Introduction

A recent Sarawak seismic imaging project covered several offshore fields in Malaysia, located in water depths ranging from approximately 80 to 160 meters. These shallow to intermediate water depths and the nature of the water bottom resulted in strong multiple contamination. The geological setting is complex, marked by extensive fault systems that generate seismic shadow zones in legacy data, as well as the presence of shallow gas and highly absorptive overburden bodies.

The study area spans approximately 2,812 km² of high-quality multisensor 3D seismic data acquired in two phases: the first in 2017 using a proprietary CSI acquisition technique, and the second in 2023 utilizing a triple-source configuration. All datasets were processed from raw hydrophone and particle-velocity measurements through a comprehensive processing and imaging workflow designed to overcome these challenges and deliver a single, seamless seismic volume for detailed structural and quantitative interpretation.

Workflow

A full imaging workflow was applied to the two main datasets, with the imaging step performed using Q-KPSDM (Kirchhoff Pre-Stack Depth Migration). Pre-migration processing included comprehensive deghosting and 3D designature to broaden the seismic bandwidth and enhance resolution. The shallow-water demultiple sequence followed a state-of-the-art workflow, incorporating multiple models for both short- and long-period multiples, along with multi-model adaptive subtraction in the curvelet domain with primary masking (Perrier *et al.,* 2017). To generate the short-period multiple models, a SWIM (Lu *et al.,* 2011, Oukili *et al.,* 2015) migration was carried out on deghosted data to produce a high-resolution near-surface reflectivity volume. This approach yielded multiple models that closely match the original input data, allowing the use of milder subtraction parameters and thereby significantly reducing the risk of primary signal distortion. A third dataset which had been recently processed with a similar flow was used as aperture data in the migration to ensure a fully imaged output area and consistent amplitudes for advanced interpretation work.

The velocity model used for the final migration was primarily constructed using Full Waveform Inversion (FWI). Multiple inversion passes were carried out across successive frequency bands, starting at 4 Hz and extending to a maximum of 24 Hz. The inversion was performed in two stages. The first stage incorporated both refractions and reflections, using all offsets under a constant-Q assumption. The second stage focused on reflection data only, with offsets limited to 5000 m, and employed a variable-Q model derived from intermediate velocity updates and geobody extraction. Prior to the final migration, the velocity and Q models were further refined through a final pass of reflection tomography.

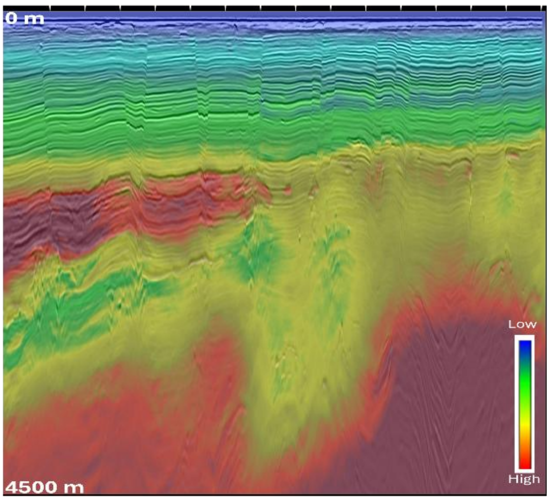

Figure 1 *Final full stack in depth domain overlaid on the final velocity model. The color scale is adjusted highlight deeper structures.*

Results

The final migrated images and velocity model show very good correlation and a high level of detail, as illustrated in Figure 1. Fault imaging appears to be very well resolved with little evidence of remaining seismic obscured areas. The image also reveals plausible structures and interpretable events which confirm the quality of the new imaging results. Furthermore, we can observe considerable uplifts in areas where strong attenuation was observed underneath very shallow anomalies. Both kinematics and dynamics effects appear to be well corrected, with a simplification of the structures and practically no amplitude distortion as seen on Figure 2. The effect is also dramatic on the gathers where the same velocity model was used for both QC (Quality Control) migrations.

Conclusions

The imaging project in the Sarawak Basin demonstrated that the new data, as well as existing data can benefit from high-end imaging workflow and high frequency FWI. The quality of the final seismic results clearly surpasses that of legacy seismic, over the entire area, whilst still resolving many of the local challenges which are critical to understand each of the reservoir targets

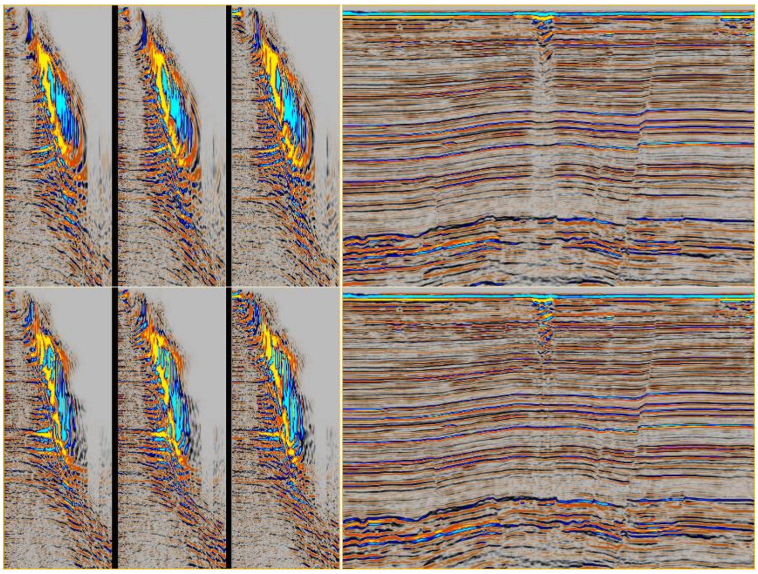

Figure 2 *Migrated gathers (left) and stacks (right) with a constant Q model (top) and the final variable Q model (bottom).*

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