Cost effective, exploration grade QI workflows – An AVO case study offshore Papua New Guinea

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SUMMARY

In exploration seismic data has traditionally been used for structural interpretation. The seismic data also contains additional information relating to the change in reflectivity with changes in the angle of incidence of the seismic wavefield.

With careful preconditioning and analysis prospects can be ranked and evaluated using this information without recourse to (often unavailable) well penetrations.

Key words: AVO, AVA, QI, exploration, PNG, fluid factor

INTRODUCTION

Exploration often requires the ranking of plays and prospects with limited data support. Structural information, for example from seismic combined with basin studies and offset well results are a primary source of information to develop exploration concepts.

In this study we show how we can extract additional information, beyond structure, from the seismic to further refine exploration objectives prior to drilling the first exploration wells. We highlight some pitfalls, where attributes derived from seismic may be false positives, and we illustrate the steps that can be taken to avoid such pitfalls.

GEOLOGICAL SETTING

The Torres basin is a Mesozoic sub-basin of the Papuan Plateau basin and is largely overlain by the Neogene to recent Aure Moresby Fold and Thrust Belt. Collectively they represent a frontier petroleum exploration province. This region boasts large, undrilled sedimentary basins, underlain by rifted Australian continental crust and characterizes the southeastern extension of the prolific Papuan Basin.

Onshore oil seeps, offshore drop-cores and seismic hydrocarbon indicators, derisk a working thermogenic petroleum system. Geochemical analysis of the Imilia light oil seep, confirms the presence of Late Cretaceous to Paleogene marine source rocks. The oil from the Imilia seep is geochemically matched to discovered oils and condensates in the Papuan and Aure basins, thus significantly extending the source fairway to the southeast of PNG. Intriguingly, deep water, chemosynthetic reef systems, paleo and present-day seabed pockmarks can be recognised. These can be linked to seepage via normal fault systems and to mass fluid escape features, with the fluids sourced from shallow reservoirs, breached by deep water unconformities. The timing and distribution of these features indicate that these reservoirs were charged at the latest, by the Mid-Pliocene and that active charging is currently occurring.

3D seismic data has revealed the synchronous and asynchronous interaction of major turbidite systems with strong contour currents. Hybrid (synchronous) and mixed (asynchronous) reservoirs, demonstrate improved reservoir quality due to the action of bottom current reworking and cleaning processes.

METHOD AND RESULTS

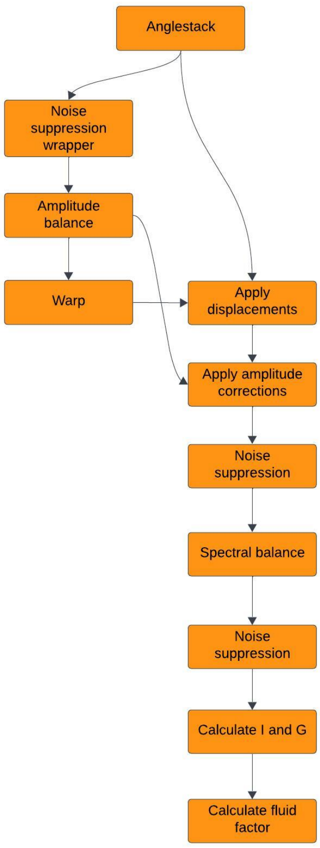

Figure 1 shows the workflow employed in this project. Extensive, iterative testing is required to ensure optimal process ordering and parameter selection. Some key steps will be focussed on.

Angle stacking – Fine angle stacking

- minimises the amount of residual move out that is stacked into the data – preserving resolution
- increases the sampling of the AVO curve across the angle range of interest
- gives additional flexibility on the range of angles to include in the analysis

In this project the data was stacked into 5° angle bands

Event alignment – Residual event moveout negatively impacts AVO attributes, particularly gradient type attributes. Unfortunately, minor velocity errors often conform with structure. This means that high AVO gradient anomalies caused by velocity errors can conform with structure and can lead to poor exploration decisions.

An AVO compliant method for aligning the events must be applied to increase confidence that observed AVO anomalies are indeed representative of changes in subsurface reflectivity with incidence angle.

Figure 1 - Overview of workflow used in this case study

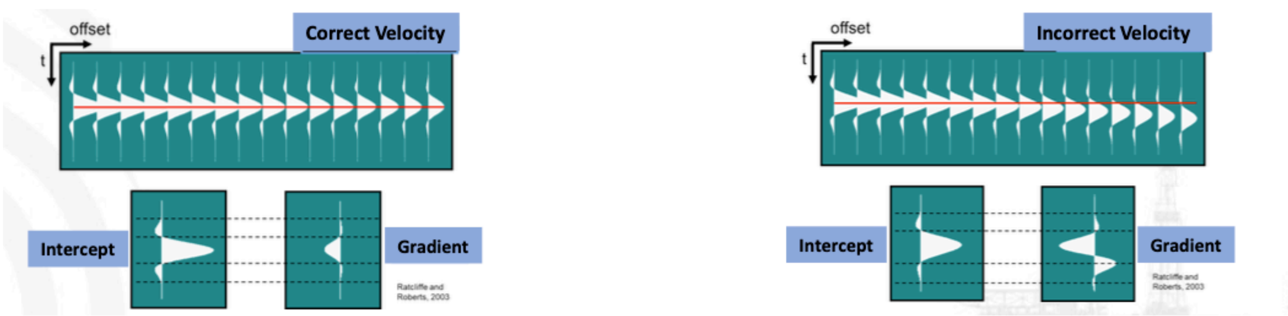

Figure 2 - Example (from Ratcliffe and Roberts 2003) on the impact of velocity errors on AVO, particularly on Gradient type attributes.

Fluid factor – The fluid factor attribute is measure of how far a piece of seismic data sits away from the background AVO trend. The background trend or mud line represents both shales and brine sands (Castagna). Therefore, one possible explanation of a high fluid factor is that that piece of seismic describes subsurface conditions where the pore fluid is a hydrocarbon.

Thus, where high fluid factors, on correctly preconditioned seismic data, conform with structure, confidence that this area is prospective in increased.

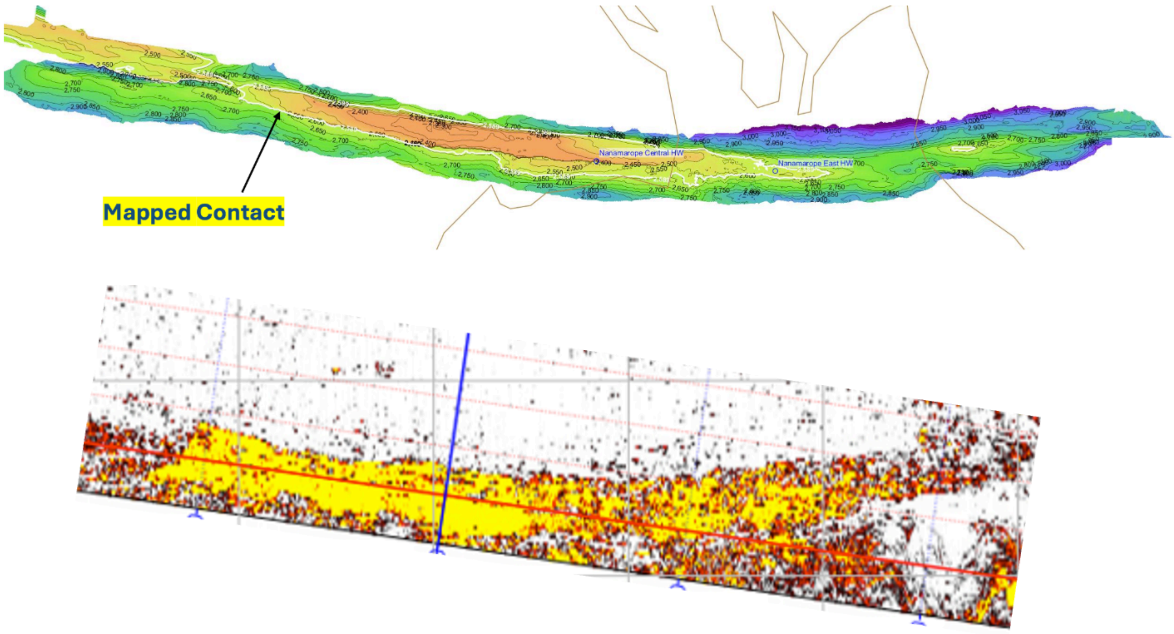

Figure 3 – Depth map of prospect structure (top) and fluid factor (bottom). Note the excellent conformance of the fluid factor with the structure and the sharp cut off of the fluid factor

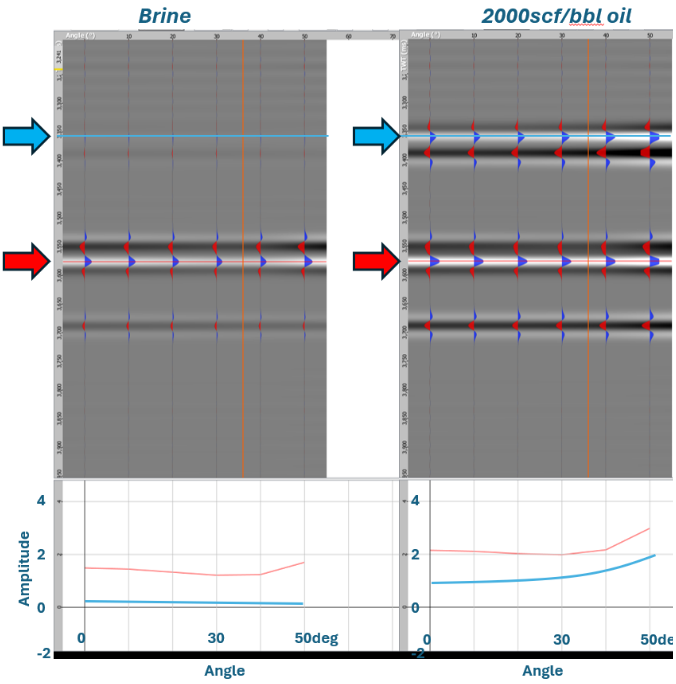

Figure 4 – Offset well fluid substitution from brine (LHS) to Oil (RHS) [ASEG polarity convention].

As seen in figure 4, under the assumption that the rock physics of the offset well, and the fluids, are representative then then we predict a change in Fluid Factor if the structures are charged dri).ven primarily by a change in reflectivity and a class II/III AVO response (Figure 5 – note that this crossplot is defined on SEG polarity convention.

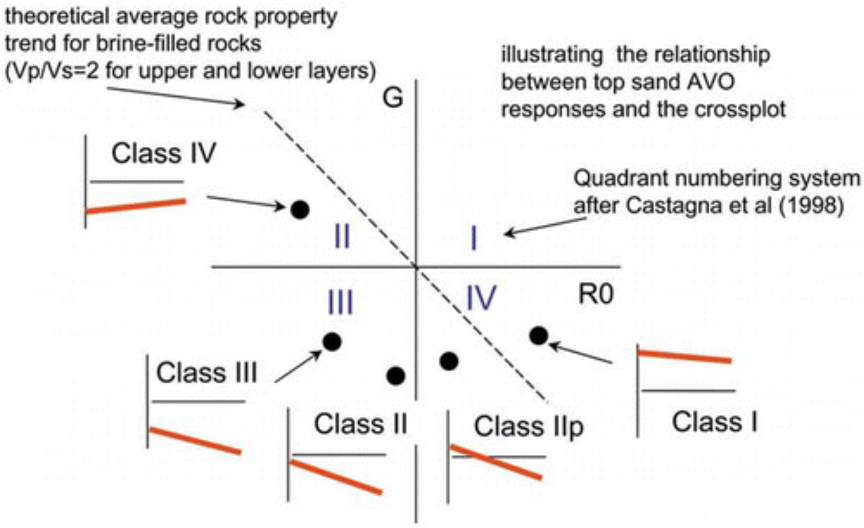

Figure 5 – AVO Classes [Simm et al., 2000] Note this plot assumes SEG polarity convention.

FURTHER WORK

In this study no seismic preconditioning was applied prior to angle stacking and an obvious point of further refinement could be to look at the gather domain data in one or more key prospects. However, the significant QI step is after the first exploration well when a calibrated inversion could be performed leveraging this studies preconditioned seismic dataset.

CONCLUSIONS

Valuable AVO information is contained in prestack seismic data.

Workflows that extract and interpret such AVO information are susceptible to noise contained within the data and (particularly) to errors in the velocity field.

Diligent preconditioning of the input data can remove false positives and highlight areas where AVO anomalies conform with structure.

These workflows offer additional data support for exploration programs and reduce subsurface risk.

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