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Hydromechanical behavior of argillaceous rocks investigated by the combination of ESEM and DIC techniques

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The hydromechanical behavior of argillaceous rocks, which are possible host rocks for underground radioactive nuclear waste storage, is investigated by means of micromechanical experimental investigations. Strain fields at the micrometric scale of the composite structure of this rock, composed of a clay matrix and other mineral particles (essentially quartz and calcite), are measured by the combination of environmental scanning electron microscopy (ESEM), in situ testing and digital image correlation technique (DIC).

The evolution of argillaceous rocks under pure hydric loading is first investigated. The strain field is strongly heterogeneous, due to the complex hydromechanical interactions between the different components of this material. Moreover, it manifests an anisotropy which is likely to be linked to a preferred orientation of clay particles. The observed nonlinear deformation at high relative humidity (RH) is related not only to damage, but also to the nonlinear swelling of the clay mineral itself, controlled by different local mechanisms depending on RH. Irreversible deformations are observed during hydric cycles, as well as a network of microcracks located in the bulk of the clay matrix and/or at the inclusion-matrix interface. Their occurrence, morphology and localization depend on the rate and direction (humidification/desiccation) of the hydric loading. It is noted that these irreversible phenomena are localized and sometimes counteract each other so that the apparent overall deformation is fairly reversible.

Then, the local deformation field of the material under uniaxial compression at three different RH is quantified. To do so, in situ uniaxial compression tests are first conducted maintaining relative humidity constant in the ESEM's chamber, by means of a specifically designed miniaturized test rig. Three types of deformation bands are evidenced under mechanical loading, either normal to stress direction (compaction), parallel (microcracking) or inclined (shear). Moreover, they are strongly controlled by the water content of the material: shear bands are in particular prone to appear at high RH states. Finally a combined test during which both relative humidity and mechanical load are subsequently changed on a same sample is performed, and the localization of deformation induced by both types of loadings are compared.