9[th] Biennial International Conference
& Exposition on Petroleum Geophysics

"HYDERABAD 2012"

P-069

Post Acquisition Quality Analysis of 3D Seismic Data Using Field Processing Unit, an aid to processing - A case study from Bengal Basin

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Summary

A seismic signal is characterized by its frequency content and signal-to-noise ratio (S/N). The quality of acquired seismic data is mainly governed by these two parameters. During seismic surveys it is ensured that the input parameters like placing of shot in a proper shooting medium, good ground coupling of sensors are optimum so that quality of acquired data is very good. Apart from this, shot and receiver positioning plays an important role in seismic data quality. Shot mis-positioning may lead to serious errors during data processing and it affects the stack quality. The present study envisages quality analysis of acquired 3D seismic data with respect to frequency content, signal content and shot-receiver mis-positioning. This study is based on a 3D reflection seismic survey in Bengal Basin of India.

Keywords*: Linear move out (LMO), Shot geometry QC, Quality Factor, shot mis-positioning, signal to noise ratio, Seisup.*

Introduction

The study area falls in the stable shelf part of the Bengal Basin (Figure-1). Paleogene-Neogene sequence is expected to be prospective in this area. In order to delineate this sequence, 320 sq. km. of 3D reflection seismic data was acquired in this area. The existing 2D data was not sufficient to decipher the stratigraphic features in the desired zone and a good quality 3D data volume was desirable. Therefore, it was pertinent to acquire and ascertain the quality of acquired data before processing.

The zone of interest was up to 3.6 km. and the two way time (TWT) up to the deepest horizon of interest was 3.3 second. Thus the frequency analysis was carried out in a window up to 4.0 second.

Frequency analysis is an established tool to find the resolution aspect of seismic data. Therefore, an effort was made to establish frequency characteristics of this 3D seismic data volume based on analysis of each and every shot. Results of high end frequency at -12 dB were tabulated and contour maps generated.

Surface elevation in the area of study varied from 5 to 12 m. Logistically, the area was very difficult to carry out 3D seismic survey because of dense population, network of rivers and canals, isolated big water bodies, standing crops and lack of connecting roads. However, the near surface was quite seismic friendly with the weathering zone thickness varying from 5 to 10 m and the weathering layer velocity varyingfrom 600 to 800 m/s.

Methodology

The present study is based on the 3D reflection seismic data acquisition in Bengal Basin, India. The acquisition geometry consisted of 12 receiver lines with orthogonal shooting pattern with explosive source. The shot depth varied from 16 m to 30 m and the charge size was 2.5 kg. Each receiver line contained 112 receivers/ channels and total no. of active channels per shot was 1344. Geophones, with 12 elements at each receiver position with natural frequency 10 Hz were bunched. Geophones were bunched due to logistic difficulties. Total number of shots per salvo was 18. The project area was covered with 7 swaths running east-west and the swath roll over was from south to north. The nominal fold of acquired data was 48. 315 up-hole surveys were carried out in a grid of 1120m X 1200m to prepare the near surface models (NSMs). The area is highly populated and full of standing crops, rivers, canals, tube wells, many isolated water bodies etc. It was difficult to find a place to blast the explosive in this logistically difficult area. Dynamic recoveries were planned and executed during the course of shooting in order to compensate for the missing foldage due to these obstacles.

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Figure.1 Location of study area

The entire 3D volume of data was loaded on field processing unit (FPU) swath wise and was geometry merged. Shot and receiver positions were plotted and are shown in Figure-2.

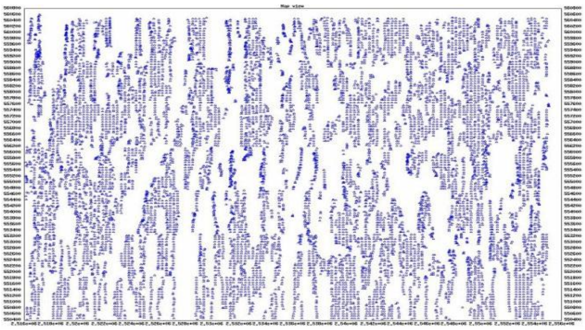

Figure-2 (a) Plot of shot positions as blue dots (From Seisup)

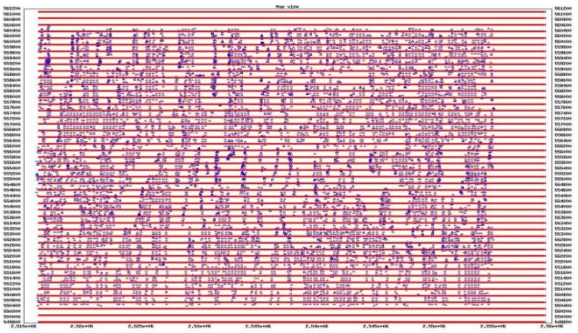

Figure-2 (b) Plot of shot & receiver positions (From Seisup). Red lines indicate receiver lines.

Post-acquisition quality analysis of each and every shot was carried out considering the frequency content and signal to noise ratio (S/N) of the shot gathers. Also the number of good channels (percentage) per shot gather was considered while computing the quality factor. Frequency analysis of every shot was carried out after loading the field data on FPU. The point map of the high-end frequency is shown in Figure- 3(a). S/N ratio was recorded by the seismic recording unit (Sercel) for each and every shot. Data quality was quantified by assigning weightages to frequency (40%), S/N ratio (40%) and percentage of good channels (20%). The point map of the overall data quality is shown in Figure- 3(b). The results of frequency analysis are tabulated in Table-1 and the the results of analysis of signal to noise ratio (S/N) ratio are given in Table-2. The fold map of the area is given in Figure- 3(c).

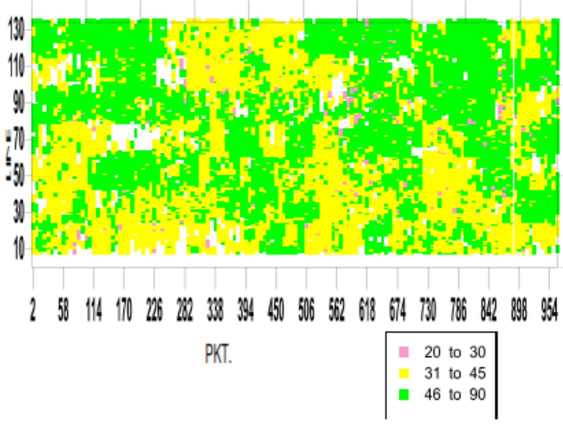

Figure-3 (a) Frequency Map (Fmax at -12 dB)

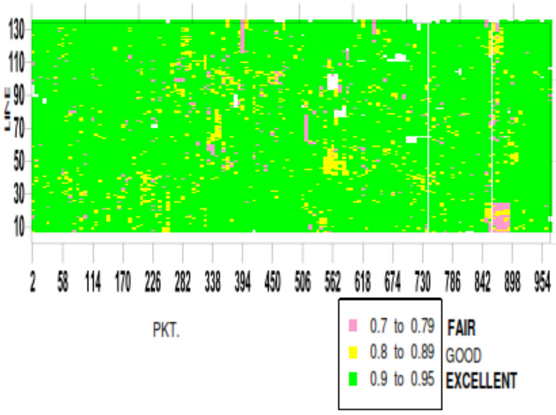

Figure-3 (b) Overall Quality Map of the area

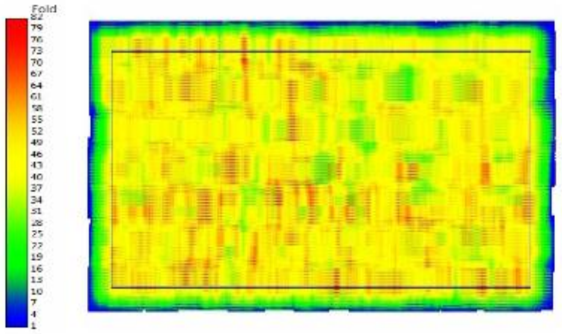

Figure-3 (c) Fold map of the area

In spite of adequate precautionary measures for obtaining accurate shot positioning, sometimes it was difficult to reoccupy the shot points. Accurate positioning could be achieved with the help of an utility namely shot geometry QC that is available in Seisup processing system (Geocenter International). The basic principle behind this technique is that given an input refraction velocity, it computes first breaks for different offsets. These first breaks are compared with the recorded first breaks. A mis-match is observed in case of wrongly reported shot positions. Shot position can be shifted manually so that both the computed and recorded first breaks match and the relocated coordinates are noted down. The database containing the shot coordinates will be automatically updated and saved for future use. Geometry can be re-merged with the seismic data by using the updated coordinates. All the shot gathers were analyzed with respect to shot geometry QC and corrected coordinates were computed before submission of data for processing. Figure- 4 depicts one shot gather before and after shot geometry QC analysis. Figure- 5 shows the window used for repositioning of shot points using Seisup software and the geometry merged data.

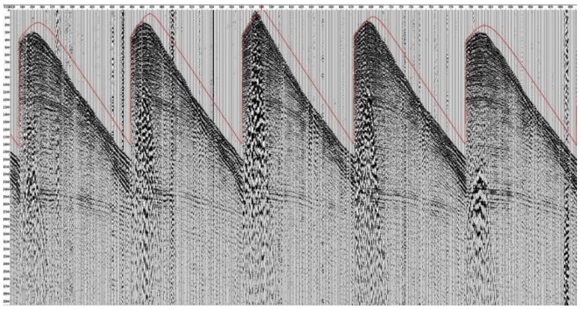

Figure 4(a) Uncorrected shot gather

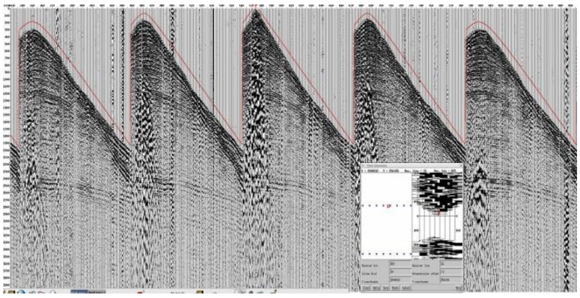

Figure 4(b) Desired position of shot points in shot gather

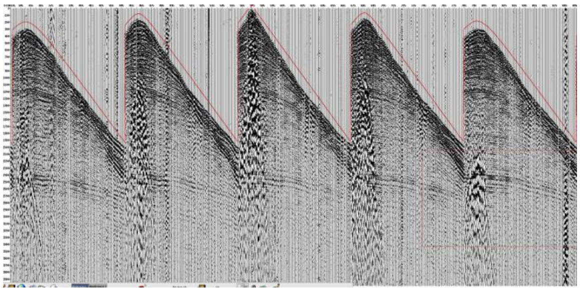

Figure-4 (c) Corrected shot position in shot gather.

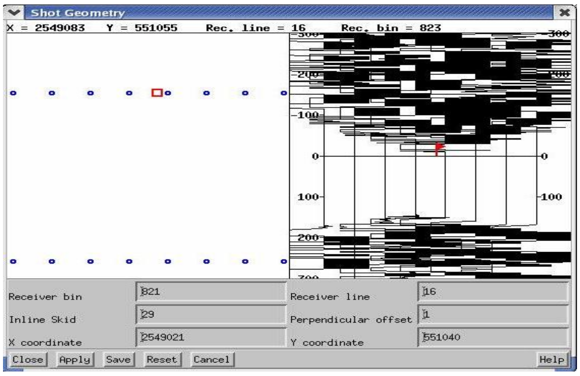

Figure-5 The window for interactive shot geometry QC (Seisup)

In order to detect positional errors in shot and receiver positions, linear move out (LMO) was applied to each and every shot gathers after geometry merging. The basic principle behind linear move out is that an input refraction velocity computes the move outs for different offsets and flattens the gather once applied. In case of mis-positioned shot, the gather does not flatten perfectly. This principle is valid for near offsets. Figure 6(a) and 6(b) show a shot gather without applying LMO and after applying LMO respectively. Figure-6 (c) and 6(d) show another gather before and after application of LMO respectively.

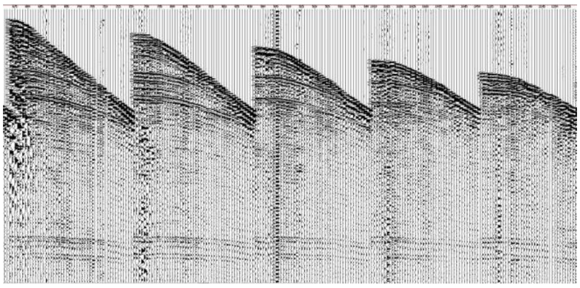

Figure-6 (a) Shot gather without applying LMO

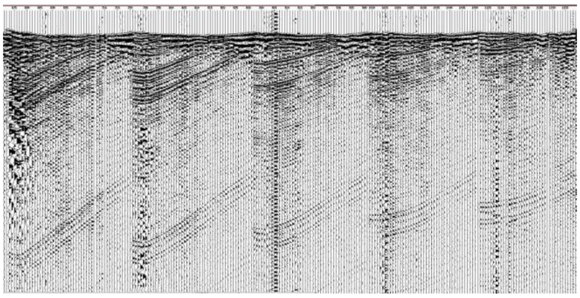

Figure-6 (b) Shot gather (as shown in Figure 6(a)) after applying LMO

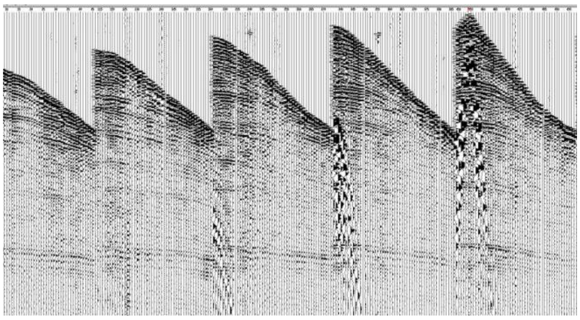

Figure 6 (c) Shot gather without applying LMO for a mis-positioned shot

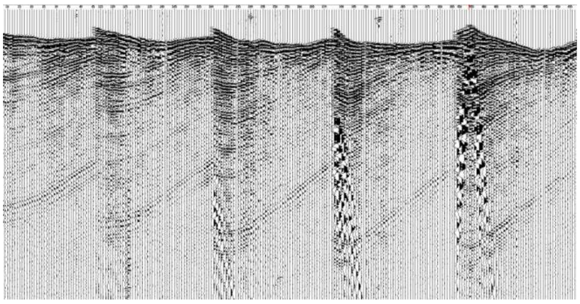

Figure 6 (d) Shot gather (as shown in Figure 6(c)) after applying LMO

Table-1 Results of frequency analysis

F_{max}	No. of shots
45 - 60 Hz	11331
30- 45 Hz	4964
15 - 30 Hz	390
Total	16685

Table-2 Results of analysis for S/N

S/N Ratio	No. of Shots
8-10	16036
5-8	451
2-5	198
Total	16685

Results and Analysis

Comparisons of Figure- 4(a), 4(b) and 4(c) show that there can be clear improvement in correcting the shot positions by using this shot position QC tool. The desired corrected position can be achieved by this method. Figure- 5 shows the window for interactive geometry QC for correcting shot positions. It can be observed that the corrected coordinate and the deviation of actual shot position from the recorded one can be noted down from this window. All the recorded 16685 shots were checked for shot geometry QC and corrections were made wherever needed. With these corrected coordinates, again geometry was merged and further processing was carried out.

In order to ascertain the correctness of shot and receiver positioning, the whole data volume was analyzed by applying linear move out (LMO). A comparison of Figure-6(a) with Figure- 6(b), indicates that both shot and receiver positions are correct as the gather flattens perfectly after applying LMO. Similarly, a comparison of Figure- 6 (c) and Figure- 6(d) shows that there are problems with shot positioning as the gather does not flatten perfectly in near offsets even after applying LMO.

Conclusions

Apart from frequency content and signal to noise ratio in seismic data, accurate shot point and receiver point positioning contribute to the quality of recorded data. A successful geometry merging with seismic data requires correct coordinates of shot and receiver positions. The present study has contributed as an aid to processing in analyzing the quality of data with respect to geometry. This method can be adopted for repositioning of shots wherever there is a probability of error in shot coordinates. Accurate shot positioning can be achieved with respect to both in line and cross line directions. An accuracy of half of the bin size can be achieved by adopting this method.

References

Singh, T. P. (2011). Operation Report on 3D seismic reflection survey in NELP Block WB-ONN-2005/3 in West Bengal.

Acknowledgements

The authors are thankful to the management of ONGC Ltd. for providing necessary support and guidance to carry out the study. The support provided by Party personnel of Geophysical Party No. 15, Western Onshore Basin, ONGC, Baroda, India is thankfully acknowledged.

The views expressed in this paper are of the Authors only