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Challenges in Merging Seismic Data (Six Vintage) at Pre-Stack Level & Time Migration of Offshore 3-D Seismic Data, Western Offshore, India: A Case Study

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Summary

Exploration for oil and gas involves the evaluation of a variety of information. 3D seismic has become a common exploration and production tool that can provide information of the subsurface within the bounds of the survey. In today's scenario most of the exploration area has been covered by 3D seismic surveys which have been carried out over a period of many years using a wide variety of recording equipments, source arrays, spread lengths, bin dimensions, grid orientation etc. The data acquired by these surveys have been processed with different objectives by using different technologies. The main objective of merging 3D seismic data of different vintages is to combine the datasets, acquired over different period of time, to get a single mosaic that would have been produced if the data over the whole area was acquired and processed using same objective & technology.

The merged volume provides for the integrated study of the entire area that helps in evolving a comprehensive geological model. Also the recent interpretation techniques can be effectively used on the integrated volume and arrive at the combined result instead of combining the results from different data sets.

This case study, describes the merging of six 3D seismic data volumes of Mumbai offshore in Pre-Stack stage & migrating the data, in time domain with the challenges to overcome the problems of different 3D volumes recorded over a long period of time using different acquisition & processing technology, in order to get a better continuity & improved imaging across the volume boundaries. The different 3D surveys covering a total area of 4200 sq. km, acquired seismic data over a period of 12 years, in a geologically complex area of Western offshore Basin, India by different agencies with parameters varying from the old acquisition technology to the latest Q-marine technology.

The processing challenges also included time & disc management as the data volume was quite huge and it had to be processed using limited resources in a fixed time frame. Hence an effective strategy for project management was adopted for successful completion of the project within the time schedule.

***Keywords**: Pre-stack time migration, Q-marine, Time & resource management*

Introduction

The merged volume provides for the integrated study of the entire area that helps in evolving a comprehensive geological model. Also the recent interpretation techniques can be effectively used on the integrated volume and arrive at the combined result instead of combining the results from different data sets.

This case study, describes the merging of the 3D seismic data of six offshore volumes at pre stack level and pre-stack time migration of the merged data in order to get better continuity & improved imaging across the individual volume boundaries. The six 3D surveys used for merging covered a total area of 4200 sq. km and data acquisition spanned over a period of 12 years, western offshore basin, India. The seismic data was acquired by different agencies

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using as old as single streamer close spaced technology to the latest Q-marine technology. The variation in bin size was from 12.5 m X 100 m to 6.25 m X 25 m. The details of the acquisition parameters are given in Table 1.

The processing challenges included time & disc management also, as the data volume was quite huge and available resources were very limited.

Merging was a difficult task particularly because of wavelet matching due to unavailability of gun-signatures for some areas. For amplitude matching between the multiple vintage datasets, utmost care was taken. Additionally, the merger of surveys was complicated by the factors such as different UTM zones, bin sizes, recording channels etc.

The final result was pre stack time migrated data volume of six vintages seamlessly merged with a good continuity and non varying amplitudes across boundaries.

Objectives

The main objective of processing was to get pre stack time migrated seismic data volume of six different blocks as a single seamless mosaic, merged at pre stack level.

Methodology

The seismic data covered, for the study, an area of approx. 4200 sq. km., equivalent to 1, 68,000 LKM. The seismic data of the six volumes A, B, C, D, E, F was acquired at different times by different agencies 1, 2, 3, 3, 4, 1 simultaneously, deploying different vessels with different source arrays and different streamers.

The shooting direction in volumes varied from 67 deg. to 69 deg. Accordingly, in preparing the master grid the direction was taken as 68 deg. There was a data gap also, in the vintage D.

To achieve the best result, it was decided to perform the pre- processing, data conditioning & signal processing of all the six volumes separately in their own grids which were created based on their acquisition grid, transfer the data to a super grid, and then merge the data in the super grid before migration (Figure 1)

The base survey plays a major role in the process of merging. Parameter testing was carried out on area B, which was taken as the base/master area, due to its location amongst all the areas. Once selected, the parameters were applied on other volumes as well to see the effect. There were several challenges in merging the seismic data of six vintages. The Challenges along with the methodologies used, are mentioned below.

1. Wavelet Matching: The data has been acquired by different air gun arrays (number of guns, volumes and pressure) and hydrophones', in streamers changing wavelet shape, over the volumes. Matching is important to avoid mismatch across volume boundaries and to have uniformity of seismic signature.

Usually the gun-signature is used for wavelet matching. However gun signature was not available for all vintages.
For Wavelet matching, wavelet was extracted from the seismic data of all areas & matching filters were designed to convert the wavelet of different areas to the master/ base area.

For design of matching filter, area B was chosen as the reference / master volume, due to its position in the area. The wavelet was extracted from the noise attenuated raw data, taking average over many similar offset traces, using the first breaks of the traces. The extracted wavelet was converted to minimum phase wavelet (Figure. 2), primarily to fulfill the condition of deconvolution.

The filter operator, to convert extracted wavelet to minimum phase, was applied on raw noise free shot gathers of area B.

Similarly for other volumes, wavelets were extracted preferably from the overlapped zones, and filter operators were designed to make these wavelets equivalent to minimum phase wavelet of master area. (Figure. 3)

2. Amplitude Matching: Amplitude matching is essential to get a uniform amplitude level across various vintages. The variation in amplitude across the surveys may be due to different type of air guns (volume/pressure) as well as hydrophones and recording instruments. Besides there may be change in amplitude decay with time as well as with offset from survey to survey. Area B was chosen as the base survey for calculating amplitude values. RMS amplitudes of other areas were scaled to rms amplitude of base survey in order to preserve relative amplitudes across volumes.

To take care for variation in amplitudes, scalars based on rms amplitude in the reference volume (area B) and in other volumes were calculated. The rms amplitude were calculated in the noise free zone, for similar offset traces. A scalar was calculated to bring this rms value to a particular level (2000). For other volumes too scalars were calculated to bring their rms amplitudes equivalent to 2000. Finally ratio of scalar of a particular volume and ref volume was calculated and that constant factor was applied on shot gathers of that volume. This way rms amplitude of all volumes were brought equivalent to the rms amplitude of reference volume (Figure. 4).

This approach resulted in uniformity of amplitudes across volumes to a great extent.

The exercise was repeated after sorting data in CDP gather also. This further reduced contrast in amplitude across the volume boundaries.

Time and offset decays of amplitude were studied for the base as well as in other volumes. The pattern were similar for both and hence no correction was applied on the data of other volumes.

3. Different Bin Dimensions: The bin size varied significantly between different volumes ranging from Q-marine dataset with 6.25mX 25m for vintage E to 12.5m X 100m for D vintage. However for merging only one bin size is used for all the volumes which generally is the most common bin size among all. The other consideration is the utilization of maximum data. The processing was done using 12.5m X 25m bin size. Hence the data was interpolated twice to convert it into 12.5m X 25m bin size for the area D and was regularized. For the area E the traces were dropped to convert it into 12.5m X 25m bin size.

4. Variation in signal to noise ratio: The signal to noise ratio varied drastically between the different 3D acquisitions vintages. Specifically, the areas D acquired by a single streamer to the acquisition done by latest Q-marine technology with 10 streamers for area E (Figure. 5).

The raw seismic data contained random as well as coherent noise. For random noise, especially for high amplitude spikes, anomalous amplitude attenuation technique was effectively used. For coherent noise mainly direct arrivals and linear refracted events, velocity based filters were used. These processes made the data free from different kinds of noise , making it suitable for matching across the vintages.

5. Different UTM Zones: As such for all the six areas navigation data was acquired on WGS84 spheroid & UTM projection system. But the central meridian & zones were different for two datasets, while for four areas data was acquired in UTM 42 N Zone (Central Meridian 69°E) and for the two areas it was in UTM 43 N Zone (Central Meridian 75°E)

The navigation data of two areas A & F were in UTM 43 N zone while for rest four areas B, C, D and E were in UTM 42 N zone. Hence the coordinates for the two areas A & F were transformed from 43 N to 42 N Zone.

Time & resource management

To make more meaningful contribution towards achievement of the project objectives we need to take time to get information about best ways to manage the project before it begins. Hence pre-processing information was collected before the beginning of the seismic data processing. The objectives of the processing, volume of data to be processed, survey parameters, observers logs, data acquisition report, gun signature, velocity information, preprocessed information of the area, if any, specific requirement by the clients during course of processing were collected. As data acquired by different agencies spanned over a long time gap of 12 years, it was difficult to get all the relevant information regarding the vintages. Although efforts were made to collect as much data information as available, strategy to handle the missing information was made prior to the processing.

It is very important to plan the route by which we expect to arrive at the desired outcome, the resources required and the expected time it will take to complete the work. These are indeed integral components of any project plan. The time spent on a particular stage will depend on the magnitude of the task, the amount of thinking and input needed for the job. At the start of the project a bar chart was prepared meticulously, giving the planned start &

planned finish date for various stages of processing, keeping in mind the given schedule & the resources available. This chart was a guideline and reference for the project activities for measuring performance & progress during the course of processing.

Also, it allowed us to manage project easily without wasting precious time. Next, keeping in mind the huge data volume, the vintages were divided among different group of processing analysts for data conditioning & signal processing. This has drastically reduced the time to reach at a particular stage. At the very outset, it was communicated to every team member what is to be done & how.

The importance of the communication and interaction with the clients and also among team members can never be ignored while processing any seismic data. In order to make informed decisions known to all, there were regular interactions among the team members, regular reviews, as well as client interactions. A quality check analysis at the end of each stage of the project was done.

Proper management of disc space is again a very crucial step in managing huge amount of seismic data & ensuring the optimum performance. Continuous monitoring of the disc space & rapid cleaning up of the data that was not required for future, was taken care as the disc space allotted for the project was much less than the input data size.

Seismic data processing involves good amount of time & effort at various stages. To eliminate risks involved, such as losing seismic data due to file corruption, disc crash, and human mistake etc., constant backups at various stages were taken in the recommended format.

Conclusion

The main challenge of the merging is to attain a final consistent volume dealing the challenges of wavelet & amplitude matching. The final processed PSTM stack volume is very good in terms of the continuity at area boundaries and as such merging of different volumes is seamless which was the main objective for merging different volumes. Moreover with the proper management of resource & time, the project was completed successfully ensuring quality output.

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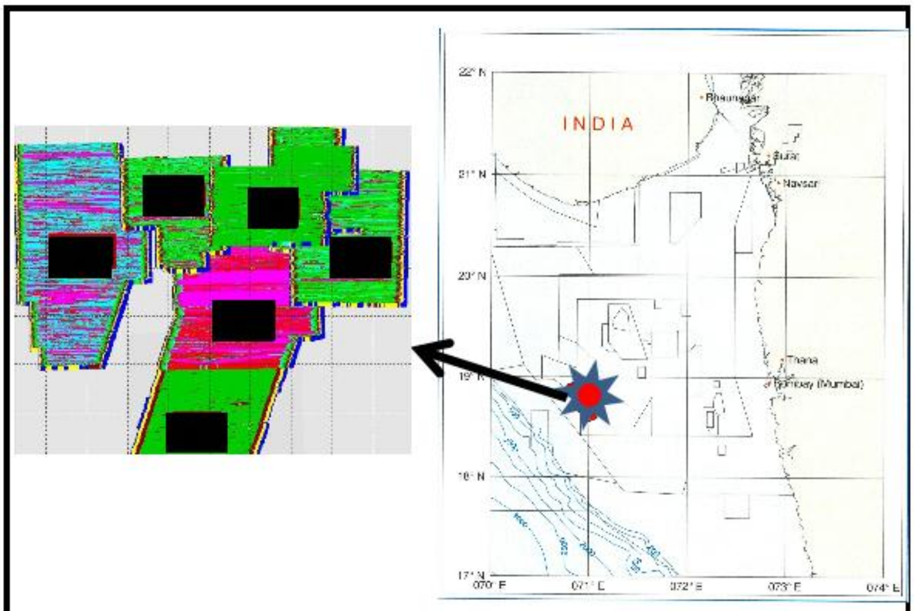


Figure1. Location map of the area showing six vintages A, B, C, D, E, F

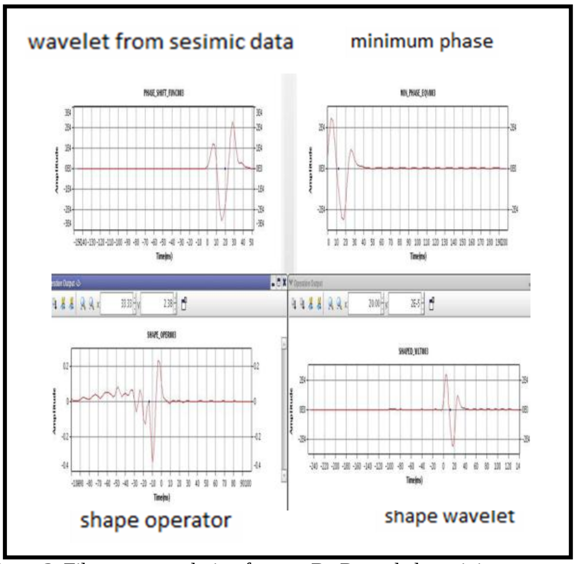


Figure 2. Filter operator design for area B : Recorded to minimum

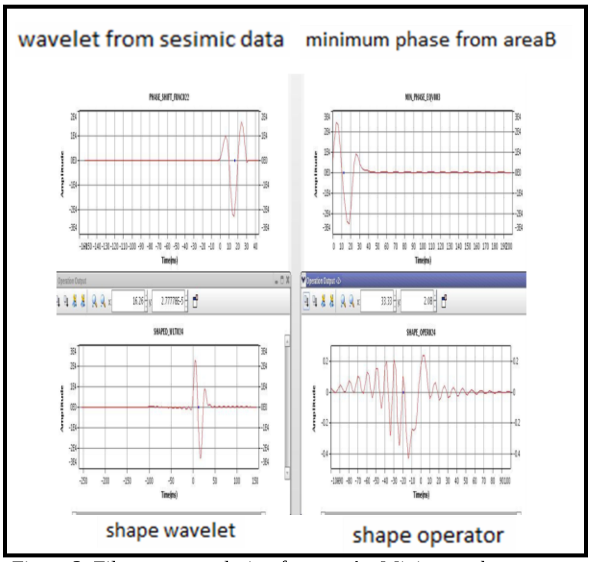
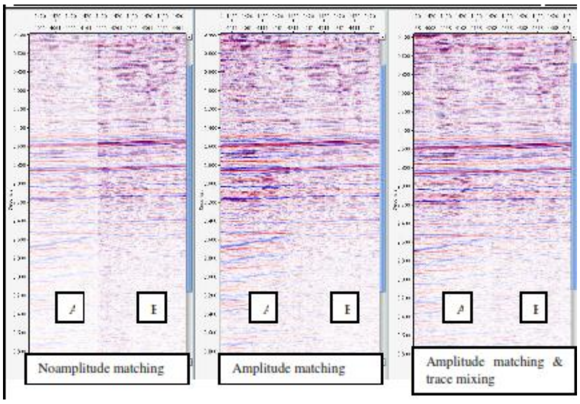


Figure 3. Filter operator design for area A : Minimum phase



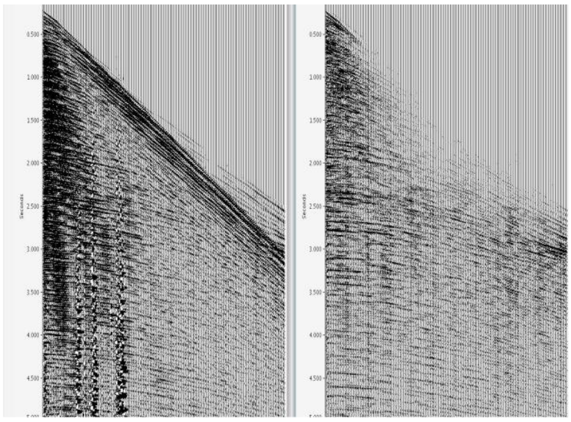


Figure5. Gather before & after Noise attenuation

Vintage	A	B	C	D	E	F
Agency	1	2	3	3	4	1
Acquisition year	2004	2005	2004	1994	2007	2004
Bin Size (m)	12.5 m X 25 m	12.5 m X 25 m	12.5 m X 25 m	12.5 m X 100 m	6.25 m X 25 m	12.5 m X 25 m
Nominal Fold	48	51	51	48	50	50
Record Length	5 sec	6 sec	5 sec	5 sec	8 sec	5 sec
Sample rate	2 ms	2 ms	2 ms	2 ms	2 ms	2 ms
Channels per streamer	3648	2080	2040	96	3648	3648
No. of Streamers	10	10	10	1	8	10
Source separation	50 m	50 m	50 m	Single Source	50 m	50 m
UTM Projection (Degree)	Zone 43 N	Zone 42 N	Zone 42 N	Zone 42 N	Zone 42 N	Zone 43 N

Table 1. Acquisition parameters of the vintages A, B, C, D, E, F

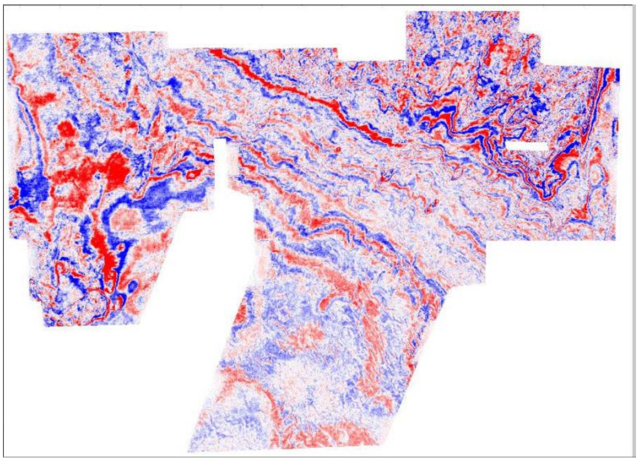


Figure 6. Time slice at 1700 ms showing continuity across different vintages

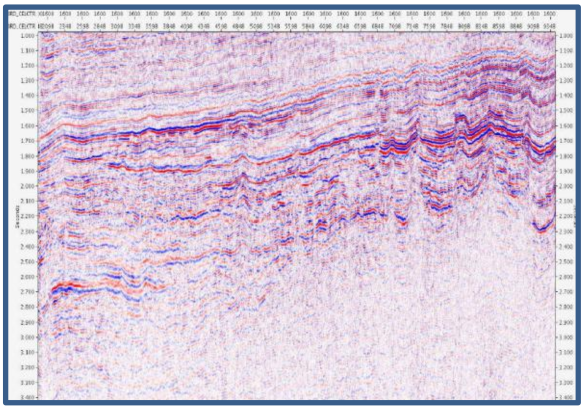


Figure 7. Inline stack across the different vintages

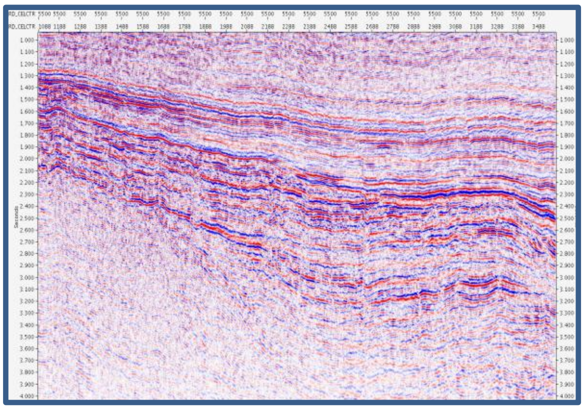


Figure 8. Xline stack across the different vintages