Figure2. Shows the extracted interval velocities in time domain along the horizon before and after smoothing applied.

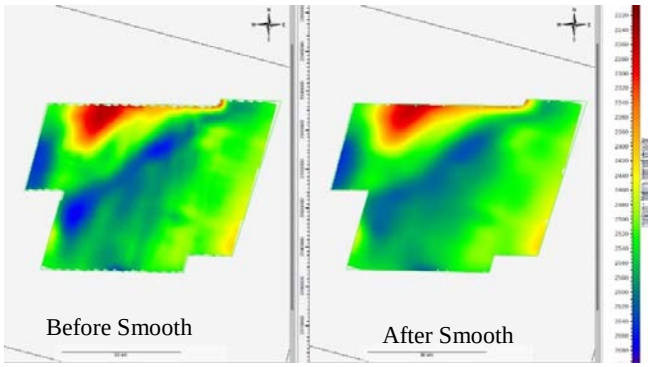

Figure 2. Interval Velocity (time domain) before and after smooth

After smoothing the velocity along the horizons, Interval velocity volume in time domain was made. The Interval velocity in time domain was converted to depth domain by DIX method shown in figure 3.

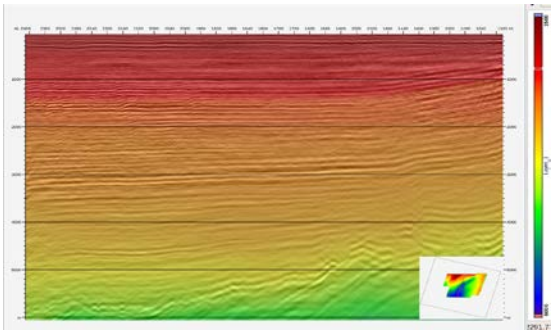

Figure 3. Initial Interval velocity along one inline

Tomography was run in isotropic mode on initial interval isotropic velocity. The inputs like dip, azimuth, and continuity volume along with the residual moveout picks from target line PSDM were given to update the isotropic velocity model. The comparison of initial isotropic velocity and updated tomo isotropic velocity along one inline was shown in Figure-4. The anisotropic tomography velocity updating was carried out by estimating the delta from the log & seismic velocity. The seismic velocity was scaled close to the well velocity by providing the trend from the sonic velocity. The Geostatistical velocity volume was created with splicing the isotropic velocity volume and the P-velocity from the logs.

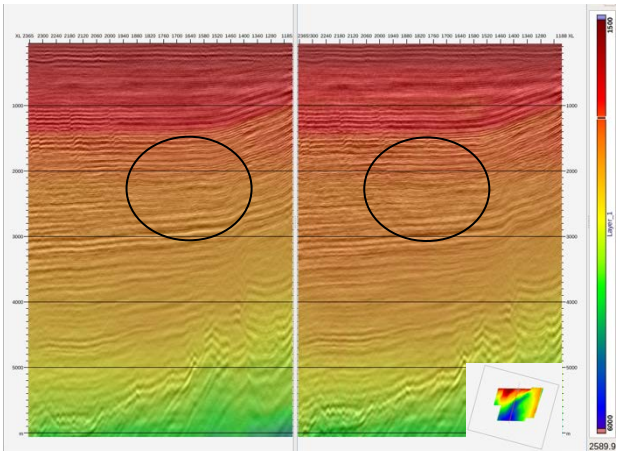

Figure 4: Initial isotropic velocity (Left) Tomo isotropic velocity (Right)

As many as 26 wells distributing across the area were considered for creating geostatistical velocity volume. The black dots in figure 5 shows the distribution of wells that are taken into account during velocity model generation. Figure 6 shows the geostatistical section of velocity at a well location at inline 2150.

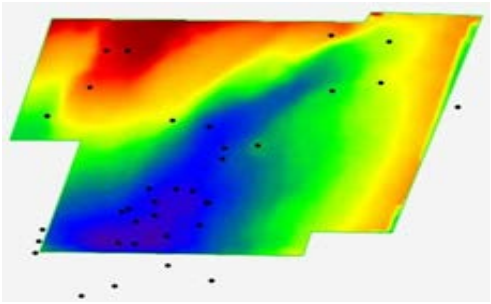

Figure 5. Location of wells in the area

Both final isotropic volume and Geostatistical volume was converted to time domain using DIX conversion. Constrained Velocity Inversion was applied between the Isotropic Volume and the Geostatistical volume as trend to generate initial

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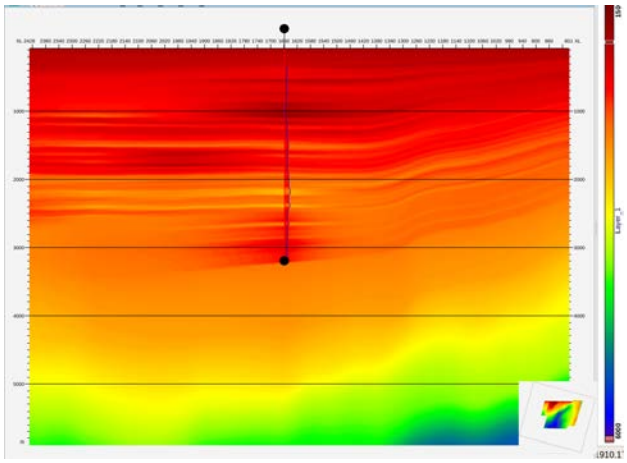

Figure 6. Geostatistical volume across well IL 2150

anisotropic volume. Constrained velocity inversion finds the global solution applying the least squares to fit. Few noisy data points are ignored here and it gives a smoother volume. Figure 7. Shows comparison of Geostatistical velocity and Initial Anisotropic Velocity at inline 2150.

Delta function was derived from this anisotropic volume (V_v) and updated tomographic iso-velocity volume (V_{nmo}) using the relationship in equation (1) above. For initial update, epsilon volume was taken same as that of delta volume. Target line PSDM was run with the Initial Anisotropic volume, delta and epsilon volume.

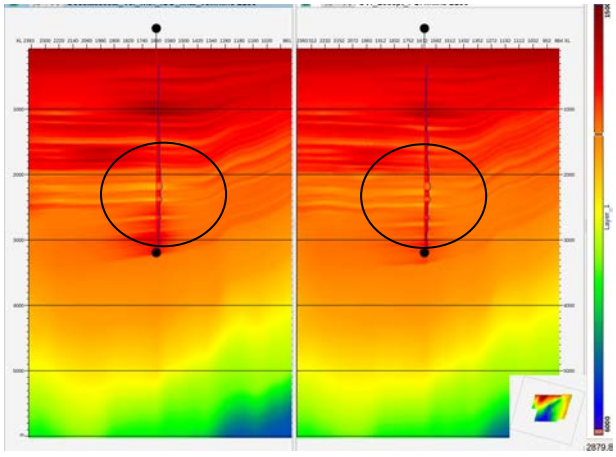

Figure 7 Geostatistical Velocity (Left) Initial Anisotropic Velocity (Right)

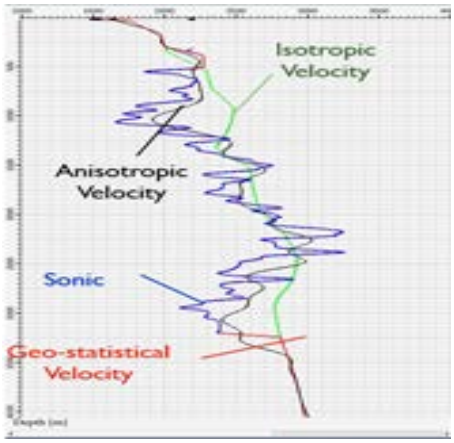

Figure 8. Vertical functions extracted at well location

Stack was made from the target line PSDM gather and seismic attributes (Dip, Azimuth & Continuity) was extracted from the stack. Auto picker was run in gathers to find the residual move out of the primaries. There after grid-tomography was run to update the initial anisotropic velocity. Figure 9. Shows the comparison of Initial Anisotropic Velocity and Anisotropic 1st Tomography updated.

After 1st tomography approach was applied on the Initial Anisotropic Velocity, it was observed that output gather has become flattened and stack quality

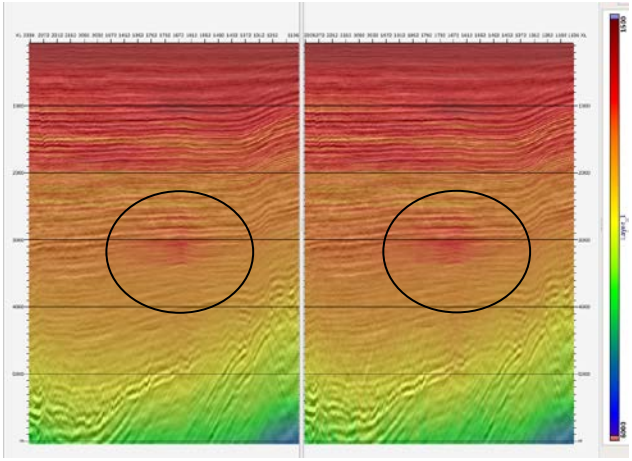

Figure 9 Initial Anisotropic Velocity (Left) Anisotropic 1st tomography (Right)

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improved. This was because proper delta function was calculated during the tomographic approach. Figure 10. Shows the comparison of gathers before and after Anisotropic 1st tomography.

Migration algorithms that set-out to handle lateral parameter variation (depth migrations) require the parameters to be in their true subsurface locations, and not arbitrarily posted vertically below the analysis points. In order to achieve this, we have to analyse parameter information for each offset independently, effectively looking back along each 3D raypath to assess which parts of the subsurface have been traversed by energy arriving at a given receiver: and this requires a tomographic inverse solution.

To update velocity obtained from 1st anisotropic tomography, 2nd time tomography was run. For that target line PSDM was run with 1st updated anisotropic velocity. Gathers obtained from target line PSDM was stacked. Attributes of dip, azimuth and continuity was extracted from the stack. With these inputs, tomography was run for the 2nd time to update the velocity. This velocity here was considered as final updated anisotropic velocity.

Figure 11 shows the improvement of velocity after 2nd Anisotropic Tomography over 1st anisotropic tomography.

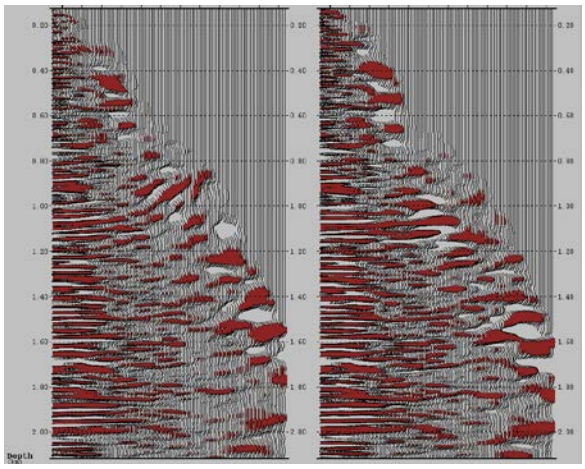

Figure 10 Gather's after Initial Anisotropic Velocity (Left) Gather's Anisotropic 1st Tomography Velocity (Right)

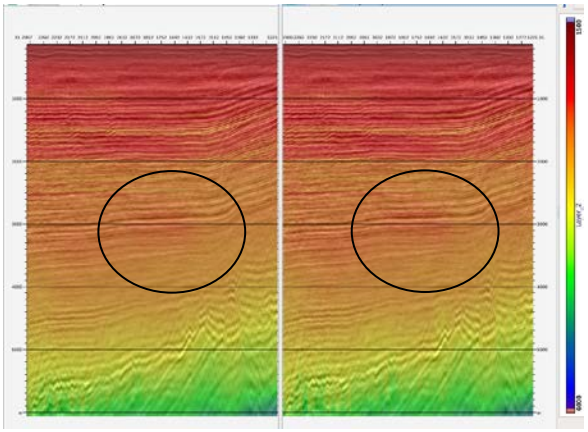

Figure 11 Anisotropic 1st tomography velocity (Left) Anisotropic 2nd tomography velocity (Right)

Well-tie tomography was applied on Anisotropic 2nd updated velocity to reduce the mis-ties. Time migrated horizons were map migrated to depth horizons with the velocity of final anisotropic volume. Mis-tie was calculated at each well (depth difference at well markers with depth horizons). With these inputs of mis-tie, well-tie tomography was run. The velocity which was obtained after running well-tie was the input for migration. Figure 12. Shows the comparison of Anisotropic 2nd tomography and well-tie tomography.

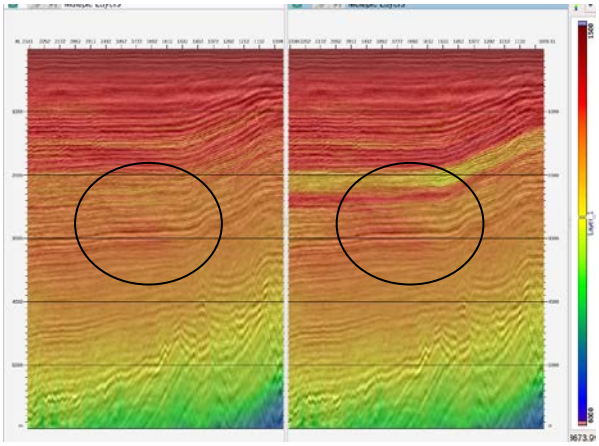

Figure 12 Anisotropic 2nd tomography (Left) Well-tie tomography (Right)

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Results

The RMS velocity which was extracted along the horizons was not smooth and hence smoothing was required. It is often better to apply smooth on data along the horizons (if we have confidence on horizon) than on the whole volume of data. If sonic velocity is incorporated from the logs then good anisotropic velocity can be obtained. From the vertical functions extracted at a well location, it can be observed that Isotropic velocity is having higher values than the anisotropic velocity. Anisotropic velocity is smooth one which was generated by CVI using both Geo statistical Velocity and Isotropic velocity. The anisotropic parameter (initial delta) was derived from this initial anisotropic volume and grid-tomography updated isotropic interval velocity volume using equation 1 above. Figure 8. Shows the vertical functions extracted at the well location for Isotropic Velocity, Anisotropic Velocity, Geostatistical Velocity and Sonic Velocity.
The velocity which is generated through hybrid approach, gives the most accurate results and it also matches with the sonic log. Figure 13 shows that the improvement from the Initial Interval velocity to final velocity.

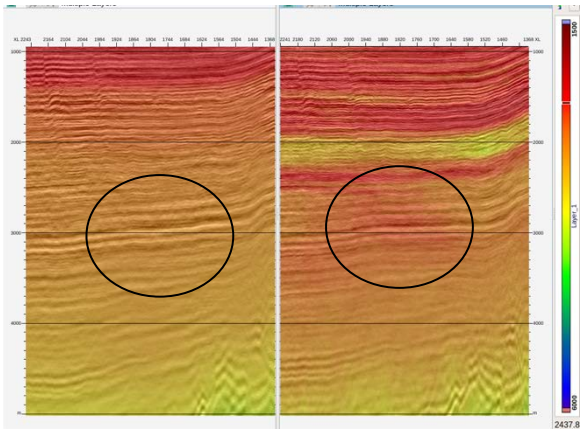

Figure 13 Initial Interval Velocity (Left) Well-tie tomography velocity (Right)

Conclusions

Generally, in depth imaging, depth calibration using well-tie updated velocity is applied in post stack data. Well calibrated velocity is most correct one as it positions structures at the proper places. In this case a final interval velocity model is achieved through combination of various techniques (Hybrid approach). This approach of velocity model is able to incorporate the small velocity variations within the layers as well as along lateral direction. The velocity anomalies captured in the volume match quite better way at well locations. Depth migration using this hybrid approach velocity not only gives flat depth gather but good match with the well tops and better focusing. Figure 14

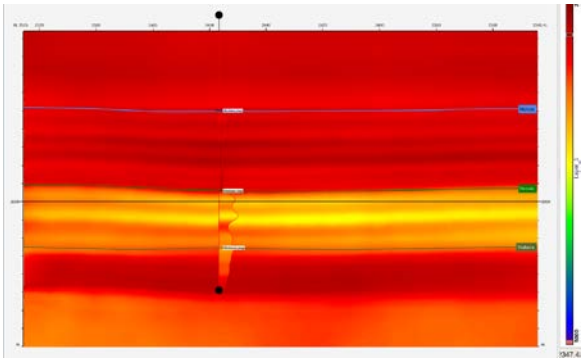

Figure 14. Displays velocity matching with P-velocity log at well location with markers

The views expressed in this paper are exclusively of the authors and need not necessarily match with official views of ONGC.

Reference:

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