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**THM-Based Infiltration Assessment for Salt Cavern Design  
accounting for Macroscopic Fractures**

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## THM-Based Infiltration Assessment for Salt Cavern Design accounting for Macroscopic Fractures

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### Abstract

Infiltration fractures are macroscopic separations within the rock salt matrix that allow fluid migration through an otherwise impermeable medium. These fractures can form during gas withdrawal phases in salt caverns as a result of cooling at gas pressure reduction. Accurately modeling the formation and evolution of these fractures - while simultaneously considering thermal, hydraulic, and mechanical (THM) effects - remains a challenging task that often requires simplifications.

In thermo-mechanical (TM) models, hydraulic processes are represented indirectly. Fracture lengths are estimated by assuming that the full cavern gas pressure acts behind the fracture front within the intact rock salt, enabling crack propagation whenever the mechanical stress state drops below a critical threshold. Since rock salt is generally considered impermeable, this assumption is deliberately conservative. However, there is growing interest in modeling approaches that more realistically reflect the pore pressure distribution around caverns and capture localized increases in permeability caused by tensile damage.

Several constitutive frameworks exist to link effective stresses and evolving permeability in salt, including the Stormont criterion, LMS Palaiseau method, TU Clausthal approach, and Minkley's minimum pressure criterion (IfG). Among these, the IUB criterion shows significant promise. This study applies the IUB criterion to identify zones where fluid transport becomes significant. An additional term is introduced to model sharp permeability increases once effective tensile stresses exceed the effective tensile strength of rock salt. This extension allows for the simulation of accelerated fluid infiltration under cooling conditions using the multiphysics finite element software COMSOL. The model captures the effect of thermally induced tensile stresses on permeability evolution near caverns.

For comparison, TM-based models implemented in FLAC3D are used, which do not explicitly couple hydraulic processes during fracture propagation. This enables an assessment of the conservativeness of simplified infiltration fracture models in FLAC3D when estimating storage rates and explores whether THM-coupled simulations provide opportunities to optimize gas storage operations.

**Key words:** Salt Cavern Design, Infiltration Fractures, THM Simulation, Permeability, Gas Storage