Collaboration and Integration of Sequence Stratigraphy, Seismic Inversion and Comprehensive Seismic Interpretation Unlocking the Remaining Exploration Potential

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Introduction

Seismic inversion is widely known as the best technology for reservoir and hydrocarbon predictions in field development and exploration area with well calibration.. However, there is high uncertainty in prediction inherited in the exploration phase as a result of lacking in well control and/or lack of elastic logs (density, p & s sonic). To date, the seismic inversion technology showed high success ratio of reservoir prediction in exploration wells, thus increases the confidence level of reservoir predictibility in exploration area. However, hydrocarbon predictibility from seismic inversion technology is still high as the result is highly dependent on trap effectiveness and hydrocarbon charge. The uncertainty of hydrocarbon prediction can be reduced by integrating results from other studies and collaboration with several keys disciplines to fill-in the gaps in Petroleum System Element.

An integrated studies was carried out at the Northeast corner of SB313 exploration block, located less than 10 km from the Erb West and the Erb South oil and gas fields. The main objective of this study is to understand the subsurface reservoir distribution, continuity and correlation within target intervals, Stage IVA, IVB & IVC for a number of prospects. The analysis was then further extended to map lateral distribution of stage IVD top seal to support hydrocarbon prediction anomaly from the seismic inversion result.

Method and/or Theory

The study was carried out in three stages 1) Seismic Inversion, 2) Sequence Stratigraphy and 3) Comprehensive Seismic Interpretation.

Simultaneous AVO Inversion was selected as the best technology and widely used for lithology and fluid prediction in AI and Vp/Vs domain (Avseth et al, 2010, Mohamed et al 2013 & 2015). The initial and key step are data quality control and conditioning of wells, seismic angle stacks and seismic velocity. Fluid substitution analysis using Gassmann Dry Rock Model is conducted to test the sensitivity of discrimination between gas, oil and water (Fig.1). The conditioned seismic interval velocity was used as secondary trend in the low frequency model building. Near, mid and far seismic stacks were inverted using respective wavelets simultaneously to produce elastic traces of AI, Vp/Vs and Density. In this study, only the inverted AI and Vp/Vs were used and calibrated with wells for lithology and fluid predictions over the area and vertical zone of interest.

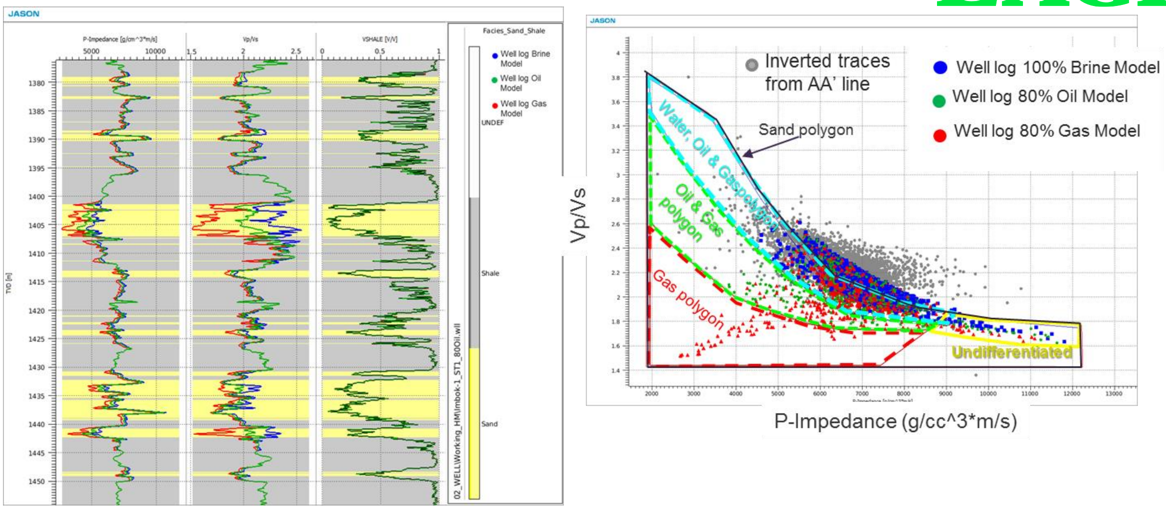

Figure-1 *(Left): Well log plot of fluid substituted elastic logs (AI and Vp/Vs) for 100% brine saturated, 80% oil saturated and 80% gas saturated. (Right): Crossplot of AI-Vp/Vs of elastics logs colour coded by modelled fluids and inverted traces.*

A sequence stratigraphic study was carried out on several selected key 2D and 3D seismic lines. Reflectors termination was firstly picked on the seismic section and identified as possible sequence boundaries, which later calibrated to wells (Vail et al, 1990). Once the sequence boundaries established, seismofacies and depositional environment within each sequences were postulated based on seismic facies characteristic (Mitchum et al, 1977) (Fig.2).

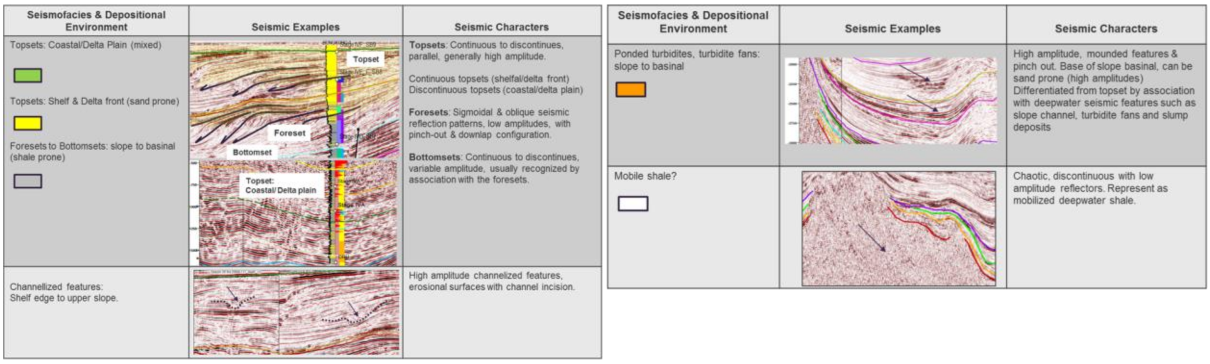

Figure-2 *Seismic facies character used for seismofacies and depositional environment interpretation.*

As a key step to assess the robustness of the inversion modelling result, a comparison between the modelled reservoir facies generated seismic inversion and reservoir facies interpreted from seismic sequence stratigraphy was conducted on the same key line. Upon satisfactory results from this step are achieved, further analysis can be made to understand the lateral distribution of the reservoir and sealing mechanism. This will further increase confidence to fluid prediction from seismic inversion. PaleoScan™ software, a new advanced interpretation technology developed by Ellis was used to produce a Relative Geological Time model (RGT) from seismic (Pauget et al, 2009). From the RGT volume, a "thinning" attribute (Lacaze et al, 2011) was then calculated from stratigraphic thickness over the whole 3D volume (Fig.3). This attribute corresponds to the vertical derivative of the RGT and reveals the instantaneous variations of the geological layers in the volume for each seismic sample. Thinning attributes extracted within a stratigraphic interval can give an insight to sediment accommodation space. The result was then compared to the existing Paleogeography maps to see areal distribution of the potential top seal over the study area.

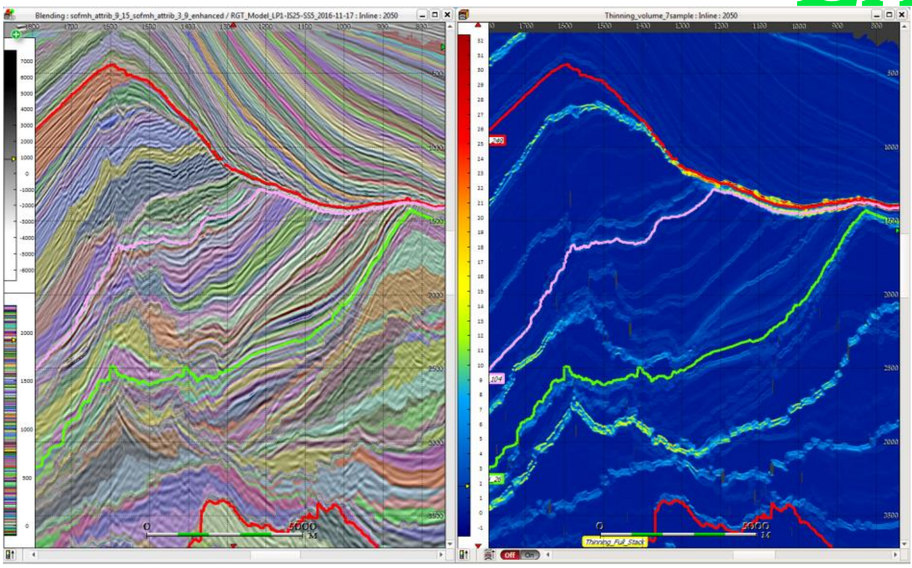

__Figure-3__ (Left): Relative Geological Time model (RGT) blended with seismic amplitude. (Right): Thinning attribute calculated from RGT vertical derivative. The observed relative maximum of thinning (hot colour) corresponds to an unconformities

Results

The stratigraphic model in figure-4 shows good agreement with sand prediction and distribution modelled through the seismic inversion method. It shows a potential presence of good seal provided by the coastal plain shale of Stage-IVD in the southern area. Based on the inversion study result, the southern flank also indicated that there is potential presence of hydrocarbon.

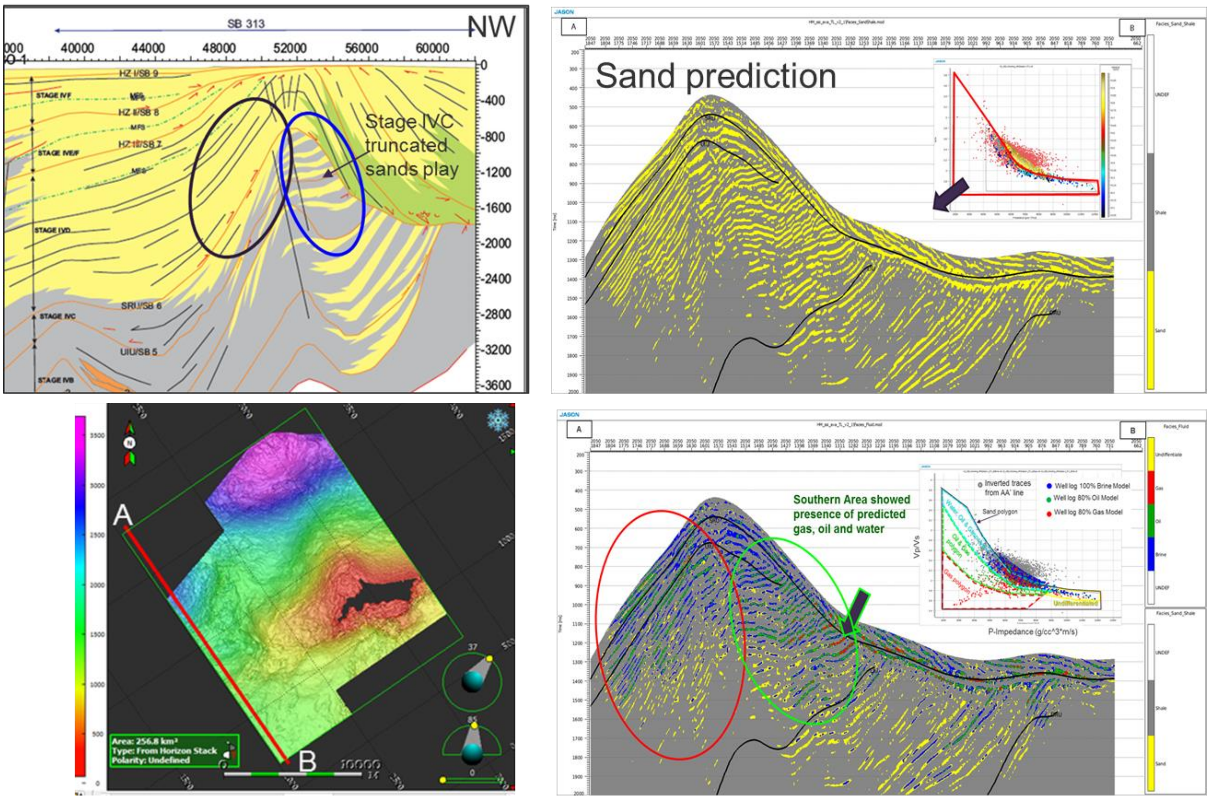

Figure-4 (Top Left): NW-SE Geoseismic section showing the sand distribution and presence of coastal/delta plain shale in stage IVD can be the top seal for underneath sediment. (Top Right): NW-SE sand prediction section produced from seismic inversion analysis. (Bottom Right): NW-SE fluid prediction section from seismic inversion analysis.

Conclusions

The integration of sequence stratigraphy, seismic inversion and advanced seismic interpretation technology (RGT model) provided value by improving confidence level in fluid predictions. Through this effort, at least three additional untested combined structural-stratigraphic traps remained in the block.

Acknowledgements

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