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Thermomechanical induced fractures in salt caverns for gas storage: Insights from DISROC fracture modeling

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Abstract

In gas storage operations, injection and withdrawal rates can reach high levels to meet increasing demand. The intensive operation methods used in salt caverns introduce significant mechanical challenges, particularly cavern thermal induced fracturing. This could produce the detachment of plates or overhanging blocks from the salt cavern walls or roof. Unlike progressive closure through creep, spalling results in minimal volume loss. This study focuses on the detachment of overhanging blocks within specific salt caverns. Wall spalling is of particular concern because it can compromise the structural stability of the caverns, posing risks to both the safety and the efficiency of storage operations. In addition to mechanical stresses caused by fluctuating gas pressure, variations in gas temperature can induce additional thermal stresses on the cavern walls. These thermal stresses generate tensile forces that exacerbate the spalling process. This study employs the DISROC software, a finite element code designed for modeling materials with discontinuities such as microcracks and fractures, to examine thermomechanical damage in UHS contexts. DISROC employs a joint element approach with a cohesive zone model to simulate fractured rock behavior. The thermomechanical joint-enriched finite element method provides a deeper understanding of the evolution of damage zones induced by thermomechanical loading. It reveals how temperature variations and depressurization lead to damage mechanisms in overhanging blocks. This analysis offers a detailed perspective on how cracks develop and propagate within the cavern structure.

Key words: Fracture mechanics, salt cavern, numerical computations, DISROC, blocks fall