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Complex intrasalt deformation in the Santos Basin, offshore Brazil: the role of density inversion

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Understanding intrasalt structure may elucidate the fundamental kinematics and, ultimately, the mechanics of diapir growth. However, there have been relatively few studies of the internal structure of salt diapirs outside the mining industry because their cores are only partly exposed in the field and poorly imaged in seismic reflection data. 3D seismic reflection from the Santos Basin, offshore Brazil reveal enigmatic allochthonous salt sheets of older evaporites emplaced above an overlying stratified evaporite sequence. Seismic-stratigraphic observations form the basis for a kinematic model invoking: (i) initial inward flow and thickening of the lower mobile salt within the rising wall, and arching of stratified overburden; (ii) breaching of the overburden, ascent of mobile lower evaporites along single or multiple feeders, and emplacement of upper-wall sheets or canopies; and (iii) later diapir squeezing due to regional shortening. We designed and ran physical models to explain how and why these structures occur, and to provide a mechanical basis for our kinematic model. Our first two models simulated salt having uniform internal density, with walls growing by (i) initially symmetric differential loading; and (ii) initially symmetric differential loading plus shortening. These models reproduced anticlines and injection folds seen in the simpler deformed walls in the Santos Basin. However, neither model reproduced the most complex structures (e.g. allochthonous intrusions, steep feeders, recumbent synclines) seen within the Santos evaporites. Thus, we argue differential loading and shortening alone are insufficient to generate these complex structures. In our third model, a less-dense lower evaporite was overlain by denser upper evaporites, similar to the density structure found in Santos Basin wellbores. In this model the wall rose solely by differential loading, with the lower mobile unit breaching the overlying stratified evaporites to form vertical diapirs feeding salt sheets and salt wings in the upper part of the salt wall. Breakout of this mobile unit folded the overlying stratified evaporites into recumbent synclines. Model sections closely resemble Santos seismic examples, suggesting that the key to forming these complex intrasalt structures is a density inversion within the evaporite sequence that creates a Rayleigh-Taylor instability.