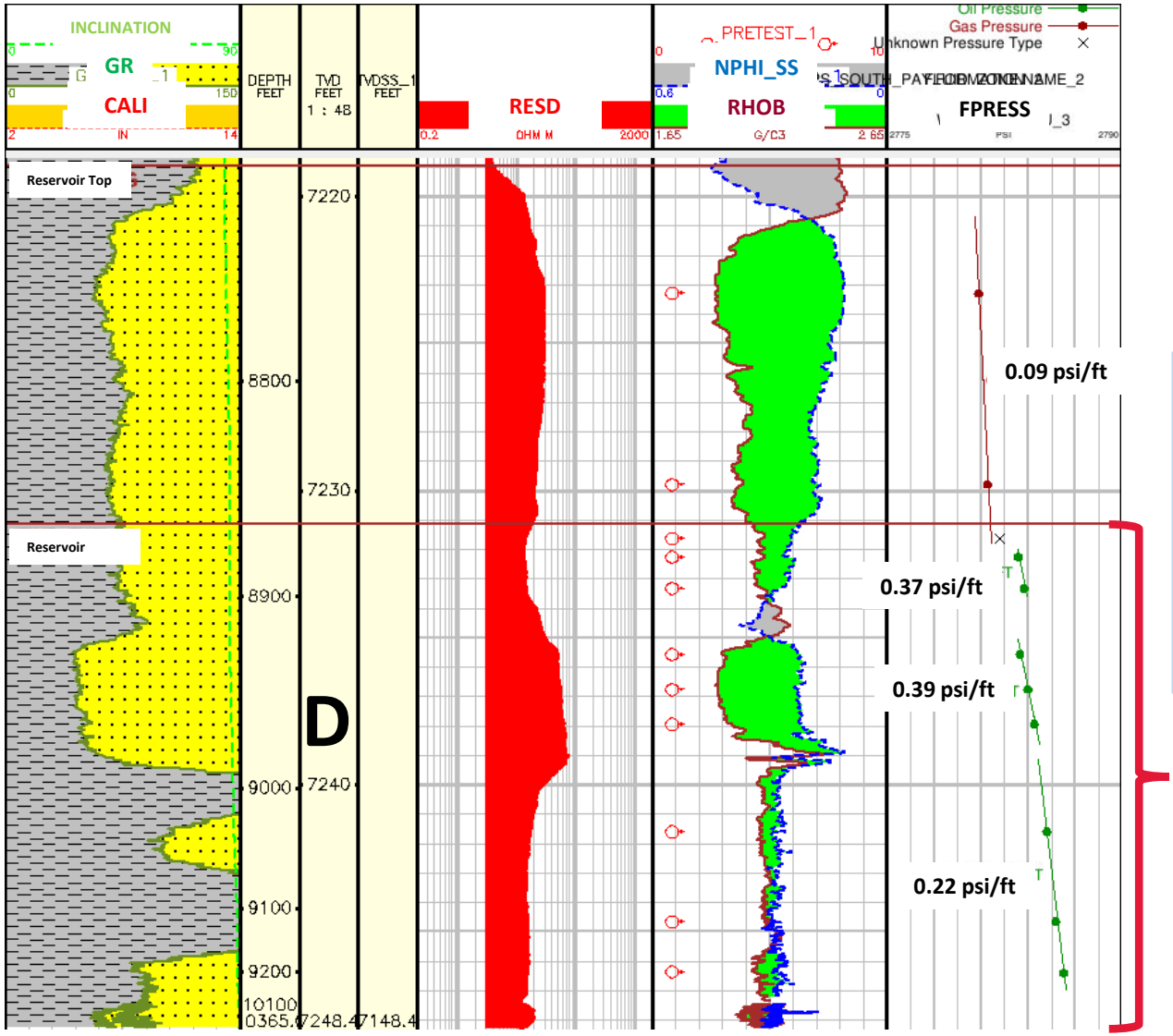

- Both lobes previously considered gas filled
- Two-point pressure gradient suggests oil!
- Fluid sampling would have helped confirm gradient
- Cased hole log validated the oil interpretation.

# Puzzling Gradient



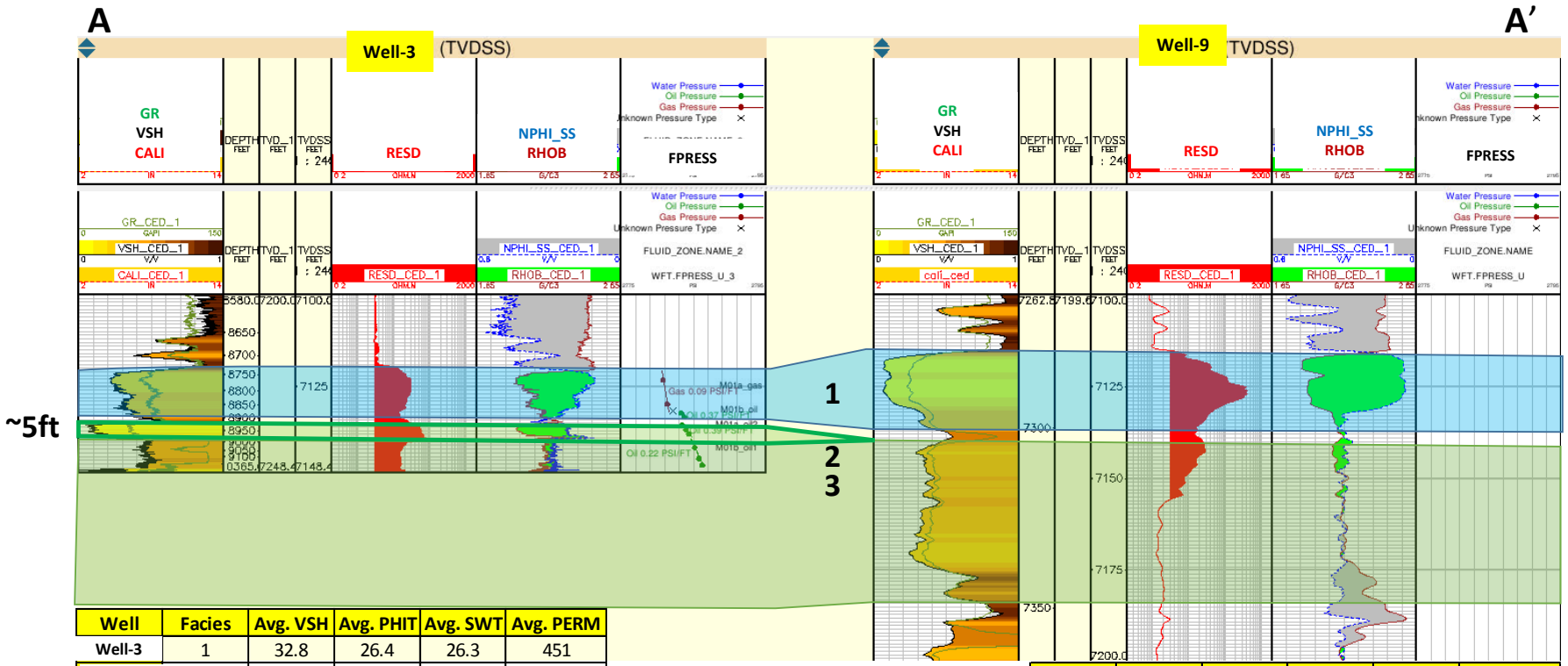

- Inconsistency between logs and pressure data
- About 40% pressure depletion from initial
- Cased hole log and production data supports hydrocarbon presence.

# Complementary Logs Signatures and Pressure Profiles




- Different pressure compartments in D interval
- Distinct gamma and porosity logs signatures

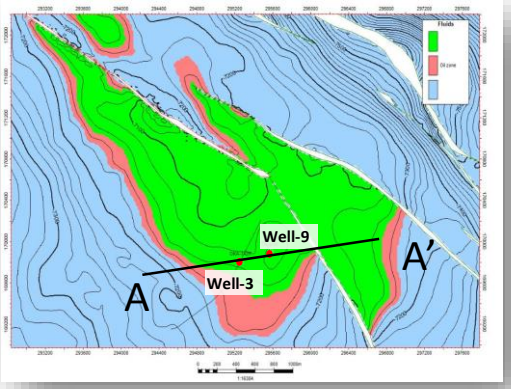
# Sand Facies Discovery




| Well | Facies | Avg. VSH | Avg. PHIT | Avg. SWT | Avg. PERM |
|---|---|---|---|---|---|
| Well-3 | 1 | 32.8 | 26.4 | 26.3 | 451 |
| Well-3 | 2 | 16 | 27.8 | 15.4 | 783 |
| Well-3 | 3 | 46.4 | 24.7 | 29.5 | 126 |

| Well | Facies | Avg. VSH | Avg. PHIT | Avg. SWT | Avg. PERM |
|---|---|---|---|---|---|
| Well-9 | 1 | 20.4 | 30.4 | 19.9 | 1425 |
| Well- 9 | 2 | | | | |
| Well- 9 | 3 | 38.8 | 28.4 | 32.4 | 840 |

- Correlation with offset well confirms facies in well 3 is not laterally extensive.



# Lessons Learned

1. Basic log data are not always conclusive on reservoir fluid types, especially in mature fields

2. Pressure data provides very useful information that may challenge current assumptions and thus help to improve our understanding of reservoirs

3. Optimum mud flow rate is very critical to LWD tool acquisition success, especially in slim holes

4. Multifunctional collaboration is essential to the success of any pressure acquisition program.

# Recommendations

1. Downhole Fluid Analysis/sampling should be considered, especially for fluid typing in thin reservoirs or in horizontal hole sections
2. Mud pumps should be in good working condition (and calibrated) to ensure optimum flow rate for LWD operation
3. Tool flushing and face re-orienting should be done often, especially after every “tight” test
4. There should be controlled drilling over reservoir sections of interest.

# Acknowledgements

Nigeria National Petroleum Corporation for approving the presentation

Chevron Nigeria for permission to present these findings.

# Q&A