Differentiating between potential reservoirs and hardrock with a holistic quantitative seismic interpretation method

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SUMMARY

Easily recognized bright events on seismic data can infer a host of phenomena, ranging from lithology interplay to indicating lucrative prospects in relatively greenfield settings. The availability of seismic angle stacks integrated to a geological model afford the petroleum explorationist more options to reduce obviously incorrect conclusions and help to identify the more likely cause(s) of these bright events within the seismic data.

A combination of simultaneous seismic inversion, and far and near angle stack comparisons gave more confident deductions on certain recognized seismic features as well as identifying potential interesting prospects to pursue and study in the context of petroleum exploration in offshore Myanmar. In the Bay of Bengal Rakhine Outer Fold Belt, exploration 3D seismic acquisition was carried out in 2010 and a significant gas discovery made in 2012. We present some examples of features that were identified on seismic data and how the range of geological hypotheses could be narrowed by seismic inversion.

Key words: Simultaneous seismic inversion, Angle substacks, Sweetness, Rock properties.

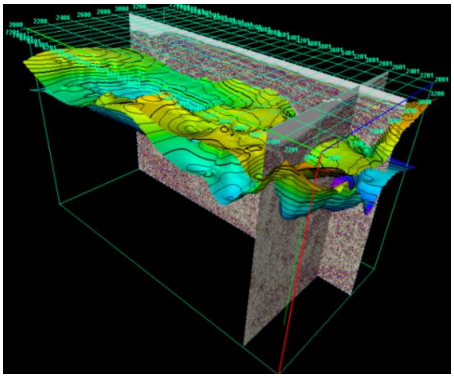
INTRODUCTION

3D seismic data has become an essential component of petroleum exploitation, from exploration through to development. Exploration targets are identified on the basis of structure interpreted directly from the seismic image, amplitude anomalies, or a combination of both. The availability of well logs within the area of a 3D seismic survey allows the constraint and calibration of the seismic data using a process known as seismic inversion. The larger the number of wells within the survey area, the better constrained the seismic inversion result, and thus the better the quality of the predicted hydrocarbon prospects.

Easily recognized bright events on seismic data can infer a host of phenomena, ranging from lithology interplay to indicating lucrative prospects in relatively greenfield settings. The availability of seismic angle stacks integrated to a geological model afford the petroleum explorationist more options to reduce obviously incorrect conclusions and help to identify the more likely cause(s) of these bright events within the seismic data.

A combination of simultaneous seismic inversion, and far and near angle stack comparisons gave more confident deductions on certain recognized seismic features as well as identifying potential interesting prospects to pursue and study in the context of petroleum exploration in offshore Myanmar. In the Bay of Bengal Rakhine Outer Fold Belt, exploration 3D seismic acquisition was carried out in 2010 and a significant gas discovery made in 2012.

This work showcases the inversion of the 3D seismic survey of over 500 km^2 (Figure 1. top), which despite containing only two wells, resulted in the identification of a number of prospects (Figure 1 bottom). An amplitude variation with offset (AVO) simultaneous seismic inversion was applied to the survey data and the computed rock properties (Dufour et al. 2002), together with other seismic attributes, provided a vastly improved model of the nature of the prospects identified.



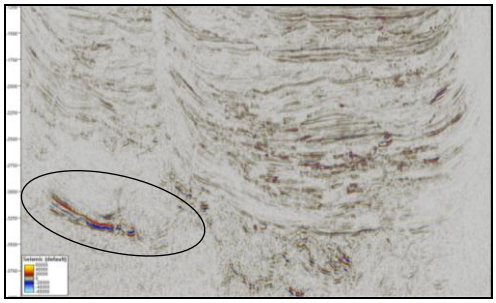


Figure 1 Top: The 3D seismic coverage showing an interpreted structural horizon and the two well trajectories

towards one end of the survey area. Bottom: One of the prospects identified is associated with the circled high-amplitude (bright) event.

METHOD AND RESULTS

Derived rock properties through seismic inversion

The rock properties derived from the AVO simultaneous seismic inversion (Avseth et al. 2005) showed that the seismic event of interest had high acoustic impedance and high MuRho values, which leads to a deduction of that event being a stiffer rock package as shown in Figure 2.

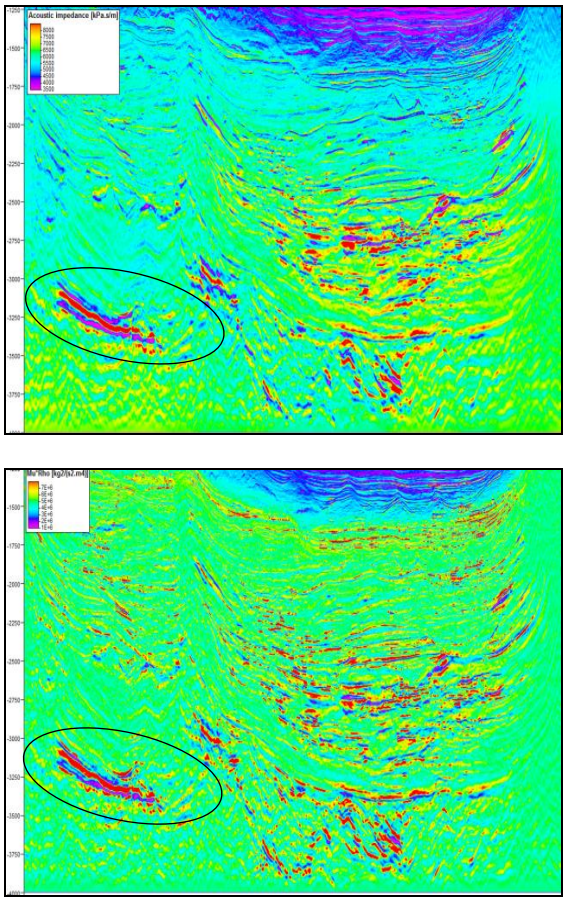


Figure 2 Acoustic impedance (top) and MuRho (bottom) results for the seismic section shown in Figure 1. The event of interest has been circled.

The stiff rock body identified could be interpreted as either a carbonate or an igneous rock in the MuRho scale (Goodway et al. 1997). The geomorphology of this rock package as identified from MuRho values are shown in Figure 3 (Top) in perspective, and Figure 3 (Bottom) in map view. Drawing from documented igneous complexes observed in seismic data [Holford et al. 2012], this geobody does not appear to be an extrusive flow mass; hence, the interpretation of this being a carbonate body is preferred.

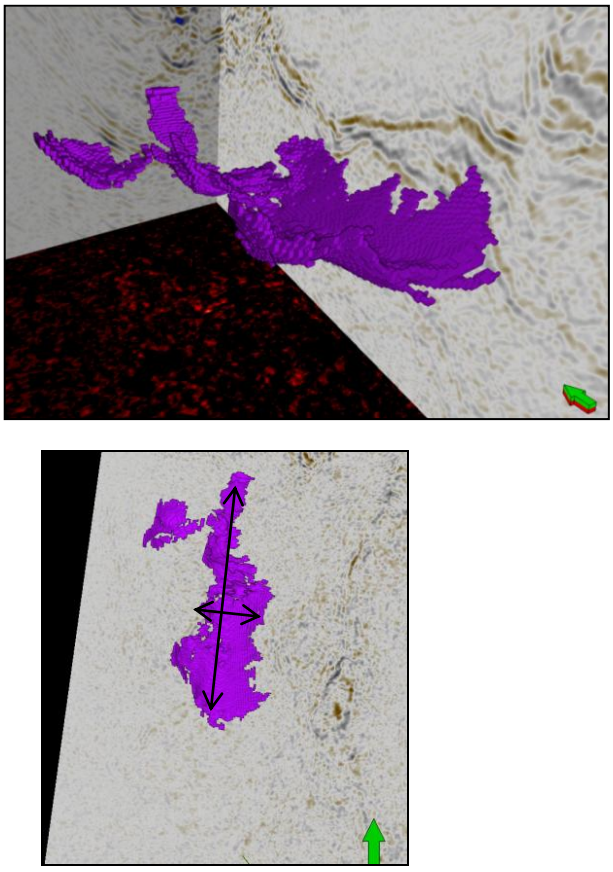


Figure 3. Top: The geobody identified by its high MuRho values. Bottom: The geobody in map view, approximately 8km long and 1.6 km wide.

Combination with other seismic attributes

Besides the AVO-based simultaneous seismic inversion a number of other seismic attributes were investigated on the angle substacks. Primarily, these allow us to inspect for AVO effects between the near (4 – 14°) and the far angles of incidence (36 – 44°). Examination of the acoustic well logs from elsewhere in the survey area confirmed that the hydrocarbon-bearing sequence exhibits a Class 3 brightening AVO effect as seen for this prospect. The near- and far-angle stacks are compared in Figure 4 and show the obvious brightening of certain sequences, as identified by the solid black ellipse. However, in the other previous mentioned area of interest indicated by the dashed black ellipse, we observe that the high-amplitude event retains its characteristics for both the near- and the far-angle substacks.

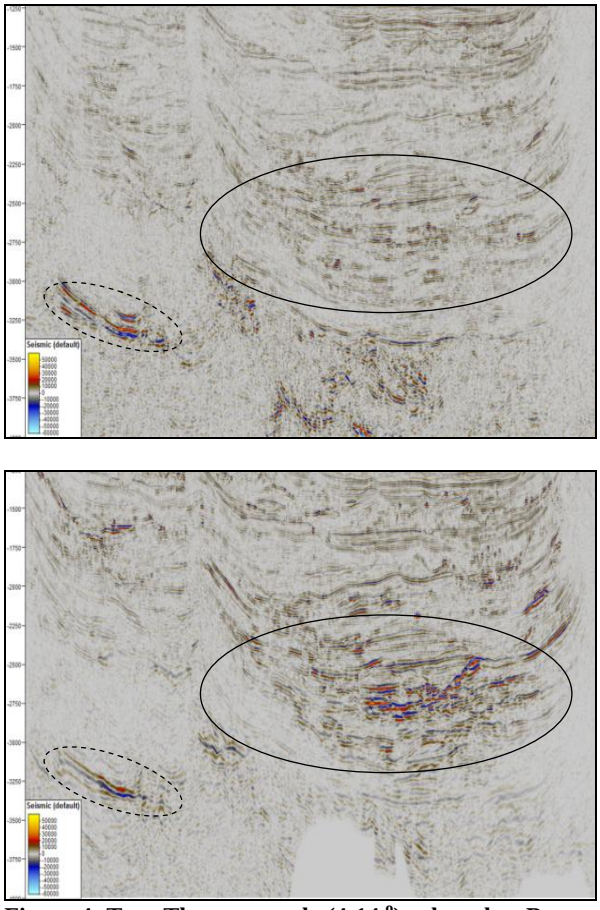


Figure 4. Top: The near-angle (4-14 ^{o}) substack. Bottom: The far-angle (36-44 ^{o}) substack.

To better quantify the level of amplitude brightening we computed the sweetness, i.e. the ratio of the seismic reflection strength to the square root of the instantaneous frequency, which is often used in channel detection (Hart 2008). We computed values for both the near- and the far-angle substacks as shown in Figure 5.

It can already be seen in Figures 4 Top and Bottom that the seismic amplitudes increase from the near- to the far-angle substacks. However, we used the sweetness attribute to quantify the difference because sweetness is not affected by the difference in bandwidth inherent in the seismic data after its division into near- and far-angle substacks. In this geological setting, and from the well controls, it is believed that reservoir quality sands exhibit a brightening with angle AVO effect.

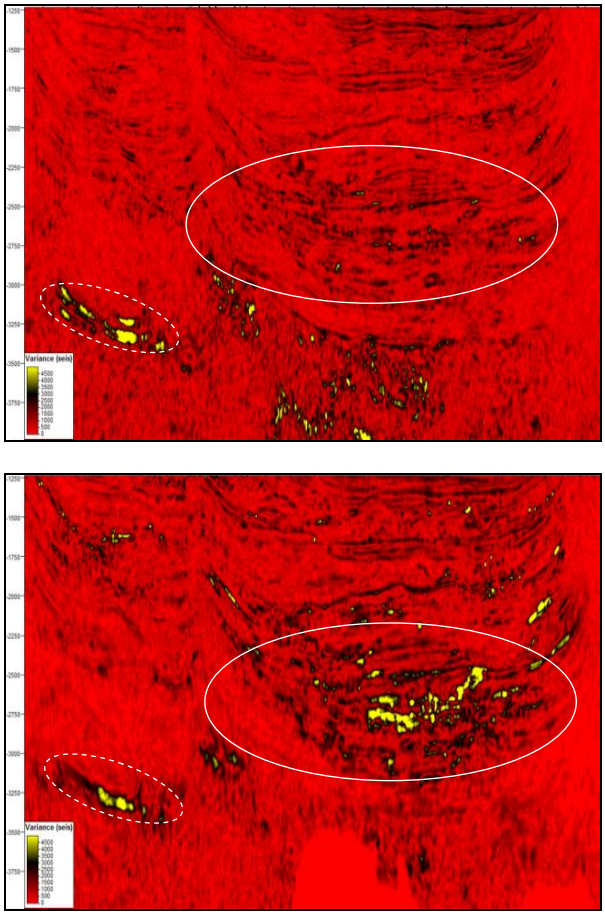


Figure 5. Top: The near-angle sweetness result. Bottom: The far-angle sweetness result.

Hence the geobody package can be identified from the difference between the sweetness results for the near- and far-angle data because they have higher values in the latter, i.e. they appear higher in Figure 5 (Bottom) than in Figure 5 (Top) within the solid white ellipses. The geobodies within the solid white ellipse of Figure 5 (right) thus identified are considered to have similar properties to the drilled reservoir shown in Figure 6 at the well trajectory.

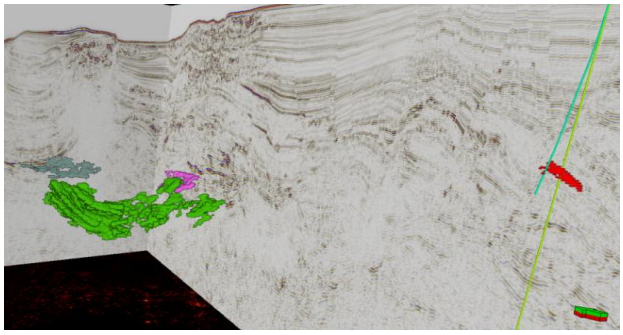


Figure 6. The connected geobodies (identified by different colours) from the difference between the sweetness results, together with the reservoir package (in red) and its two well trajectories.

CONCLUSIONS

The application of seismic inversion to an area of over 500 km^2, with what is effectively a single well calibration, is primarily an exploration project as we would typically incorporate results from at least two or three additional wells. The different investigation methods presented here include rock properties derived from an AVO simultaneous seismic inversion and a variation of the standard AVO effects observations. These investigations and observations inferred the rock type of the high-amplitude seismic event and also enabled us to reduce the uncertainty on the lithology and potential fluid content of additional potentially interesting exploration targets consistent with the first discovery within this area.

ACKNOWLEDGMENTS

We thank MPRL E&P Pte Ltd and WesternGeco for permission to present this work.

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