Real Time Integration of Reservoir Modeling and Formation Testing

Adriaan Gisolf

Reservoir Domain Champion,

Norway

Schlumberger

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.

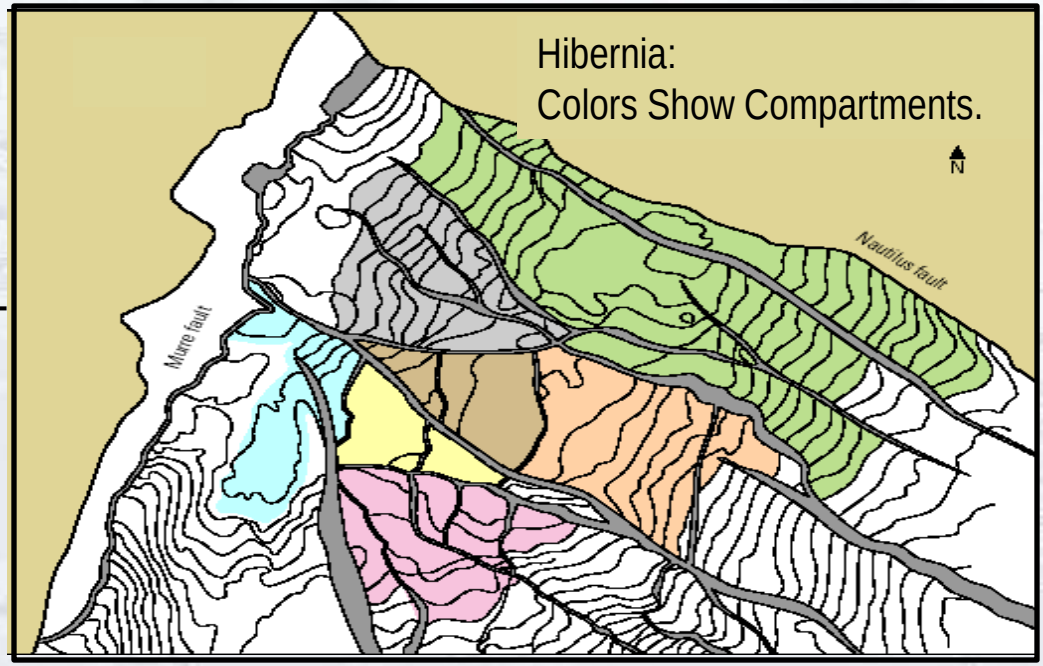
1. Gravity
2. Biodegradation
3. Active charging
4. Charge history
5. Water washing
6. Convection
7. Seal leaking
8. Thermal diffusion

Bottles from one column. Hani Elshahawi, Shell

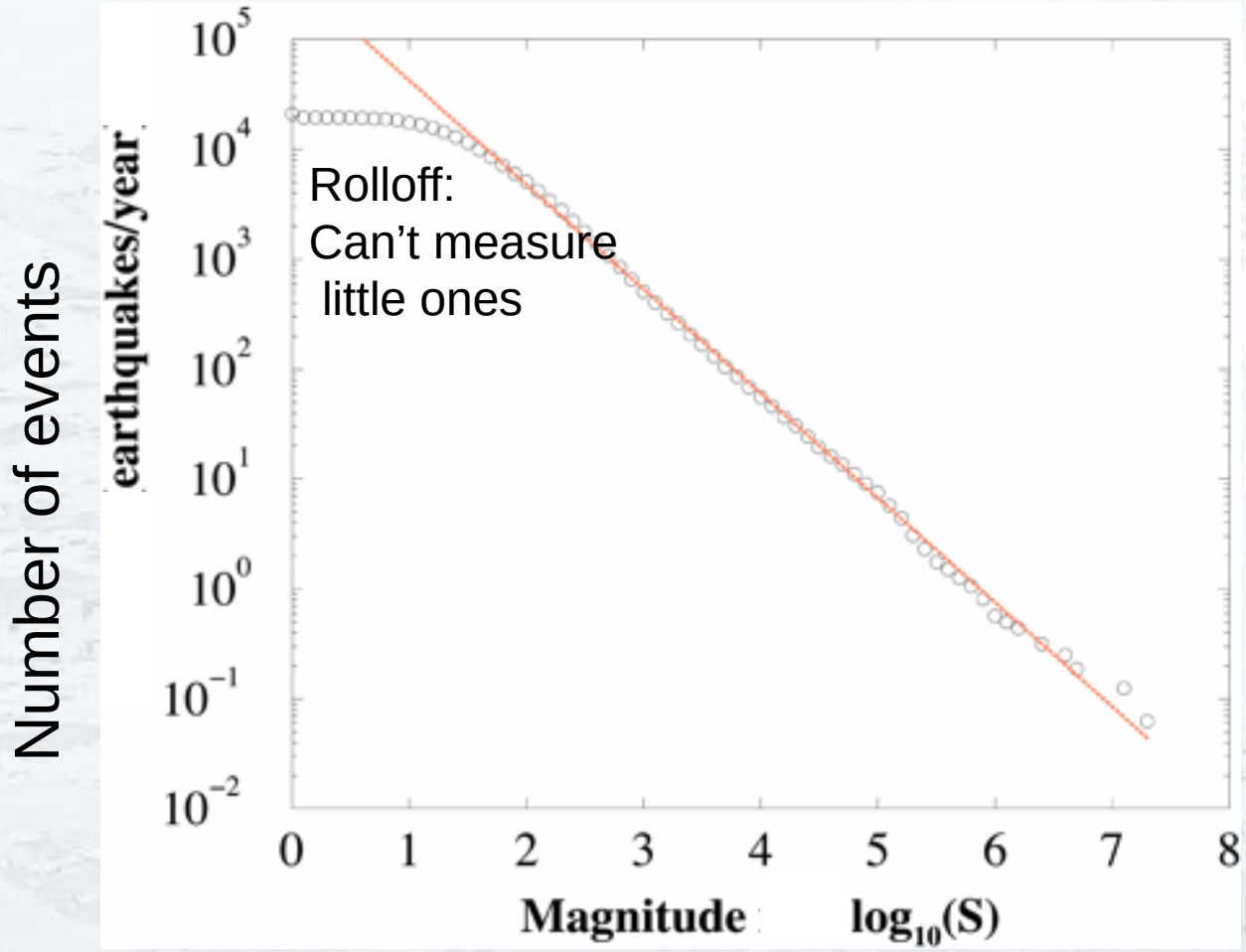
II. Reservoir Architecture

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



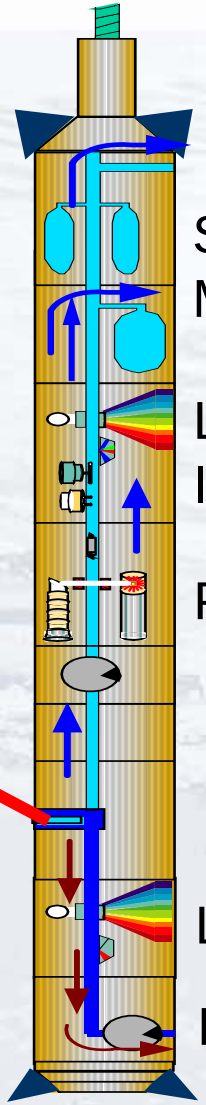
Small Geophysical 'Objects' are MUCH more numerous Earthquakes



MDT Downhole Fluid Analysis

Fluid Entry

Probe



Sample Modules

LFA / CFA IFA

Pump

LFA

Pump

DFA Tools

Contamination

Phase change

GOR

Composition

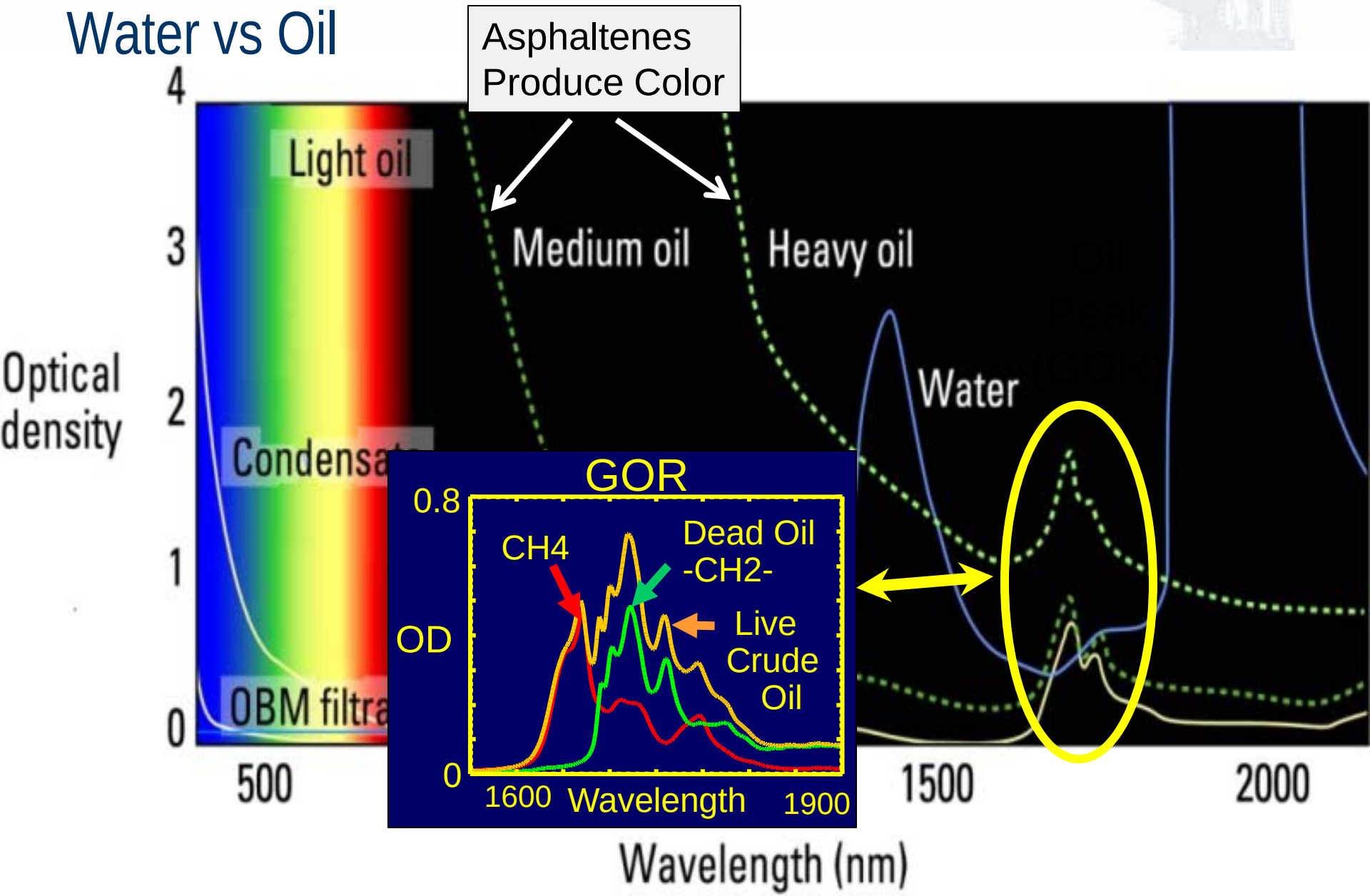
CO2

Density

Viscosity

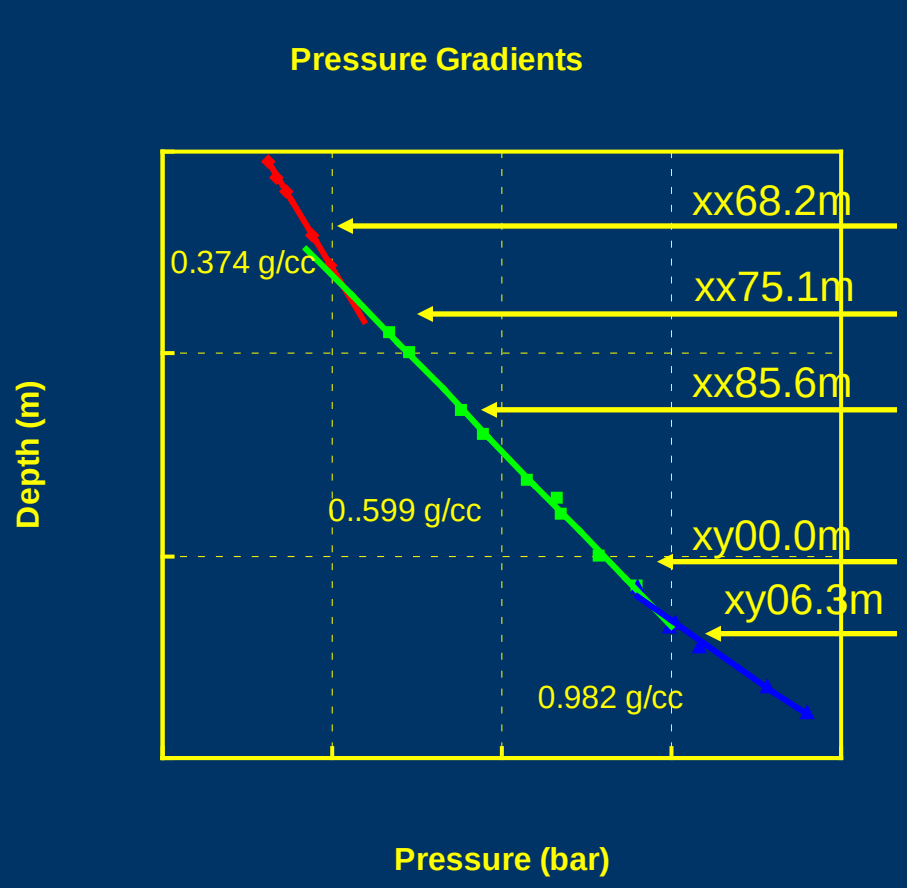
Asphaltene

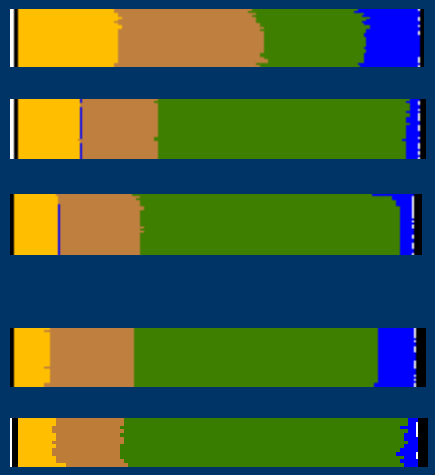
DFA uses Downhole Optical Spectroscopy Water vs Oil



Discovery well Fluid analysis

Vertical composition gradient is observed in an exploration well

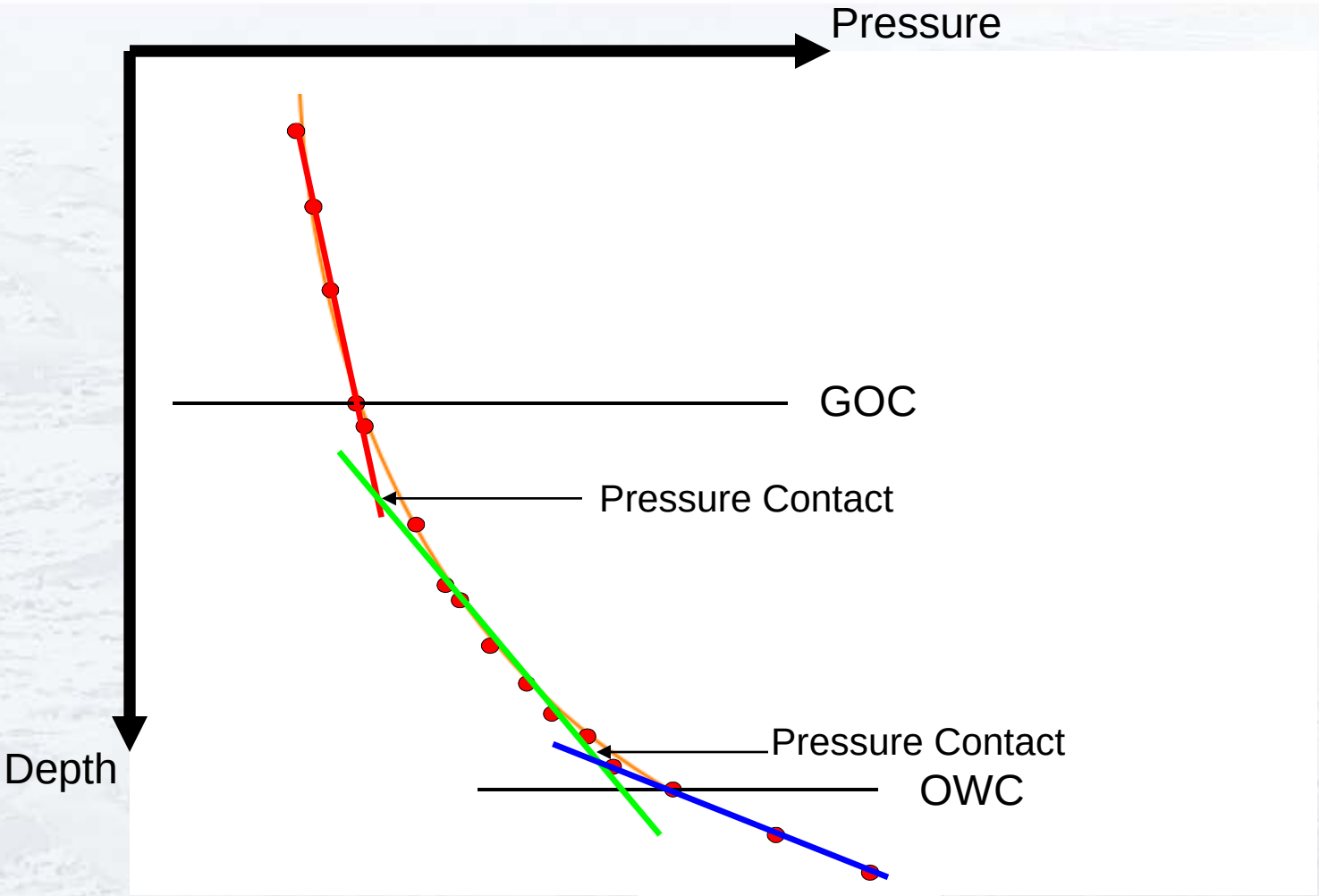




	Tool (M^3/M^3)	Lab (M^3/M^3)
xx68.2m	1410	1085
xx75.1m	450	336
xx85.6m	360	312
xy00.0m	320	284
xy06.3m	270	265

Curved Gradient Schematic

SPE 89704, SPE 108494

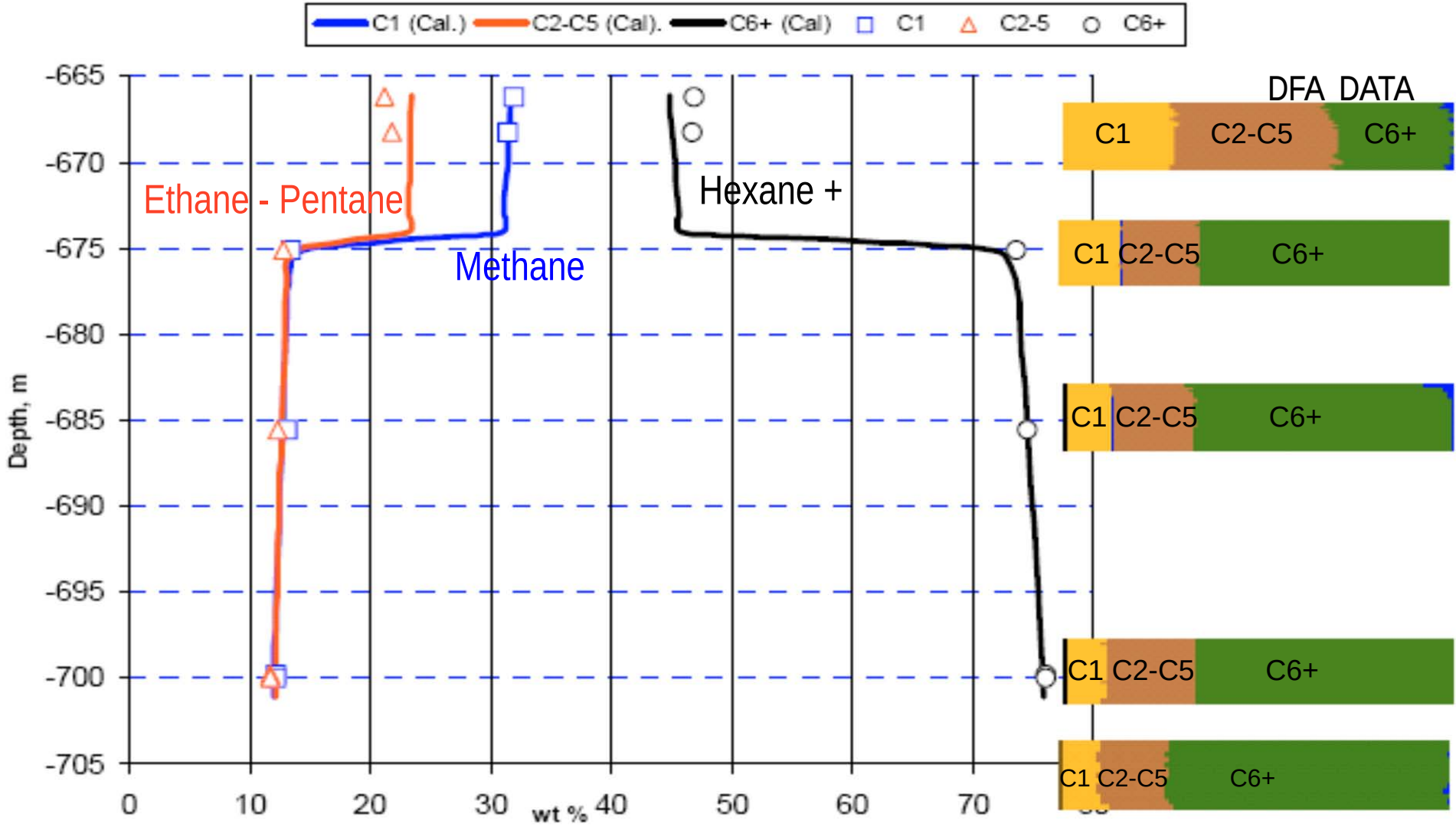


Equation of State Fluid modeling

- 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

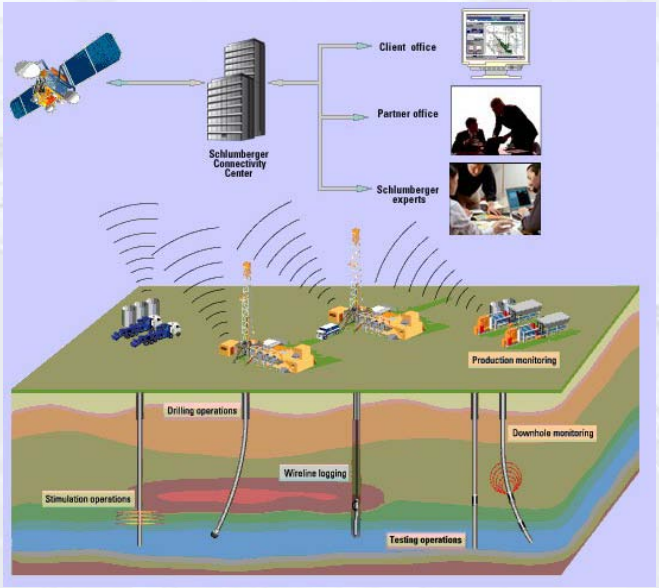


Logging optimization

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.



Logging optimization

Fluid modeling Assumptions:

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

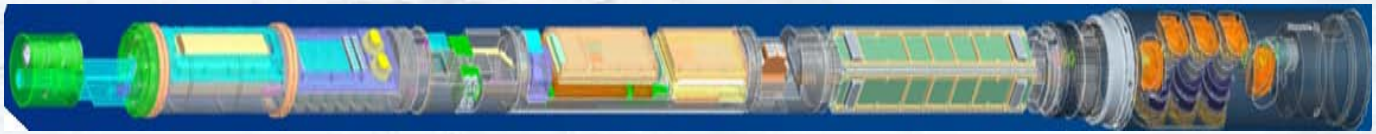
Validation

- 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.

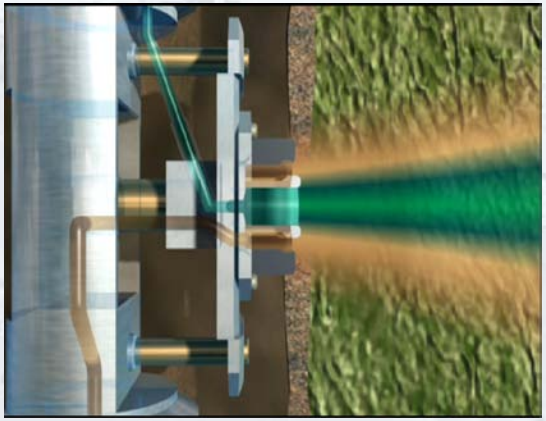
Fluid Model Validation

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

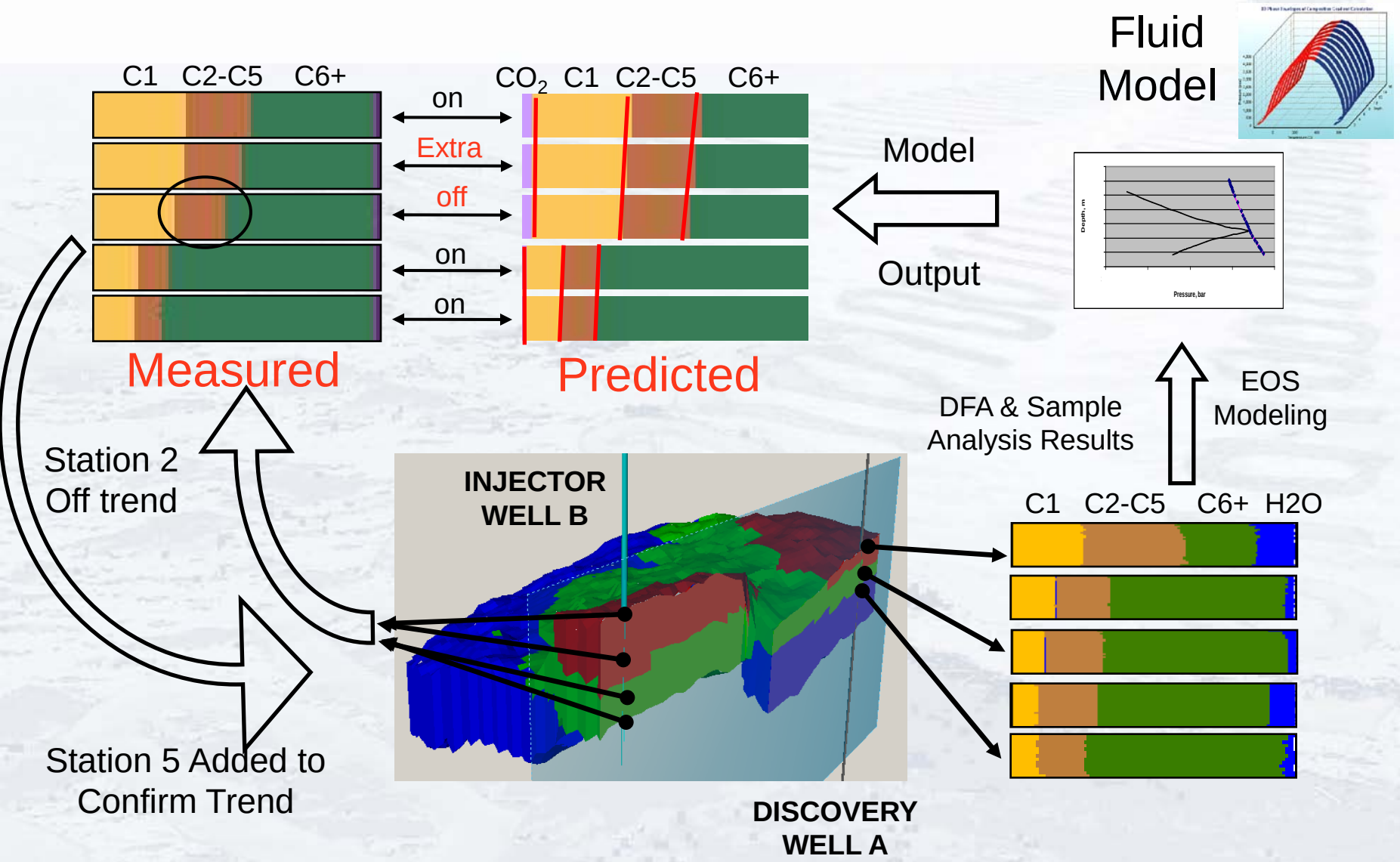


- High resolution DFA with quantified accuracy is preferred.

- Contamination Management



DFA predictive Modeling Workflow



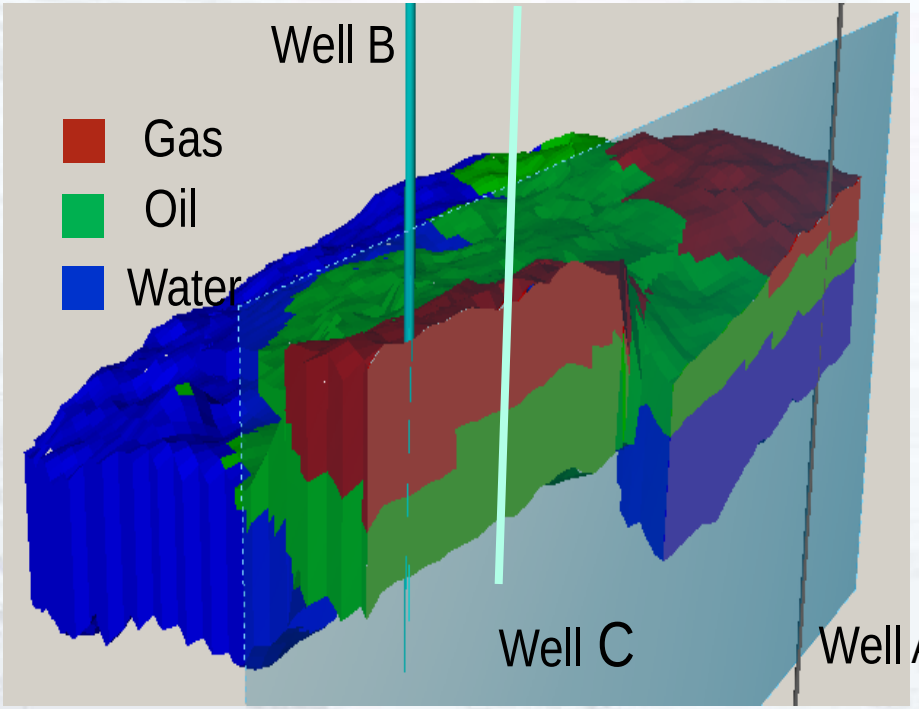
Complete Dataset Acquired

GOCs different by 20 Meters TVD.

Two Separate Gas Caps in “One” Sand.

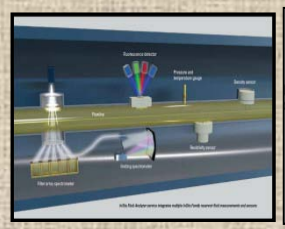
Can be explained by either

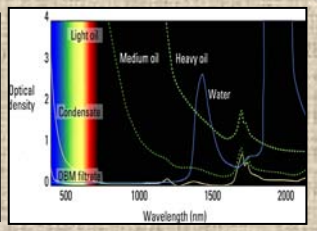
- Compartment or
- Lateral Disequilibrium.



New Approach – Integrating Asphaltene Science

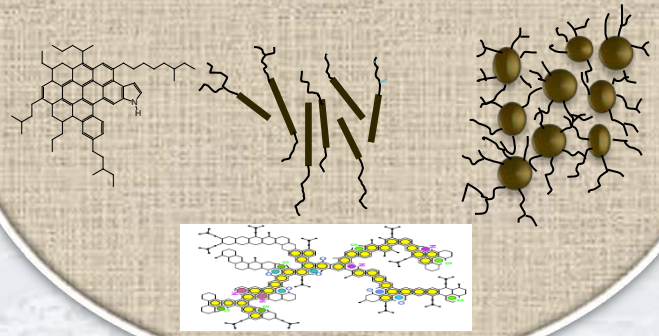
New DFA Technology



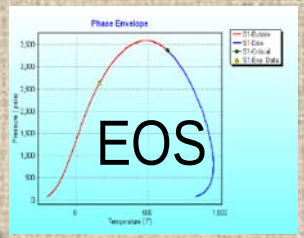


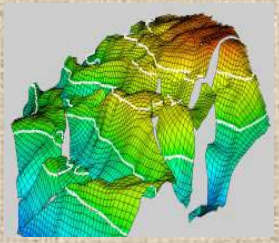
Insitu Fluid Analyzer

New Asphaltene Science



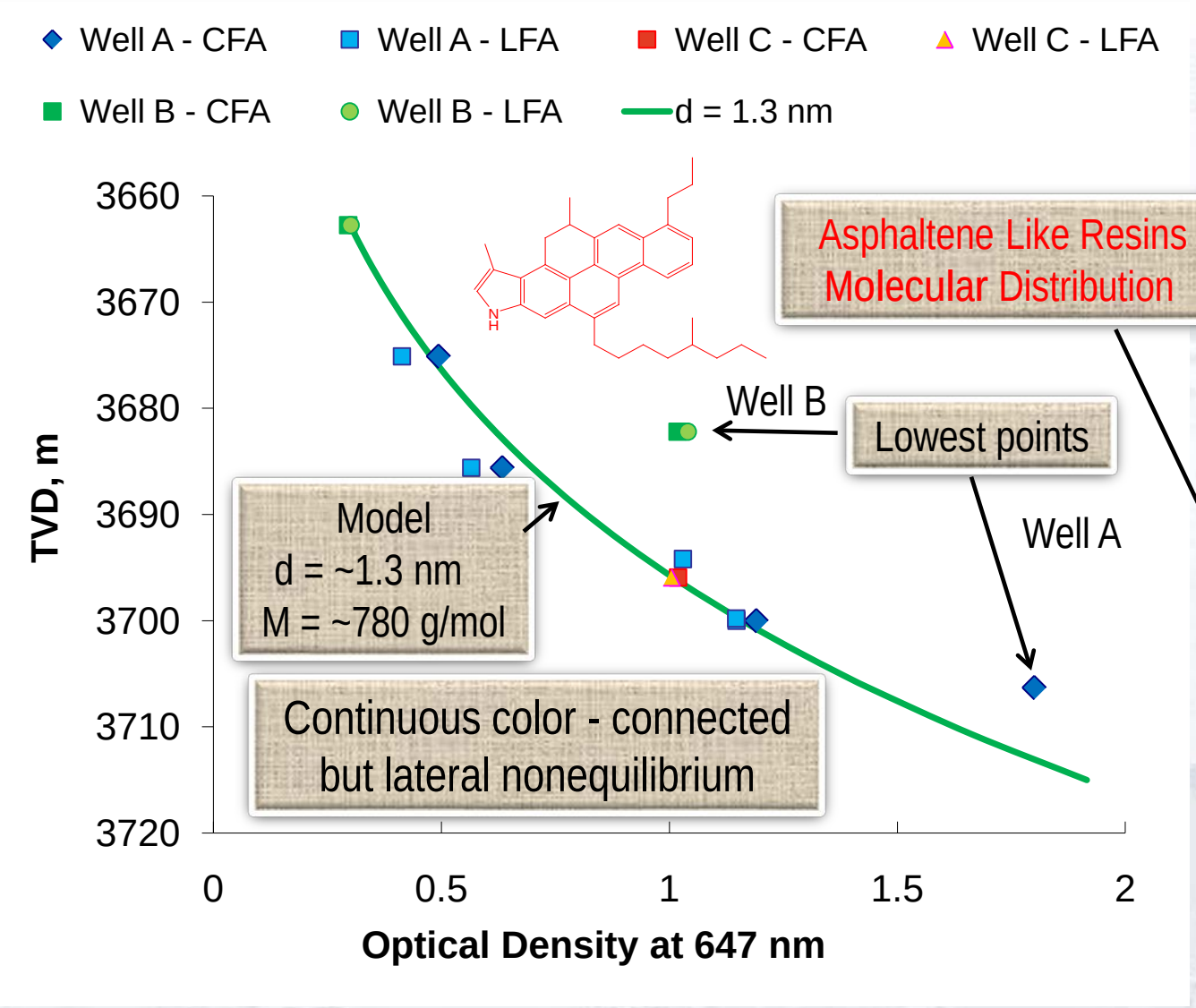
New Theory & Workflow

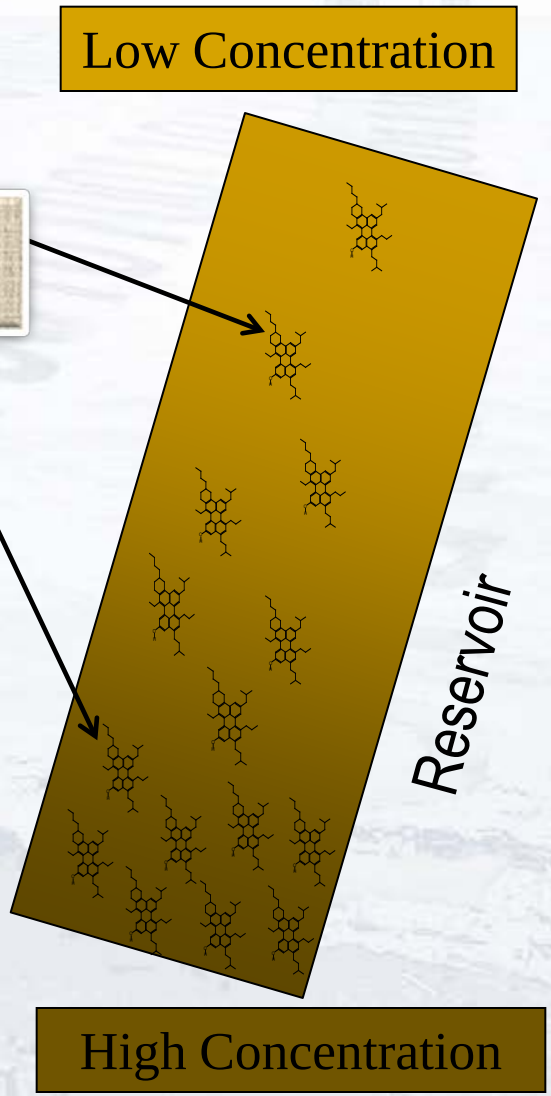




Flory-Huggins

Color Seems Continuous (neglecting lowest point !)





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 discover 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.