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Successful Application of Horizon Velocity Analysis for Imaging in Seismically Obscure Area:-A Case Study from Mumbai Offshore Basin

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Summary

Velocity undoubtedly is the asset upon which the entire understanding of the seismics relies upon. Apart from giving a meaningful look to the section it is also the measurable/derivable factor which directly relates to the geology of the subsurface. CDP methods made possible the analysis of Velocity from the acquired data itself for stacking of the data. Various techniques have evolved since then and accurate RMS velocity analysis is possible with image gathers.

Conventional velocity analysis (Vertical Velocity Analysis, VVA) provides velocity information at every time gates at selected CMP/CRP locations and velocity field are created with the interpolation techniques for all the CDP/CRP locations. This method of velocity analysis sometimes provides not so satisfactory results. Horizon velocity Analysis(HVA) is an efficient way to get velocity information at every CMP location along selected key horizons. Horizon velocity Analysis provides the detailed lateral velocity variations along a marker horizon, which may be missed by conventional velocity analysis that are sparsely spaced along the line. A velocity analysis were attempted in a project where objective was to improve imaging in Seismically Obscure Areas (SOA). This technique has successfully brought out the accurate velocity and hence resulted in the improvement of image quality in SOA. The 3D data set pertains to Mumbai offshore Basin and this paper deals with the methodology adopted for successful improvement in overall image quality of the subsurface

Keywords*: Horizon Velocity Analysis, Mumbai Offshore Basin, PSTM*

Introduction

Velocity analysis forms the backbone for creating seismic section from the seismic gather. With the revolutionary advent of CDP technique of seismic exploration it has become possible to extract velocity information at the desired spatial location. Stacking Velocity analysis is based on the assumption that move out on CMP gathers is hyperbolic. It is performed by scanning a range of velocities. For each velocity a move out is created. The coherency of the data within a defined time window, and along the calculated hyperbolic curve, is measured by computing semblance value. Stacking velocity analysis or RMS Velocity Analysis in vertical mode creates one semblance values for each CMP gather. Horizon based velocity analysis enables to create stacking/RMS velocity along the selected key horizon of interest. This principle of estimating the velocities by this method is the same as that of the velocity spectrum. The output coherency values derived by hyperbolic time gates are displayed as a function of velocity and CMP position.

Seismically Obscured Area (SOA) caused due to severe loss of amplitude suggests absorption or dispersion of compressional wavefield, Time sags at the reservoir level suggests low velocity above the reservoir and Gas within overlying sediments is a likely cause but its distribution is not understood. To delineate SOA , an accurate velocity model is required to obtain improved images. As RMS velocity analysis in vertical mode is carried out at discrete CMP locations its consistency along horizon is not maintained . It further worsens if the structure is complex in nature. For such cases horizon based analysis gives structurally consistent velocity. PSTM using such velocity analysis (Horizon Based) gives proper images and improve the result. This methodology was adopted in a three dataset pertaining to an area of Mumbai Offshore Basin (Fig.1). The objective of processing was to improve the data quality

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and resolution of the data in SOA to facilitate the better interpretation of the data.

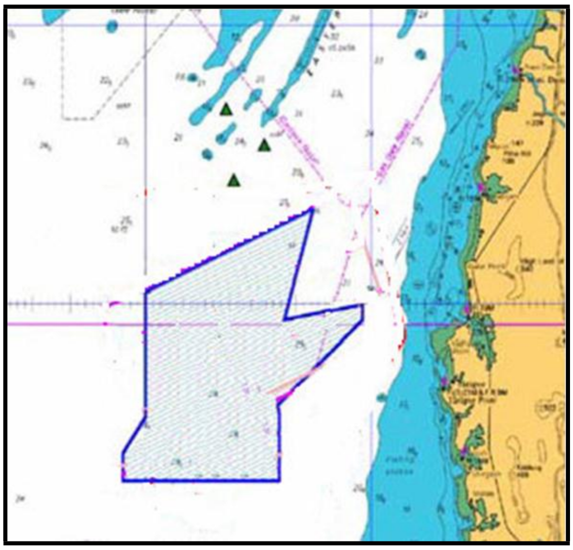

Figure 1: Study Area

Geological Setting

The Mumbai Offshore Basin came into existence during Upper Cretaceous times because of faulting of the Deccan Trap Basement. It is a rift basin evolved in a passive margin basin through four evolutionary stages in two major phases: 'Early rift' phase comprising of - Narrow rift valley stage and Proto-oceanic stage and 'Post Rift' phase comprising of – Shallow marine platform stage and Open marine stage. The stratigraphic fill of basin consists of Tertiary sediments, which are in places more than 5000 mts thick. Initial subsidence in Trap basement and deposition of probably Trap-derived fine clastics in isolated depressions started in Late Paleocene. During this time small depression developed in the Tarp Basement which were filled with finer clastics. This sequence was followed by a period of large scale faulting resulting into several horst and graben features which were filled with a dominantly finer clastics sequence alongwith presence of medium and coarse clastics indicating high energy conditions towards the margins of the basin close to the graben forming basement faults as witnessed in Cambay basin where these represent a coarse clastic sequence in general. This sequence shows large thickness variation, as its deposition is related to basement tectonics. Widespread transgression indicated by the extensive development of Panna marker and development of carbonate sequences during Middle Eocene.

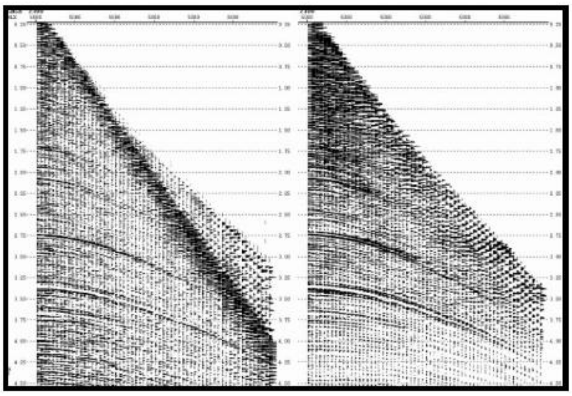

Figure 2: CMP gathers before and after noise elimination

Methodlogy

The scrutiny of CMP gathers revealed that the gathers were contaminated with trapped energy and other noise and events are visible only at near offset (fig2). Hence to overcome this, noise elimination process was applied on the data. Six interpreted horizons with adequate time interval between them, were selected based on the data quality and zone of interest. In the first step target line migration was carried out using RMS velocity generated from vertical functions picked in vertical mode. Picking was carried out using inverse NMO. On this de-nmoed data, semblance was generated along all horizons selecting optimum mute(fig3). Picking was carried out at every 20thinline(i.e. 500m) . The output coherency values derived from hyperbolic time gates are displayed as a function of velocity and CMP position. Correlation values are computed from a gate that includes the horizon of interest and changes accordingly. Horizon times are digitized and input to the Horizon Velocity Analysis. After picking of RMS velocity in Horizon mode for all the horizons a RMS volume was created for final migration.

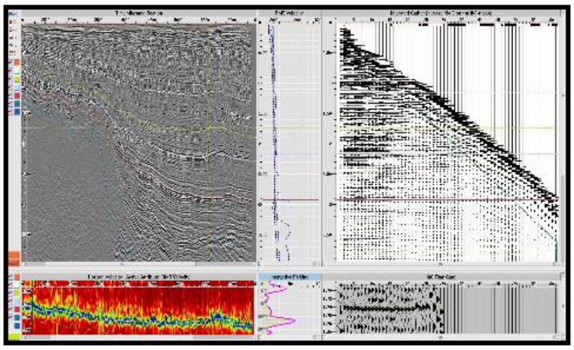

Figure 3: Horizon Velocity Analysis for the Horizon 3

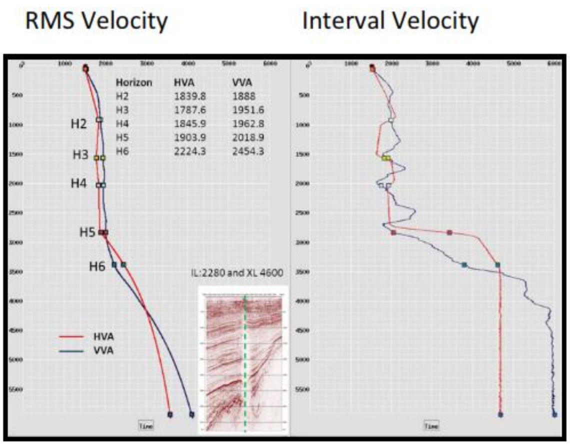

Figure 4: Comparison of Vertical Function obtained from HVA (red) and VVA(Blue)

Results

A comparative study was made between PSTM section obtained from horizon based and vertical based velocity analysis at seismically obscured area.Fig.4 shows the vertical function of vertical velocity vs horizon velocity extracted from volume. This shows that reduction in RMS velocity corresponding to horizon H3 ,H4&H5 has taken place. Horizon H6 shows slight increase in velocity both in terms of RMS and interval. Interval velocity between horizon H1&H2 and again horizon H3&H4 is fairly matching in both horizon as well as vertical based velocities.

Fig.5 shows comparison of velocity section obtained with vertical velocity analysis vs horizon velocity analysis. The lowering of velocity is evident in both the case, however it becomes more prominent and clearly discernible with volume created from horizon velocity analysis. The areal extent of the shadow zones is clearly identified.

The shadow zone in PSTM stack using velocity picked in vertical mode is clearly visible in fig6.Theimaging in this zone has been improved to a large extent with the use of velocity picked in horizon mode. Using the accurate velocity (horizon based velocity) proper imaging has taken place and continuous events are visible in obscured area, which were not focused by vertical velocity analysis. Thus one of the main concerns was adequately addressed.

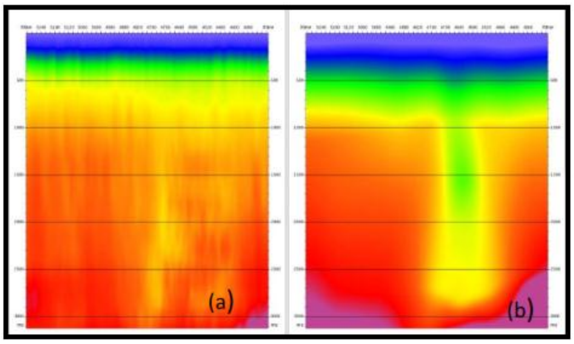

Figure 5: Velocity section from volume created by VVA (a) and HVA (b)

Conclusion

The image with vertical velocity analysis is severely degraded in comparison to horizon based.Horizon based velocity can help in demarking the zone of anomalous area in seismic section.Severe loss of amplitude suggests absorption or dispersion of compressional wave field,Time sags at the reservoir level suggests low velocity above the reservoir and Gas within overlying sediments is a likely causeand hence identification of such low velocity zone is necessary. Horizon based velocity analysis clearly brought out this anomalous zone and improved the image.Such an anomaly (lowering) in velocity within the sediments indicates the presence of gas (blowout position) as marked in figure6.

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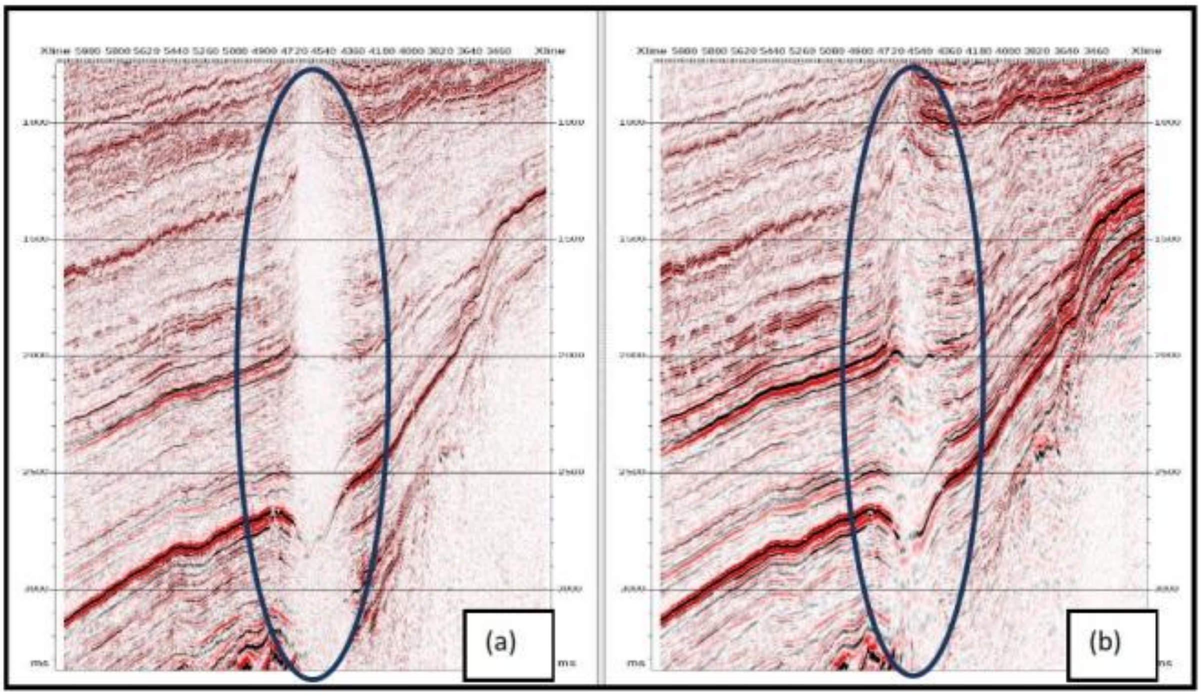

Figure 6: Improvement in PSTM Stack (b) compared with earlier PSTM section(a)