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Pre Stack Depth Migration: A case study for improving the imaging of the Triassic and Jurassic events in Bonaparte Basin, Australia

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Summary

Localised amplitude dimming due to absorption in the shallow part of the section is always a challenge for imaging the deeper part, which affects the amplitude at the reservoir levels. These anomalies are seen in the Western Australian basin. In this paper we discuss how a good velocity model along with Q-Controlled Beam migration was able to improve the structural continuity and fault definition. In addition, it was able to compensate for the loss of amplitude, frequency and phase distortions, thereby bringing out a high resolution structural details of the target reservoirs.

Keywords: *Q-PSDM, Controlled Beam Migration, Q Tomography*

Geology of the area

The Vulcan sub-basin has a complex structural & depositional history (Figure. 1). A late Carboniferous-early Permian extension tectonics led to a NE-SW trending proto Vulcan sub-basin and deposition of clastics initially in Glacio-fluvial environment followed by shallow marine to Fluvio-Deltaic environment which extended till late Triassic age. North–south transgression in the Late Triassic (due to Fitzroy movement) caused wrench reactivation of existing structures resulting in uplift and erosion. The early Jurassic was marked by Clastic deposition while the late Jurassic is characterized by organic rich shale. Widespread NE-SW trending block faulting and uplift commenced in the late Middle Jurassic (Callovian - Oxfordian), and led to extensive erosion of Jurassic and Triassic strata. There was a complete change in the depositional pattern in the Paleogene and Neogene age with Subtropical and tropical carbonates being deposited throughout the region.

Processing Challenge

One of the key challenges in the Vulcan sub-basin is the loss of energy and high frequency component in seismic waves travelling from the Carbonate environment (in the Neogene-Paleogene sequences) to the clastic environment in the Mesozoics. As a result, at deeper level the low frequency component is dominant hence vertical resolution gets reduced. The situation is further compounded by the complex faulting history during the extensional and compressional phase and existence of shallow gas pockets. All this has led to poor illumination of the deeper strata particularly the Jurassic and Triassic sequences which are the potential hydrocarbon bearing reservoirs. Another challenge in the PreSTM data was an anomalous low velocity layer seen in the deeper strata without any geological validity (Figure 4). These challenges need to be addressed with a multi-disciplinary approach wherein all geological complexities need to be synthesized while processing the data. A strategy was also devised to get the optimum results for devolving the structural and stratigraphic subsurface information.

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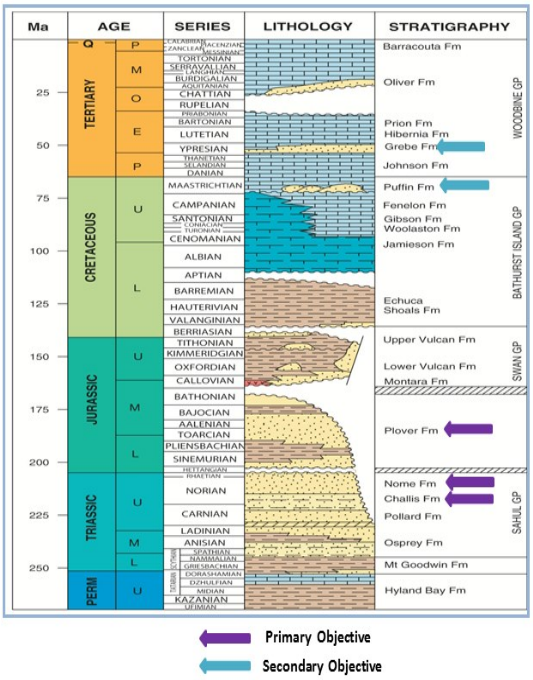

Figure 1: Generalized stratigraphy of Vulcan sub basin (after Edwards et al., 2004)

Technical Solution

The PreSDM study was the chosen option to improve the quality of the data as the proper velocity model was the key for enhancing the data quality. The Q compensation within the PSDM algorithm was another tool which was expected to compensate localised amplitude dimming due to absorption in the shallow part of the seismic which in turn affects the imaging of the deeper part. The right type of migration algorithm was a challenge by itself, hence as a strategy it was decided to test 25 square Km of 3D seismic data with three types of algorithms viz. Kirchhoff, migration, Controlled Beam migration (CBM) and Reverse Time migration (RTM).

A hybrid model was used for depth-velocity modelling. It was a gridded model (50*50*20m 3D bin size) where geological horizons were used to introduce, enhance and preserve some features (velocity boundaries) which were considered important for the velocity model. PreSTM RMS velocities were used to build the initial interval velocity model. Depth variable smoothing was applied to remove non-geological velocity variations in deeper sections caused by the presence of shallow heterogeneities. Available well information from three wells - Cash-1, Mapple-1 and Paqualin-1 was used to QC the initial model, iterations of the model, updating and also to calibrate PSDM velocity model in depth. Several re-interpreted horizons were used during depth-velocity modelling to preserve and enhance corresponding velocity contrasts (Figure 2). The depth-velocity modelling sequence included 12 iterations of seismic tomography. A few additional iterations were run to evaluate the workflow and test its parameters. Initially, VTI anisotropy was introduced into the model but due to the geological complexity it was transformed to TTI mode.

Q-tomography was applied to build a spatially variable Q model for the compensation of loss of energy and high frequency component in seismic wave (Figure 3), and this model was used within the depth migration.

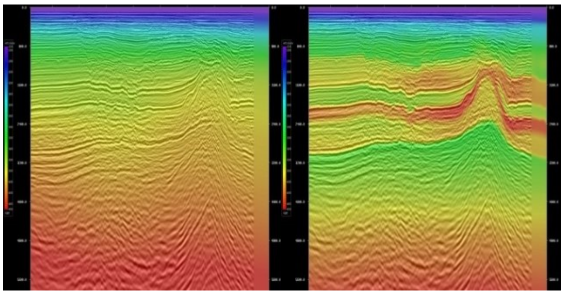

Figure 2: Interval Velocity Models overlaid over the Final Stack - Initial (left) and Final (right)

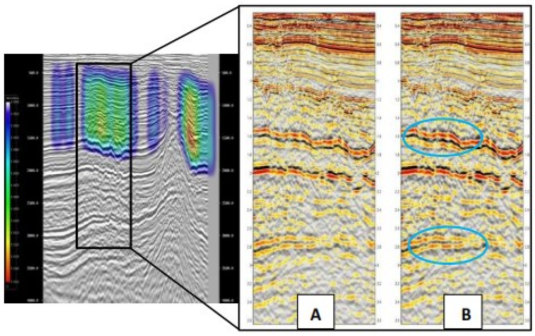

Figure 3: Final Q Model & effect of Q: Seismic sections (A) without QPSDM & (B) with QPSDM

Results

The encircled abnormal low velocity zone (Figure 4) present in the PSTM RMS velocities, which could result in wrong interpretation, got corrected in the PSDM model building. This confirms the dip of structures and position of faults.

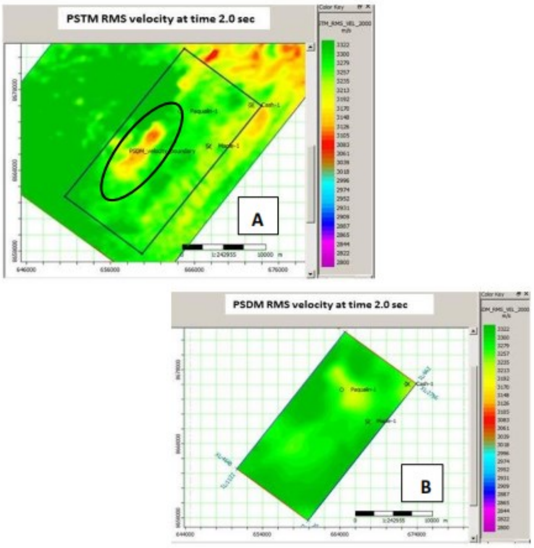

Figure 4: Comparison between Vintage PSTM RMS Velocity (A) and Final PSDM RMS Velocities (B)

After CBM with Q , handpicked time varying inner Mute, coherency enhancement, dip filtering and low frequency processing removed most of the high frequency diffracted and scattered multiples and improved the image of Jurassic and Triassic appreciably. Figures 5, 6 and 7 clearly show this improvement.

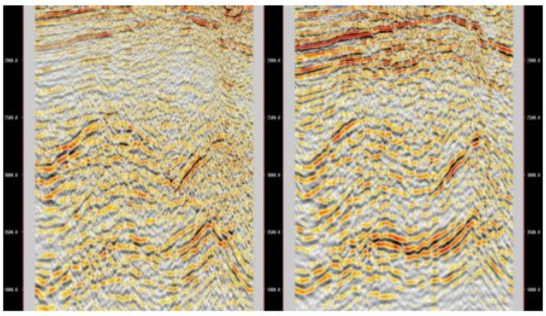

Figure 5: Comparison Vintage PSTM Stack and Q-CBM Stack: Inline

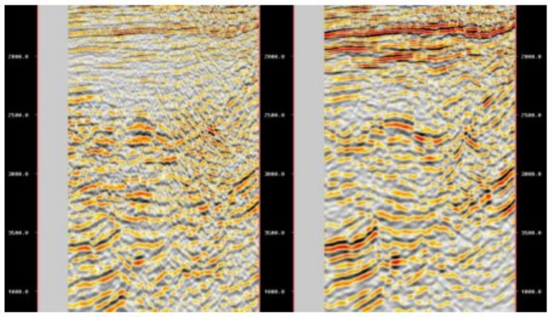

Figure 6: Comparison Vintage PSTM Stack and Q-CBM Stack: Xline

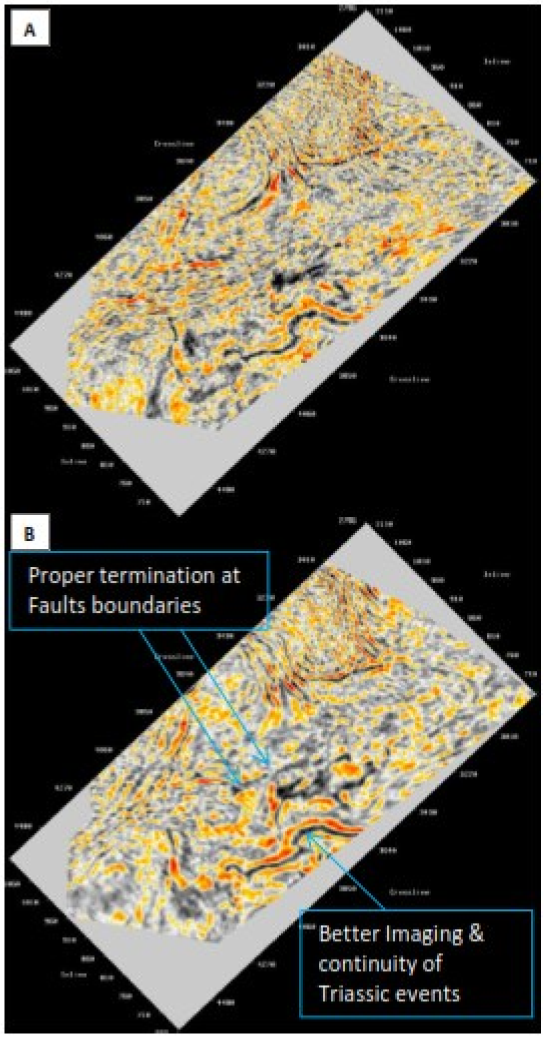

Figure 7: Comparison Vintage PSTM Stack (A) and Q-CBM Stack (B): Time Slice 2660ms

Conclusions

Final results clearly show that QPSDM study (Controlled Beam Migration with Q-tomography) has achieved the geological objectives of illuminating the Jurassic and Triassic section apart from substantially improving the shallow data.

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