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Tectonomagmatic evolution of the Eastern Santos Basin Outer High and the Cabo Frio High

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Introduction

Rifted continental margins form through the process of crustal extension and thinning, leading to the breakup of the continental lithosphere and formation of oceanic crust. This process is commonly influenced by magmatic events (White et al., 1987), especially at the distal and outer domains (e.g., Planke et al., 2000; Bernt et al., 2001; Abdelmalak et al., 2018). However, the nature of the crust and emplacement mechanisms at the outer domain remain poorly understood, primarily due to the scarcity of high-resolution geophysical and well data. Advancing this understanding is crucial for defining rifted margin's external boundaries, with implications for plate tectonic reconstructions and a proper evaluation of its potential for mineral reserves.

The Santos Basin exhibits recurrent magmatism since the rift-onset to the drift stages (Mizusaki and Mohriak, 1992; Oreiro et al., 2008; Oliveira et al., 2023; Gordon et al., 2023; Garcia and Stanton, 2023). This work aims to investigate the long-lasting magmatism from the Cabo Frio High to the basin's outer high. Based on integrated high-resolution seismic and magnetic data, we discuss the morphology, plumbing system, and emplacement mechanism of these magmatic highs, exploring their possible tectonic origin and the economic implications for the basin's exploration.

Methods

This work is based on seismic reflection surveys and well data provided by ANP, and Reduced to the Pole (RTP) magnetic grid (Stanton et al., 2019) and its first vertical derivative.

Results and Conclusions

In the Eastern Santos Basin, several magmatic structures are observed emplaced in the Pre-salt and Post-salt sedimentary sections from the Cabo Frio High to the basin's outer high. The outer high exhibits elongated NE-SW high-positive magnetic anomalies corresponding to ridge-shape structural highs characterized by igneous-like seismofacies. These structural highs are associated with thickened crust and display tectonically inverted rift and Pre-salt deposits. Based on this evidence, these structures are interpreted as Outer Magmatic Ridges (Stanton and Gordon, 2025), formed by excess of magmatism at the end of rifting preceding the continental breakup. After breakup during the Eocene, magmatic structures were emplaced at the adjacent Cabo Frio High, comprising a series of cinder cone volcano complexes, sills, dykes, laccoliths, and hydrothermal vents (pipe-like structures). The sill-feeding-sill system and its spatial correlation with volcanoes suggest that it was a key component of their magmatic plumbing system. The vents are spatially associated with sills and volcanoes and may have used these pre-existing conduits for fluid and gas migration. This evidence indicates reheating, reactivation, hydraulic fracturing, and concentration of fluid migration through the buried volcanoes. The Cabo Frio High magmatism is expressed by NE-SW and N-S magnetic lineaments correlated to basement/pre-salt fault systems. This suggests an interplay between tectonism and magmatism at different stages affecting the basin, with a heat source possibly linked to a mantle thermal anomaly (Ernesto, 2002). A detailed knowledge of these tectonomagmatic highs is crucial for evaluating their influence on the formation and/or preservation of hydrocarbons and other mineral resources.