# Enhancing reservoir imaging and interpretation: a dual-azimuth case study offshore Ghana

Z. Greplowski[1], K. Heggelund[2], F. Larsson[2], K. Mjøen[3], Ø. Runde[3], P. Christian[3], M. Bubner[1], B. Danielsen[1]

[1] TGS; [2] Pecan Energies; [3] AkerBP

## Summary

A high-resolution seismic reprocessing project was conducted offshore Ghana. State-of-the-art processing sequence at 2 ms sampling and full waveform inversion based velocity model building enhanced imaging and resolution of the dual azimuth data. The iterative workflow allowed for continuous refinement of processing parameters, enabling better noise attenuation, improved AVA fidelity. Significant advancements in structural imaging and interpretability were achieved, providing a clearer understanding of reservoir continuity and trap systems. These results demonstrate the value of combining innovative techniques and dual-azimuth data to support field development and near-field exploration in complex geological settings.

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## Introduction

Insufficient resolution and uncertainty in time-depth conversion were identified as main challenges in the seismic data library over the Deepwater Tano Cape Three Points (DWT/CTP) block offshore Ghana, hindering the accelerated development of the area. To address these issues, the operator, Pecan Energies, initiated a project to rejuvenate existing dual-azimuth seismic volumes. A broadband processing sequence, and a reliable high-resolution velocity model were deemed essential to better characterize the trap systems associated with existing discoveries and to map reservoir sand layers effectively.

From the outset, the project emphasized retaining the 2 ms sampling rate. This decision was driven by the need to resolve sand packages, which are generally too thin to be accurately delineated on legacy 4 ms seismic. Additionally, the new high-resolution processing aimed to support geohazard evaluation and well-planning efforts.

## Iterative project execution

The project was structured as an iterative processing initiative. The primary objective of this approach was to evaluate results on an image volume that closely resembled the expected final output, while maintaining the flexibility to revisit and refine specific processing stages. A 100 sq. km target area was selected for the iterative workflow, resulting in four processing iterations. Figure 1 illustrates the iterative scheme, highlighting processing stages under evaluation in blue and intermediate stages in yellow.

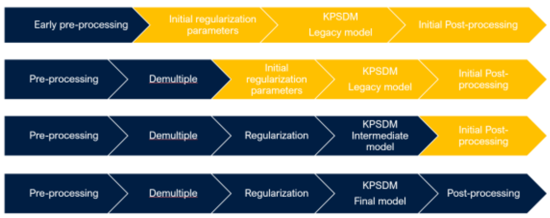



***Figure 1*** *Iterative processing scheme. QC at each stage focused on the blue steps, carried out with optimized parameters. Yellow steps were applied with initial parametrization.*

Although the iterative approach requires additional resources and meticulous change control, the resulting QC volumes, stacks and gathers, were instrumental in assessing selected processing parameters. This methodology encouraged an early start for testing migration and post-processing parameters, enabling the identification of potential challenges at earlier stages. Moreover, the datasets enabled preliminary amplitude versus angle (AVA) evaluations in close collaboration with geologists, ensuring efficient feedback loop between asset and processing teams.

As an example, the iterative approach highlighted the need to revise the strategy for Q compensation. The initial plan assumed a Q value suitable for 2 ms sampled input data to maximize resolution at the target level. However, early iterations revealed that high-frequency noise was being amplified beyond acceptable levels. This prompted targeted noise attenuation testing and ultimately led to a revision of the Q model.

While iterative processing provides flexibility in designing the processing sequence and selecting parameters, it remains constrained by the project's timeframe and budget. Careful planning of iterations from the outset significantly increases the likelihood of maximizing the value of intermediate data volumes. Clear objectives should be set for each iterative volume. In the first iteration, data should be processed using best-guess parameters informed by experience from legacy work, rather than relying on an oversimplified fast-track approach.

**Dual azimuth processing and velocity model building**

The processing and velocity model building workflows were specifically designed to preserve maximum information from the dual-azimuth (DAZ) acquisition. The two azimuths were integrated through an optimized DAZ stacking process, resulting in an enhanced structural image with improved continuity of the target horizons. A warping flow was applied to refine the continuity of the DAZ stack. Figure 2 compares azimuth 237 deg full stack and corresponding root mean square amplitude (RMS) map with DAZ full stack and corresponding RMS amplitude map at target level.

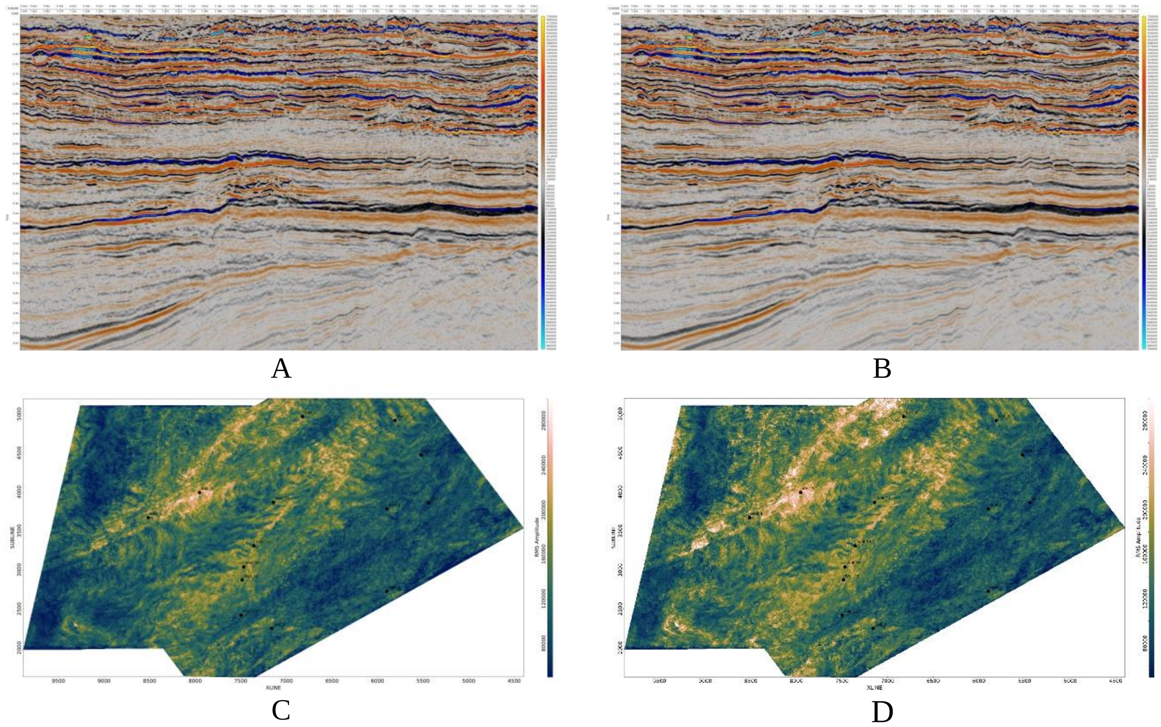



***Figure 2*** *Azimuth 237deg stack (A) and optimized MAZ stack (B) with corresponding RMS maps at target level: azimuth 237deg (C) and optimized MAZ stack (D). Uplift in DAZ imaging stack is reflected in the continuity of the RMS map.*

Velocity model building (VMB) incorporated both azimuths, leveraging Full Waveform Inversion (Ramos-Martinez et al., 2016 and Whitmore et al., 2020) and tomography workflows. The Full Waveform Inversion (FWI) sequence placed particular emphasis on resolving complex overburden pod structures and achieving sufficient vertical resolution of the velocity model at the target level. Hydrophone data with offsets range up to 8 km and frequencies up to 12 Hz were used as input to the FWI sequence. Figure 3 shows velocity and isochore map at reservoir level. High-velocity target layers are clearly delineated across the survey area and correlate well with the interpreted reservoir structures.

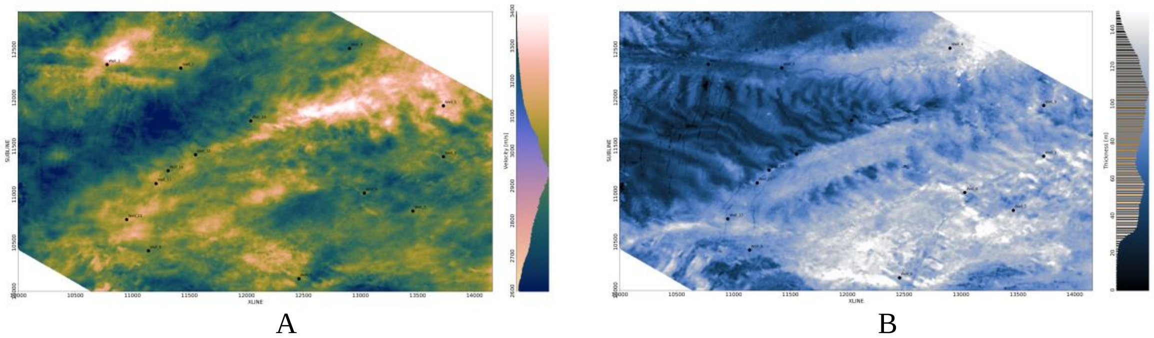
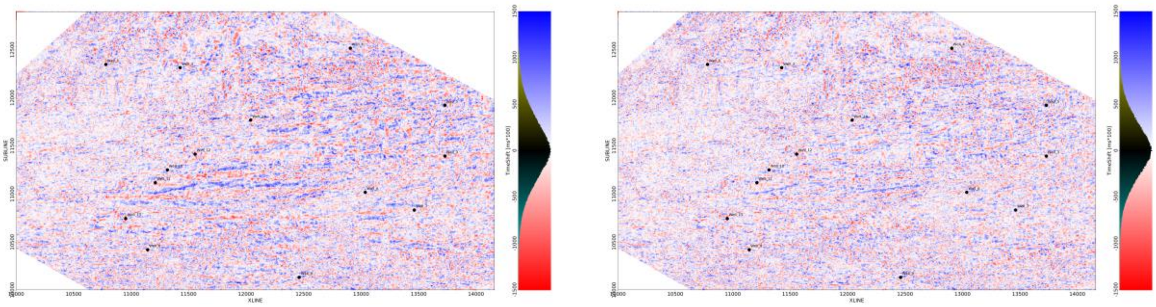



***Figure 3*** *Velocity at reservoir level (A) and isochore map of the reservoir section (B)*

Shifts between azimuthal angle stacks were used as an additional QC measure to verify the VMB results, ensuring optimal alignment between the datasets. Figure 4 shows time shifts calculated between azimuth 237deg and 327deg at reservoir level from intermediate seismic volumes (VMB QC products), before (A) and after (B) final pass of FWI at 12Hz. Alignment between azimuth improves significantly with the 12Hz inversion. Remaining residuals can most likely be attributed to differences in illumination. The effects of azimuthal anisotropy were also considered but the results were inconclusive.



A B

***Figure 4*** *Time shifts between azimuth 237deg and 327deg calculated from mid stacks 15-30deg. A – input to final pass of FWI 12Hz, B – after final pass of FWI 12Hz. Notice the improvements in time shifts after the 12Hz inversion.*

**AVA analysis of the results**

The iterative approach, combined with fully imaged and post-processed QC volumes, enabled continuous monitoring of the AVA response throughout the project. This workflow also allowed benchmarking against legacy data at each stage. Spectral balancing within the pseudo-gathers was done before the AVA analysis. The final results demonstrate an improvement in signal-to-noise ratio and a closer match to synthetic pseudo-gathers. Both azimuths consistently align with the anticipated response, preserving the expected AVA behavior: AVA Class 2p at Top Reservoir 1 and AVA Class 4 at Top Reservoir 2.

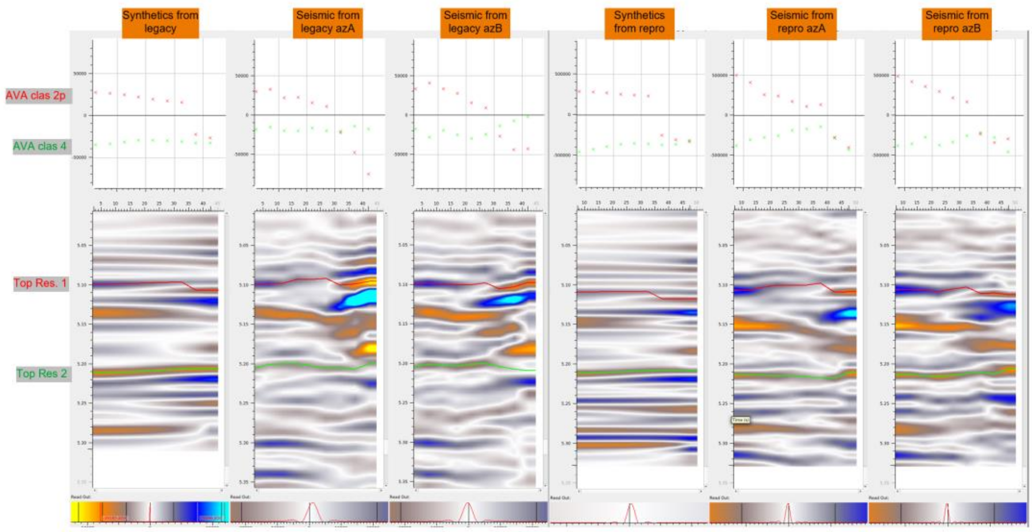
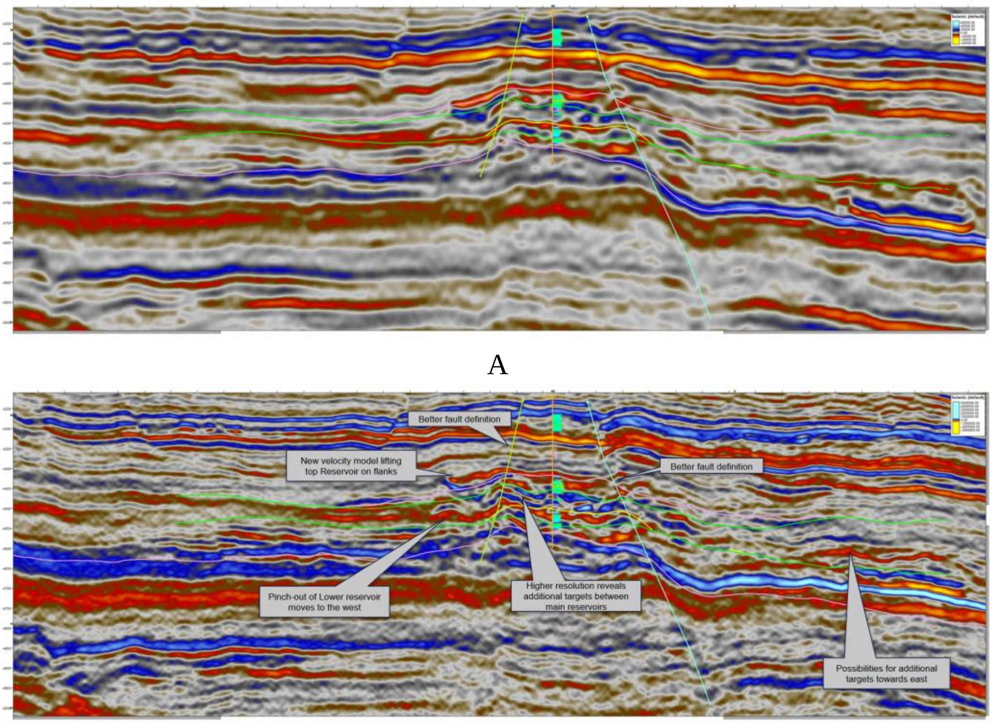



***Figure 5*** *AVA Analysis along well track. The reprocessed data show good match between azimuths, preserved AVA behaviour and improved signal to noise.*

## Observations on the imaging results

During the iterative processing special attention was given to existing discoveries. Retained 2ms sampling rate and advanced velocity modelling utilizing FWI gave an improved imaging of the different reservoir levels and a sharper fault delineation. Figure 6 shows a cross-section comparing the full stack from the last iteration post-migration volume (A) with the legacy full stack volume (B) showing significant uplift in resolution.




B

***Figure 6*** *Seismic observations comparing full stacks from legacy processing (A;4ms sampling) with new reprocessing (B;2ms sampling).*

## Conclusions

The iterative processing approach and dual-azimuth integration successfully addressed challenges in the seismic data library, delivering enhanced structural imaging and reliable velocity models. Key improvements include better signal-to-noise ratio, continuity of target horizons, and preservation of AVA responses were critical for reservoir evaluation. Early-stage QC volumes facilitated close collaboration with asset geologists, ensuring alignment with geological expectations. These advancements provide a robust foundation for field development planning and near-field exploration in the Deepwater Tano Cape Three Points (DWT/CTP) block.

## Acknowledgements

The authors wish to thank Pecan Energies and partners for permission to present the results and TGS processing team for their contribution to the project and support in preparing this publication.

## References

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