



How to maximize the value of mature HC fields?

Workshop

Budapest, 18. November 2010.

Society of Petroleum Engineers

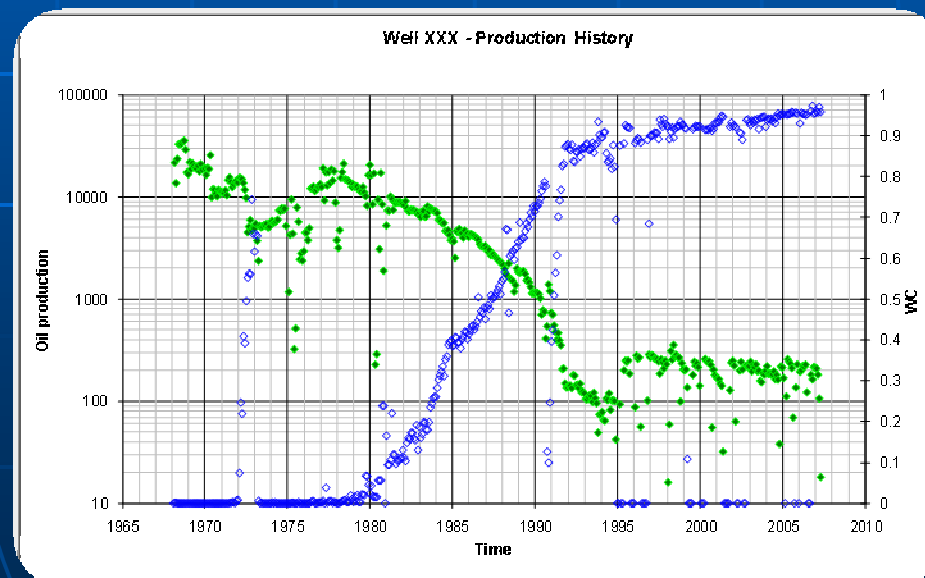


Getting the Most out of PNC & PNS Logs To Increase Production in Mature Fields

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Schlumberger

Getting the Most out of PNC & PNS Logs To Increase Production in Mature Fields

- Diagnose Existing Problems in Producing Wells
- Find Bypassed Hydrocarbons
- Remedial Actions



Petrophysical Evaluation Problems

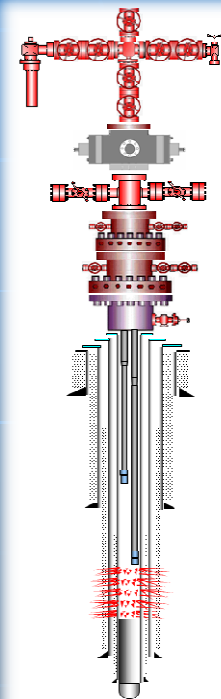
- Completions Restrictions (Tool OD)
- Behind-Casing Measurements
- Flowing or Shut in



Tubing Scale or Corrosion



Casing Condition

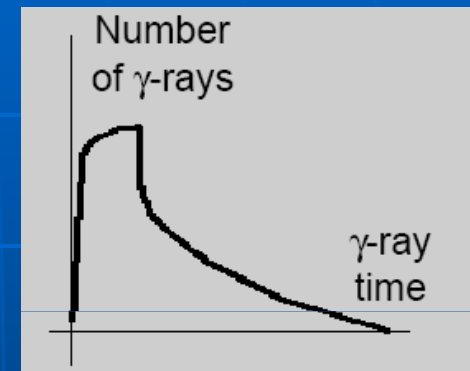


Completions Design

PNS Vs PNC

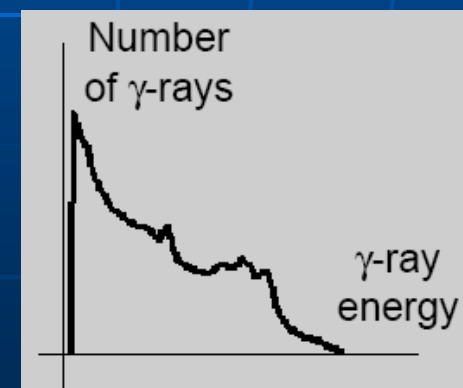
- Pulsed Neutron Capture
 - GR Count Vs time
 - Measuring macroscopic neutron cross section (Σ)

PNC



- Pulsed Neutron Spectroscopy
 - GR Count Vs Energy
 - For C/O Ratio
 - Spectroscopy

PNS



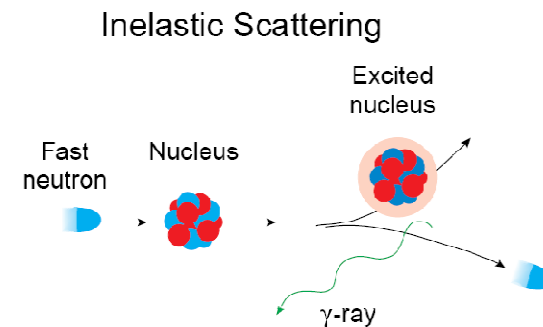
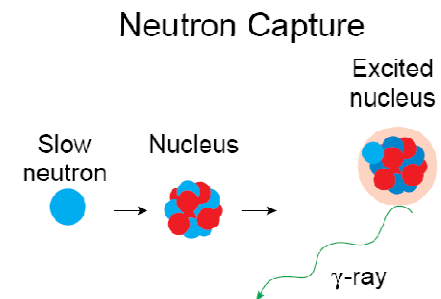
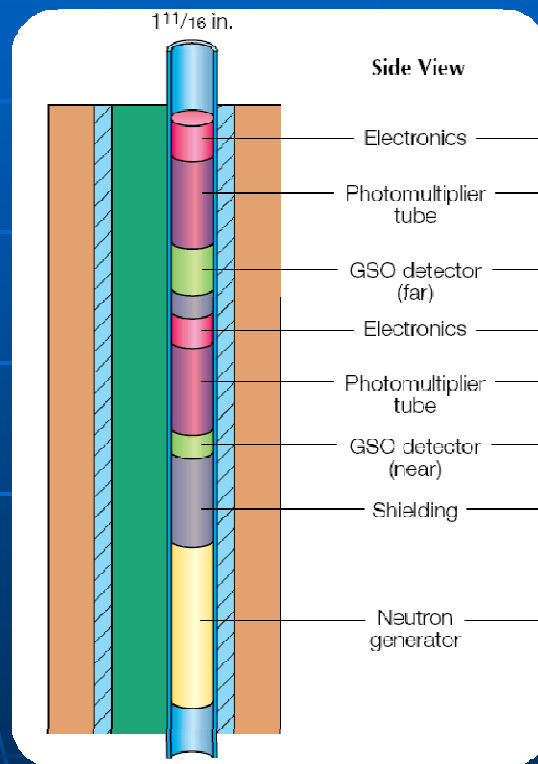
Applications in Mature Fields



Problem	Conditions	Solution
water saturation in depleted oil reservoir	Salty connate water	PNC logging
water saturation in depleted oil reservoir	Fresh water	PNS logging
Bypassed gas zone detection	Thin layers	PNC logging with WINR gas detection
Petrophysical evaluation in old field	Only resistivity-SP open hole logs available	PNS & PNC Spectrolith for lithology
Oil saturation	Gas cap	PNS and PNC
Current oil saturation	Water injection, variable water salinity	PNS and PNC
Water production	Flow behind casing	Water flow logging

PNC and PNS Diagnostics

RST Pro

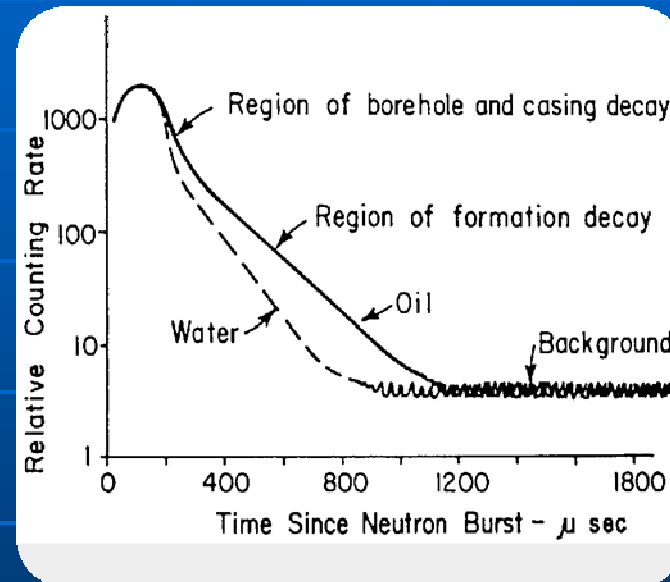


PNC Measurement

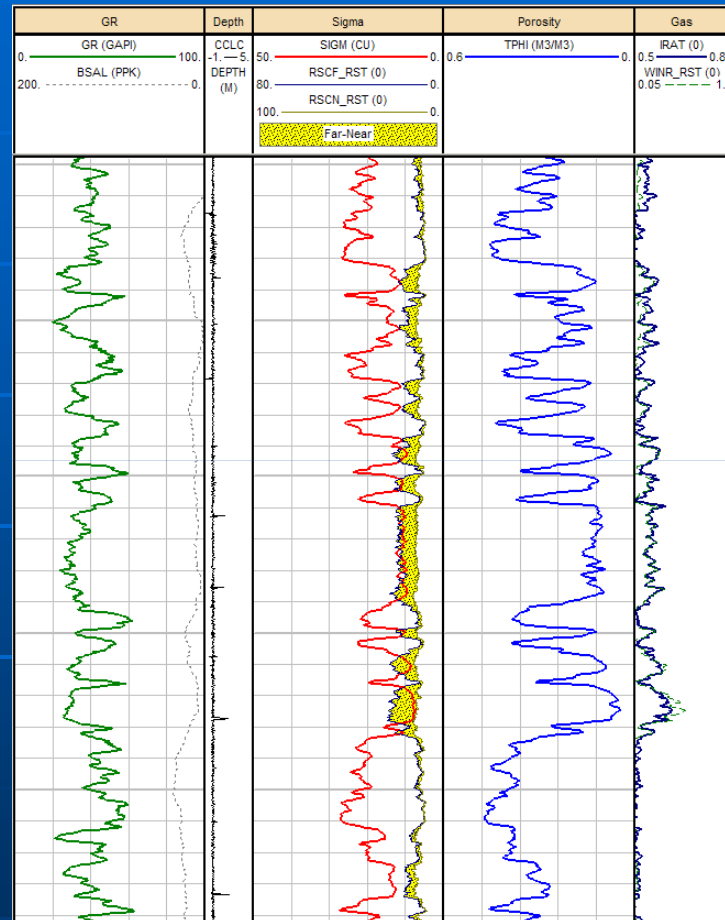
Sigma (Σ)

Porosity

Borehole
Salinity



Sigma Log



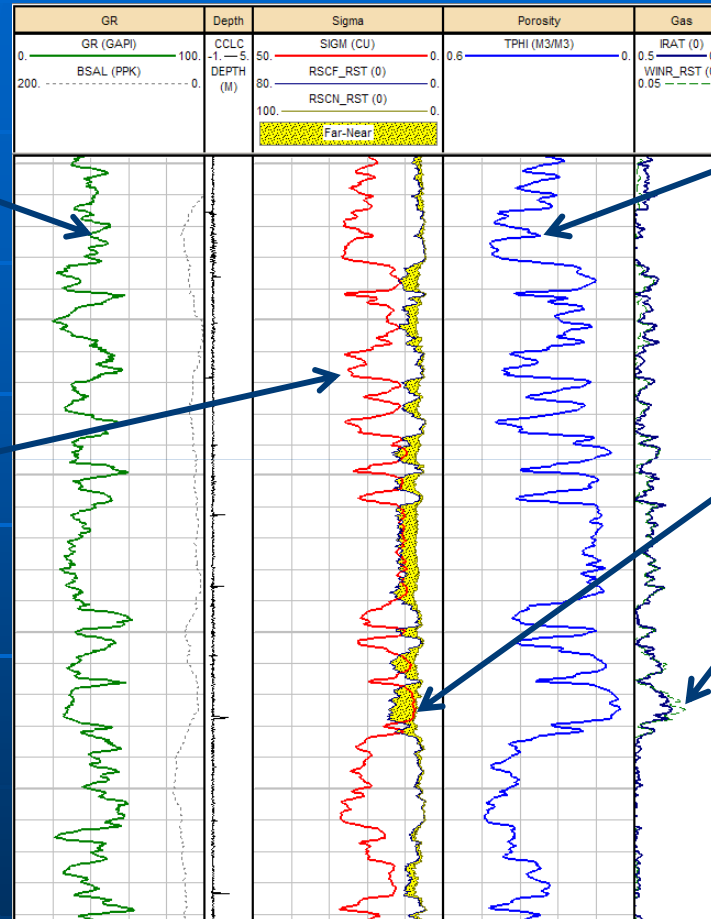
Sigma Log

GR
Correlation Shale
Volume

Sigma

Neutron Porosity

Gas Indication
Count Rates
IRAT
WINR



Problem

Bypassed gas zone detection

Conditions

Thin layers

Solution

PNC logging with WINR gas detection

GR
Correlation Shale
Volume

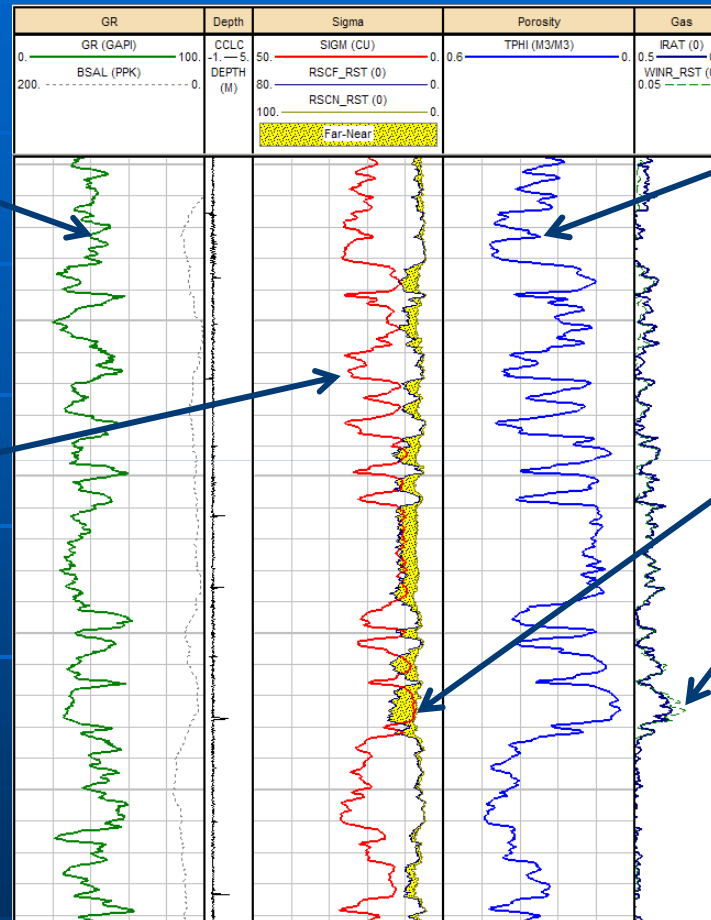
Sigma

Neutron Porosity

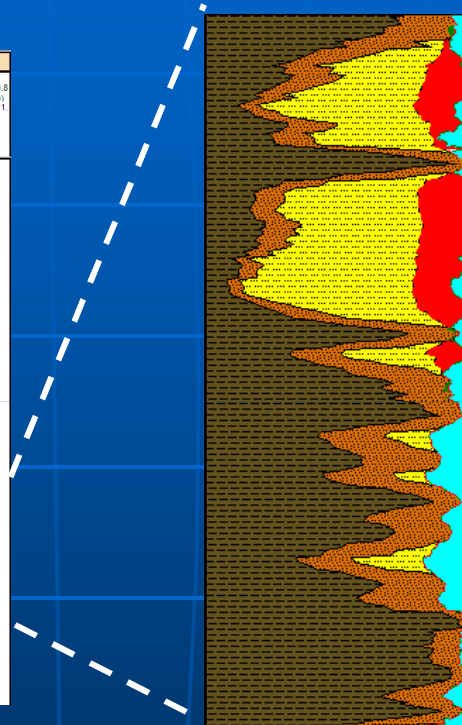
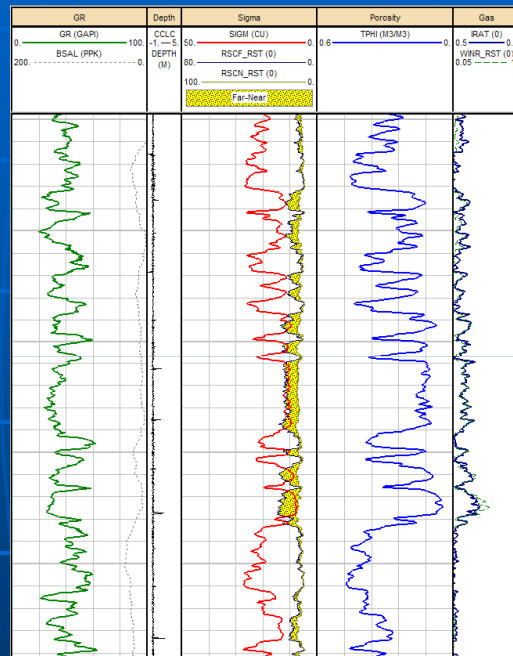
Gas Indication
Count Rates
IRAT
WINR

$$\Sigma_{log} = (\Sigma_{water} * \phi S_w) + (\Sigma_{hydrocarb} * \phi(1-S_w)) + (\Sigma_{matrix} * (1-\phi-V_{shale})) + (\Sigma_{shale} * V_{shale})$$

Water
Hydrocarbon
Matrix
Shale



Sigma Log



VOLUME

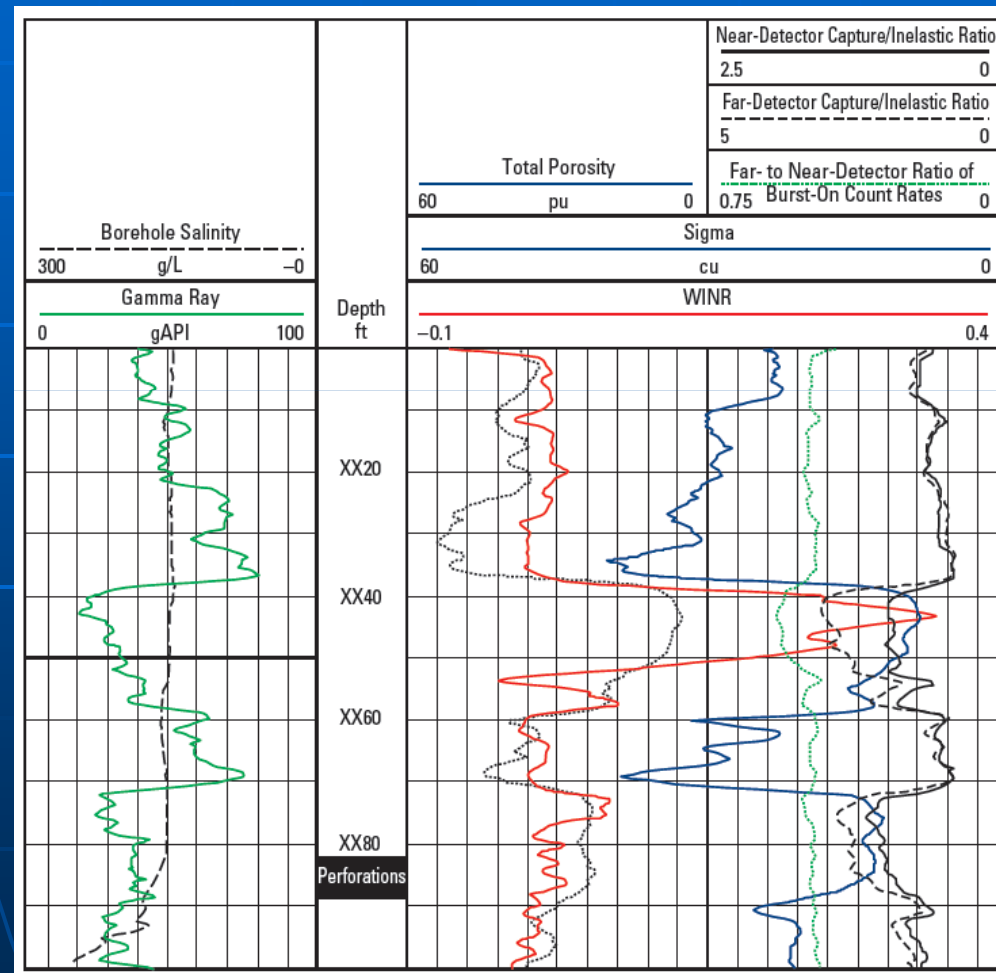
Gas
Oil
Water
Shale
Sandstone
Calcite

SIGMA (CU)

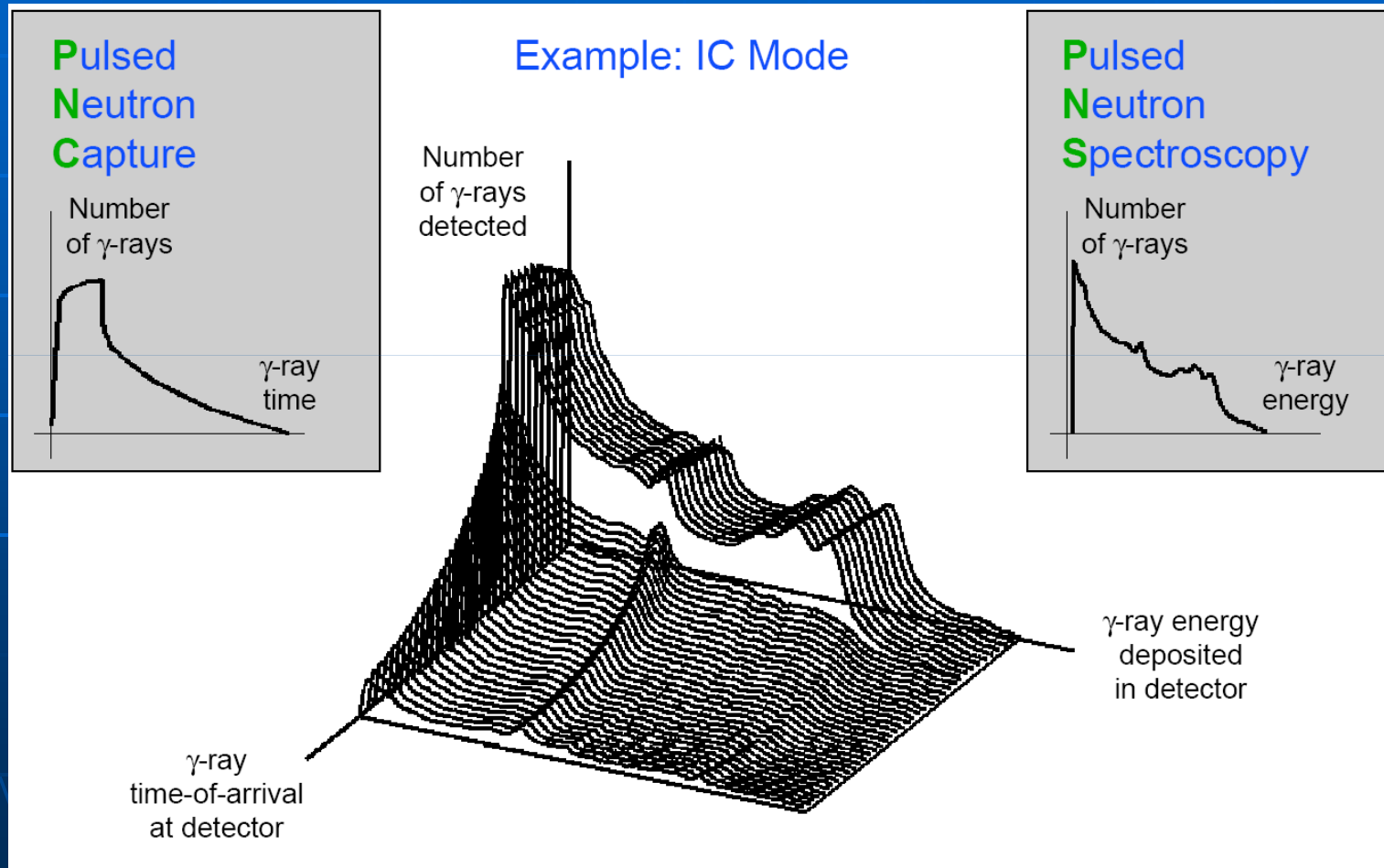
0-12
18-20
22-130 (fresh -> saline)
35-55
8-12
7.1

$$S_w = \frac{(\Sigma_{\log} - \Sigma_{ma}) - \phi(\Sigma_{hy} - \Sigma_{ma}) - V_{cl}(\Sigma_{cl} - \Sigma_{ma})}{\phi(\Sigma_{wa} - \Sigma_{hy})}$$

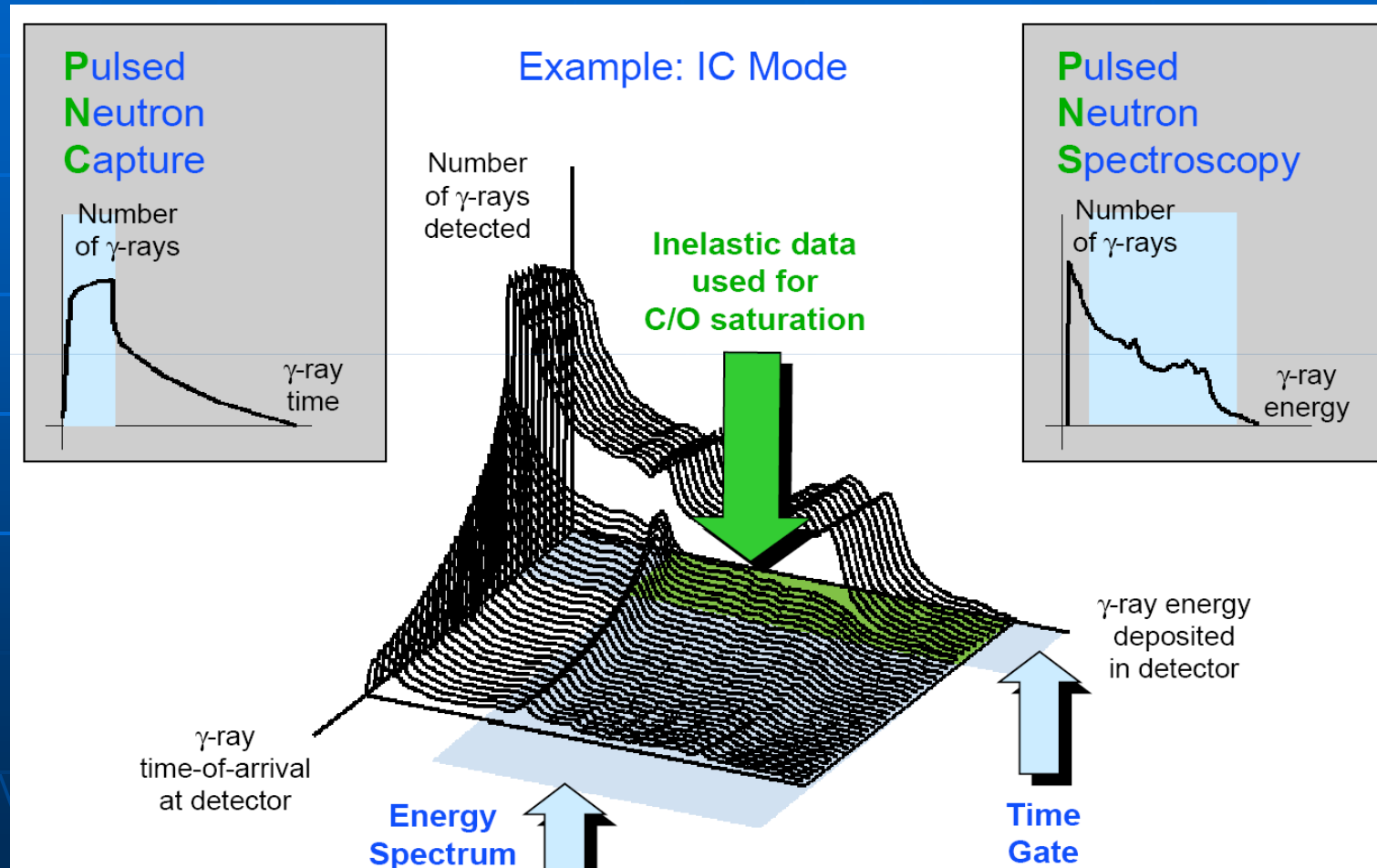
WINR Curve for Gas



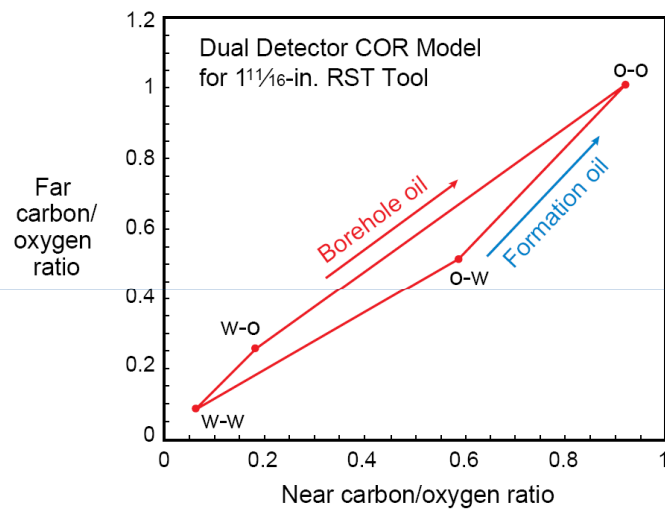
PNC Measurement



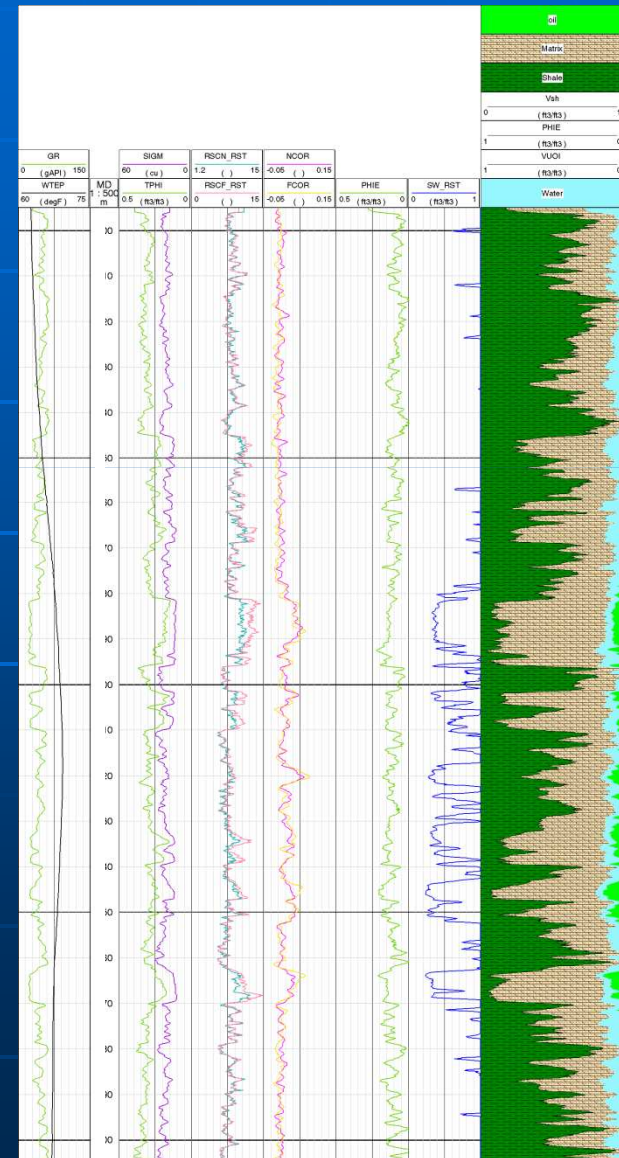
PNS Measurement – C/O



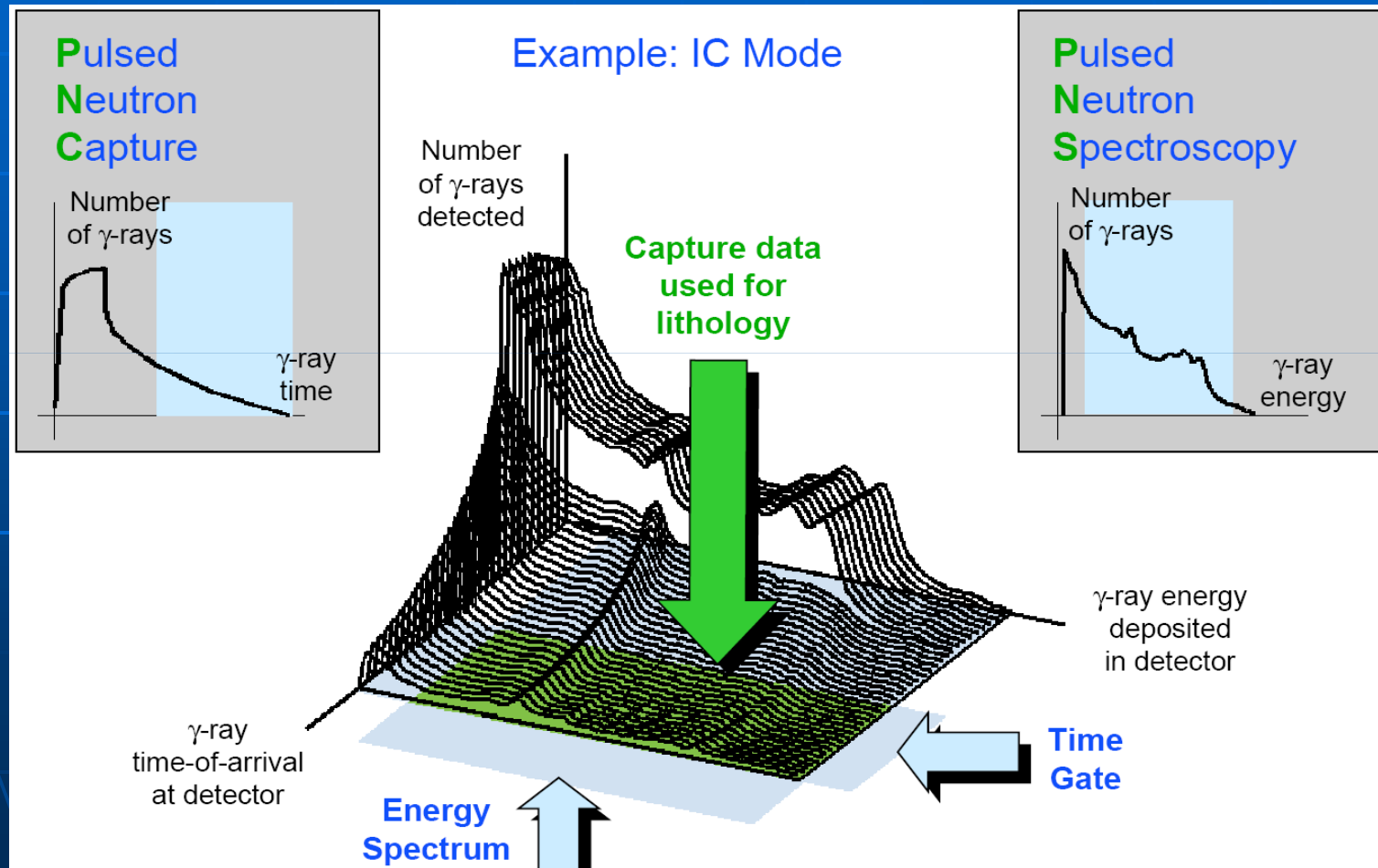
PNS Measurement – C/O



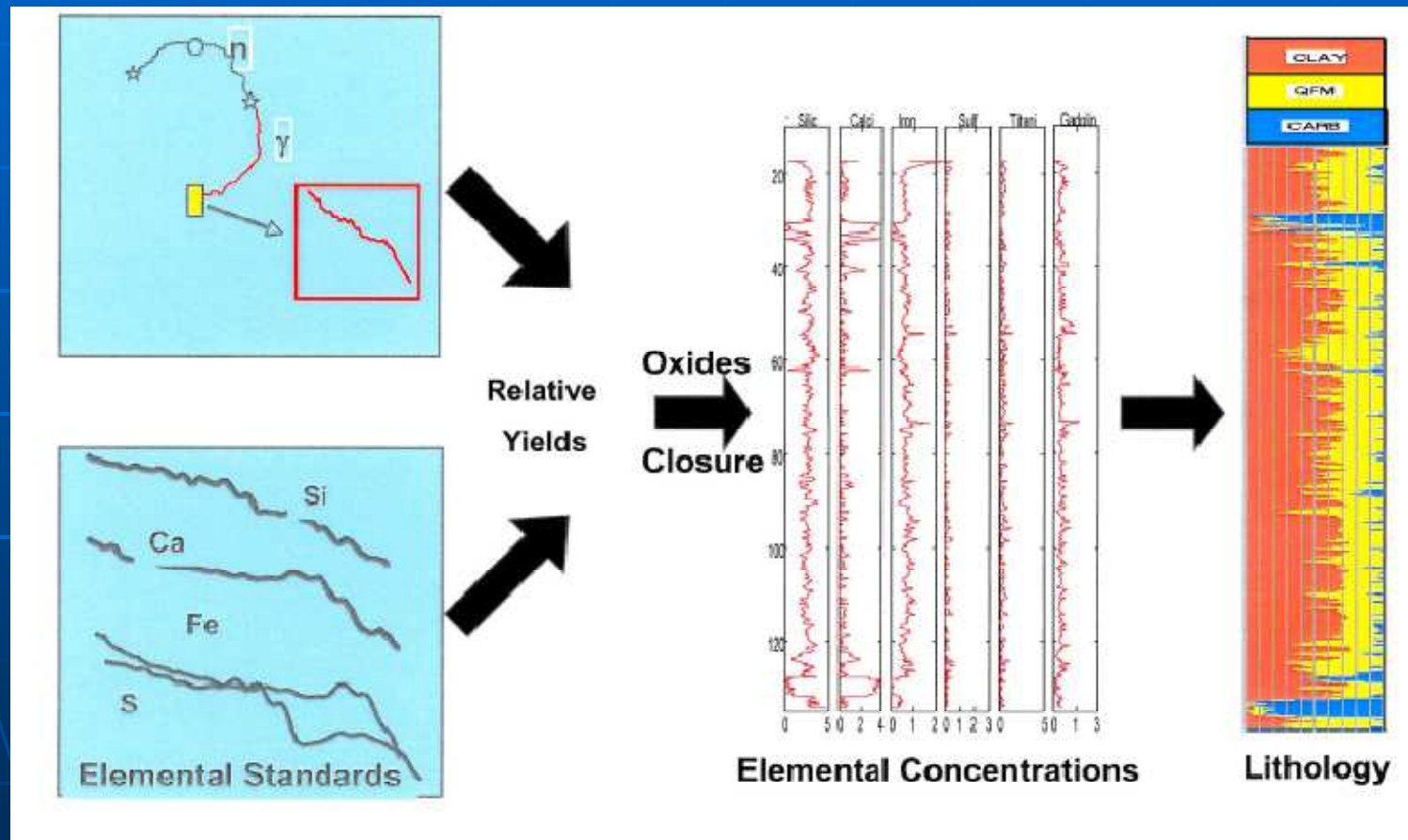
w-w:	water in borehole	water in formation
o-w:	oil in borehole	water in formation
o-o:	oil in borehole	oil in formation
w-o:	water in borehole	oil in formation



PNS Measurement – Spectrolith



PNS Spectrolith



Problem

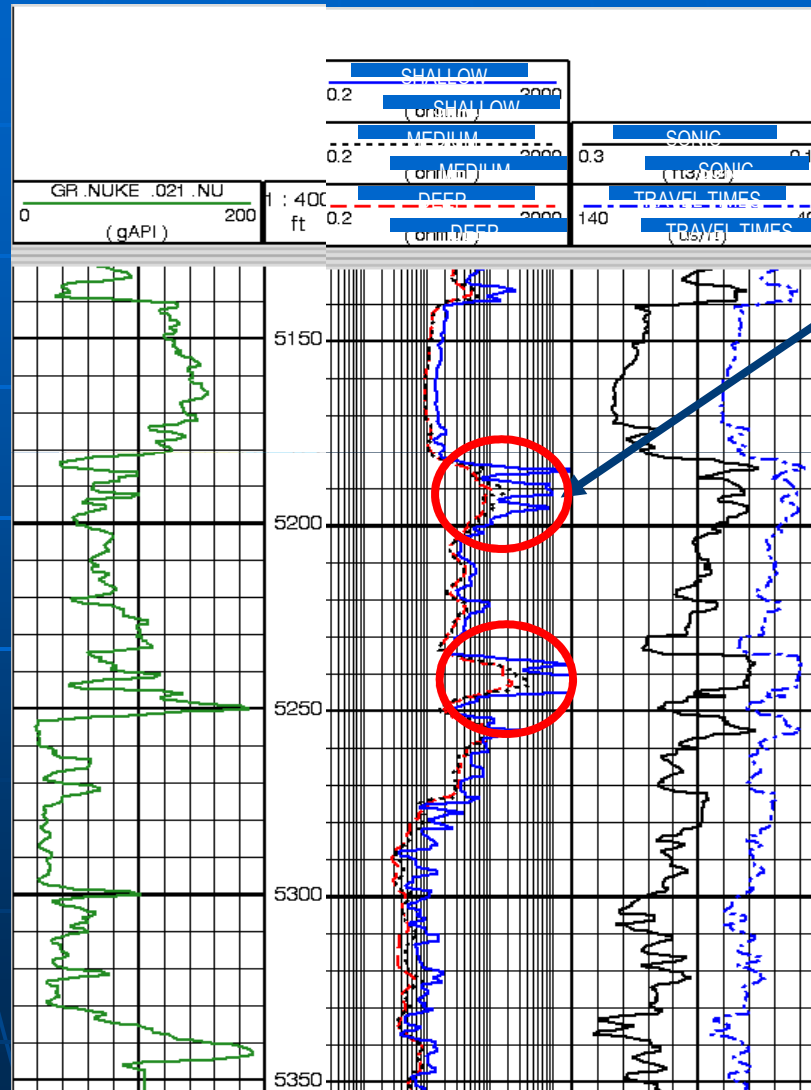
Petrophysical evaluation in old field

Conditions

Only resistivity-SP open hole logs available

Solution

Spectrolith for lithology determination



Are high resistivity intervals pay?

Problem

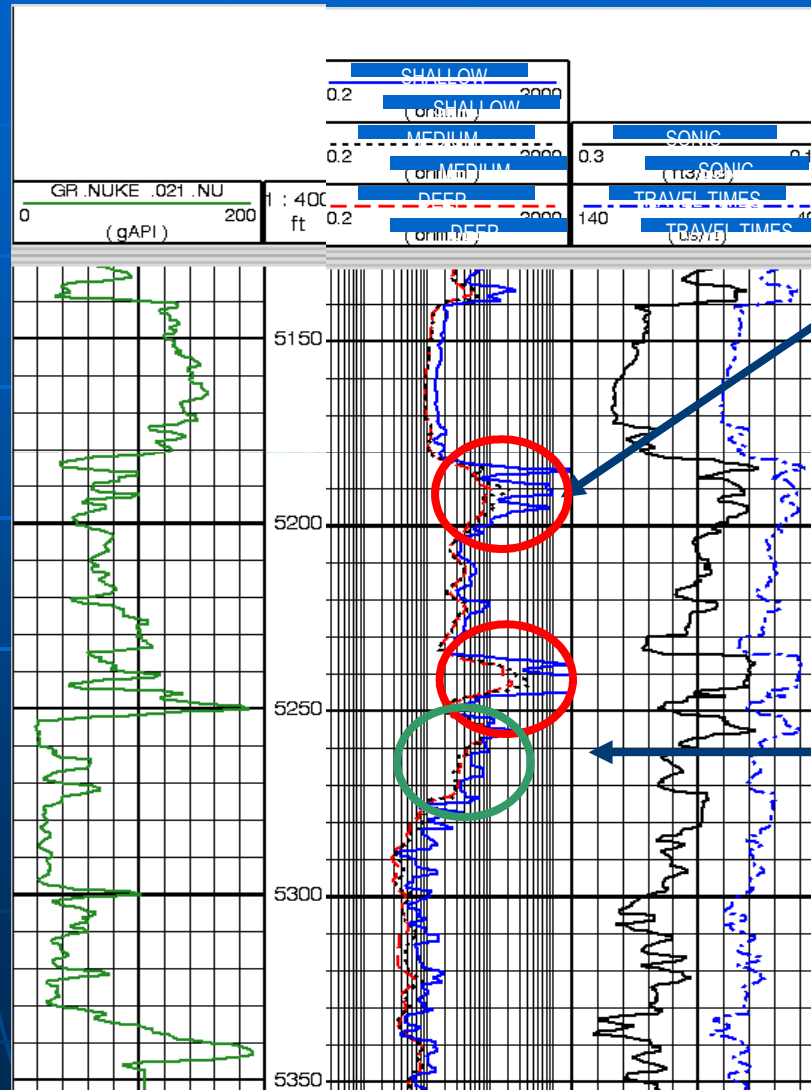
Petrophysical evaluation in old field

Conditions

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Solution

Spectrolith for lithology determination



Are high resistivity intervals pay?

Pay Zone?

Problem

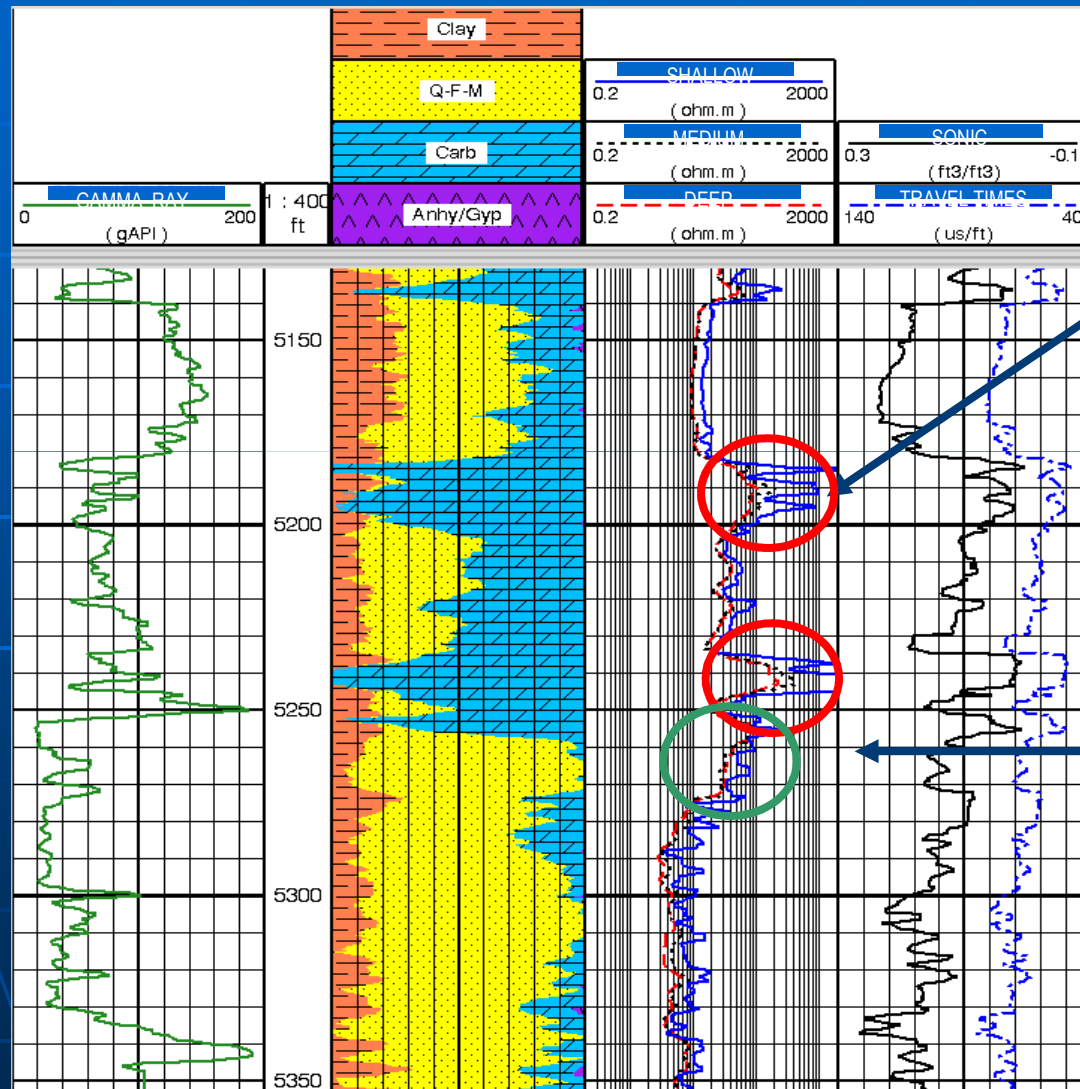
Petrophysical evaluation in old field

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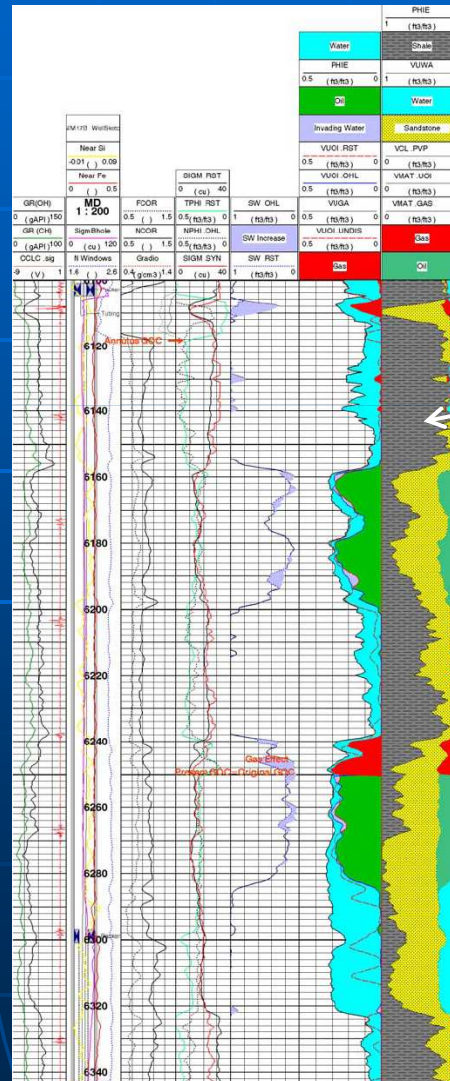
Are high resistivity intervals pay?
NO

Pay zone in sand?
YES

Oil saturation

Gas cap

PNS and PNC



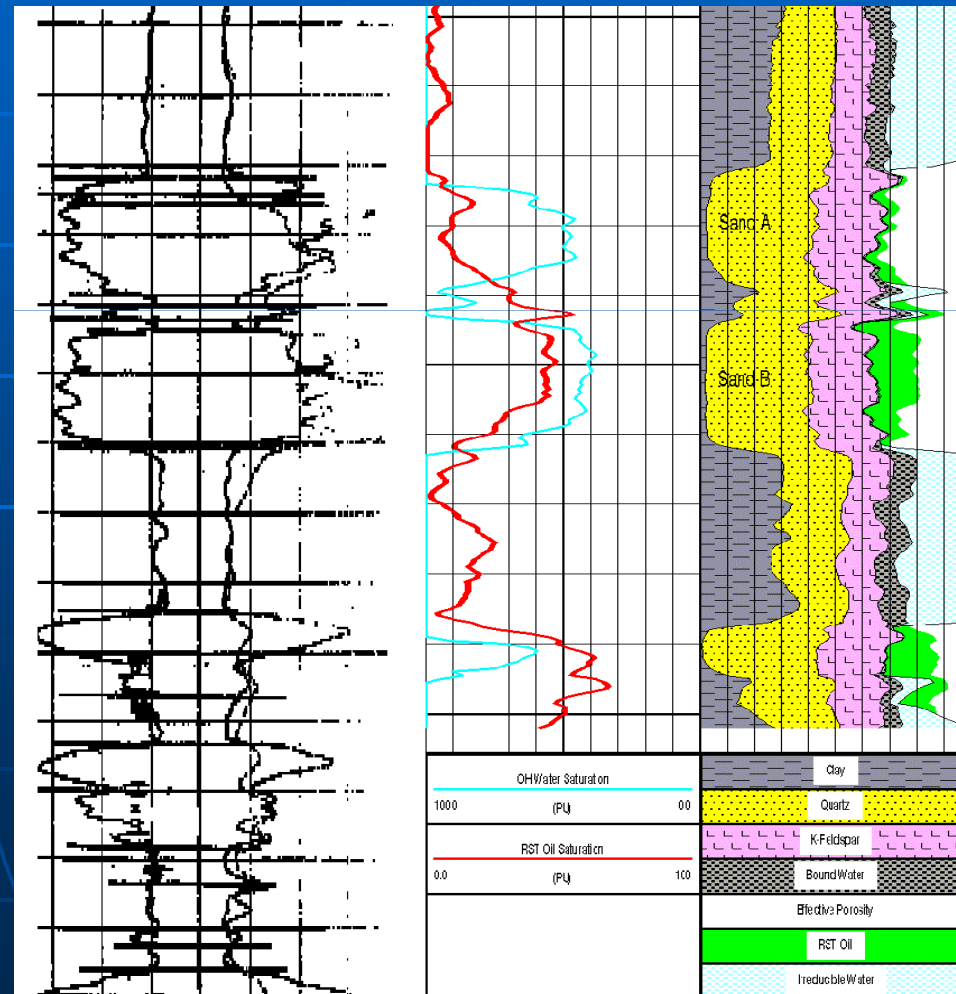
Lithology

Gas – Sigma

Oil – Sigma & C/O

Problem	Conditions	Solution
Petrophysical evaluation in old field	Only resistivity-SP open hole logs available	Spectrolith for lithology determination

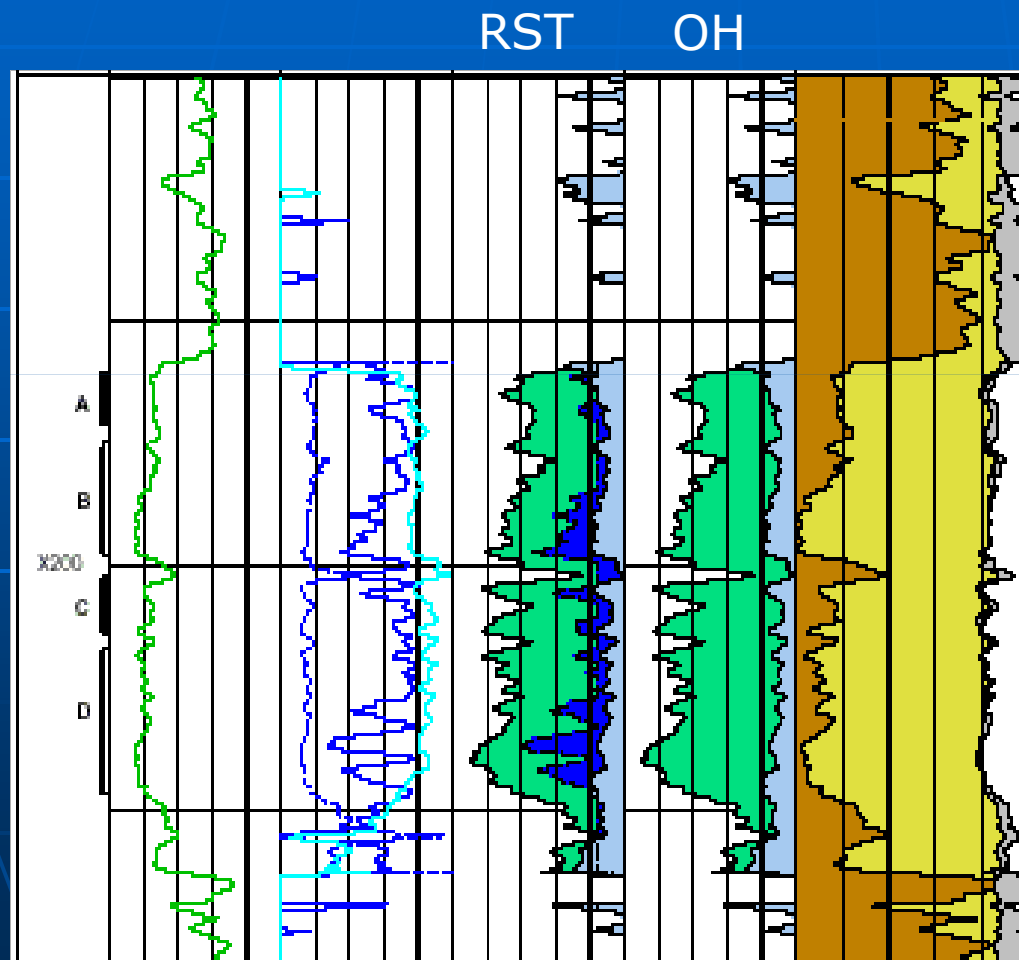
Old Logs



Depleted Layer

Unswept Oil

Problem	Conditions	Solution
Current oil saturation	Water injection, variable water salinity	PNC logging



- Water injection:
- Fingering of injected water drops initial production (300b/d)
 - Variable water salinity – C/O mode

Conclusion

- PNS and PNC measurements from RSTPro (Sigma, C/O, Spectrolith) are used to maximize the value of mature fields
- Diagnose existing problems
 - Water saturation in depleted oil reservoirs
 - Identify fluid contacts (water-oil-gas)
- Find bypassed hydrocarbons
 - Gas detection in thin zones
 - Remaining oil saturation
- Remedial actions
 - Water production behind casing
 - Quantitative petrophysical evaluation in old wells

Questions