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Please fill in your manuscript title.	Enhancing Multi Survey Merging Technic of Marine Towed Streamer Data on Post Migration Data Workflow: A Shallow Water Malaysia Basin Case Study

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Abstract

Merging 3D seismic surveys data with different acquisition geometries has always been challenging for seismic data processing due to difference in recording equipments, source arrays, spread lengths, bin dimensions, and grid orientation. Avoiding such footprints after the survey merge becomes even more difficult if the processing workflows between the surveys are largely different. Generally, the survey merging is conducted on the pre-stack time domain, prior to migration. For this study, the survey merging was performed on post-migrated common midpoint (CMP) to achieve quick turnaround time.

De-noise and de-multiple suppression processes poses another challenge during this survey merge. More often than not, these noises could not be removed entirely during processing. Such noises affect the interpretation of subtle faults and structural features required for reservoir interpretation and well prediction.

In this study, our goal is to establish a reliable workflow for survey merging. We first attempt to understand the conventional survey merging workflow then we focus on revising the new workflow. First, we establish the workflow to apply High-Resolution Radon de-multiple processing (Moore, I. & Kostov, C., Stable, G., 2002) and followed by the 3D Anti-Alias Matching Pursuit Fourier Interpolation (3DMPFI) (Xu, S. Zhang, Y. and Lambaré, G., 2010) with pre-stack data to attenuate residual multiple and aliasing noise to improve signal to noise ratio of the seismic data.

Second, we revisited the post stack merging method with soft boundary 3D merging by rejecting ‘un-fully migration’ data as much as possible at the overlap areas to provide optimized survey merging.

This resulted in improved signal to noise ratio, allowing for better seismic Quantitative Interpretation (QI) products to be generated for an enhanced geological feature identification such as sand channels and faults features.

Introduction

Two seismic marine surveys offshore the Malay basin with different acquisition configurations were merged using post migration data as input to a de-risking campaign to identify a possible new prospect between the two surveys. The conventional post migration multi survey matching result was completed several years ago and was used as benchmark for comparison to the new survey matching.

The conventional workflow was studied and revised to provide better result with a new workflow based on improved methodologies, which enhanced the quality of the merged survey. We believe that the workflow could be improved with concentrating on enhancement of signal to noise by application High-Resolution Radon de-multiple processing (Moore, I. & Kostov, C., 2002), 3D Anti-Alias Matching Pursuit Fourier Interpolation (Xu, S. Zhang, Y. and Lambaré, G., 2010) and soft boundary 3D merging.

In this paper we attempt to build an efficient and accurate new workflow for better survey merging. We use a Malay basin example from offshore Malaysia to illustrate this improvement. The new survey merging results could further support the Quantitative Interpretation (QI) study by providing an input, which is more compliant towards AVO studies.

Examples

Survey merging was applied to two surveys offshore Malaysia Basin based on the conventional global matching techniques with the processing sequences below:

- Input was Kirchhoff Pre-Stack Time Migration (KPSTM) gathers from processing of survey A (target) & survey B (source)
- Trace interpolation from 12.5x25m to 6.25x12.5m on survey B
- Performed rotation to re-grid Survey B to Survey A grid (as target survey)
- Generate full fold and angle stacks from KPSTM data
- Derive and apply a single statistically computed matching operator to match one survey, for a better match of the amplitude, phase, and timing.
- Hard boundary merging for two surveys

The survey merging sequences were revised with the new techniques as below:

- Apply High-Resolution Radon de-multiple processing (Moore, I. & Kostov, C., 2002) to Kirchhoff Pre-Stack Time Migration (KPSTM) gathers from processing of survey A (target) & survey B (source)
- Preform the 3D Anti-Alias Matching Pursuit Fourier Interpolation (3DMPFI) (Xu, S. Zhang, Y. and Lambaré, G., 2010) in offset domain from 12.5x25m to 6.25x12.5m grid and re-grid on survey B
- Generate full fold and angle stacks from KPSTM data
- Derive and apply a new single time variant statistically computed matching operator to match one survey, for a better match of the amplitude, phase, and timing.
- Soft boundary merging for two surveys to reject the not fully migrated at the overlap areas to provide optimized survey merging

Figure 1 shows the results of the High-Resolution Radon demultiple (Moore, I. & Kostov, C., 2002) applied to the input seismic gathers for survey A. The residual multiple was attenuated in the pre-stack domain to improve the signal to noise ratio for angle stacks generation. The same process was applied to survey B to obtain the better quality of the input for survey merging.

After the Radon demultiple, the data for survey B was required to be rotated to the same grid as in survey A. The conventional method was post stack interpolation and rotation using sinc interpolation, which did not address the aliasing introduced by the acquisition shooting in different direction. This aliasing noise could be attenuated by apply the 3D interpolation using Anti-Alias Matching Pursuit Fourier Interpolation (3DMPFI) (Xu, S. Zhang, Y. and Lambaré, G. 2010) in the pre-stack offset domain. Figure 2 illustrates the interpolation results using conventional and new method. The aliasing noise is significantly reduced with the new technique.

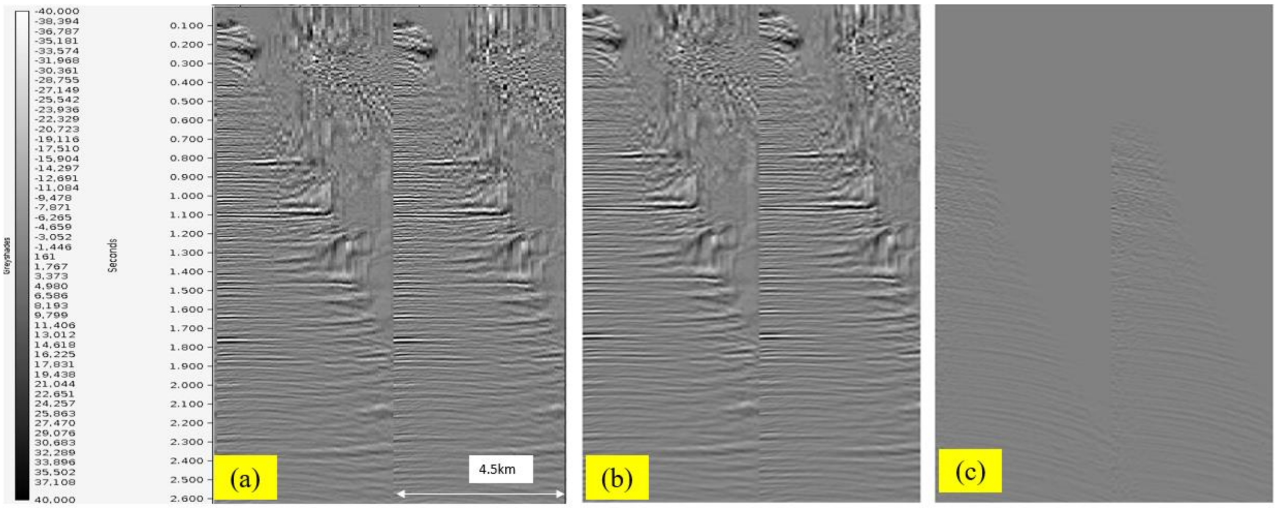

Figure 1: *Survey A Seismic KPSTM gathers a) before **High-Resolution Radon De-multiple** b) after **High-Resolution Radon De-multiple c) Difference before and after High-Resolution Radon De-multiple.** Residuals have been attenuated after applying High-Resolution Radon De-multiple.*

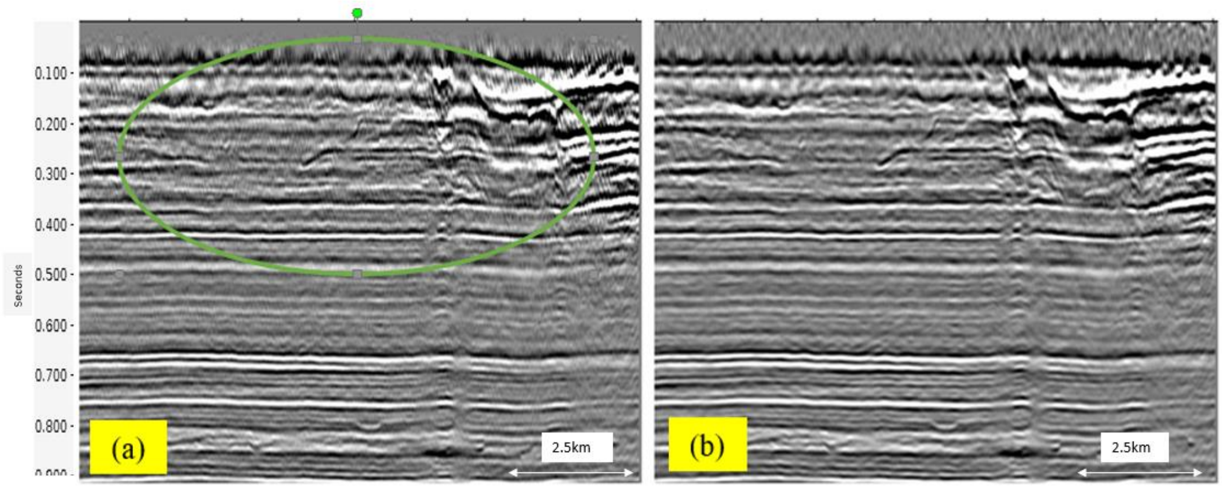

Figure 2: *Survey B Re-grided Seismic Full Stacks a) before **3D Anti-Alias Matching Pursuit Fourier Interpolation (MPFI)** b) after **3D Anti-Alias Matching Pursuit Fourier Interpolation (MPFI).** Aliasing was observed to be removed after applying 3D MPFI, pointed by the green circle.*

During the survey merge, one of the challenges was to select the right amount of the merging area at the overlap area with the fully migrated data to merge. For the conventional method, the merging was applied using the entire migrated data including the partially migrated data at the edge of both surveys as shown in Figure 3. However, the new merging survey limited the overall coverage of the overlapping areas in both surveys. This was designed to limit the un-migrated data contribution to the merging process and improve the final merging result (Figure 4).

The merging results were compared with RMS map extracted from the full stack generated from both methods as displayed in Figure 5. The AVO analysis derived from angle stacks was also produced for both methods as shown as Figure 6.

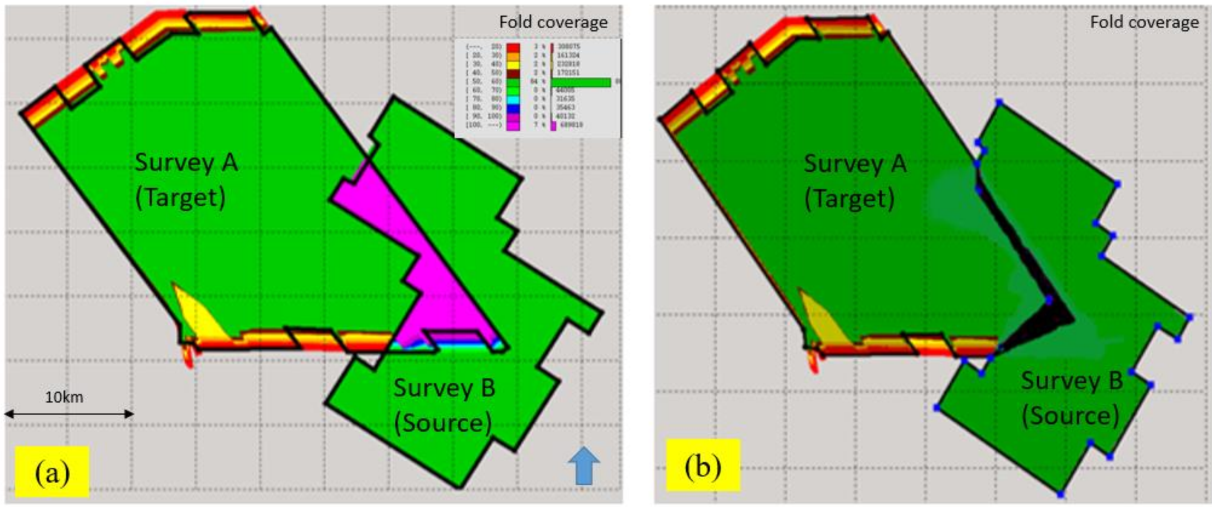

Figure 3: *Merging method of a) merging with all migrated data for conventional approach (highlighted in purple color) and b) limited the fully migrated data as possible for new approach at the overlap area (highlighted in black color).*

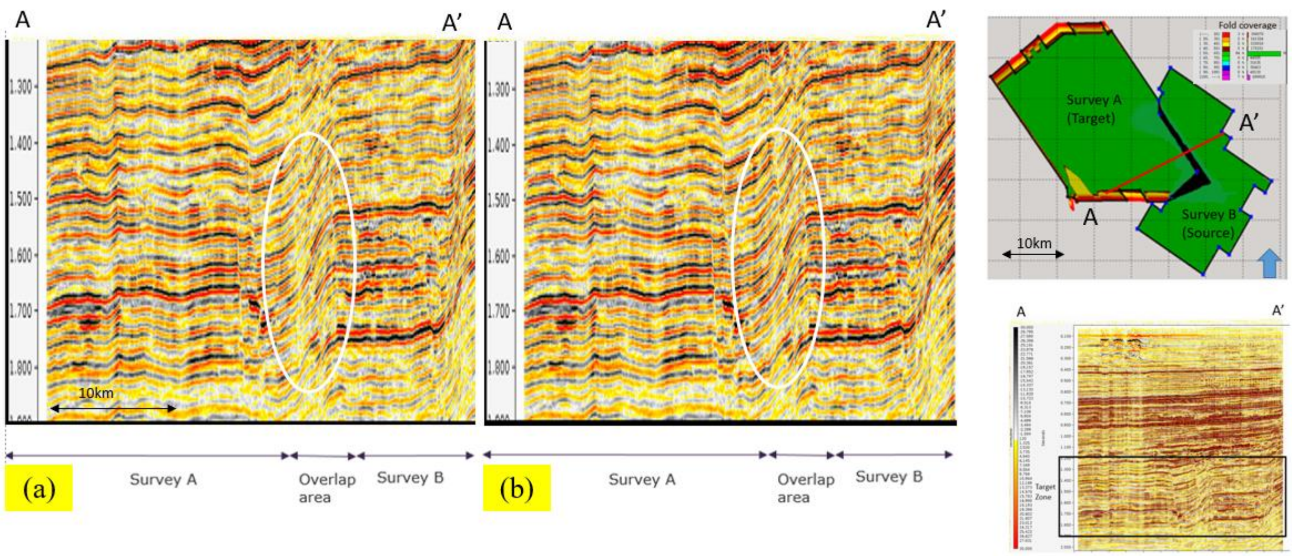

Figure 4 *Full stack after merging with conventional method (left), compared to new method (right).*

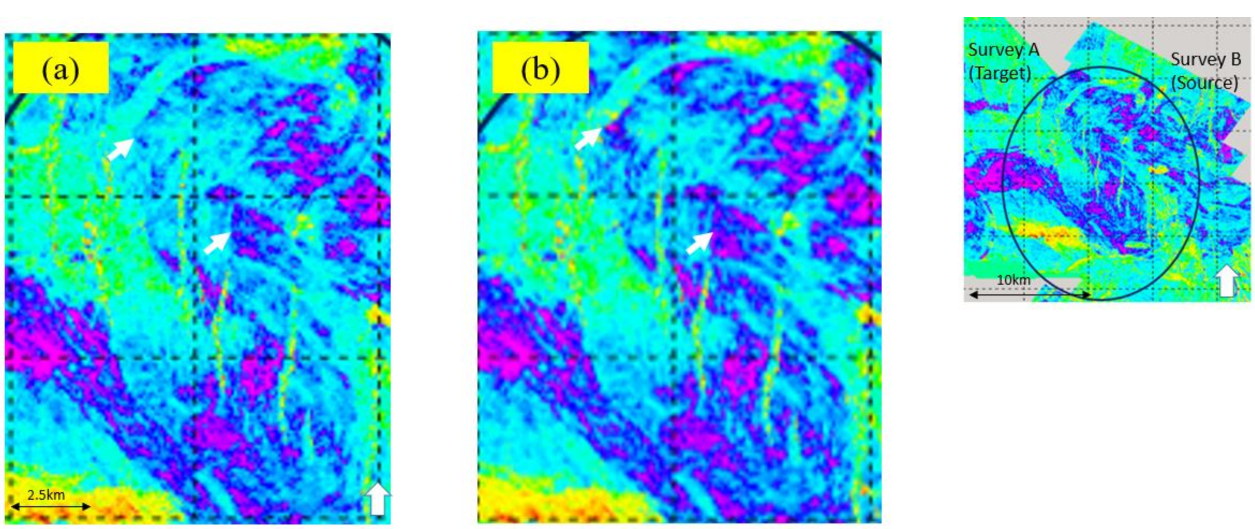

Figure 5 *RMS map at target window extracted from full stack using conventional method (left), compared to new method (right). Significant improvement at the new method in the survey B area.*

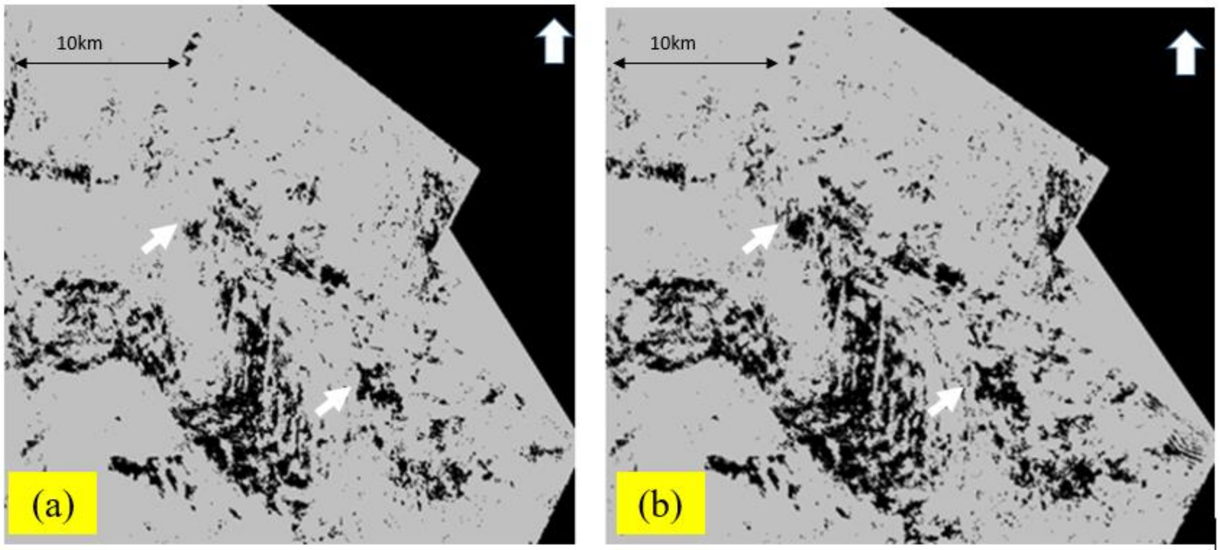

Figure 6 *AVO analysis of Intercept Gradient plot using conventional method (left), compared to new method (right). Significant improvement at the new method in the overlap area.*

Conclusion

With the new merging approach, the final result was improved after the application of 3D Matching Pursuit Fourier Interpolation, followed by Radon de-multiple processing and re-selection of the overlapped area. The result was improved significantly at the survey overlap area between the two surveys, which is the target area for the drilling plan in the near future.

Although the appropriate merging approach is to apply the merging in pre-stack time domain, i.e. prior to migration. Through our study we proved that merging the pre-stack data after migration can deliver promising results with faster turnaround time. As shown in above results, the improved signal to noise ratio provides better interpretation, AVO analysis and decreased the uncertainties.

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References

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