

Quantifying Gas Saturation in Tight Gas Sand Reservoirs Behind Casing

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Outline

- Introduction
- Gas Saturation Monitoring
- A New Formation Nuclear Property
- Case Study
- Evaluation Results
- Summary



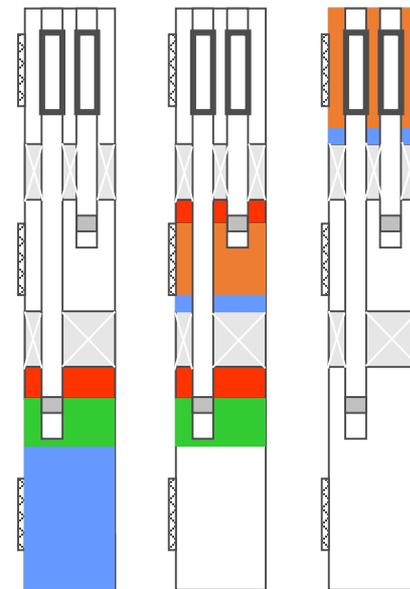
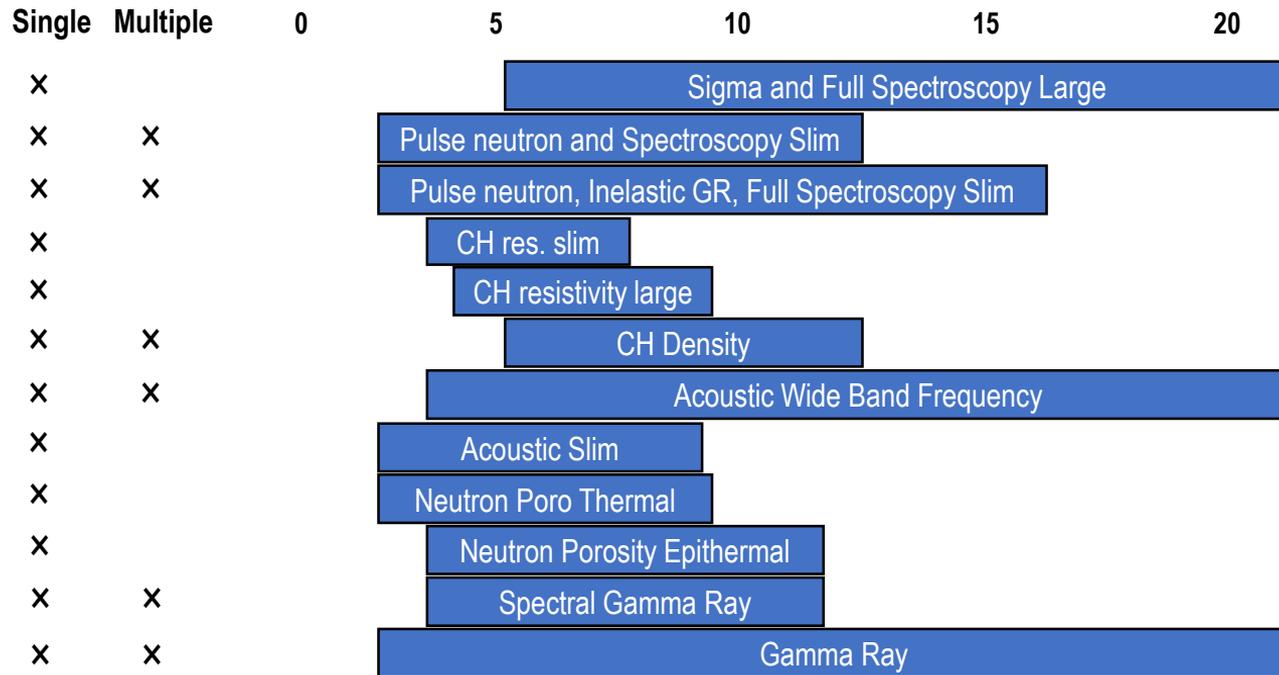
Introduction

- Cased-hole formation evaluation has a primary role for the proper description of the existing reservoir systems and also new players in particular conditions.
 - Help finding that additional drop of oil
 - Assisting completion design or intervention programs
 - Characterization of new reserves managing costs and operational risks.
- Alternative saturation methods are available; with or without open hole logs
- Current technology is the enabler, even in tough logging conditions.

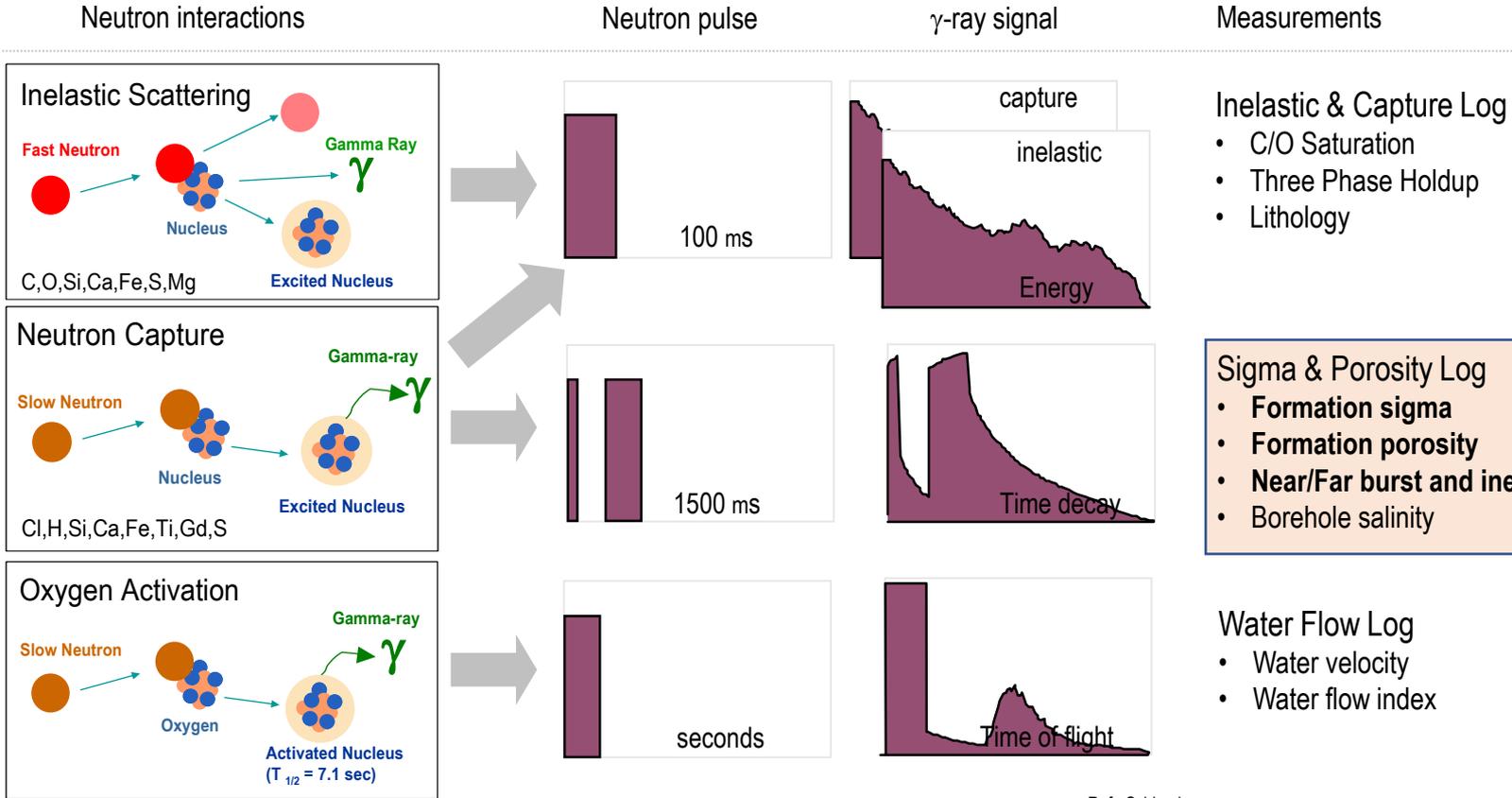
Logging Behind Casing....mostly with open hole logs

Casing / Completions

←----- Casing or hole size range ----->



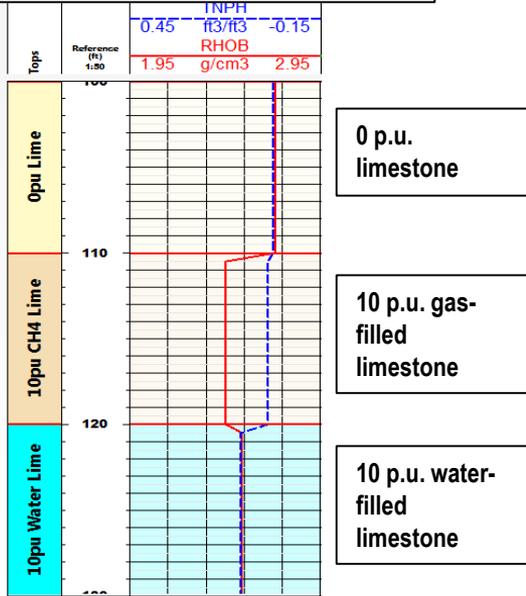
Pulsed Neutron Interactions



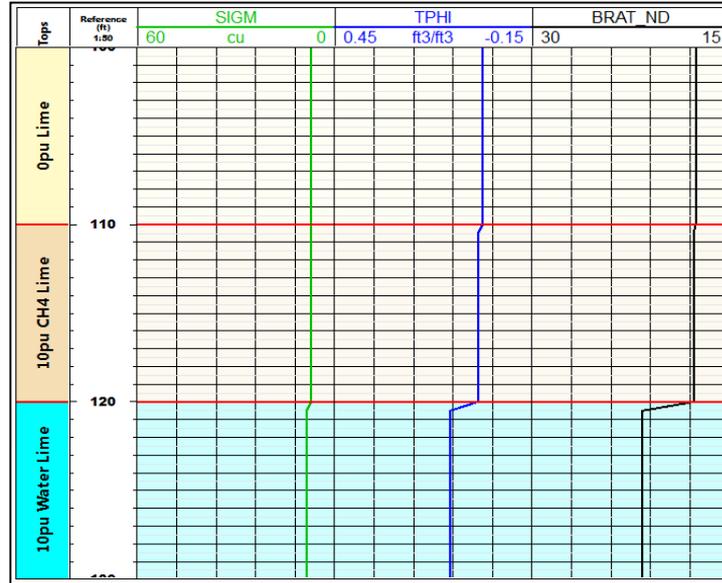
Ref.: Schlumberger

Why A New Independent Cased Hole Gas Measurement

OH Gas Detection Based on Density/Neutron Logs

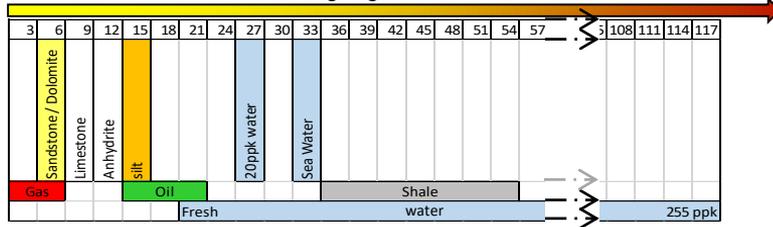


Conventional CH PNL Cannot Differentiate Gas-Filled Porosity from Low Porosity



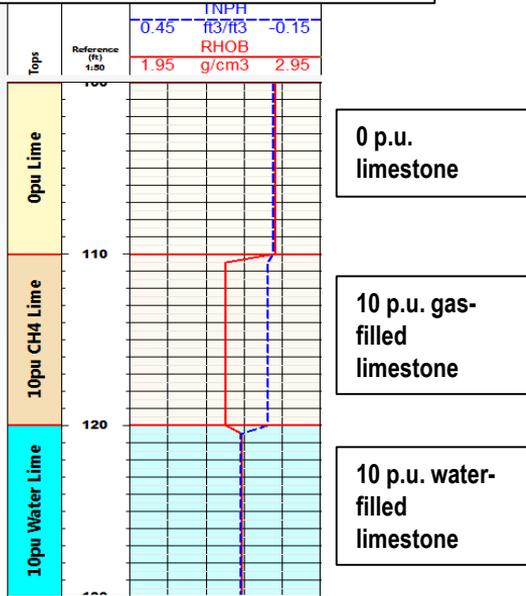
Different flavors of GR ratios cannot differentiate gas-filled porosity from low porosity

Increasing sigma values

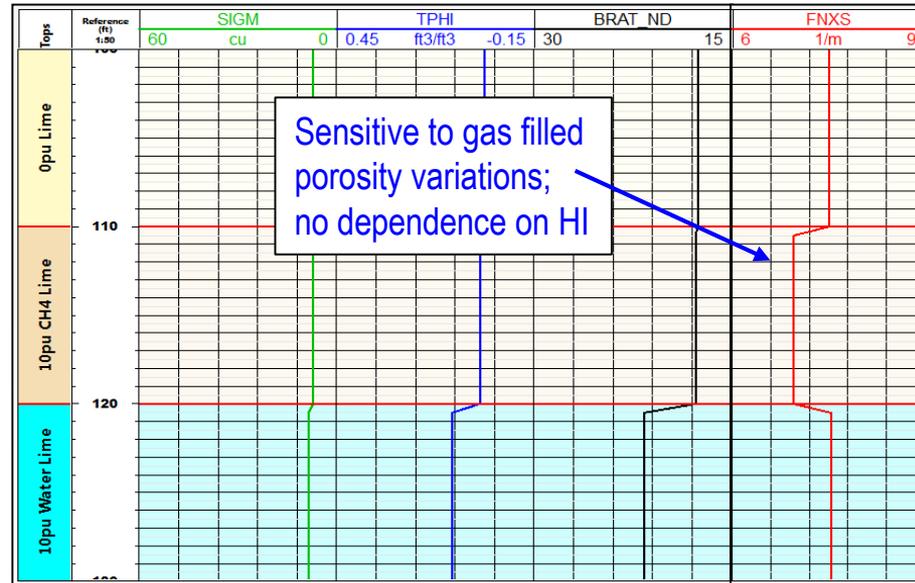


Why A New Independent Cased Hole Gas Measurement

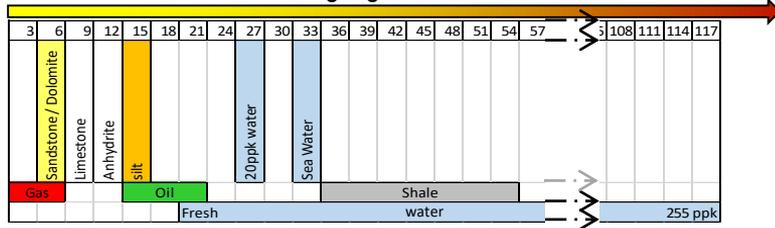
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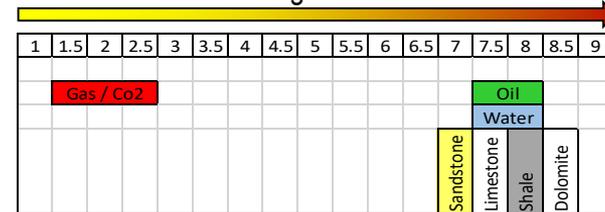
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Increasing sigma values

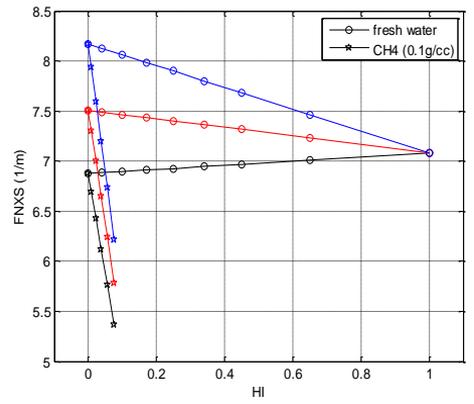
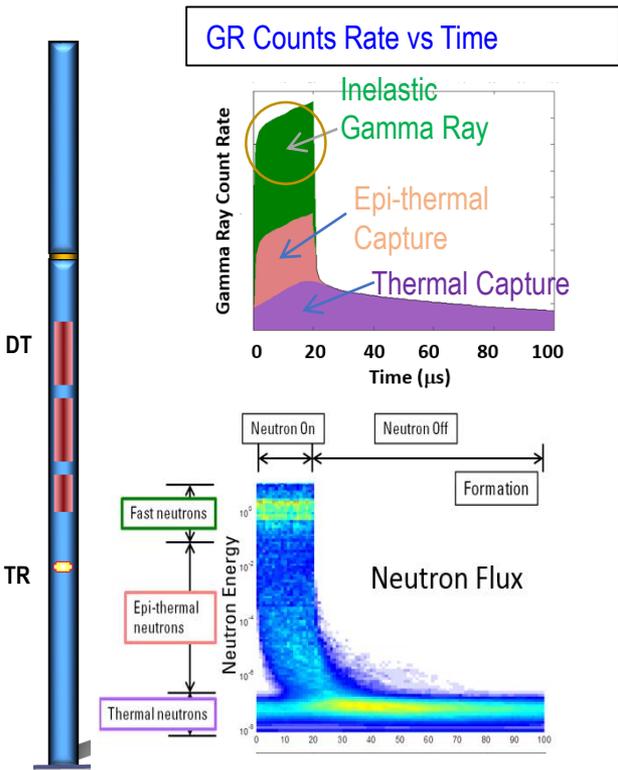


Increasing FNXS values

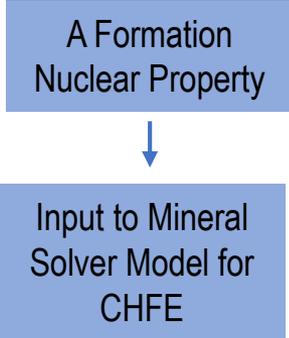


Gas Saturation from Fast Neutron Cross-section Measurement

- Probability of fast neutrons to interact with atoms; directly sensitive to atom density and gas filled porosity, independent of hydrogen index

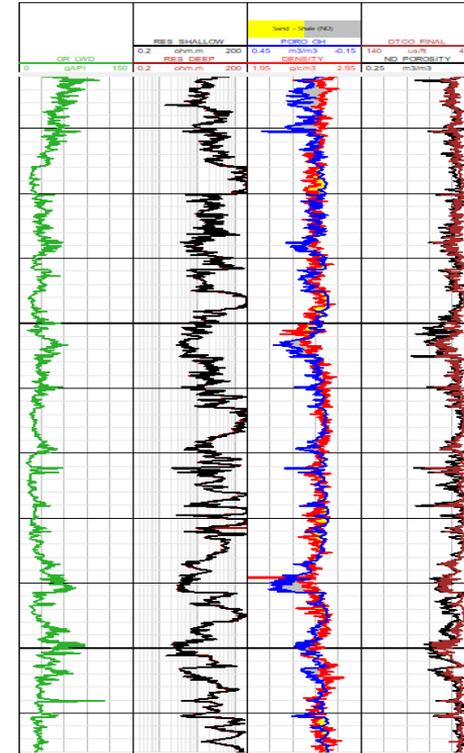


Material	SIGMA (cu)	TPHI	FNXS (1/m)
Sandstone	4.55	0	6.84
Limestone	7.08	0	7.51
Dolomite	4.7	0	8.51
Shale	20 to 40-50	0.2-0.4	8.02
Fresh Water	22	1	7.8
25ppk Water	30.1	0.97	7.74
Diesel	23.84	1	7.85
CH4(0.1g/cc)	5	0.08	1.34
CO2(0.6g/cc)	0.03	-0.12	2.24



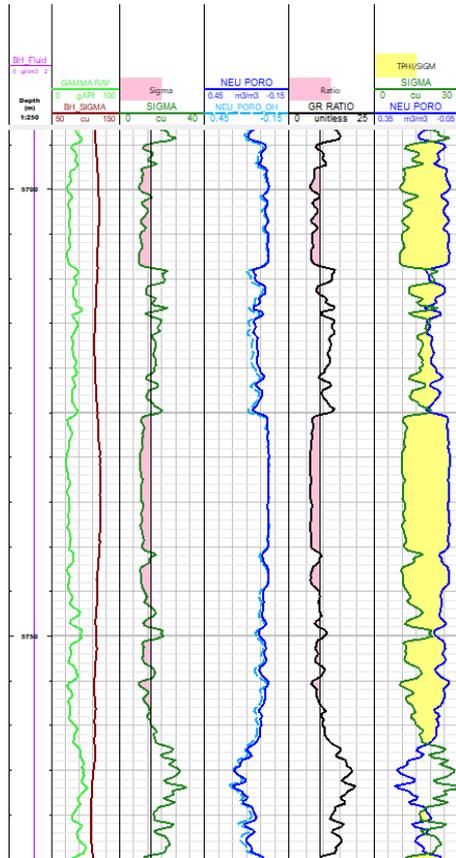
Tight Gas Field Evaluation Example

- Gas producing field
- Alternating very low-porosity sandstone and gas-filled zones, within a tight limestone matrix.
- Mixed salinity effects
- Improved logs evaluation required to guide perforation
- Cased hole logging for formation evaluation performed behind single and multiple casing strings



Independent Gas Measurement: FNXS

Producing field; heterogeneous rock with low porosity gas-filled and very low porosity zones alternating.



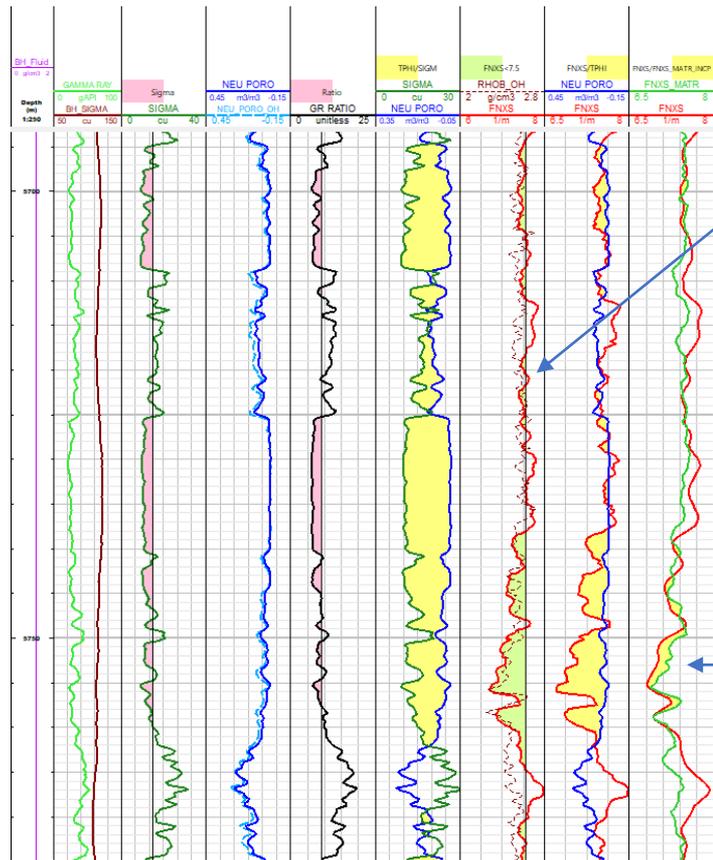
Conventional methods are inconclusive due to low porosity and contrast

Low Sigma and porosity, counts ratio change and constantly low – Gas?

Need a new measurement to differentiate gas filled porosity from very low porosity

Independent Gas Measurement: FNXS

Producing field; heterogeneous rock with low porosity gas-filled and very low porosity zones alternating.



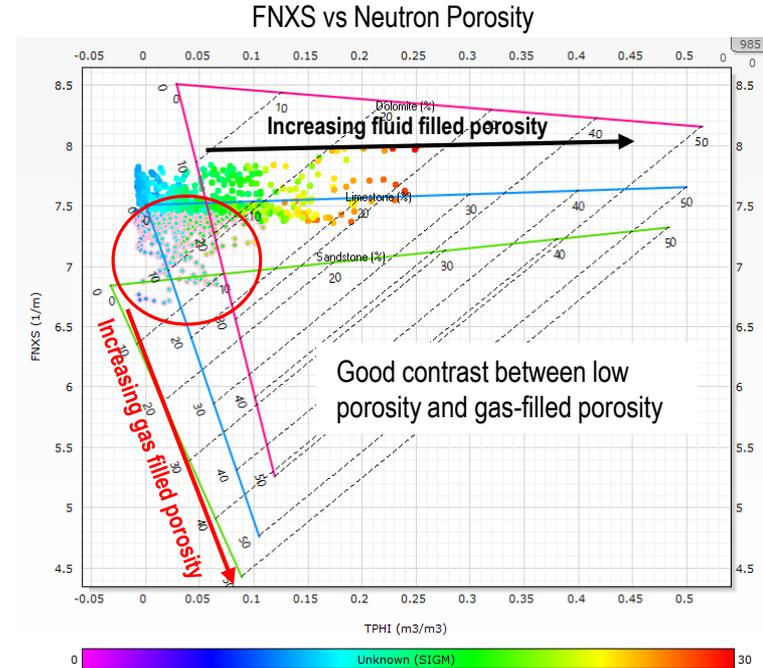
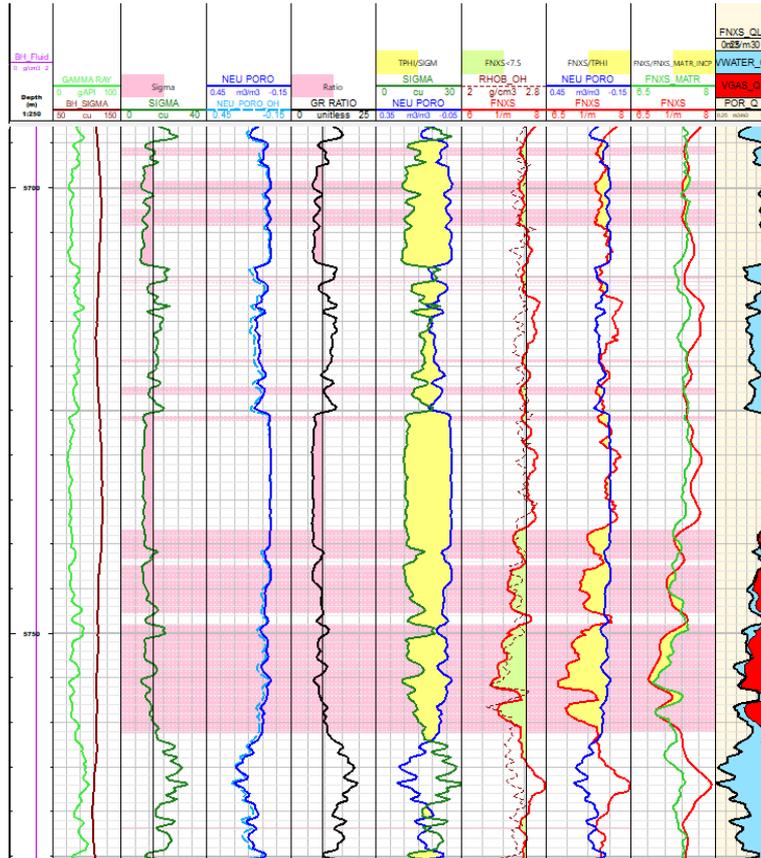
FNXS deflection correlates to gas volumes changes in the formation

FNXS show liquid in this zone
(previous PNL and methods might have flagged
low water-filled porosity as gas - erroneously)

FNXS vs FSNX of matrix (dry)
support the fluids identification

Prompt Gas Volume and Porosity

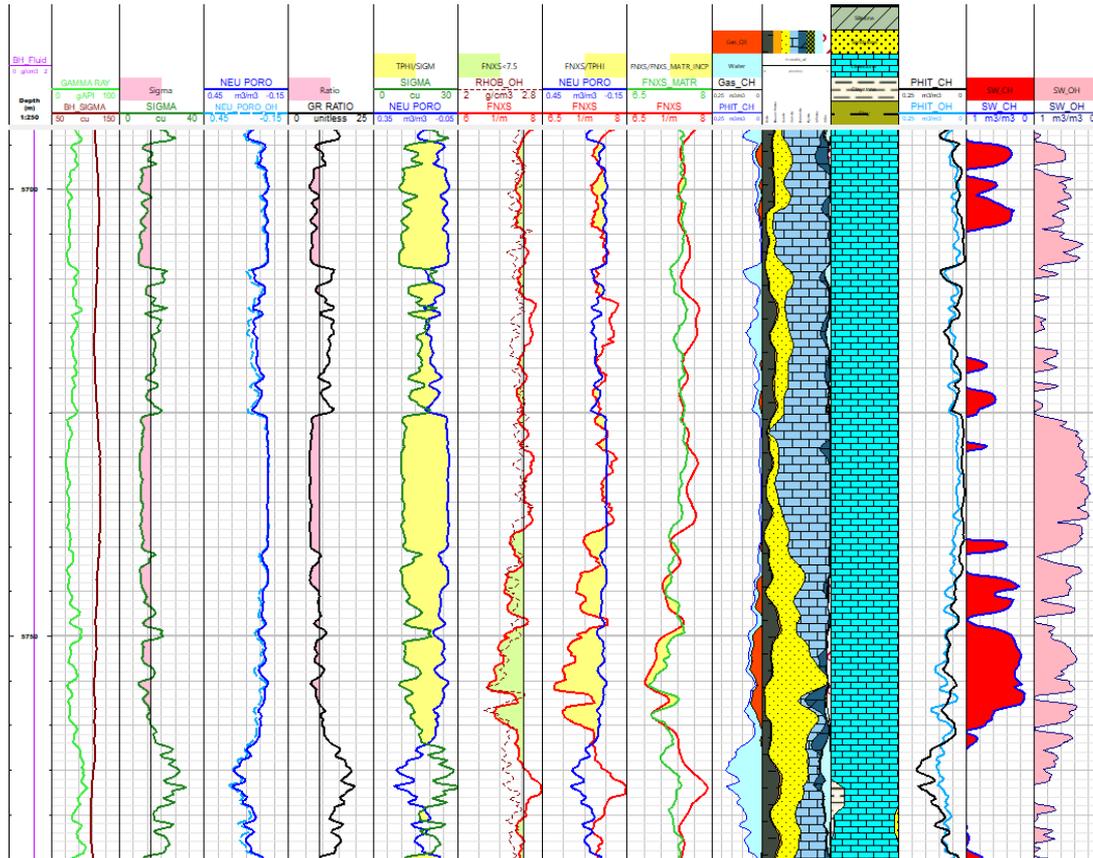
FNXS and Neutron porosity combined for QL crossplot porosity and gas volume as typically done with N-D logs



Quick gas volume and porosity estimate with FNXS and Neutron Porosity

Standalone Volumetric Formation Evaluation

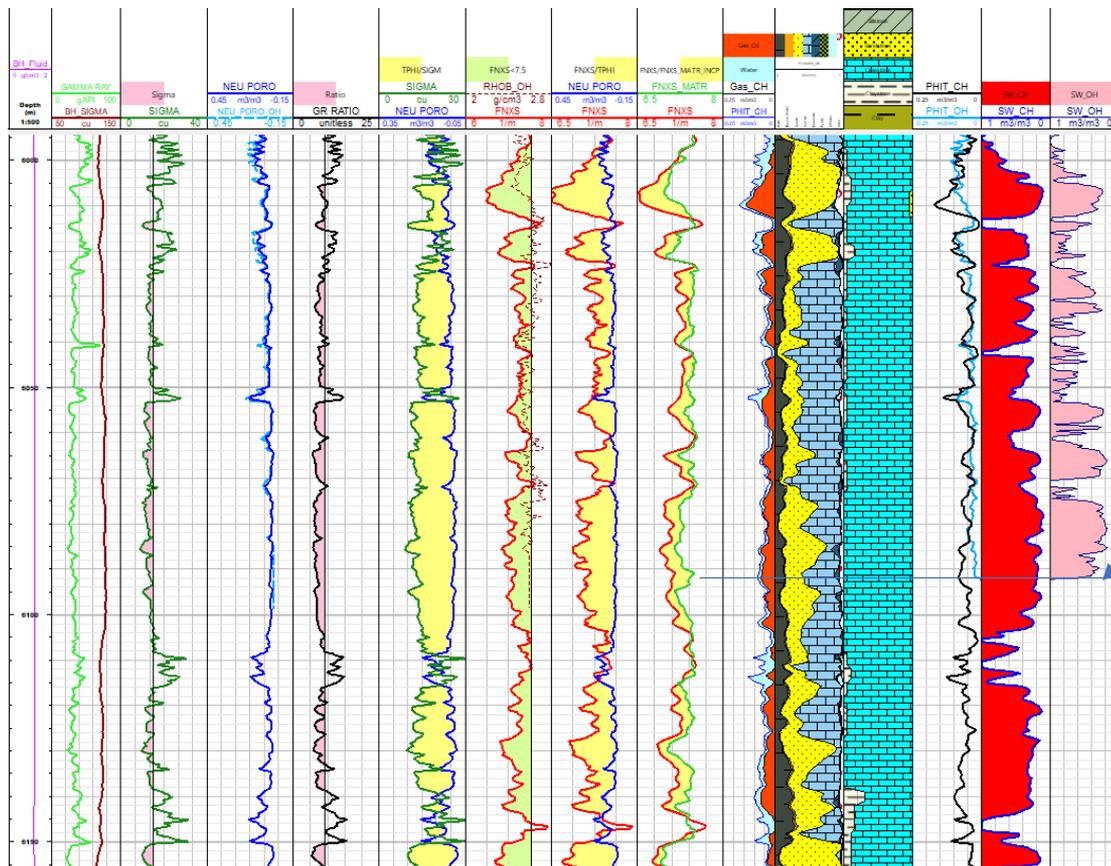
Linear volumetric measurements, with the addition of elemental composition and matrix calculation, allow quantitative analysis.



- Comprehensive and multi-mineral solver analysis and porosity computation where original conventional logs had difficult to describe the lithology and porosity; hence provide a clear understanding of storage capacity and fluids' dynamics.

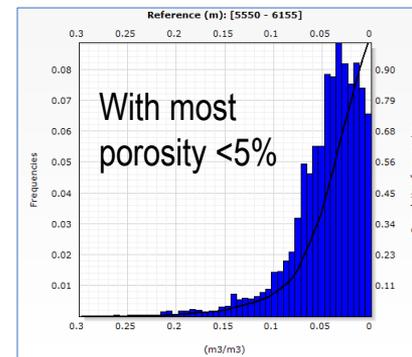
De-risking Deep Gas Reservoirs

Data recorded much deeper to characterize deeper low-porosity sandstone that could not be evaluated before



- Finding quality pay in deeper reservoir, otherwise not accessible

Open hole logging deepest evaluation depth



In summary

- Novel independent methods for saturation monitoring from logs behind casing and within completion extend the evaluation envelope to complex rock and wellbores.
- In the case study, fluids saturations are obtained without complex nuclear models nor the need for formation salinity input, assumptions otherwise required for the data interpretation.
- And the cased hole data could be packaged to as if it was a conventional open hole acquisition for fast correlation and integration to other wells data.
- The information is key to define field development strategy.

