Least-Squares Migration for Enhanced Quantitative Interpretation: Applications in the Buzios Field and Beyond

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Accurate seismic imaging in complex pre-salt and post-salt environments is essential for reliable reservoir characterization. This study highlights the advantages of data-domain least-squares migration (LSM) over conventional migration techniques in the Buzios field, the second-largest pre-salt hydrocarbon reservoir in Brazil's Santos Basin. Located approximately 230 km offshore Rio de Janeiro at a water depth of 2 km and extending 5 km below the mudline, the Buzios field is estimated to hold over 3 billion barrels of oil.

A major challenge in the region is the reduced illumination and signal quality caused by massive salt structures, which limit the resolution and amplitude-versus-angle (AVA) fidelity of seismic data. By addressing these challenges, LSM provides a significant improvement in subsalt imaging. This technique stabilizes pre-stack seismic amplitudes, enhances illumination across broader angle ranges, and delivers improved resolution and balanced amplitudes. These advancements allow for more accurate characterization of reservoir properties, such as elastic attributes, and reveal previously unobserved structural details, including fault planes and lateral heterogeneities within the reservoir interval.

The study demonstrates that LSM yields a better AVA response, validated by a closer match to well data compared to conventional migration results. Enhanced AVA trends and relative Vp/Vs attributes reveal critical lateral heterogeneities, which could significantly impact volumetric assessments and reservoir management strategies.

Beyond the Buzios field, LSM has been successfully applied in other reservoirs characterized by complex overburden and salt geometries. These applications consistently demonstrate improvements in reflector continuity, amplitude fidelity, and AVA analysis, ultimately reducing exploration uncertainty.

In conclusion, the results of this study demonstrate that least-squares migration offers significant advantages over conventional migration techniques. The findings underscore LSM's potential as a transformative tool for de-risking exploration and optimizing reservoir management in challenging geological settings. Given its transformative impact on seismic imaging and its ability to address longstanding challenges in subsalt and other complex environments, LSM should become a standard procedure in modern data processing workflows to ensure optimal imaging and interpretation outcomes.