

Pre-stack Merging of Onshore Multi-3D seismic surveys having discrete Vintage, Azimuths & Acquisition Geometries: A case study from Upper Assam Basin

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Keywords

Pre-stack merging, Matching Operator

Summary

3D Pre-Stack Merging is a method of processing of multiple 3D projects acquired in different conditions (time of realization, geometry, grid orientation and other parameters) offering the same results as if in case of single, coherent set of data acquired and processed as one large project. 3D Seismic data from three (3) blocks viz. Block-1, Block-2 & Block-3 within Upper Assam Basin were taken up for merging in the pre-stack domain along with Pre-stack time migration processing. These blocks have both oil and gas prospects. Seismic data in these blocks were acquired over different vintages starting from 2002 to 2017 and processed & interpreted separately over a period of time.

Integrated study of these datasets with each seismic volume processed independently poses significant challenges in seismic attribute analysis, apart from structural mapping in general and more specifically in the overlap regions. Pre-stack merging of these three (3) surveys has enabled in better imaging of the subsurface, all with due accounting of the phase frequency and amplitude levels of all the blocks to a level wherein the relative response are closer to the true representation of the subsurface anomalies.

Sequential steps of pre-Stack Merging process and its advantages in reducing the variance within and inter-block in terms of various geophysical signature, attributes and better illumination of subsurface structural elements is being presented in this study. The deliverables of the study are envisaged to open up a new understanding of the area and help upon in minimizing the uncertainty in appraisal/development of the fields in near future.

Introduction

Block-2, Block-1 & Block-3 survey blocks encompass producing fields from Oligocene and Paleocene-Eocene age reservoirs. All the three (3) blocks are located in the central part of OIL's operational area in Upper Assam basin. These 3D

surveys have been recorded over a period of several years and denote datasets of varying vintages. These blocks cover an area equaling approximately 300 sq. km. with fair amount of overlap with each other (Figure-1).

Several producing structures have been mapped from these surveys individually. Due to different 3D campaigns, mapping the extension of the structures in the overlap zone was uncertain. Pre-STM processing from raw shot level of these Vintage 3D datasets and further Pre-stack merging of the datasets does enable to extract and generate geologically conformable images of the subsurface for further analysis. Pre-stack merging of the datasets shall also enable a regional level understanding for identification and delineation of structural & stratigraphic prospects with a higher degree of confidence through the availability of a single merged (unified) large 3D data. This will surely help the appraisal of the existing producing structures in the area of study.

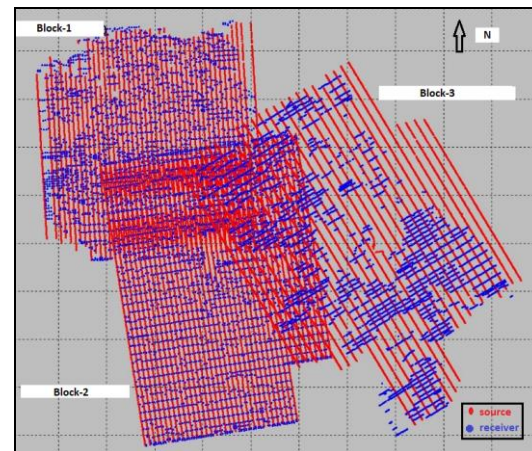


Figure 1 Base map

As the seismic data were recorded in these blocks in different vintages using different configurations of recording equipment, spread length, bin size, fold and inline orientation, selection of a Base survey and a

Pre-stack Merging of Onshore Multi-3D seismic surveys

common Master Grid for all the dataset assumes critical significance and is quite a technical challenge. A step by step approach with continuous Quality control check mechanism was employed throughout the course of the study.

Geology of the Area:

The study area is located in prolific oil producing area of Upper Assam basin. The Upper Assam Basin is bounded by three major thrust faults viz. Himalayan orogenic belt in the north, Mishmi Thrust in the east and Schuppen Belt in south. Sediment thickness in this basin varies from around 3.0 km to 10.0 km. Topographically, the Assam Shelf fore-land basin part is a normal flood plain area of the River Brahmaputra and its tributaries.

Method

Following table comprises of the acquisition and recording parameters of all the three (3) blocks.

Parameters	Block-2	Block-1	Block-3
Year of acquisition	1993-94	2002-03	2016-17
Shot Interval	100 m	100 m	40 m
Receiver Interval	50 m	50 m	20 m
Shot Line Interval	350 m	400 m	360 m
Receiver Line Interval	200 m	400 m	360 m
Nominal Foldage	24	32	40
Bin Size	25*50m	25*50 m	10*20 m

The workflow employed to obtain the optimum unified 3D dataset is as below-

- Geometry Merging
- Pre-processing – Trace editing, FB Picking
- Gain recovery
- Noise attenuation
- Surface consistent Amplitude balancing
- Surface consistent deconvolution
- Velocity analysis & Residual statics (Two Passes)
- Survey Matching
- Unified grid & Survey Merging
- Regularization & Interpolation
- Pre-Stack Time Migration
- Residual velocity analysis
- Stacking & Mute
- Post-stack Processing

As the dataset were acquired in different vintages, each dataset was having different noise pattern. To address this issue, each vintage of data was treated separately for Noise attenuation. Various noise suppression techniques including the application strategy and different domains for application were tested for both random and coherent noise attenuation.

In order to ensure spatial consistency of all the processes that ought to be applied, the dataset were thoroughly tested and reviewed, specific consideration was given to the overlap regions of the block to ensure integrity of the dataset. As an outcome of the test and evaluation, all the surface consistent processes viz. Refraction Statics, SCAC (Surface Consistent Amplitude Compensation), Deconvolution and Residual statics were computed in the single unified grid. However, the application was done separately. Velocity analysis for the blocks were carried out separately in two phases; the first at 1km x 1km grid, the second at 0.5km x 0.5km grid.. Special emphasis was given to the target horizons and consistency of velocity model.

Reliable near surface modelling for static computation was also very crucial, hence all the refraction statics algorithms viz. Refraction Tomo, Delay time method were tested in order to get the optimum static solution in a global sense over the expanse of the three blocks and more importantly its implication on the image in the overlap regions. Elevation static was also tested. Delay time method was found to be the most suitable one here.

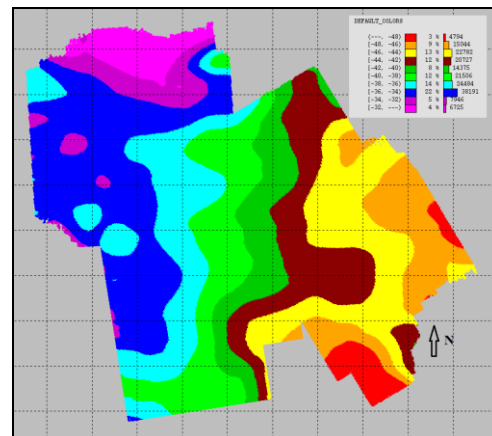


Figure 2 Mean Statics (CMP Statics) Map

Pre-stack Merging of Onshore Multi-3D seismic surveys

Pre-stack data merging:

After processing all the three blocks separately, the Pre-stack merging was done prior to the data regularization. In this process, the objective was to achieve a single volume with unified geometry and coherency enhancement. In pre-stack merging, a base survey was selected and other surveys were considered as target survey. A Matching Operator was designed to match other target surveys to the Base survey.

Pre-stack merging procedure followed consisted of following three (3) steps –

- **Define Base Survey and Target Surveys:** Block-2 and Block-1 were having same geometry, however, Block-3 was having different geometry (Grid size of Block-2 & Block-1 were 25m*50m, whereas Block-3 was having 10m*20m grid). After analysis, it was decided to use 25m*50m grid for the final merged block to obtain better contribution from all the three blocks. Block-2 was having more regular source & receiver distribution as well as better data quality over Block-1 & Block-3 and good overlap with other blocks. So, it was decided to use Block-2 as the base survey and other two blocks as target survey for merging.

- **Define unified geometry:** Unified Grid Geometry was prepared through expansion of Block-2 3D grid (Base Survey) to cover the whole survey. It is also called as Merged Grid.

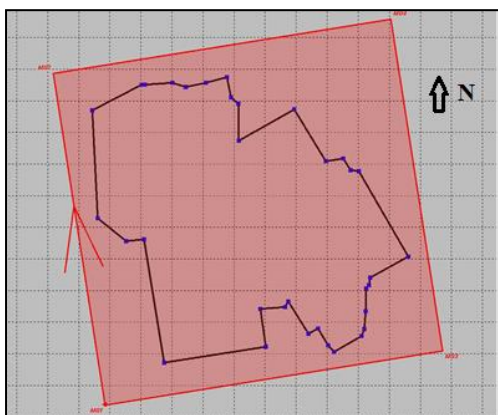


Figure 3 Unified Geometry

- **Amplitude, Phase & Time-shift Analysis:**

Comprehensive analysis was carried out in the overlap zones to derive an optimum Matching operator for balancing the target surveys with the base survey, in terms of amplitude, phase and time. Matching operator was designed as followed:

- Overlap zones between two surveys (Base and one of target surveys) with good data quality was selected for analysis.

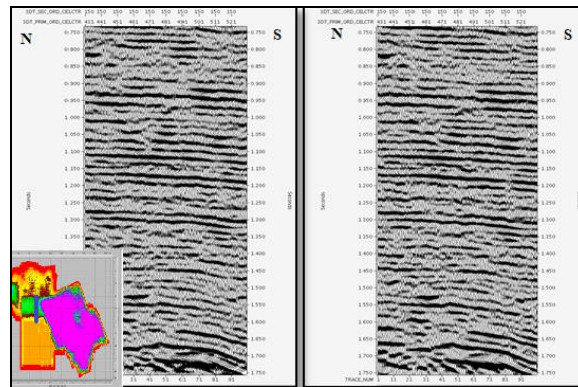


Figure 4 Overlap zones Block-1(left) and Block-2 (right)

- Each surveys were stacked individually. Autocorrelation of stacked traces for base and target surveys and cross-correlation of two surveys were generated(Figure 5(a)). Cross-correlations for all the stacked traces were aligned (Figure 5(b)).

- Autocorrelations and crosscorrelations were stacked in order to get average Cross- correlation(Figure 5(c)) and used for deriving matching filter (Figure 5(d)).

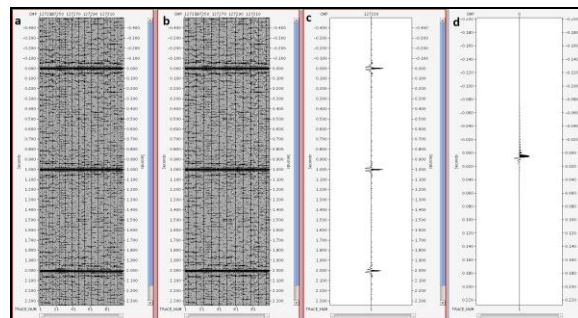


Figure 5 Deriving matching filter

After correcting for Amplitude, phase and Time shift, moveout corrected CMP gather from all the three

Pre-stack Merging of Onshore Multi-3D seismic surveys

blocks were merged using the unified 3D merged grid.

For data regularization & interpolation of missing traces 4D Interpolation scheme were applied after testing 3D, 4D and 5D schemes.

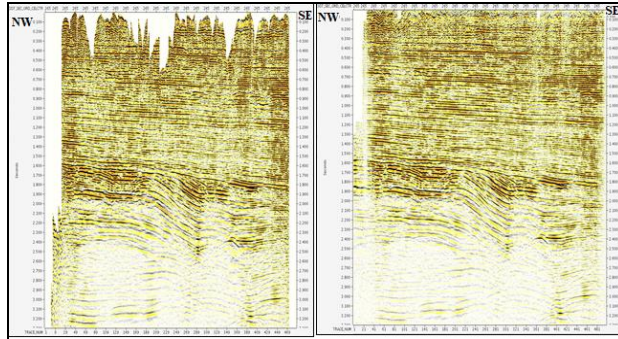


Figure 6 Random Inline before (left) and after (right) interpolation

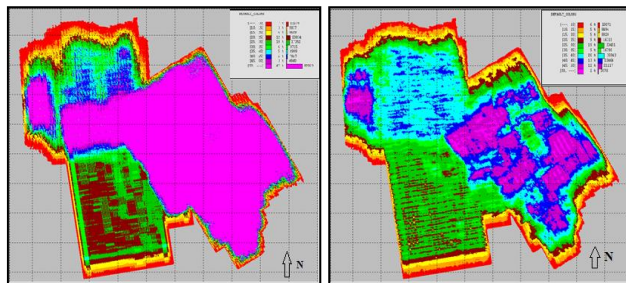


Figure 7 Fold plot before (left) and after (right) regularization

Full isotropic Kirchhoff pre-stack time migration (Pre-STM) was applied on the data. Different migration parameters viz. dip and aperture were tested on selected target lines and its effectiveness & applicability was QC'ed thoroughly before migrating the entire data volume. Smooth interval velocity for target line migration was prepared by merging the velocity of all the three surveys. In the overlap region, average of all the picked velocity (for 3 survey) was taken and QC'ed thoroughly for consistency.

One pass velocity analysis at 0.5km x 0.5km grid was carried out for obtaining migration velocity from preliminary migrated gathers.

Migration and interpolation applied here use common offset gathers. Nominal foldage and bin size of three (3) surveys were different. Hence deciding no of

output offset classes and their interval was very crucial in this case. Some residual noise attenuation and post-stack processing schemes were applied further to prepare the final output.

Results & Conclusions

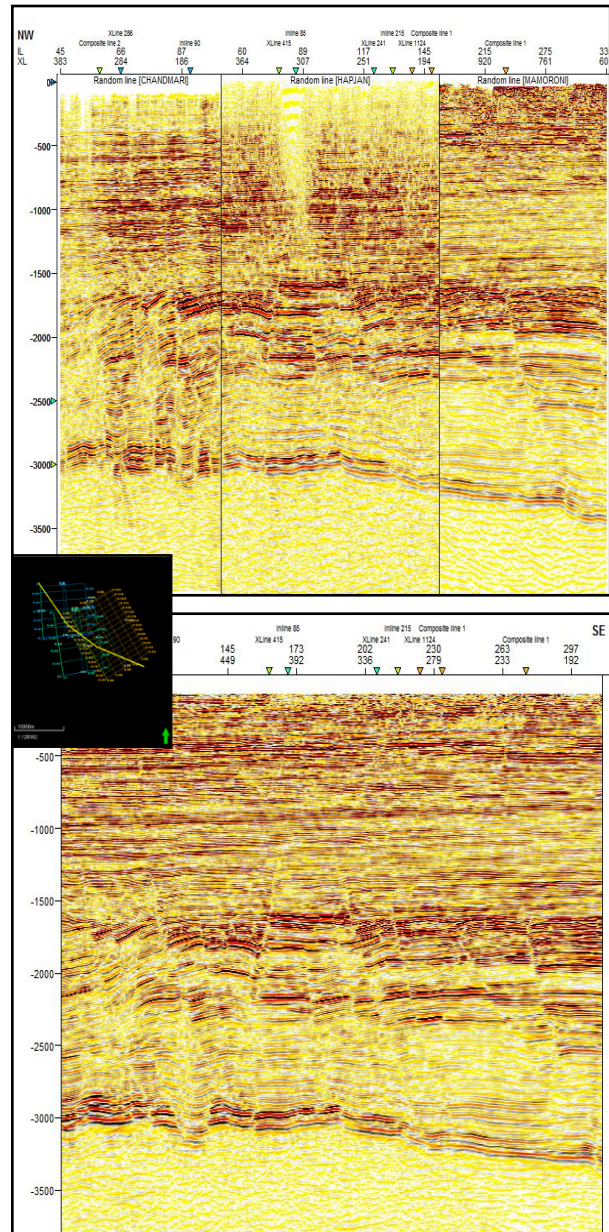


Figure 8 Comparison with vintage (without merging) (above) and after merging (below) along a random line

Pre-stack Merging of Onshore Multi-3D seismic surveys

Figure 8 depicts that mis-tie issues between the surveys are resolved after merging exercise. Also, structural elements are resolved quite well from the subsurface image generated with the advance signal processing algorithms. Here, subsurface geology is attributed with lot of minor and major faults. One major bounding fault passes through all the blocks. Fault structure in the overlap zone is quite well resolved from the merged volume.

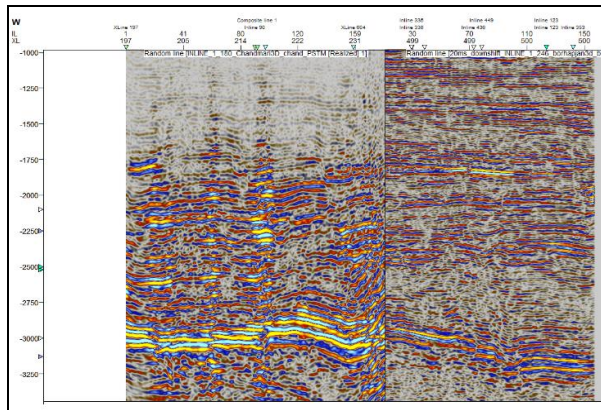


Figure 9 (a) Seismic image without pre-stack merging (non-normalized)

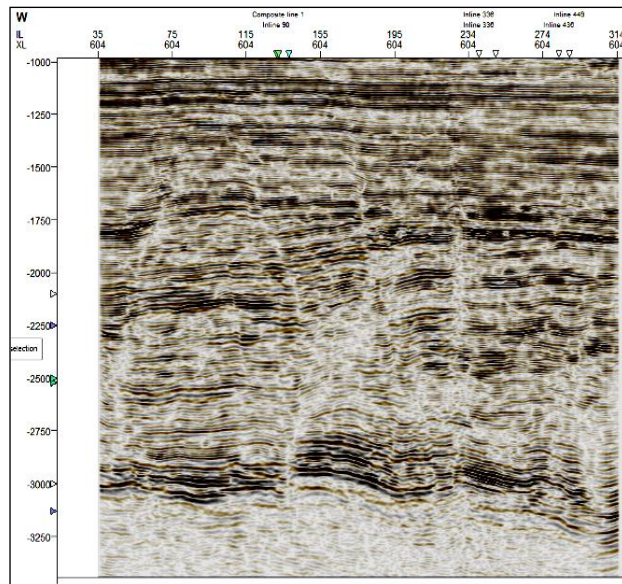


Figure 9 (b) Seismic image with pre-stack merging

Figure 9(a) and 9(b) shows the seismic image along a random line before and after merging respectively.

Hukanguri structure in the overlap region is quite well mapped in the merged volume. Figure 9(a) also shows amplitude level difference between the surveys before pre-stack merging.

This study will definitely help in appraisal/development of the producing structures in the field.

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