



Understanding the Complexity of the Bakken Oil Play

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Agenda

Complexity because of Heterogeneity

Heterogeneity and its impact on Bakken production

Identification of Heterogeneity

Complexity because of Heterogeneity

Vertical and Lateral Heterogeneity exists in the Bakken

Heterogeneity can have a strong impact on 'basin scale' production quality

It can also be significant over the 'well scale' requiring control

Heterogeneity is variations in

- Lithology
- Porosity
- Permeability
- Ability of the rock to fracture and
- Ability to retain an effective fracture aperture over time

Heterogeneity and its Impact on Bakken Production



Porosity and permeability

- Better porosity and permeability are known to relate to better production
- Larger pore size is the key

Lithology

- Clay & Limestone tends to kill porosity and permeability in the Bakken
- Dolomite & Quartz tends to improve porosity
- Fracture initiation is also easier in low clay rock

Natural Fractures

- When connected to existing fractures, bigger surface area can be accessed
- Pre-existing fracture frame work facilitates frac. Initiation
- Fractures and faults may lead frac. fluid to a non-productive area, hence wasting stages or contacting geo-hazards

Heterogeneity and its Impact on Bakken Production

Rock Lamination

- Creates TIV Anisotropy, which results in significant differences in horizontal vs vertical resistivities
- Determination of true resistivity and hence a correct S_w is challenged by laminations

Changes in R_w

- Lodgepole exhibits sharp abrupt changes in connate water resistivity ' R_w '

Differential Horizontal Stress

- High stress contrast tends to create bi-wing fractures vs complex fractures
- Low stress areas produce better over the long term

Common Questions to be asked in the Bakken



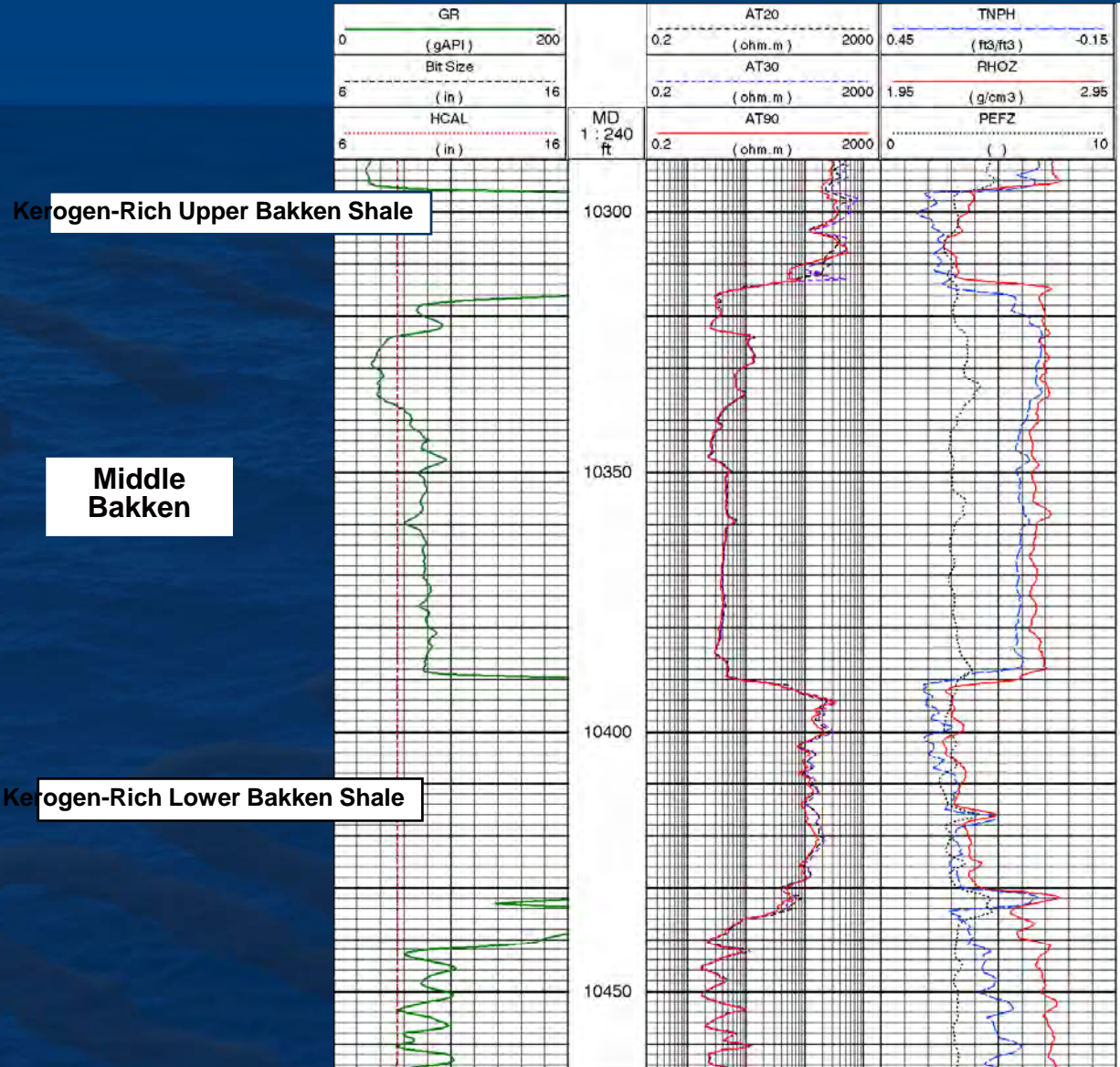
How does the lithology of my zone vary?

What is the distribution of the porosity?

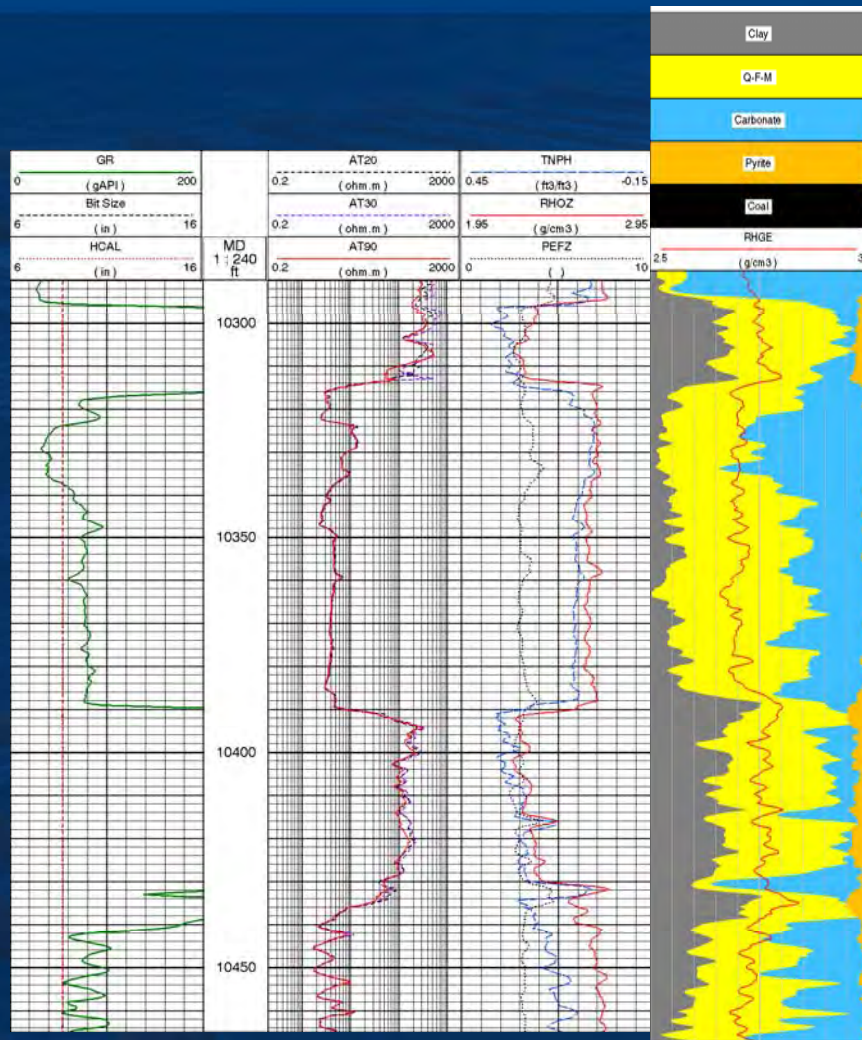
How is pore size varying?

What combination of properties will lead to the best Frac.
Performance?

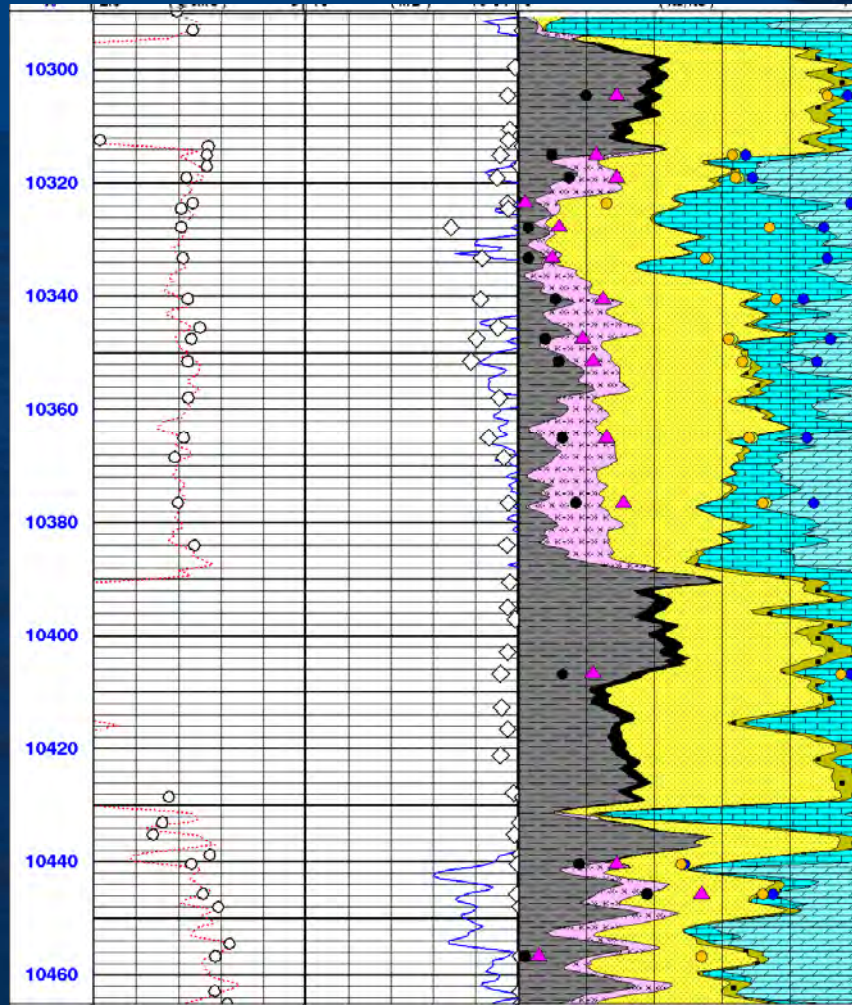
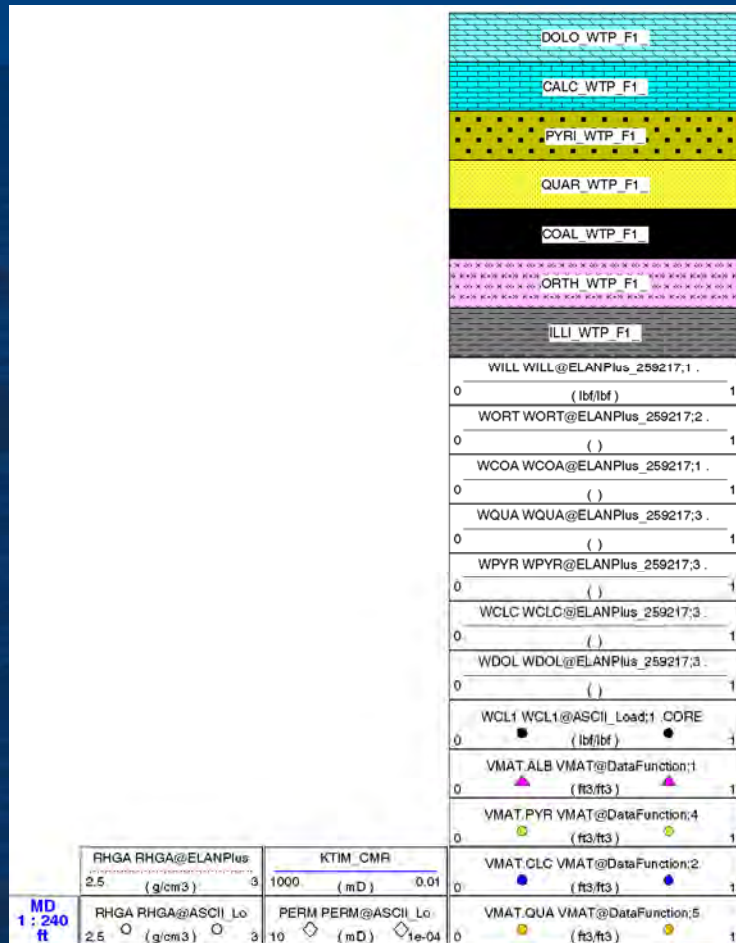
Conventional Log Data in Bakken



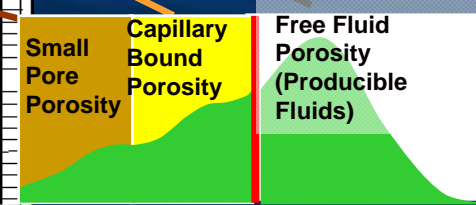
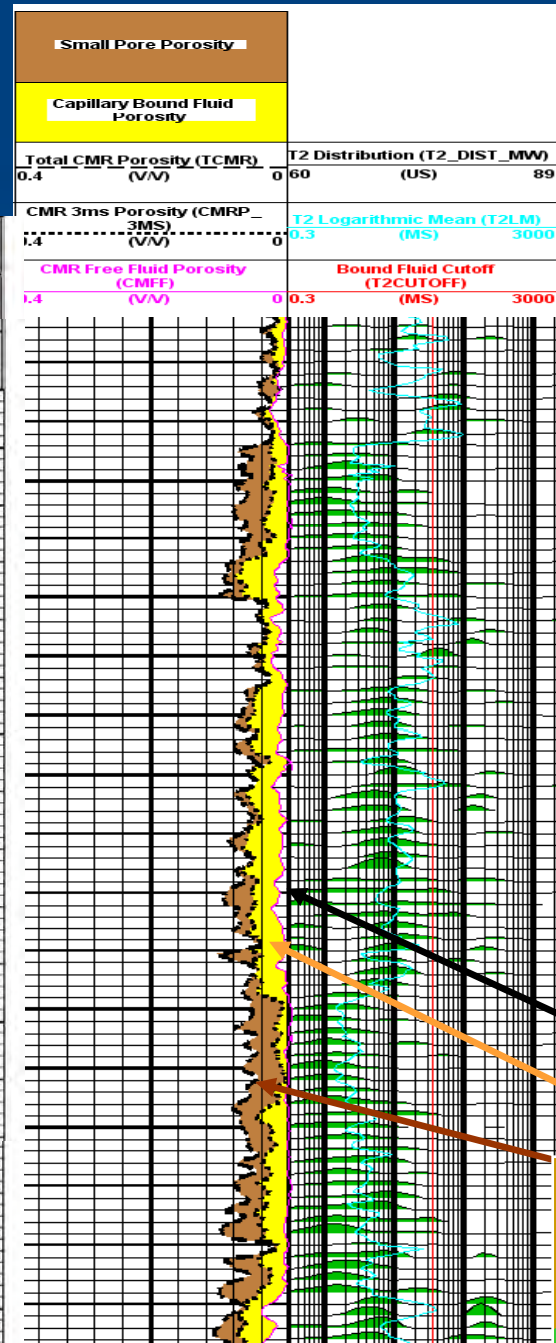
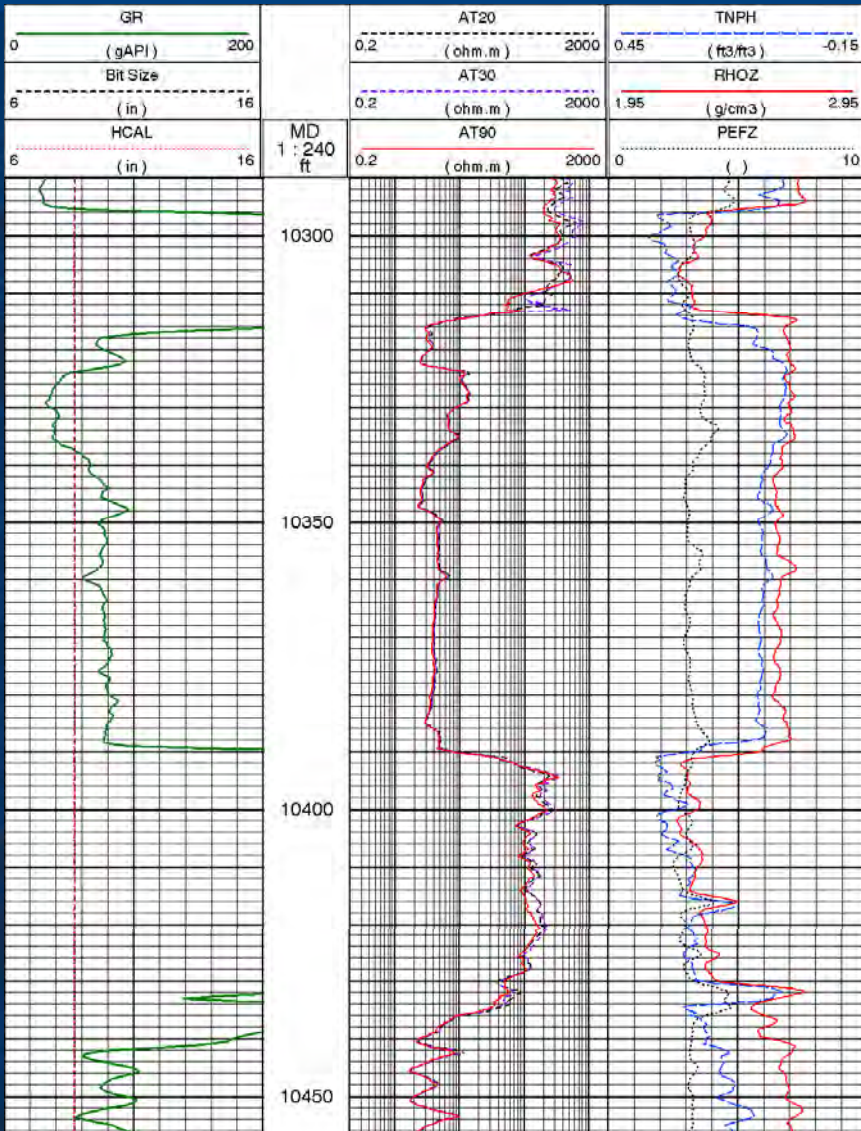
Addition of Spectroscopy Data



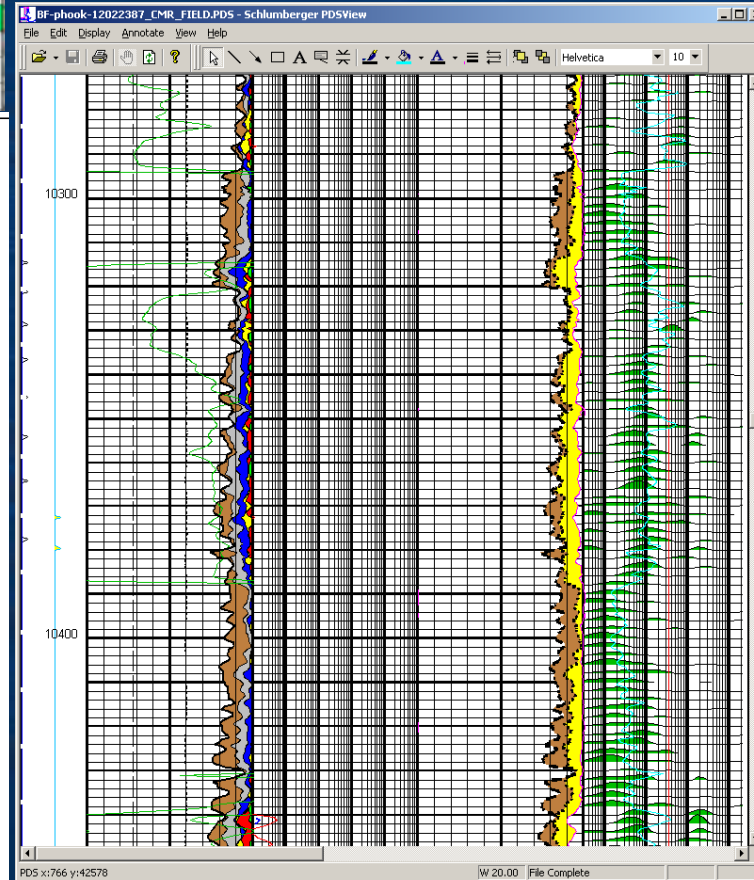
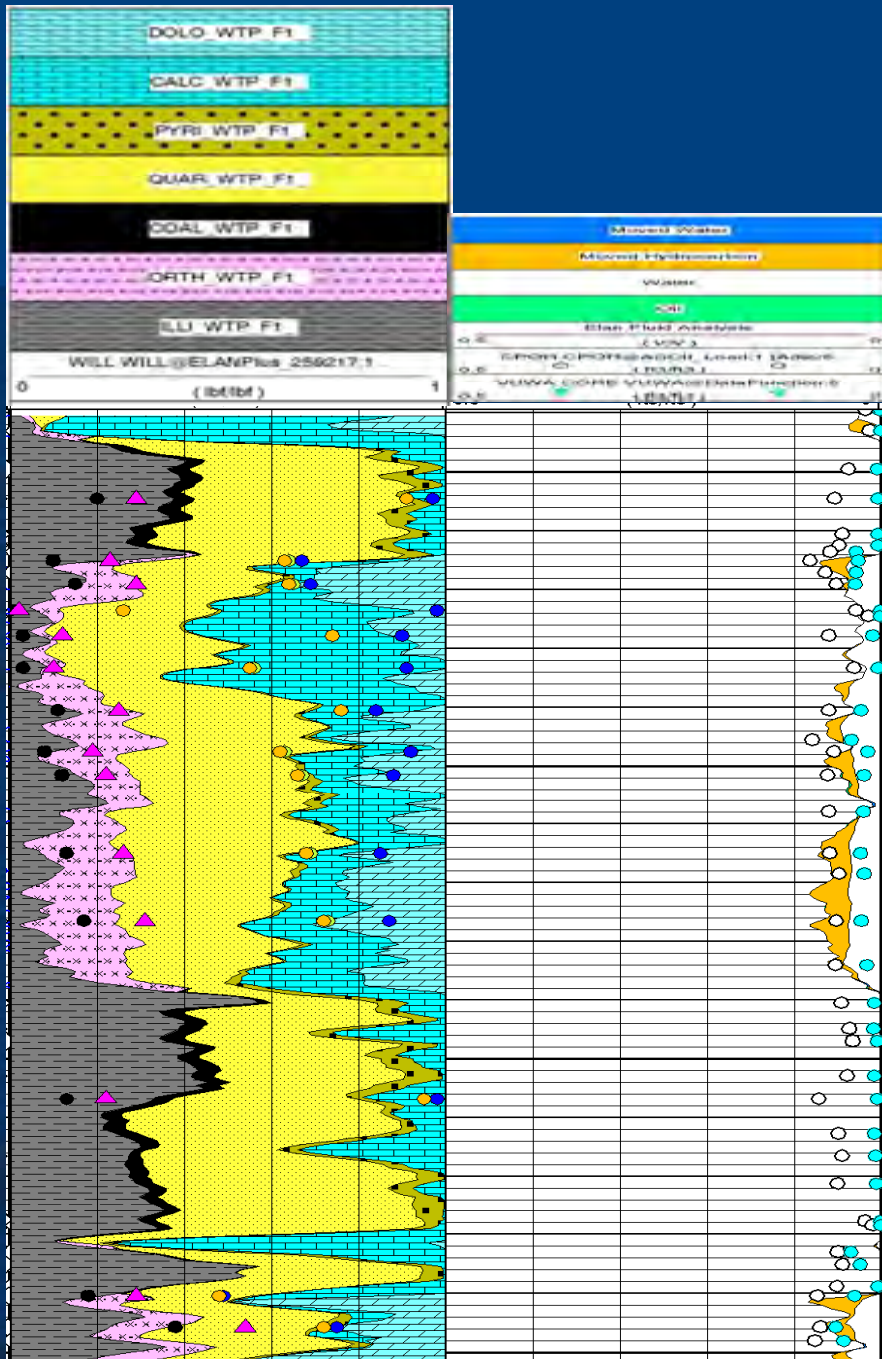
Spectroscopy vs XRD



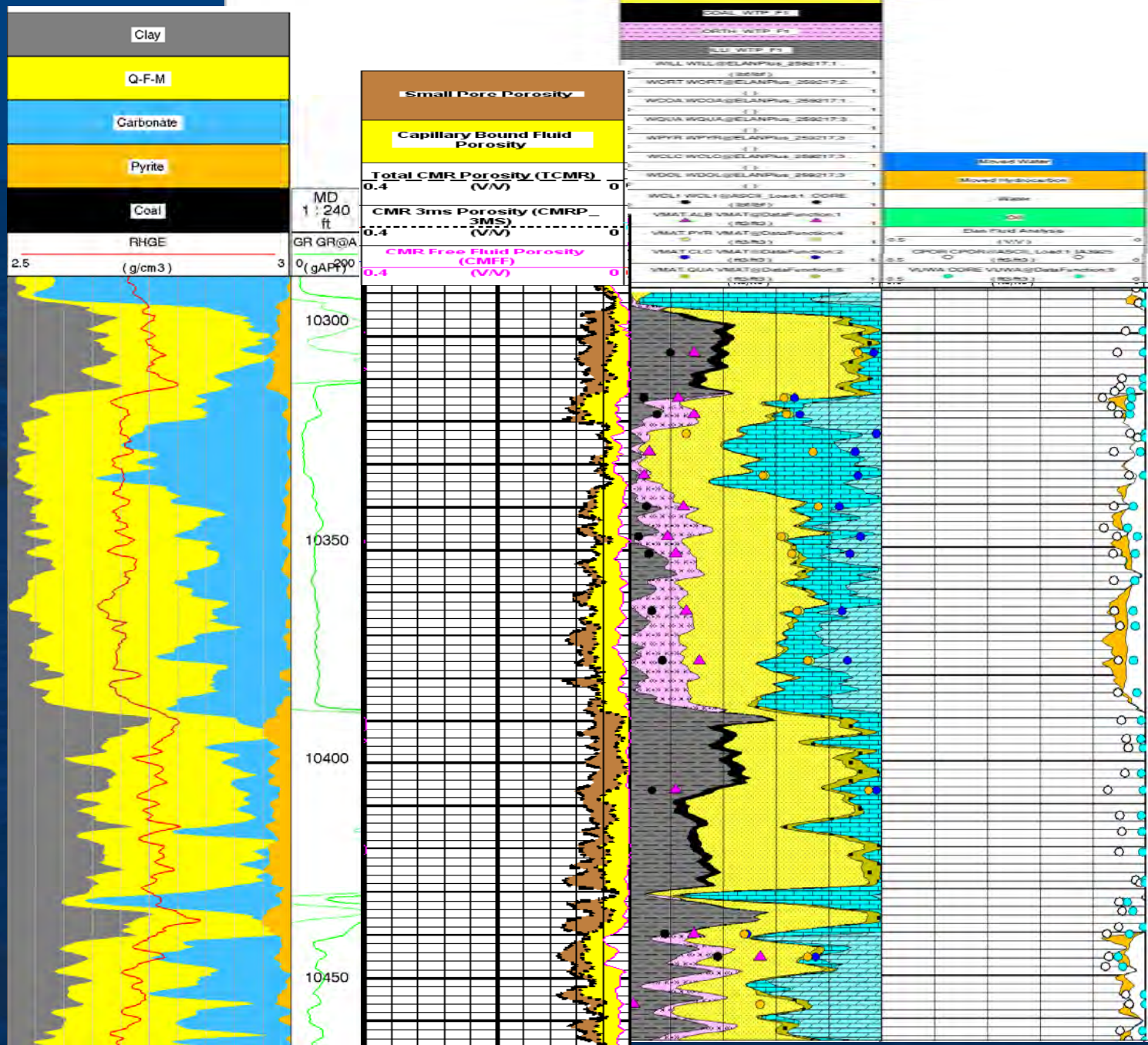
Magnetic Resonance in Bakken



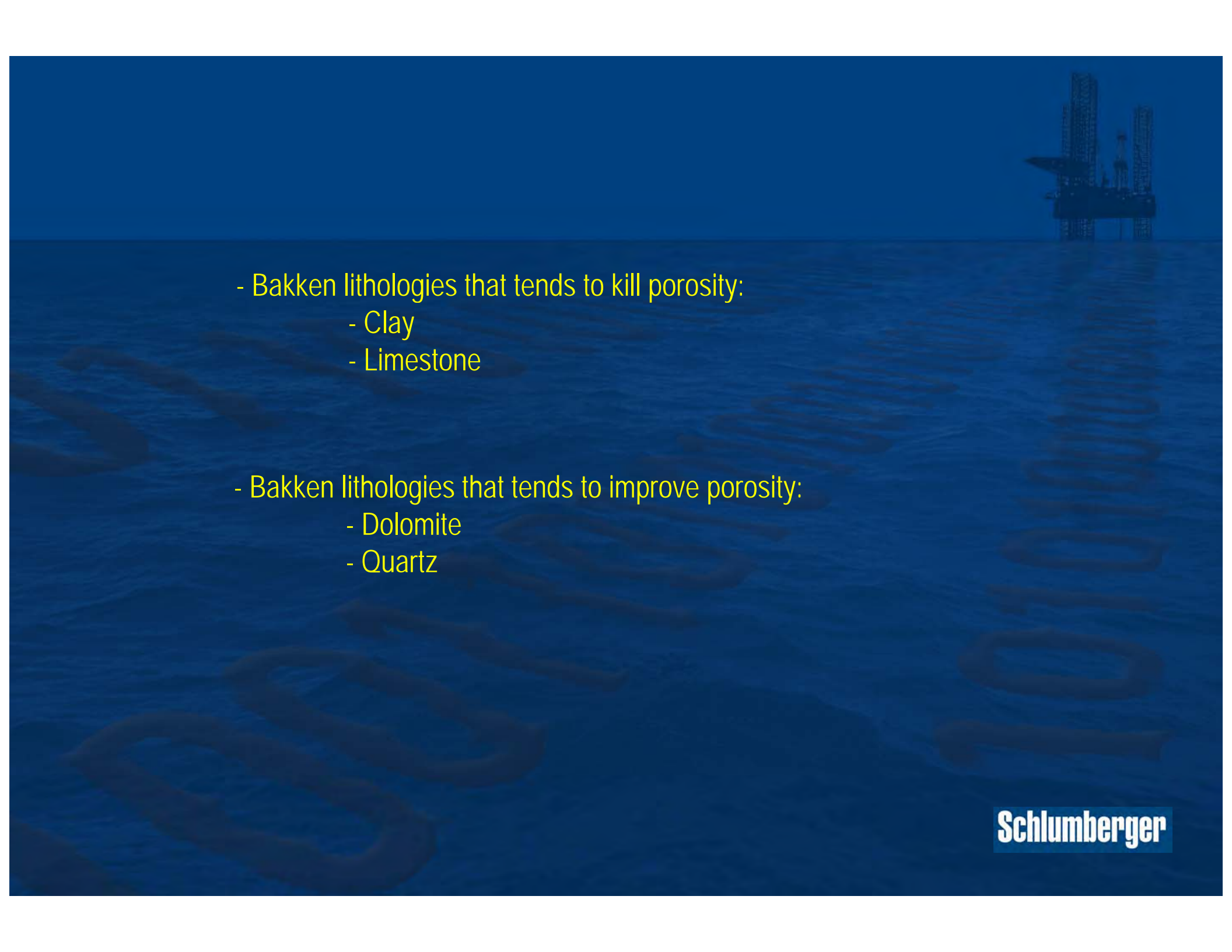
But does NMR agree with core Porosity?



Analysis Using NMR and Spectroscopy

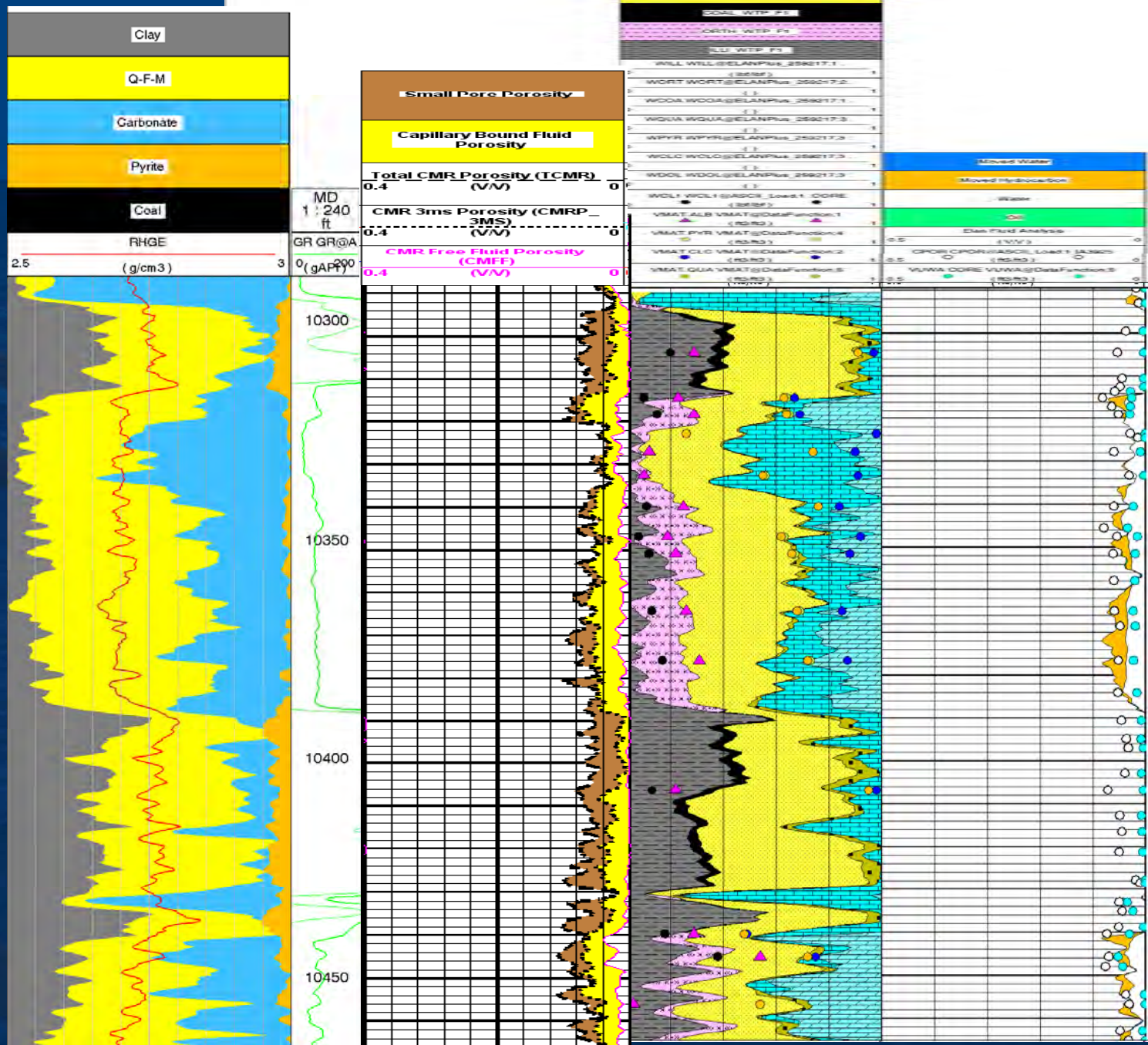


So are there porosity trends related to the lithology?

- 
- Bakken lithologies that tends to kill porosity:
 - Clay
 - Limestone

- Bakken lithologies that tends to improve porosity:
 - Dolomite
 - Quartz

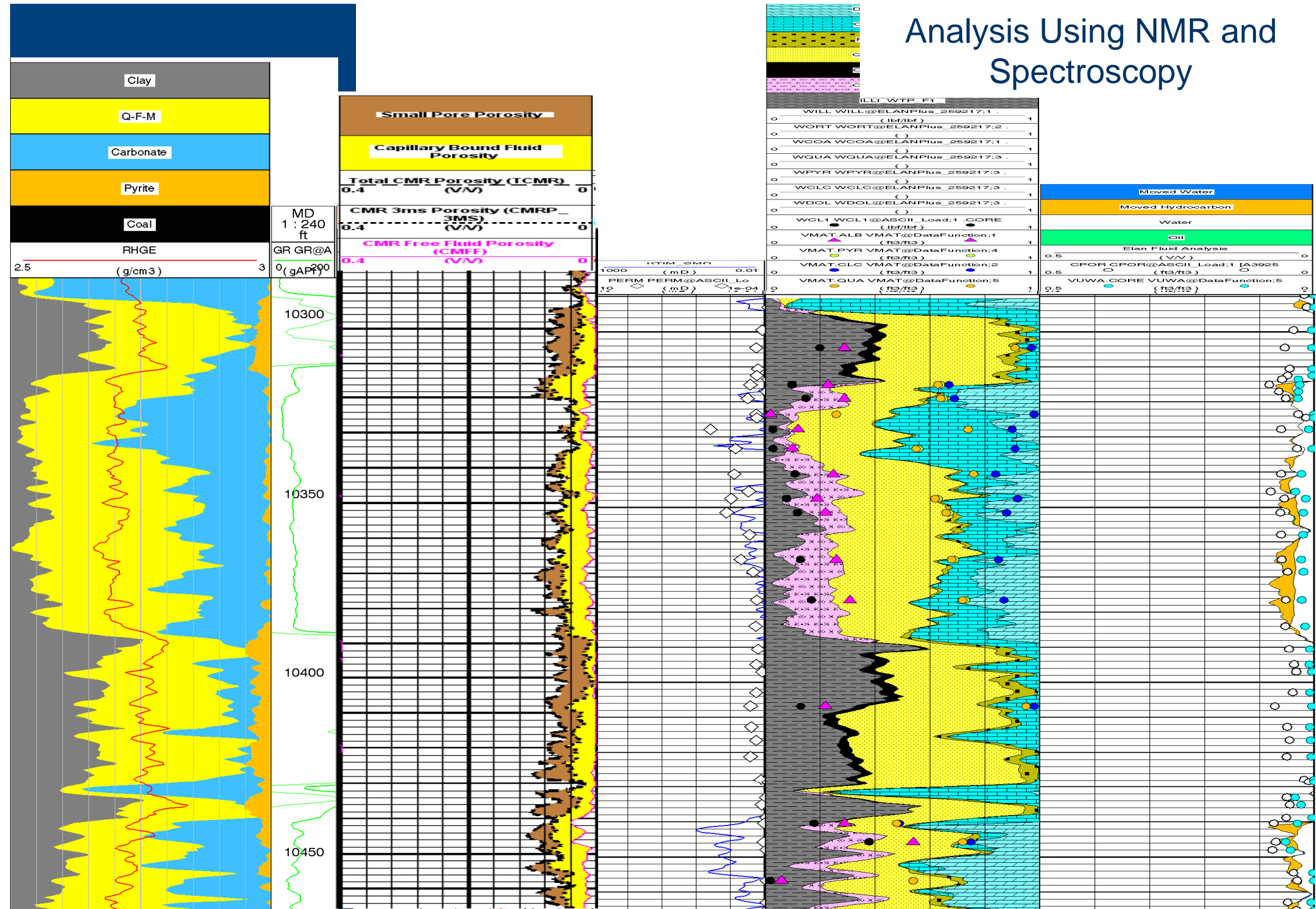
Analysis Using NMR and Spectroscopy



- So which zones have good perm?

- Where is the "sweet spot"?

Analysis Using NMR and Spectroscopy





- NMR perm agrees with core.

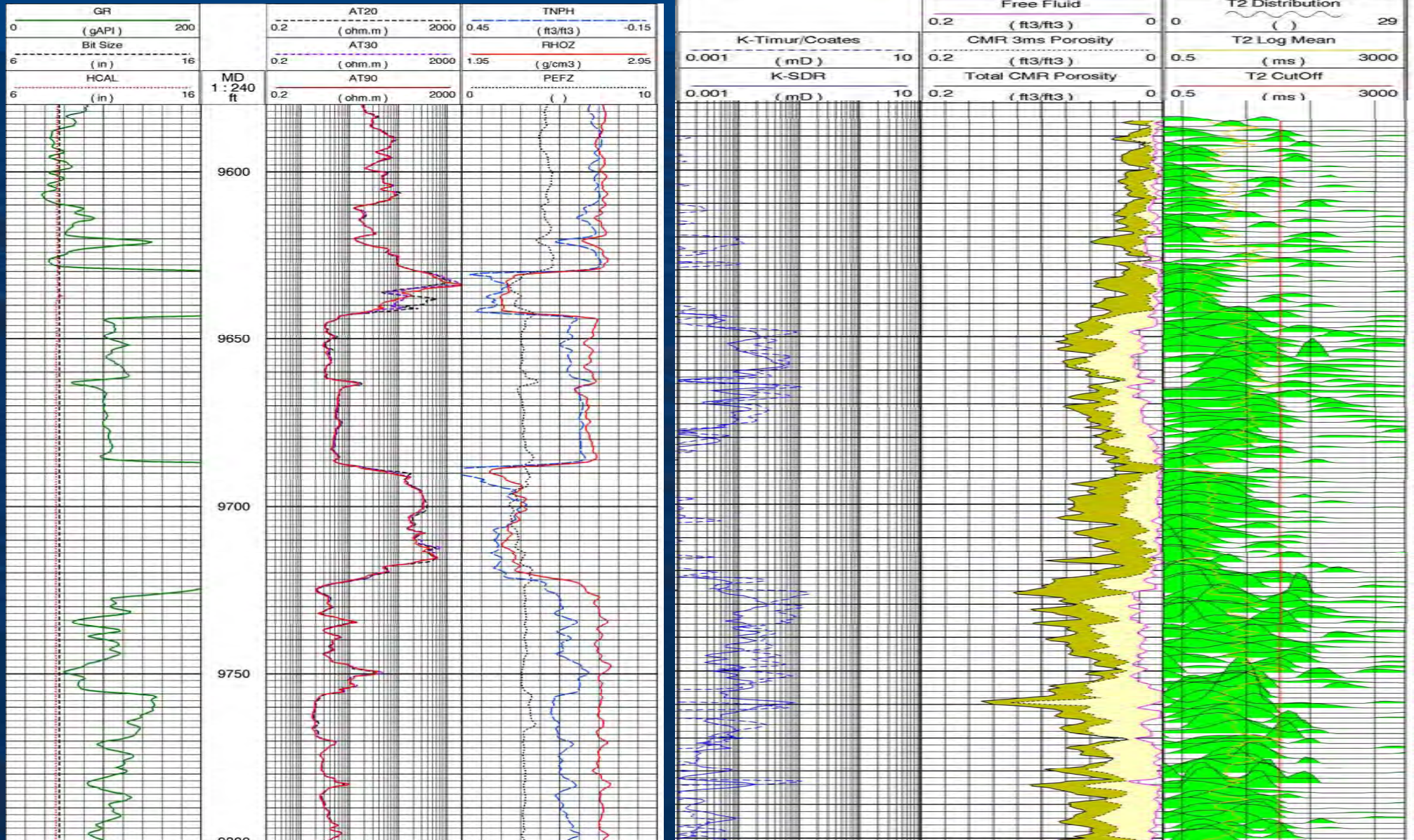
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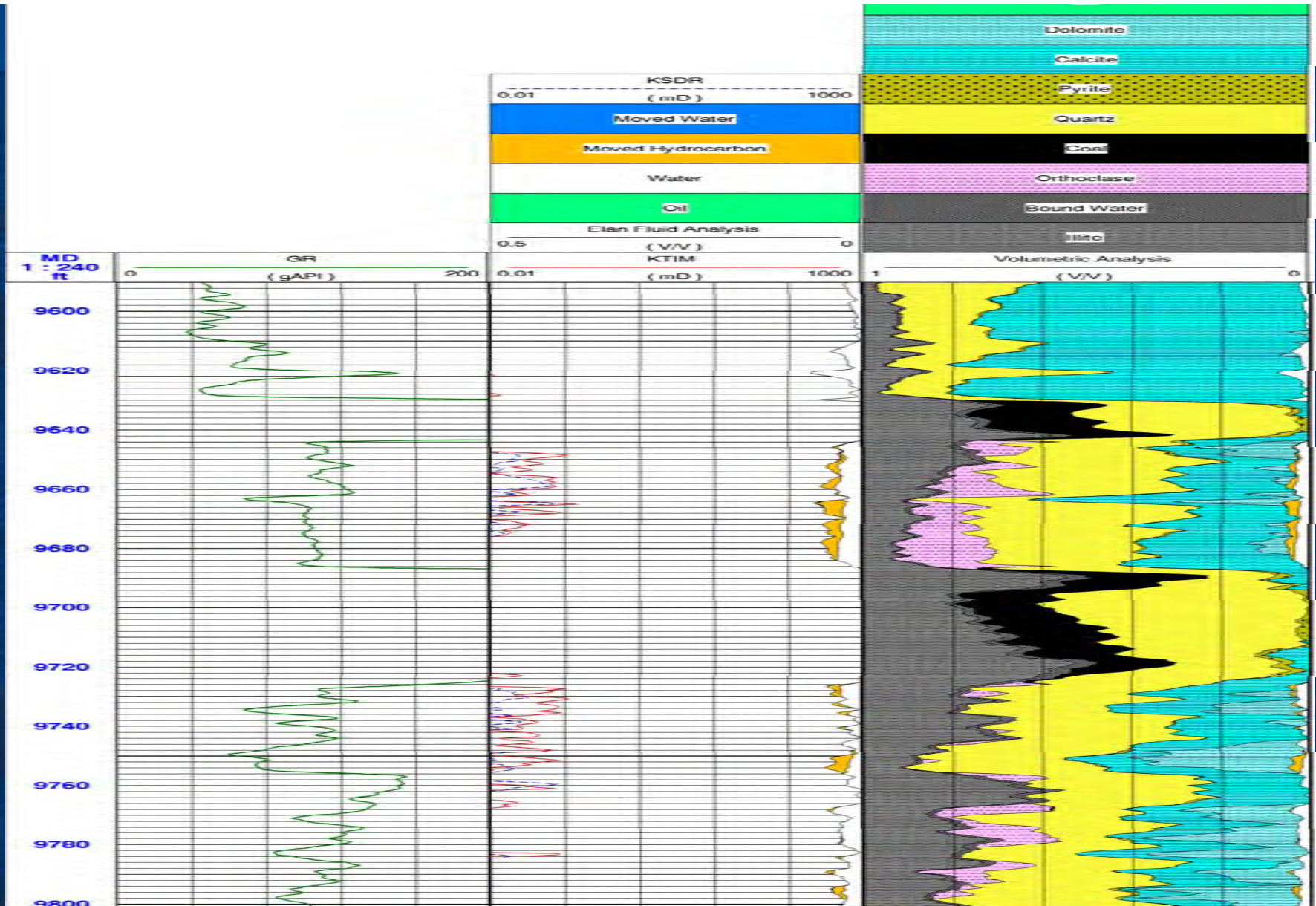
Other Released Bakken Log Data

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Conventional versus NMR Data



Petrophysical Analysis using Conventional Logs, NMR and Spectroscopy



Petrophysical Analysis using Conventional Logs, NMR and Spectroscopy



Reported Production from NDIC Oil & Gas

North Dakota

nd.gov Official Portal for North Dakota State Government

North Dakota LEGENDARY



- Related Links**
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- Field Production
- Get This Well File

Get Well Production History Data

Enter File Number:

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NDIC File No: **17096** API No: **33-061-00680-00-00** CTB No: **117096**
 Well Type: **OG** Well Status: **A** Status Date: **6/2/2008** Wellbore type: **Horizontal**
 Location: **NWNW 11-157-92** Footages: **500 FNL 500 FWL** Latitude: **48.4436094788015** Longitude: **-102.535538843644**
 Current Operator: **FIDELITY EXPLORATION & PRODUCTION COMPANY**
 Current Well Name: **FARHART 11-11H**
 Elevation(s): **2474 KB 2454 GL** Total Depth: **15336** Field: **COTTONWOOD**
 Spud Date(s): **3/14/2008**
 Casing String(s): **9.625" 2243' 7" 9943'**
 Completion Data
 Pool: **BAKKEN** Perfs: **9943-15336** Comp: **6/2/2008** Status: **AL** Date: **6/24/2008**
 Cumulative Production Data
 Pool: **BAKKEN** Cum Oil: **14197** Cum MCF Gas: **0** Cum Water: **11168** [Show Performance Curve](#)
 Production Test Data
 IP Test Date: **6/24/2008** Pool: **BAKKEN** IP Oil: **228** IP MCF: **168** IP Water: **214**

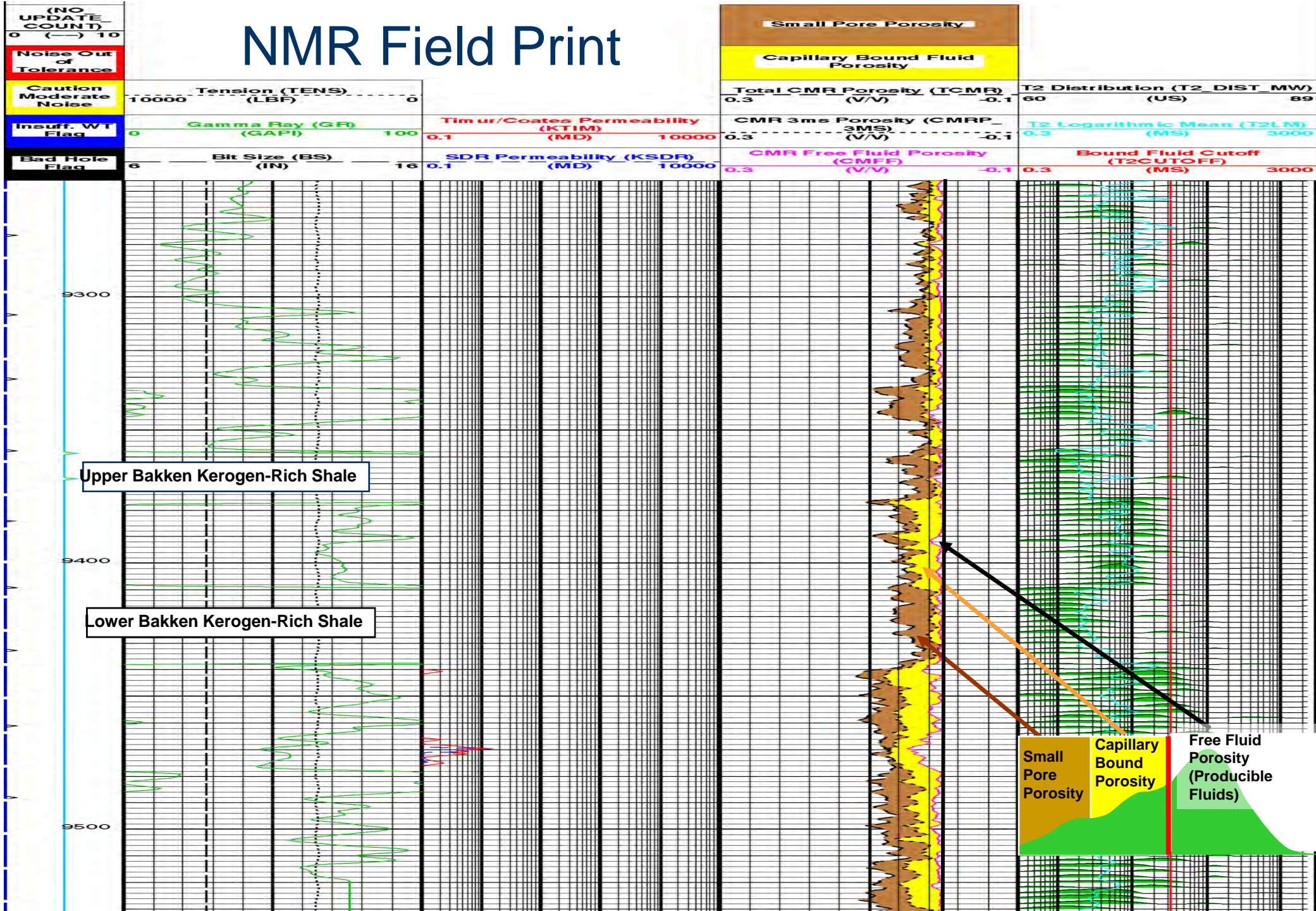
104 bbl/da
Oil

Pool	Date	Days	BBLs Oil	Runs	BBLs Water	MCF Prod	MCF Sold	Vent/Flare
BAKKEN	9-2008	30	2924	2785	612	0	0	0
BAKKEN	8-2008	15	1765	1626	1502	0	0	0
BAKKEN	7-2008	31	4671	5098	4218	0	0	0
BAKKEN	6-2008	19	4837	4180	4836	0	0	0



Another NMR Example

NMR Field Print

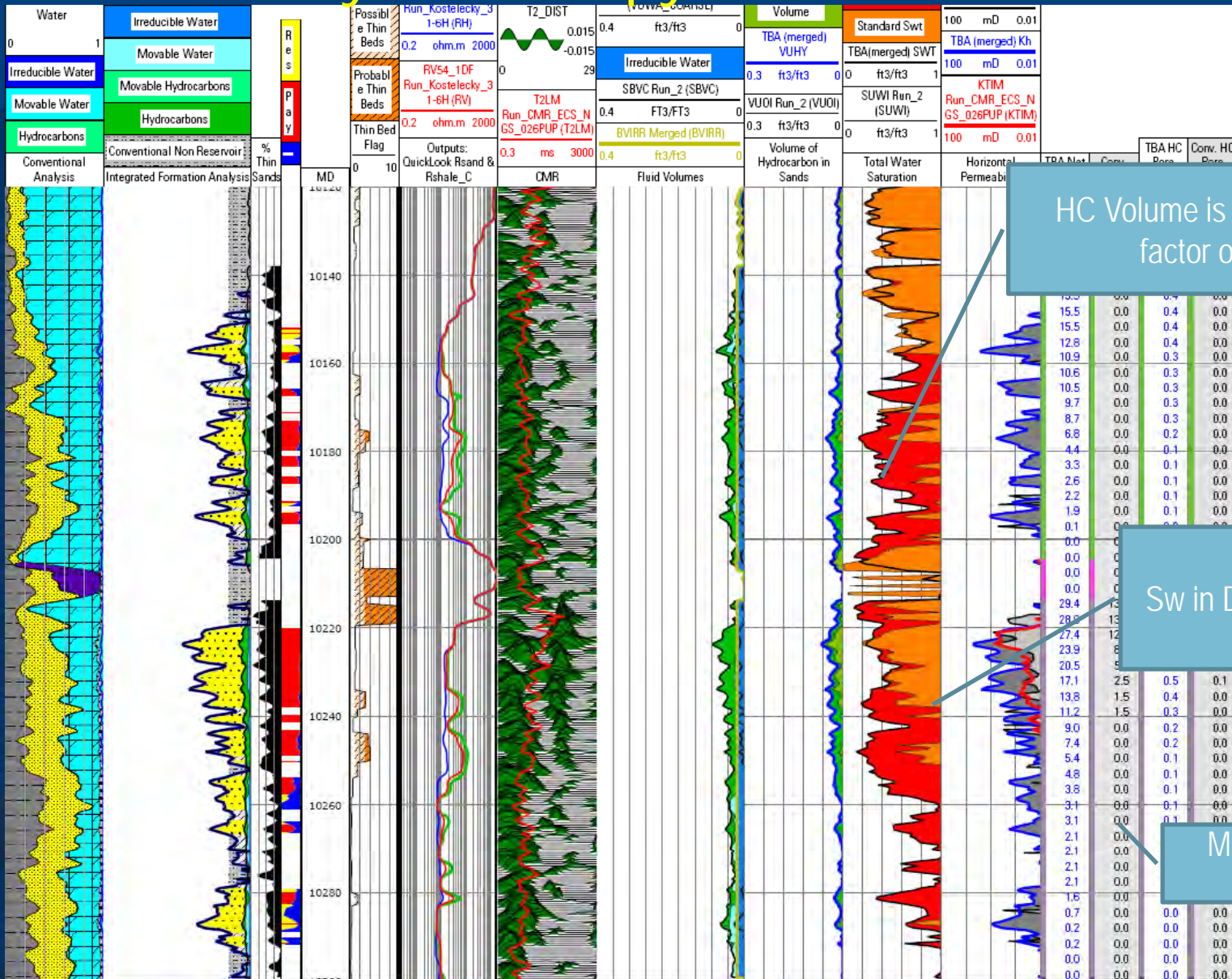


An offshore oil rig is visible in the distance on the right side of the image, set against a dark blue sky and sea. The rig consists of several tall, thin towers and a central platform.

- This well has no recorded production

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3-D Resistivity Anisotropy Evaluation



HC Volume is higher by factor of 2

Sw in Dolomite is 50% less

More accurate reservoir summation



Conclusions

- The Middle Bakken lithology is complex, requiring spectroscopy log data to accurately evaluate.
- The complex lithology complicates porosity evaluation from nuclear measurements, requiring NMR log data to accurately evaluate.
- Placing well laterals in zones of highest permeability results in faster drilling rates and better well production.
- Quartz and dolomite are associated with better porosity. Clay and limestone tend to kill porosity.
- NMR perm agrees with core.
- NMR free fluid porosity and permeability are predictive of well production.
- 3D Anisotropic Resistivity evaluation will help achieve a more accurate S_w which leads to a more accurate reserve estimate.



Thank you

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