Imaging for a Sharper Subsurface View Through PSTM

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Summary

PSTM is a more advanced and technically accurate processing algorithm, and due to the reduction in the cost of the computing power, it is being used in large scale as an exploration tool. In this paper we have shown that the conventional methods for velocity field building can provide a good rms velocity field used for PSTM stack. Subsequently, this can be used for intial velocity model building for depth domain processing. The value of 3D PSTM over 3D PoSTM has resulted in significant improvement in the image quality. The byproduct of PSTM Processing, CRP gathers through Kirchoff algorithm can regularize our acquisition geometry, which is evident from the fold distribution plot. This uniformity in fold can help in focusing the exploration targets with confidence. Further, imaging capabilities of PSTM was shown by generating attributes to prove that interpreters have more confidence in delinations of reservoir parameters.PSTM is a more advanced and technically accurate processing algorithm, and due to the reduction in the cost of the computing power, it is being used in large scale as an exploration tool. In this paper we have shown that the conventional methods for velocity field building can provide a good rms velocity field used for PSTM stack. Subsequently, this can be used for intial velocity model building for depth domain processing. The value of 3D PSTM over 3D PoSTM has resulted insignificant improvement in the image quality. The byproduct of PSTM Processing, CRP gathers through Kirchoff algorithm can regularize our acquisition geometry, which is evident from the fold distribution plot. This uniformity in fold can help in focusing the exploration targets with confidence. Further, imaging capabilities of PSTM was shown by generating attributes to prove that interpreters have more confidence in delinations of reservoir parameters.

Introduction

Imaging the subsurface in a complex area is a difficult task, and the cost of computation time through PSTM / PSDM has made it a costly affair. It is also a wellestablished fact that post stack migration holds up fairly even, if there is a strong lateral velocity variations to some extent, but after a particular level of velocity variation, the migration breaks down, and so prestack imaging is required. An additional advantage of prestack imaging is that, it has the potential to retain amplitude variation with offset and phase change. It is also a well accepted fact that optimal seismic imaging in the area of complex structural geology can only be achieved by depth domain processing through valid velocity depth model; however CRP gathers the byproducts from PSTM can be used for building a better intial velocity model required by prestack depth migration. In this paper, we have stressed more on building a 3D velocity field, which would be used for prestack time migration for imaging and positioning subsurface images, and this velocity model lays a foundation for the iterative velocity-depth model building. Further the 3D PSTM algorithm can also take care to get regularize acquisition geometry, so that the acquisition footprint on migrated volume is reduced to a greater extent.

We have further shown that once the geometry has been regularized by the attributes analysis carried over both PSTM and PoSTM shows that attributes generated over PSTM section can help in better delineation of structural and stratigraphic features.

3D Velocity Field Building

Imaging practitioners often states that *"we really have the velocity problem and not the migration problem"*. The velocity field tells the migration algorithm, how far to position and image, the reflecting events, at the correct locations. Inadequate knowledge of velocity results in the image being over or under migrated. During the process of velocity field building, we have stressed more on manual picking of velocity from semblance plot and verifying the reliability of that picks, as prestack time migration is sensitive to small velocity variation.

Methodlogy

The methodology used for building 3D velocity field was based on conventional approach. The steps used are as follows:-

- Non-NMO corrected residual statics applied volume was used, and velocity analysis was performed on time and spatially corrected data, to produce a velocity field. This velocity field was later used for full prestack time migration. The output obtained was in the form of CRP gathers.

- The CRP gathers were the basis for refinement of the velocity field, an inverse NMO was applied to these CRP gather and a second pass velocity analysis was performed in the form of close grid the base map of velocity control point is shown in fig 1.
- An rms velocity field was generated. The velocity control points, on the velocity field, were further refined through composite velocity plots, taken for each chosen velocity line, on a velocity field, by refining the anomalous velocity values shown in fig:- 2.

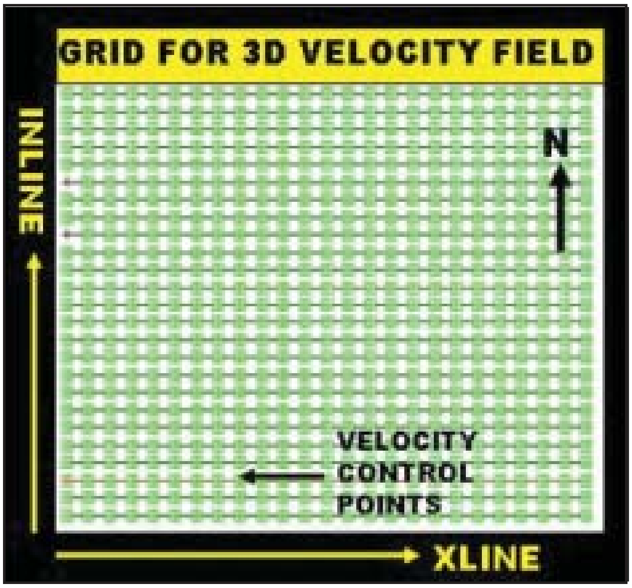

Fig. 1 : Grid showing the velocity control points

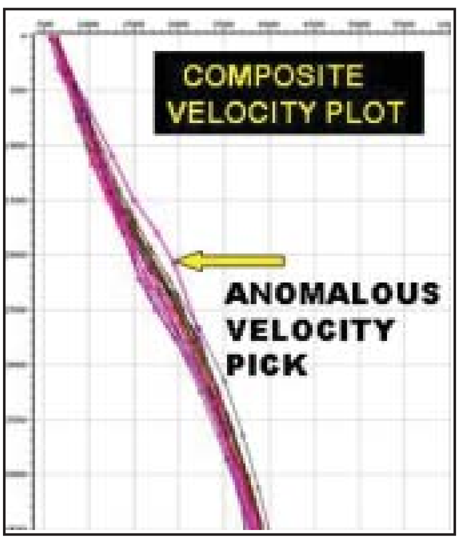

Fig.2 : Composite Velocity Plot

- After the velocity field was built, it was applied on inverse nmo applied gathers of the selected lines, to observe the flatness of events on the PSTM gathers. Since variations on the imaging velocity were observed, the velocity field was varied by selecting percentages (i.e. 5% increment) and several panels were outputted for each selected lines, as shown in fig: 3. Optimum velocity panels were picked by observing the flatness of the events on the gather.
- After the velocity field was built, composite stack plots were generated for the lines and, whenever required, reinterpretation of velocity was carried out.
- After the velocity field was finalized, velocity slices were taken from rms and interval velocity volumes, for checking the presence of any anomalous velocity zones. It is necessary to validate its authenticity through well velocities as shown in fig 4.

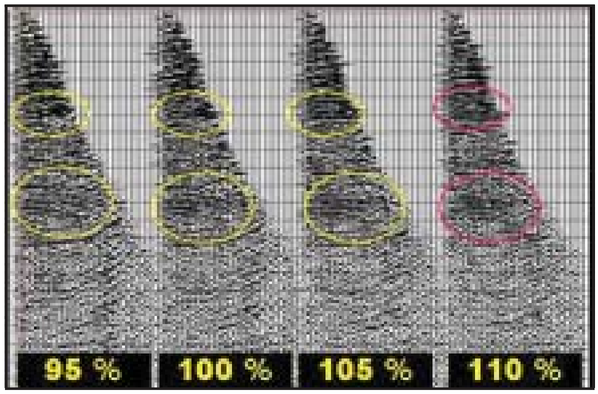

Fig. 3 : Validation of Velocity Field

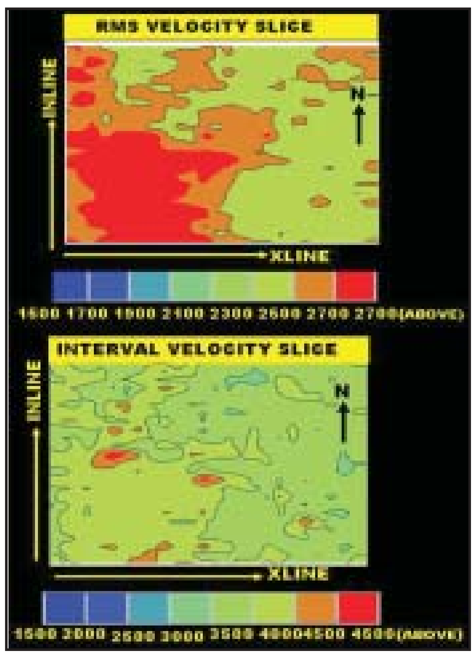

Fig. 4 : RMS & Interval Velocity Slice

Real Data Examples

Once the velocity field was finalized, we used this methodology to migrate the data volume shown in the following examples in prestack mode. These examples indicate better seismic imaged resolution with 3D PSTM in comparison to 3D PoSTM.

Example 1 : (Furkating Area)

The seismic section shown in fig: 5 are from the 3D PSTM and 3D PoSTM volume pertaining to Furkating Area (South Assam Shelf). The images clearly show that prestack time migration provided a higher resolution and a better structural image of the subsurface. The results are further validated from time slices shown in fig: 6, where the fault patterns are better defined and may be critical for the success of hydrocarbon reserves.

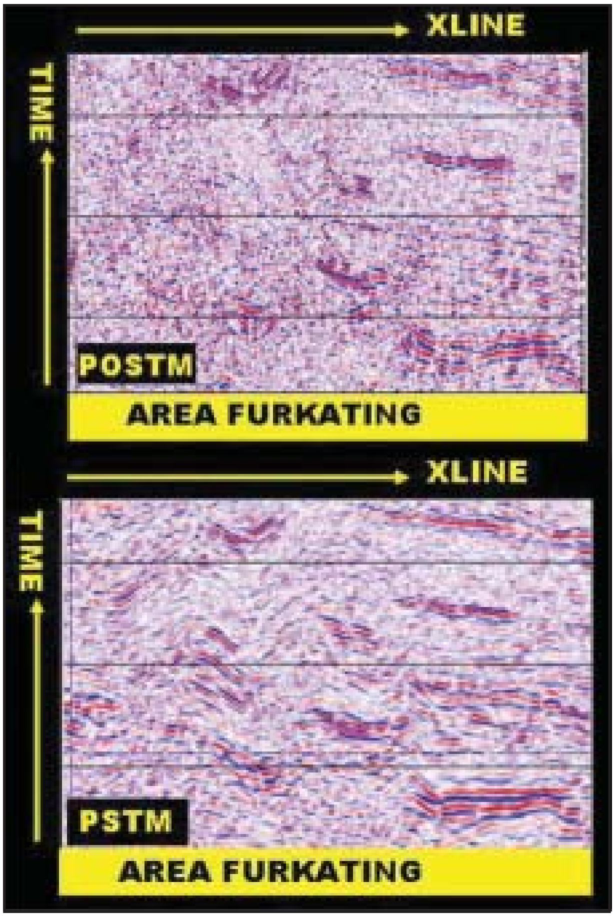

Fig. 5 : - Example-1

Example 2 (Panidihing Area)

The PSTM and PoSTM processed volume of north

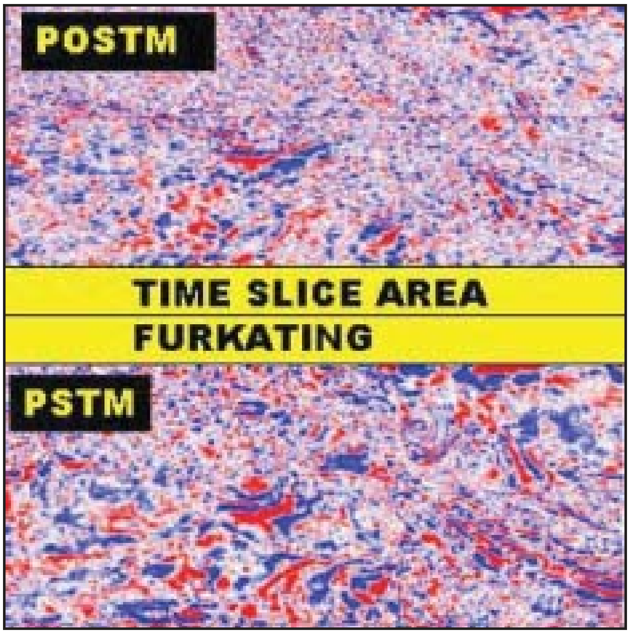

Fig. 6 : Example-1

Assam shelf is shown in fig: 7. With a good intial velocity field, we can achieve a high quality migrated stack, because of proper positioning and imaging of the reflection events. The Encircled area in fig: 7 clearly indicates the improvement brought out with PSTM in disposition of the fault pattern. Moreover, the structural style is precisely delineated in PSTM volume. Further, the time slice shown in fig: 8 clearly indicate a much better resolution, imaging and fault delinations.

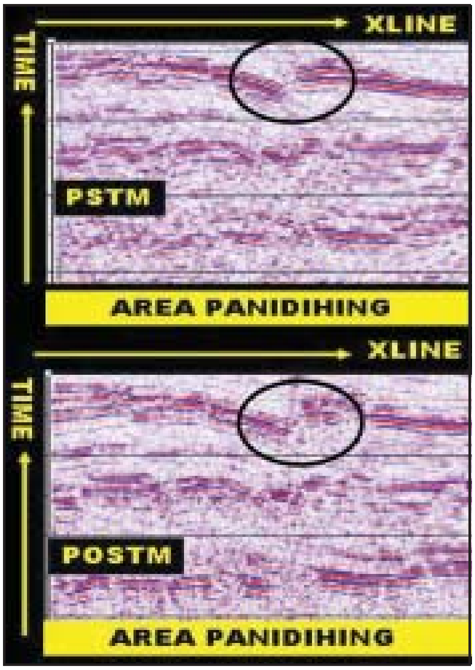

Fig. 7 : Example-2

Example 3 (Adamtilla Area)

Fig. 9 indicates a comparison of PSTM and PoSTM volumes in Adamtilla area of Cachar Fold Belt. Cross faults were delineated in the PSTM volume. Time slice of PSTM further shows the improved structural imaging and resolution in Fig 10.

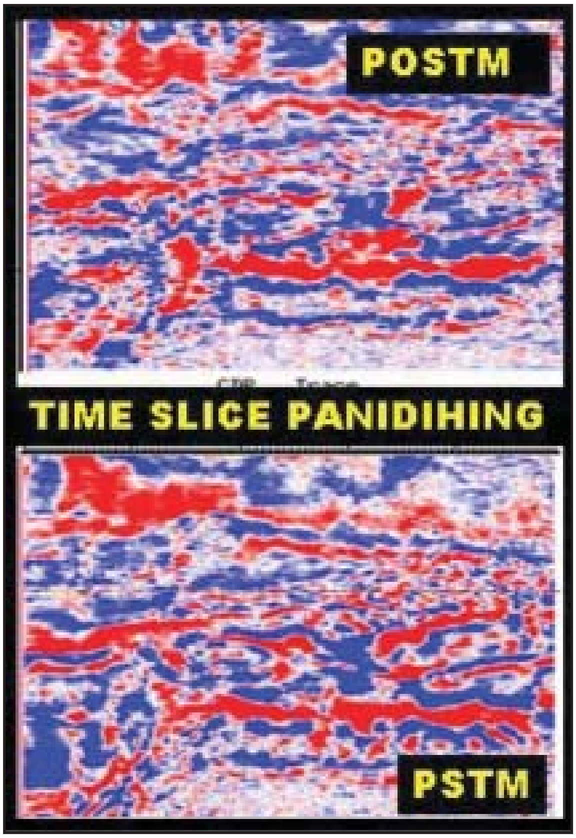

Fig. 8 : Example -2

Regularization of Geometry

It has been observed that the irregular acquisition geometry results in irregular spatial distribution of input traces. This result in contaminated migrated output showing acquisition footprints, which could result in incorrect interpretation and wrong generations of attributes, required for reservoir characterization. We strongly believe that the regularize output prestack CRP gather volume is a correct replacement for flexi binning technique, usually used for regularization of geometry, which many schools of thought consider outdated because of being replaced by advance interpolation techniques. The migrated output by Kirchoff algrothiom has regularized the data by considering that all input traces are located at the center of the bin regardless to true position.

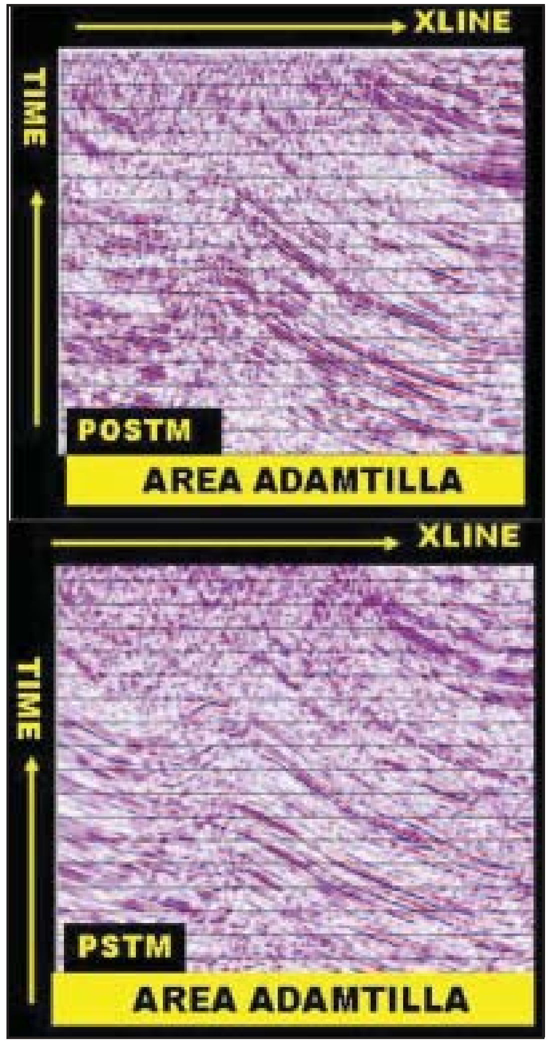

Fig. 9 : Example -3

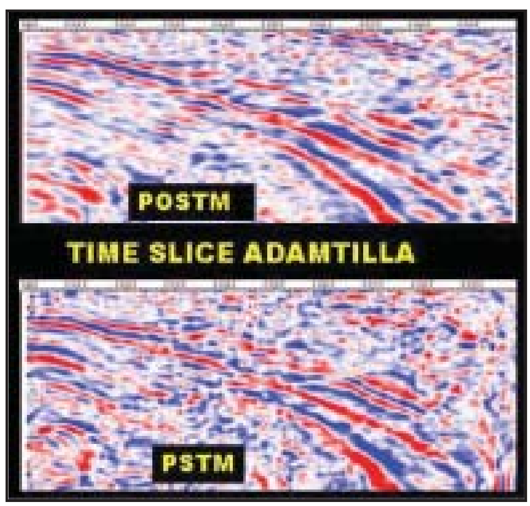

Fig. 10 : Example -3

However, the true azimuth and offset valves of all input traces are preserved; this is evident from the fig 11. The fold map generated from PSTM volume shows a uniform fold as compared to PoSTM generated fold. This means that the subsurface is regularly sampled so that a uniform illumination of surface could be achieved.

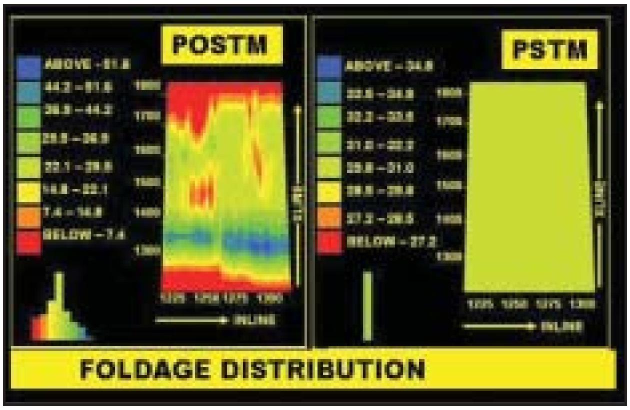

Fig. 11 : Fold Distribution

Attributes

The byproducts from the PSTM i.e. CRP gathers can further be used for pre-stack and post-stack amplitude inversion. In prestack mode, we can generate different AVO attributes to get the elastic properties of the underlying earth. We have generated attributes i.e. Amplitude envelope, instantaneous frequency and phase to prove the imaging Capabilities of PSTM over PoSTM. Fig: 12, 13 clearly shows that PSTM Attributes can give interpreter more information in term of structure and stratigraphic features, so that, at the later stage of interpretation, they can be directly helpful in recognition of depositional features, patterns, subtle stratigraphic features and lithology

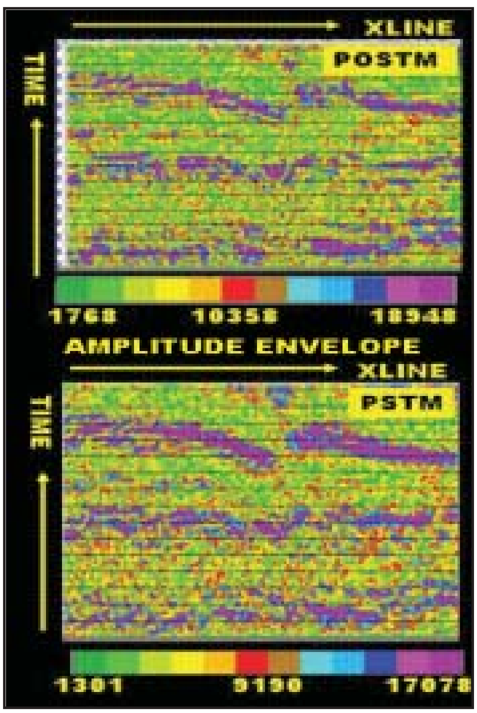

Fig. 12 : Amplitude Envelope

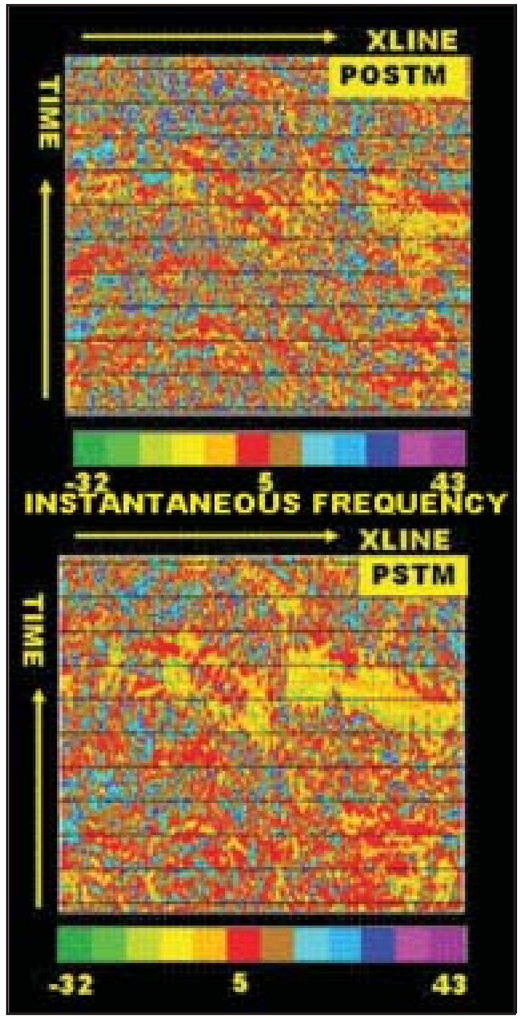

Fig. 13. Instantaneous Frequency

Conclusions

- CRP (common reflection point) gathers byproduct from PSTM serve as an ideal input for the AVO analysis, especially in the area of complex geology, and these CRP gathers are the basis for the further refinement of the velocity field.
- The enhance time migration velocity field can be later used to derive an intial velocity depth model for depth migration.

- Using Kirchoff algorithm for PSTM can help in regularization of acquisition geometry.
- The examples clearly show that PSTM images are less noisy and more phase continuous and these images clearly shows that the faults are better interpretable.
- Attributes analysis carried further proves the imaging capabilities of PSTM.

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