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Structure, Kinematics and Origin of Radial Faults: 3D Seismic Observations from the Santos Basin, offshore Brazil

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Salt stock growth is typically accompanied by the development of geometrically and kinematically complex fault networks in the surrounding country rock. The most common networks comprise radial faults; these are characterised by low displacement (<100 m) normal faults that extend radially outwards from the salt stock into flanking strata. Radial faults are commonly observed in an arched, unpierced roof developed above a rising salt stock; in these cases, the faults are typically well-imaged seismically and likely form due to outer-arc extension during overburden stretching. Radial faults are also found at deeper structural levels, in strata flanking the diapir stem; in these cases, they are typically less well-imaged, thus their structure, kinematics and origin are less well understood. Furthermore, understanding the growth of radial faults may provide insights into hydrocarbon reservoir compartmentalisation and the evolution of neighbouring salt stocks.

Here, we use high-quality 3D seismic reflection data from the Santos Basin, offshore Brazil to determine the structure and kinematics, and infer the likely origin of exceptionally well-imaged radial faults overlying and flanking a mature salt stock. Furthermore, we compare the geometric (e.g. throw, geometry, spacing, distribution etc.) and kinematic (e.g. timing of formation and duration of activity) characteristics of radial faults at both structural levels, allowing us to infer their temporal relationship and likely origins. We show that radial faults regardless of their structural level typically have aspect ratios of c. 1.8 - 2, are laterally-restricted in the vicinity of the salt, and have lengths of <3 km that vary with depth. Expansion indices of c. 1, with low throw gradients of 0.05 – 0.1 at the upper tip indicate that radial faults were likely blind. Throws range from 5 – 80 ms, with throw-maxima within 1 – 2 radii of the salt diapir. However, we note that the position of the throw maxima is not at the same level for all radial faults.

We propose that radial faults nucleate and initially grow as blind structures in arched roofs above actively rising diapirs, rather than outward pushing from the adjacent diapir. With time, these faults accrue displacement and interact with neighbouring radial faults as they are buried adjacent to the salt stock. Significant variations in the radial fault structural style exist at different structural levels, with the radial fault distribution, length and position of the throw maxima changing with depth. The results of this study not only provide a fundamental understanding of radial fault growth around salt stocks, but also show that radial faults can grow and interact to create complex 3D throw distributions.