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Residual Moveout Correction; its impact on PSTM Processed data: A Case Study

Anand Prakash*, S.K.Bora, Anil Kumar,
Regional Computer Centre,P-32 Transport Deport Road, Kolkata 700088
_a_prakash999@hotmail.com_

Summary

In recent years, the search for hydrocarbon reservoirs has moved into deep and ultra deep waters in East and West coast of India, especially in East Coast encouraged by the recent Gas finds in the region. Complex depositional environment in deep water calls for most advanced imaging tools to reduce the huge economic risk. Prestack time/depth migration (PSTM/PSDM) is most widely used tools for subsurface imaging. PSTM has now become routine processing and major building block for PSDM processing. For PSTM processing and ultimate quality of the processed output, appropriate RMS velocity field is very crucial. Residual moveout analysis is the basic step in velocity field refinement.

In the paper, a case study pertaining to Mahanadi Offshore in the East Coast of India is presented. PSTM processed data has shown low/high amplitude bands on amplitude map of a horizon interpreted as Neogene channel-levee system. A thorough analysis was carried out to establish the causative of these amplitude stripes. Residual moveouts on PSTM gathers well corroborating to the low/high amplitudes stripes are observed. So, residual velocity analysis was carried out for the whole volume. Residual moveout correction was applied on CRP gathers and stacked. Amplitudes were again extracted along the mapped horizon. The problem of amplitude striping is resolved. The overall data quality has also improved significantly. The possible reason for the residual moveouts on PSTM gathers might be (i) highly faulted areas (ii) fast lateral velocity change and (iii) sparse migration velocity analysis grid

Introduction

Prestack time/depth migration (PSTM/PSDM) is most widely used tools for subsurface imaging. PSTM has now become routine processing and major building block for PSDM processing. For PSTM processing and ultimate quality of subsurface imaging,appropriate migration velocity field is very crucial. Residual velocity/move-out analysis is the basic step in velocity field refinement. A different approach for updating velocity field and its impact on subsurface imaging was discussed by Rawat M.S.,2006. Tisserant Thomas, et.al(2003) analyzed the Residual move-out analysis on common image gathers in angle domain for updating migration velocity field rather than in offset domain.

The normal PSTM work flow is given in the Figure 1. To obtain satisfactory subsurface image scheme 2 is generally followed if the data volume is quite large and the velocity field is sufficiently accurate.

The present study deals with a 3D seismic survey conducted by M/s CGG in Mahanadi Deep water block during 2006 to explore Paleogene and Neogene channel complex and fan lobes. The data was processed onboard

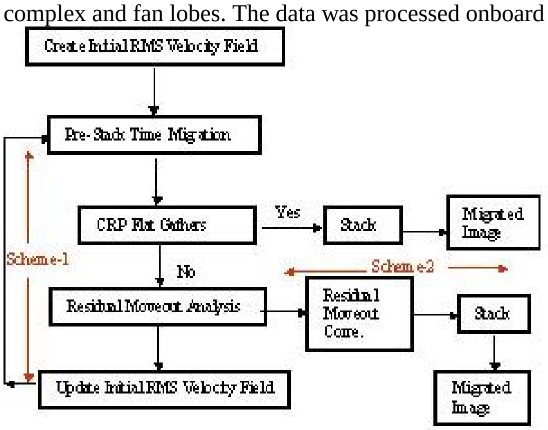

Figure 1. Pre-Stack Time Migration Work Flow

and PSTM processing was carried out using Geodepth S/W. Migration velocity analysis was carried out on PSTM gathers in 1X1 Km grid. Migration aperture test was carried out and it was found that an aperture of 3.0km is adequate keeping in mind the resources available and time schedule of the project.3D Kirchoff's PSTM was run using RMS velocity field created.

The horizons corresponding to Miocene channel-levee complex are tracked and mapped. The amplitudes along the horizon are extracted in a window of 100ms. Low/high amplitude stripes are observed having no geological significance. Acquisition footprints or processing pitfalls might be the causative of the amplitude stripes. But a careful analysis of the data reveals residual moveouts on PSTM gathers giving low amplitudes on stacked data. The residual velocity analysis was carried out on whole PSTM gathers in a grid of 1X1Km. The PSTM gathers are then flattened applying residual moveout corrections and stacked after designing the mute functions.

The problem was resolved successfully with improved overall data quality. The time slice shows beautiful channel -levee complex, incised valley and fills. The fault patterns are beautifully seen on the section.

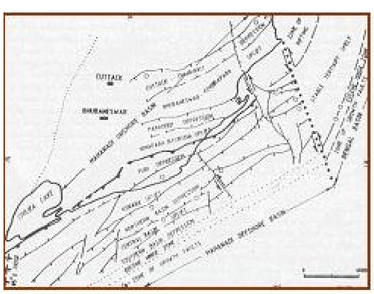

Figure 2. Tectonic map of Mahanadi basin

Geological Set-up

The Mahanadi basin is among the several sedimentary basins developed along east coast of India as a result of rifting and break-up of Gondwana land during Jurassic period. This cover an area of over 50000 Sq.Km , of which nearly one fourth is in onshore and the rest is offshore. The onshore covers the Mahanadi delta lying in the state of Orissa. Tectonically, these basins are developed around a triple junction between the NE-SW trending east coast of India (which represents an Atlantic type passive continental margin) and the NW-SE trending Mahanadi graben within the Indian shield.(Fuloria R.C. et.al. , 1992). The basin is separated from KG basin by 85°E ridges. Major tectonic features are shown in Figure-2. Geologically, the onshore part of Mahanadi basin is significantly different from its offshore part. The hydrocarbon prospects of offshore basin are rated good as it belongs to a petroleum province(Jagannathan C.R. et.al, 1983), whereas those of onshore basin are rated as fair. Deep-water part of Mahanadi basin attracted much exploration attention due to its proximity to the deep-water area of KG basin having proven huge Gas reserves.

Paleogene and Neogene section in deep-water basin exhibits channel complex; highly sinuous often stacked vertically due to shifting of depositional axis both in space and time (Nath. Et.al.,2006). A sinuous channel-levee complex often results in submarine fan lobes towards deeper part of the basin. Incised valley and valley fill sequences are also prevalent during Paleogene and Neogene periods.

Data Processing

The 3D data was processed onboard using standard processing sequence. Table-1 shows the processing sequence. For PSTM processing, deconvolved dataset was used. CRP gathers was generated for migration velocity analysis using the RMS velocity volume created by velocity analysis in a grid of 2X2 Km. Finally, migration velocity analysis was carried out on PSTM gathers in

1X1km grid. Migration aperture of 3.0Km at 5.0 Sec. was used. PSTM gathers are muted and stacked. Random noise attenuation and Band Pass filter was applied on the stacked data.

Table-1.. Processing Parameters

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Spher div. Correction ,Swell Noise attenuation
Radon linear noise attenuation
Designature to min. phase and reverse polarity
Tidal correction
Deconvolution ,Rdaon anti-multiple
Flex Binn., Gun/cable static correction
Spher div. corr. removal
Kirchoff PSTM for velocity analysis
Velocity Field generation
Full Volume Kirchoff PSTM
Residual Velocity analysis
Final Stack,Final Scaling/filtering

After preliminary interpretation, it is observed that all structural features are very well brought out, however, low/high amplitude bands having no geological significance are observed on amplitude map of shallow horizons. These are either processing pitfalls or acquisition footprints. Careful analysis of final processed data along cross line shows some amplitude variation in the shallow data zone at -12dB gain. These variations of amplitude are well corroborating to the non-flattened PSTM gathers. It is therefore, decided to carry out residual velocity analysis in a grid of 1X1km and PSTM gathers were corrected for residual moveouts. The remaining processing steps are kept same.

Discussion

Horizon amplitude map for top of Miocene level shows channel -levee system and terminal lobes from earlier processed data volume beautifully (Figure -3), however low/high amplitude bands are observed. These amplitude bands are detrimental to reservoir characterization - lithology, sand content, fluid content and porosity based on

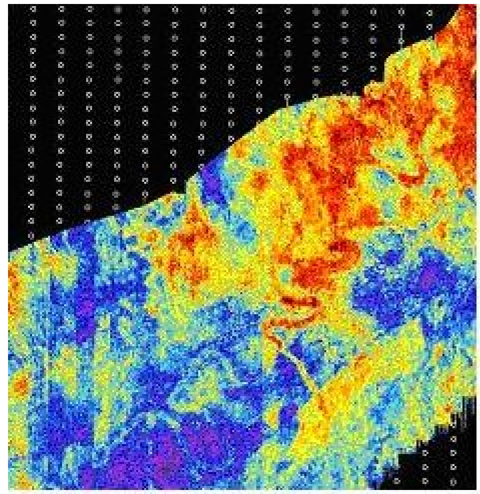

Figure 3 : Amplitude Section along the Horizon –A

the amplitude study. These amplitude bands are either processing pitfalls or data acquisition footprints. Field records are analyzed but no amplitude variation from shot to shot or line to line are observed. Careful observation of PSTM processed data along cross line at -12dB gain shows variance in amplitudes (Figure 4a).

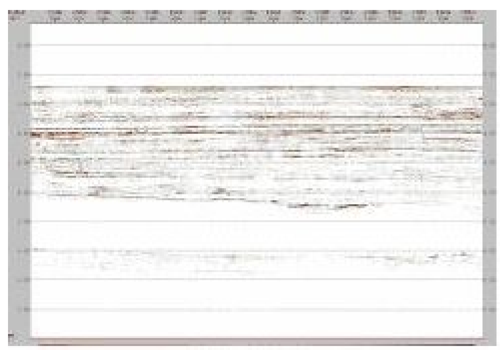

Figure –4a PSTM Section-Cross Line 1500

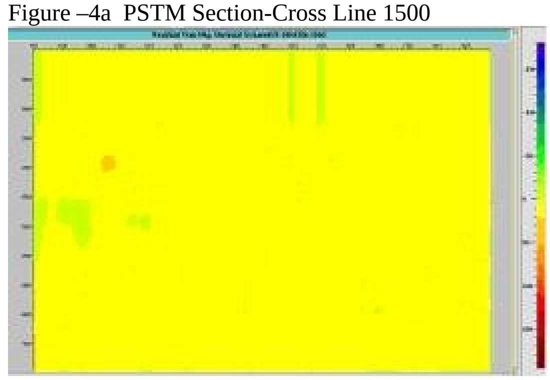

Figure -4 b Residual Moveout Section-Cross line A

Low amplitude bands are because of non-flattened PSTM gathers which have given less amplitude after stacking. Figure-5 shows PSTM gathers having residual moveouts at locations of low amplitude bands. Figures-6 shows PSTM gathers having no residual moveout, which corresponds to normal amplitude area. Intense faulting and rapid geological variation along inline and cross line might have caused rapid velocity variation and so the migration velocity analysis in grid of 1X1Km seems inadequate. Further, velocity in zone of interest are low(of the order of 2200m/s) and even 4 to 6 percent velocity change caused the residual moveout producing low stack response and that might have caused the amplitude stripes.

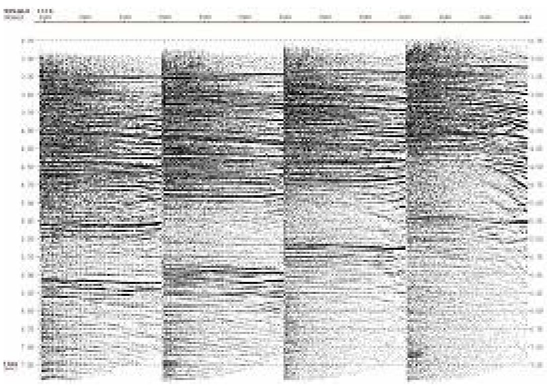

Figure -5 PSTM Gathers along Inline A showing Residual Moveout

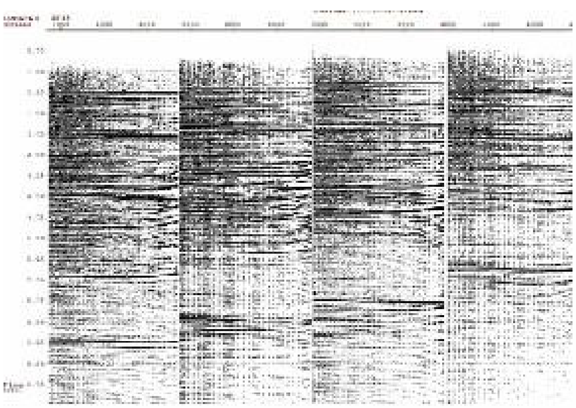

Figure -6 PSTM Gathers along Inline B showing Very Less/No Residual Moveout

Residual velocity analysis in a grid of 1X1km was carried out. The residual moveout section along cross line is well corroborated to the variation of amplitude along the seismic section (Figure 4b). The residual velocities are not much (< 5%) as seen in figure-7.

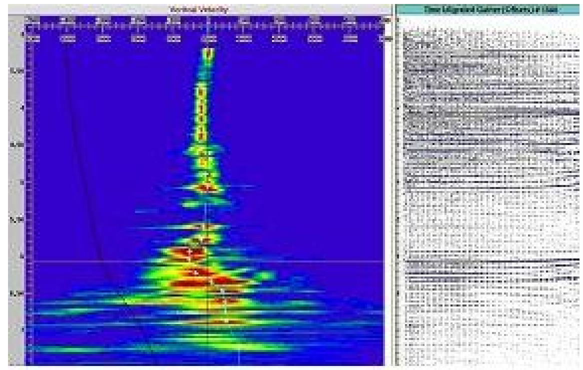

Figure-7 Residual velocity analysis inline A

The residual velocity section and RMS velocity section are shown in figure 8. The variations are seen along the narrow bands. Residual moveout corrected gathers are processed following the previous processing sequence.

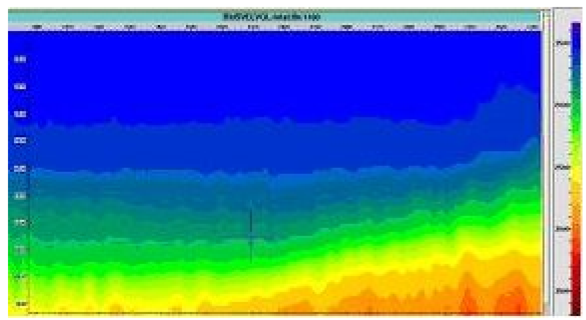

Figure-8a Migration Velocity Sections-Inline A

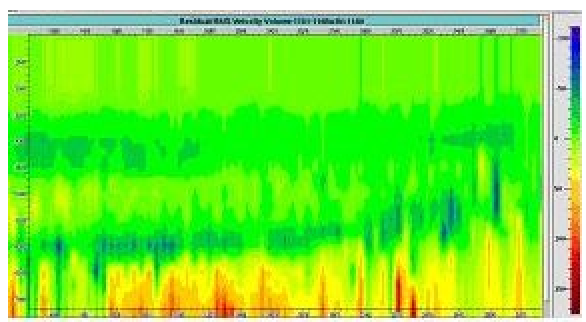

Figure-8b Residual Velocity Sections-Inline A

The horizon amplitude map generated from the new data volume. Major problems of amplitude stripes are resolved (Figure-9). The overall amplitude standout has significantly improved. Figure-10b shows much improved seismic section as compared to the previously processed data(Figure-10a).

The fault system is beautifully imaged (Figure-11). Figure-12 shows incised valley showing different episodes of deposition. Highly sinuous stacked channel-levee system is beautifully seen in figure 13. Indications of Gas Hydrate deposits are also seen in the data. Figure-14 shows Bottom Simulating Reflector (BSR) cutting across the geological strata .The polarity of BSR is seen opposite to the sea floor reflector.

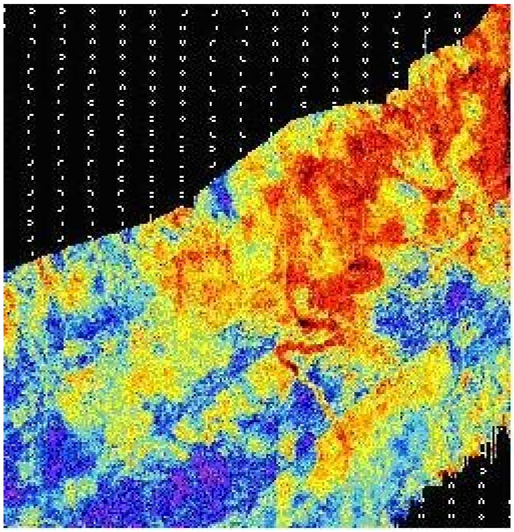

Figure 9 : Amplitude Section along the Horizon –A from residual moveout corrected processed data volume

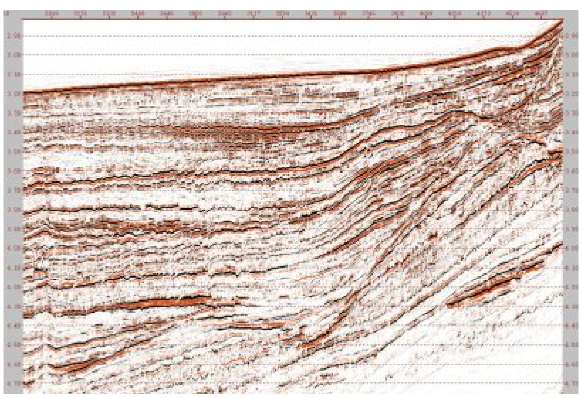

Figure 10a Section before Residual Moveout Correction

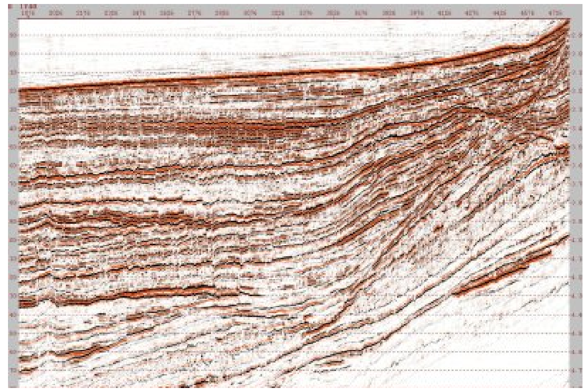

Figure 10b Section after Residual Moveout Correction

Figure-11 Section showing fault system in the area

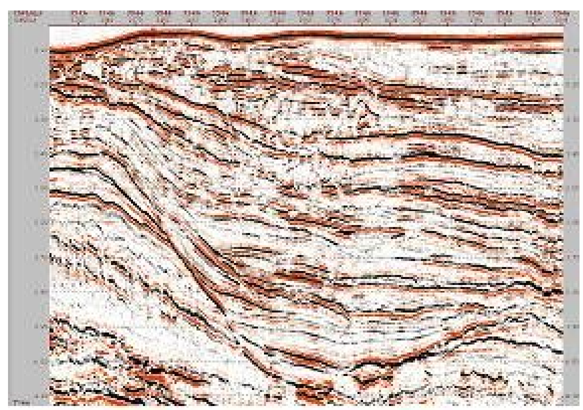

Figure-12 Section showing incised Valley and different episodes of filling

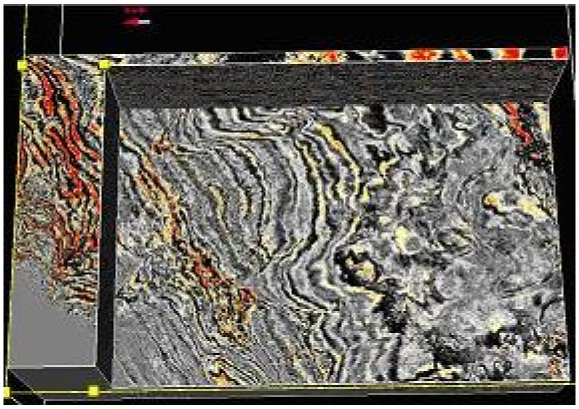

Figure-13 Chair-cut showing Neogene Channel-Levee System

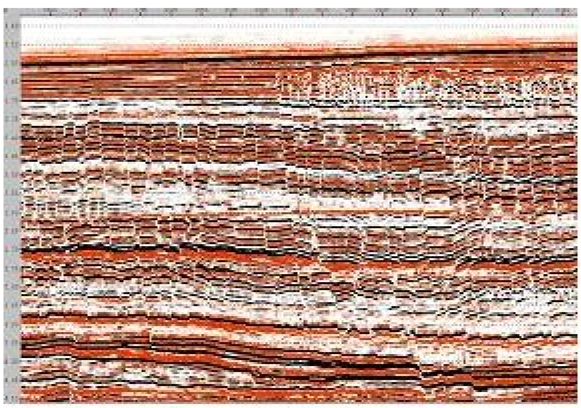

Figure-14. Seismic section showing BSR at 3.6 Sec.

Conclusions

Residual moveout analysis in close grid resulted in better migrated image. The overall data quality has improved significantly. It has been observed that a variation in RMS Velocity of the order of 4-6% produced sufficiently large residual moveout correction, which might have caused amplitude variance along inline and crossline especially in such a highly complex geologic setup of Mahanadi Deep Water. The possible reason for the residual moveouts on PSTM gathers might be (i) highly faulted areas (ii) fast lateral velocity change and (iii) sparse migration velocity analysis grid.

Note: The concept and ideas of this paper is solely of author's view.

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