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Geophysical response to dissolution of undisturbed and fractured evaporite rock during brine flow

Michael Stanley Dale^{1,2}, Ismael Falcon-Suarez¹, and Hector Marín-Moreno³

¹National Oceanography Centre, European Way, Southampton, SO14 3ZH, United Kingdom

²School of Ocean and Earth Science, University of Southampton, European Way, Southampton, SO14 3ZH, United Kingdom

³Norwegian Geotechnical Institute, PB 3930 Ullevål Stadion, NO-08906 Oslo, Norway

Dissolution of halite rock can significantly impact underground constructions (e.g., caverns for energy storage and abandoned caverns) and above ground constructions (e.g., highways and buildings) potentially causing a threat to human life from land subsidence and sinkhole hazards, instability to underground construction and pollutant release. In this work, we explore and quantify changes in elastic and hydromechanical properties during dissolution of halite rock by migration of water.

We evaluated the impact of dissolution on the geophysical properties of pristine (non-fractured) and fractured halite samples (with ~2.7% dolomite), using a synthetic (seawater-like) brine solution (3.5wt% NaCl). The dissolution test commenced by setting an initial effective pressure of 15 MPa (with minimum pore pressure of 0.1 MPa), equivalent to a depth of ~720 m below ground level. This confining pressure of 14.9 MPa ensured the adequate contact between sample and the ultrasonic instrumentation (P- and S-wave sensors), and the set of electrodes for electrical resistivity. The test procedure was set to investigate the effect of increasing pore pressure from 0.1 to 14 MPa on dissolution. This procedure was only successful for the non-fractured sample, as dissolution rapidly occurred in the fractured sample during the initial stage of the test.

The non-fractured halite shows that P-wave velocity increases with increasing inlet pore pressure initially, followed by a lower pore fluid sensitivity stage. After this stage, the P-wave and the Vp/Vs ratio reduce and then ultrasonic velocities tend to their original values when effective pressure tends to zero. These results suggest that capillary pressure effects are initially increasing the bulk properties of the rock by filling the micro-pores, while dissolution is occurring locally, nearby the inlet-flow port, and therefore invisible to our geophysical tools. The small porosity fraction of 1.1% allows the saturating fluid to rapidly equilibrate with the surrounding halite within the pores, slowing down the dissolution process. In a close halite system with a local and continuous brine supply source, local dissolution may allow pressure increase up to the overburden stress and affect the geomechanical integrity of the reservoir by a combined fracturing-dissolution process.