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Evolução do Processamento Sísmico Terrestre na Petrobras: Superando Desafios com Inovação Tecnológica

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Evolution of Onshore Seismic Processing at Petrobras: Overcoming Challenges with Technological Innovation (Font: Arial bold, 12)

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Introduction (Font: Arial Bold, 10).

Petrobras has established itself as a reference in seismic processing through a multidisciplinary team of highly specialized geophysicists. Within this ecosystem of technical excellence, a nucleus dedicated exclusively to processing onshore seismic data stands out, facing challenges significantly different from those encountered in the marine environment. Onshore seismic processing presents particular complexities, such as static corrections, attenuation of coherent surface noise (ground-roll), irregular topography compensation, and treatment of non-uniform distribution of sources and receivers. These variables require specific methodological approaches and customized solutions for each Brazilian geological province. Throughout decades of exploratory activity, Petrobras has developed singular expertise in the continuous improvement of its processing workflows, enabling the revitalization of historical data acquired with less sophisticated technologies. This ability to extract maximum value from the seismic database represents a strategic competitive advantage for the company. The progressive refinement of processing steps – from the initial conditioning of field records to the generation of the final image – has provided significant gains in signal-to-noise ratio, with efficient noise suppression and optimized preservation of reflection events. The implementation of adaptive algorithms and advanced multicomponent filtering techniques has been fundamental to this qualitative advancement. As a direct result of this methodological evolution, the processed data reaches higher quality standards, enabling the construction of more accurate and robust velocity models. This translates into depth-migrated sections with greater structural reliability and significant reduction in uncertainty levels, supporting exploratory and development decisions with enhanced technical and economic security.

Method and/or Theory

Petrobras holds a vast collection of onshore seismic data, comprising two-dimensional and three-dimensional surveys in multiple geometric configurations - parallel, slant, and orthogonal. Particularly in 3D surveys, slant and orthogonal configurations have enabled the implementation of cross-spread geometry, which represents a significant advancement in the organization and quality of acquired data. This cross-spread geometry has proven decisive in overcoming one of the main challenges of onshore seismic processing: the attenuation of the high noise levels characteristic of this environment. The orthogonal arrangement between source and receiver lines provides highly efficient three-dimensional imaging with superior azimuthal resolution, substantially facilitating the identification and suppression of directional noise that compromises seismic signal quality. To optimize the processing of data acquired in logistically complex scenarios, such as urban areas or regions with environmental restrictions - where ideal geometric regularity is often compromised - we have implemented advanced data regularization methodologies. Techniques such as Common Reflection Point (CRP), Common Reflection Surface (CRS), and 3D regularization in the shot domain have been systematically applied to compensate for gaps and inconsistencies in acquisition, preserving signal integrity and maximizing spatial coverage. A critical methodological advancement was achieved in

constructing more precise velocity models through the integration of refraction tomography for refinement of shallow layers, traditionally problematic in onshore data. Additionally, regularized data provided optimized calibration of reflection tomography in deep zones, with further implementation of artificial intelligence algorithms to eliminate complex residual noise, particularly internal multiples that compromise seismic resolution. The robustness of velocity models has been significantly enhanced through multidisciplinary integration with the reservoir team, leveraging the extensive collection of well data available in producing areas. This well-to-seismic calibration allows fine adjustments in the models, resulting in depth imaging with high structural and stratigraphic fidelity, substantially reducing interpretative uncertainties and optimizing exploratory and development decisions.

Results and Conclusions

The new depth-migrated data offer images with superior focusing and greater structural reliability when compared to time data from previous workflows. This evolution provides more accurate information in geologically complex areas, directly impacting exploratory decisions. Petrobras has implemented important technological advances in onshore seismic processing. Artificial intelligence stands out as a transformative tool, being applied in the automatic picking of first breaks and in the efficient attenuation of internal multiples, significantly reducing processing time and increasing the precision of results. Refraction tomography serves as a technique for the precise characterization of shallow layers, traditionally problematic in onshore data. In parallel, the adaptation of Full Waveform Inversion (FWI) to the onshore environment will enable the construction of high-resolution velocity models, capturing subsurface heterogeneities with greater fidelity. These methodological innovations, combined with high-performance processing on advanced computational infrastructure, have provided a qualitative leap in onshore seismic images. As a result, the company expands its ability to extract maximum value from onshore seismic data, both from recent acquisitions and from the historical collection, consolidating its technical excellence in onshore seismic processing.