



**Broadband processing of conventional flat streamer data using pre-migration deghosting, a case study on data from the offshore Philippines**

Sonika Chauhan<sup>1\*</sup>, Kiran Negi<sup>1</sup>, Sambit Ghosal<sup>1</sup>, Damien Semon<sup>1</sup>, Lam Pham<sup>1</sup>, Toby Read<sup>2</sup>, Dan P. Carlos<sup>3</sup>

<sup>1</sup>CGG, <sup>2</sup>Arex Energy, <sup>3</sup>Philex Petroleum Corp

**Keywords**

Receiver ghost, Broadband, Deghosting, GWE

**Abstract**

Conventional flat streamer seismic data normally have a narrow frequency bandwidth. However, we can enhance the bandwidth using deghosting technology to compensate for ghost notches during the processing of such data. Pre-migration deghosting is thereby a key step in broadband processing. In this paper, we demonstrate the effectiveness of broadband processing in enhancing the usable bandwidth of the data by reducing the ghost notches using a case study of conventionally acquired 2D seismic data from offshore Philippines.

**Introduction**

Towed streamer data are affected by the receiver ghost whose frequency depends on the depth of the receivers. Therefore, when the marine seismic data are acquired with all the streamers at the same constant depth, ghost notch diversity is poor, i.e., the notches occur at nearly the same frequencies for different offsets. This limits the usable bandwidth in the data. It is widely accepted in the industry that broader bandwidth is helpful in seismic data processing as well as interpretation. Broader bandwidth typically gives the following advantages for interpretation:

- a) better texture,
- b) higher resolution,
- c) layering effect of the seismic image.

A standard practice for broadband processing is receiver deghosting. In this paper we use a suite of 2D receiver deghosting algorithms termed ghost wavefield elimination (GWE). Here we show the advantage of broadband processing using GWE on conventional 2D data. The data is from block SC-75, offshore North-West Palawan (location map shown in Figure-1). The water depth in this area is generally deep, varying from 350 m to

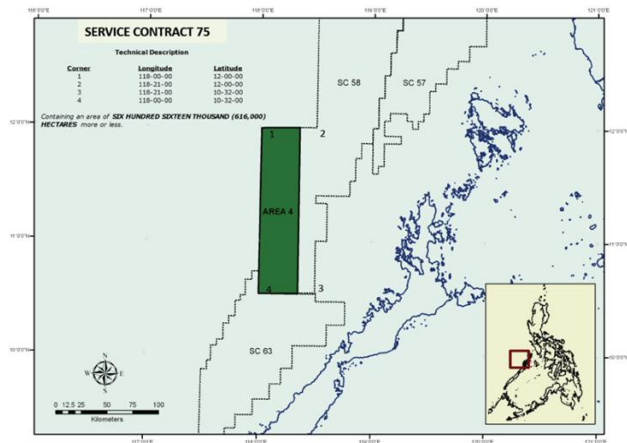


Figure-1: Survey location map.

Sonika Chauhan, CGG Services India Pvt Ltd  
Email: sonika.chauhan@cgg.com

## Broadband processing of conventional flat streamer data

3000 m. This 2D marine seismic survey has been recorded with a conventional 6 km flat streamer, 6 m source depth and 7 m streamer depth. The shot interval is 25 m and the channel interval is 12.5 m. The other basic acquisition parameters are: 480 channels in the streamer, near offset of 120 m and fold of 120.

### Broadband Technology Overview

Hydrophones record both the upgoing and downgoing seismic wavefields. The downgoing wavefield is created by reflection of the upgoing wavefield at the water surface, with a reversal of polarity. When the upgoing and downgoing waves interfere destructively at some frequencies, notches will be created in the frequency spectrum.

The latest marine acquisition techniques such as acquisition with variable-depth streamers (Soubaras, 2010) address this need for broad frequency bandwidth. In case of variable-depth streamer acquisition (shown in Figure-2), the increasing depth of the receivers along the curved streamer profile help in recording seismic data with ghost notches at different frequencies for different offsets and the deep tow results in good signal-to-noise ratio for the low frequencies. The notch diversity ensures that signal is present in every part of the frequency band. The bandwidth of seismic data can be enhanced by using broadband processing. An important part of broadband processing is the ghost wavefield elimination (GWE). One of the GWE tools developed by Wang and Peng (2012) is termed the bootstrap method. The bootstrap method does an iterative least squares inversion to estimate the ghost-free data.

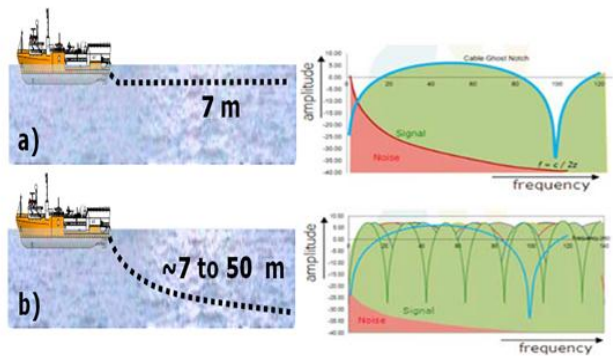


Figure-2: a) Flat streamer acquisition;  
b) Variable-depth streamer acquisition

Although broadband acquisition solutions are superior to pure processing solutions, there are still a lot of conventional data being used in the industry which will benefit from broadband processing.

### Processing Flow

The data were processed at 2 ms sample interval to get the full advantage of broadband processing. Both conventional and broadband processing flows were tested (as shown in Figures 3a and 3b). Keeping denoise and SRME demultiple flow the same, receiver deghosting was introduced in the conventional flow before Radon demultiple. SRME demultiple before deghosting simplifies the processing work flow for conventional streamer data as we can use already streamlined and efficient multiple modelling and subtraction parameters (Shivaji, 2014). The conventional pre-stack time migration (PreSTM) stack was then compared with broadband PreSTM stack.

Both the upgoing and the downgoing wavefields are present in the recorded data. Both these fields have similar amplitudes but opposite polarities, and this results in destructive interference at the frequencies near ghost notches. Therefore it is needed to remove the ghost from the data to compensate these frequency notches. In this case study,

## Broadband processing of conventional flat streamer data

receiver ghost was removed using GWE tool 'bootstrap method in  $\tau$ -p domain' (developed by Wang and Peng, 2012). This method first uses the NMO correction method based on 1D ray tracing for creating mirror data from shot domain data and then gives receiver ghost free data by doing an iterative joint inversion of the original and the mirror data.



Figure-3a: Conventional processing flow.



Figure-3b: Broadband processing flow.

## Results and Conclusion

Before starting the broadband processing for the whole survey, a test was run on one line to compare the conventional processing flow with broadband processing. After analyzing PreSTM results from both flows, it was concluded that the broadband processing result was reducing the ghost notches and broadening the bandwidth (Figure-6). Broader bandwidth was overall giving better texture, higher resolution and layering effect of the seismic image (Figure-4). In the deeper part, it was observed de-ghosting predominantly helped to enhance the low-frequency content of the conventional data (Figure-5), with a much improved signal-to-noise ratio (Figure-8). Event continuity was improved after broadband processing. Reduction in side lobes and potential interferences with neighbouring events resulted in reduced ringing behaviour of the seismic data, which led to easier interpretation of the seismic events. Extension of the amplitude spectrum to lower frequencies offers a significant improvement in the imaging of deeper targets and faults. Based on the above observations it was decided to go for the broadband processing of the full survey.

Figure-4 shows the shallow zoomed section comparisons while Figure-5 shows deep zoomed section comparisons between conventional PreSTM data and the broadband PreSTM data. Figure-6 shows the amplitude spectrum

---

Sonika Chauhan, CGG Services India Pvt Ltd  
Email: sonika.chauhan@cgg.com

## Broadband processing of conventional flat streamer data

comparison and Figure-7 shows frequency panel comparisons of conventional PreSTM with broadband PreSTM focusing on the low and middle frequencies. Figure-9 and Figure-10 shows a comparison of conventional PreSTM stack with broadband PreSTM stack in full frequency bandwidth (0-250 Hz).

In conclusion, the comparison of conventional result (Figure-9) with the broadband result (Figure-10) clearly shows that the broadband processing significantly improved the seismic quality by compensating the receiver ghost notch frequencies in the data. This helped in better interpretation of geological boundaries (horizons and faults) and layers. Based on this successful test, it is expected that the existing conventional flat streamer data in this region could benefit from reprocessing with the latest broadband processing flow.

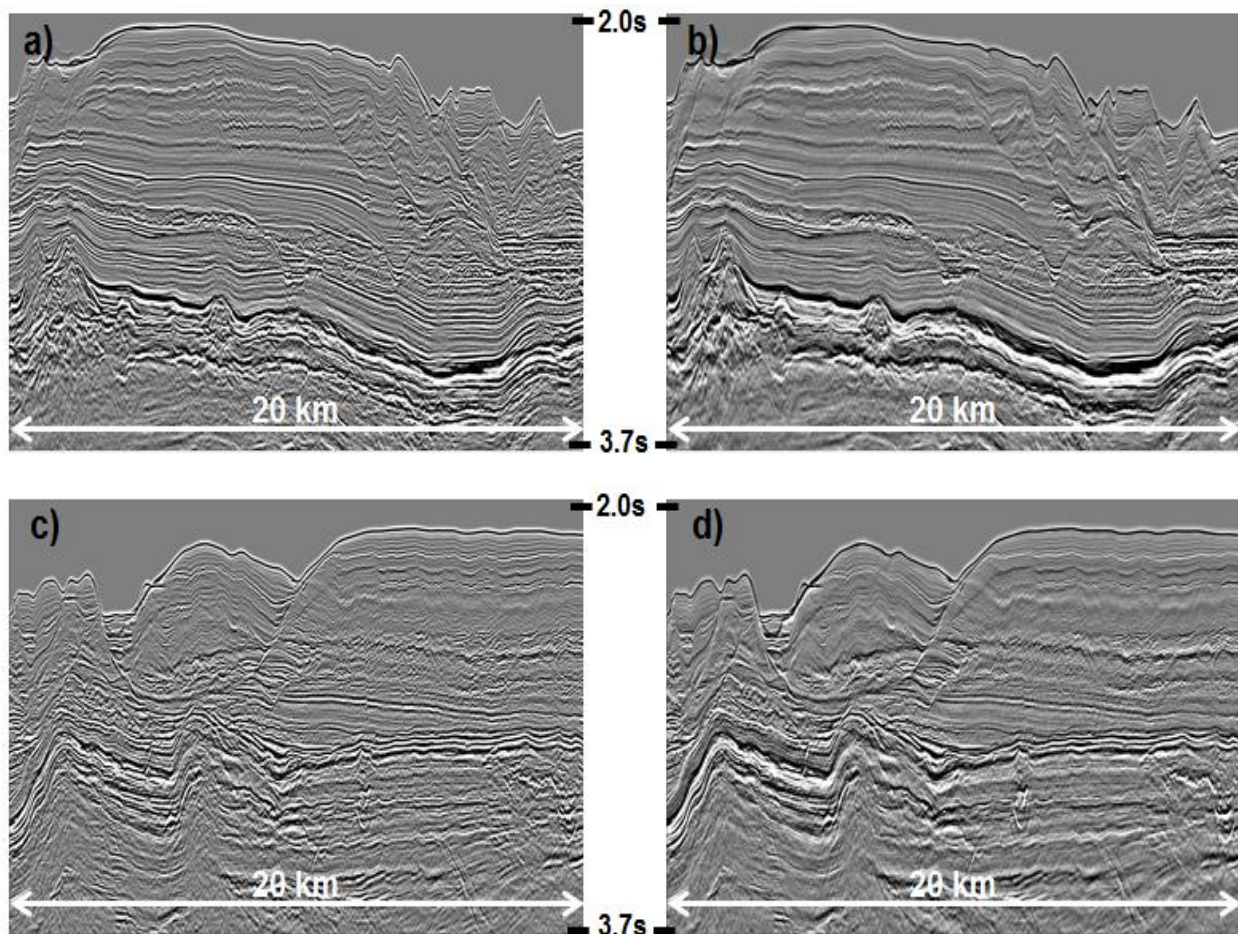


Figure-4: Shallow zoomed sections. Conventional PreSTM stacks are shown on the left in Figures a) and c); corresponding broadband PreSTM stacks are shown on the right in Figures b) and d), respectively.

Broadband processing of conventional flat streamer data

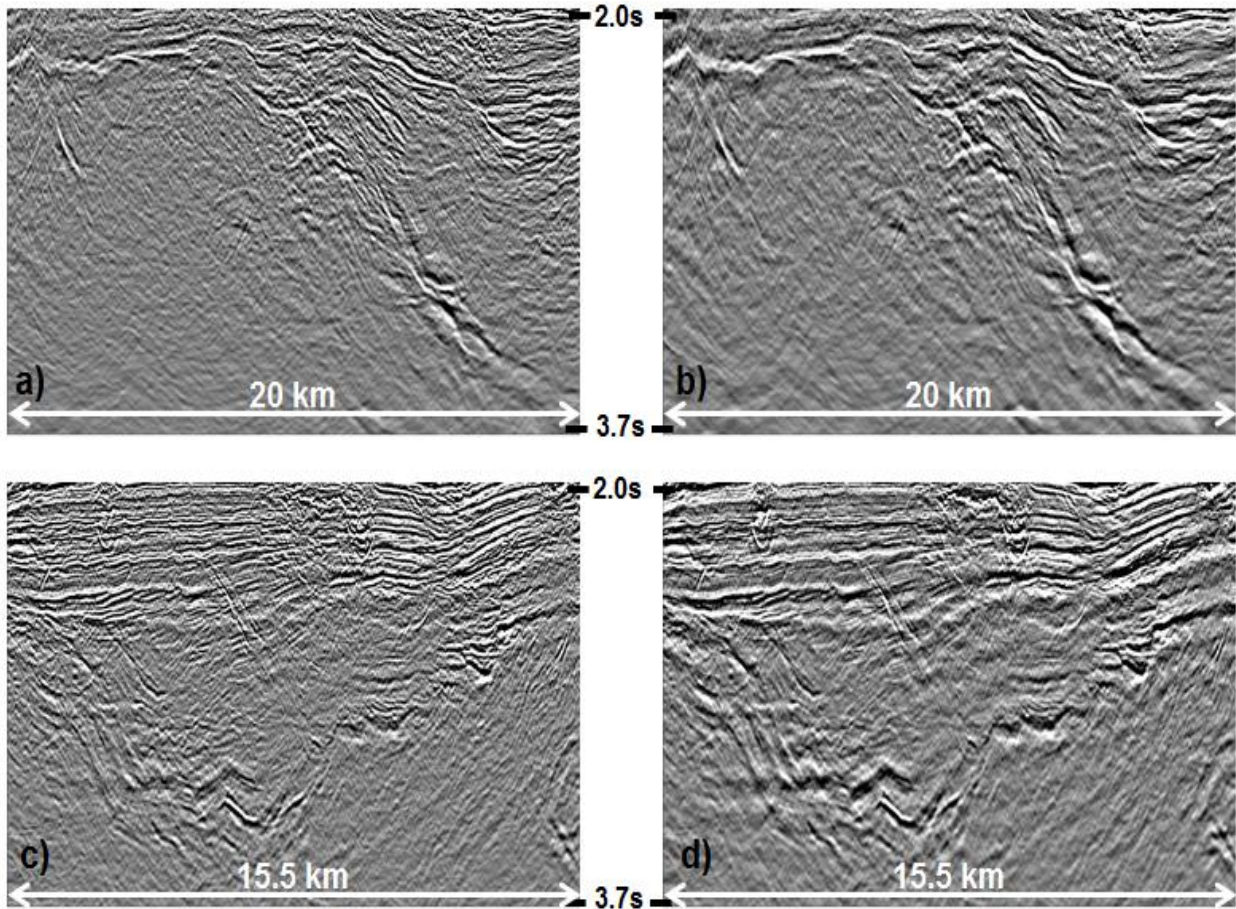


Figure-5: Deep zoomed sections. Conventional PreSTM stacks are shown on the left in Figures a) and c); corresponding broadband PreSTM stacks are shown on the right in Figures b) and d), respectively.

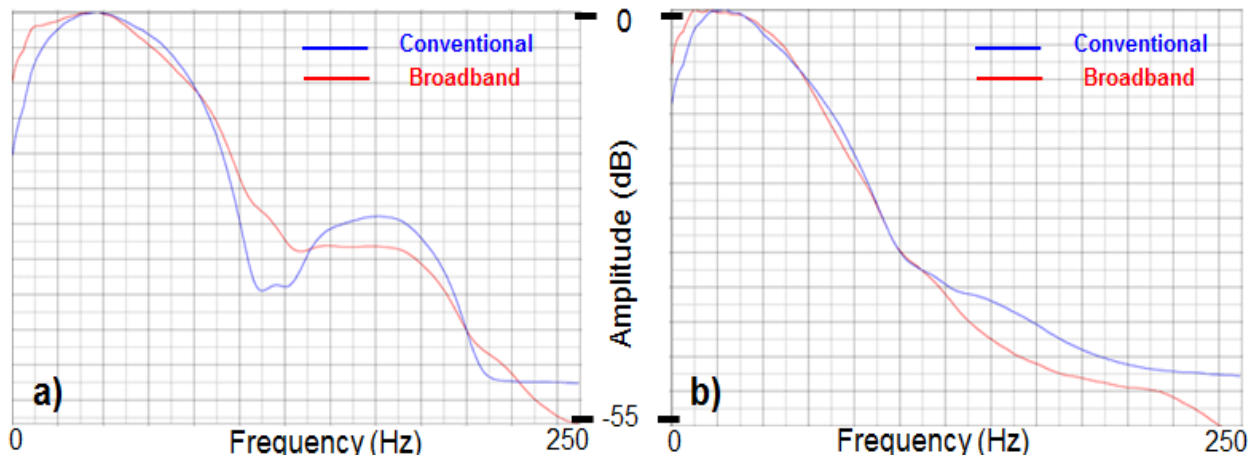


Figure-6: Amplitude spectra comparison of conventional PSTM stack vs broadband PSTM stack; Figure a) shows the shallow amplitude spectra and Figure b) shows deep amplitude spectra.

---

Sonika Chauhan, CGG Services India Pvt Ltd  
Email: sonika.chauhan@cgg.com

Broadband processing of conventional flat streamer data

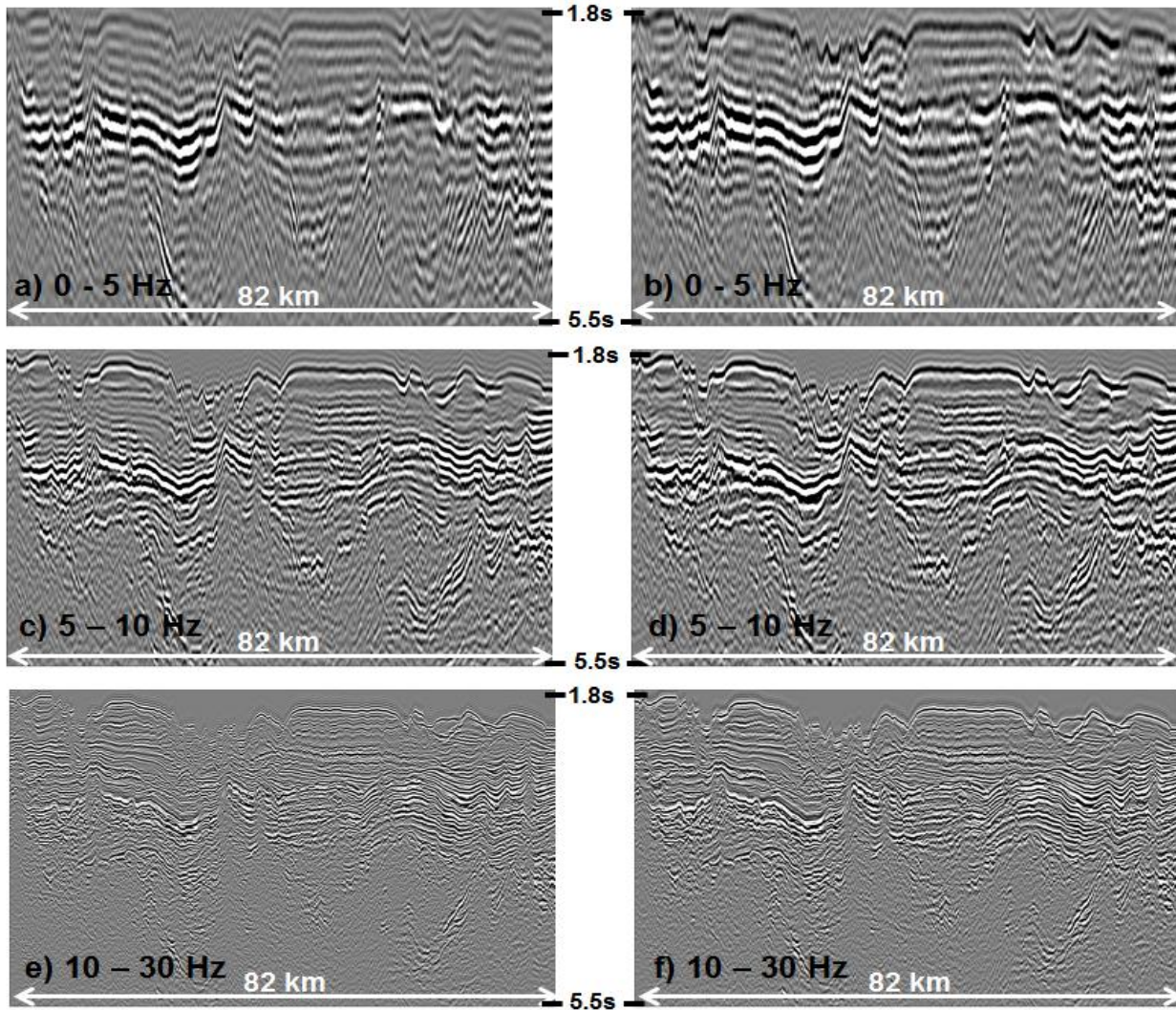


Figure-7: Frequency panel comparisons. Conventional PreSTM stacks are shown on the left and corresponding broadband PreSTM stacks are shown on the right.

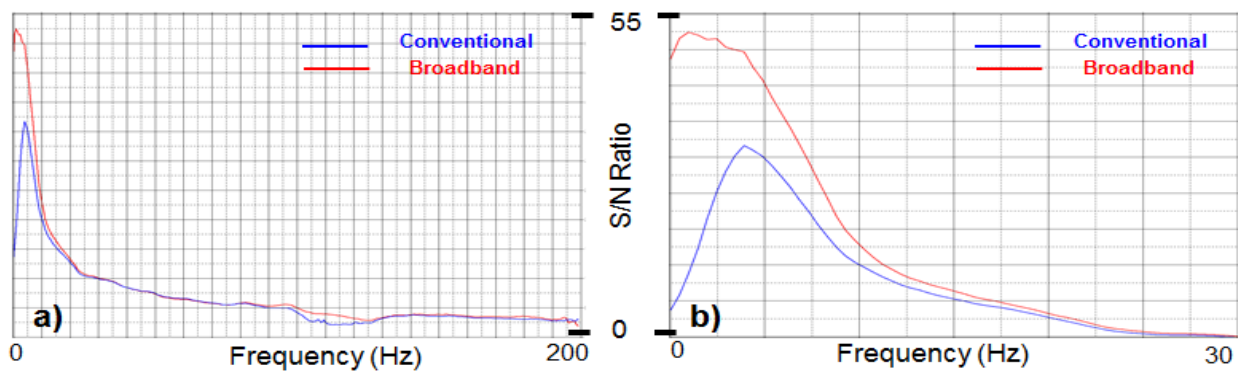


Figure-8: Signal-to-noise ratio comparison of conventional PSTM stack vs broadband PSTM stack.

Sonika Chauhan, CGG Services India Pvt Ltd  
Email: sonika.chauhan@cgg.com

Broadband processing of conventional flat streamer data

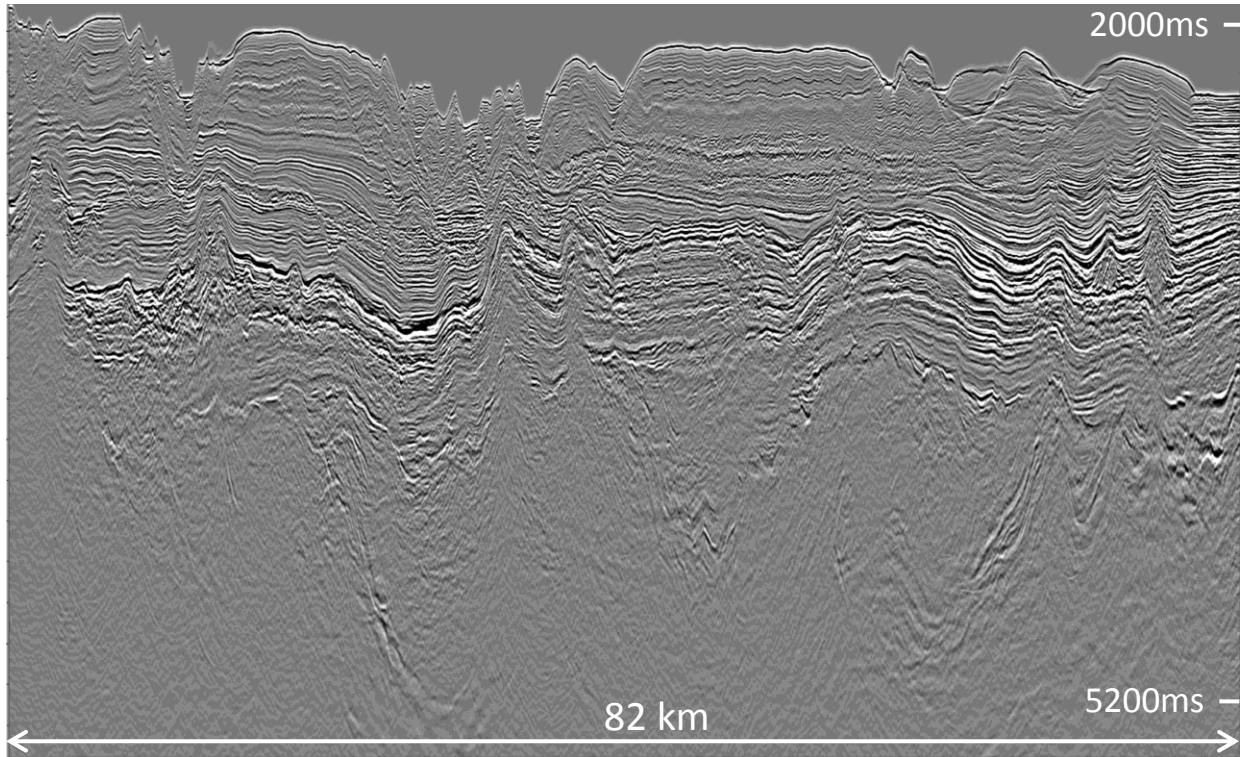


Figure-9: Conventional PSTM stack (0-250 Hz).

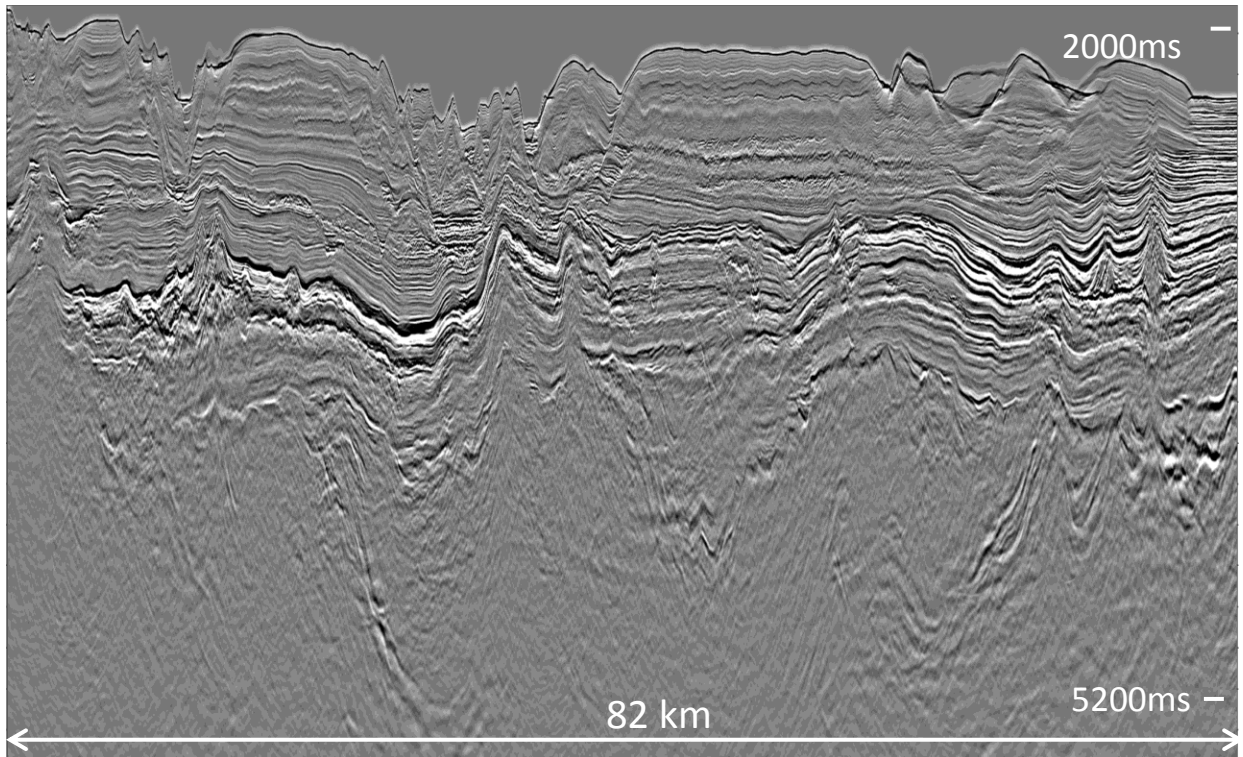


Figure-10: Broadband PSTM stack (0-250 Hz).

---

Sonika Chauhan, CGG Services India Pvt Ltd  
Email: [sonika.chauhan@cgg.com](mailto:sonika.chauhan@cgg.com)

## **Acknowledgements**

The authors would like to thank Philex Petroleum Corporation, together with its Service Contract 75 partners PNOG Exploration Corporation and PetroEnergy Resource Corporation, and CGG for granting permission for publishing the results. The authors would also like to thank Jason Sun and Rakesh Walia from CGG for their help in editing.

## **References**

Wang, P., Ray, S., Peng, C. and Li, Y., 2013, Premigration deghosting for marine streamer data using a bootstrap approach in Tau-P domain; 75<sup>th</sup> EAGE Conference & Exhibition, Extended Abstracts.

Bai, B., Chen, C., Yang, M. and Huang, Y., 2013, Ghost effect analysis and bootstrap deghosting application on marine streamer data; 75<sup>th</sup> EAGE Conference & Exhibition, Extended Abstracts.

Soubaras, R., 2010, Deghosting by joint deconvolution of a migration and a mirror migration; 80<sup>th</sup> Annual International Meeting, SEG Technical Program Expanded Abstracts, 3406–3410.

Maitra, S., Murthy, J.V., Woodford, D.T., Hodgkiss, G., Poh, K.W., Vercesi, R. and Andersen, E., 2014, Broadband Processing for Conventional Streamer Data – A Review of the Demultiple Workflow; IPTC Expanded Abstracts.