Pre-Stack Merging of seven volumes of 3D seismic data of Linch – South Kadi area, Cambay basin.

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Keywords

Pre-stack merging, vintage merging

Summary

This case study deals with practical aspects of merging of seven seismic 3D Land surveys of Linch-south Kadi area. These 3D surveys were acquired over a decade long time span by different field crews, with different acquisition parameters, objectives, instruments etc. As a result, this gave rise to variations in data quality, amplitude, time and phase shifts among the individually processed volumes leading to correlation difficulties. The reprocessing of the data was taken up to create a seamless mosaic of 3D seismic volume. The reprocessing comprised of seismic data pre-processing (including pre-stack data merge) followed by pre-stack time migration of seven seismic vintages. The final processing workflow adopted for this project was designed based on specific needs of the data and several tests carried out at each processing step.

Introduction

The area of study falls under Ahmedabad - Mehsana block of Cambay basin, which is a rift basin with narrow elongated graben running NNW-SSE direction (Fig-01). The basin came in to existence during the late Jurassic period. During the late Cretaceous, major volcanic eruption took place and Deccan Trap formed the technical basement of the basin. Subsequently different depositional units came into existence in various depositional environments. There are a large number of oil and gas fields in the basin; South Kadi, Kalol, North Kadi, Linch, Jotana, Nandasan, Wadu etc. At deeper levels oil and gas accumulations occur mostly in lenticular sand bodies developed within the Cambay Shale at different stratigraphic levels.

The area of study consists of seven seismic investigations (Fig-02). These datasets were acquired over a large span of time and with varying acquisition parameters. The acquisition was performed under different conditions as well as with different recording instruments.

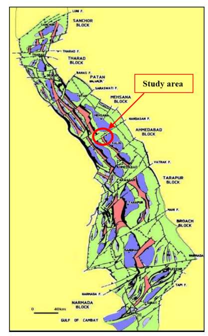

Fig-01: Tectonic Map of Cambay Basin (Mathur et al., 1980)

These datasets were processed individually with different processing parameters in the past, which resulted in variation in data quality, time and phase shifts, among the volumes. Also, correlating an event across the volumes as well as across the two tectonic blocks wasn't possible because of above-mentioned constraints associated with the data. Hence, to enhance event correlatibility across the two tectonic blocks and to improve subsurface image of the Linch- South Kadi area, pre-stack merging of these datasets was taken up.

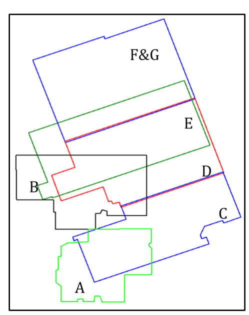

Fig-02: Geometrical disposition of the seven volumes

Processing work Flow

Since these volumes were processed independently in the past, decon gathers of four volumes (A, B, C, & D) and denoise gathers of three volumes (E, F & G) were taken from earlier processed data. The data was originally acquired with bin size varying from 10x10 to 20x40m. The 20x40m bin size was considered for further processing because the data of four volumes were acquired with this bin dimension. Hence re-gridding of all the data was done to bin size of 20x40meters for better estimation of residual statics in subsequent steps. The processing steps included are the result of specific needs of the data and several tests carried out at each processing step. Fig-03 shows detailed processing workflow, adopted during the course of the project.

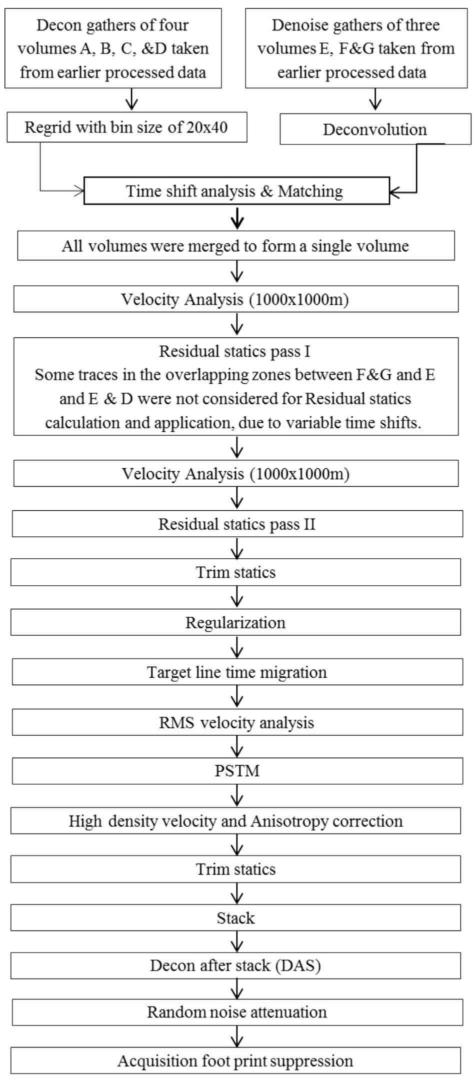

Fig-03: Processing workflow

The denoise gathers of volumes E and F&G, were subjected to deconvolution with PD=28ms and OL=280ms in order keep the deconvolution parameters same with the gathers of rest of the volumes.

1.1 Matching of data

Polarity of gather data of all volumes was analyzed. It was found that the first break energy is appearing as trough in all volumes. Hence no corrective action was required in this regard.

Initially, stack data set of one volume overlapping with the reference volume E was compared in the overlap zone. Common IL and XL of the overlapping zone were considered and the relative time shift was applied on the concerned volume. A schematic representation of this exercise is shown in Fig- 04.

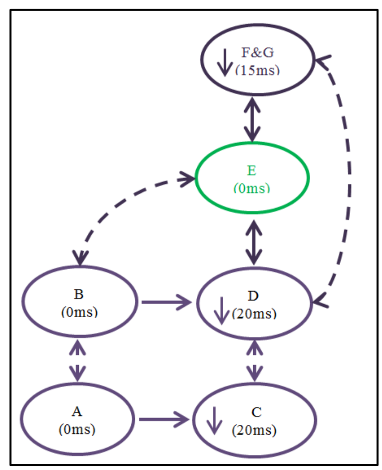

Fig-04: Schematic representation of time shift analysis loop (E- reference volume)

There were variable time shift problem among datasets viz. D & E, and E and F&G, causing mismatch at some places, although it has perfect matching at other locations (Fig- 05-06). To tackle this problem a time shift was identified which was suitable at most of the locations. It was anticipated that after application of this bulk shift, the remaining inconsistencies will be taken care by residual statics application.

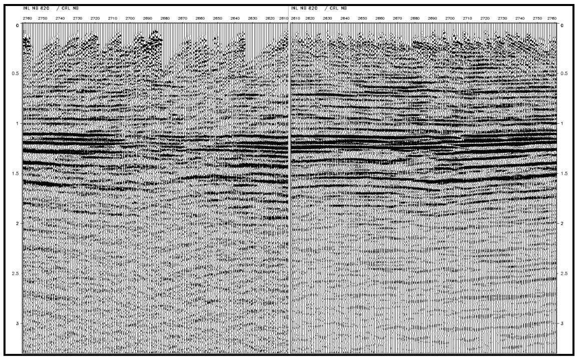

Fig-05: Variable time shift: E and F&G at Inline 820 / Xline 2610 (Time Shift = 10ms)

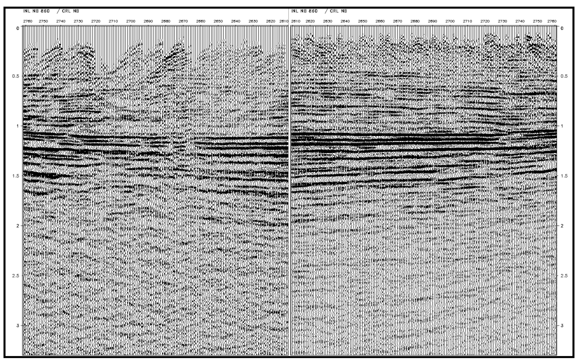

Fig-06: Variable time shift: E and F&G at Inline 860 / Xline 2610 (Time Shift = 25ms)

1.2 Velocity analysis and statics solutions

Decon gathers after applying the respective static time shifts from all seven volumes were taken to form a single volume of decon gathers and velocity analysis was carried out on those gathers at 1000x1000 grid interval. The decon gathers and velocity picked at this stage were used for residual statics calculation.

The output of first pass residual statics application was however not very encouraging because there was presence of sharp junctions that might be caused by variable time shift in the overlapping zones of the data, which were supposed to get addressed by first pass residual statics application. But the problem aggravated after first pass residual statics application (Fig-07).

After trying different approaches and doing all the brainstorming to find out any logical cause for this problem, it was concluded that the problem is occurring because of the inconsistency of the data in that zone. Hence it was decided to leave out some traces in the overlapping zones of D & E and E& F_G, where the problem was worse. The reference volume E was kept intact because it covers most of the Linch area, which was the target area of this project. The problem of false structure got rectified after dropping of the traces, as shown in Fig- 07.

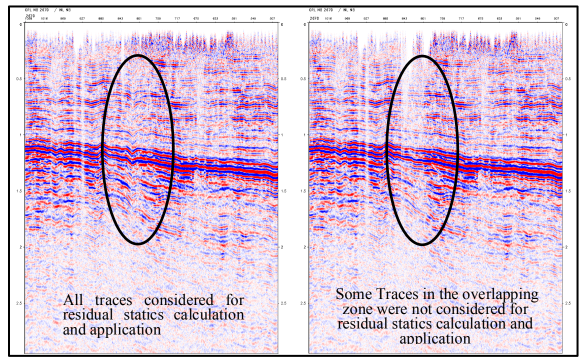

Fig-07: Stack after residual statics application: Before and after dropping traces

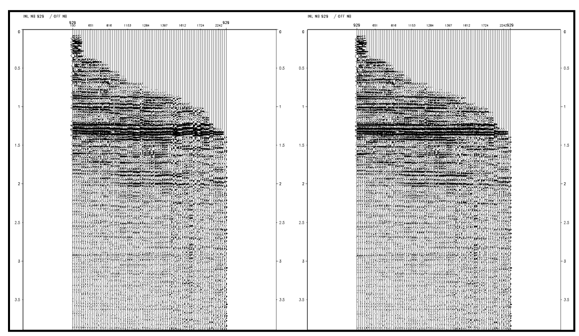

Fig-08: CMP gather before and after residual statics application

After first pass residual statics estimation and application, a velocity analysis was carried out on residual statics applied de-convolved CMP gathers at an interval of 1000 m x 1000m. This Velocity was used for second pass residual statics calculation. Effect of residual statics on gather data is shown in Fig- 08.

In a bid to obtain seamless merging among all volumes, CDP-trim statics was applied in order cure minutest inconsistencies. The stack quality and consistency among different volumes increased considerably after the application of trim statics.

1.3 Data Regularization

Trim statics and residual statics applied decon gathers were taken as input for data regularization. These gathers were subjected to regridding with bin size of 20m*20m before regularization to keep the data in conformity with the earlier processed data. Fold variation across the volumes and gaps owing to missing offsets necessitated data regularization to harmonize the fold across the volumes. In general fold varied from 2-200 folds. Effect of data regularization on gathers and fold distribution is shown in Fig- 09 and Fig- 10 respectively.

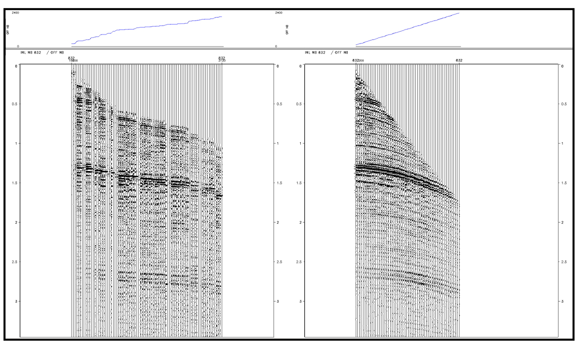

Fig-09: CMP gather before and after regularization

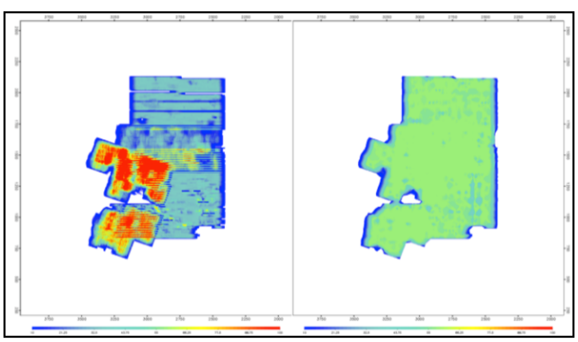

Fig-10: Fold distribution before and after data regularization

1.4 Pre Stack Time Migration (PSTM)

Pre Stack Time Migration was carried out on regularized gathers using smoothed RMS velocity using Kirchhoff approach. A full aperture of 6000m and dip limit of 70 degrees was chosen for final migration. High-density velocity and anisotropy estimation (HDPIC) was carried out on PSTM gathers at 100m *100m. Application of high-density velocity and anisotropy analysis resulted in better flattening of events. Subsequently random noise attenuation was carried out in CDP domain. Acquisition footprints were suppressed using F-Kx-Ky domain filtering on PSTM stack data. Decon after stack (DAS) was applied to enhance the amplitude spectrum of the data. Representative Inline, xline, and time slice of final PSTM stack are shown in Fig-11 to Fig-13. Comparison of current results with the earlier processing is shown in Fig-14 to demonstrate the value addition.

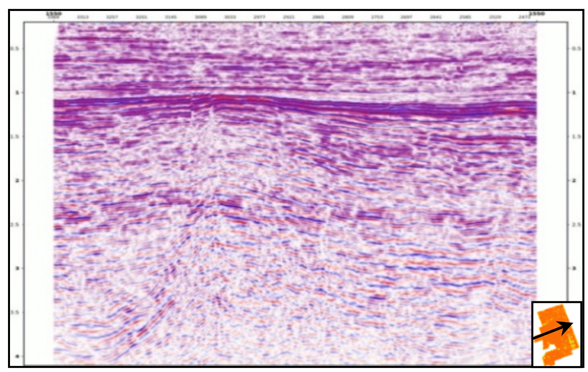

Fig-11. A representative Inline of Final PSTM stack

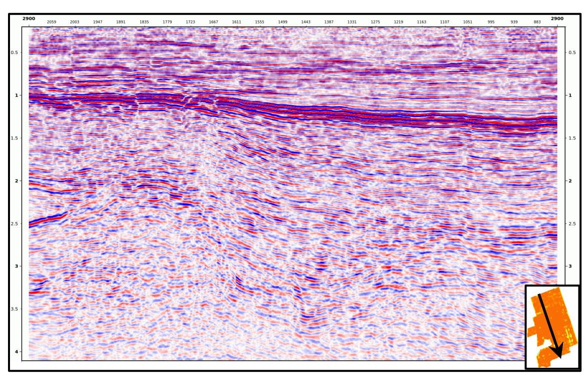

Fig-12. A representative Xline of Final PSTM stack

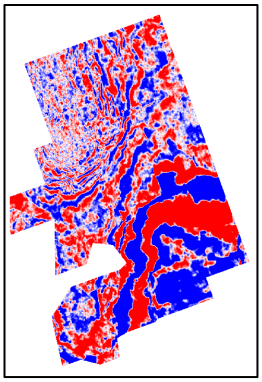

Fig-13. Time slice at 1400ms

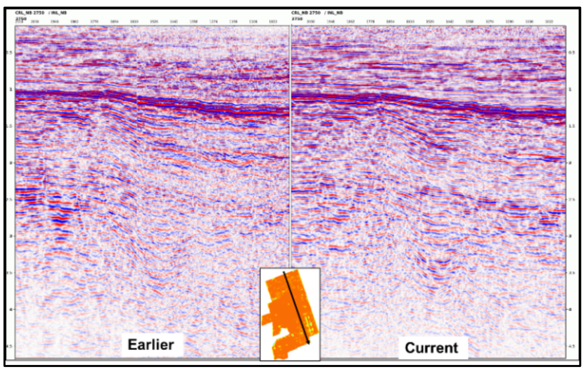

Fig-14. Comparison of a cross line from earlier (left) and current (right) processing

Conclusions

Seven volumes of 3D data of Lich-south Kadi area were reprocessed and merged to generate a seamless 3D volume of data. The time shift-matching step arose as a major challenge during the course of the project, which was dealt carefully and thoughtfully to get a seamless merging of the given volumes. Emphasis was given to velocity analysis, which resulted in better imaging of the sub-surface. Final output shows smooth transition from one volume to the other and there are no signs of any inconsistency across the different seismic volumes. This has resulted in improvement in the event correlatibility across the volumes, which will help in the integrated study of the area.

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