Tupi Ocean Bottom Nodes Diffraction Imaging: Challenges and Opportunities in Using Full-Azimuth Local Angle Domain for reservoir characterization.

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The Tupi field is one of the major pre-salt oil producers, located in Santos Basin approximately 300 km off the coast of Rio de Janeiro, Brazil. The pioneering Tupi ocean bottom nodes (OBN) acquisition encourages the application of the latest seismic processing and imaging technologies that benefit from the survey's full azimuth, long offset, and broadband acquisition (Cruz et al., 2021, Cruz, 2021). The Full-Azimuth Local Angle Domain (LAD) migration is an alternative imaging technology. The method generates in-situ, full-azimuth reflectivity and directivity image gathers from the recorded seismic wavefield. The directivity gathers were used to create diffraction imaging & preferentially "weight" certain types of energy in the recorded wavefield to identify & highlight subsurface features that were difficult to recover with standard imaging methods.

The objective of this study was to apply full-azimuth local angle domain imaging to the Tupi OBN data to recover & enhance additional subsurface features and details at the pre-salt carbonate reservoir level. This imaging method generates in-situ 3D full-azimuth reflection gathers (opening angle) and directional gathers (dip angle). 3D full azimuth reflection gathers were used for full azimuth velocity analysis and to perform anisotropic inversions (VvAZ and AvAZ) to estimate fracture intensity & stress orientation. 3D full-azimuth directional gathers were used to separate specular and non-specular energy and create diffraction images volume & dip/azimuth limited image stack volumes.

This work is based on the application of full azimuth imaging in the local angle domain as described by Koren and Ravve, 2009. This system decomposes the full recorded seismic wavefield into azimuthally dependent angle-domain image gathers. It comprises the mapping of seismic data collected on a surface acquisition grid to a local angle domain (LAD) reference system of subsurface image points. Konyushenko, A. et.al., (2014) described the full-azimuth ray tracing, as a rich set of rays propagated from the subsurface local angle depth domain to the surface, with a uniform increment in aperture angles and azimuths to achieve a full and even illumination of the subsurface. The output of this migration is two common image gathers type, 3D full azimuth reflectivity angle gathers, and 3D full azimuth directivity dip gathers. The full azimuth directivity dip gather contains specular and non-specular energies. Therefore, a separation of these energies must be made to reveal diffraction information. The diffraction filter is designed to emphasize small-scale discontinuities to reveal faults, karts, and fracture systems.

Figure 1 presents three horizon slices extracted from the top of the carbonate reservoir. Figure 1A is a horizon slice extracted from a full stack image. Note the preferential emphasis on the continuous energy and the suppression of low energy events and stratigraphic detail. Figure 1B is a top of reservoir horizon slice extracted from a directivity stack with an azimuth selection of 90°-180°. With this image, it was possible to highlight main faults and structures with much higher resolution and definition in comparison to Figure 1A. Figure 1C is a top of reservoir horizon slice extracted from an discontinuity attribute using directivity stack mentioned. It highlights secondary faults and fractures zones detailed.

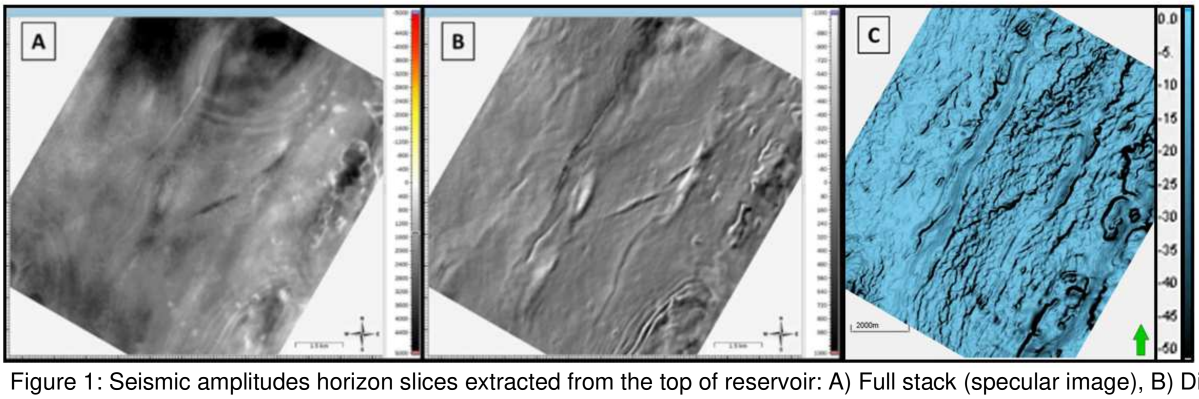

Figure 1: Seismic amplitudes horizon slices extracted from the top of reservoir: A) Full stack (specular image), B) Directivity Stack (90° - 180° azimuth selection), C) Discontinuity attribute.