MOTIVATION

Larger volume 3D surveys

Smaller volume prospective opportunities

Selection time pressure ... etc ...

all conspire to make prospect exploration success more difficult to attain.

Seismic Data Mining offers a robust, rapid and exhaustive tool to scan seismic volumes for features that lead to rating and ranking of a wide range of prospective opportunities.

We review RESERVOIR PROPERTY data mining.
Data Mining Workflows

- Seismic Sub-stacks
- AVO Inversion
- Interface Rp & G
- KSOM Clustering
- AVO Data Mining
- Pay, Wet Classes
- Lithology Mining
- Sand Lithology
- Sand Porosity
- Sand Fluid
- Interval RZp & RZs
Impedance – both compressional and shear - are common data types used to hi grade prospective opportunities, however visualizing their mutual response is not always straightforward.

Well studies often indicate separation of sands (pay and wet) from encasing rock (shale) in a given formation.

Firstly, the seismic volume is mined to highlight the location of sand bodies (carbonates may also be mined).

Progressive mining for porosity and fluid is performed only on the sand bodies.

We call this process Reservoir Properties Mining.
WORKFLOW

Perform AVO inversion to generate relative Zp, Zs (RZp, RZs).

Establish slope trend between Zs & Zp.

Compute RMS of Zp and of RZp.

Apply scalars and constants to simulate generation of derivative attributes \( \rightarrow \) pseudo absolute attributes.

Generate PC1 & PC2 from pseudo absolute Zp & Zs.

Generate LR, MR, RHOKS and RATIO from pseudo absolute Zp and Zs.
Relative Zp and Zs generated from absolute Zp and Zs by subtracting constants
WELL #1 – PC1 & PC2 Attributes

PC1 & PC2 generated from relative Zp and Zs using local trend

Well log data courtesy of Anadarko Petroleum
Well #1 - Impedances

Absolute Zp, Zs – deterministic sand and shale trends in orange and brown.

Relative domain – blue local trend used to rotate data.

Discrimination of hydrocarbon sand, wet sand and shale maintained in relative domain.
Well #1 – Lithology Discriminators

PC2 attribute discriminates oil sand and wet sand from shale.

Pseudo absolute attributes generated from relative impedances with scalars and constants applied.

Lambda-rho provides similar discrimination to PC2 $\rightarrow$ Lambda-rho functions as a lithology discriminator.

Mu-rho struggles to discriminate lithology.
RPC1 and RZp very similar response.

Rho.Ks (product bulk modulus & density) shows better defined relationship with porosity.
Pseudo Absolute Lambda-rho discriminates oil sand from wet sand.

Ratio (AZs/AZp) also discriminates fluid type.
**Attribute Recommendation**

Lithology Discriminator – PC2  
Fluid Discriminator – RATIO (Zs/Zp)  
Porosity Discriminator – Rho.Ks

**Strategy**

Visualize individual attributes.  
Combine multi-attribute response by Kohonen neural network classification.
Lithology Indicator (RPC2)

Seismic data courtesy of TGS
Lithology Indicator (Lambda.Rho)

Lambda-Rho computed from pseudo absolute Zp and Zs (formed from the relative attributes).

Seismic data courtesy of TGS
Porosity Indicator (Rho.Ks)

Seismic data courtesy of TGS
Porosity Indicator (RPC1)

Seismic data courtesy of TGS
Fluid Type Indicator (Zs/Zp)

Seismic data courtesy of TGS
Anomalous Absorption – Full Stack

Seismic data courtesy of TGS
The BLI produces a higher resolution result than RAI. There appears to be more variation in the AVO Zp impedance. All three attributes tell a similar story.
Lambda-rho was the attribute used to generate the surface. Note large minimum ridge running up from well #6 – follows neither strike nor dip of surface – not imaged down to well #6 in the anomalous absorption image.

Possible OWC delineation shown below well #3.

The absorption anomaly shown here is down dip from the upper gas sand – is this low gas saturation?
Porosity, Fluid Indicators

Both RhoKs and the Ratio show zones down dip from well #2ST1 and #6. Will these zones be drained by these wells?
The zone down from well #6 appears disassociated by a small fault – is this preventing connectivity?
Seismic Data Mining Conclusions

PC2 works well as a lithology attribute – discriminating sand from shale – and is AVO Class insensitive.

RhoKs appears to be superior to PC1 as a porosity discriminator.

Ratio works as a fluid discriminator – as Poisson’s Ratio does.

The absorption attribute targets the gas saturation – and assists in the discrimination when used in conjunction with the impedance derivative attributes.

Seismic data mining provides a focusing tool allowing rapid and accurate assessment of prospectivity without the time and expense of performing more exacting technologies – which can be applied to prospective regions identified by seismic data mining.

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an alternative to Seismic Reservoir Characterization