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POTENTIAL CONTROLS ON THE ORIGIN, NATURE AND DISTRIBUTION OF SHEAR ZONES IN SALT STOCKS: SALT TECTONIC INSIGHTS WITH A SOLUTION MINING PERSPECTIVE

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Abstract

Although commonly depicted as homogeneous, salt stocks are typically highly heterogenous bodies that can contain a variety of lithologies, structures, textures, fluids, gases, and complex internal salt flow patterns. One of the key challenges facing the solution mining industry is to predict the nature of internal heterogeneities within salt formations so that the placing of salt caverns can be optimized. In this respect, collaboration within the broader salt tectonic community and the solution mining industry might be key to improve understanding of the origin, nature, and distribution of heterogeneities inside salt stocks. Developing this knowledge and improving our predictive capabilities will ultimately improve drilling safety, provide greater control on cavern geometry, and lower risks regarding cavern placement. The drive for this knowledge is the likely upscaled demand for hydrogen storage in salt caverns over the coming decades.

Here, we examine potential controls on the origin, distribution, and nature of intra-stock shear zones. Intra-stock shear zones have been recognized and described in nature, yet constraining their origin and distribution in different areas of salt stocks requires reappraisal in light of modern salt tectonic concepts. Using observations from natural salt stocks from a range of basins worldwide (Gulf Coast and Paradox Basin, US; Offshore Brazil; Northwest Europe; Iran) along with those from numerical and physical models, we address the following questions: What mechanisms can create lateral flow velocity variations in salt that could be expressed by the formation of a shear zone? What are the different classes of intra-stock shear zones? Where are shear zones most likely to form in salt stocks? To what extent does layering in the source bed influence shear zone development?

Our initial assessment identifies the following aspects as important to consider when trying to unravel intra-salt complexities: i) intra-stock shear zones can be classified as either of endogenous (not caused by external structures), or exogenous origin (physically connected to external structures that have propagated into the stock), and provide a range of possible salt tectonic mechanisms that may explain the origin of each type; ii) all stocks are likely to be influenced by processes that may generate shear zones irrespective of the initial layering of the evaporite sequence and salt tectonic boundary conditions; iii) the initial compositional layering of the salt can strongly influence the likely distribution, amount and formation processes of shear zones in salt stocks, and; iv) the more compositionally heterogeneous the initial layered evaporite sequence, the wider the range of possible mechanisms for developing intra-salt shear zones. Overall, we propose that modern salt tectonic concepts, most commonly applied to offshore oil and gas exploration activities, can contribute towards the long-term goal of improving our ability to predict the distribution and nature of intra-salt heterogeneities in onshore salt bodies so that better predictions of intra-salt heterogeneities assist in the planning and placing of salt caverns.

Keywords: Salt Domes; Evaporites; Storage Caverns; Salt Tectonics; Shear Zones; Anomalous Zones; Energy Transition; Hydrogen Economy