Early Crustal Deformation and Petroleum Prospectivity of the Northern Pelotas Basin

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ABSTRACT

The subsurface of the northern Pelotas Basin (aka "Pelotas Norte") is considered under-explored. It is positioned in southern Brazil, south of the Santos Super-Basin. This region sits north of the Florianapolis Fracture Zone but south of the salt province to the north. Recent high-quality oil and gas discoveries on the conjugate Namibian margin have renewed interest in the region (Hedley et al., 2022). Recently acquired 3D data reveal intense early crustal deformation of the magmatic material making up the economic basement in the region. Here we assess the regional events leading to the emplacement of these structures. Additionally, we evaluate the hydrocarbon prospectivity of the overlying stratigraphic units using regional well data points and seismic facies.

For this study we use 3D and 2D seismic data totaling, 17,450 km^2 and 115,000 km, respectively. A suite of structural-enhancing seismic attributes was calculated to identify fault trends within the basement and the overlying stratigraphy. Instantaneous seismic attributes were also employed as a method to identify potential reservoir units in the area of interest (AOI). Published exploration well results were also used to constrain geologic ages of sedimentary packages.

The Early Cretaceous volcanic margin development of the northern Pelotas Basin occurred in a magma-rich setting, creating wide zones of Seaward Dipping Reflectors (SDRs). The 133-113 Ma accretion of SDRs (Stica et al., 2014) continued until the magmatic supply waned and the onset of oceanic crust production began. Albian carbonates were built in a shallow marine setting while the margin was thermally buoyant. Once thermal subsidence was underway, the accumulation of predominantly clastic sedimentary deposits occurred. Two minor salt bodies are present in the northern extent of the 3D seismic volume.

Regional 2D seismic lines confirm SDRs in a proximal position east of the coverage of the 3D volume. Therefor it can be concluded that that the basement to the east would be igneous in composition and related to a magmatic spreading ridge. The Santos Sul 3D seismic volume reveals a complex post-SDR attenuation of this SDR/igneous crust (Figure 1). This structural episode occurred prior to the onset of any magnitude of sedimentation. Offsets in seismic units within the immediate overlying units is quite rare. Two SW-NE trending elongate ridges are divided by depocenters in the west. In the east, sinuous, complex faulting is present with a multiple episode of vergence alternations, indicating a degree of wrenching was present. The eastern region of the basement is the deepest for the dataset and extends into the central axis of the Abimael Ridge, a previously reported failed rift feature in the Santos Basin (Mohriak et al., 2011)

Published well data in the area permits constraining ages of stratigraphic units in this region. The BP-6 well confirms Albian carbonate units, analogous to the prolific reservoirs in the Santos Basin, are present on the Torres High. These facies extend to the north along the paleo-shelf of Pelotas Norte (Figure 2). Cretaceous channel facies, mass transport units, Tertiary channel complexes and turbidites have been mapped across the shallow and deep-water domains. These reservoir facies are complimented by the recorded evidence of three organic rich source rocks in the basin with total organic content (TOC) as high as 4.8% (Rizzi et al., 2023).

High resolution 3D seismic data have revealed the extent of early SDR deformation related to the Abimael failed rift event that terminated in the Santos Basin. Calculated seismic attributes on reservoir facies, conjugate data points, and well analysis indicate an elevated level of prospectivity in the region.

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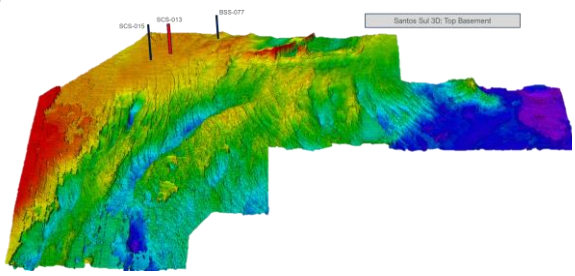

Figure 1: Interpreted "Top Basement" for Santos Sul 3D where a complex fault system is revealed. From the west, two ridges are separated by two elongate half grabens and high-frequency normal faults are present in the east.

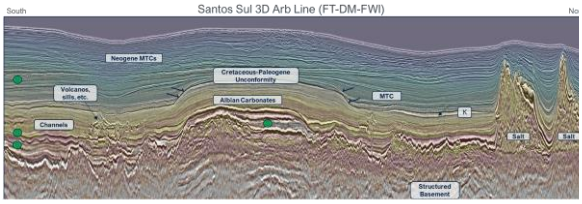

Figure 2: A 3D arbitrary seismic section highlighting various prospective basin elements and petroleum system elements as interpreted from nearby wells. Santos Sul 3D was processed using Dynamic-Matching Full-Waveform-Inversion (DM-FWI).