Poster 14

BOREHOLE IMAGES AND VSPS AS AID TO ATTRIBUTE AND INVERSION ANALYSIS

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Borehole images have inherent information on sedimentary structure and lithofacies that are typically used qualitatively. There are ways of unlocking this potential by doing a comprehensive facies analysis and obtaining quantitative outputs with new applications like neural network or multivariate histogram techniques. However even with these approaches the high-resolution quantitative facies data is still only at the borehole, capturing near-wellbore characteristics which are difficult to translate and propagate into the interwell space. Needed at this critical barrier, is a tool to tie-in high-resolution borehole image and log derived facies with something that will also have a correlation with attributes that characterize the interwell and 3D-space. We test rock-physics attributes like acoustic impedance and Poisson's-ratio and attributes generated from vertical seismic profiles (VSP) as being the likely links between high-resolution near-borehole information and interwell/3D space represented by seismic data.

Borehole seismic data in logs and VSPs capture seismic reflection and rock-physics characteristics at a high-resolution and VSPs have a higher frequency content than 3D seismic. These datasets (rock-physics and VSPs) may have a bearing on the lithofacies contrasts seen at the borehole, at a higher-resolution than 3D seismic. However VSPs and rock-physics approaches are typically underutilized for facies analysis and only used for checkshot time-depth conversions, velocity modeling and as calibration for AVO inversion.

This paper addresses the feasibility in an actual dataset, to correlate and test whether facies driven contrasts from the borehole have any response in rock-physics and VSP data. If this is possible then the propagation of image-derived near core-like high-resolution facies, across domains (quantitatively between geology to geophysics) may be possible. This by way of using the geophysical data as the initial tie-in point with borehole image facies that enables cross-domain collaboration whereby lithofacies information from the borehole can be propagated into 3D seismic, albeit at a coarse scale.

In this case-study on the West Belumut-3 well from Newfield in Peninsular Malaysia, facies analysis was performed using a neural network approach. The inputs were density, neutron, gamma-ray and lamination density (a textural attribute log derived

Warta Geologi (Newsletter of the Geological Society of Malaysia), Vol. 34, No. 1, January-February 2008

Petroleum Geology Conference and Exhibition 2008

14th – 15th January 2008 • Kuala Lumpur Convention Center, Kuala Lumpur, Malaysia

from the FMI) which was trained to estimate the four lithofacies (Figure 1): massive thick-bedded sandstone; sandy heterolithics; shaly heterolithics; and massive shale.

The lithofacies represents a braided channel fluvial system in the lower reaches of the borehole below the K-20 marker. The intermediate interval, between the J-15 and K-20 markers (Middle J and Upper K Group), represent a shallow marine shoreface/sub-tidal bar environment. The upper interval above the J-15 marker (Upper J Group) represents a lower coastal-plain predominantly comprising of tidal flats. This depositional facies trend shows a progressively lower net:gross trend captured in the lithofacies, from bottom to top.

The VSPs inherently have a higher frequency content (around 100-120 Hertz) than the corresponding seismic data. In this case the acoustic impedance and poisson's ratio in association with the migrated zero-phase vsp trace displayed a secular trend that matched very well with the the progressively lower net:gross upsection.

The geological facies derived from log data (GR, TNPH, RHOZ and Lamination Density) can be predicted with high confidence (corr. coeff: 0.80) by combining rock physic properties i.e. acoustic impedance (AI) and poisson's ratio. Cross-plotting of AI versus Poisson's ratio overlaid with color-coded lithofacies reveals well defined facies clusters (Figure 2). The two intermediate classes being heterolithics, has some overlap in attribute space. This suggests that lithofacies as defined in this well, can be predicted from geophysically derived rock physical properties (Figure 3) away from the well via prestack inversion and could be used to map geobodies using a quantitative interpretation scheme.

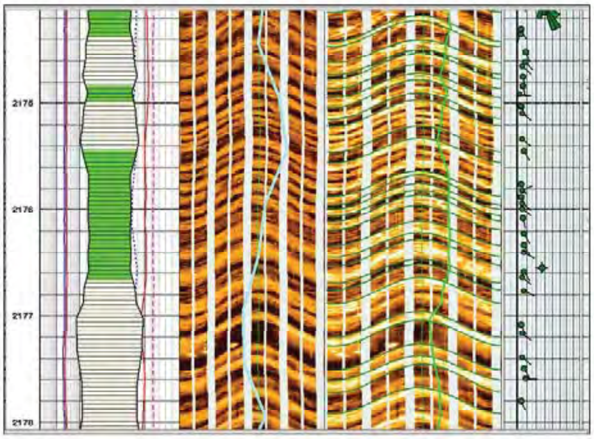

Figure 1: Borehole image with estimated neural-net facies, picked feature tadpoles and logs

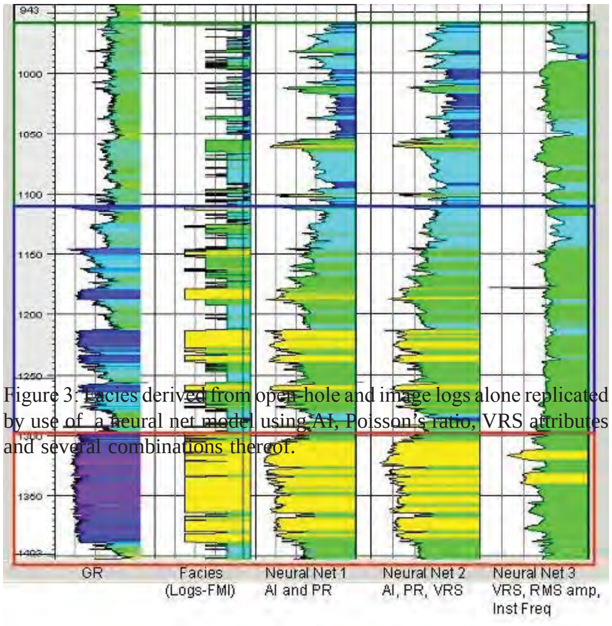

Figure 3: Facies derived from open-hole and image logs alone replicated by use of a neural net model using AI, Poisson's ratio, VRS attributes and several combinations thereof.

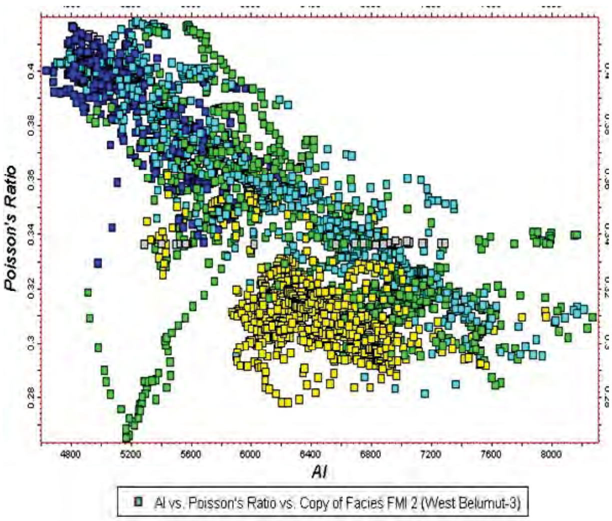

Figure 2: Crossp-plot of AI versus Poisson's ratio overlain by color-coded geological facies