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Case study: Successful application of 3D depth processing in Eromanga Basin, Queensland.

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SUMMARY

The majority of seismic imaging performed on Australian land seismic data is carried out using time migration processing sequences. The Eromanga Basin in Queensland, Australia has geological features which are difficult to resolve using time migration.

Here we demonstrate the use of pre-stack depth migration to successfully image such features. The pre-stack depth migration used successive iterations of residual curvature analysis to update the velocity model using a top-down approach. Major geological horizons and well data were fed into the 3D tomographic model updates to arrive at a final velocity model that images the subsurface and is consistent with the well-ties.

The final pre-stack depth migrated image resulted in a significantly improved interpretation when compared to the pre-stack time migrated equivalent. Observed unconformities and complex structures are resolved within the depth image.

We demonstrate that depth processing has resulted in a more confident structural understanding of the survey area. We believe that due to general proximity of reservoirs to formations containing velocity anomalies, that depth investigation be warranted to more accurately image potential exploration targets.

Key words: land, depth migration, Eromanga Basin, Pre-SDM,

INTRODUCTION

The Eromanga Basin is a large Mesozoic sedimentary basin in Central and Northern Australia. The basin contains an ancient meteorite crater (astrobleme), which has produced a complex geology which leads to the distortion of time migrated seismic images. The basin covers an area of $1x10^6$ km^2 and is the location of significant Australian onshore petroleum and natural gas deposits including the nation's largest onshore oilfield at Jackson. In recent years, onshore Australia has seen an increasing number of petroleum and gas exploration activity particularly in the Eromanga and Cooper Basins. Conventional vibroseis and dynamite seismic data is almost exclusively processed via a pre-stack time migration (PSTM) processing sequence. Our recent experience with a pre-stack depth migration (PSDM) in this region has shown significant image enhancement and improved interpretation.

Initially we performed a pre-stack time migration and subsequently a pre-stack depth migration sequence on a 300sqkm block in the basin, with the objective of imaging intricate formations with potential for presence of hydrocarbon. The basin comprises mainly of sandstone, siltstone, mudstone, coal and shale, with the hydrocarbon reservoirs typically located at depths of 1200m.

Vibroseis seismic data was processed through an amplitude-preserved and surface-consistent sequence followed by offset-class regularisation and pre-stack time migration. Refraction and residual statics were applied to correct for near surface temporal distortions.

The time migrated data illustrates high signal-to-noise ratio with generally flat rock beddings with some noticeably complicated formations at known horizons, forming strong velocity boundaries. These formation oddities generally appear from Cadna-Owie (C) Formation and deeper; the Top C horizon is of significance for exploration as the top of the unit approximates a distinctive seismic reflector and is mappable throughout the entire basin.

The time migration velocity is laterally smoothed to be used as initial depth model. During each depth iteration, pre-stack Kirchhoff depth migration was run with a sparse grid output. The migrated gathers were subject to residual curvature analysis (RCA). Gamma volumes were used to QC the residual error after each update. Using a top-down velocity update approach we arrived at model convergence down to the Permian basement after five depth model iterations.

During depth-velocity modelling it was revealed that there are significant velocity variations of the order of 500m/s at Top C and other boundaries (Figures 1 & 2). Time imaging was not able to successfully image these intervals. Depth migration improved the seismic image quality, especially in fault shadow zones and areas with complex seismo-geological settings (Figures 3 & 4).

CONCLUSIONS

We show how land seismic data could benefit considerably from pre-stack depth migration. The value of depth imaging in the Eromanga Basin data was demonstrated by significant improvement of structural conformity and increased confidence in interpretation results.

Additional by-products from depth imaging such as a well-compliant velocity model and more precise amplitude from spherical divergence will benefit reservoir interpretation in subsequent stages of exploration.

ACKNOWLEDGMENTS

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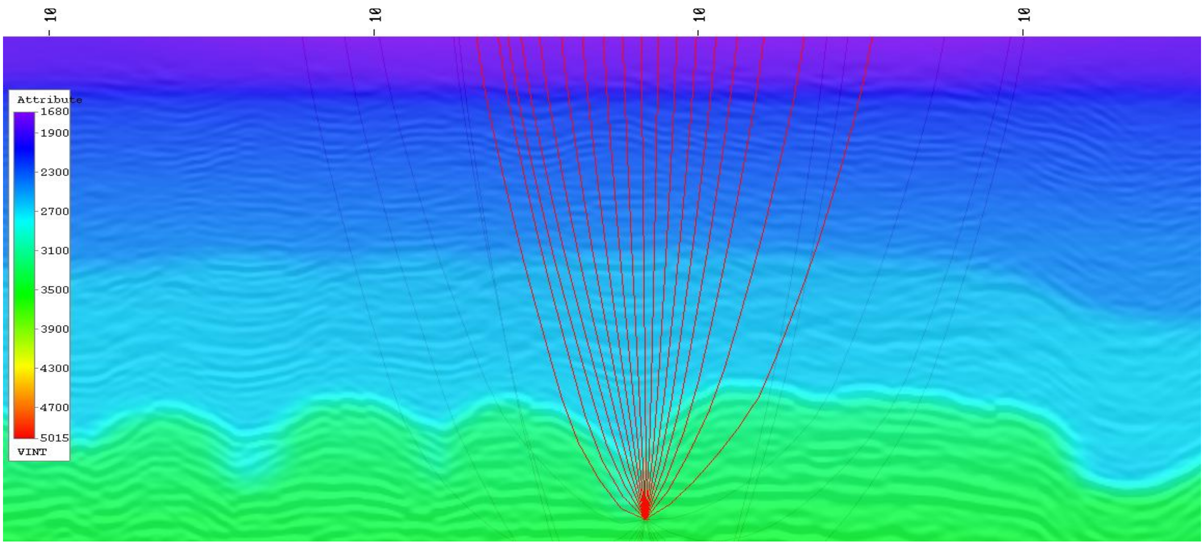

Figure 1. Ray tracing within the final velocity model. A fan of ray paths eminating from a single reflection point and separated by constant angle increments propagate through the model. The rays arrive at the surface at irregular spatial intervals and are temporally distorted.

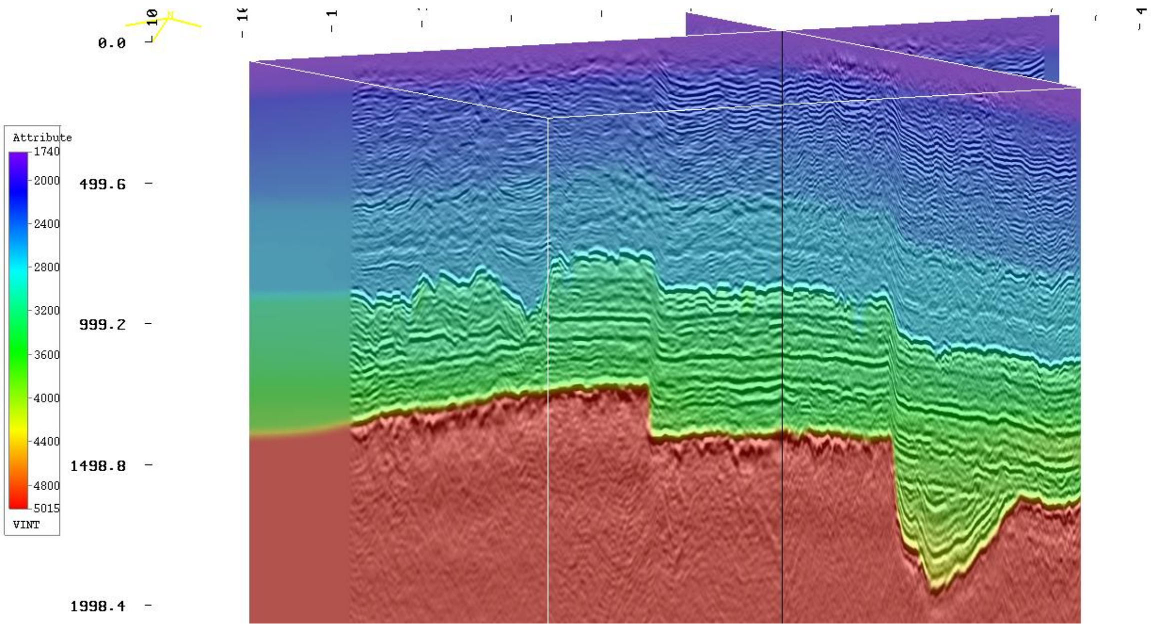

Figure 2. PSDM section in depth overlayed with velocity model. Horizon-constrained velocity boundaries are clearly observable and confirmed by well logs. Data courtesy Santos Ltd.

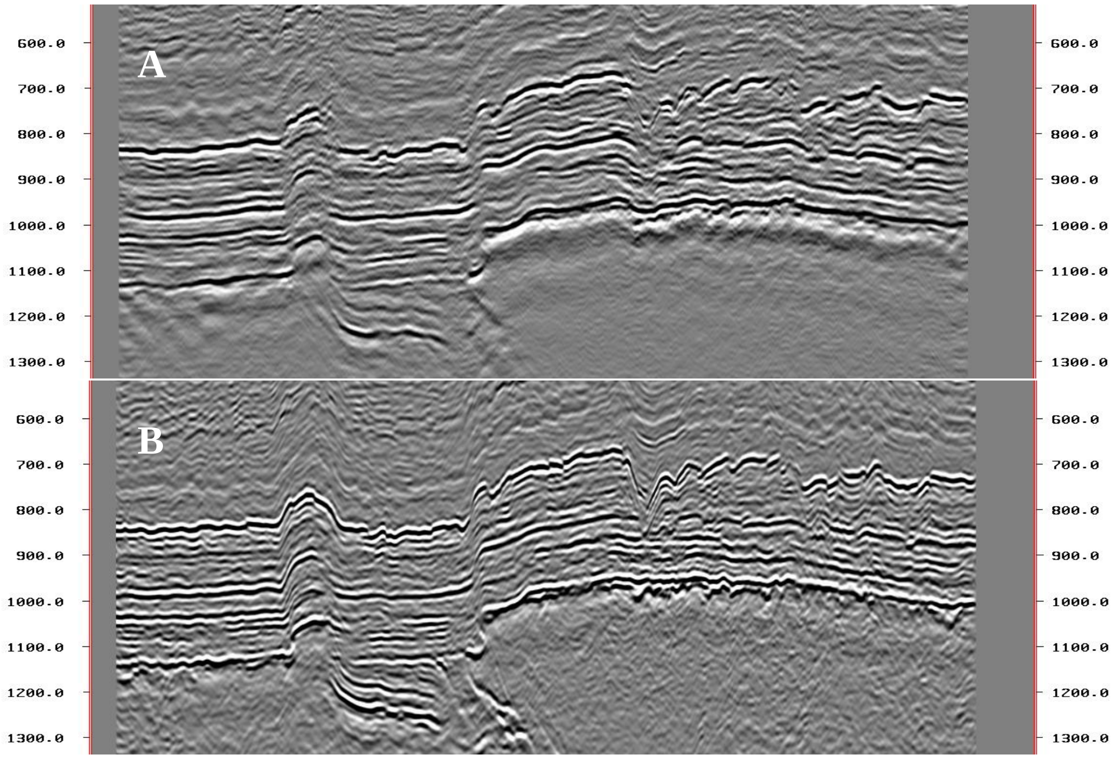

Figure 3. Comparison of time-domain stack sections of initial 2006 PSTM (A) and subsequent 2012 PSDM repro (B). The PSTM section shows discontinuity in Top C horizon and depth perturbation effects below discontinuity zones. The PSDM section shows significantly improved structural continuation and illumination of deeper events. Data courtesy Santos Ltd.

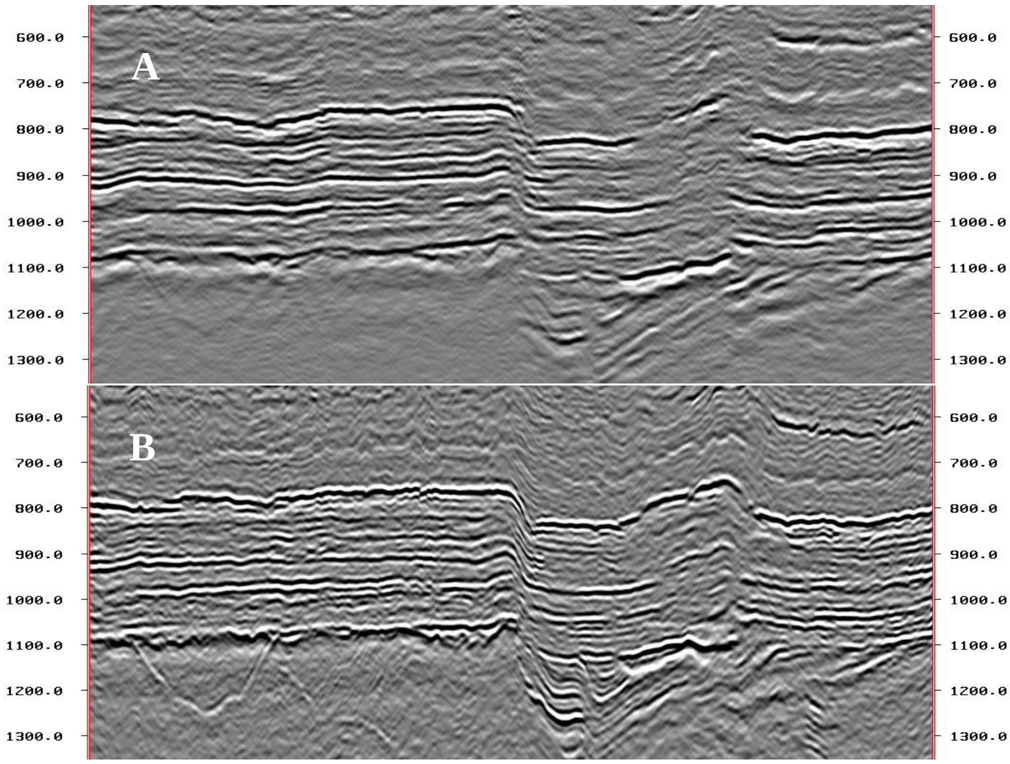

Figure 4. Comparison of time-domain stack sections of initial 2006 PSTM (A) and subsequent 2012 PSDM repro (B). On the left hand side of the PSTM section the Top C is generally flat with some rolling features that perturb all reflectors underneath. The corresponding area of the PSDM section maintains the rolling Top C character but the reflectors underneath are significantly flatter. On the right hand side of the image an obscure faulted syncline zone was imaged through PSDM. Data courtesy Santos Ltd.