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Micro mechanical study of shales

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In the following years, the French nuclear wastes will be buried in the underground repository in shales, that will be excavated at 490 m in depth, within the Callovo Oxfordian (Cox) argillaceous formation. The hydro-mechanical behavior of the argillaceous rock is complex, like the multiphase and multi-scale structured material itself. The argilaceous matrix is composed of interstratified Illite-Smectite particles, it contains detritic quartz and calcite, accessory pyrite, and the rock porosity ranges from micrometre to nanometre scales. Besides the bedding anisotropy, structural variabilities exist at all scales, from the decametric-metric scales of the geological formation to the respectively millimetric and micrometric scales of the aggregates of particles and clay particles
Our study aims at understanding the complex mechanisms which are activated at the micro-scale and are involved in the macroscopic inelastic deformation of such a complex material.An experimental protocol was developed in order to perform uniaxial deformation experiment at controlled displacement rate, inside an environmental scanning electron microscope (ESEM), under controlled relative humidity, in order to preserve as much as possible the natural state of saturation of shales.
Three sample orientations (90°, 45° and 0°) were used in order to characterize the mechanical anisotropy and the mechanisms involved in the deformation. The observed smple surfaces were polished by broad ion beam in order to reveal the fine microstructures of the argillaceous matrix. Digital images were acquired at different loading stages during the deformation process and Digital Image Correlation Technique (DIC) was applied in order to retrieve full strain fields at various scales from sample scale to microstructure scale. The analysis allows for identification of the active mechanisms, their relationships to the microstructure and their interactions.