Improved fault plane imaging using advanced seismic processing technologies

Supriyo Paul*, Sushobhan Dutta, Maheswara Phani, C. G. Rao, Kondal Reddy, and Chandan Saha
Cairn Oil & Gas, Vedanta Limited
Email: Supriyo.Paul@cairnindia.com

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Summary

RJ-ON-90/1 onshore block, located in Barmer Basin, Rajasthan is under the operatorship of Cairn Oil & Gas, Vedanta Ltd along with ONGC as its Joint Venture partner (Figure-1). This basin has a number of major discoveries like Mangala, Aishwariya, and Bhagyam.

The current study is from one of the appraisal field situated in the North-Eastern part of Barmer basin. The objective of the current study is to de-risk exploration prospect by improving the seismic imaging with the use of advanced processing technologies. Most of the area was covered mainly by 2D seismic and low fold 3D dataset. However, in 2016 a wide azimuth 3D seismic data was acquired and processed with the advance technologies to address the interpretation issues. Possible causes of poor quality seismic data may be attributable from complex near surface static, sub-optimal groundroll attenuation, ray path distortions due to complex subsurface structures and complex velocity model. In this paper, we will demonstrate how the high resolution tomography velocity model building followed by the depth imaging has helped in imaging a complex sub-surface geology and also provide a plausible explanation why an exploratory well did not penetrate the Fatehgarh formation drilled on hanging wall prospect.

Introduction

Recent advancements in seismic data processing such as tomographic static analysis, 3D model based ground roll attenuation, 5D Interpolation, OVT binning and high resolution tomographic velocity model building will be the key drives for better imaging solution. As the depth migration processing better handles the velocity anisotropy in comparison to time migration processing, it resulted in a better fault plane imaging in the study area. Here, in this paper we will mainly discuss about the depth imaging results and its role for exploration de-risking by providing the better solution for well placement.

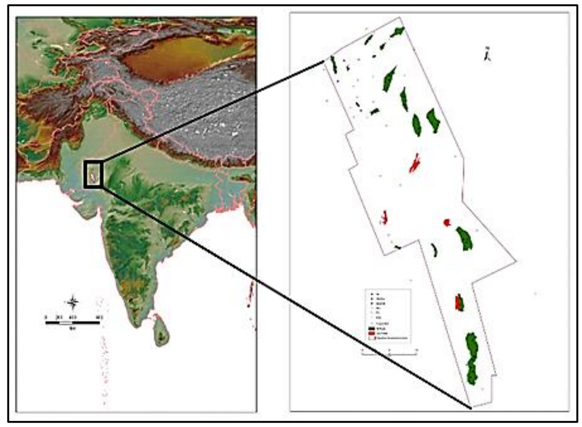


Figure 1: Left panel - location map of the Barmer Basin, Rajasthan, India. Right panel – location of the different fields (Green: Oil Fields, Red: Gas Fields

In this area the time structure map depicts the fault block as shown in the seismic section with a large throw (high lateral velocity contrast). The main motivation of this study is based on a well-placement on the hanging wall side of a fault block which did not penetrate the reservoir that was interpreted by using vintage datasets. Instead the well went through the main bounding fault and hit the basement.

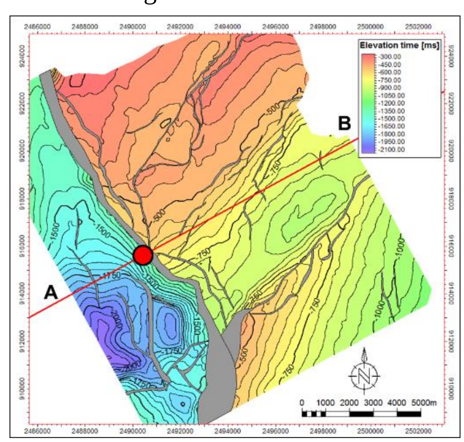


Figure 2: Time structure Map showing the location of the well (red marker) along an inline AB.

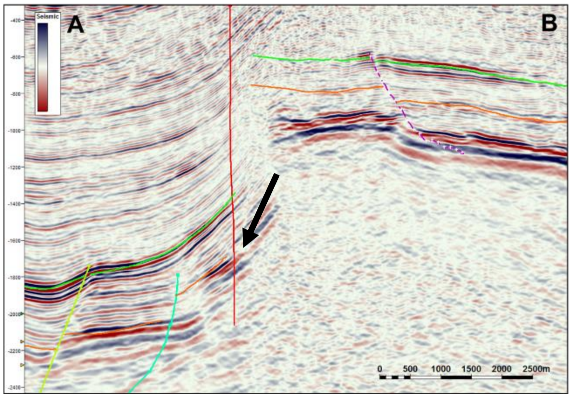


Figure 3: Vintage Seismic inline section along AB as marked in the time structure map. The arrow indicates the target event.

With the processing & merging of newly acquired and vintage data using advance technologies, we are able to improve the fault plane imaging which has helped the interpreters for better structural understanding of the area. The newly processed seismic dataset is superior compared to the vintage in terms of statics, improvement in signal to noise ratio and fault imaging. Here, we will be discussing on the workflow used to reduce exploration risks through improved velocity model building and imaging.

Velocity Modelling Methodology

Grid or cell-based 3D tomography is a velocity model optimization tool that uses residual velocity (depth-error) information derived from pre-stack depth migration common image or angle gathers. Prestack depth migration handles significant lateral velocity variations, which pre-stack time migration cannot, but using an incorrect velocity model will result in output Common Image Point (CIP) gathers on which the reflected events are not flat and a migrated stack which is poorly imaged and incorrectly positioned. The optimization of the velocity model, through analysis of the non-flatness of the gathers (residual moveout), thus forms the key part of a depth imaging project. When all the gathers are generally flat across all offsets – i.e. all the events image at the same depth for all offsets – then the velocity model is considered correct within the resolution limits of the seismic data. Also it is preferred to bring in as many constraints as possible (Sonic logs and well markers, VSP-s and interpreted seismic horizons) for velocity calibration.

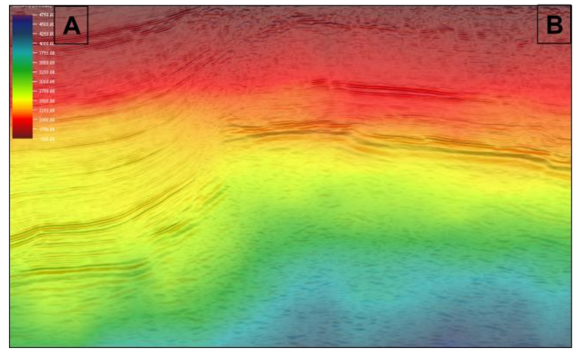


Figure 4: Vintage PSTM Velocity model

Tomography updates may be derived globally or in layers (termed 'hybrid' tomography), whichever best suits the velocity regime. To make the realistic velocity model consistent with geology, many iterations of tomographic velocity model are required which overall depends upon the initial model and complexity of the data. A good starting model will help the process to converge to its optimum solution most quickly. Such a model will be a good representation of the velocities (such as a Pre-stack Time Migration velocity model or well data provided it is sufficiently available). A little bit of smoothness may be required to have a meaningful velocity model because a highly variable velocity model may be too complex and potentially include localized anomalies which might be erroneous. For each tomographic update, a grid of gathers is used for determining the residual moveout. The residual moveout may be picked automatically or manually, depending upon

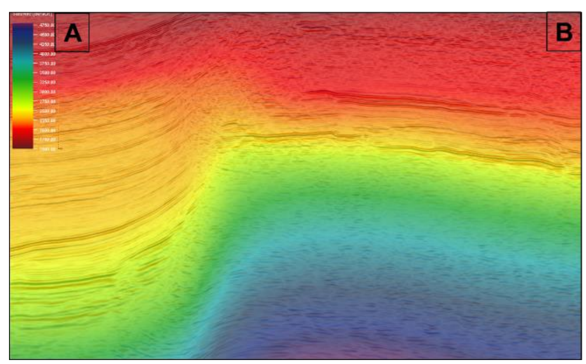
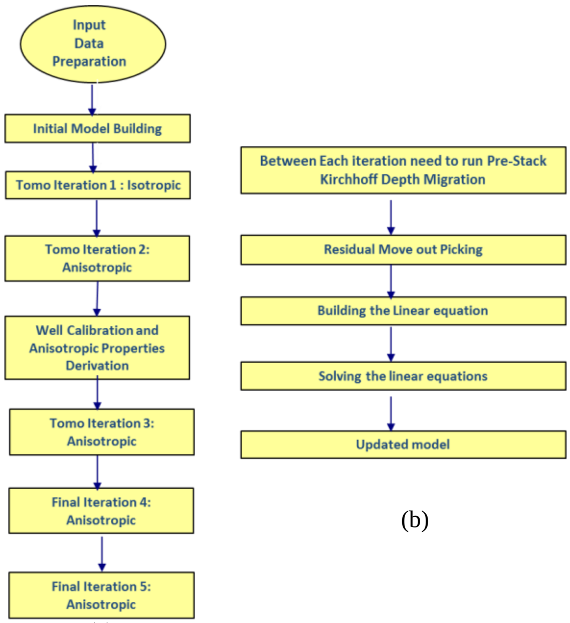


Figure 5: Final PSDM RMS Velocity model

the data quality. Thus the residual move out is used for further tomographic updates and thus we generate a robust velocity model.



(b)

(a)

Figure 6: a) Workflow used for Velocity modelling (1 isotropic and 4 anisotropic) b) Tomographic velocity model building flow

Imaging and Calibration

The high resolution Velocity model is used for the final PSDM production. Here we have incorporated additional inputs like well velocities, well markers, well logs, VSP-s and interpreted seismic horizons for final velocity calibration. Due to VTI Pre-SDM, the movement of the hanging wall prospect towards up-dip addressing the prospect. Remarkable improvements in imaging from Vintage PSTM to New PSTM/PSDM have been achieved as shown in the following Figures 7; A, B and C. The events on the hanging wall of Vintage data turns out to be pitfall in PSTM imaging.

Conclusions

Final imaging solution after incorporation of advance processing technologies along with high resolution tomography velocity modeling helps the interpreter for prospective analysis. This will help in de-risking the exploration uncertainties by optimal well placement on better imaged seismic. The study also shows the benefit of depth migration process in comparison to time migration specifically for better fault plane imaging.

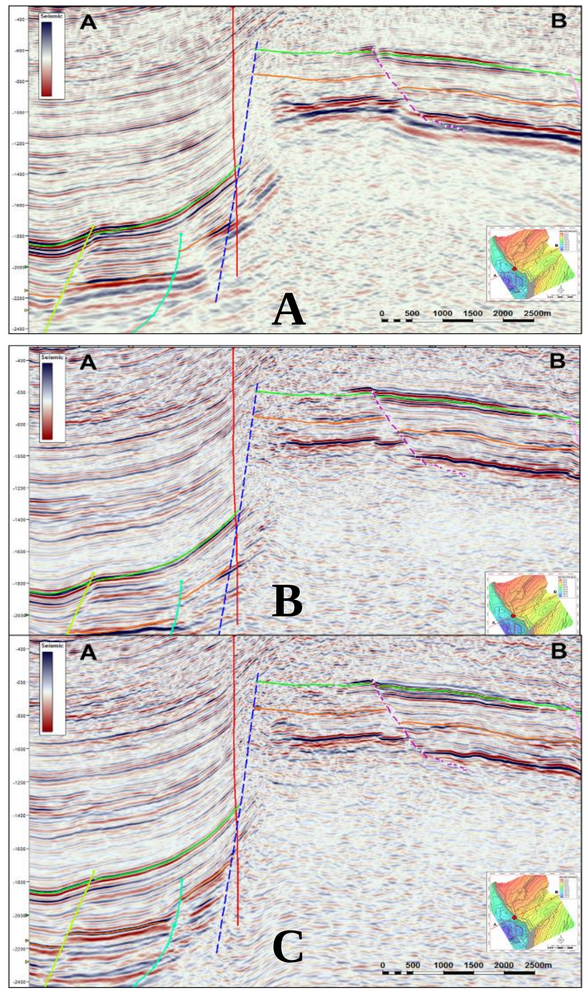


Figure 7: The above picture shows the comparison among (A) Vintage PSTM, (B) New PSTM and (C) New PSDM (time scaled) seismic data. Please note: The horizons and faults are interpreted on the newly PSDM (C) data and is overlayed on all the section. The vertical red line shows the well location on the hanging wall prospect.

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