



Application of Shot Domain Trim Statics as a Substitute of Interactive Refinement of Receiver Statics in Converted Wave Processing

C. B. Yadava*, T. R. Muralimohan, Kunal Niyogi

GEOPIC, Oil & Natural Gas Corporation Ltd, Dehradun, E-mail: yadava_cb @ yahoo. co. in

Summary

2D-3C data was acquired in North Cambay basin targeting Kalol and Kadi formations. One line from this data set was used for the present study. Proper binning, Shear wave receiver statics, Gamma estimation and Birefringence are some of the important issues in converted wave processing. Two different approaches were adopted for Shear wave statics refinement, generating two different Pre-stack time migrated converted wave outputs. Final processed PSTM stack with alternative approach of shear wave statics refinement, consisting of shot domain trim statics, has resulted in improved imaging and better continuity of events.

Introduction

Hydrocarbon strikes in deeper sedimentary sequences in north Cambay basin have attracted the due exploratory effort but Kalol formation still remains the main producer. Formations below Kalol being mainly shaly in nature, RMS velocity does not rise appreciably with depth. Lack of sufficient impedance contrast at deeper sands, result in poor reflectivity. Coal seams deposited within Kalol and Mehsana formations of middle and upper Eocene age generate strong multiples and ringing effect masking weaker reflections from deeper horizons. In such cases, converted wave (PS) stack may provide a better image of sub-surface in comparison to compressional wave (PP) output. 2D-3C data was acquired in year 2005 in three different areas of Cambay basin targeting Kalol, Mehsana and Mandhali formations. Two way PP time corresponding to these formations fall in the range 1000 – 2000 ms.

One line from this data set falling in the area Kadi-Linch-Nandasani was taken for the present study (figure-1). Processing softwares Focus and Geocluster were utilized judiciously for optimum results. PP data as well as converted wave data were processed upto PSTM stage. In converted wave processing proper binning, shear wave statics, gamma estimation and birefringence are some of the important issues. Processing of PS data was carried out

adopting two different approaches of refining shear wave statics, which are (i) interactive refinement of shear wave statics followed by automatic residual statics alongwith trim statics and (ii) application of shot domain trim statics. This paper deals with the improvement observed in the final processed output by adopting the second approach of shear wave statics refinement.

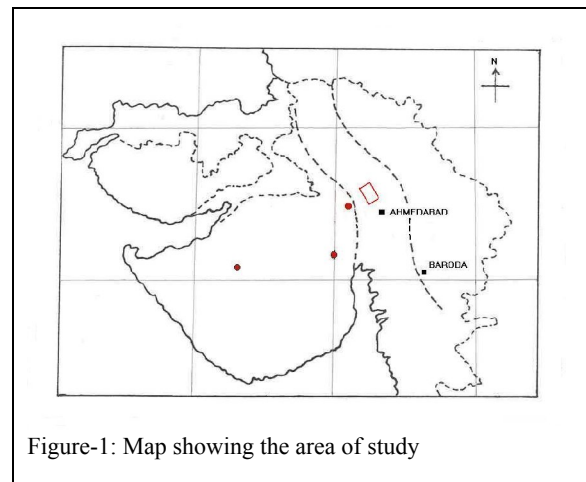


Figure-1: Map showing the area of study



"HYDERABAD 2008"

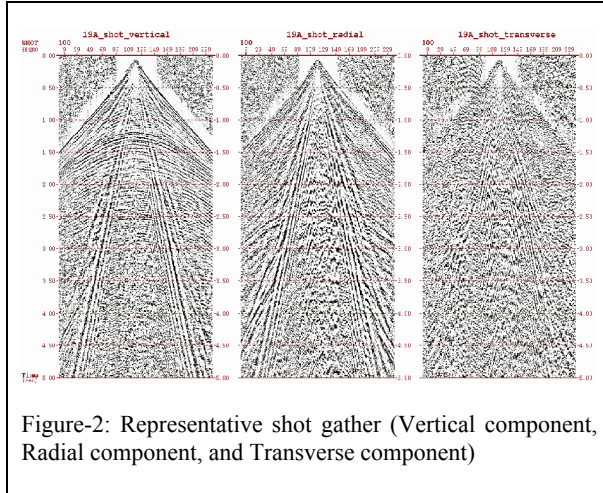


Figure-2: Representative shot gather (Vertical component, Radial component, and Transverse component)

Data Analysis

Data was acquired using I/O's System Four recording instrument and VectorSeis 3-component digital sensors. Spread geometry consisted of 25 mt group interval split spread with maximum offset 3000 mt. Figure-2 shows a representative shot gathers for the three components. The prominent reflector corresponding to Kalol horizon is seen at about 2300 ms on Radial gathers which is co-relatable to PP reflector at 1200 ms. Transverse component, shown on right is devoid of any coherent energy except ground roll. With the help of two way time on PP and PS gathers, a priori gamma was calculated to be 2.8.

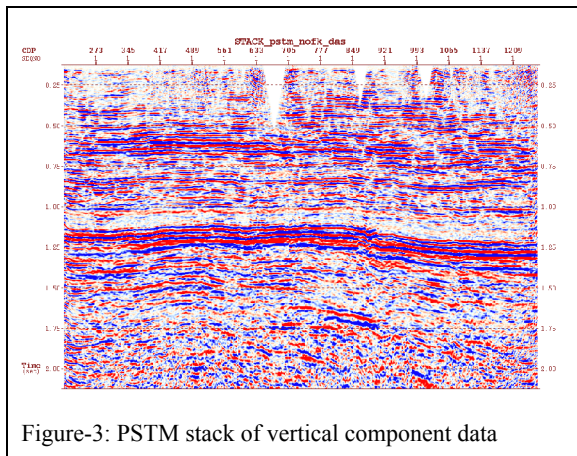


Figure-3: PSTM stack of vertical component data

PP gathers were processed upto pre-stack time migration stage in a conventional way. Figure-3 shows the PSTM stack of PP data. Compared to PP mode processing, there are many critical issues in PS processing which include

- 1) Because of asymmetric ray path, mid point binning is no longer valid for converted wave data. Proper CCP binning requires reliable S wave velocity along with P wave velocity. Estimation of S wave velocity and CCP binning being inter-dependent, the process is iterative in nature.
- 2) Generally Shear statics is estimated from PP statics by scaling it with gamma function. Any error in PP statics is bound to be amplified in Shear statics. Moreover an inaccuracy in gamma value further compounds the statics error.
- 3) It is also important to ascertain the presence of Azimuthal anisotropy, if any. In the area having Azimuthal anisotropy, shear wave gets splitted into two components which need to be separated by moving the data from acquisition coordinates to natural coordinates and processed separately.

Initial Binning

For initial asymptotic conversion point (ACP) binning of converted wave data and receiver statics estimation, V_p to V_s ratio was taken as 2.8. Gamma analysis was carried out at an interval of 1 km using Focus software. Figure-4 shows a representative gamma analysis panel. It was observed that gamma value was very close to 2.5 through out the profile. Therefore ACP binning and statics estimation were repeated considering gamma value 2.5.

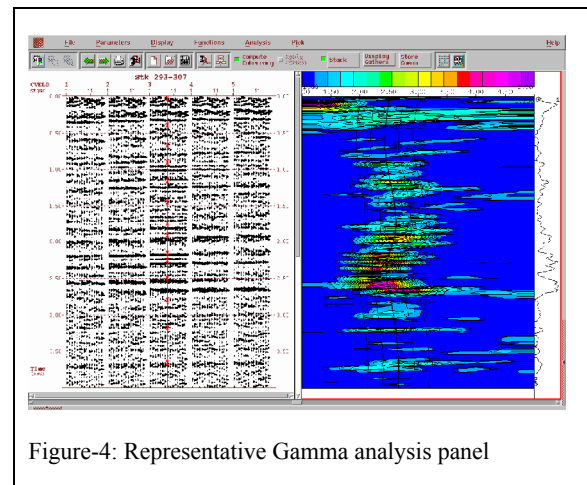
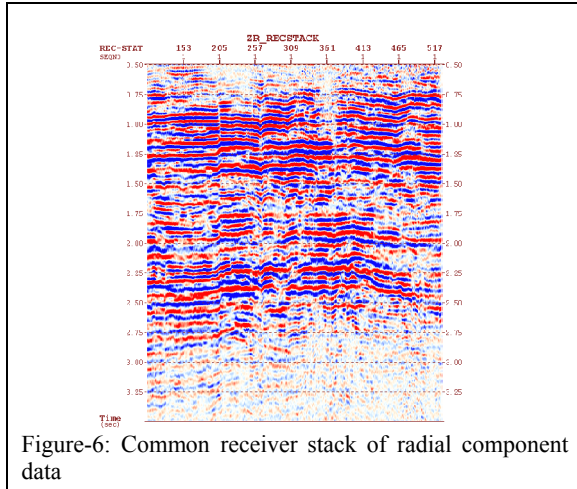
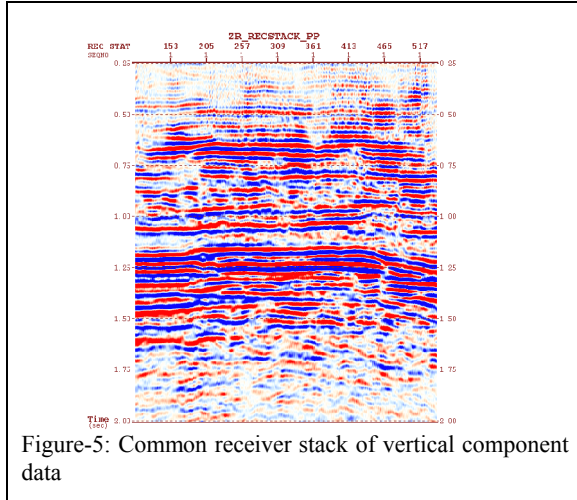


Figure-4: Representative Gamma analysis panel



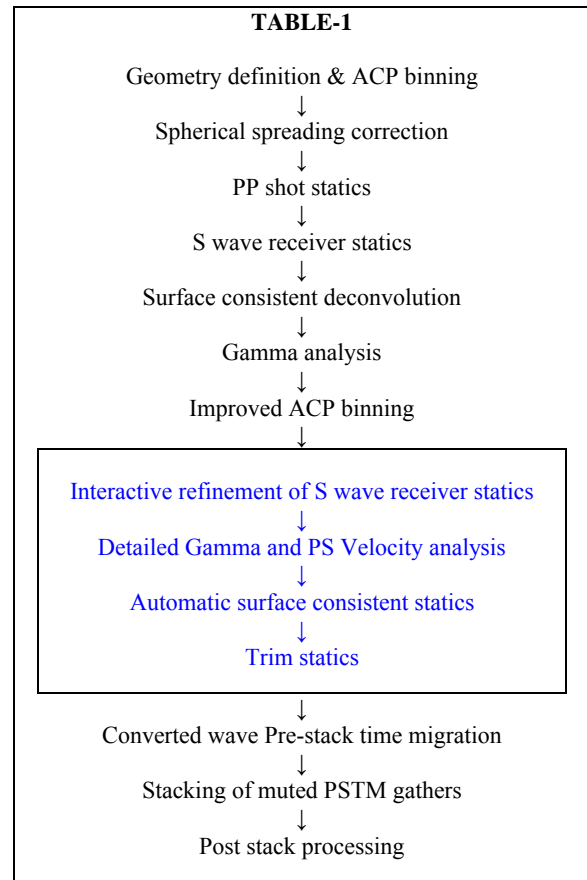
"HYDERABAD 2008"



Statics Issues

For Radial as well as Transverse data, shot statics was directly taken from PP statics, whereas receiver statics was taken as 2.5 times of PP receiver statics. Common receiver stacks were generated for PP as well as Radial component data (figure-5 and figure-6). Prominent reflector corresponding to Kalol formation shows some jittering in converted wave receiver stack. These jitters reflect the gross errors in receiver statics. The errors were corrected interactively, using the marker reflector at 2.2 second as reference and taking guidance from same marker horizon on PP receiver stack. After interactive correction of the error, detailed velocity analysis was carried out, followed by automatic residual statics based on stack power optimization and trim statics. Basic flow chart with this approach is shown in table-1.

However interactive correction of statics error is always subjective in nature and may result in an inappropriate static solution. This prompted to look for an alternative approach of refining the shear wave receiver statics.

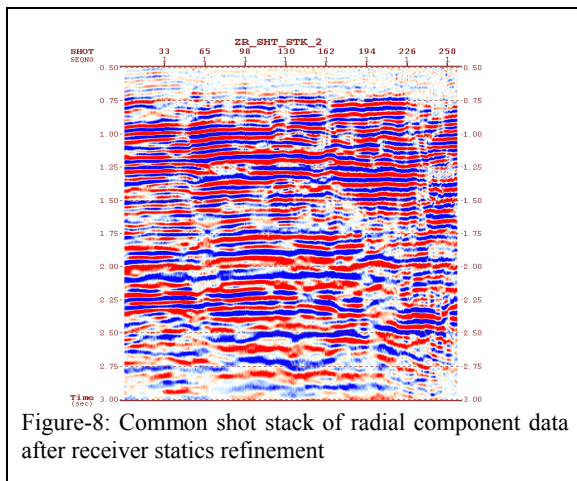
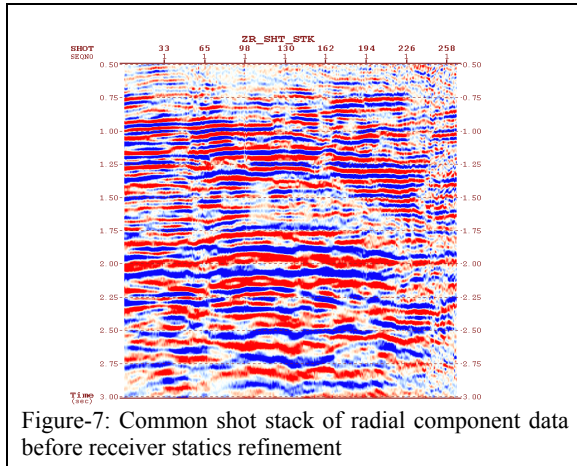


Alternative approach of Receiver statics refinement

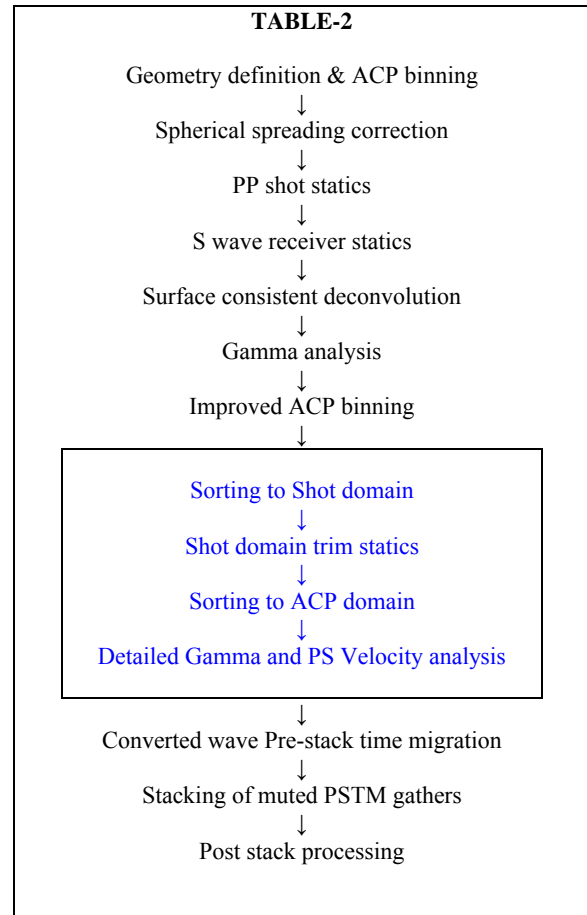
Alternative approach is based on the premise that on using finalized PS velocity, common shot stack generated before and after receiver statics refinement will have similar arrival time of events. Shot stack generated without statics refinement is shown in figure-7. Using this stack as pilot, trim statics was estimated in shot domain. Since there is no major geological dip in the area and the velocity is good enough to flatten the events, this trim statics provides the residual correction for receiver statics. Shot stack generated with the application of residual correction is shown in figure-8. It can be seen that two way time of reflectors on both these shot stacks are same, however, because of improved receiver statics, events are better focused in figure-8. Basic flow chart with this approach is shown in table-2.



"HYDERABAD 2008"



As a quality check ACP (asymptotic conversion point) stacks were generated considering the refined receiver statics. Figure-9 shows the ACP stack using interactive refinement approach, whereas figure-10 is the ACP stack with statics refined using shot domain trim statics.



Birefringence Analysis

ACP stacks were generated for Radial and Transverse component data. A portion of both the stacks is given in figure-11. In comparison to Radial component the Transverse component stack has negligible energy. This indicates that either there is no splitting of shear wave or line orientation is along the axis of natural coordinates (axis of Azimuthal anisotropy). In any of these situations component rotation is not required and only Radial component provides the converted wave output.



"HYDERABAD 2008"

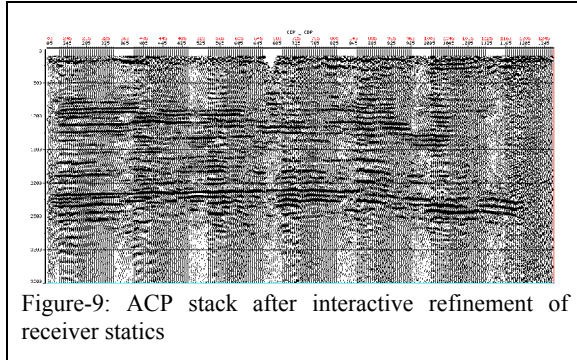


Figure-9: ACP stack after interactive refinement of receiver statics

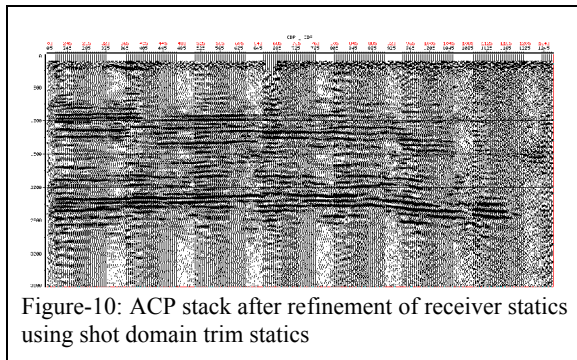


Figure-10: ACP stack after refinement of receiver statics using shot domain trim statics

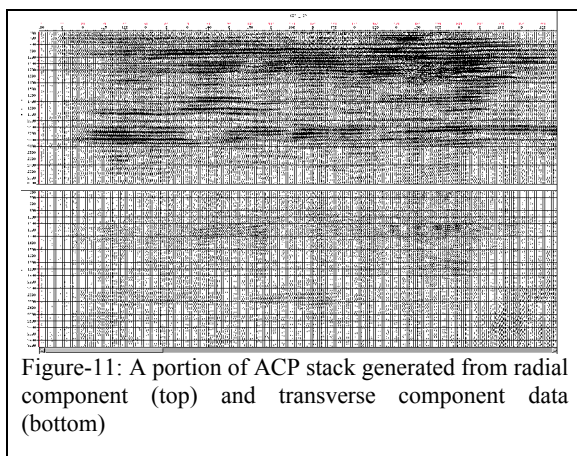


Figure-11: A portion of ACP stack generated from radial component (top) and transverse component data (bottom)

Pre-Stack Time Migration

After finalization of space and time variant gamma function and PS velocity, Kirchhoff pre-stack time migration for converted wave was run using Geocluster software. Figure-12 shows the PSTM stack taking input data using flow chart-1, whereas figure-13 is the PSTM stack using input data with receiver statics refinement by shot domain trim statics.

A comparison of two approaches shows the improved imaging of various reflectors with alternative approach of receiver statics refinement. There is a marked improvement in continuity of weaker events between 1.5 to 20.0 seconds.

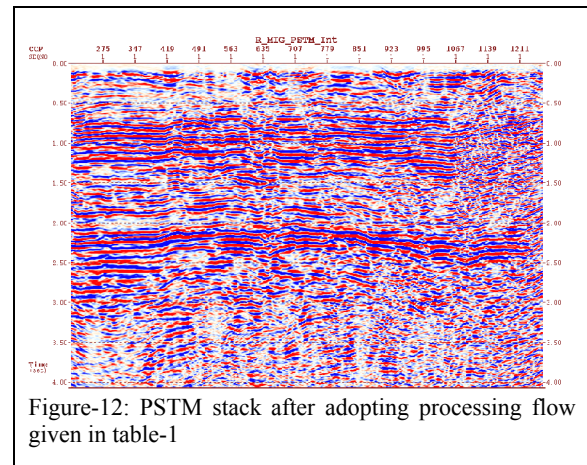


Figure-12: PSTM stack after adopting processing flow given in table-1

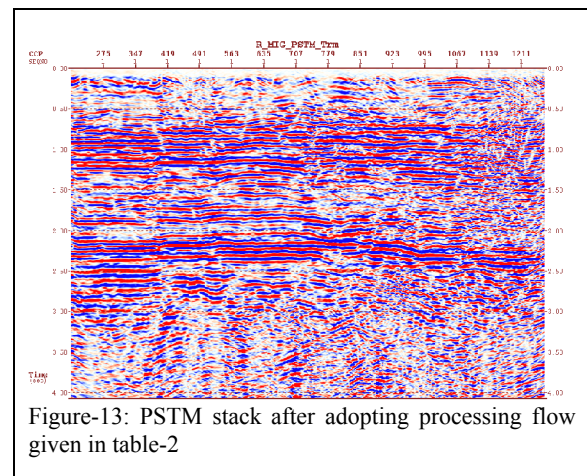


Figure-13: PSTM stack after adopting processing flow given in table-2

Conclusion

Converted wave data of one line pertaining to Kadi-Linch-Nandasani area of Cambay basin was processed adopting two different approaches of shear wave receiver statics refinement. PSTM stacks were generated using same PS velocity and gamma function. Processing sequence consisting of shot domain trim statics has resulted in improved imaging and better continuity of events.



"HYDERABAD 2008"

References

- 1) Harrison M. P., 1992, Ph. D. dissertation on Processing of P-SV Surface Seismic Data: Anisotropy Analysis, Dip Moveout, and Migration
- 2) Zabik G., Podolak M. W., 2006, Land 3C-2D Seismic Data Processing- Analysis of Crucial Issues, presented at SPG-2006
- 3) Stewart, R. R., 2006, Advances in Converted Wave Seismic Exploration, presented at SPG-2006.

Acknowledgements

The authors place on record their sincere thanks to Director (Exploration), ONGC, for his kind permission to publish this work. The authors are deeply thankful to Shri S. K. Das, GGM (GP), Head, GEOPIC, ONGC, Dehradun, for providing opportunity and resources to take up the work. It was his keen interest and active involvement due to which this study could take a shape.

NB: The views expressed in the paper are solely of the authors and do not necessarily reflect the views of ONGC.