The Barque Structure Offshore New Zealand: Improving the Seismic Image Using Prestack Depth Migration*

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Search and Discovery Article #41516 (2015)
Posted January 19, 2015

*Adapted from extended abstract prepared in conjunction with presentation at CSPG/CSEG/CWLS GeoConvention 2013, (Integration: Geoscience engineering Partnership) Calgary TELUS Convention Centre & ERCB Core Research Centre, Calgary, AB, Canada, 6-12 May 2013, Datapages/CSPG © 2015

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Abstract

The Barque structure is a large four-way dip closure located in the southern ocean offshore southeastern New Zealand in Petroleum Exploration Permit PEP38259. This permit is situated in the offshore part of the Canterbury Basin towards the southern end of the continental shelf of the basin. Figure 1 shows the geographical location of the permit area.

Significant velocity and seismic imaging issues arise due to large submarine canyons, which distort the time image over the structure. In 2009, the Joint Venture acquired nine new lines of 2D seismic over Barque and processed these with prestack depth migration (PSDM). A key element used for this PSDM imaging was a technology to estimate the near water bottom interval velocity of the sediments using geo-mechanical principles. The results showed that this new methodology provided good improvement in the seismic image. The Joint Venture therefore decided to reprocess a vintage grid of 1982 and 1984 lines over the prospect in order to improve the images from the legacy data and aid in mapping the structure.

Here, we present the state of the art seismic reprocessing and imaging workflow, explain the idea of using geo-mechanical principles to estimate the sediments just below the water bottom and show the improvements in imaging gained from the prestack depth migration of the vintage seismic data.

The Velocity-Depth Model Workflow

The major challenge in developing an accurate velocity depth model for the Barque structure is to address the strong lateral velocity variations associated with the highly rugose water bottom caused by the presence of major canyons. These introduce significant changes in seismic velocity in the near surface sediments caused by juxtaposition of alternating presence of a water column and shallow sediments. The resultant differences in compaction and stress fields lead to velocity variations that are difficult to detect with conventional seismic acquisition and processing configurations. We solve the problem using a technique called geomechanical velocity modelling (Birdus, 2009). This enables a more accurate initial near surface model to be generated compared to the overly smoothed velocities that are derived from time migration. The full workflow is then carried out using the following stages:

1. Build an initial interval velocity model using prestack time migration and the associated RMS velocities.
2. Apply a geomechanical correction to the near surface interval velocity field in areas of the variable seafloor depth.
3. Perform prestack depth migration using this initial geomechanical update model to check the accuracy of the update on both common image gathers and structural consistency of the stacked image.
4. Continue with iterations of reflection tomography based on minimising the residual curvature observed on migrated gathers until the full depth model is updated.

Following the completion of the PSDM, we optimised the stack response of each line using a final velocity trim, high resolution Radon demultiple and post stack signal enhancement. Figure 2 shows the main elements of this workflow.

Results

Figure 3 and Figure 4 show a comparison of the prestack depth migrated image using the velocity field derived from the initial prestack time migration and the image that we obtained after the final prestack depth migration. We have achieved considerable improvement beneath the water bottom canyons with our PSDM imaging workflow. For consistency here, we present the initial PSDM image obtained from the same reprocessed input data as that used for the final PSDM.

Conclusions

Successful seismic imaging in areas of rigose seafloor, such as that over the Barque structure requires use of prestack depth migration. A key element of this workflow is to develop a reliable velocity model of the sediments near the seafloor. The geomechanical approach that we have used here to solve this problem allows for a robust solution that converges quickly and which complements subsequent tomographic updates for the prestack depth migration model building. Our results demonstrate the improvements of the seismic image that can be achieved using this workflow. The Barque structure is a large anticline in an offshore frontier area that remains untested. To reduce the risk on this prospect, any future exploration over this structure must certainly require 3D seismic and imaging using a similar workflow as we have described here.

Reference Cited

Birdus S., 2009, Geomechanical modeling to resolve velocity anomalies and image distortions below seafloor with complex topography: 71st EAGE Conference & Exhibition, Extended Abstracts, U014.

Figure 1. Location of PEP38259 Offshore New Zealand.

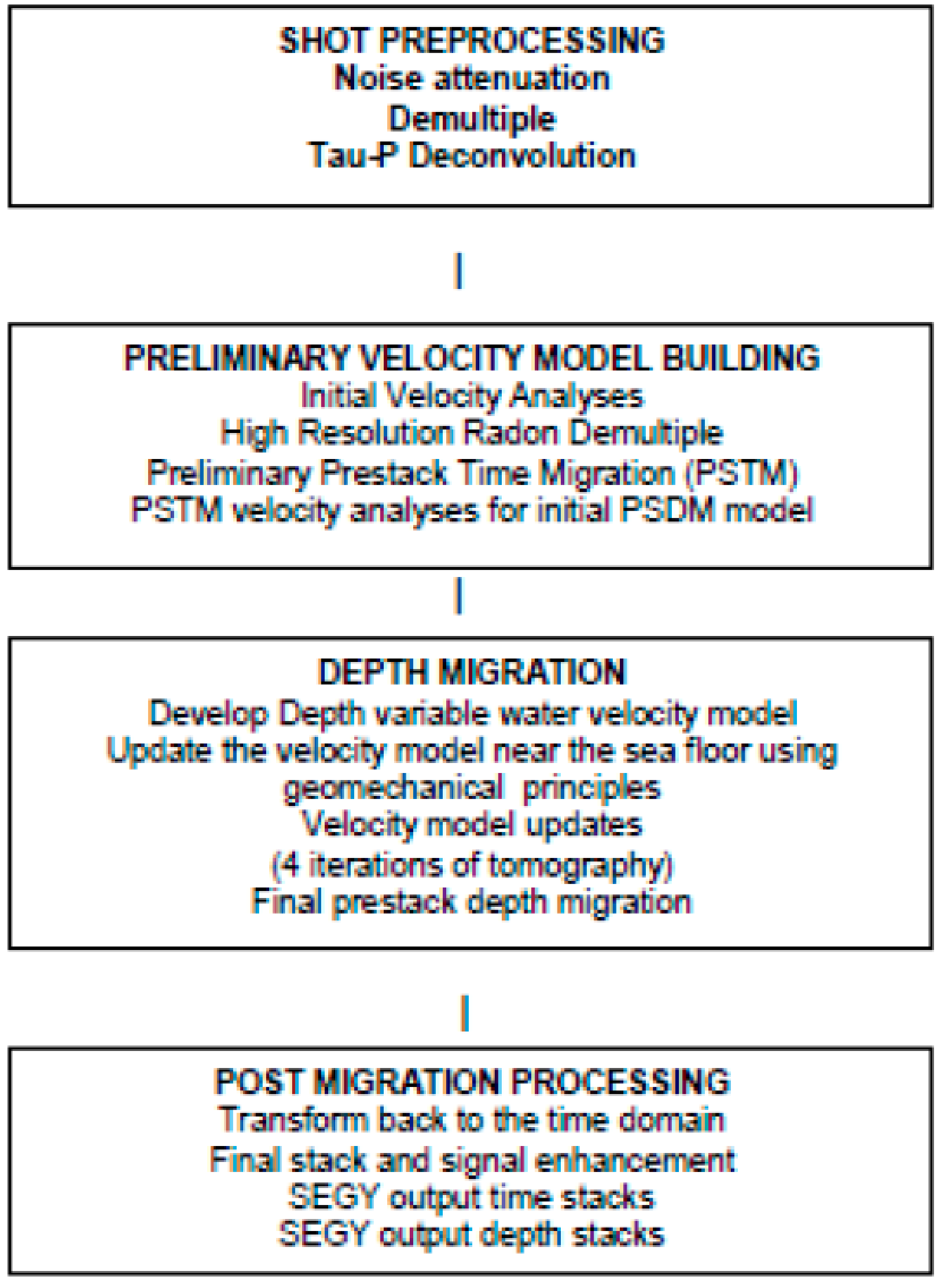

Figure 2. PSDM reprocessing Workflow.

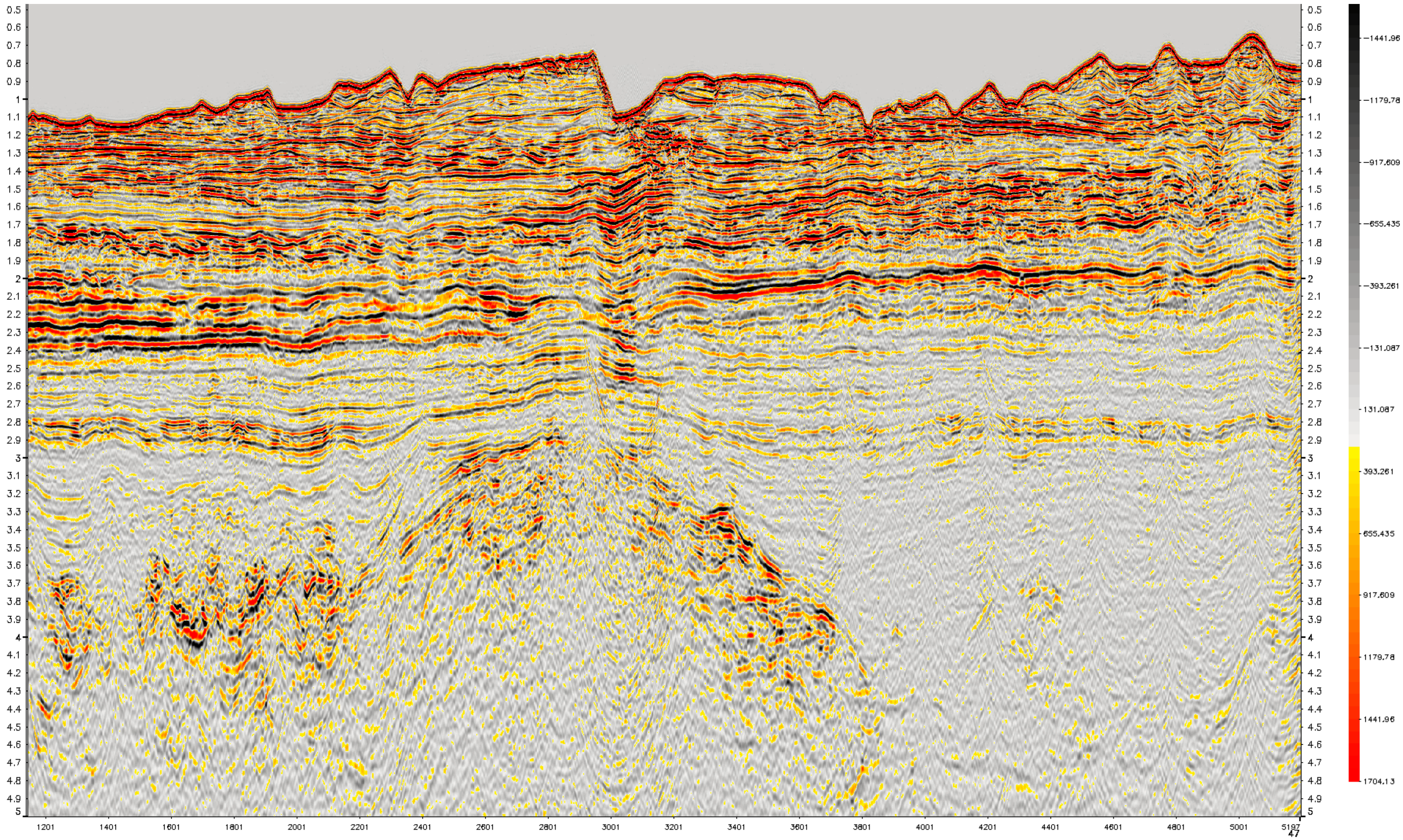

Figure 3. The initial prestack depth migration. Note the imprint of the variable water depths on the seismic image. The vertical scale is depth in km.

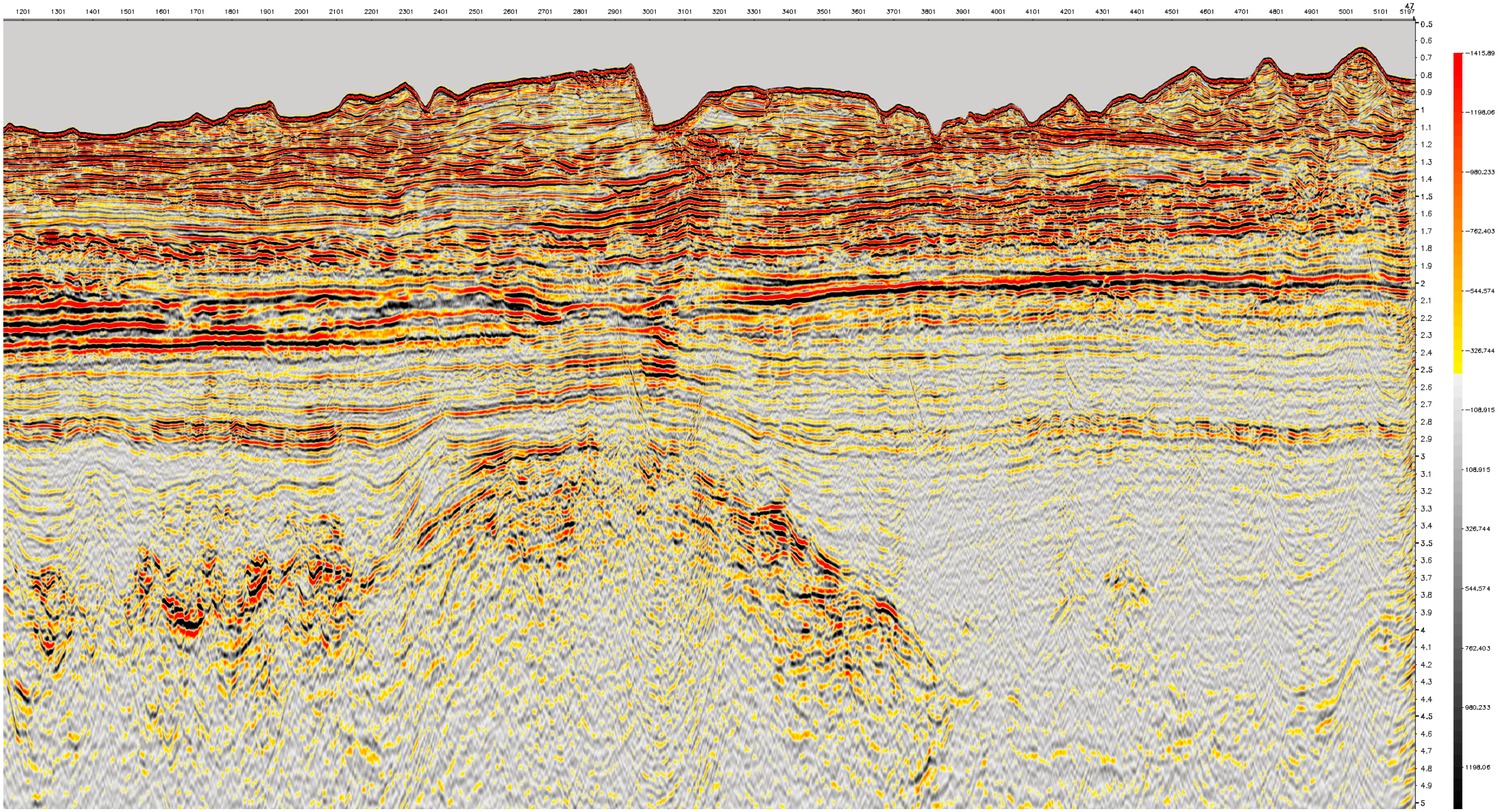

Figure 4. The final prestack depth migration demonstrates considerable improvement in the image. The vertical scale is depth in km.