Broadband Processing and Anisotropic PSTM, Enhanced Imaging of Basement Configuration and Thin Sands Reservoir in Tapti Daman Area.

- A case study of Western Offshore Basin, India.

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Abstract

Broadband processing of conventional seismic data brings out better imaging of basement reflector as well as improved resolution of thin sands at Daman Mahua sequences in Tapti Daman area. Tapti-Daman fields lie within the Surat Depression, a broad depo-center of Tertiary age clastic sedimentation, characterized by the intertidal to shallow-marine finer sequences, in the North-eastern portion of the Bombay Offshore Basin. Most of the discoveries are predominantly gas in this area. In marine data processing, multiple suppression is also a very challenging task and there no single approach is suitable for all scenario. For shallow marine environment like this case study, for water layer multiples, we have used deterministic water layer multiple prediction and elimination approach and for surface related multiples, we have used the 3D surface related multiple elimination technique. With broadband sense processing and anisotropy inclusion in time migration, seismic resolution in desired zone could be enhanced significantly, which will help to establish, yet to find hydrocarbon potential in Daman Mahua sequences of Tapti Daman area. In current case study we have emphasized to increase the signal to noise ratio of the data, hence increasing the usable bandwidth across that defined frequency range, resulting in better imaging of deeper reflectors.

Introduction

Conventionally acquired marine seismic data is severely affected by the ghost energy, generated at both the source and receiver sides thereby lowering the bandwidth of recorded data. These ghost events need to be removed from the data during processing in order to broaden the data bandwidth. For better resolution, frequency bandwidth of seismic data were broadened both in lower & higher side. Figure 1 shows the location map of the area.

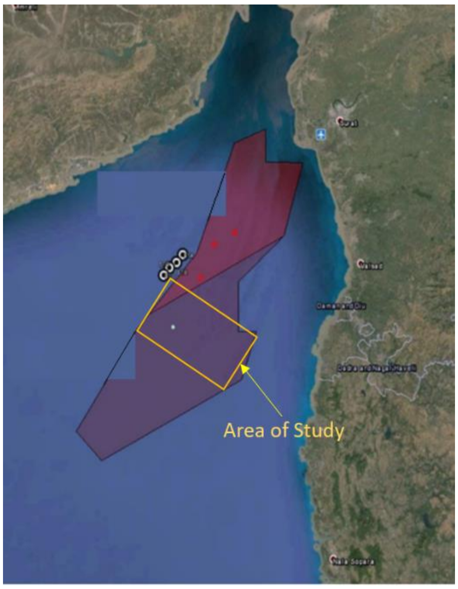


Figure 1: Location map of the area.

After applying the broadband process in the recent processed data the faults clarity & image continuity seems better. In this case study the advance multiple suppression technique like deterministic water layer demultiple and 3D surface related multiple elimination used to eliminate the water layer and other surface related multiples, brought out better resolution at Daman-Mahua sequences.

Present case study involves the broadband sense processing of the conventional streamer data and considering the anisotropy in nature, the final Time Migration velocities were picked with eta field incorporation which resulted in better demarcation of the basement and generated the AVO analysis amenable gathers at reservoir level.

Processes that impacted the result

In the present work these are the important processes which impacted the results.

- Broadband Sense Processing.
- Water layer and surface related multiple attenuation.
- Eta Function incorporation in Final PSTM Velocity and Migration.
- Q- Compensation.

Broadband Sense Processing

Conventionally acquired marine flat streamer data is affected by ghosts, these ghost reflections interfere, either constructively or destructively, with primary reflections and distort the frequency by creating notches and the phase spectrum of the recorded seismic data. Figure 2 shows schematic diagram of primary reflection, source and receiver ghost events.

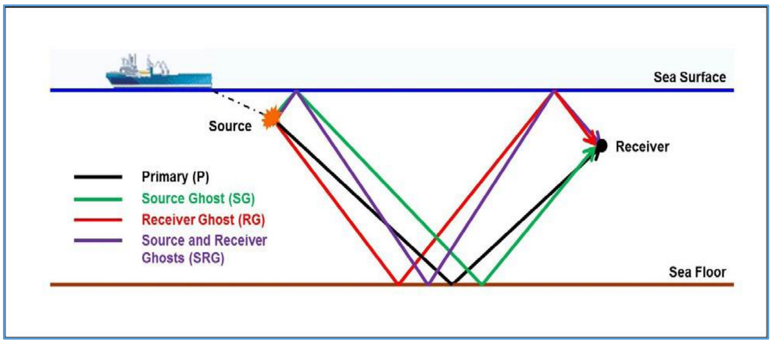
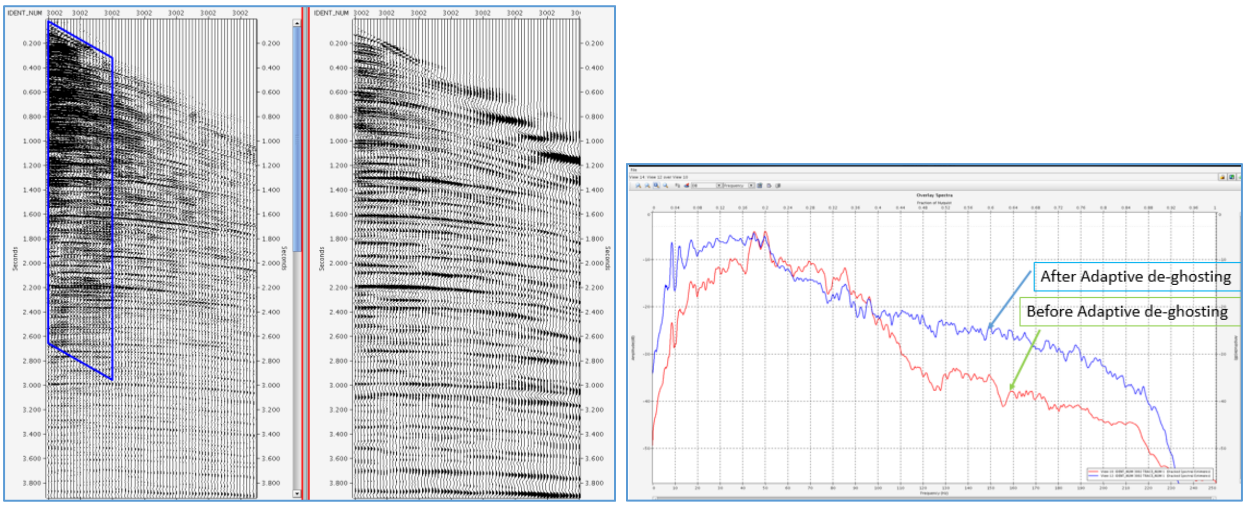


Figure 2: Schematic diagram of source and receiver ghost in conventional Streamer data acquisition.

Marine ghosts are unavoidable since both seismic source and streamer cable are towed beneath the sea surface. In general, the effect of the sea surface ghost on constant-depth towed streamer is greatly influenced by source and receiver depths as well as water velocity and sea state. These ghost events need to be removed from the data during processing in order to broaden the data bandwidth. This was achieved using adaptive De-ghosting technique.



(a) Before (b) After (c) Amplitude Spectra

Figure 3: Shot gather before (a) and after (b) adaptive de-ghosting and their amplitude spectra (c).

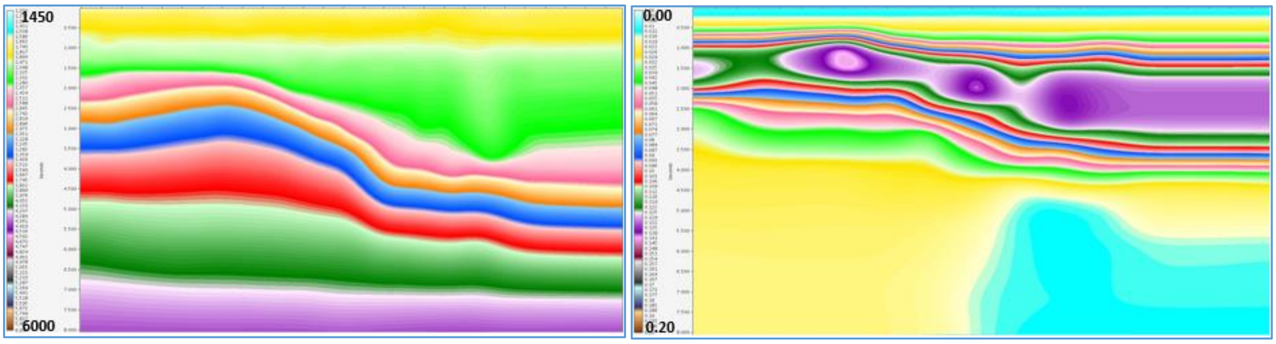
This method was used to simultaneously remove source and receiver side ghost events. Figure 3a & 3b shows shot gather before and after adaptive de-ghosting and figure 3c shows amplitude spectra of shot gathers before and after adaptive de-ghosting process.

Water layer and surface related demultiple

For water multiples we have used the deterministic Water Layer Demultiple (DWD) that attenuates water layer multiples. This process is appropriate for shallow water areas with high water bottom reflectivity. Water bottom range in this area is varying from 30 to 60 m. The water bottom two-way travel time, and the water velocity must be known with reasonable accuracy. A rough estimate of water bottom reflectivity is also required. This technique comprises of three steps. Near offset extrapolation is required to predict multiples at the nearest recorded offsets. Hence first of all near offset traces were extrapolated which were not present in this seismic data. Then a water layer multiple model was prepared. Finally the prepared multiple model was adaptively subtracted from the input seismic data.
For surface related multiples we have used the 3D Surface related multiple estimation technique, this technique works based on surface multiple prediction on the pre-stack dataset, surface multiple may be generated from any geologic structure, and with sufficient surface sampling multiple can be predicted from the data. The predicted multiples are subtracted from the input pre-stack dataset using an adaptive subtraction. After effectively applying these demultiple techniques and broadband sense processing fault clarity significantly enhanced.

Eta Function incorporation in Final PSTM Velocity and Migration.

Considering the anisotropy in nature, the final PSTM velocities and interval Eta (η) fields were picked simultaneously and anisotropic pre-stack time migration was run to get a higher order NMO corrected flat gathers. Figure 4(a) & 4(b) shows RMS velocity and interval Eta (η) fields.



(a) (b)

Figure 4: Picked RMS velocity (a) and Interval Eta (η) field (b).

Seismic anisotropy is defined as velocity dependent and it will depend on incidence angle or offset. Anisotropic effect on seismic data is important for amplitude analysis and stacking. Events are not flat after applying the RMS velocity, based on two term hyperbolic moveout equation.

Due to the anisotropy in medium there will be some hockey stick effect present on gathers at far offsets. So in this present work we have picked the eta field also which will take care of anisotropic effect and incorporated in the Kirchhoff pre stack time migration to get more reliable image.

After incorporation Eta field in Pre stack time migration, gathers are more flattened up to 44 or more degree angle, at far offset in zone of interest, which may be good for AVO Analysis. Figure 5 shows the gather flatness. AVO relies in part of fitting gradients to amplitude observations over a range of trace offsets. In order to get reliable AVO analysis, all the steps in data processing must accurately preserve the relative amplitude.

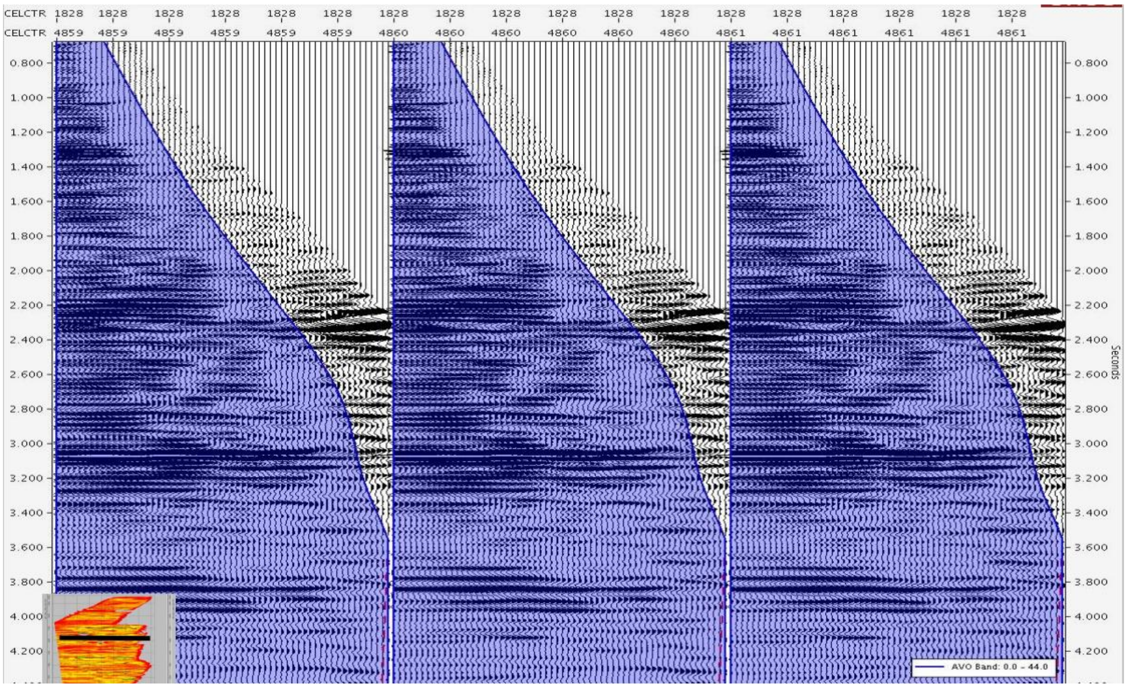


Figure 5: Eta Incorporated Time Migrated gathers (successive) with angle band up to 44°/4500m offset.

Q Compensation

Seismic attenuation affects both amplitude and phase of seismic signals. The effects of attenuation are dispersive with frequency and can result in reduced stack coherency. To compensate for the earth Q-filter, time-variant amplitude compensation was applied using a frequency-constant Q model of earth attenuation. This amplitude compensation was applied after migration and phase compensation applied before migration.

Post Stack Processing

On migrated gathers random noise attenuation performed in inline and x-line direction, it reduces random noise, increase continuity of coherent events and attenuate non-linear noise. Weighted least square radon application applied to the data in order to model residual multiples and removed them based on moveout criteria. The improved resolution over a conventional Forward Radon Transform was achieved through a time variant weighing scheme applied during the transform to increase the sparsity of the model. Figure 6 shows previous processed stack section without broadband processing and Figure 7 shows recent processed stack with broadband processing hence improved resolution.

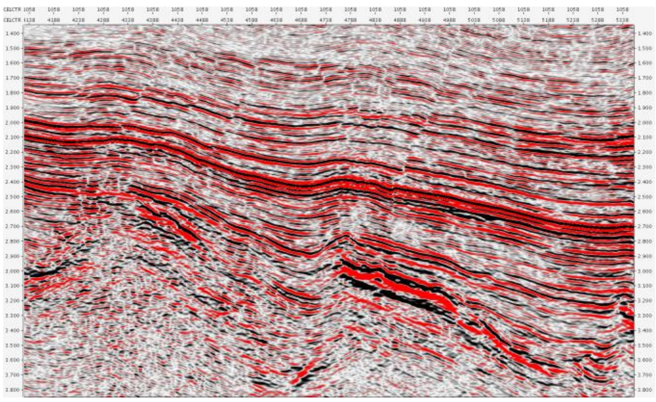


Figure 6: Previous Processed Time Migrated Stack without broadband processing

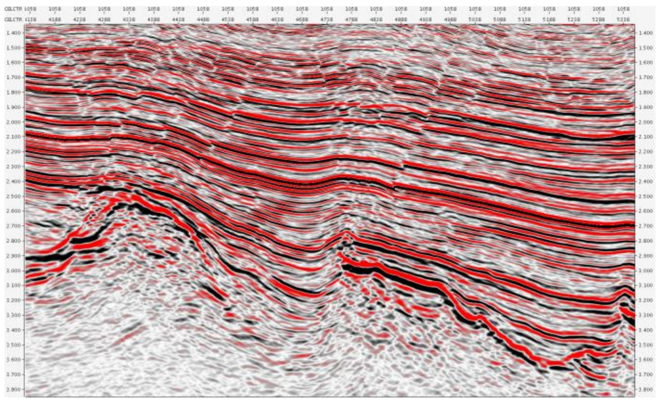


Figure 7: Recent Processed Time Migrated Stack with Broadband Processing

The amplitude of seismic data generally decreases with time and distance travelled from the seismic energy source. This amplitude decay is a result of wavefront divergence, transmission loss, earth's attenuation and other complicating factors. Therefore, it is important to correct these effects before studying changes in reflectivity (e.g. analysis of amplitude-versus-offset or bright spots) of data. All of these effects can be corrected either deterministically or statistically. Surface consistent amplitude compensation (SCAC) sequence attempts to compensate amplitude variations within given dataset. In the final stack section we can see the improvement in deeper part also Figure 8 & 9 shows vintage and recent processed time migrated stack sections.

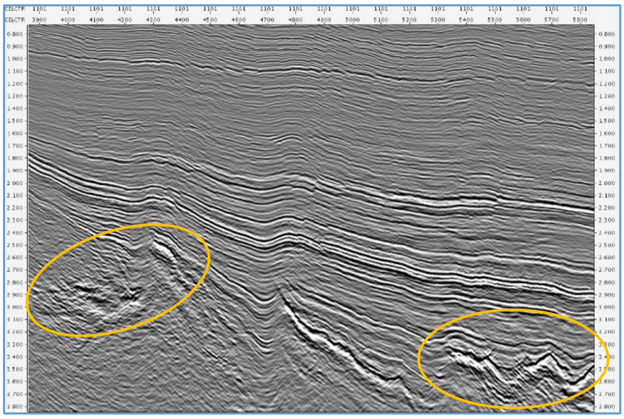


Figure 8: Previous Processed Time Migrated Stack without broadband processing.

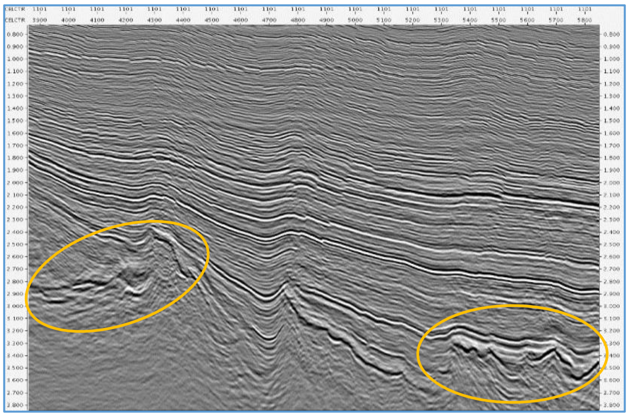
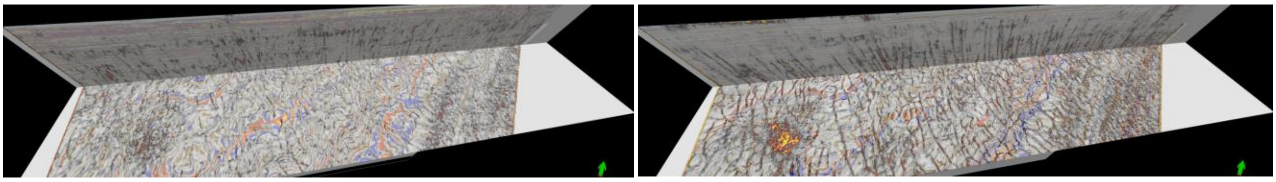


Figure 9: Recent Processed Time Migrated Stack with Broadband Processing.

After applying all the post processing steps we have taken the variance cube to see the fault pattern in vintage data and recent processed dataset, figure 10(a) & 10(b) shows the fault pattern from variance cubes of vintage and recent processed datasets. Figure 11 & 12 shows the time slices at 2100 ms of vintage and recent processed datasets.



(a) (b)

Figure 10: Variance Image of Fault pattern in previous (a) and recent processed Time Migrated Stacks (b) (These images have been taken in petrel software in 3D view, horizontal and vertical axes are Inline and Crossline respectively)

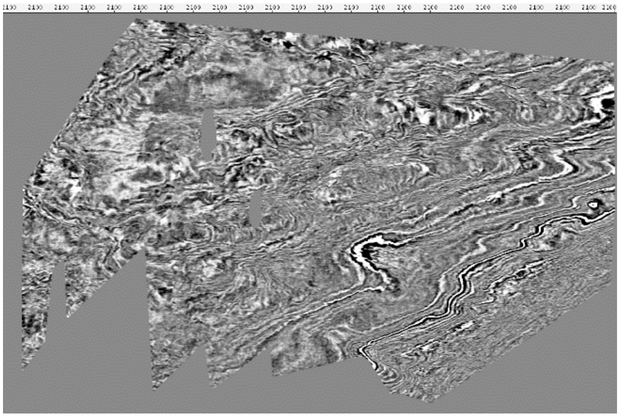


Figure 11: Time Slice at 2100ms from previous Processed Time Migrated Stack.

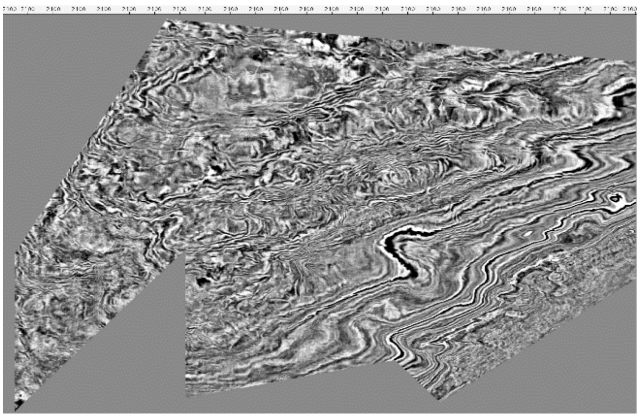


Figure 12: Time Slice at 2100ms from recent Broadband Processed Time Migrated Stack.

Conclusion

The advanced processing techniques like Adaptive De-ghosting (Broadband sense processing), Demultiple techniques like Deterministic water layer demultiple and 3D Surface Related Multiple Estimation to eliminate the water layer other surface related multiples, brings out better resolution at Daman-Mahua sequences and fault clarity were significantly enhanced. With broad bandwidth dataset structural mapping and reservoir characterization can be done more accurately. Kirchhoff Pre Stack Time Migration performed with Eta field incorporation, which resulting in better demarcation of Basement and overall better subsurface imaging.

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