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Numerical Analysis of Coupled Hydraulic-Mechanical Effects on the Barrier Integrity of Opalinus Clay Considering Shrinkage and Fracturing

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The present study has been carried out within the project GeomInt, funded by the German Federal Ministry of Education and Research (BMBF), which investigates the geomechanical integrity of prominent host and barrier rocks. The understanding and prediction of barrier integrity is crucial for the assessment of potential consequences of human interventions in the geological subsurface, such as the safe storage of heat emitting nuclear waste, or the cyclic storage of energy carriers. To this end, one aspect of the project puts its focus on the consequences of swelling / shrinkage due to humidity variations as well as pore-pressure changes induced by fluid injection of Opalinus clay, which is investigated by means of in-situ experiments at the Mont Terri rock laboratory in Switzerland and corresponding numerical simulations using the open-source software OpenGeoSys (OGS). In particular, we focus on the coupling between hydrodynamics and geomechanics of the porous host rock to gain a better understanding of the evolution and propagation of cracks and fissures within the geotechnical barrier. These processes are far from being well understood and adequate process models remain to be established. Within the project GeomInt, a campaign of mechanical experiments was carried out to gain a better understanding of the relevant processes at play and to improve parameterization strategies for numerical modeling techniques for discontinuities such as the Lower-dimensional Interface Elements (LIE) and the phase-field method. These models will be parameterized using the hydro-mechanical experiments and then compared to data provided by the in-situ experiments from the Mont Terri site. The results are anticipated to help establish predictive tools for the development of preferential pathways within the porous claystone to improve the safety assessment of the clay-based geotechnical barriers. We will show first tests of these efforts including a model validation by various benchmark test cases, such as the fracture along a fault plane, and the computation of a desiccating gallery surface in the Mont Terri laboratory.