

Object Oriented Reprocessing – A case study from Jotana area of Cambay Basin

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Summary

3D seismic data of three volumes pertaining to Jotana area of Cambay basin was acquired in two phases using scorpion I/O-IV recording system. This data was taken for reprocessing to improve imaging at Mehsana, Mandhali and Linch equivalent levels. These sands in Mehsana block of North Cambay Basin are known for multiple hydrocarbons bearing sand reservoir within Younger and Older Cambay Shale. The limitations for the area are complex weathering and sub weathering media resulting into low signal-to-noise ratio and low frequency content in the recorded data. The data also contained high frequency noise burst and ground roll. All the due care was taken during the processing of the data .The final processed output shows a marked improvement at all the levels.

Introduction

3D – Seismic data of three volumes pertaining to Jotana area of Ahmedabad-Mehsana tectonic block of Cambay Basin was acquired by WON Basin Vadodara with objectives to map better seismic image of strati-structural features within Mehsana, Mandhali and Linch equivalent pay sands. These lenticular sands are having thickness varying from 8 m to 12 m. As the previously processed individual outputs had limitations and it is difficult to track the events across the volumes, it was felt to reprocess the data to improve seismic imaging for mapping of prospects within Mehsana, Mandhali and Linch levels.

Geology of the area

The Cambay Basin is located in western margin of Indian peninsula and it is divided in five tectonic blocks, starting from Narmada block in the South to Serau -Tharad block in the North. The study of area i.e., Jotana, Mandhali. Linch and Nandasani field falls in Ahmedabad – Mehsana tectonic block which are fairly well developed producing fields of North Cambay Basin .These fields are the main members of both Older and Younger Cambay shale. Mandhali member constitutes broad deltaic deposits with tidal influence. Mehsana sands are thin and lenticular and show varying stratigraphic position with respect to top of Mehsana coal. The origin of this basin is related to break up of Gondwana super continent in the late Triassic / Early Jurassic and it was formed in Early Cretaceous age. The Cambay Basin consists of Graben flanked on its West and East by fairly wide shelves dipping towards the center of Graben. The Cambay shale overlying Olpad formation is overlain by Kadi formation that has been divided in three distinct members Mehsana, Mandhali and Chhatral separated from each other by Marine transgressive distinct shale breaks, known as lower and upper tongue.

Fig-1 is showing the Location map in tectonic block with study of area in red box and Fig-2 shows the boundaries of three volumes.

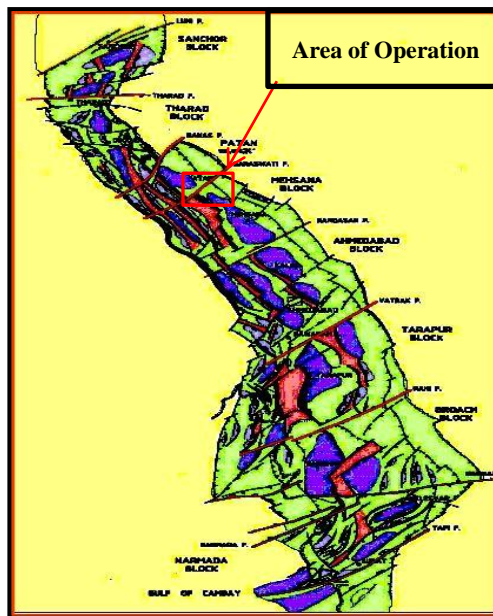


Fig-1: Tectonic map of Cambay basin with study area in red box

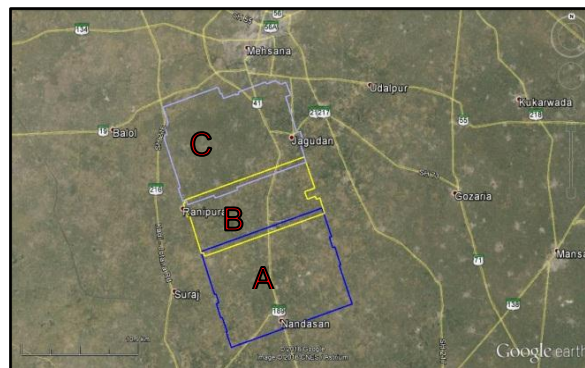


Fig-2: Showing the boundaries of the three volumes vintage

## Input Data

All the three volumes were acquired by using Scorpion I/O-IV recording system with same acquisition geometry and parameters. The asymmetric split spread (160-40) geometry with 12 numbers of receiver lines and 200 numbers of active channels per receiver line were adopted for all the three volume. The shooting direction was used West to East with orthogonal swath shooting method having 10x10 m bin size. Out of the three volumes, volumes B & C were acquired by using same sensor SM-24 while volume A was acquired by using SS 10 PN sensor which is technologically equivalent to SM-24 sensor. The input data was received in SEG Y and SEG D formats in 3592 cartridges and the SPS data was received in DVDs. In general, data sets are characterized by strong ground roll, noise bursts, spikes & etc. The area was covered with towns, roads; busy highways and railway lines with augmented the severity of noise in the data. The main challenges in the data are to handle the different types of noise retaining the signal. Other issue is to suppress the multiples available in the area.

## Processing Methodology

The input data received in SEG Y and SEG D format was converted to local CGG format and geometry merging was done of each vintage separately. Rigorous QC was carried out to ensure proper merging of SPS with seismic data. Vintage A and B were acquired in Everest 1830 coordinate system while Vintage C was acquired by using WGS 1984 coordinate system. During the processing, care was taken in noise suppression and velocity analysis. Each seismic vintage was processed independently up to deconvolution stage after that the coordinate system of Vintage A and B were converted to WGS 1984 and then all the three volumes were regrided and brought in common grid of WGS 1984 coordinate system. All significant attributes like common gridding, polarity check, time shift study and wavelet matching were taken care in to account to bring each vintage on a single platform prior to making a single volume. General processing flow used is given in Fig-3.

## Signal Conditioning

Analysis and elimination of noise was handled carefully and judiciously with the combination of different denoise modules. Noise strips, spikes, random, linear and frequency dependent noise were suppressed extensively using frequency dependent noise attenuation techniques. Coherent noise attenuation was handled by FK filtering. During the processing, all the low frequencies were preserved which helped in imaging the deeper reflectors. Fig-4 to Fig-7 show shot gathers before and after noise suppression respectively and Fig.8 shows the stack section before and after denoising.

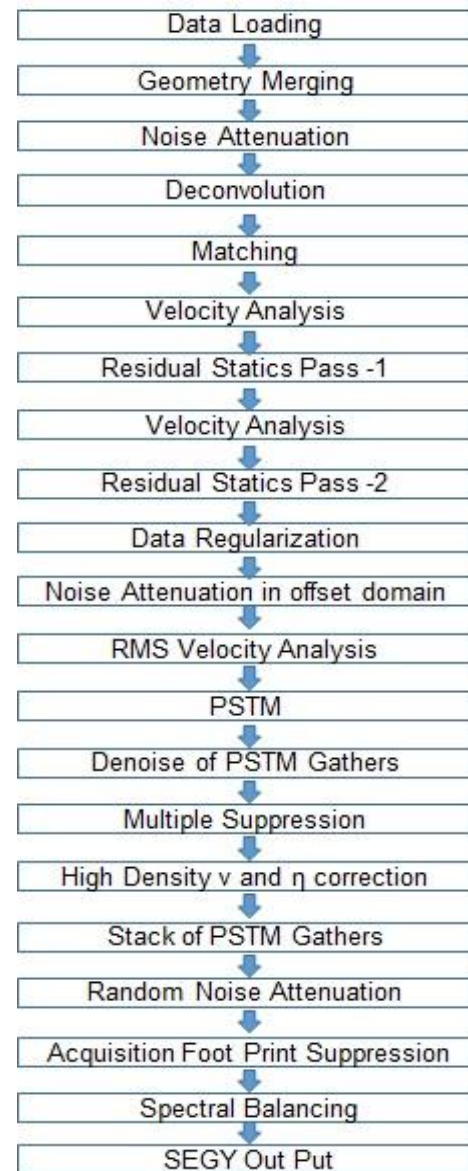


Fig -3: General processing flow

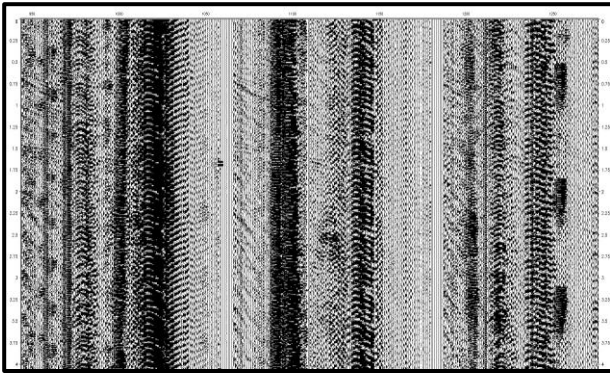


Fig-4: Raw shot gather with noise strips

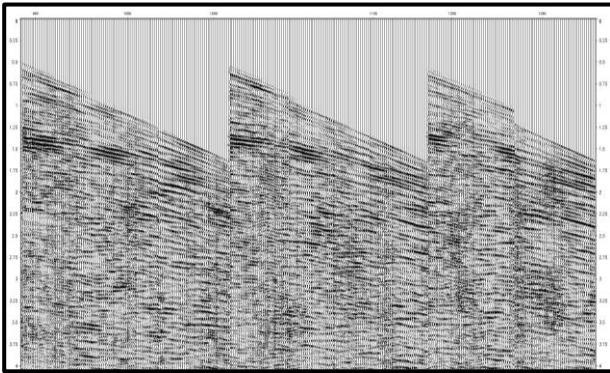


Fig-5: Shot gather after noise attenuation

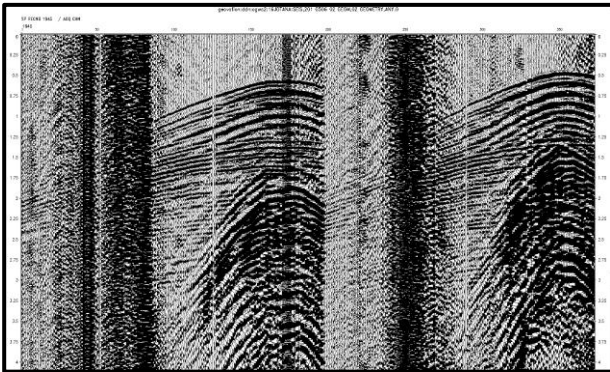


Fig-6 Raw shot gather with ground roll

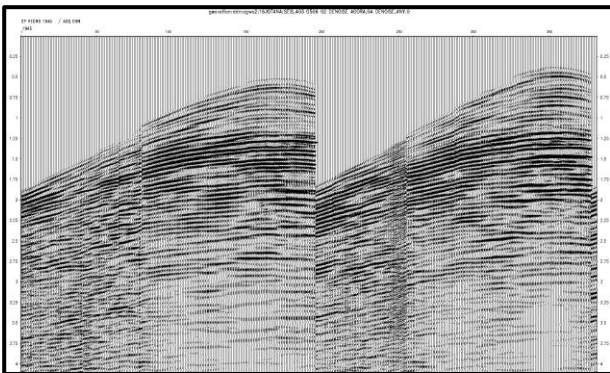


Fig-7: Shot gather after noise attenuation

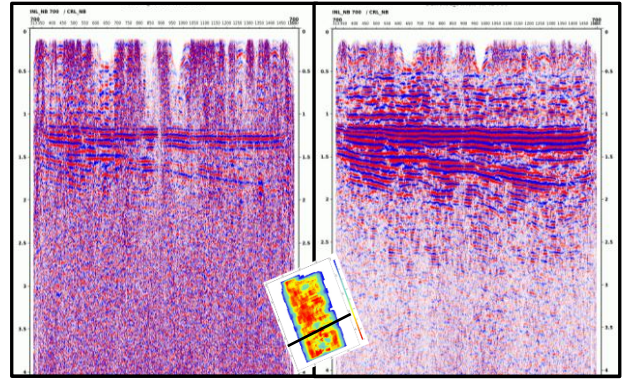


Fig.8 Stack section before and after Denoise stack

### Polarity Check

Polarity of shot gather data of all three volumes was analyzed, it was found that the first break energy is trough in all the volumes and no data set has opposite polarity. Hence no any corrective action was required in this regard.

### Deconvolution and Velocity analysis

Autocorrelation of representative de-noised gathers was analyzed to get the first hand idea of wavelet and ringing present in the data. In second step, Decon stacks with different predictive distance and operator length of 300ms were taken based on the analysis of ringing present in auto-correlation output. On the basis of test results, a two window de-convolution using prediction distance of 36ms and operator length 300ms was found optimum and same was applied on the data. Band pass filter was applied on the data with frequency range 1-3-70-80 Hz. Amplitude spectrum before and after Deconvolution at one inline (Time Window: 500-3000 ms) is shown in Fig 9. Velocity analysis was carried out on decon applied merged data. Computed velocity volume was used to generate decon stacks

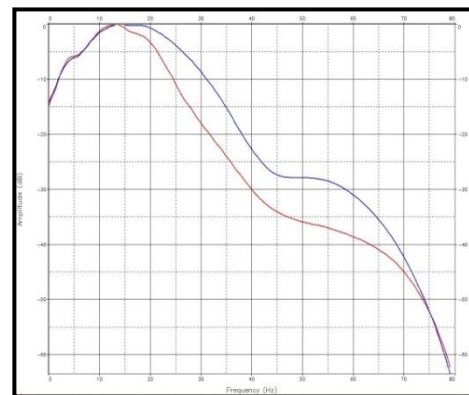


Fig-9: Amplitude spectrum before and after decon application (Red color before Decon)

## Time shift correction

As shown in Fig-02, all the three volumes overlap to each other. Initially the stack data of common zone of volume A & B taken for time shift matching, it was observed that there is a time shift of 20 ms between them. In the same manner stack data of common zone of volume B and C were matched and it was found that there is no any time shift between volume B and C. Hence a 20 ms time shift was applied in the volume A to bring out it equivalent to other two volumes. Fig-10 shows the time shift matching loop diagram and Fig-11 shows the stack section before and after time shift matching.

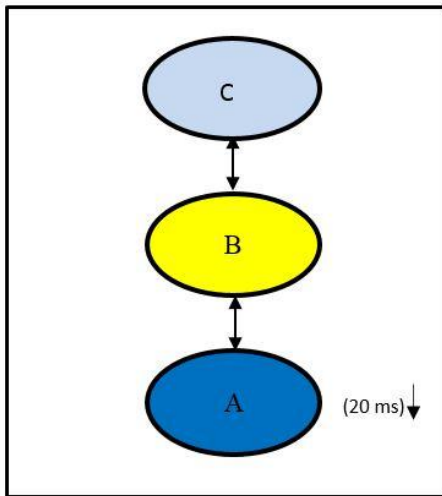


Fig-10: Time shift matching loop diagram

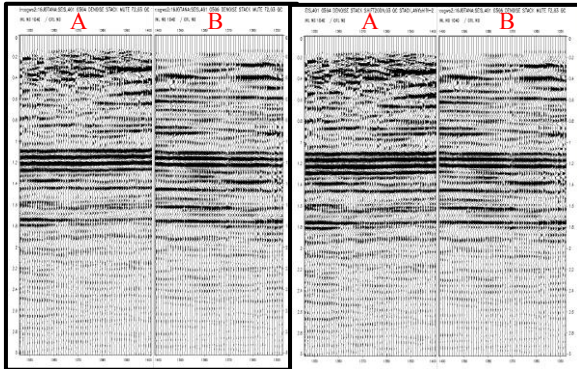


Fig-11: Stack section before and after time shift matching

## Amplitude and phase matching

As all the three volumes were acquired by same recording system and same acquisition parameters. Thus no wavelet and phase difference was observed in the data. Hence no wavelet and phase matching was needed.

## Residual statics estimation, application & Velocity analysis

Velocity volume computed on decon applied gathers was used to calculate first pass residual statics. Using first residual statics applied gathers; second velocity analysis was carried out in the grid of 1000 m x 1000 m. This refined velocity volume was used for estimation of second pass residual statics. Stack was generated after the application of two passes of residual statics. Stack after residual statics application showed fair degree of improvement as compared to decon stack. The issue of low fold due to data gap was taken care by fold regularization in offset class domain.

## Data Regularization

Two pass residual statics applied decon gathers were taken as input for data regularization. In general, fold varied from 1-60. Few gaps owing to missing near offsets and were observed, which necessitated "Data Regularization". Considering the fold variation, sixty offset classes were generated. Offset class increment of 60 m was chosen for offsets up to 3600 m. These offset classes were taken as input for data regularization. Data was regularized using bin sizes of 10mX10m. Effect of 3D offset regularization on gathers is shown in Fig-12 and Fig- 13 (before and after regularization), and the stack sections before and after data regularization are shown in fig.14, Fig.15 is showing fold map before and after data regularization.

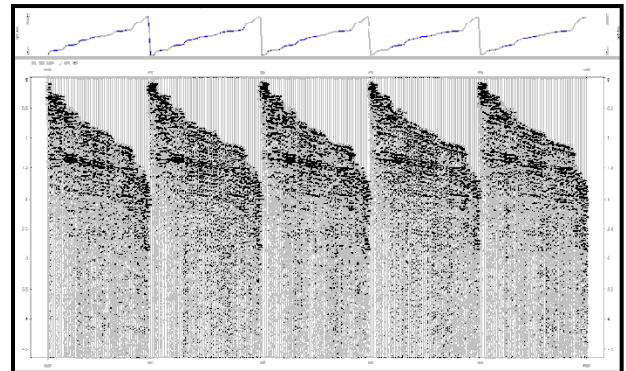


Fig-12: CMP gathers before data regularisation

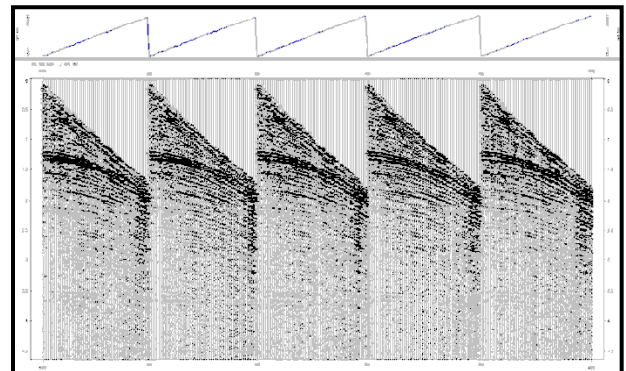


Fig-13: CMP gathers after data regularization

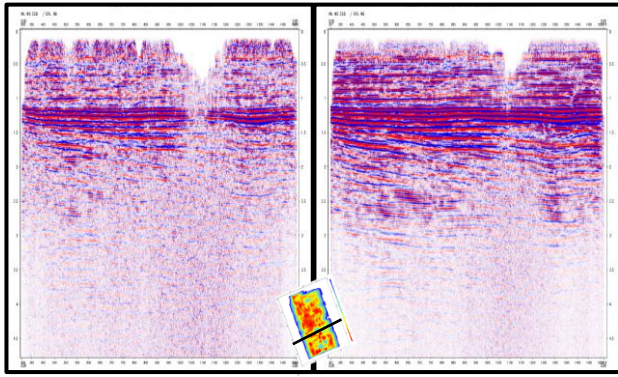


Fig-14 CMP Stack without (left) & with (right) regularization

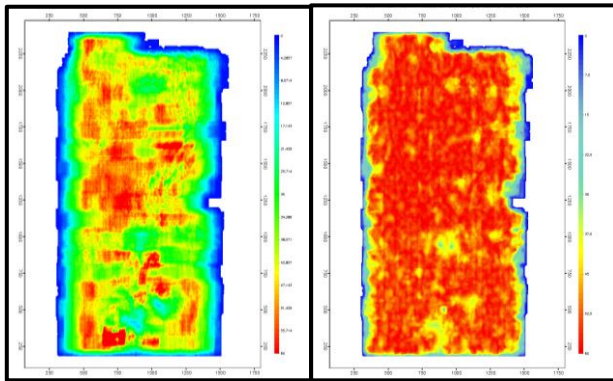


Fig-15: Fold map before (left) and after (right) regularization

### Pre-Stack Time Migration

For RMS velocity analysis, pre-stack time migration was carried out along the target velocity lines. Residual statics applied (Regularized) deconv gathers were used for the migration. RMS Velocity analysis was carried out at 500 x 500 m interval. Representative RMS velocity analysis panels are shown in Fig-16. Migration Aperture testing was done with different migration apertures. It was observed that the sections with full aperture of 6000m was optimum, hence it was finalized for final migration with Dip limit of 70°. Taking smoothed RMS velocity, final migration job was executed in offset class domain with considering offset from 40 m to 3600 m using Kirchhoff's time migration algorithm. Multiple attenuation job was run on PSTM gathers. The normal move out difference between primary and multiple signal was small. Hence multiple attenuation was done optimally. High density velocity and anisotropy picking (HDPIC) was also carried out at a close grid of 100mX100m for better flattening of gathers. Taking the flattened PSTM gathers, PSTM stack was generated. In final post stack processing was done which was followed by random noise attenuation by projection filter, acquisition foot print suppression using F-Kx-Ky filter and finally spectral balancing was carried out to improve frequency content in the data.

The final processed outputs in In-line and Cross-line are given in Fig.17 and 18 respectively, and a representative time slice at 1800 ms is given in Fig.19. The comparisons of earlier processed v/s reprocessed outputs are shown in Fig. 20 to 22.

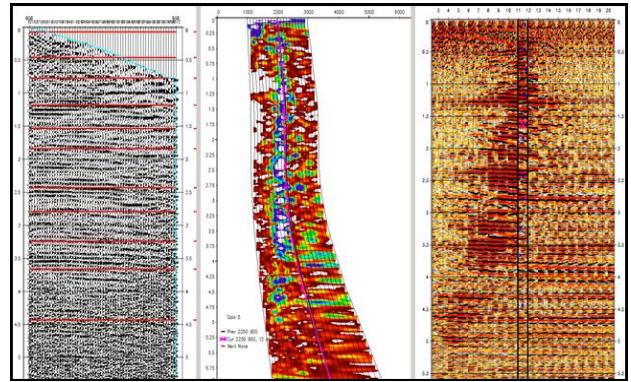


Fig-16 RMS Velocity analysis

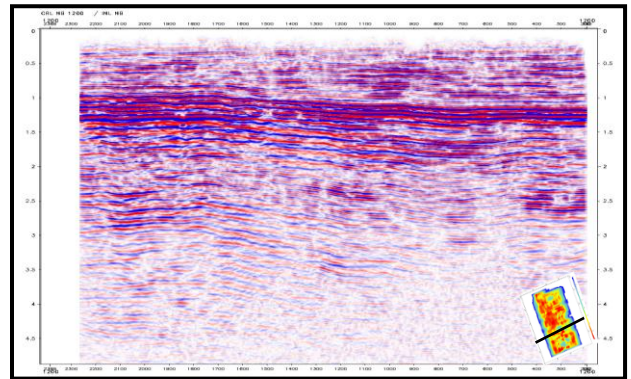


Fig-17: Final PSTM Stack along In-Line

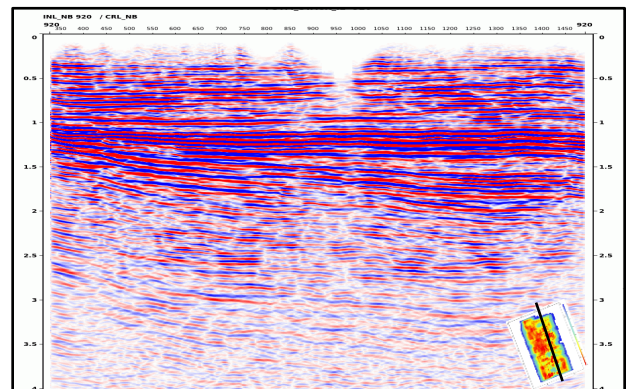


Fig-18: Final PSTM Stack along cross-Line

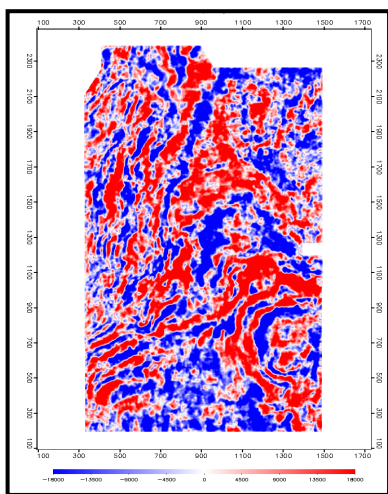


Fig-19: Time slice at 1800 ms

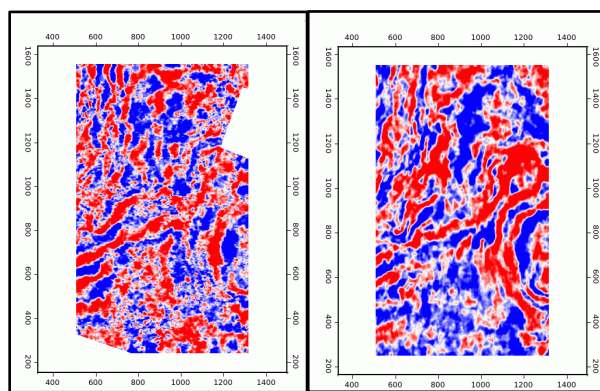


Fig-22: Time slice Legacy (left) reprocessed (right)

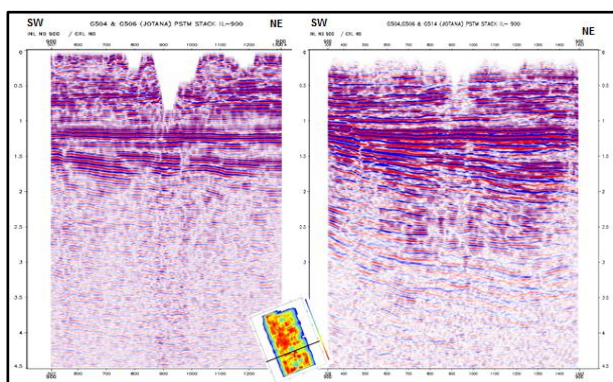


Fig-20: An Inline Legacy section- left, reprocessed section - right

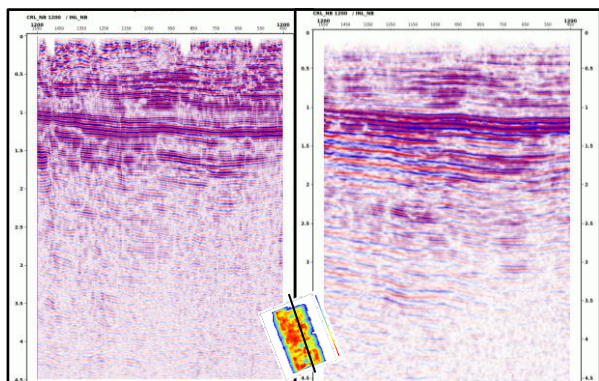


Fig-21: A, Cross-line Legacy section- left, reprocessed section - right

## Conclusions

The processing steps included standard signal conditioning followed by pre-stack time migration. Emphasis was given during noise suppression and velocity analysis, which resulted in better imaging of the sub-surface. Irregular offset distributions across the bins were effectively accounted with 3D data regularization. Post migration processing for random noise suppression, spectral enhancement, multiple attenuation and acquisition footprint attenuation was used to derive the final results. The final merged output shows significant improvements at Mehsana, Mandhali and Linch equivalent sands.

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## References

1-Petroleum geology of Cambay basin, Gujarat India, L.R.Chaudhary, Indian petroleum publishers, 2004 Technology and Engineering

*\*Views expressed in this paper are solely of the author's only and may not necessarily be of ONGC.*