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Well Tie Tomography an accurate Time-Depth Conversion

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Summary

Geo-steering and horizontal drilling is becoming more common in deep water and shale resource plays. It requires more precision on depth prediction of not only target horizons but also for possible geo-hazard to be avoided during drilling operations above target. Well velocities obtained from VPS/Check shot survey or well logging operations are accurate but available at sparse locations. Imaging velocity which is derived from seismic data during processing and imaging, for example RMS velocity and Tomographic interval velocity are available at each bin location but are not so accurate for depth conversion. Depth on seismic section after Depth imaging often does not match well. The main reason for this miss-match is anisotropy and velocity-depth ambiguity. In many cases velocity determination accuracy may suffer due to bad data quality and small depth-offset ratio available for velocity analysis.

Traditionally the miss-ties between seismic and well markers are corrected using a calibrated seismic velocity. Calibration factor is estimated at each well location and distributed in whole volume using kriging method or other suitable interpolation methods. This may produce a good match at well location but very poor match elsewhere and often post drill well never match. Results are highly dependent on the method used for miss-tie distribution.

Well Tie Tomography is based on tomographic principle, where depth errors are converted to time error along Zero-offset/offset rays to calculate the error in velocity model. The result is robust, not so much dependent on the miss-tie distribution method as stated above. On number of projects done in past post drill has confirmed the accuracy of this approach.

Since well tie tomography produces a correct velocity perpendicular to geological surfaces (symmetry axes in TI anisotropy) it can be efficiently used in converting the isotropic velocity model to an equivalent anisotropic velocity outputting velocity along symmetry axis and Thomson's delta required for TI anisotropic description.

In this paper, well tie tomography has been successfully applied on an offshore data from western offshore India. It has produced very good match with well markers and a geologically consistent velocity model.

***Keywords*:** *Well Tie Tomography, PSDM, Time-Depth Conversion*

Introduction

Seismic velocities are widely used for Depth imaging, depth conversion and pore- pressure prediction. Tomographic velocities are best suited among all seismically derived velocities. For accuracy of these results anisotropy should be taken into account during velocity modeling process. Well tie tomography is a novel approach based on the tomographic principles to incorporate anisotropy during velocity modeling.

In one of our offshore velocity modeling and imaging projects a miss-tie of the order of 300m was observed on the target horizon clearly indicating the presence of anisotropy in the overburden.

In this paper we have used Well Tie tomography to convert this isotropic to anisotropic model for better well tie. We can further extend this work to Anisotropic imaging at latter stage.

Method and Workflow

Tie Tomography usesthemistie between the well markers and the corresponding interpreted surface on theseismic volume at the well locations. The misties are then interpolated/extrapolated to generate mistiemaps along the

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interpreted horizons. The mistie along the horizons is then used as input to the 3D GridTomography for updating the velocity/anisotropy parameters. It is an iterative process.

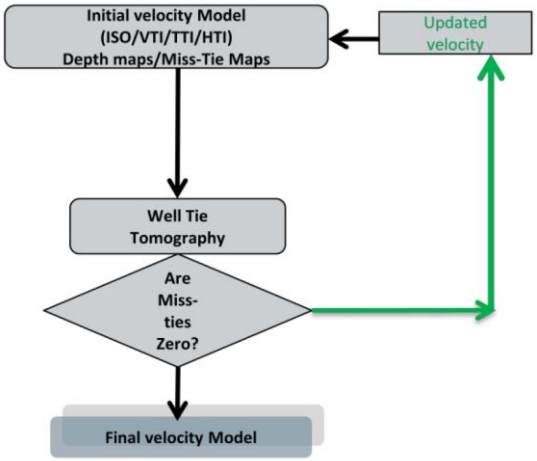

Figure1: Showing the workflow

Case Study

In this case studyWell tie tomography was run in isotropic mode to get the velocity for seismic and well marker tie. This example is taken from western offshore India. The area of interest and well distribution in this area is shown in Fig.2. Fourmarkers identified in these wells as shown in Fig.3 were used for generating the mistie maps. The markers do not match the corresponding seismic events on the depth migrated section as seen on the fig 4. The range of mistie is37m at shallower horizon to -310m at deeper horizon.Mistie maps are generated for these four markers as input to well tie tomography method. These maps are shown in fig.4.

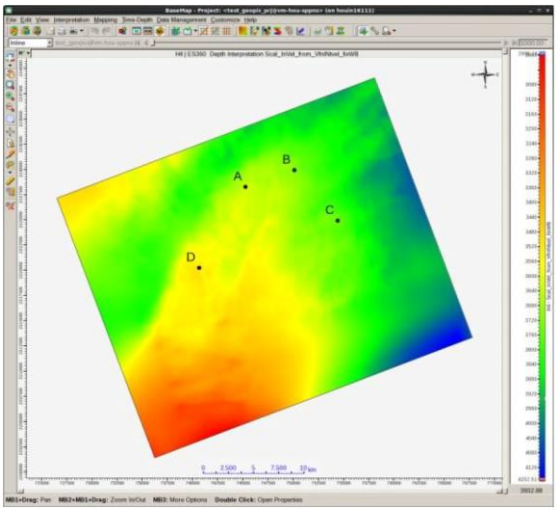

Fig2: Showing Target area and well distribution

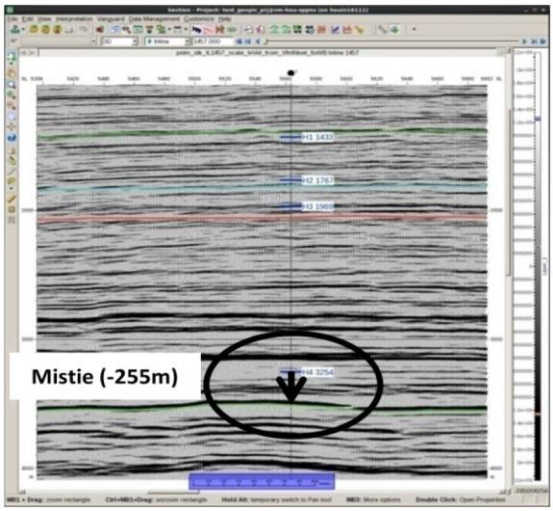

Fig3: Showing markers and mistie with seismic

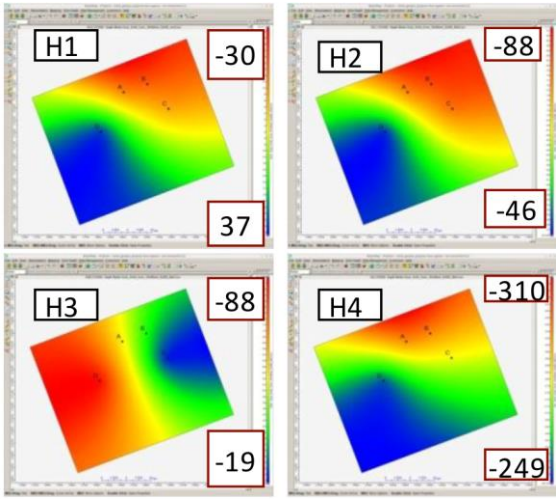

Fig.4: showing mistie maps with ordinary kriging and minimum curvature methods

Results

Initial velocity is updated using well tie tomography and seismic section is scaled to time with migration velocity and scaled back with tomography updated velocity to check the mistie after Tomography. Fig. 5 and Fig 6 compare the match between seismic and well markers before and after the Welltie Tomography. The well tie velocity is also compared with sonic log in the well. PSDM velocity is much higher than the geological velocity as seen in sonic velocity. Well tomography velocity is close to sonic velocity. This shows that welltie velocity not only produces good marker match it also produces a geological velocity.

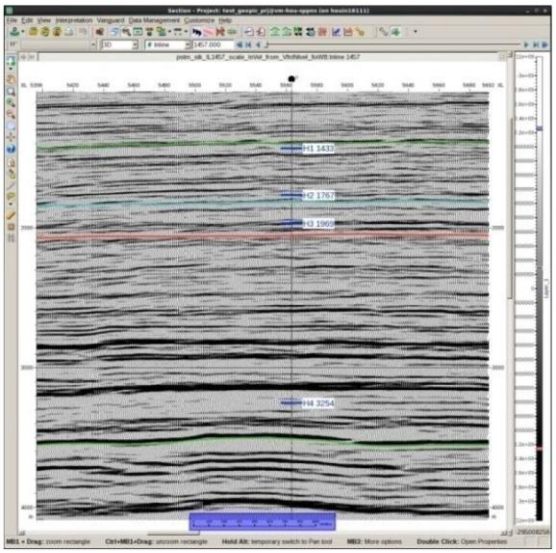

Fig.5: Showing mismatch before Tomography

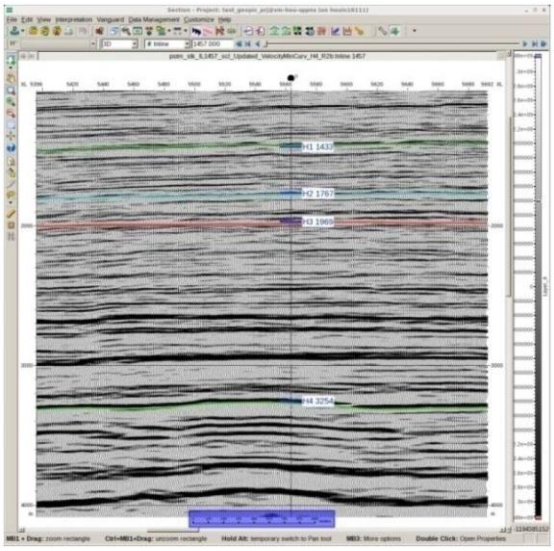

Fig.6: Showing a very good match after Tomography

Conclusions

Well tie tomography is a very robust solution for producing marker match with seismic and a geologically consistent velocity. The anisotropic mode can be run to solve for Thomson delta parameter to derive anisotropic model.

The views expressed in this paper are solely of the authors and do not necessarily reflect the views of their organization.

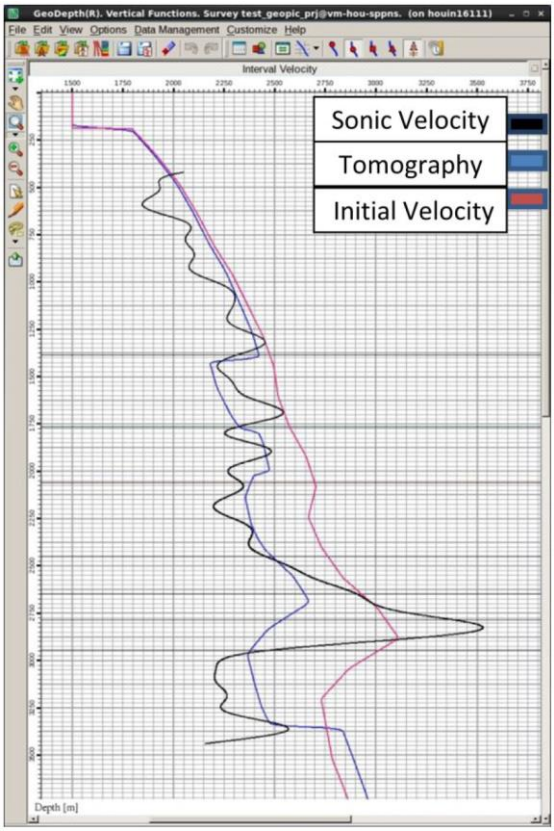

Fig.7: showing comparison of velocity before and after welltie Tomography with Sonic velocity. Note the good match between Sonic and welltie velocity.

Acknowledgements

Authors are tankful to ONGC for giving permission to publish this paper. We also acknowledge Paradigm for support on WellTie Tomography during this project.