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Seismic Characterization of Salt Weld and Its Impact on the Petroleum System of Campos Basin

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Introduction

The Campos Basin located offshore Brazil is a highly productive hydrocarbon region, prolific in both post-salt and pre-salt stratigraphic intervals. Salt tectonics, and specifically salt welds, play a crucial role in the region's petroleum system. It can either act as seals for pre-salt prospects or hydrocarbon migration pathways for post-salt objectives (from pre-salt matured kitchen). Salt welds develop at the interfaces between salt bodies and surrounding strata, and they are considered the primary hydrocarbon migration pathways for post-salt prospects in the basin. The effectiveness of these welds as seals or migration pathway is controlled by a range of geological factors, including lithological heterogeneity, structural integrity, and the presence of interconnected migration pathways within, and surrounding the weld zones.

Method and/or Theory

This study investigates the influence of salt welds in governing fluid flow dynamics, hydrocarbon migration pathways, and entrapment mechanisms, with a particular focus on their dual functionality as hydraulic seals or migration pathways. The primary objective of this paper is to present different salt weld behavior observed in the fields within Campos Basin. In the first case, salt weld acts as a barrier, effectively separating pre-salt and post-salt targets into two different pressure system. This is evidenced by the presence of two distinct oil-water contacts in pre-salt and post-salt sections. In contrast, the second case demonstrates that salt weld functions as salt window, created pathway for hydrocarbon migration or leakage from pre-salt to post-salt section, allowed pressure connectivity between two different intervals. This behavior is characterized by a single oil-water contact across both pre-salt and post-salt layers, suggesting active fluid migration through the weld zone. In order to understand the salt weld behavior, comprehensive study integrated suite of geological and geophysical techniques was conducted, including well log analysis to identify lithological variations, salt thickness mapping to assess salt body geometries, and seismic amplitude analysis to detect possible changes in lithology, fluid contents and structural features.

Results and Conclusions

The results of this study significantly enhance the understanding of the interaction between salt weld and petroleum systems, offering critical insights into their role in controlling hydrocarbon migration, entrapment, and accumulation within the Campos Basin. According to the current literature, salt welds characterized by remnant evaporites thinner than 50 meters and with large areal extents greater than 10 km² are statistically associated with an increased risk of hydrocarbon leakage. However, the analysis of two nearby analogues in the basin reveals that even salt weld with thicknesses below 50 meters can function as effective seals, challenging the conventional assumption that salt thickness and weld areal size can dictates sealing capacity. These observations underscore the importance of considering additional geological factors such as lithological composition, fracture networks, and tectonic history when assessing the sealing potential of salt weld in the context of hydrocarbon migration and accumulation. In conclusion, salt welds with specific lithological attributes are crucial for hydrocarbon accumulation, and their behavior as either seals or leakage pathways can be accurately predicted using a comprehensive methodology that integrates lithological, geomechanical, and tectonic analyses. These findings provide valuable guidance for exploration strategies within the Campos Basin, particularly by emphasizing the influence of salt welds on hydrocarbon accumulation in both pre-salt and post-salt reservoirs.