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Thrust belt Seismic Processing-A case study from NE part of India

Mayank K Banerjee*, Surendra K Dass, Dharam S Manral, Akshya kumar, Dr. Rahul Dasgupta
(Oil India Ltd)

Summary

Structural Imaging of topographically challenging and geologically very complex acreages of OIL's operational area in Upper Assam and Arunachal Pradesh remains one of the prime challenges of the company. The study area belongs to one of the heavily thrusted part of NE India. This area is also known as boulder-bed area as at many places the boulder beds are exposed to the surface or is underlying at a very shallow depth. Primary problems associated with such type of area are poor penetration of seismic energy, sudden change in topography and subsurface geological complexity.

In this paper, we present the processing strategy of such thrust belt data. The processing was constrained by the geology of the area. Introduction of latest noise attenuation algorithm, better static & residual static solutions and mixed velocity picking are key to achieve the objective of the study.

Introduction

Processing of seismic data from the foothills & mountainous region of N-E part of India has always been a challenging problem. The study area is surrounded by Mishmi thrust bordering its eastern side while Naga thrust at its south (**Figure 1**). The area is also known as Manabhum folded zone, includes foreland thrust/fold anticlinal structures. They appear to have formed by Himalayan thin skinned foreland thrusting (**Figure 2**). Dhekiajuli formation is found in patchy outcrops to the north of Margherita thrust, and forming a large NW-SE trending outcrops along the manabhum folded zone.

The main operational challenges in this area are: surface exposure and shallow depth of boulder-beds making shot hole drilling impossible leading to poor energy penetration, abrupt change in elevation and complex subsurface geology. All these lead to poor S/N ratio in the data. 2D seismic data was acquired in this area during multiple seasons due to extreme logistic challenges and small time window of operation.

Noise contamination of the data was very high due to surface and subsurface related problems. Primary objective was to apply good noise attenuation solution and then to test for better static solution and stacking velocity. QC plots and displays were extensively used to judge the effectiveness of each algorithm on the data set.

Processing strategy

Considering the poor energy penetration first step of this study was to improve the S/N ratio. Minimal process approach was adopted to reduce the processing artifacts which may get introduced during processing and extensive QC for each filter was done so that noise doesn't get exaggerated. Key steps in the processing sequence are as follows

- Random/surface related noise attenuation
- Estimation of refraction & residual static correction
- Velocity estimation

Random/surface related noise attenuation

First breaks were picked to determine the correct positioning of source points and were corrected accordingly. Spectral analysis of seismic data indicates the dominant surface related noise to be of 11 Hz with a velocity of about 300 m/s (**Figure 3**). surface wave noise attenuation was found to be effective in addressing this issue. Spiking Deconvolution with mild pre-whitening was found giving good result (**Figure 4**).

Seismic Data Processing Centre, R&D Building, Duliajan, 786602, Assam, India mayankbanerjee@gmail.com

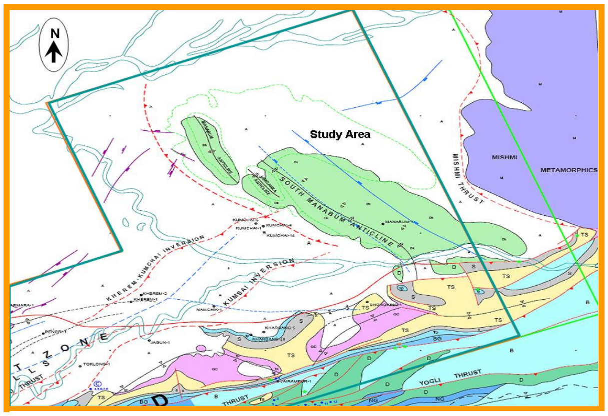

Figure 1: structural element map of the study area depicting the complexity of geology in the area.

Preprocess gathers were stacked with elevation statics and brute velocity to get a preliminary picture of the subsurface. CDP ranges having good and poor S/N ratio were identified and discriminated as **Area A** and **Area B** respectively **(figure 5)**. Parameters used for processing were tested repeatedly on these zones to optimize the better one.

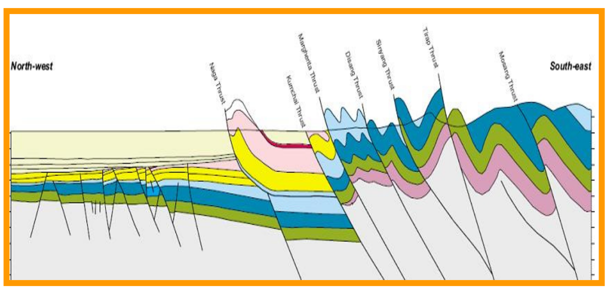

Figure 2: cross section displaying structures formed due to thrusting in the area. Erosion after thrusting has caused exposure

Random noise contamination was found to be high in **Area B.** algorithms such as Eigen value filter and F-x Deconvolution were tested on Area B and Eigen value filter was found to be effective in suppressing the random noise.

Estimation of refraction & residual static correction

First breaks arrival times picked to QC the geometry were used to estimate refraction statics. However, elevation statics was also used to compare the effectiveness of refraction statics. After the application of refraction statics residual statics algorithm were tested on the data and maximum-power statics algorithm was giving good results. This algorithm works well for data with poor S/N ratio.

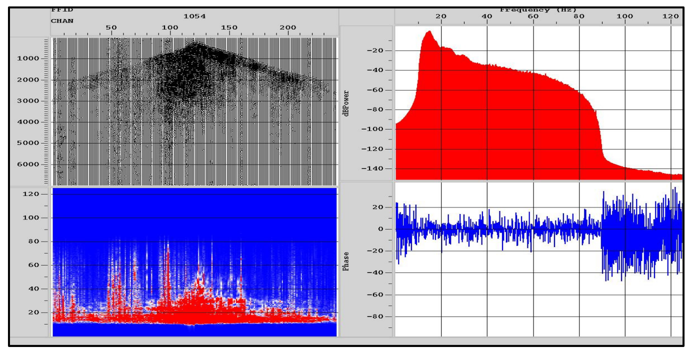

Figure 3: spectral analysis of records indicate noise contamination at lower frequencies.

It is widely known that accurate velocity estimation requires good static estimation, while success of residual statics depends on how good the stacking velocities are. An iterative approach of velocity picking and residual statics was taken to improve the stack.

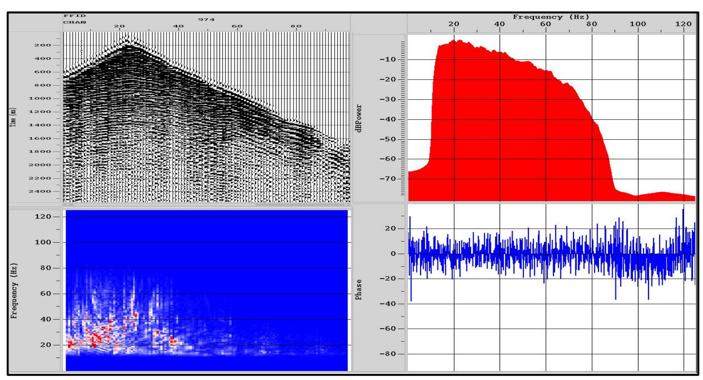

Figure 4: spectral analysis of noise attenuated data indicates the improvement of S/N ratio.

Velocity estimation

Velocity estimation is a real challenge when the topography is changing abruptly and subsurface conditions are varying. In a geologically complex area it can be improved if the static corrections are proper and vice-versa.

Velocity analysis of area of poor record i.e. Area B and good record i.e. Area A were analysed separately. CVS of fine velocity interval of wide range were generated over Area B where as interactive analysis was performed over Area A. CVS helped to record and observe the changes on quality of the stack with variation in velocity. Hence proper velocity selection could be done with the area of poor record.

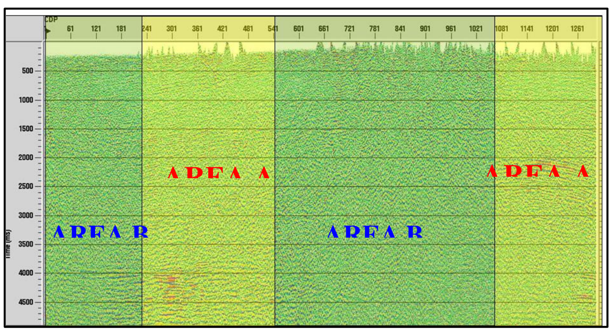

Figure 5: Demarcation of area with good record and poor record to have different velocity estimation approach.

An iterative approach has been taken to strengthen the estimation of velocity and residual statics. To map the lateral variation in velocity, velocity analysis was performed in every 150 m and QC of velocity was done by generating migration sections. With every iteration of static correction and velocity analysis, QC migration was run to see its effects on the data. After every iteration, a preliminary broad interpretation of the data is done to understand the geology and with this geological constraint next iteration of the entire process was done.

Results

Objective of this study was to see the effect of noise attenuation, static correction and role of stacking velocity in improving the structural imaging of thrust belt data. Suppression of random/ surface related noise caused huge improvement in the quality of the stack.. A satisfactory result was obtained by noise attenuation followed by iterative analysis of velocity and statics **(Figure 6 & 7)**.

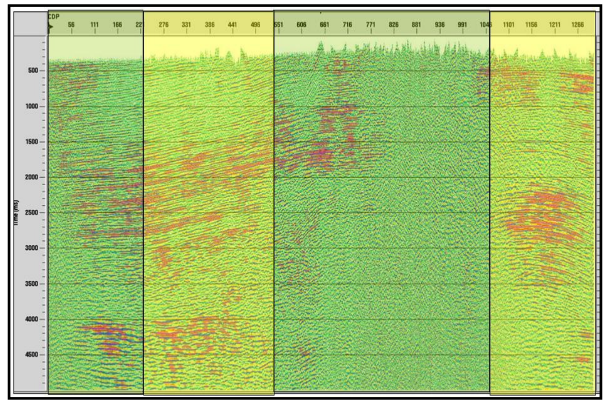

Figure 6: improvement in the final stack after application of good stacking velocity, residual statics and random noise attenuation.

Conclusions

Imaging in thrust belt area is always a challenging problem all over the world. However, with a good acquisition planning and advanced processing technique faithful results can be obtained. With this geologically constraint processing workflow, interpretable and realistic imaging of the sub-surface was achieved. Application of latest seismic processing techniques which can take care of lateral variation in the characteristic of surface related noise will generate superior results.

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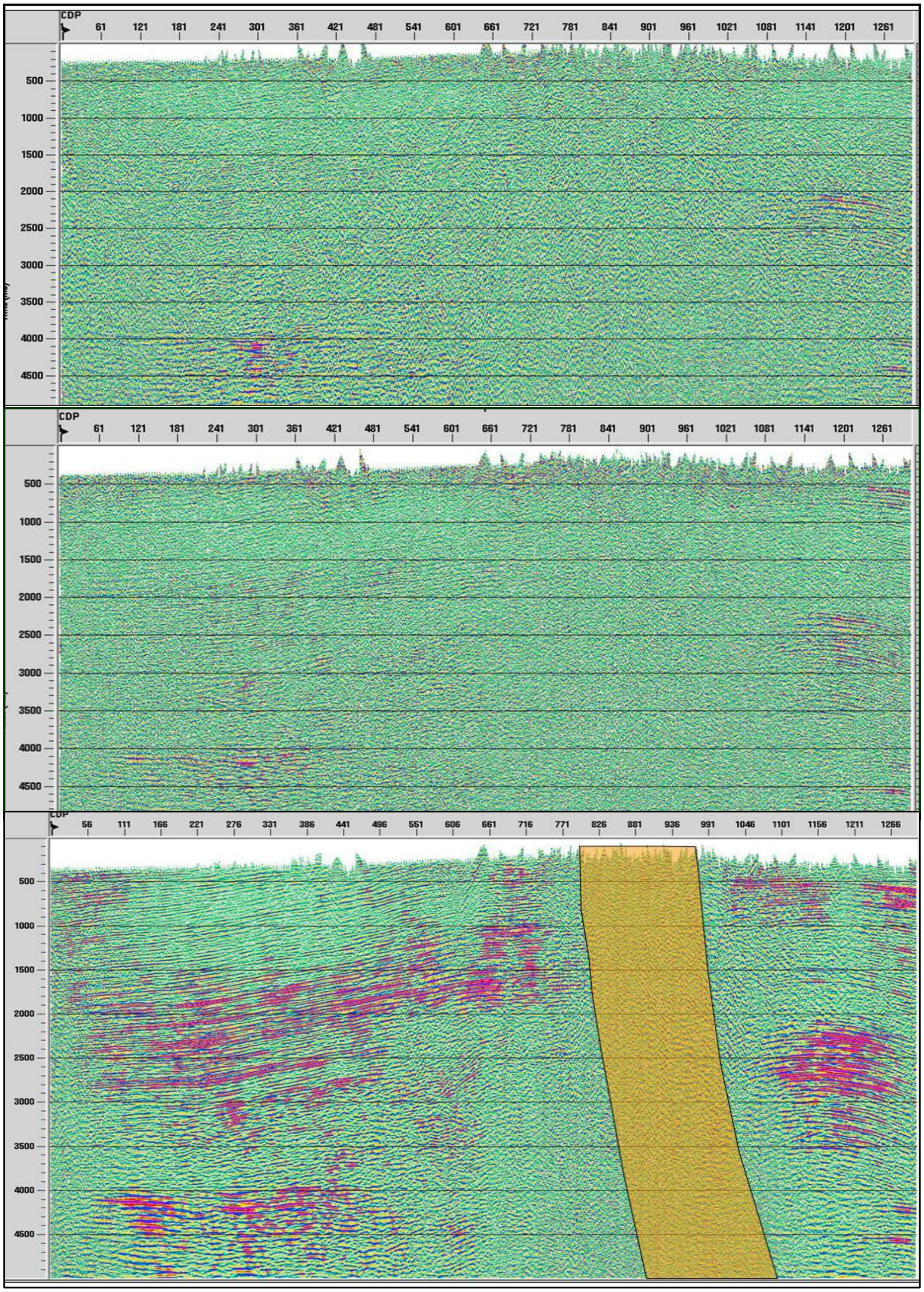

Figure 7 Stack comparison: Elevation statics (top) refraction statics (middle) residual static with random/surface related noise attenuation