

## Handling near surface complexities of 3D seismic data of Jaisalmer basin using combination of various static solutions

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### Key words

Sand dunes, Tomo statics, Iterative velocity analysis & residual statics, Regularization

### Abstract

Near surface complexities on land predominantly in sand dunes have been the toughest challenges in seismic data processing. Varying near surface degrades the seismic image in land, because of the distortions occurring to the body waves while passing through the complex near-surface. Complex near surface velocity variations introduce static issues which influence the accuracy of the resulting imaged time structure. The present workflow addresses the challenges and difficulties observed in the processing of the data acquired in sand dunes. The statics issues were dealt with the combination of Tomo statics and iterative Reflection residual statics.

### Introduction

The present study was carried out on seismic data acquired in desert part of the Rajasthan, north-west part of India. 3D seismic data of four volumes (A, B, C & D) were acquired in Jaisalmer basin with Vibrator source. The four volumes were merged together at pre-stack level. Figure – 1 shows the Location map of survey areas.

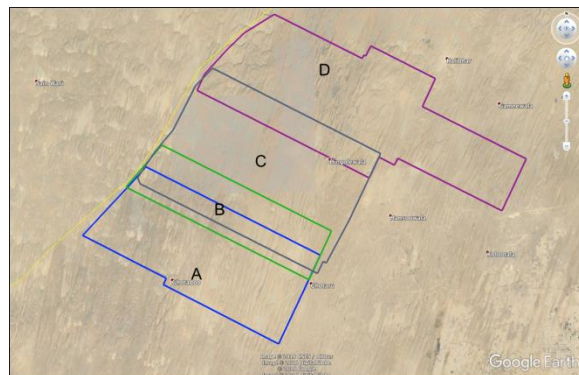


Figure - 1: Location map of survey areas

The Rajasthan sedimentary province forms a part of gentle westerly and northwesterly dipping eastern flank of Indus Shelf. Jaisalmer Basin is one of the four main structural elements of this province and it is a late Paleozoic basin with Permian rocks resting

unconformity over Phylite and Schists of doubtful Proterozoic age. The adjacent Bikaner-Nagaur Basin to north has widely differing geological history during Paleozoic and Mesozoic times. The Basin is further divided into Shahgarh Depression, Kishangarh Shelf and Miajlar Depression

### Challenges

Due to the near surface complexity of the area, the data contains three major challenges i.e., non – coherent shot generated noise (unlike the usual ground roll), long & short wavelength statics and velocity analysis.

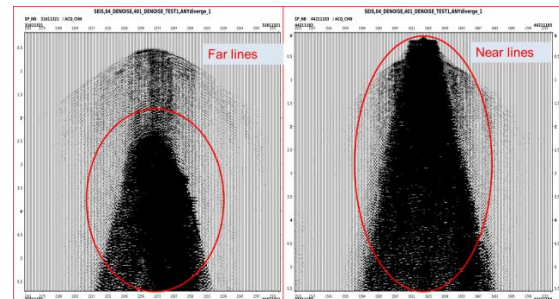


Figure - 2: Shot gather with noise in far & near lines

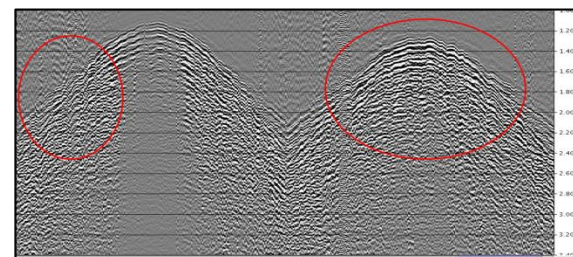


Figure - 3: Shot gather with statics issues

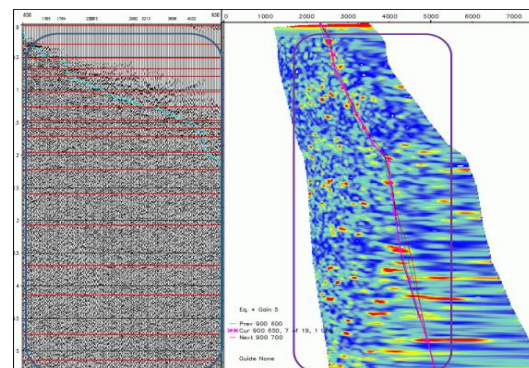


Figure - 4: CMP Gather with velocity semblance

This data was acquired in sand dunes with vibrator as a source. The data contains the shot generated noise which is spread over the almost entire signal bandwidth (Figure – 2). The low S/N made statics estimation an even bigger problem that made velocity analysis very challenging which can be seen from the semblance contours. Also the reflection events present are difficult to view on the CMP gathers (Figure – 4).

### Processing work Flow

To achieve the better results, we have slightly modified the work flow in our regular processing. For long wavelength statics solutions Refraction based statics (Tomo statics) were calculated and applied on the data set. Special care was taken during the noise analysis. For the short wavelength reflection statics and velocity analysis we have followed iterative approach with more number of iterations. In this paper we discuss the major steps that improved the imaging.

Processing workflow:

- ❖ Data loading & QC
- ❖ Tomo statics
- ❖ Signal conditioning
- ❖ Wavelet and Time shift matching
- ❖ Iterative velocity analysis & Residual statics
- ❖ 3D regularization
- ❖ Target line migration
- ❖ RMS velocity analysis
- ❖ Pre-stack time migration
- ❖ Post migration processing

### Tomo Statics

Refraction based statics estimation and application was carried out. The first breaks for all the shots were picked by auto picker. The second pass picks were generated using synthetic picks as guiding picks. Also, bad and noisy traces were zeroed out before first breaks picking.

Travel time trajectory was picked while honoring the change in gradient. Determined the near-surface layer velocities and thicknesses inferred by the picked travel time trajectory. Then, build an initial model for the near- surface based on these layer velocities and thicknesses.

3D ray tracing was performed to compute the travel times associated with the initial velocity model using the shot and receiver locations. Then, perturb

the initial model parameters until the difference between the modeled and the picked travel times are minimum in the least-squares sense, using nonlinear travel time tomography that accounts for changes in travel time gradient.

Using the near-surface model estimated and the floating datum and intermediate datum picked, the shot and receiver statics were computed. The computation was done in two steps: first, shots and receivers were moved down from topography to the intermediate datum using the velocity field associated with the near-surface; second, they were moved up to the floating datum using the replacement velocity 2200 m/s. Also calculated the refraction based shot and receiver residual statics.

Applied the refraction and refraction residual statics on raw shot gather of each vintage. Figure – 5 shows the shot gather before and after statics application. Data was leveled at MSL using replacement velocity 2200m/s for each vintage.

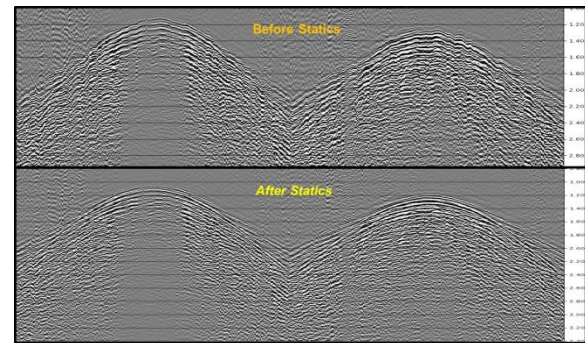


Figure – 5 Shot gather before and after statics application.

### Signal Conditioning

Noise stripes, spikes, random and high frequency noise were suppressed extensively. The noise observed in this data is different from normal. Mainly Frequency Dependent Noise Attenuation technique and

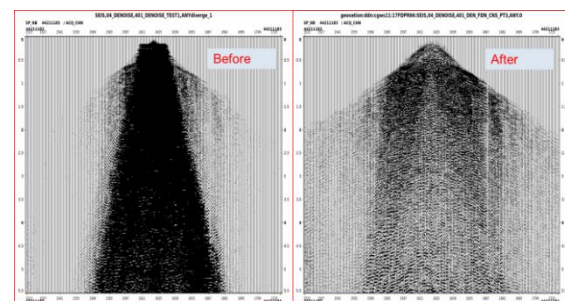


Figure -6: Raw shot gather before and after Denoise

Coherent noise attenuation & signal enhancement tools used to suppress the noise. Figure - 6 shows shot gather before and after noise suppression.

Before deconvolution the data was converted to minimum phase. On the basis of test results for deconvolution operator, prediction distance of 12ms and operator length of 240ms was adopted and applied on the data. Band pass filter 3-6-80-90 Hz was applied on the data.

### Iterative Velocity Analysis & Residual statics

In typical land data two or three pass residual statics estimations were enough to improve the imaging. But In this data set we had to run 5 iterations for residual statics estimation and after every iteration velocity analysis was done. Two techniques were used to estimate residual statics, i.e., linear and nonlinear approaches. First one is based on cross correlation and another one Monte Carlo techniques. After 5 iterations of Velocity analysis and Residual statics application the output showed fair degree of improvement as compared to Deconv Stack.

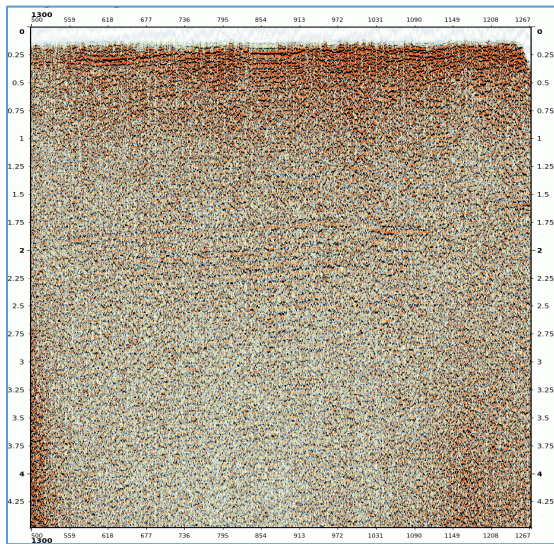


Figure – 7a: Deconvolution stack

Figure – 7a shows deconv stack, Figure – 7b & 7c shows stacks after 3<sup>rd</sup> iteration of residual statics and velocity analysis.

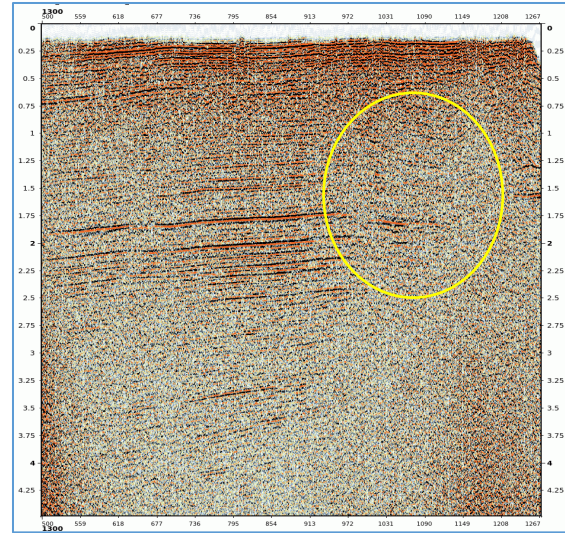


Figure – 7b: Residual statics applied stack after 3<sup>rd</sup> iteration

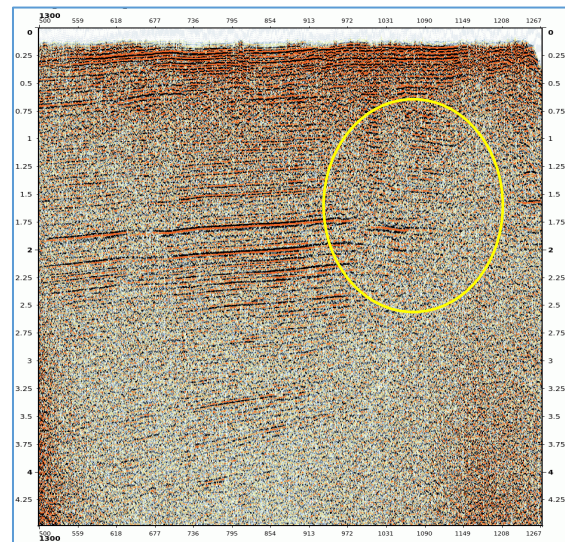


Figure – 7c: Residual statics applied stack after 5<sup>th</sup> iteration

### Data Regularization & PSTM

After residual statics application 3D regularization was done in offset class domain. Considering the fold variation, 148 offset classes were generated. Offset class increment of 80 m was chosen for offsets upto 7200m. Each offset classes were regularized using bin size of 20mX20m. Figure - 8 shows the Fold map before and after regularization. Figure – 9 shows a gather before and after regularization.

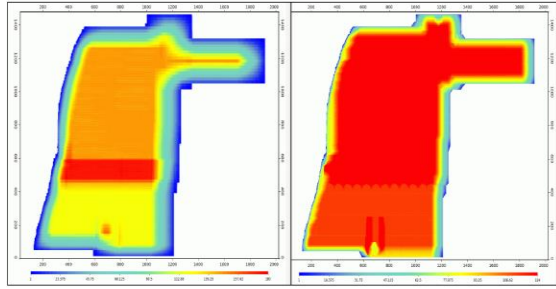


Figure – 8: Fold map before and after regularization

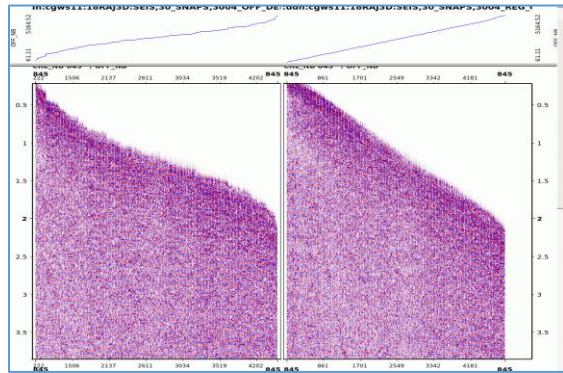


Figure – 9: Shot gather before and after regularization

PSTM was run for all offset classes using Kirchhoff algorithm and PSTM gathers were generated. Random noise attenuation was carried out on PSTM gathers.

### Post stack processing

High density velocity and anisotropy picking was carried out at a close grid of 200mX200m for better flattening of PSTM gathers before stacking. Post stack processing on final outputs included random noise attenuation using F-X projection filter and acquisition foot print removal in F-kx-ky domain. Final results of PSTM stack & time slice after post stack processing are shown in Figures - 10 & 11.

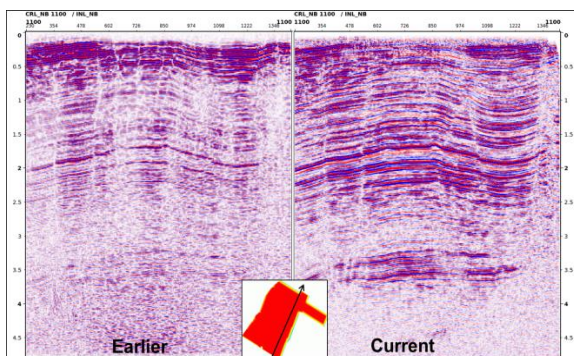


Figure – 10: Comparison of stacks at Crossline 1100

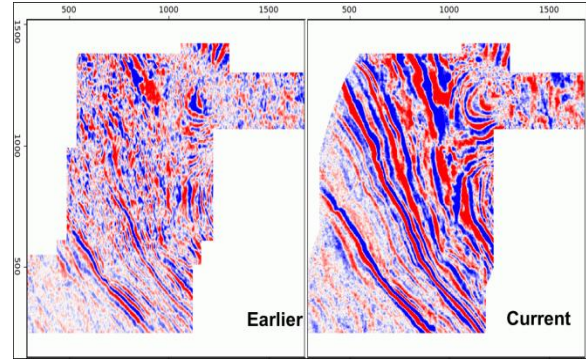


Figure - 11: Time slice at 3100ms

### Conclusions

Near surface complexities in land data still remains a challenge. The suppression of shot generated noise in sand dunes due to the vibrator source needs further investigation. Tomo statics, iterative velocity analysis and iterative residual statics have helped to improve the image quality in the area.

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*Views expressed in this work are entirely of the authors only and do not reflect those of ONGC.*

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