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Revitalizing Legacy Seismic Data in the Campos Basin: Complex Imaging Insights from the Raia Project

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Introduction

The Raia project is one of Brazil's most significant gas developments, situated in the pre-salt region of the Campos Basin, approximately 200km offshore at water depths reaching up to 2900m. It contains large recoverable reserves of natural gas and oil/condensate. Drilling activities for the first phase are scheduled to commence in 2026, with the objective of drilling six wells and initiate production by 2028.

To effectively support the field's development, it is essential to (1) maximize the potential of existing seismic data and (2) employ state-of-the-art processing technology to minimize uncertainties during the well-planning phase, while considering time and cost implications in the decision-making process.

In this seismic reprocessing project, we utilize three towed-streamer surveys acquired between 1999 and 2013. We apply and adapt the latest processing techniques and seismic velocity model-building technologies within a multi-azimuth framework to leverage the value of narrow-azimuth data, with Full Waveform Inversion (FWI) regarded as a key contributor.

Method and/or Theory

The Raia area is covered by a multi-measurement dual-azimuth (DAZ) seismic survey, featuring shooting directions of 56/236 degrees and an 8km cable length. The other two surveys, which overlap the DAZ survey, cover the western and eastern sides of the license area, and were acquired using conventional cables of 4km and 4.8km lengths with an E-W shooting direction. We conducted a full broadband reprocessing using a 3D deghosting approach, ensuring consistency in wavelet processing and preserving low frequencies for optimal pre-salt imaging. We also performed interbed multiple attenuation based on the Marchenko prediction method, which effectively removed multiple energy that interfered with the reservoir image.

We enhanced the migration velocity model through a joint multi-azimuth Time-Lag FWI inversion approach. A known challenge of FWI is its tendency to converge to local minima; thus, low-frequency and long-offset data are preferred. To mitigate the absence of diving waves due to the short cable lengths in two of the surveys, we utilized all available field recordings, including diving waves, reflections, multiples, and ghosts. Additionally, we combined FWI with common-image-point (CIP) tomography iterations to stabilize and complement deeper updates, where FWI relies solely on reflections. We have produced preliminary MAZ images using Kirchhoff and reverse time migration (RTM), and plan to conduct an image-domain least-squares Kirchhoff pre-stack migration to address illumination differences and support quantitative interpretation (QI) tasks.

Results and Conclusions

The final reprocessed images exhibit a significantly broader frequency range, markedly improved seismic focusing, and enhanced signal-to-noise ratio. This has resulted in clearer visualization of reservoir seismic textures and improved facies differentiation. Key factors contributing to these results include broadband processing, enhancing the usable lower frequencies, and FWI, providing a migration model that honours the MAZ seismic data and borehole information. These results suggest promising de-risking by increasing confidence on well placement. Further deliverables are anticipated to enable higher-end QI work and support ongoing field operations.