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Abstract

The Aptian Paripueira evaporites of the Maceió Formation, deposited during the rift phase of the Alagoas Basin in northeastern Brazil, represent a significant, yet underexplored, opportunity for large-scale geological energy storage. These evaporite deposits occur as a sequence of at least four distinct cycles covering an area of approximately 200 km² (77.2 sq mi). These salt beds are locally folded and tilted by halokinetic deformation and rift-related faults. The evaporitic succession also presents high-frequency interlayers of insoluble layers, which pose geomechanical challenges for the development of energy storage projects. Despite the potential opportunity, the complex tectono-structural framework involving these evaporitic deposits requires a detailed characterization to ensure the technical success of potential storage projects based on the construction of artificial caves. This study presents a comprehensive assessment of the suitability of these salt deposits for developing hydrogen storage in artificial caves.

To address these complexities, a multi-source dataset, including 15 wells, 15 2D seismic sections, a 3D seismic cube, and a gravimetric survey, was integrated to build a 3D tectono-stratigraphic model. Geostatistical analysis was applied to produce geomodels considering key engineering and geological parameters. These included depth to the top of the evaporitic succession, evaporitic beds thickness, percentage of insoluble materials, quantity and thickness of interlayers, and the distance to the border of the evaporitic basin. The geometry of the main faults was discretized for modeling. After the modeling, the parameterized grids were cross-correlated through a scoring methodology to produce comprehensive favorability maps, highlighting areas with the most suitable conditions for cavern construction.

The research products provided a thorough guide to mitigate future investment risks. Despite the inherent geological complexities, the analysis identified favorable zones that support the allocation of a conceptual field with 237 caverns. This configuration yields a total effective energy storage potential of approximately 13.5 TWh, establishing the area as a strategic asset for a potential regional hydrogen hub in northeastern Brazil. This region presents enormous potential for green hydrogen production due to the immense availability of renewable energy, which reinforces the strategic importance of evaporite deposits studied here. It must be noted, however, that this assessment is conceptual, and a definitive allocation of the number and capacity of caverns is contingent upon corroboration from detailed field investigations, including dedicated drilling and specific engineering design.

Key words: Hydrogen storage, De-risk analysis, Tectono-stratigraphic modeling, Geostatistical modeling, Paripueira Evaporites, Geological screening.