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## Value Addition through Objective Oriented Reprocessing of Land 3D Seismic Data: A Case Study from Cambay Basin

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### Summary

3D seismic data pertaining to South of Nawagam area was processed for 3D Prestack inversion to resolve Kalol sands and middle pay units. The requirement of Prestack inversion warranted a new look at the data with emphasis on the conditioning of the gathers, removal of noises and higher order residual correction for close velocity analysis. The presence of thick coal layer present within Kalol formation resulted in the multiple reflections and attenuation of seismic energy. The multiples were attenuated using parabolic radon transform and the energy loss was taken care during preprocessing.

### Introduction

The study area is located in the northern rising flank of Tarapur depression, forming northern peripheral part of Cambay-Tarapur tectonic block of Cambay basin Fig.1 The area is surrounded by oil fields of Nawagam, Vasna in the north; Dholka, Naika, Mahelaj in the west, Asmali and Vatrak in south west and Bhalada, Kanwara in the south. The 3D was acquired with an objective to resolve Kalol and deeper levels.

To fulfill the interpretation objective special emphasis was given to removal of noise pattern and removal of multiples present in the data especially due to coal layers.

### General Geology and Stratigraphy

Study area is located in the northern rising flank of Tarapur depression, forming. The area includes the wells of oil fields, Naika, Mahelaj. Hydrocarbons have been established in the area from exploratory wells drilled in Sadra from Kalol Pays (K-VIII, K-IX and K-X).

The regional geological model envisaged by earlier work indicates that the depositional system appears to be a single system from Ahmedabad to west Bhalada in the south for both K-IX and K-X units. The upper pays are marked by two distinct coarsening para-sequences ending with coal. The thickness of each para-sequence increases gradually

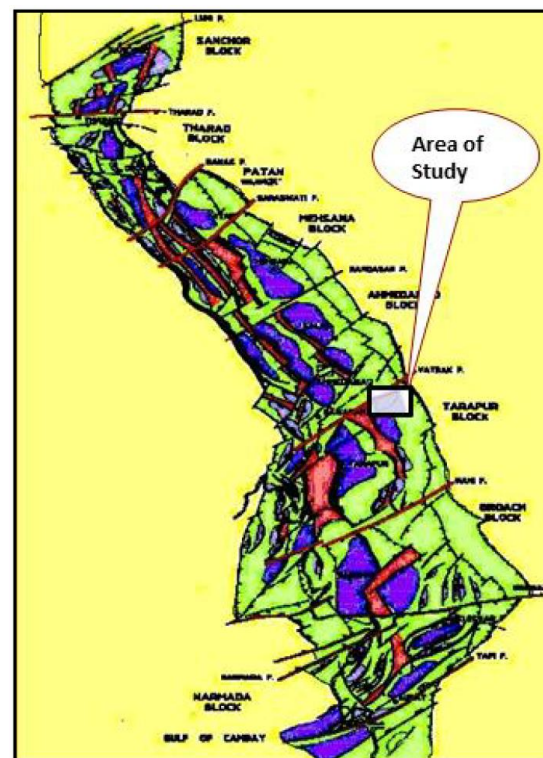


Fig 1. Tectonic map of Cambay Basin with study area

towards south and maximum thickness is observed in the well west Bhalada-1 in south-east. The entrapment style of the upper pays (K-IX+K-X), KVIII units appears to be

strati-structural. No oil water contact has been encountered in these pays. The hydrocarbon entrapment generally depends upon the reservoir development. Structures appear to play little role for the entrapment.

The middle pay or younger Cambay shale is also found to be hydrocarbon bearing in Naika-Mahelaj area situated towards west of this area. The study of electrolog and facies analysis of the drilled section has revealed thin silty/sandy layers deposited in a shale regime. The entrapment style appearsto be stratigraphic innature. Stratigraphic nature of the reservoir needed special attribute studies to be carried out in this area.

### Acquisition

The data of the study area was acquired during two field seasons i.e. 2006-7 & 2007-8. Brief details of the acquisition parameters are given below. Base map and fold map of study area is shown in **Fig.2 & Fig.3**.

- **Geometry type** : Split spread
- **Shooting configuration** : Symmetric Shooting
- **Bin size** : 20 X 40 M
- **Fold** : 40
- **No. of receiver lines** : 4
- **No. of shot per arm /lines** : 24
- **Far offset** : 2780
- **Near offset** : 20 m
- **Direction of shooting** : East to West
- **Direction of swath roll-over** : North to South
- **Record length** : 6sec
- **Sampling Interval** : 2 ms

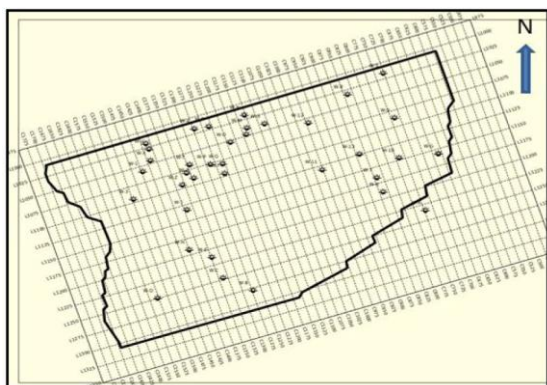


Fig 2. Basemap showing wells in study area

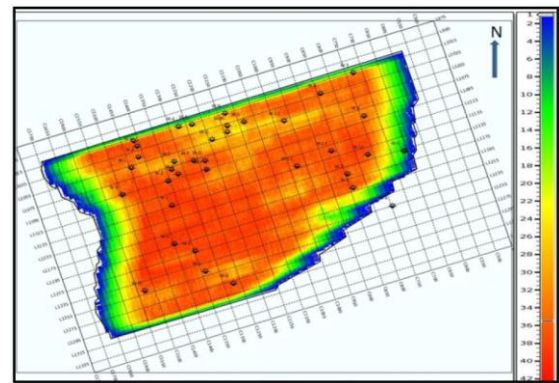


Fig- 3 Fold Map of the study area

### Processing Analysis

The reprocessing was carried out keeping in view the quality of the 3-D image needed for the special studies and in view of the future use of PreSTM gathers for inversion and AVO studies.

In the present study, the processing sequence was regular flow that is used in petroleum industry; however, certain refinements in processing were made to generalized processing flow is as below.

#### Processing Sequence

- Format Conversion
- Geometry Merging
- Geometrical Spreading Correction( $T^{*1.8}$ )
- Pre-Filter
- Denoise
- Surface Consistent Amplitude Correction Applied For Source, Receiver, Offset
- Surface Consistent Deconvolution
- Decon Velocity Analysis
- 3D Residual Statics – Two Pass
- Demultiple through Radon transform
- Residual Velocity Analysis Two Pass
- PreSTM On Target Lines
- RMS Velocity Analysis
- Final PreSTM Kirchhoff algorithm
- Residual noise and multiple attenuation through radon transform on PreSTM gathers
- Final PreSTM Stack
- Post Stack Processing(3D Random Noise Attenuation)

- 1) Emphasis was given to the removal of noises .Gathers was scanned for any high amplitude DC bias which was present. Noise was removed in 3D mode also by

generating cross spread and applying conical shaped filter in F-Kx-Ky domain. F-K filter was applied on shot gather data to remove the ground roll effect. **Fig.4 & Fig.5**

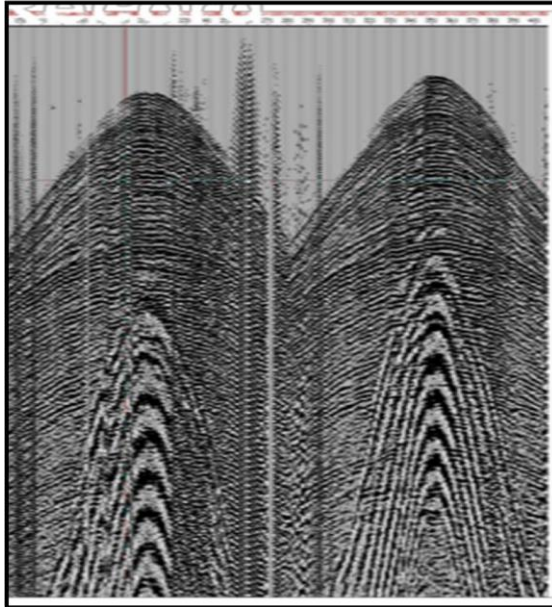


Fig. 4: Raw record

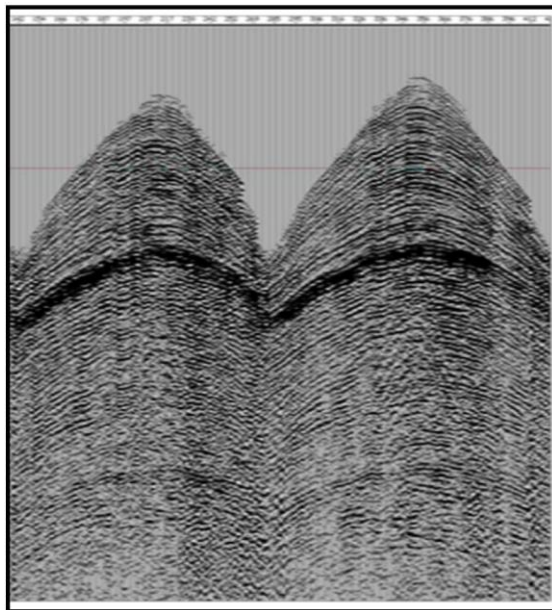


Fig- 5: De -noised record

2) To offset the distortion in amplitude and the phase of the data surface consistent amplitude scalars in shot, receiver and offset domain were calculated and applied to pre stack data.

- 3) Broad band filtering was applied to remove the unwanted frequencies after adequate testing.
- 4) To improve the resolution of prestack data, it important to choose optimum decon parameters in the form of prediction distance, operator length, white noise and window for designing the inverse operator. We tested these parameters for single trace and multi trace deconvolution and chose surface consistent deconvolution (multi trace) and applied in shot, receiver, offset and CDP domain. Velocity analysis was done in close grid.
- 5) Two pass surface consistent residual statics correction was carried out and each pass is followed by close grid velocity analysis, we have observed multiples in our zone of interest. Stack section of different stage is shown in **Fig.6 to Fig.8**. Time Slice was generated at each level of processing as a quality check **Fig.9 to Fig.11**. The Multiple attenuation was carried out using high resolution radon decomposition in Tau-P domain by using high resolution Radon decomposition.

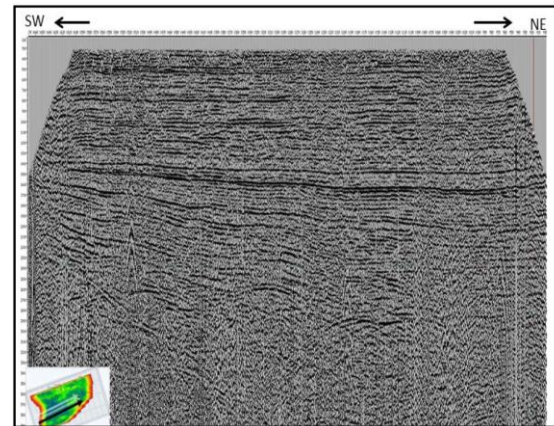


Fig-6: Brute stack Inline: AA

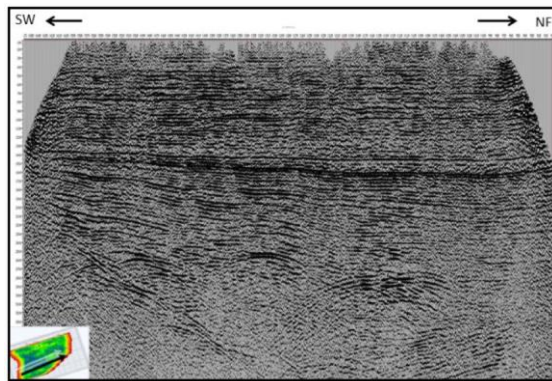


Fig- 7 De- noised stack inline: AA

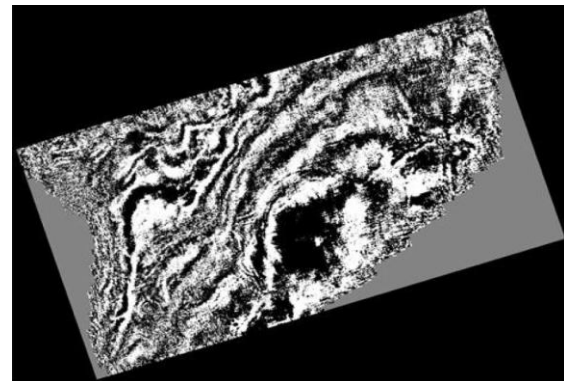


Fig 10. Time Slice 1620ms (De- Noised stack Volume)

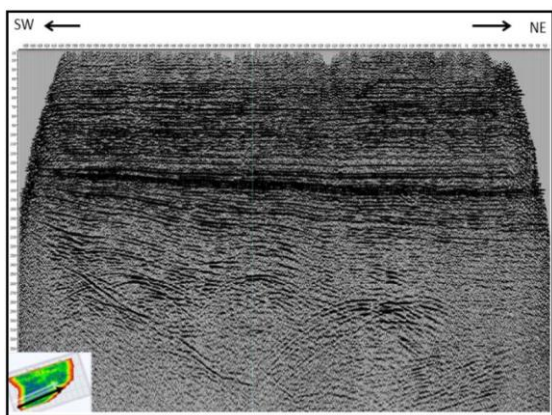


Fig 8. Residual stack inline: AA

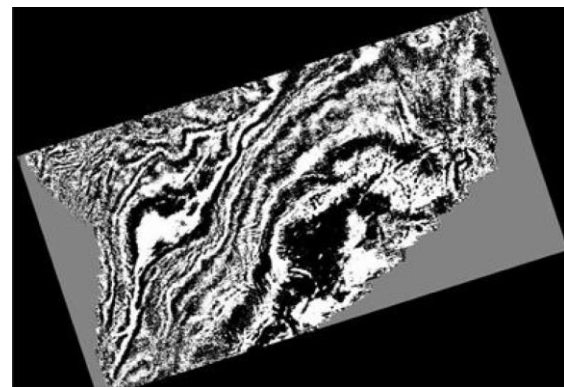


Fig 11. Time Slice 1620ms (Residual stack Volume)

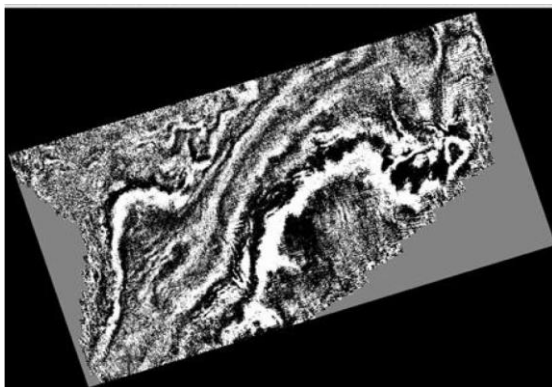


Fig 9. Time Slice 1620ms (Brute stack volume)

### Methodology of demultiple

The module used by us performs Radon decomposition ( $u$ ) of the data ( $d$ ):  $d = L.u + n$ .  $L$  is the modeling operator from the Radon ( $\tau$ - $p$ ) plane to the data. ( $n$ ), named the noise, is the part of the data that cannot be modeled. The decomposition ( $u$ ) can be split by a mute to a primary (or signal) part ( $u_p$ ) and a multiple (or linear noise) part ( $u_m$ ):  $u = u_p + u_m$ .  $L.u_m$  is then subtracted (adaptively, to compensate for the modeling errors) from the data ( $d$ ),

Once multiples are attenuated, we again carried out velocity analysis on the demultiple gathers as shown in **Fig-12** to **Fig-15** to generate velocity field for running migration on target lines to get PreSTM gathers required for RMS velocity analysis, we have carried two pass velocity analysis that include horizon based velocity analysis followed by residual velocity correction to get the flattened gathers which validates that the velocity model is correct.

After finalizing the velocity field PreSTM was run on entire data and the output product were in the form raw PSTM gathers and stack.

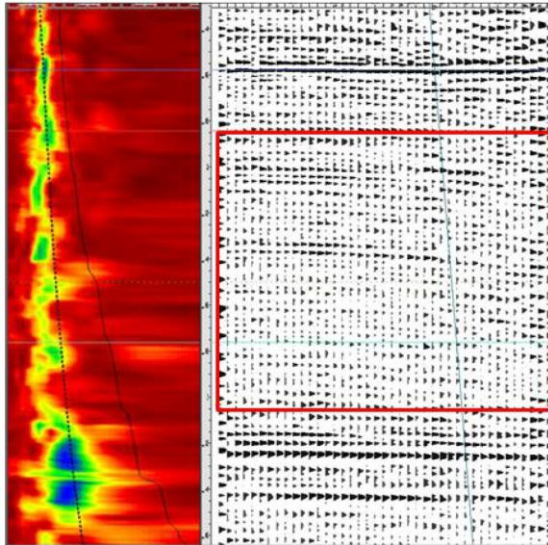


Fig-12: Velocity semblance with multiple gather

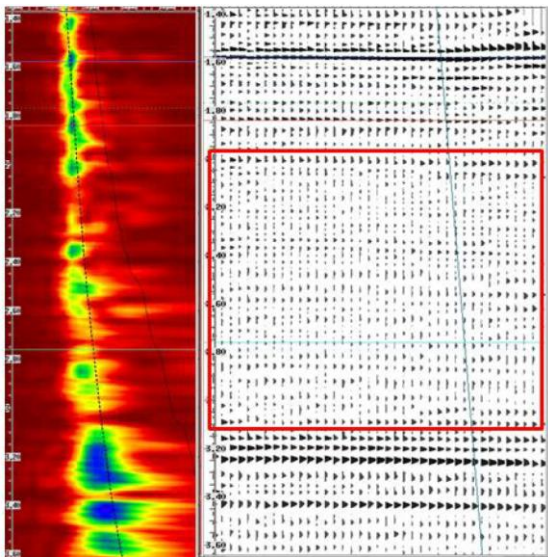


Fig-13: Velocity semblance with Demultiple gathers

As client requirement is to have noise free PSTM gathers for prestack inversion so we again conditioned the PSTM gathers for residual noise and multiples using radon transform. Final PreSTM section and time slice at different levels is shown in **Fig-16 to Fig-19**.

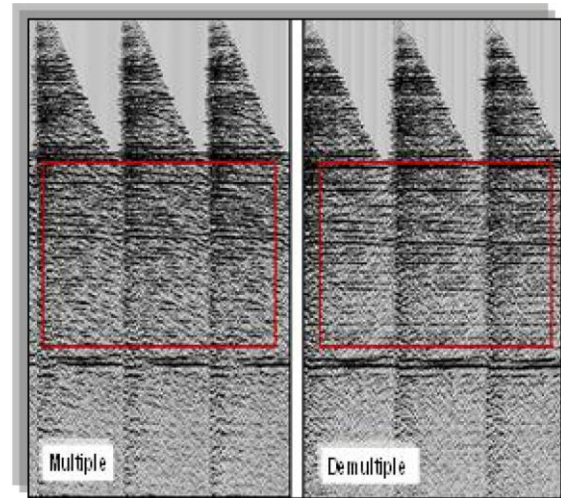


Fig-14: Comparison between multiple and demultiple gathers

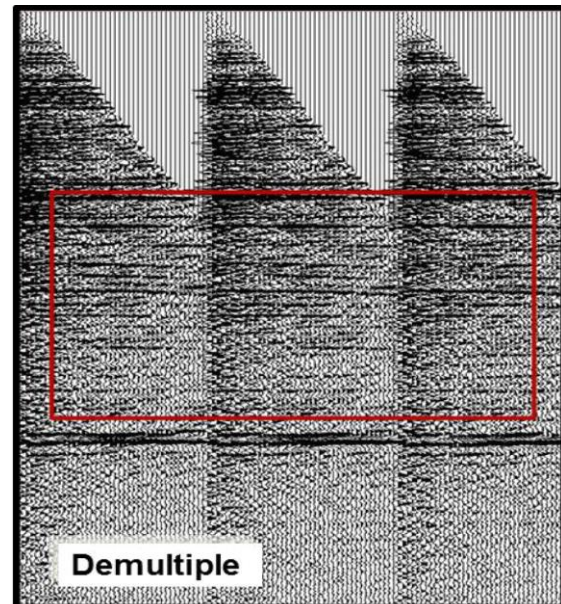


Fig-15: Final PreSTM gathers (Zoomed)

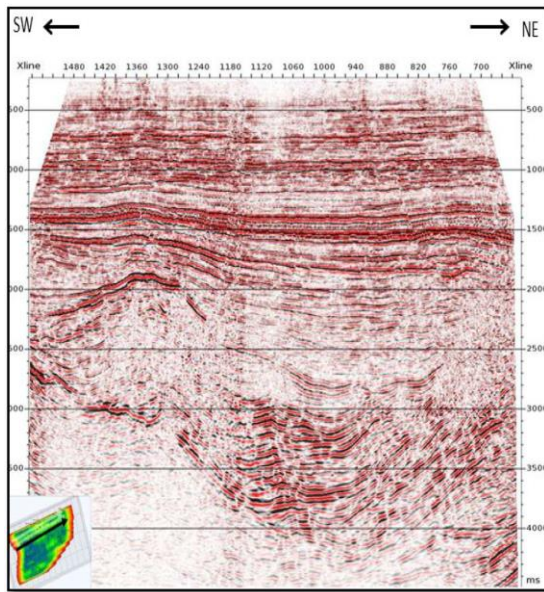


Fig- 16: PreSTM stack Inline: BB

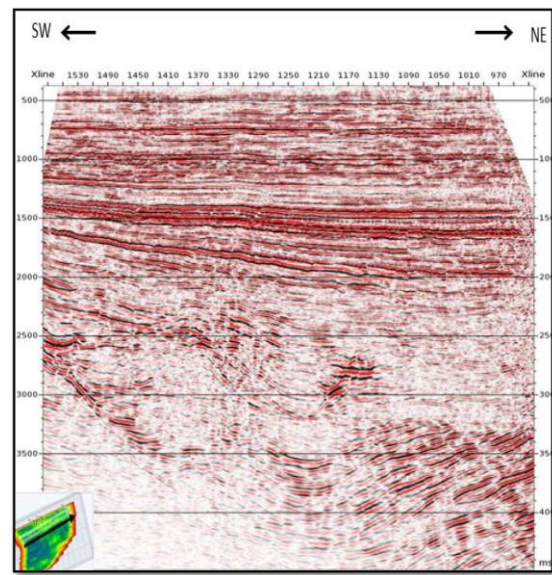


Fig- 18: PreSTM stack Inline: DD

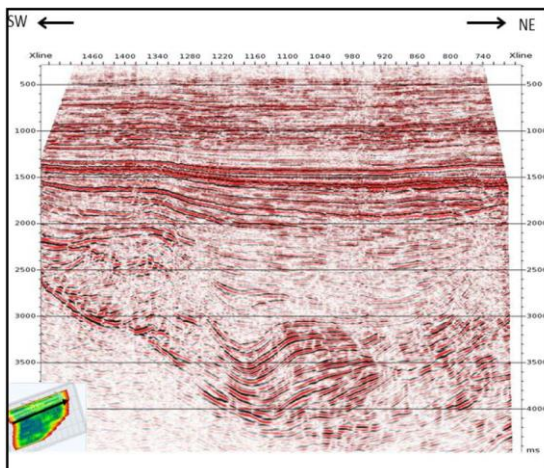


Fig- 17: PreSTM stack Inline: CC

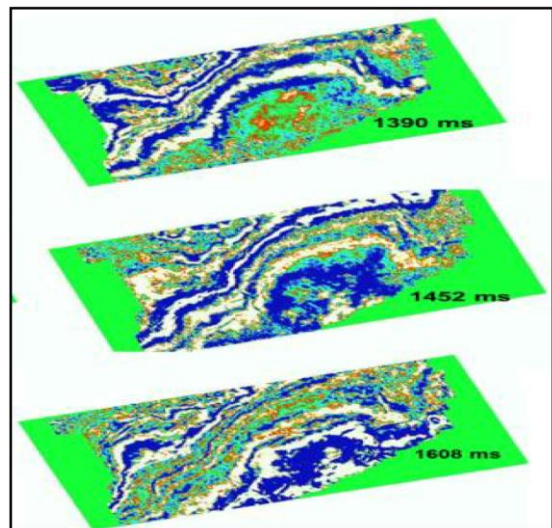


Fig-19: PreSTM Time Slice at different levels (Reprocessed)

## Results and Discussion

Our main aim was to get conditioned PreSTM gathers for prestack inversion studies. Hence during every step of preprocessing we studied noise pattern and then used noise removal technique to attenuate them and generated the quality control plots at each steps **Fig.4 to Fig.11**.

- It is observed from the shot record ( **Fig.4**) that the field record is contaminated with high amplitudes ground rolls and high frequency noises and the conditioned record after noise attenuation and it looks to be a balance record(**Fig.5**)

- We have stressed more on multiple attenuation on the residual and PreSTM Gathers keeping in mind that it severely affects the inversion results. Fig.12 to Fig.15 shows gathers before and after demultiple. The technique we used is high resolution parabolic tau-p domain to model the multiples and subtract it from the input gathers. Multiple attenuation was carried in two pass one on residual gathers and other on PreSTM gathers to remove the remnant multiple energy.

- After conditioning the PreSTM gathers flatness of the events along the zone of interest has increased but variation in the wavelets peak alignment was observed, so we decided to apply Trim statics to entire PreSTM gathers. After fixing the mute carefully we generated a PreSTM stack volume.
- It is observed from Fig.16 to Fig.19 that remarkable improvement is seen in Kalol and mid pays which are of interest

### Comparison of earlier and reprocessed data

- On comparing the reprocessed data with earlier processed section as shown in Fig.20 to Fig.23 we found, that the continuity and resolution of the events has increased and micro faults are clearly seen on our zone of interest on reprocessed section.

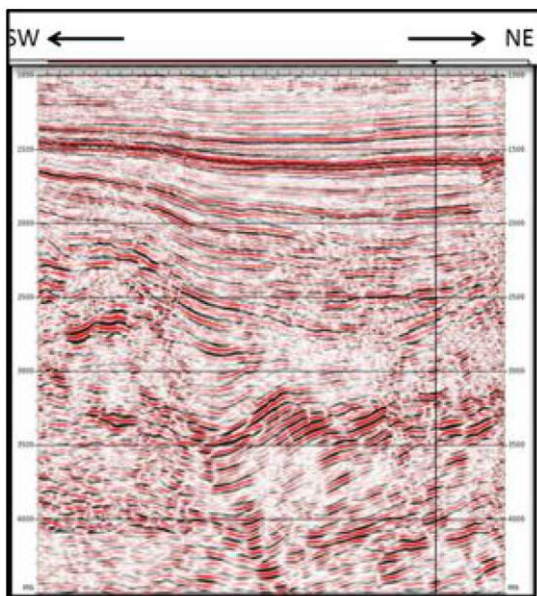


Fig-20 Earlier section inline: EE (PreSTM)

### Conclusions

- Objective oriented reprocessing has brought up good results and the final products i.e PreSTM stack and gathers shall be helpful in carrying out Prestack inversion studies .
- The results when compared with the previously processed data clearly indicate much better events in terms of continuity, resolution and fault definition.

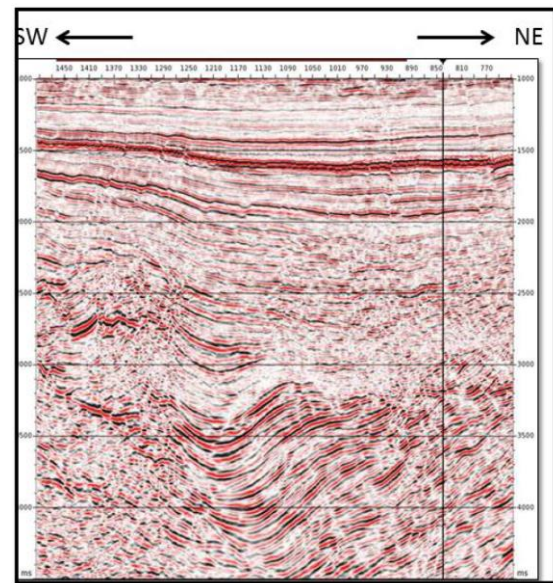


Fig-21: Reprocessed section inline: EE (PreSTM)

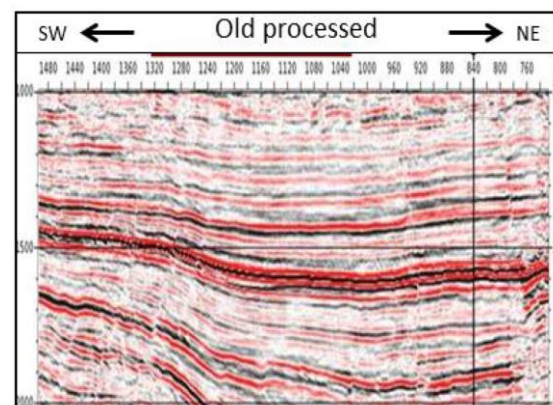


Fig-22: Earlier processed section (Zoomed)

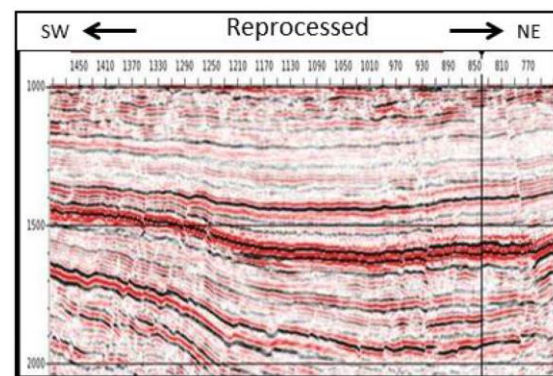


Fig-23: Reprocessed section (Zoomed)



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