Pre-Stack 3D Land Data Merging – A Case History from South Assam Shelf, India

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Abstract

Pre-stack merging of various vintages of 3D seismic data of 1150 sq. km. acquired using different recording instruments and acquisition geometries over the time has been attempted. This project is intended to improve regional understanding of the play concept as well as mapping of Pre-Cambrian Basement to Alluvium Namsang Sediments. Most of the intricacies like polarity variations, static shift, bandwidth difference etc. of pre-stack merging have been addressed systematically during processing.

Key words: Pre-stack Merging, Polarity, Static Shift, Regularisation

Introduction

A number of 3D seismic surveys have been carried out over the years in the South-Assam Shelf region of north eastern part of India (Fig.1). Twenty six 3D vintages in this block (Fig.2) covering an area of around 1150 sq.km have been taken for pre-stack merging. This project is intended to improve the correlatibility of the hydrocarbon play concept in regional sense. The orientation and shape of different vintages has led to many complications including irregular fold, variable offsets, edge effects and data gaps etc. Data has been acquired in between 1989 to 2008 with wide range of acquisition parameters**.** The various recording instruments are DFS-V, SN-368, SN-388 and UL-408 and I/O Scorpion. The total active channels associated in different investigations vary in between 60 to 1280. Acquisition geometries varied from simple swath shooting to orthogonal shooting. Folds varied from 28 to 60 and the near offset varies between 50 m to750 m and far offset ranges between 2200 m to 4190m.The parameters of acquisition are summarised in table1.

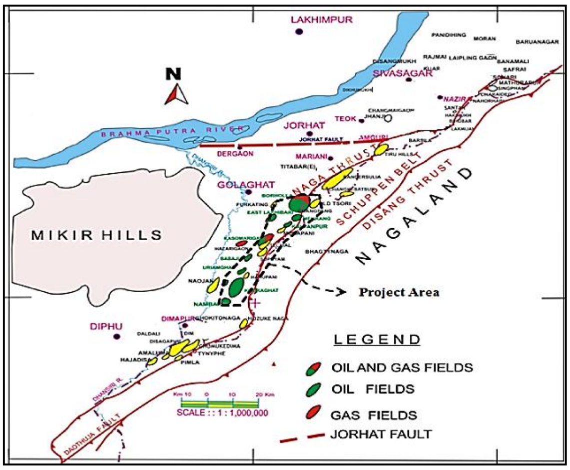

Fig. 1: Location map of the area

Key factors for 3D Land Data Merging

The problems involved in merging of several 3D vintages which have been recorded over a long period of time using widely varying acquisition technology, geometry and objectives are difficult to handle. The key issues identified in this kind of pre-stack vintage merging are as following:

- Different Acquisition Geometry/Grid
- Geometry errors and different polarity conventions
- Amplitude and Phase of the data sets do not match always
- Amplitude decay and gain balancing problem
- Bandwidth and S/N ratio as a function of frequency
- Surveys do not have smooth overlap zones
- Irregular folds and offset distributions
- Number of discrete gaps in data vulnerable to migration edge effects

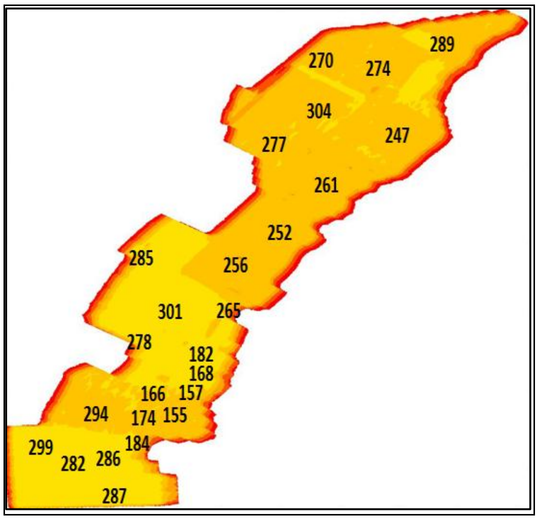

Fig.2: Different 3D vintages in the area

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No of Investi-gations	Instruments	Year of Acq.	Samp.Int. (mSec.)	RL (Sec)	Bin Size (m x m)	Offset Range	Folds	Active Chan.
26	**SN-368, DFS-V,UL408, I/O Scorpion**	**1989-2008**	**2**	**5**	**25x25,25x50**	**50-4190**	**28-60**	**60-1240**

Table 1: Major Acquisition parameters

Data Processing

Objective of the project is to obtain single 3D volume of seismic data which have been acquired and processed individually over the years. The job of combining all the existing individual data fulfilling all the processing quality norms is really a challenge. The key issues, in general, inherent in this kind of merging have been addressed systematically. The generalised processing sequences followed is shown in the table (Table2).The individual volumes are processed seperately in local grid upto the level of residual static application.Then the subsequent processes are performed in master grid.

1. Reformatting.
2. Geometry merging
3. Field Static Correction
4. First Break Muting, Edit, and Denoise
5. Surface Consistent Deconvolution.
6. First pass velocity analysis
7. Residual Static Correction

** Above steps performed in individual local grid

8. Polarity and Static Time Shift analysis.
9. Gain Balancing and Spectral whitening
10. Residual Static correction in full volume.
11. Second pass velocity analysis
12. Offset Regularization
13. Target Line Migration
14. RMS Velocity Analysis on PSTM gather
15. RMS Velocity Smoothening/QC
16. Pre-Stack Kirchhoff Migration in Offset classes
17. Random Noise attenuation on PSTM gather
18. Mute and Stack, post stack noise attenuation
19. SEG-Y Deliverable

Table-2: Processing sequences

Survey Co-ordinate Reference System and Master Grid

It is essential that the co-ordinate systems be identified before merging any seismic information. Fortunately, We have all the vintages acquired on same spheroid (Everest 1830) and same projection system (Lambert's Conformal Conic-Single Parallel). Hence projection system transformation was not required. Reference datum is kept at **91** meters above mean sea level.

Geometry Merging, denoise and polarity issues

Quality checks are meticulously performed while geometry data is merged with raw seismic data. (Fig.3).It has also been found that some of the data have different polarities convention in acquisition level which has been taken care meticulously. Stacking produces poor quality images in the overlap zones due to different polarities of the adjacent data sets. One example is shown in the Fig.4 where opposite polarity in adjacent datasets deteriorates the stack quality.

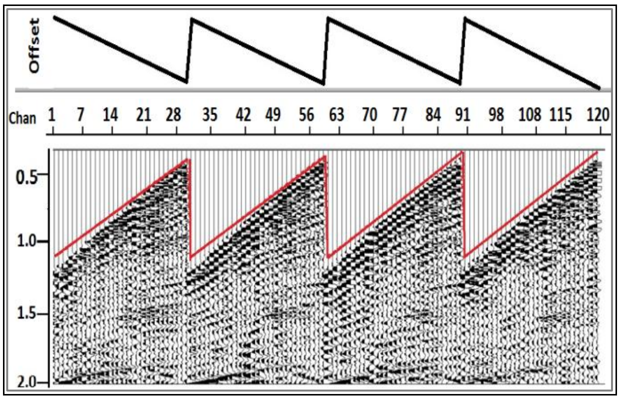

Fig.3: Geometry merging

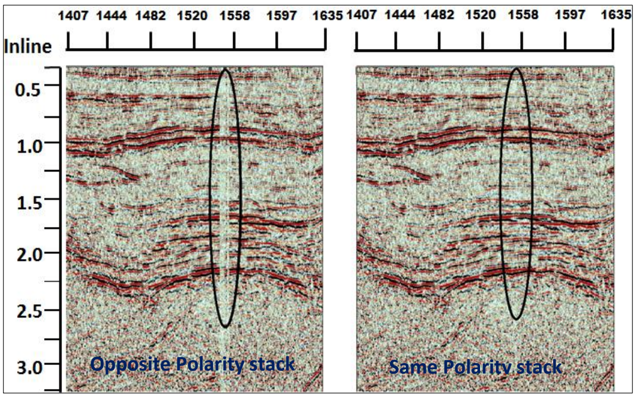

Fig.4: Opposite polarity in adjacent datasets results poor quality stacks in overlap zone

Gain Balancing & Spectral Whitening

One of the main issues here is change in amplitude form one investigation to another. Even the same has been found between different shot gathers of the same investigation. Full window gain equalization has been done in RMS sense to balance gain throughout the surveys. Explosives were used as sources of energy for all the campaigns. No wavelet matching filter was attempted across the volumes. However,Spectral whitening was applied for smoothing out the frequency spectra across the campaigns.Result of spectral whitening is shown in Fig.5.

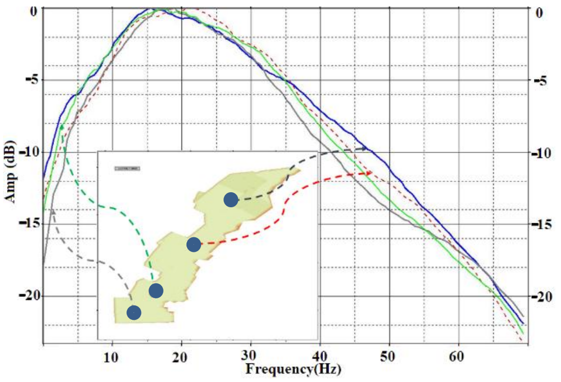

Fig.5: Average Amplitude spectra from different campaigns

Static Shift

Another important factor in Pre-stack merging is static time shift between data sets. First we estimated the shifts between two adjacent data sets and shifts were adjusted. Then successive data were analysed and necessary shift was applied.

Residual Statics

All the individual volumes have been subjected to residual static corrections seperately. Also,two pass residual static corections have been carried out in full volume which have very well adjusted minute static shifts in overlaping zones of adjacent campaigns.

Offset Regularisation

The mid-point regularisation in offset volumes has been carried out using Dealiased Fourier Reconstruction method. Rregularisation has been helpful to fill small data gaps (Fig.6a&Fig.6b) by 3D interpolation.The comparision of stacks after regularisation with non- regularised one is shown in Fig.7.

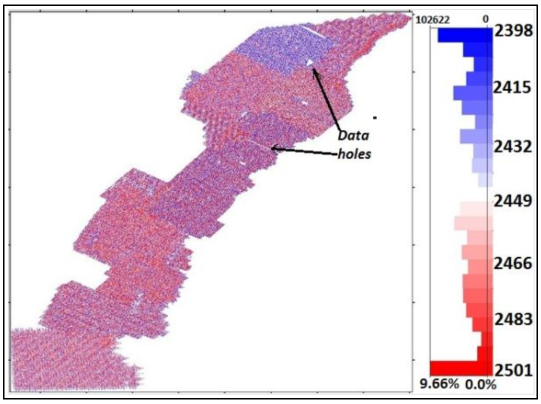

Fig.6a: Offset distribution before regularisation(offset range 2400-2500 m)

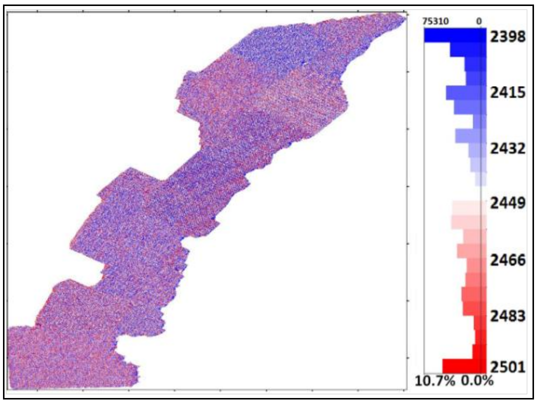

Fig.6b: Offset class in Fig.5a after regularisation

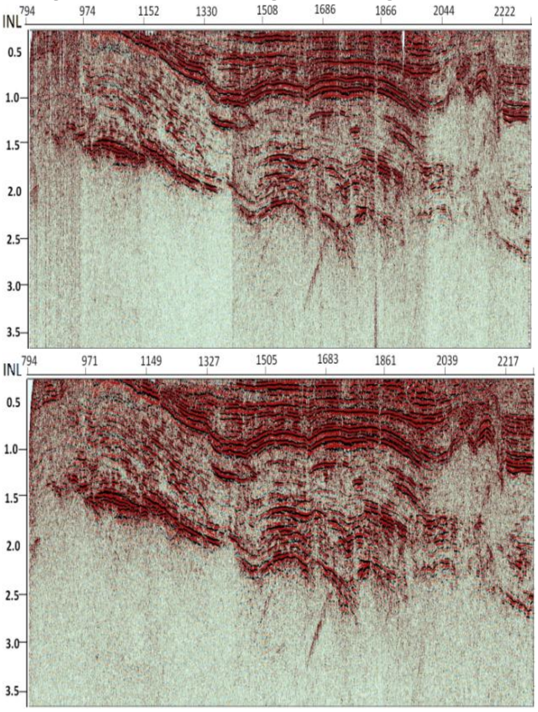

Fig.7:Top section is stack before regularisation, bottom one shows stack after regularisation

Velocity Analysis

Final RMS velocity analysis is performed in a grid of dimension 250 m x 500 m. Smooth RMS velocity function is used for pre-stack migration. Fig.8 shows velocity overlaid on seismic (cross line 1600) as a QC tool.

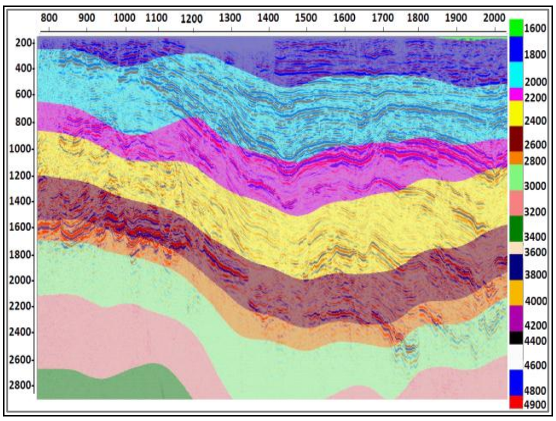

Fig.8: RMS velocity overlaid on seismic

Migration and Post Stack Processing

Kirchhoff Pre-stack Migration parameters like full aperture, maximum dips etc. are tested on selected lines to optimise parameters. Finally, Pre-stack migration of regularised data is carried out in offset class. PSTM flat gathers are shown in Fig 9.Final stack is done with maximum offsets of 3000 m. This gives a uniform fold of 30 with offset class of 100 m.

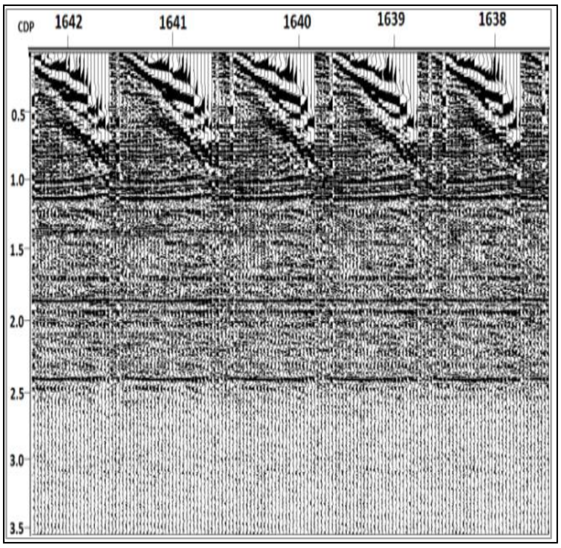

Fig. 9: PSTM flat CDP Gathers

Results:

Extracted time slices from final volume are shown in Fig.10a & Fig.10b. Some inlines (Fig.11a &11b, 12a & 12b) are compared with the earlier merged outputs. Reconstructed line PQ is also taken for comparisons (Fig. 13a & 13b). Improvements are clear in reprocessed merged volume. What could have been interpreted as cross faults are no longer present in the new data sets (Fig. 14a & 14b).The artefacts are results of improper merging at the campaign boundary.

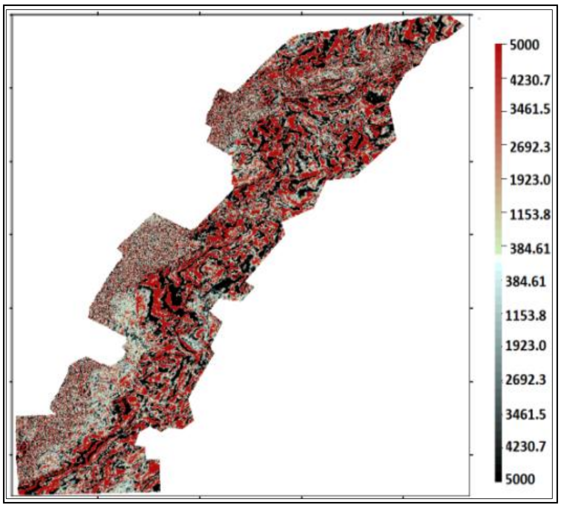

Fig. 10a: Time Slice at 1200 mSec

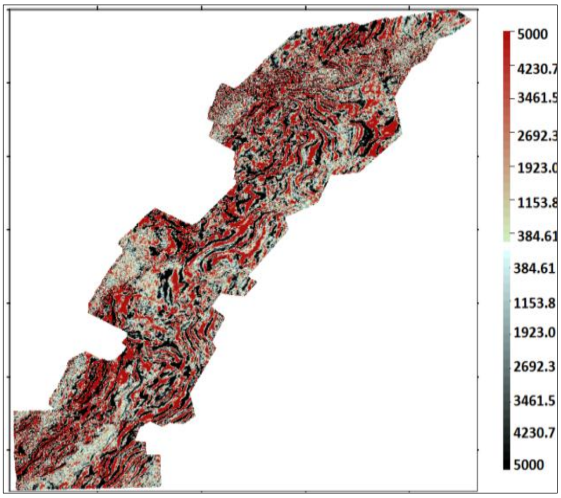

Fig. 10b: Time Slice at 1600 mSec

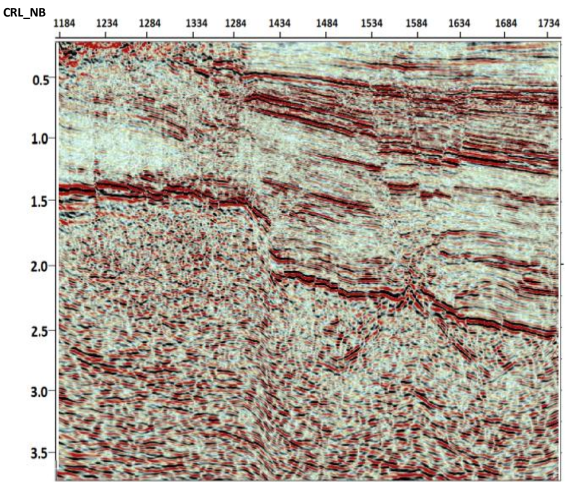

Fig. 11a: inline 1450 from old merged data

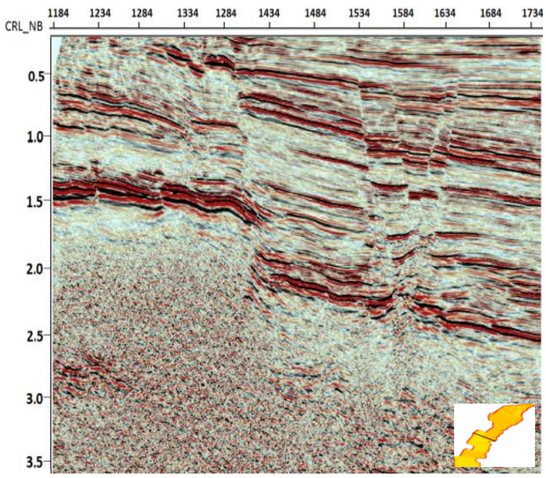

Fig. 11b: inline 1450 from new merged data

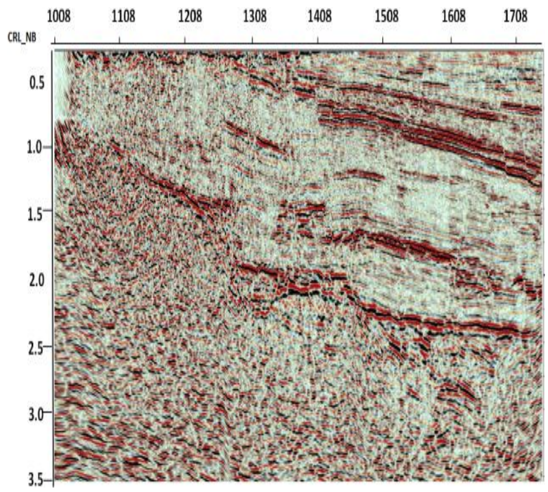

Fig. 12a: inline 1870 from old merged data

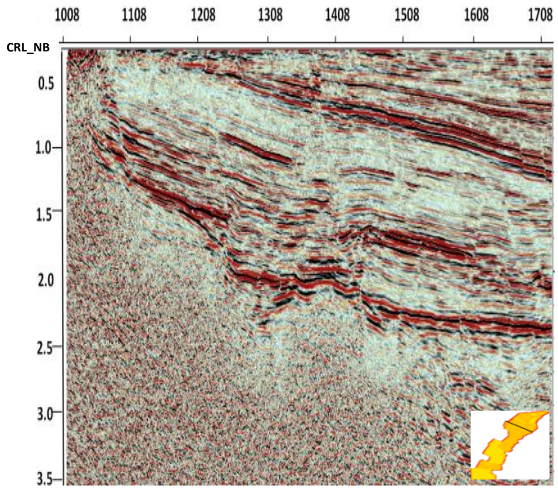

Fig 12b: inline 1870 from new merged data

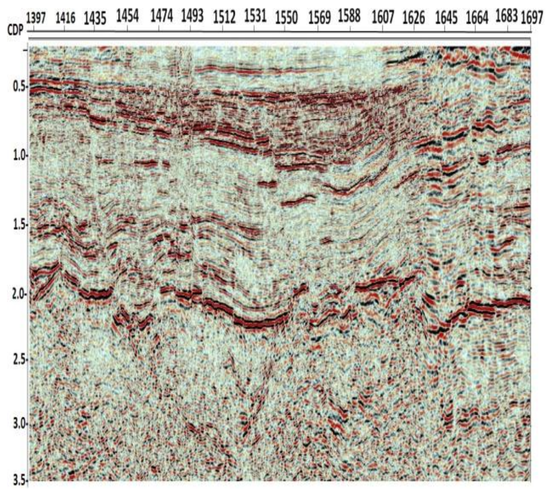

Fig.13a: RC line PQ from earlier merged data

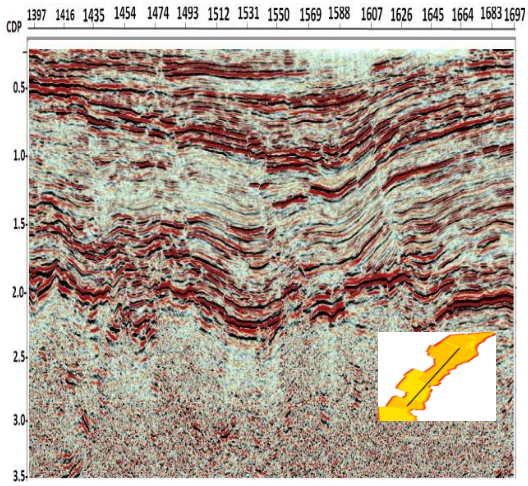

Fig.13b: RC line PQ from reprocessed merged

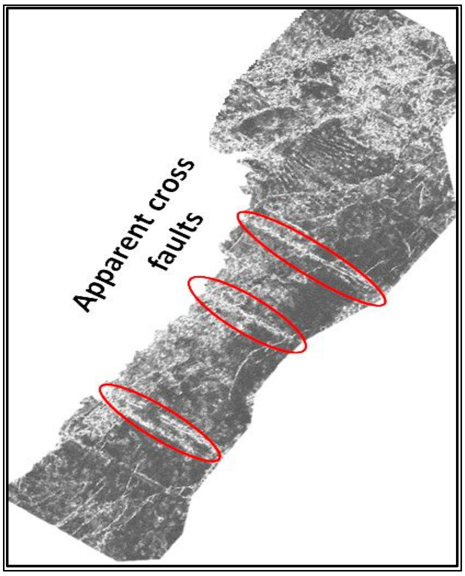

Fig.14a: Coherency attribute from earlier data

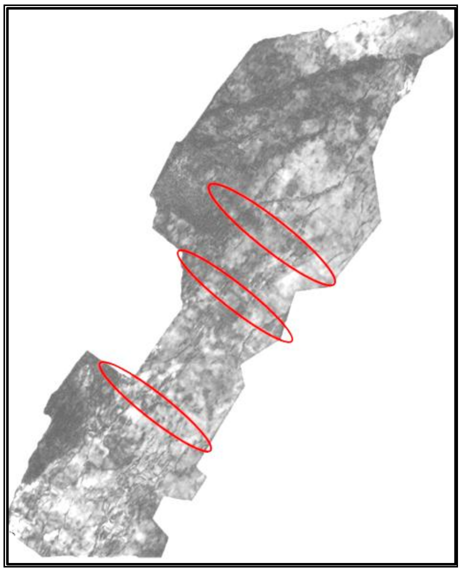

Fig.14b: Coherency attribute from new data

Conclusions

Twenty Six 3D seismic datasets in the South Assam Shelf area with diverse acquisition parameters have been attempted for pre-stack level data merging. The dissimilarities were logically minimised to arrive at a merged output. Equalization of Amplitude and spectral contents and polarity issues were accounted. Offset regularisation across the vintages resulted in filling the small holes in data sets and smooth out the edges to a large extent. Kirchhoff migration was implemented for the regularised offset classes to obtain the final image. Comparison between the final processed sections with earlier existing volumes show the exercise resulted in a seamless better quality datasets which may be useful for further interpretation purposes. The new merging exercise has added value to the interpretation.

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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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