
A static 3D geomechanical approach for simulating heterogeneous stresses and fault distributions in the vicinity of intricate salt formations: An application to the Santos Basin, Brazil

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Résumé

Geologists and engineers utilize the Finite Element Method (FEM) for modeling salt-related deformations and to enhance their comprehension of stress distribution surrounding salt structures. This approach has been in use since the 1990s and has significant economic and environmental implications for various industry applications, including oil and gas exploitation, hydrogen and CO₂ storage, as well as geothermal production. However, building FEM models for intricate salt-related structures can be a challenging and time-consuming task. Additionally, the modeling of elaborated, non-linear mechanical behavior, such as salt, can take several hours to process.

To overcome these challenges, we have developed an alternative approach that is both complementary and effective. Instead of modeling salt's non-linear mechanical behavior, we assume that it can be modeled as a pressurized body. The unknown parameters, such as salt pressure and far field stresses, are then inverted using available data, such as observed natural fractures, measured displacement, or recorded stress data associated with recent deformation around the salt. This approach, based on the Boundary Element Method (BEM), allows for a static simulation that is both accurate and efficient. To validate our method, we compared the results obtained using BEM with known 3D analytical solutions for pressurized spherical bodies, as well as with published non-linear 3D FEM salt models.

Our approach is shown to be effective and industrially applicable in terms of mechanical simulation, as demonstrated by the example of fault network development affected by salt diapirism in the offshore Santos Basin of Brazil.

Mots-Clés: salt diapirs, faults, numerical modeling, geomechanics, stresses, Santos Basin

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