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Influence of chemo-mechanical processes and microstructural geometry on the mechanical behavior of geomaterials

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The mechanical behavior of geomaterials depends primarily on their microstructure and in particular the geometry of their pores. This microstructure and its evolution in time due to deformation or chemical transformations also strongly affects the thermo-hydro-mechanical-chemical (THMC) processes in these porous materials. In the last decades, the development of micro-computed tomography has allowed to obtain accurate images of the rock-microstructures and how they evolve subjected to various factors. Many studies have used these 3D geometries of the porous space to characterize primary properties that depend on the microstructure, such as porosity, permeability or elastic moduli, by numerically solving field equations on µCT scan images of rock. For most projects of energy production or waste storage in geological media though, rocks eventually reach their limit of elasticity and the complementary plastic properties are needed to describe the full mechanical behaviour. In this contribution, we will show how we can assess the mechanical behavior of geomaterials in the long-term by solving nonlinear equations directly on realistic microstructures. First, we will discuss the necessary morphometric invariants that can be used in an upscaled constitutive law and show how we can predict the yield surface and its evolution with the chemical alteration of the rock from µCT scan images. Then, a phase field model that allows to simulate interface evolution is applied to investigate pressure solution creep at the grain scale and how it is influenced by microstructural geometry and catalyzing/inhibiting effects like temperature or clay content.