Elastic FWI unlocks complex geology: advancing streamer-based imaging offshore Brazil

Introduction

Offshore Brazil comprises a diverse set of geological provinces, from the deepwater salt provinces of the Santos and Campos Basins to the less mature, structurally complex Equatorial Margins. Despite differing in tectonic history and depositional environments, these regions share common imaging challenges – strong impedance contrasts, stratigraphic heterogeneity, and complex salt or carbonate bodies – that hinder conventional velocity model building (VMB) workflows. While acoustic full-waveform inversion (aFWI) has proven useful for refining models, its simplifying assumptions often limit its effectiveness in these geologically demanding settings. This paper explores the application of elastic full-waveform inversion (eFWI) to towed-streamer datasets, demonstrating it can deliver meaningful improvements in subsurface velocity models across Brazil's offshore basins using typical legacy seismic data that is abundant in the region.

Method

The starting point for rejuvenating legacy data is typically narrow-azimuth, towed-streamer acquisition with an initial velocity model developed using tomography and multi-scale aFWI. While aFWI improved resolution in the sedimentary overburden, it fails to adequately capture the full complexity of features such as salt boundaries and within layered high-velocity carbonate intervals. To improve the model, we transition to eFWI – utilizing pressure and shear wave information, along with density estimates – which better captures the full physics of wavefield propagation in complex settings. Despite the offset and azimuth limitations of many streamer datasets, the inclusion of elastic physics provides a better match between recorded and synthetic data, particularly in regions where strong velocity contrasts dominate wavefield behavior. It also reduces model artefacts and enhances convergence.

Results

Elastic FWI significantly improved the definition of complex, high-contrast geological features. The resulting velocity model showed reduced smearing at high-contrast boundaries compared to the aFWI output, and more accurately captured variations in the post-salt and intra-salt sections. These updates led to more geologically consistent migrations, with fewer structural distortions beneath complexities in the overburden. Migrated images showed enhanced resolution, and common image gathers exhibited flatter events and improved coherence, indicating greater accuracy in the underlying model.

Conclusion

Applying eFWI to legacy narrow-azimuth streamer data offshore Brazil can deliver tangible benefits, even without the long-offset, full-azimuth sampling achieved with OBN acquisition. By incorporating elastic effects overlooked by acoustic workflows, eFWI improves model fidelity in complex geological environments, particularly near salt and carbonate interfaces. These improvements lead to clearer seismic images, increased confidence in structural interpretation, and better-informed exploration and development decisions. Elastic FWI represents a practical and impactful upgrade to VMB workflows, offering new value from legacy streamer datasets across Brazil's offshore basins.