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Thematic set:
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Petroleum Geoscience

Published online July 23, 2019

https://doi.org/10.1144/petgeo2019-086 | Vol. 25 | 2019 | pp. 249–250

Mechanics of salt systems: state of the field in numerical methods

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Received 21 June 2019; **accepted** 21 June 2019

This special, two-part, thematic presents studies that employ numerical methods to understand the mechanics associated with salt systems. The thematic captures some of the latest developments in modelling micro- and macro-structural salt behaviour, as well as the interaction between salt and basin sediments. The presented studies provide insights into halokinesis, deformation, pore pressure, and stress in wall rocks, and their implications for trap integrity and the viability of underground storage systems.

Over the past few decades a key component of understanding the evolution of salt structures was achieved through physical experiments (Vendeville & Jackson 1992; Letouzey *et al.* 1995; Ge *et al.* 1997; Dooley *et al.* 2015). Kinematic restoration has also been a fundamental tool to study the evolution of salt geological systems (e.g. Rowan & Kligfield 1989; Rowan & Ratliff 2012; López-Mir *et al.* 2016). The significant contribution of numerical methods is the ability to use representative material constitutive laws to accurately simulate the behaviour of both salt and wall rocks. In addition, scaling of numerical models to natural analogues is relatively straightforward compared to physical experiments. Numerical methods also offer the flexibility to examine the role of a variety of geological parameters, including depositional history, tectonic loading, and initial basin geometry.

Numerical models have been used in various forms to study different aspects of geologic systems. Large-strain numerical models have long been used to understand the mechanics associated with the evolution of regional and crustal systems (Willett *et al.* 1993). Historically, these models have coupled large-strain deformations with sedimentation and tectonic loading (Beaumont *et al.* 2000). In salt systems, these large-strain numerical models have advanced our understanding of the fundamental interaction between sedimentation, tectonic processes, and salt diapirism (Schultz-Ela 2003; Chemia *et al.* 2009; Gradmann *et al.* 2009; Albertz & Beaumont 2010; Fuchs *et al.* 2011; Allen & Beaumont 2012; Goteti *et al.* 2012; Fernandez & Kaus 2015; Baumann *et al.* 2017; Pichel *et al.* 2017). Earlier models simulated basin sediments as non-porous materials. However, in the last 15 years, an increasing number of numerical studies have been using poromechanical principles to better understand the interrelationship of stress and pore pressure in basins. Most poromechanical models have been static, simulating stress and pressure around existing salt bodies, based on their present-day geometry (e.g. Fredrich *et al.* 2003; Koupriantchik *et al.* 2004; van-der-Zee *et al.* 2011). More recently, evolutionary poromechanical models are offering a powerful tool to couple large strains, depositional processes, and fluid flow to better understand stress and pore pressure in evolving salt systems (Goteti *et al.* 2017; Luo *et al.* 2017; Obradors-Prats *et al.* 2017; Nikolinakou *et al.* 2018).

In this two-part volume, we have collected examples of the most recent numerical studies of salt systems, in an effort to demonstrate current capabilities and limitations and to inspire future developments. The first part of the thematic published in this issue includes:

a) A study of CO_2 storage in salt rock (**Shen & Arson**). The study employs a micro–macro healing mechanics model to understand the time-dependent behaviour of halite during the storage phase and evaluate the healing potential of salt in cavities used for CO_2 storage.

b) A study of salt movement in extensional settings (**Hamilton-Wright *et al.***). The paper develops evolutionary poromechanical models to examine the influence of geological parameters on field-scale salt structures and their corresponding deformation pattern.

c) A study on the impacts of stress perturbation around salt on seismic imaging (**Li *et al.***). The study uses a static geomechanical model to estimate stress perturbation around a salt sphere and incorporates the estimated values into a seismic imaging process to forecast the image of the salt sphere.

d) A study on the impacts of a laterally continuous permeable bed on the evolution of a salt diapir and the pore pressure and stresses around it (**Heidari *et al.***). The study uses a 2D evolutionary finite-element model to simulate the rise of a salt diapir in a basin with and without a permeable bed. The two models are compared to demonstrate various impacts of the permeable bed.

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