ELASTIC IMPEDANCE INVERSION FOR RESERVOIR DELINEATION
– A QUANTITATIVE INTERPRETATION CASE STUDY IN THE MALAY BASIN

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This case study focuses on development well targeting using the methodology of elastic impedance inversion to identify effective seismic attributes for delineating thin gas sands formed in a tidal environment with massive coal-beds.

The study area is located in the Malaysia-Thailand Joint Development Area (MTJDA) to the north of the Malay Basin. The reservoir sands, statistically are less than 10 meters and inter-bedded with coals (Fig-1). Seismically, the reservoir sands are below seismic tuning thickness resolution and strong coal reflections interfere with the conventional post-stack seismic data.

A comprehensive workflow based on pre-stack elastic impedance inversion was developed to address the aforementioned effects and gain more value from the seismic data. The workflow includes three key steps: modeling, processing and interpretation.

1) Modelining - Rockphysics and seismic modeling, to understand the reservoir behavior and seismic response

Based on rockphysics and seismic modeling (Fig-1), Vp/Vs related seismic attributes (i.e. Poisson's Ratio) are effective for discriminating gas-sand from coal reflections. Using conventional Amplitude Variation with Offset (AVO) attribute based on seismic reflectivity to interpret thin reservoirs inter-bedded with coals is difficult. Relative Poisson's Ratio (RPR) based on Elastic Impedance (EI) inversion is potentially the most effective attribute (Fig-2).

2) Processing - Pre-stack seismic data conditioning and elastic impedance inversion, to generate effective "AVO" attributes. Data conditioning processes include:

- Unload terabyte pre-stack seismic Normal Move-out (NMO) gathers from tapes to super-gathers for enhancing the signal-to-noise (S/N) ratio;
- Transform super-gathers into angle-gathers for true Amplitude Variation with Angle (AVA) processing;
- Band pass filtering to mitigate noise;
- Trim static to align seismic events; and
- Offset scaling to balance the amplitude.

Fig-3 demonstrates the improvement of data quality.

Elastic impedance inversion utilizing the colored inversion methodology (Blache-Fraser, 2004) gives good performance and uses the conditioned pre-stack data as input. Fig-4 shows the dramatically improved seismic resolution and interpretability of elastic impedance inversion stack (i.e. dominant frequency increased from 35 to 60 Hz).

Based on elastic impedance gathers, conventional AVO technology is adopted to generate post-stack attribute volumes. The attributes include Relative Acoustic Impedance (RAI, AVO Intercept, Fig-4b), Gradient Impedance (GI, AVO gradient), Relative Shear Impedance (RSI) and Relative Poisson's Ratio (RPR, Fig-5) etc.
3) Interpretation - Reservoir interpretation and attribute mapping

Using the elastic inversion results, 38 reservoir horizons were interpreted with volume tracking based on stratal-slices. Horizon attribute maps were extracted using 12 ms window length for reservoir delineation and property prediction. Fig-6a reveals the gas sand distribution using Relative Poisson's Ratio attribute. Fig-6b shows the correlation between RPR attribute and water saturation of 0.65.

The main conclusions from this case study are:

- Post-stack seismic attribute indicates strong coal reflections instead of gas sands
- Poisson's Ratio is an effective attribute for discriminating gas sands from coal beds
- Seismic data quality can be improved by conditioning pre-stack gathers
- Elastic inversion can improve seismic resolution and interpretability;
- Detail reservoir delineation is feasible by using elastic inversion technology

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Reference:

Gregory Blache-Fraser etc. BP, Increasing seismic resolution using spectral blueing and colored inversion: Cannonball field, Trinidad, SEG Technical Program Expanded Abstracts -- 2004 -- pp. 1794-1797

a) Average reservoir thickness about 3 meters

b) Vp/Vs of gas-sand is the lowest at each zone

Fig-1 Statistics grouped by reservoir zones, showing thin gas sands can be discriminated from others using Vp/Vs ratio
Fig-2 Seismic modeling showing Poisson’s Ratio is an effective attribute to identify thin-gas-sands

Fig-3 Pre-stack seismic data conditioning and elastic inversion

a) Angle gathers before conditioning  

b) Angle gathers after elastic inversion
Fig-4 Data conditioning and elastic inversion improve seismic resolution, S/N ratio and interpretability.

Fig-5 Detailed reservoir interpretation with RPR reveals gas-sands and mitigates coal beds.

Fig-6 RPR attribute map and reservoir property Sw prediction, correlation at 0.65.