Challenges in Well tie Tomography depth migration processing -A case study from Upper Assam Shelf, A&AA Basin

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Keywords

WAZ, Local Angle Domain (LAD), Full-Azimuth Angle-Domain, Specular and Diffraction Imaging

Abstract

The subsurface velocities cannot be uniquely determined by the surface recorded seismic data alone. Well information is used for reducing the ambiguity, generating a geologically plausible velocity model .In the presence of anisotropy, tying the horizons to the well markers play a critical role in the velocity model building workflow.
Conventionally, mistie between well marker and seismic horizons were derived in post stack mode.
A well calibration factor was calculated using the available well markers in the area. The well calibration factor obtained was applied in the depth stack volume. This will not yield an accurate velocity model. This is done at PSDM stack level.
To obtain the accurate solution well tie tomography was done in pre stack mode and anisotropic parameters were calculated in VTI mode.
The objective here is to find a velocity model that can be used for migrating the seismic data and can yields flat gathers with minimum mistie.
This paper discuss the Well tie Tomography in prestack mode, challenges encounter and their probable solutions to get reliable geological consistent velocity model.

Introduction

Upper Assam Basin is a composite foreland basin which is located between the eastern Himalayan foot hills and the Assam - Arakan thrust belt. The basin is confined to northeast by Mishimi Hill block and to southwest it is partly disrupted by the Shillong plateau basement uplift. It is in the northeastern part of the Indian Plate. The compressional forces have generated a number of thrusts outcropping formations of Barail and Tipam groups in folded Schuppen belt to the east and southeast of study area.

Area of study

Lakwa area is located in the southern bank of the Brahmaputra River (Fig.1). The main formations of interest are Tipam, Barail, Kopili and Tura formations corresponding to Mio-Pliocene,Oligocene and Eocene formations respectively. The targets occur at a depth range of 2400 to 3150 m. The objective for the survey was to map thin sands in the Kopili and Sylhet formations, as well as the fractures in the basement.

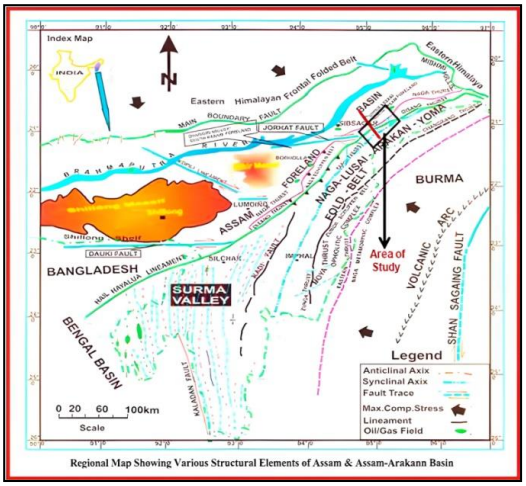

Fig.1: Area of study

Methodology

The residual statics-applied time gathers and RMS velocity volume is used as input for study. For well tie tomography twenty six wells and seven depth horizons were utilized. The initial depth-interval velocity modelling is performed from refined RMS velocity using constrained velocity inversion (CVI). Constrained Dix inversion (CVI) imposes geological boundary conditions in inverting RMS velocity to interval velocity.

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The Time horizons are image ray map migrated to depth model maps using the initial depth-interval Residual moveouts (RMOs) are auto picked in 3D LAD reflection angle-azimuth gathers in a dense manner.

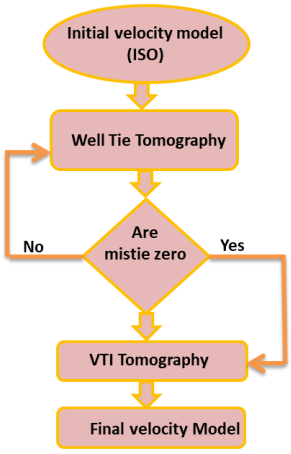


Fig.2: General processing flow diagram

Tomographic matrix is then built and solved in isotropic mode with optimized parameters. The updated isotropic depth interval velocity shows the anomalous lower velocity. The lowering in velocity is caused by presence of multiples in data. value and needs to be corrected.

Four iterations of grid based full azimuth tomography are performed that compensate the RMOs, flatten the gathers, updates interval velocity and give updated depth model maps and flattened the depth gathers up to incident angle of 30 deg.

After Grid tomography, Well-tie tomography was performed in isotropic mode and anisotropic parameters were calculated using VTI.

The purpose was to create a velocity model which provides flat gathers and minimum mistie. Mis-ties map were used in tomography for updating interval velocity and anisotropic parameters.
The updated interval velocity along with epsilon and delta field with the input residual gathers was used for ES360 PSDM.

Challenges
Majors challenges encounter are
1. Anomalous velocity due to presence of multiple

Fig.3 shows the wells used in study.Fig.4 shows the anomalous low interval velocity observed due to presence of multiples. Proper QC of initial velocity model should be done to get better interval velocity model. Input CMP residual gather should be conditioned properly to get better RMO picks and better initial interval velocity

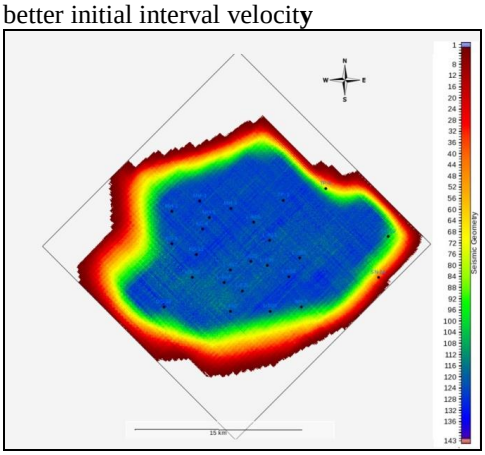


Fig.3: Location of wells (data used in the project) on acquisition fold map

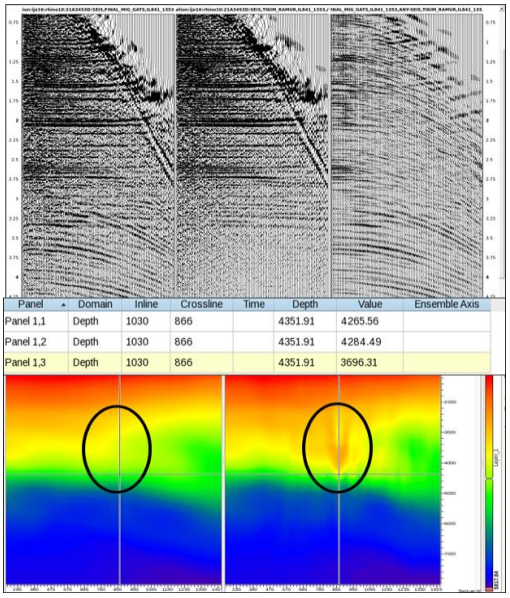


Fig.4: QC of input CMP Gather and Conditioned data &corresponding interval velocity QC.

2. Well tie Tomography and QC of mistie maps

Well tie tomography was the major challenge in the whole study. For well tie Tomography twenty six wells and seven depth horizons were utilized. The target is to get reliable velocity model with minimum mistie and flat gathers.

Mistie maps were generated at seven levels i e Namsung, Girujan, Tipam, LCM, BCS and Basement and it was observed that initial mistie is varying from 47m to -272m from shallower to deeper horizon.

As shown in Fig.5. Mistie maps obtained, shows both positive and negative misties. Negative mistie means well marker is above the horizon while positive mistie means marker is below the horizon .

Mis-ties from the initial model should generally be negative (interpreted reflectors are deeper than their true location). This is due to the fact that if the true model is anisotropic, the isotropic velocity is actually higher than the true vertical velocity.

Fig. 5 also shows the flatness of gather after well-tie tomography. The flatness of gathers got disturbed after well tie tomography.

Even after eight to ten VTI tomography iterations the gathers not got flattened. VTI2VTI and Grid tomography was also performed, but solution is not achieved. Big mis-tie values from certain formations yield unsatisfactory results.

To overcome this problem, detailed QC of well markers along with the depth horizons was done. All horizons were discussed and every well markers was checked with the Basin team and wherever required correction is made in horizons and well markers.

With the interpretation support basement is re-picked and mistie at basement level got minimized. Mistie maps were generated again using the corrected horizons and well markers and these maps were used for Well-tie tomography.

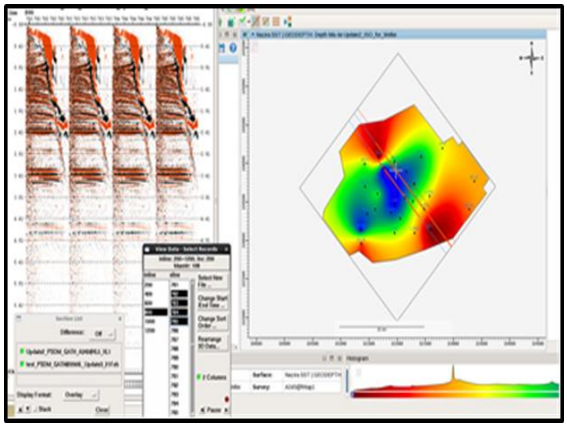


Fig.5: QC of PSDM Gather after mistie and mistie map at Namsang level.

3. Selections of depth Horizons

Initially nine depth horizons were received from the interpretation team. Some of the horizons were very near to each other and two horizons were dropped.

Well tie tomography was performed incoporationg seven horizons. In QC the low velocity is observed, at Sylhet level.

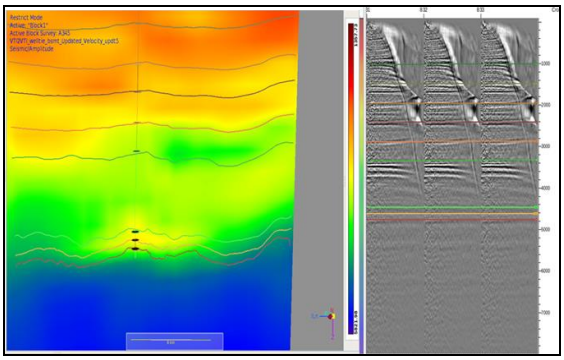


Fig.6: QC of interval velocity model and PSDM Gather flatness after well tie tomography

Fig.6 Shows the QC of interval velocity model and PSDM Gather flatness after well tie tomography. The anomalous low velocity is very much localized and studied and it was found that interval velocity is not satisfying the well velocity and gather flatness. Detailed QC of well markers along with the depth horizons was done. The sylhet horizon was dropped.

Derived interval Velocity is then calibrated with wells velocities. PSDM gathers flatness was checked and QC. Once interval velocity model got finalized, VTI was performed using constrained epsilon and delta and interval velocity is kept unchanged. As a result PSDM gather flatness has improved beyond 30 degree.

Results

Fig. 7 shows the initial PSDM gather and Final PSDM gathers. PSDM Gathers were quite flat beyond 30 deg. also.

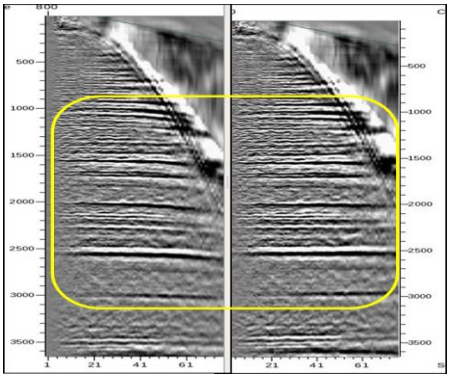


Fig.7: QC of interval velocity model and PSDM Gather flatness after well tie tomography

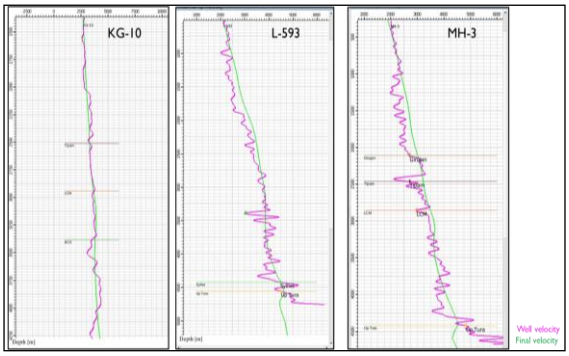


Fig.8: Well Velocity Vs Interval velocity QC at different well location

Fig.8 shows the derived interval velocity which quite well matched with well velocity. Fig.9 shows the final mistie which is quite low.

This shows that well tie velocity not only produces good marker match it also produces a geological velocity.

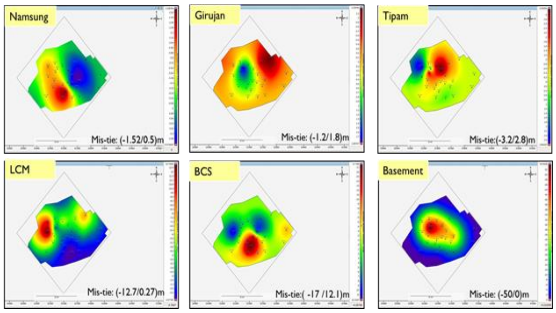
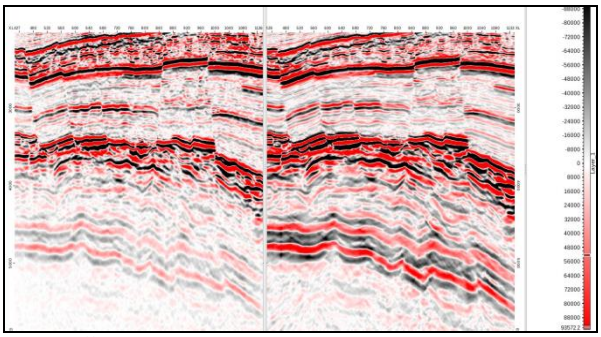


Fig.9: Final Mistie Analysis at different levels



Kirchhoff PSDM **ES360 PSDM Specular Stack**

Fig.10-Comparison with Kirchhoff PSDM Vs. ES360 PSDM Specular Stack

Fig. 10 shows comparison with Kirchhoff PSDM Vs. ES360 PSDM Specular Stack. At all the levels the stack has been improved.

Conclusions

Welltie Tomography is a full tomographic inversion procedure used to correct depths of seismic reflectors using depth mis-ties and reducing the ambiguity, generating a geologically plausible velocity model. Well tie tomography is iterative procedure and should be QC. Well tie tomography is performed in pre-stack domain yields better results corroborating with the geological markers. At all the well locations the interval velocity is better matched. The derived interval velocity model fits well where wells not present. The challenges that were encountered helped us to reach to a better solution.

NB: Views expressed in this paper are those of the author(s) only and may not necessarily be of ONGC.

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