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Pressure-Driven Percolation in Rock Salt and Barrier Integrity in the High-p-T Regime — the PeTroS project

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Rock salt is a potential host rock for nuclear waste repositories because of its favourable barrier properties: As a polycrystalline viscoplastic material, undisturbed rock salt typically lacks a connected pore space network and can be considered impermeable to fluids in the undisturbed state.

Decades of experience in salt and potash mining, as well as lab and in situ experiments, have led to a consistent picture of the mechanisms of fluid transport in salt rocks and the conditions for barrier integrity. Fluid migration in rock salt requires the generation of flow paths, either by mechanical damage (dilatancy), or by the fluid pressure itself. The latter mechanism, so-called pressure-driven percolation, is dominant in the far field and controls the integrity of the geological barrier. It is characterised by a percolation threshold: There is no fluid flow as long as the fluid pressure p is below the minor principal stress σ_3. Hence, both fluid pressure and stress state in the rock need to be considered, and a simple Darcy-type permeability model is inadequate for a proper assessment of barrier integrity.

However, based on a discussion of the dihedral angle in the halite-brine two-phase system, it has been claimed in the literature that rock salt should become permeable at high stress and temperature, including conditions that might occur in repositories for heat-generating nuclear waste.

We argue that this claim is conceptually unfounded and at odds with existing lab and field data.

To directly test this hypothesis in the lab and to widen the existing experimental data base, the ongoing project PeTroS studies pressure-driven fluid percolation in rock salt at p-T conditions that could be relevant for geological disposal of nuclear waste. Percolation experiments were performed in a triaxial cell at pressures up to 36 MPa and temperatures up to $180°$C on core samples drilled from German rock salt formations. Nitrogen and saturated NaCl brine serve as percolation fluid. The results obtained so far show that the percolation threshold is present even for high pressure and temperature. These results deepen the understanding of fluid transport in rock salt and complement the geomechanical basis required for a possible safety case of a nuclear waste repository.