Enhancing the Imaging Quality of Pay sands and improving the deeper Paleocene and Cretaceous sediments through advancements in seismic processing and Full Azimuth Imaging from land & OBC data-a case study from KG Basin, India

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Abstract

With the conventional Kirchhoff PSTM & PSDM many imaging problems were addressed by the improvements in Kirchhoff migration algorithm, however it does not utilize the azimuthal information in migration process. Latest advancements in seismic processing like Geo-statistical interval velocity derivation and full azimuth imaging has improved many geologically complex and structurally deeper sediments . The study area falls in the Kesanapally West of KG Basin, where the subsurface is structurally complex due to the presence of shallow Mio-Plio cut surface, high-dips, rapid lateral structural variation and complex growth faulting. So imaging of pay sands and improving the deeper sequences is a challenging job here. In this work full azimuth imaging tool combined with well controlled Geo-statistical interval velocity was used. Significant improvements has been observed in terms of pay sand delineation, reflectors geometry, fault focusing and imaging of deeper sediments.

Introduction

The area comprises of both onland, transition zone and shallow water (Fig.1) seismic data was acquired using geophones on the land part & Ocean Bottom Cable (OBC) in shallow water part with different geometries. For the this study an area of 750 SKM comprising of 100 SKM onland data and 650 SKM offshore data processed with a bin size of 25mx25m. This paper describes the Interval velocity model building & processes and outputs of Anisotropic full azimuth angle domain depth imaging.

The study area (Fig.1) covers partly the present day onland and partly offshore part. Towards the southwest in the coastal tract of the study area lies the major hydrocarbon field(Fig.1) Kesavadasupalem(red box) that is producing hydrocarbons from Miocene . The other major hydrocarbon fields Kesanapalli west and Kesanapalli are in the central part. The sands of Eocene, Oligocene and Miocene are the main producers from these fields.

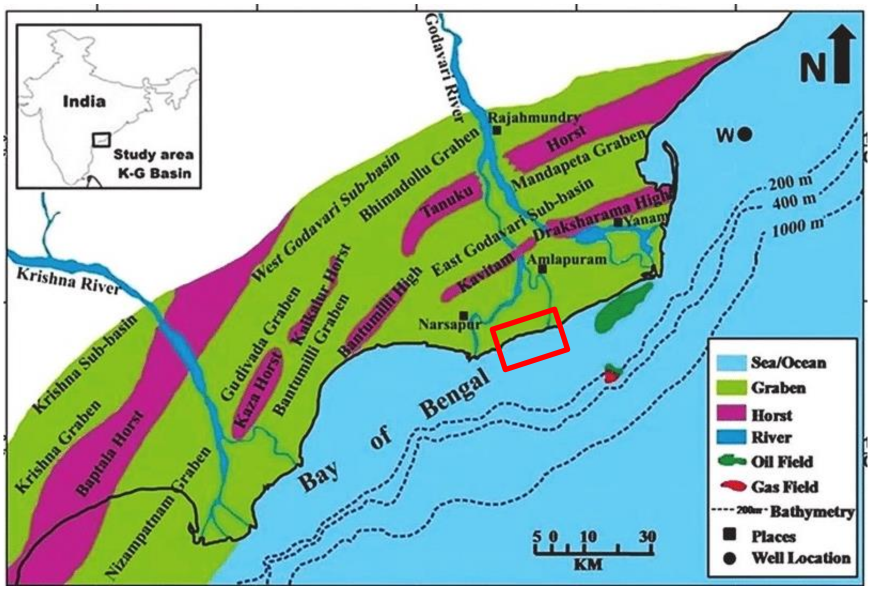

Fig.1 Location map of the study area (DGH)

Geology of the Area:

Krishna- Godavari Basin, located along the east coast of India, a pericratonic basin is vastly occupied by the deltas of both Krishna and Godavari rivers. The basin presents a fully developed passive margin sequence during Cretaceous Tertiary period, that rests over the Permo-Triassic rift fill sequence. The deltaic facies in the basin represents the Early Drift phase in the basin .

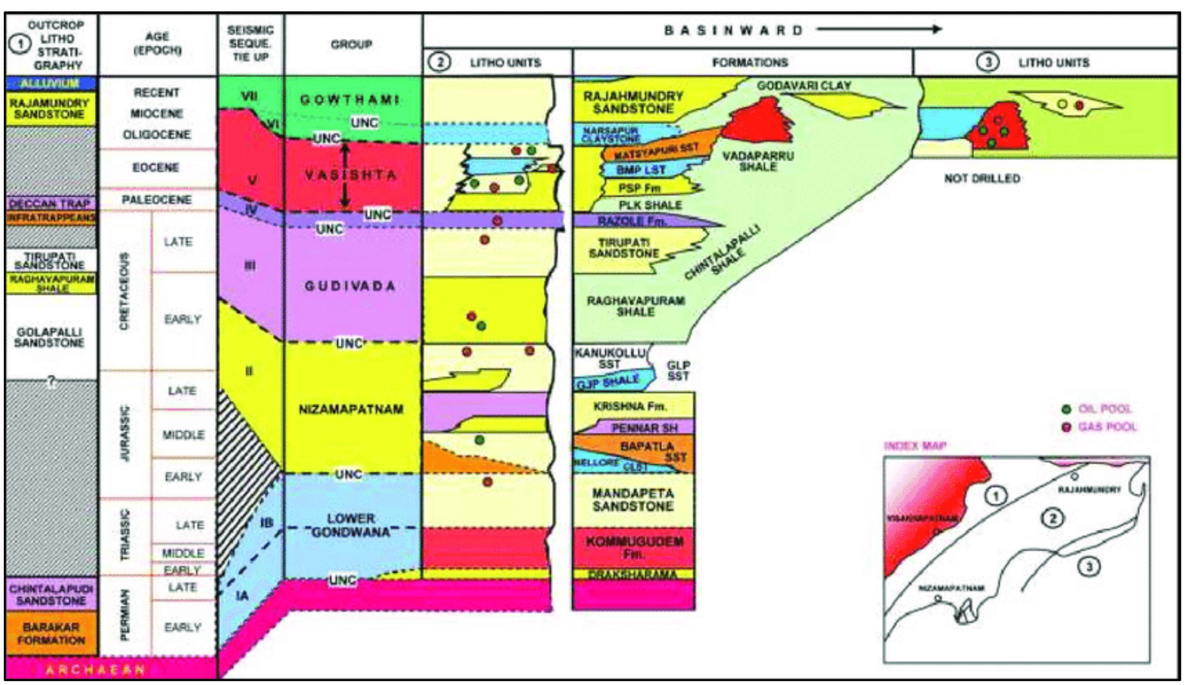

Fig.2 Generalized Stratigraphy of KG Basin (R. Venkatrangan et al., 1993)

In the onshore part, the Oligo-Miocene unconformity surface cuts the older sequences, resulting in erosional truncation and progressively younger sequences onlap the unconformity surface. This boundary corresponds to top of major Oligocene regressive phase. The sediments associated with the low stand deposition bypassed the shelf area, with subsequent erosion and were deposited on the basin floor. The Mio-Pliocene unconformity corresponds to a Late Miocene major global sea level fall. The unconformity is a prominent erosional surface, and the magnitude of hiatus spans between 22Ma and 2.5Ma (S.G.K. Mohan at all). The later part of Pliocene regression continued into Recent times.

Input data & Data Conditioning:

PZ summed Conditioned CMP gathers after Residual statics of OBC seismic data for shallow water and for Land part ,seismic data after residual statics applied CMP gather was used for the study. For the merging of OBC and Land seismic data a processing grid of 25 m X 25 m was chosen as the OBC data was acquired in 25m X 25 m grid, the most challenging job here is the matching of phase and amplitude . The both the data sets were individually processed for residual noise attenuation and signal conditioning and then the phase , amplitude and frequency was matched by keeping OBC data as base.

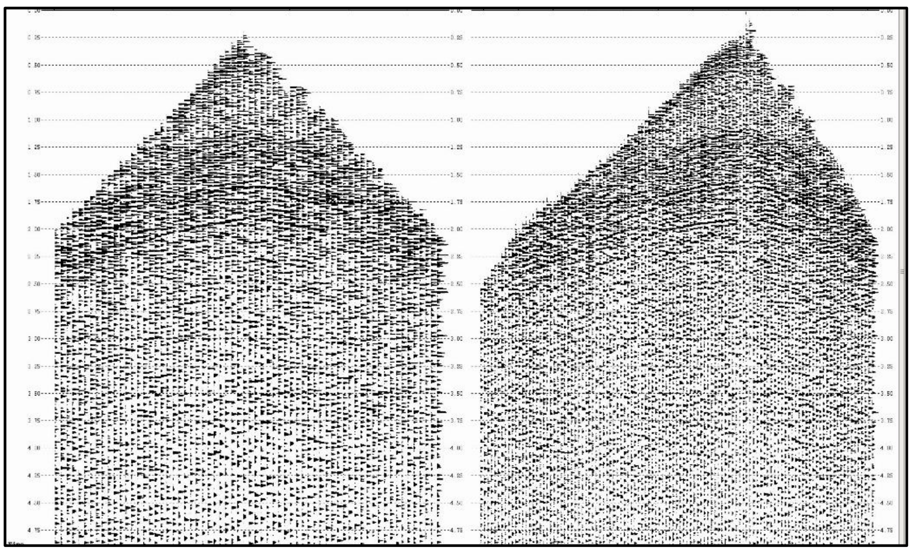

Fig.2a OBC CMP gather (Left) and Land &OBC CMP gather(right) after conditioning & matching.

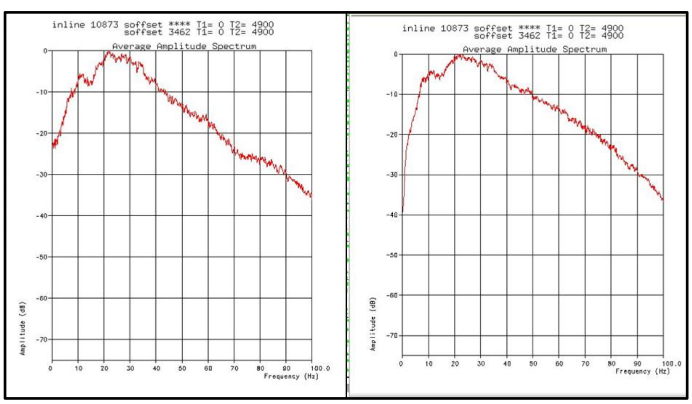

Fig.2b Frequency Spectrum of OBC CMP gather (Left) and Land &OBC CMP gather(right) after conditioning & matching.

Signal to Noise ratio enhanced after residual noise attenuation and matching (Fig 2a,2b& 2c), Residual statics were computed and applied on the merged gathers before offset regularization. A few gaps owing to missing near offsets were observed, which necessitated data regularization. Data regularization carried out with offset class increment of 100m in the bin size of 25mX25m.

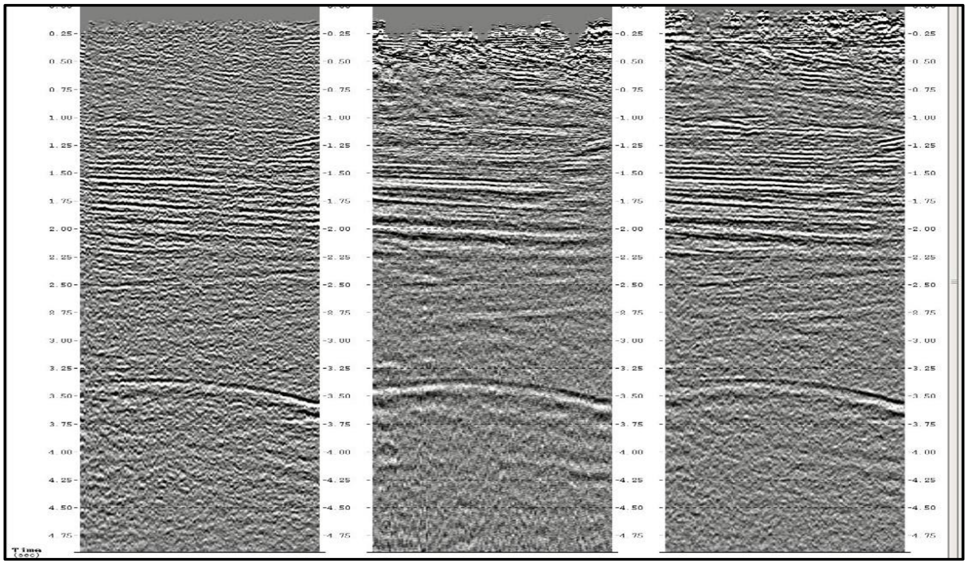

Fig.2c showing CMP stack of OBC(left),Land(mid) and stack after merge & Regularisation (Right)

Velocity model building:

All available geological information should be included in the starting model. Interval velocity model building incorporating well log data will enhances the imaging quality and reduces the well to seismic tie. To estimate the geologically realistic velocity field, an initial model(Dix) was prepared by using RMS velocity and later combined with Horizon interpretation(Fig3a) and well log data in Geo-statistical manner. Geo-statistical approach uses RMS velocity as a back ground and brings the interval velocity variations as per the sonic log data in structurally confirmable way(Fig 3b). This interval velocity which is then iteratively improved until the CRP image gathers are flat .

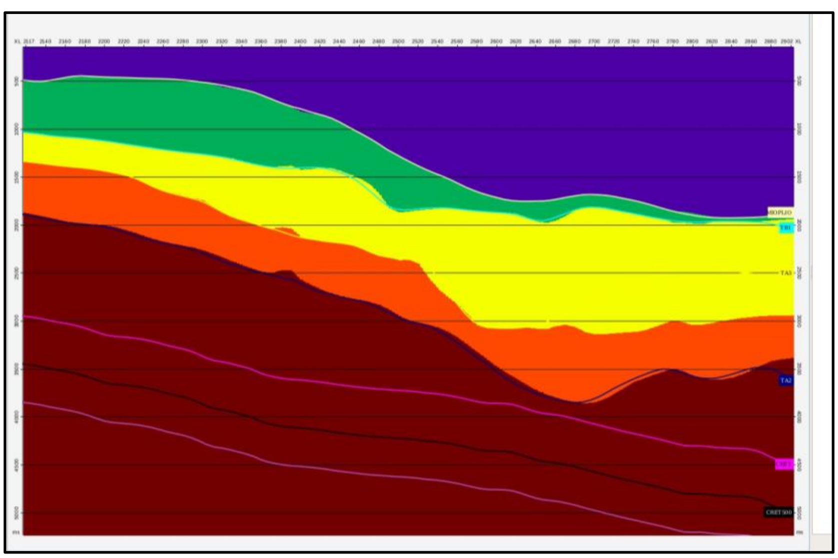

Fig.3a Geological Model used for Inverval velocoty Model building.

Velocity updating involves picking the residual moveout, calculating the ray paths for each picked horizon through the velocity model then performing a tomographic inversion that modifies the velocity field in order to eliminate the residual moveout along the ray paths. We have carried out two pass model based Tomography and two pass Grid based Tomography for the gather flattening in iterative manner. Once the gathers are flat till 30 degree, Anisotropic parameters delta & Epsilon are computed using well markers and generated initial VTI velocity volumes. The final VTI interval velocity derived after two pass Grid Tomography shows very good match with sonic log (Fig 3c) and structurally consistent.

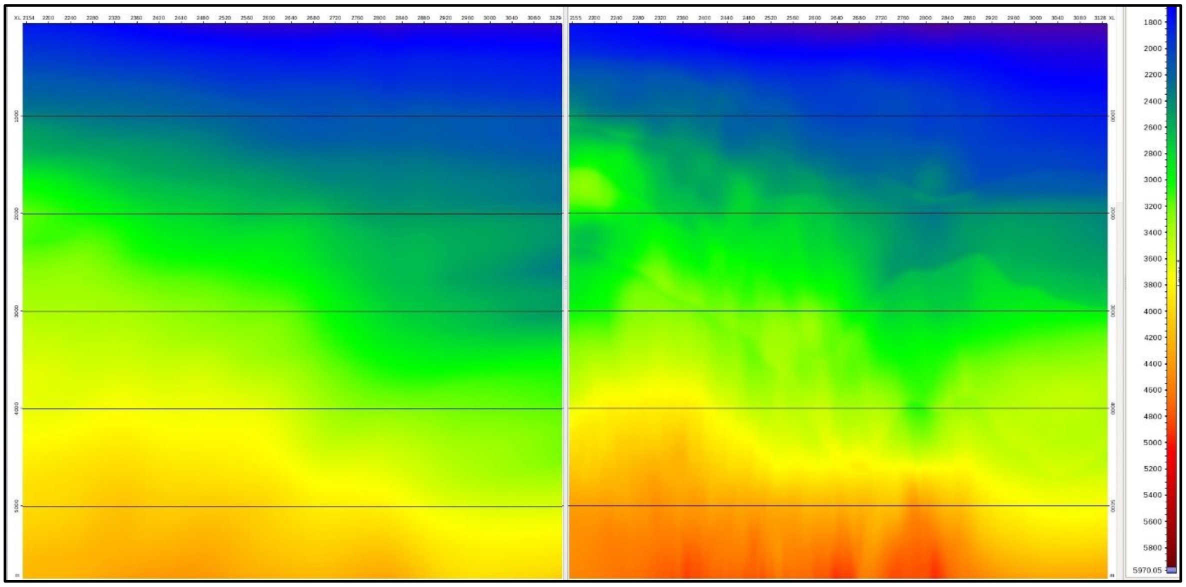

Fig. 3b DIX method of Interval velocity(Left) and Geo-statistical velocity (Right)

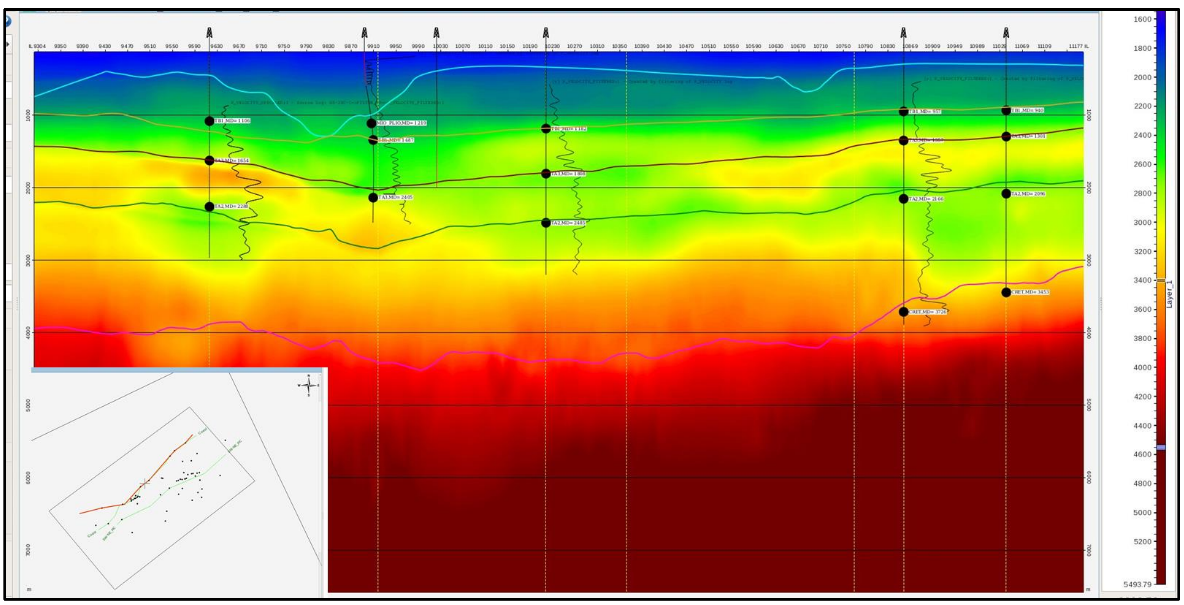

Fig.3c Final Interval velocity with sonic log

Full Azimuth Imaging:

The Full azimuth imaging tool works in angle and azimuth domain ,where every depth point in the subsurface will be simulated with all possible source and receiver ray pairs. Ray tracing will be done using thousands of rays from every depth point, these ray passes through complex subsurface structure and reaches to source and receiver positions on the surface(Koren Zvi at all). The recorded traces for these ray pairs and amplitudes are mapped on the sub surface point according to the travel times. The depth migration tool used for this study is full azimuth angle domain imaging which produces two sets of Migrated gathers(Fig.4)

1.Directional Angle gather :

- Decomposes to specular and diffraction imaging .
- Leads to simultaneous emphasis on both continuous structural surfaces and discontinuous objects such as small faults and small-scale fractures

2.Reflection Angle gather:

- Provides better residual moveouts (RMO) and amplitude variations.
- The full-azimuth, angle domain RMO enables accurate velocity model determination.
- Full-azimuth, angle domain amplitude variations result in better reservoir characterization.
- Useful in analysis of VVAZ & AVAZ.

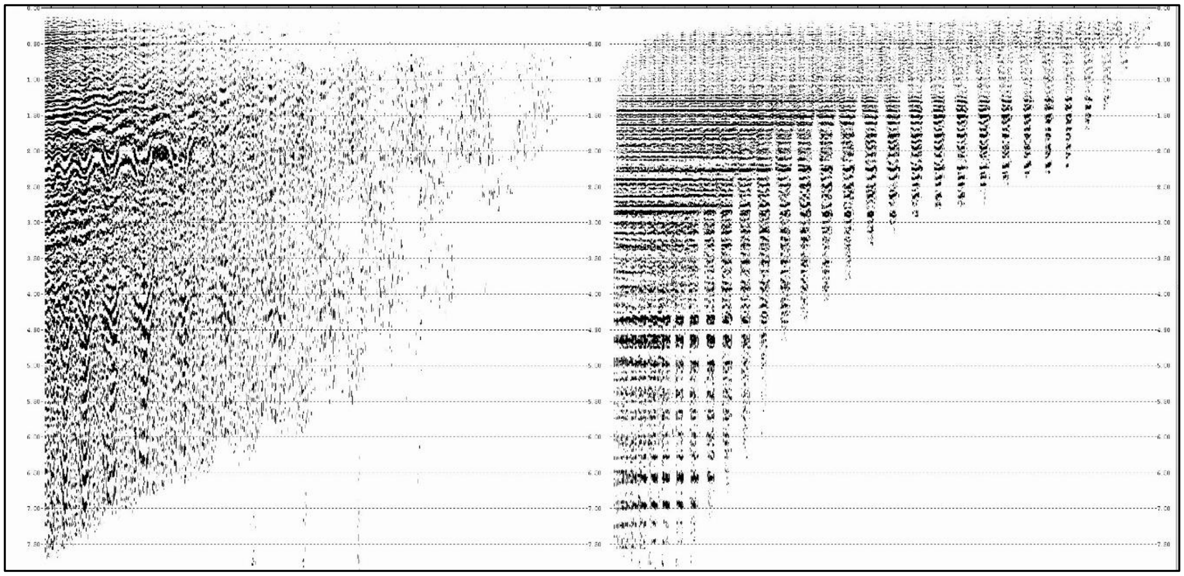

Fig.4 showing Directional (left) and Reflection Angle gather(right) at same location

Results:

The seismic sections shown in Figure 5,6& 7 clearly shows enhanced resolution at pay sand level and improved continuity in the deeper sediments in the scale time (specular stack) stack. The overall imaging is tremendously improved than the vintage processed data. The delineation of pay sands and Structural mapping of deeper Paleocene and Cretaceous sediments is now possible with good confidence.

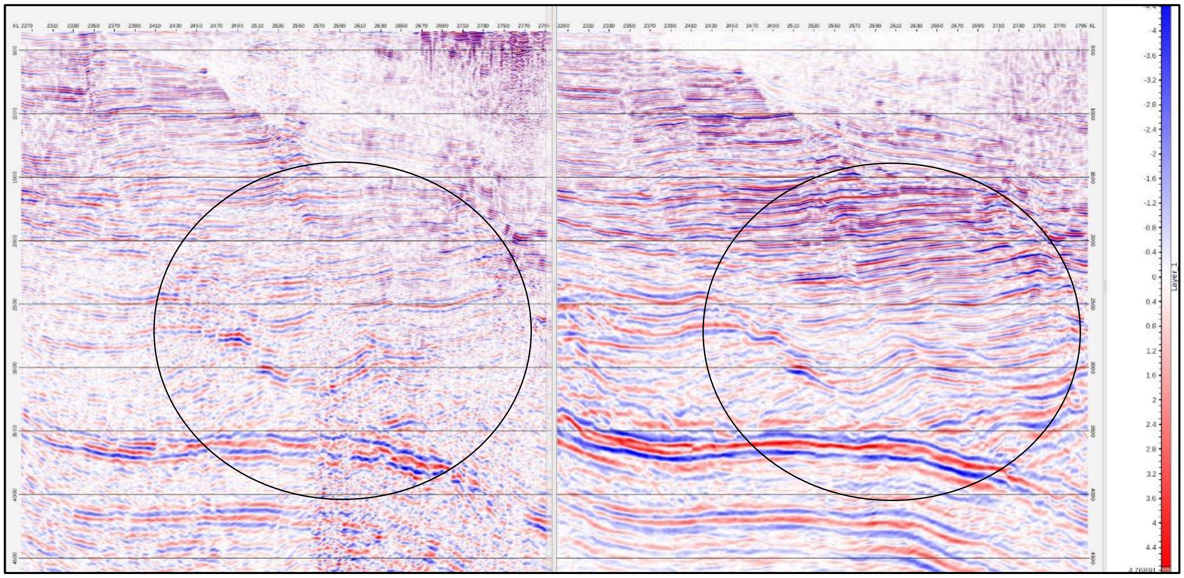

Fig.5 comparison of Inline old PSTM vs PSDM scale to time (Specular stack)

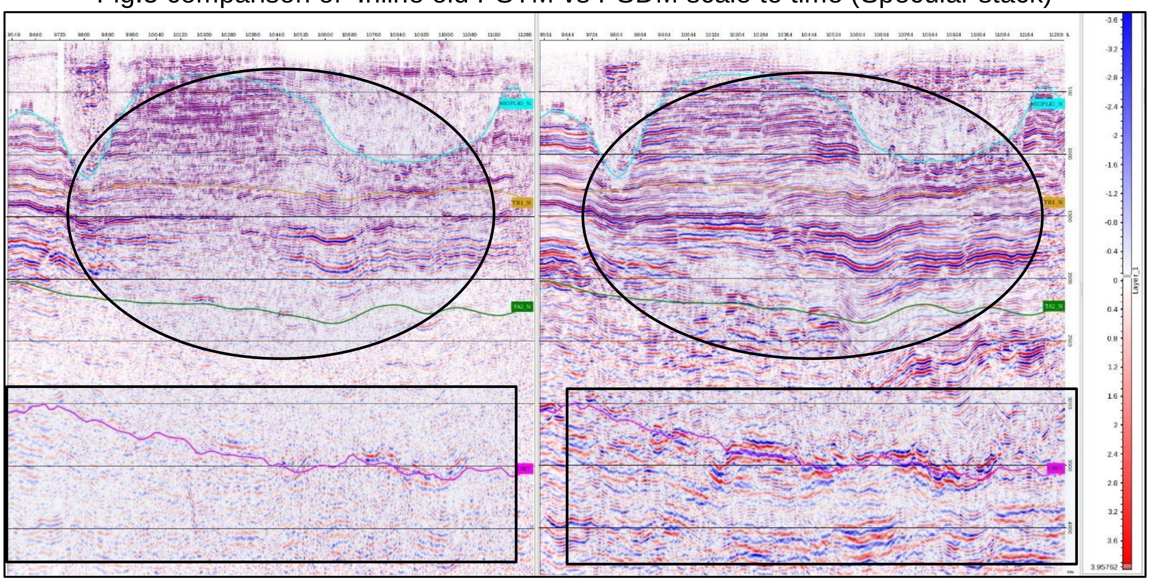

Fig.6 comparison of Cross line old PSTM vs PSDM scale to time (Specular stack) showing the improvement in pay sand level (top circle)and deeper sediments.

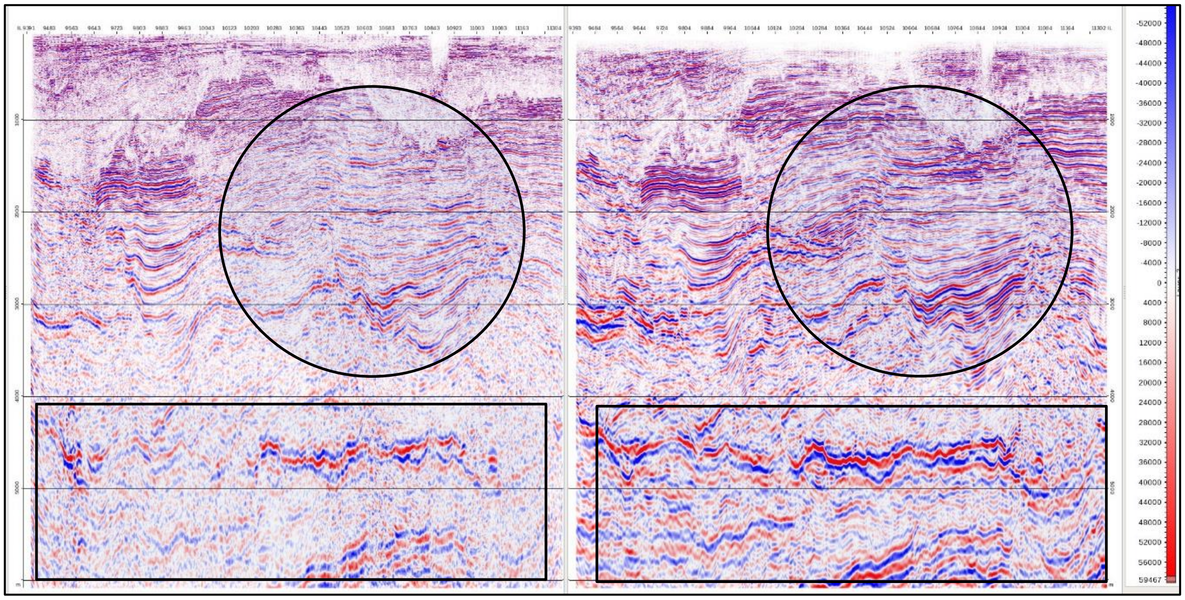

Fig.7 comparison of Cross line old PSTM vs PSDM scale to time (Specular stack) showing the improvement in pay sand level (top circle) and deeper sediments.

Conclusions:

This case study presented here depicts that the better signal conditioning of land and OBC data sets , use of sonic log and interpretation data especially during the definition of the initial interval velocity model and use of latest imaging tool has played a major role in enhanced seismic imaging in delineation of pay sands and improved understanding of deeper reflectors. The VTI Interval Velocity derived here matching with sonic log which is reliable for time to depth conversion. The output shows a remarkable improvement at all levels in the volume as compared to the earlier processed outputs. The advanced processing methodologies i.e. Geo-statistical method of deriving interval velocity coupled with Full azimuth angle domain imaging outlined in this study led to significant uplifts in the final PSDM image.

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Views expressed in this paper are that of the author(s) only and may not necessarily be of ONGC

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