Rock Physics Diagnostics for Porosity and Lithology Mapping in NE GOM

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Agenda

• Well log data & Rock Physics Diagnostics
• Up-scaling data and transform
• Influence of high impedance layers
• Porosity from up-scaled impedance & seismic
• Cumulative attributes
• Summary
Well Log Curves

interval shows shale and sand packages forming separate trends in the impedance-porosity cross plot
Well Log Curves - Shale

linking depth intervals to domains in cross-plot helps identify rock physics trends
Well Log Curves – Wet Sand

- upper wet sands generally blocky
- pay sand fining upwards
 impedance-porosity trend in pay sand different to trend in wet sand
the influence of calcite streaks on seismic response is examined later
Impedance v Total Porosity

brine substituted saturation

uncemented sand model curves 0, 25, 50, and 75% clay

original saturation color shows where pay sands map

this “common fluid denominator” process concentrates on lithology and porosity effects.

data contained within 0 – 75 % clay.

uncemented sand model curve for 10% clay

in-situ saturation
Measured & Modeled Sonic Data

computed from uncemented sand model

comparison indicates suitability of the transform
Measured & Modeled Porosity

- confirms suitability of using this model to predict porosity from impedance.
- also used to predict Poisson’s Ratio (not available this well).
  - $PR_{paysand} = 0.13$
  - $PR_{wetsand} = 0.28$
  - $PR_{shale} = 0.35$

Uncemented sand model provides average impedance to porosity transform –
best fit model of form

$$\phi = a.Ip^2 + b.Ip + c$$
Synthetic Seismic – 50Hz Ricker

AVO Class I
pay sand

pay zone

Pseudo Impedance & Poisson’s Ratio

Angle Stack

Ip PR RIp RPR
Can the impedance-porosity transform be used at seismic scale?
Up-scaled Porosity, Impedance & Poisson’s Ratio

Backus up-scaling
log scale details are suppressed at seismic scale

up-scaled curves
Porosity v Impedance – Various Scales

- Log scale porosity v log scale impedance
- Log scale porosity versus up-scaled impedance
- Up-scaled porosity versus up-scaled impedance
- Best fit model – site specific

Upscale trend generally follows the original trend – slight porosity over estimate.
Influence of High Impedance Layers

Calcite streaks influence on up-scaled impedance is small.
Synthetic with High Impedance

[Graphs showing various parameters such as Angle, Stack, Ip, PR, RlP, and RPR over time.]
**Synthetic without High Impedance**

Small changes in synthetic reflections confirms prior observation.
Porosity from Up-scaled Impedance

up-scaled porosity and porosity estimated from up-scaled impedance are quite similar

up-scaled porosity

porosity from up-scaled impedance

Log Porosity

Sw

Depth

Porosity

Depth
Porosity from Seismic Inversion

minimum PR strip aligns with reservoir
maximum Ip is slightly below reservoir
porosity in the reservoir estimated using transform for sand with hydrocarbon
3D Fluid & Porosity Mapping

Impedance Volume

Poisson’s Ratio Volume

Porosity Volume

transform applied volumetrically to samples selected by low Poisson’s Ratio
Cumulative Porosity v Depth

- Cumulative Porosity gives pore volume estimate for pay sand only.
- Cumulative log scale and up-scaled porosity curves are very similar, implying seismic derived cumulative porosity and log scale cumulative porosity are very similar.
one possible cumulative attribute is the cumulative impedance in the pay zone
another is the cumulative inverse impedance

new type of seismic attribute – CATT – cumulative attribute
have to use a different attribute to delineate application zone
have to calibrate cumulative inverse impedance to cumulative porosity
Summary

- Rock Physics Diagnostics establishes a local effective medium model suitable for transforming elastic properties to rock properties.
- The effective medium model allows perturbation of rock properties to predict elastic response away from the well.
- A model established using log scale data has to be up-scaled to seismic scale before application to seismic elastic attributes.
- Introduced a new type of attribute – the cumulative attribute used to estimate volumetric reservoir porosity.
an alternative to Seismic Reservoir Characterization