



Real Time Integration of Reservoir Modeling and Formation Testing

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Outline:



New Understanding of Reservoirs

DFA – what is it.

DFA & Compositional Variations

New Work Flows

Detailed Example Analysis

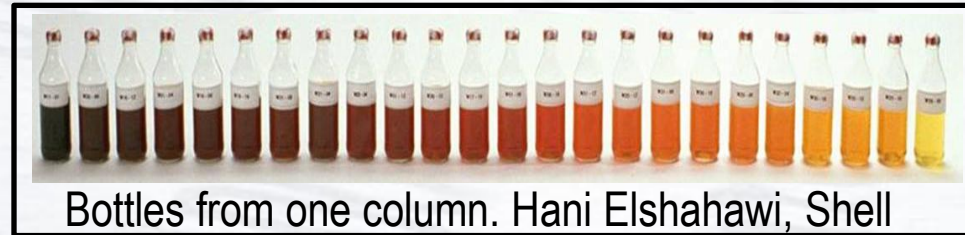
Conclusions

Key Reservoir Issues

I. Compositional Grading:

Reservoir fluids are often highly graded and often not in equilibrium.

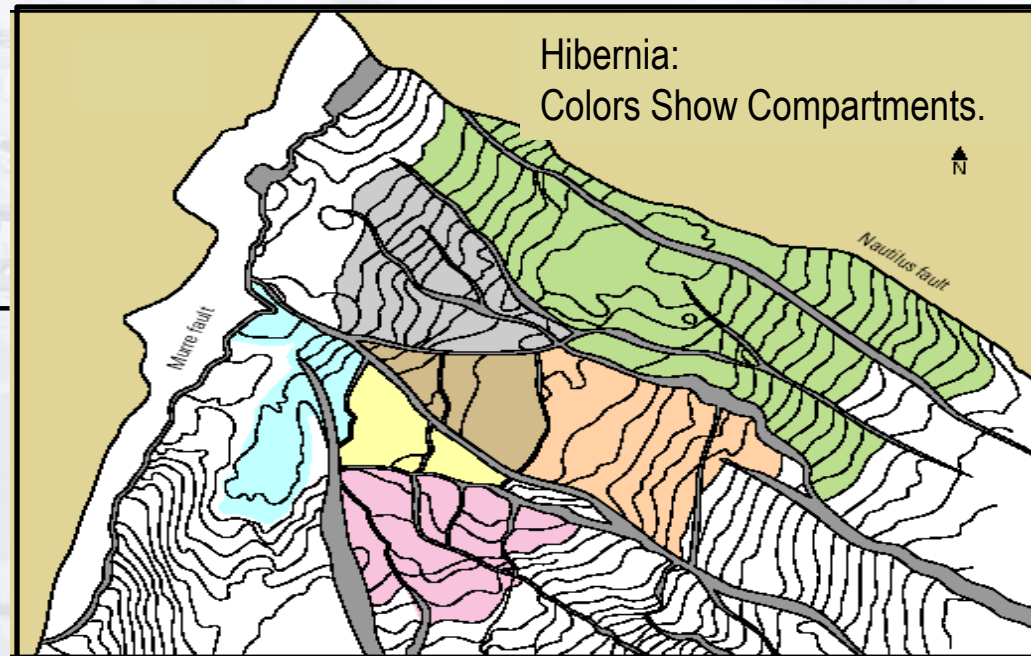
1. Gravity
2. Biodegradation
3. Active charging
4. Charge history
5. Water washing
6. Convection
7. Seal leaking
8. Thermal diffusion



II. Reservoir Architecture

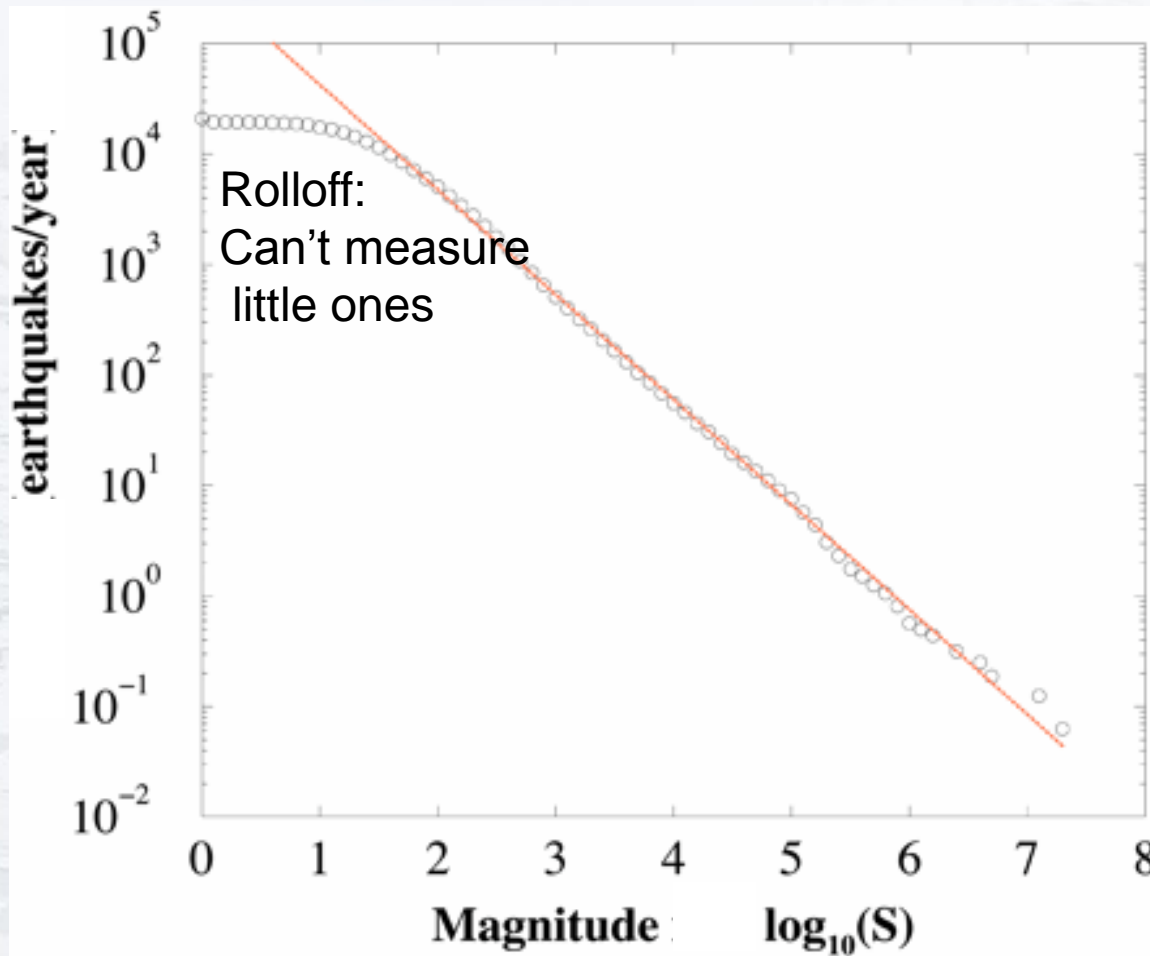
Compartments, Sealing Barriers, Baffles

1. No possible physics to image compartments
2. Pressure communication does NOT mean flow communication
3. Industry expectations about compartments violate geostatistics



Small Geophysical 'Objects' are MUCH more numerous Earthquakes

Number of events



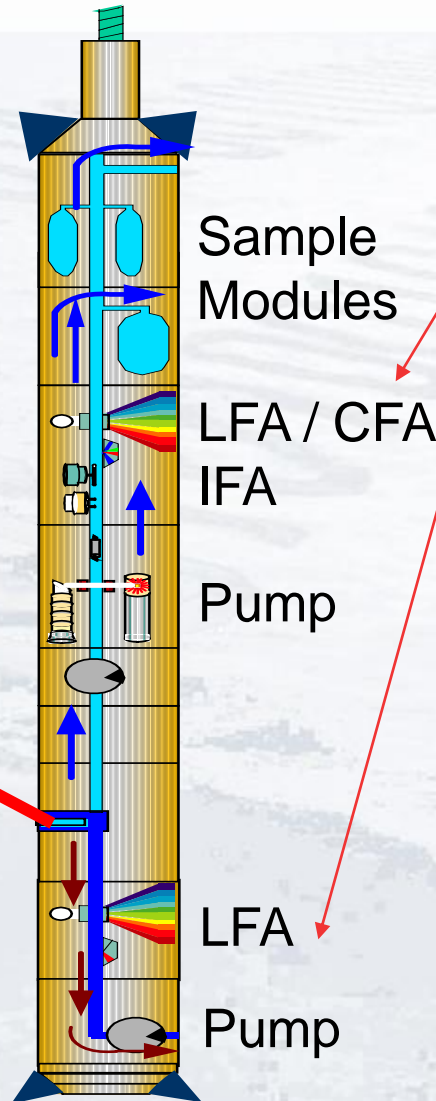
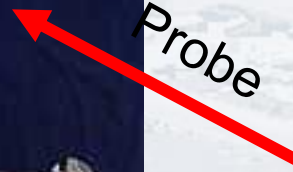
MDT Downhole Fluid Analysis



Fluid Entry



Probe



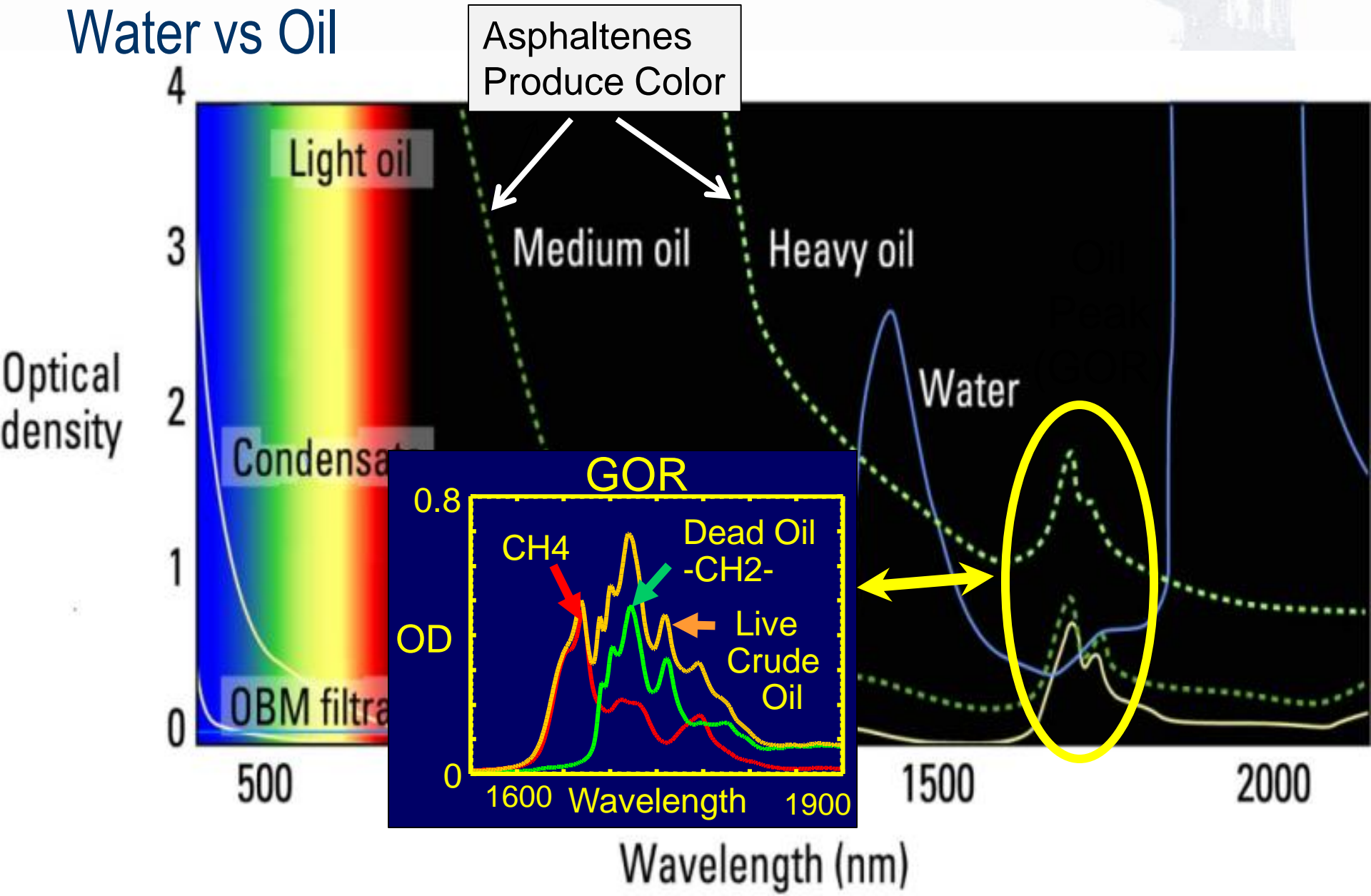
DFA Tools

- Contamination
- Phase change
- GOR
- Composition
- CO₂
- Density
- Viscosity
- Asphaltene



DFA uses Downhole Optical Spectroscopy

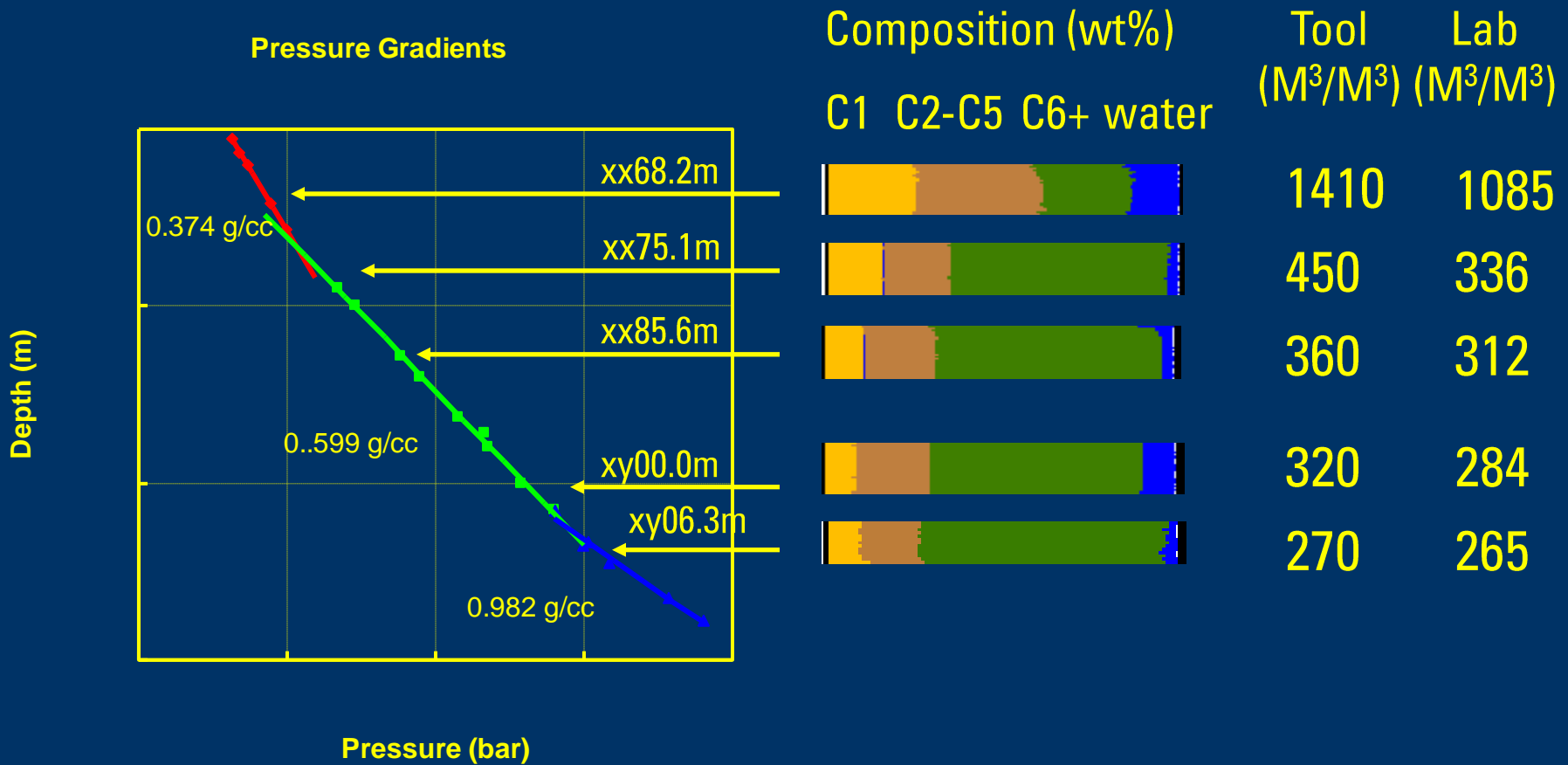
Water vs Oil



Discovery well Fluid analysis

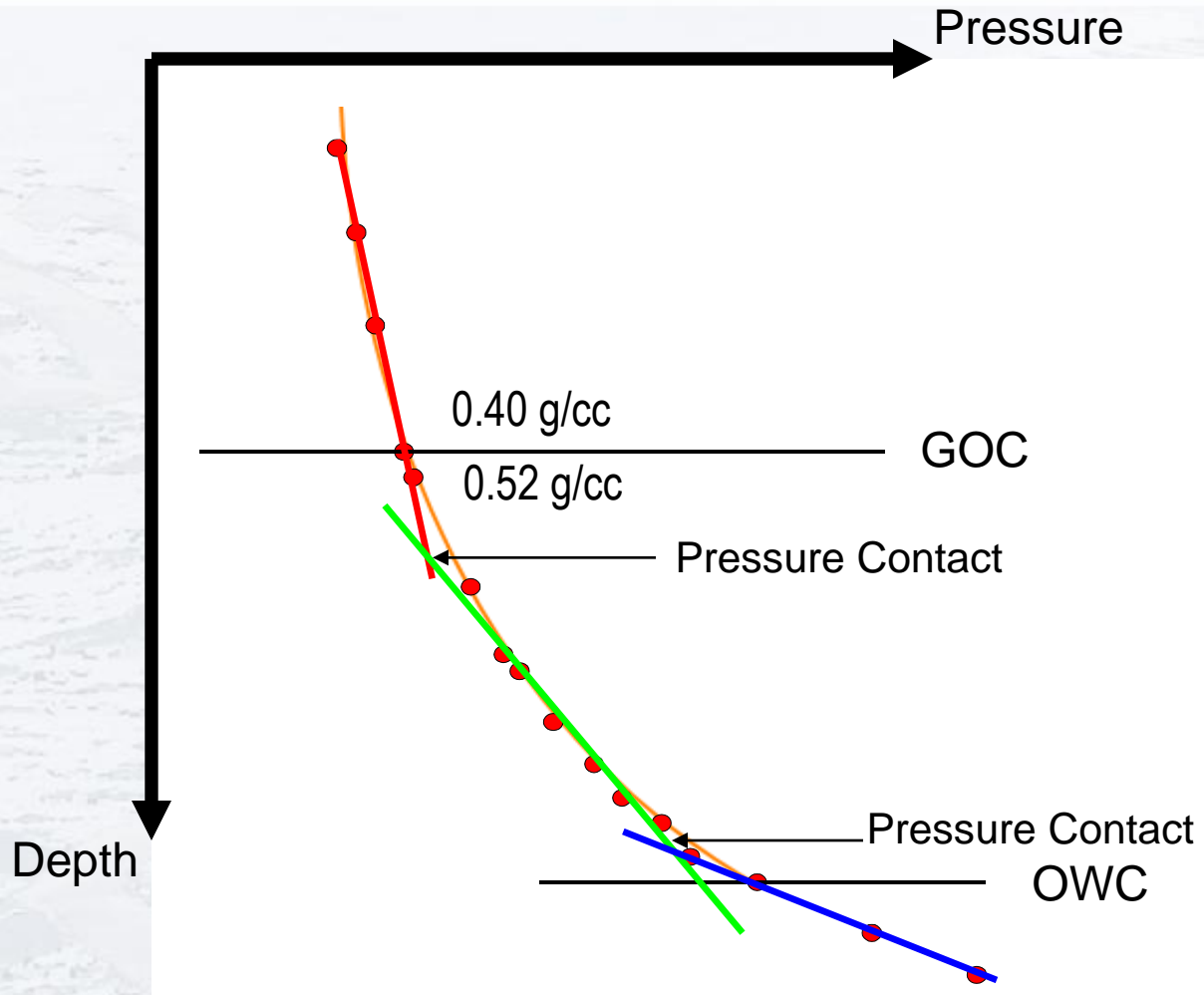


Vertical composition gradient is observed in an exploration well



Curved Gradient Schematic

SPE 89704, SPE 108494



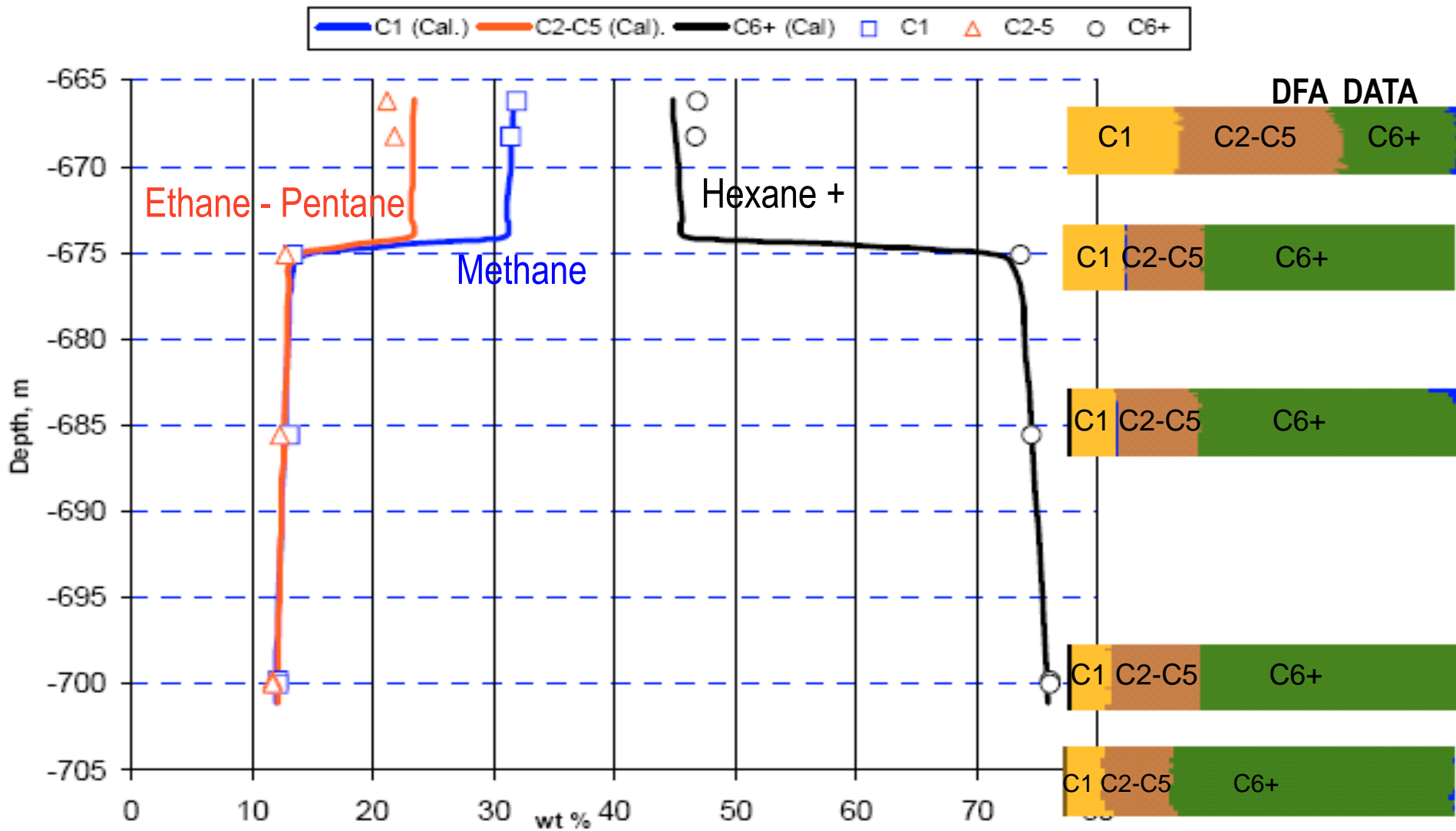
Equation of State Fluid modeling



- In Equation Of State modeling, sample compositions, pvt data and DFA data are used to build a fluid gradient model.
- Based on a gravity & chemical potential equilibrium.
- Fluid model can be build in a relatively short time

The model contains continuous fluid composition & PVT properties as a function of depth.

EoS Fits DFA Data

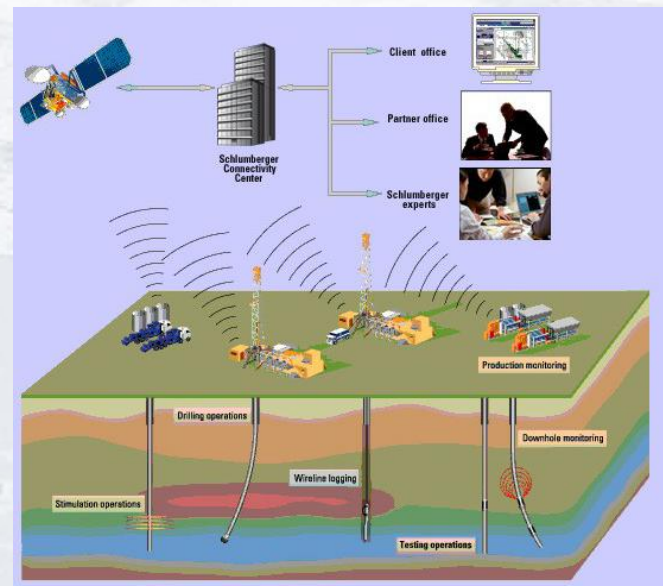


Logging optimization

We can use this knowledge of fluids and fluid grading of a discovery well, to:

A) determine fluid connectivity to an offset well, in real time.

B) Quality control the DFA data.



Connectivity

Fluid modeling Assumptions:

- We assume that the fluid in the discovery well and the offset well are the same

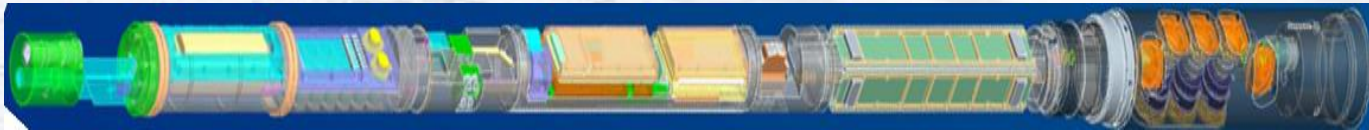
Validation

- Compare measured to predicted DFA compositions
- Agreement indicates the same fluid column. Differences indicate a fluid compartment.

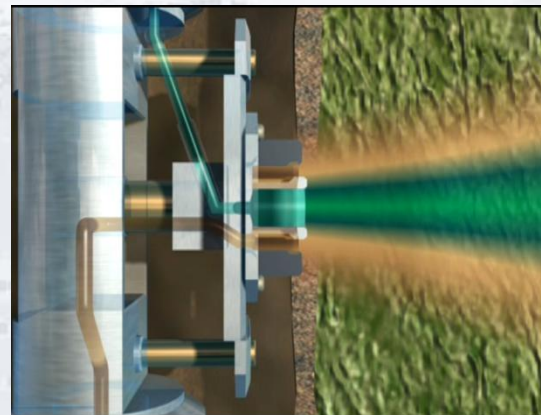
When a compartment / difference from the model is identified **real time** then the WFT program can be adjusted to investigate. Identification after rig down may leave unanswered questions.

Fluid Model Validation

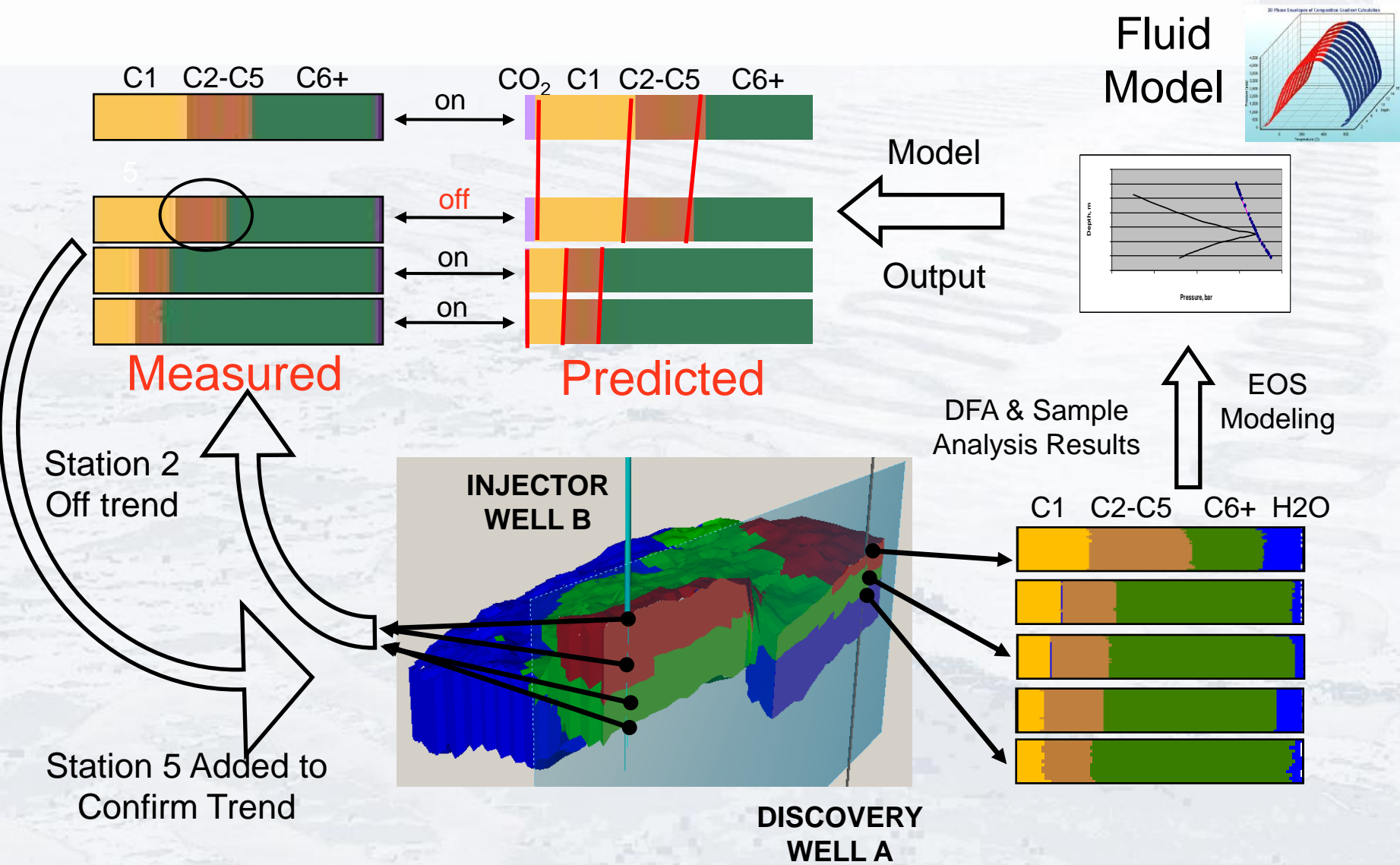
- It is possible to compare compositional data (C1, C2, C3-C5, C6+, CO2), asphaltene gradient, GOR, Density, pressure & fluid contacts in real time.



- High resolution DFA with quantified accuracy is preferred.
- Contamination Management



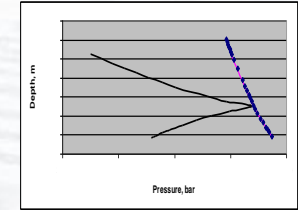
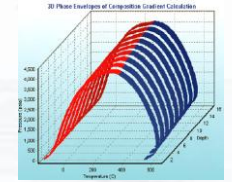
DFA predictive Modeling Workflow



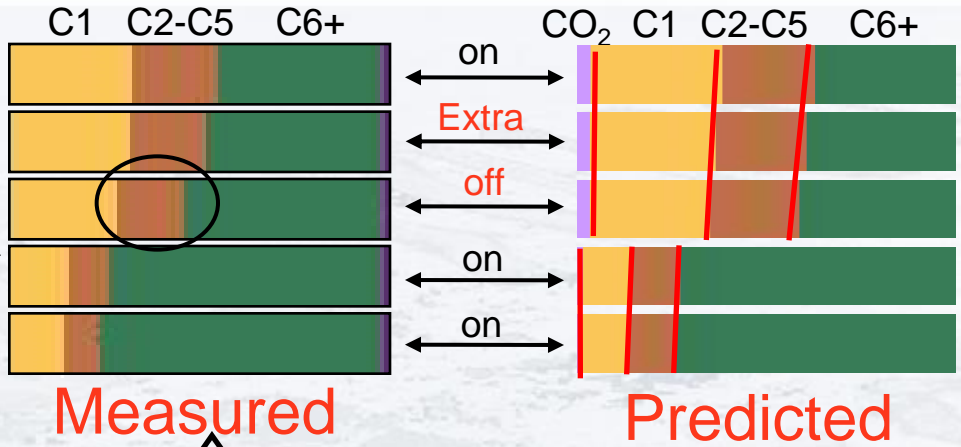
DFA predictive Modeling Workflow



Fluid Model

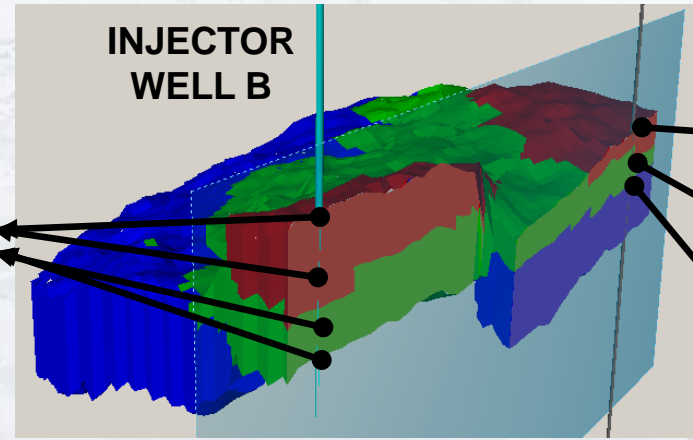
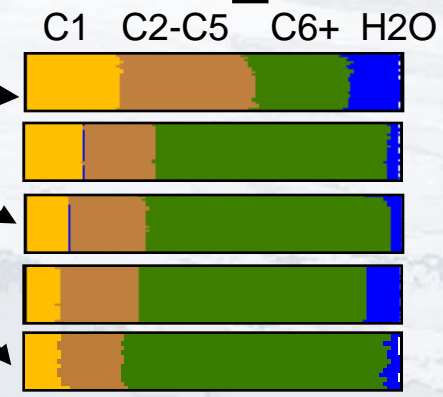


Model
Output



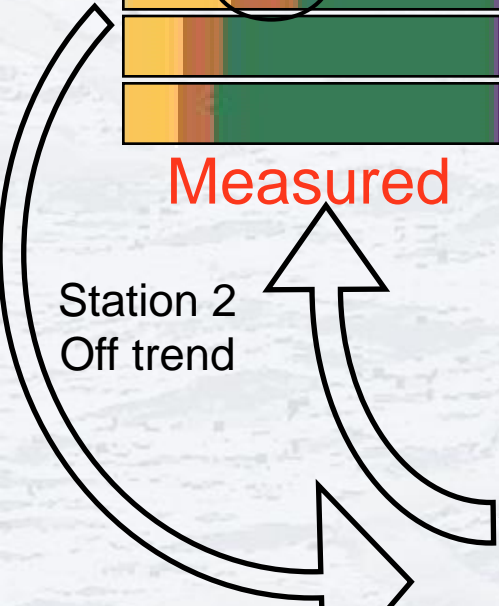
DFA & Sample Analysis Results

EOS Modeling



Station 2
Off trend

Station 5 Added to
Confirm Trend

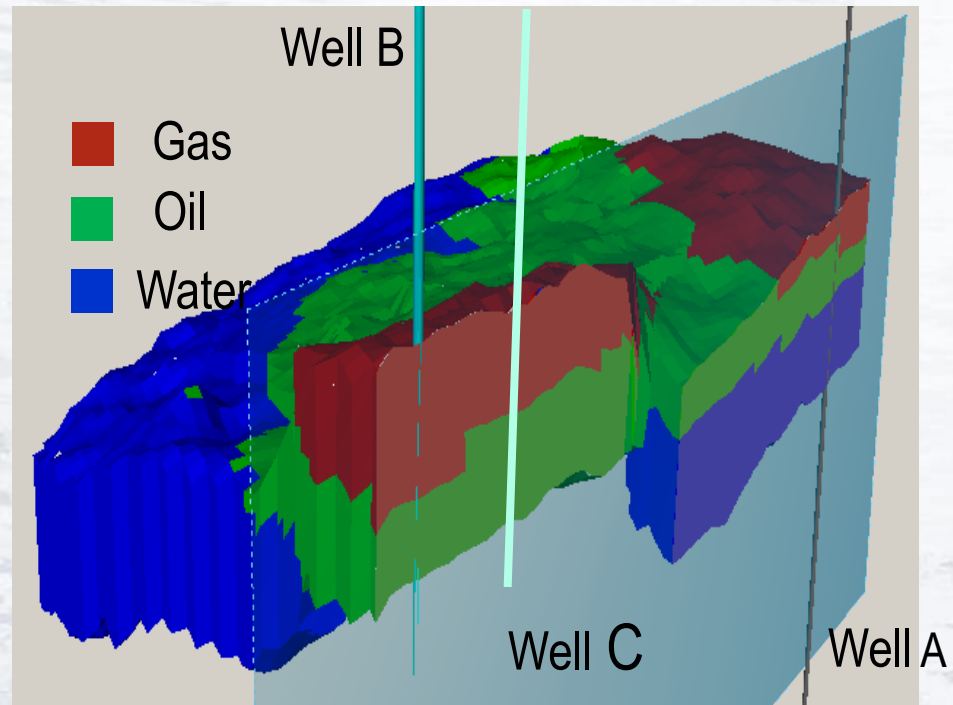


Connectivity

GOCs different by 20 Meters TVD.
Two Separate Gas Caps in “One”
Sand.

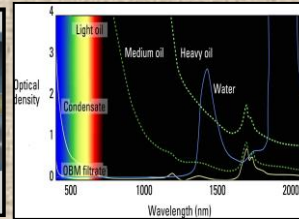
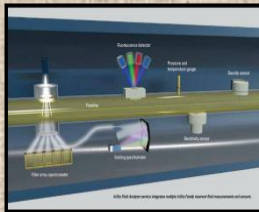
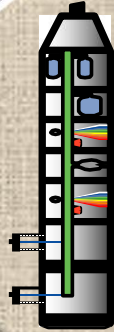
Can be explained by either

- Compartment or
- Lateral Disequilibrium.



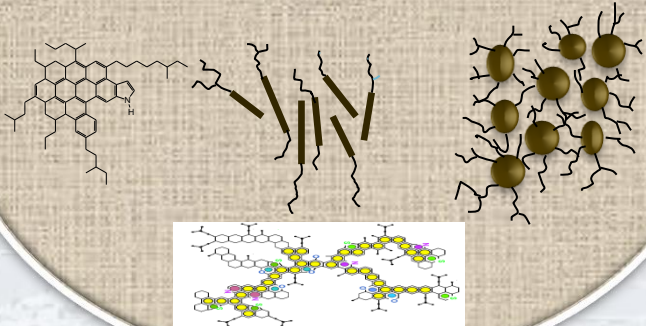
New Approach – Integrating Asphaltene Science

New DFA Technology

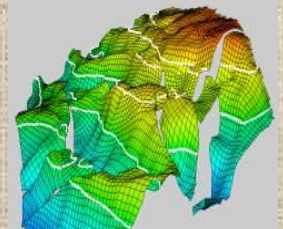
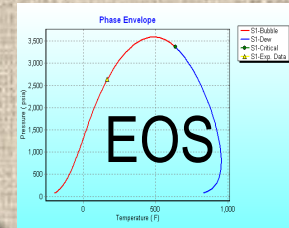


Insitu Fluid Analyzer

New Asphaltene Science

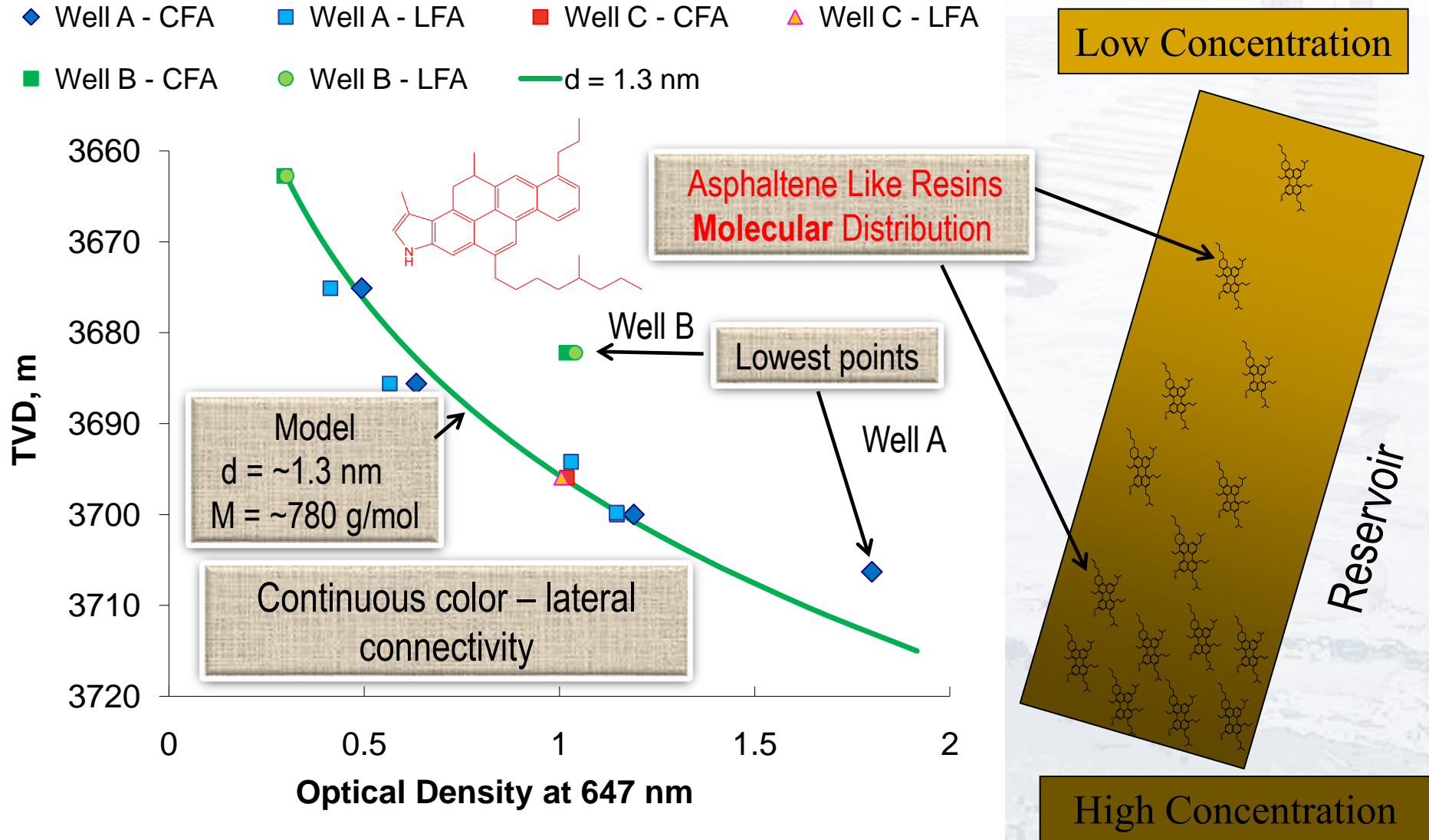


New Theory & Workflow



Flory-Huggins

Color Seems Continuous (neglecting lowest point !)

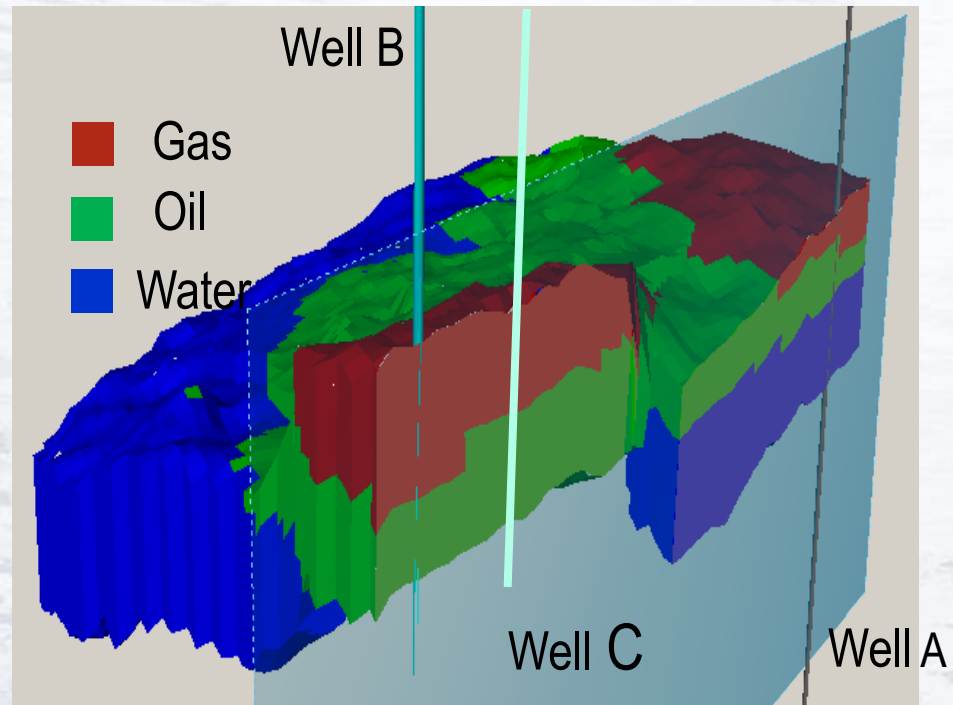


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Conclusions

Integration of **New Asphaltene Science, Models and Workflows with DFA** is a powerful approach to find fluid compositional grading, compartments & connectivity and help to quality control formation tester data acquisition, in real time.

The use of this newly developed workflow resulted in:

- Identification of one station where the flowing fluid was not representative of the native fluid.
- The conclusion that fluids in the discovery and offset well can not be in equilibrium if the wells both penetrate a single compartment.
- Identification of a continuous color gradient, suggesting a continuous reservoir in disequilibrium.
- Subsequent production data confirmed the reservoir is continuous.