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Effect of retarded acid treatment on limestone hydro mechanical properties, a multi scale approach.

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CO_2 geological storage is considered as the most effective way to prevent CO_2 release into atmosphere and to reduce consecutive greenhouse effect. CO_2 injection implies geochemical reactions between the reactive brine and in situ formations, leading to modification of their petrophysical and geomechanical properties. The evolutions of these properties, related to sample alteration, are studied following a multi-scale approach. Carbonate samples are subjected to retarded alteration, using a thermally activated acid, which technique ensures homogeneous increase of sample porosity and mimics long-term CO_2 effects on host rocks.
Firstly, the alteration impact on the evolution of flow properties related to microstructural changes is studied at successive levels of alteration by classical petrophysical measurements of porosity and permeability (including NMR, mercury porosimetry and laser diffraction) and by observations of microstructures on thin sections and by SEM.
Secondly, the mechanical properties of samples are investigated by classical macroscopic triaxial and uniaxial tests. The evolutions of the mechanical properties are discussed in terms of the structural modifications. The macroscopic tests indicate that the alteration weakens the material, owing to the decrease of elastic moduli and Uniaxial Compressive Strengths, from 29MPa to 19MPa after 6 cycles of acid treatments.
The study is further complemented by full (mechanical) field measurements, performed by coupling mechanical tests and Digital Image Correlation (DIC). This technique allows for continuous quantitative micro-mechanical description of sample by defining precisely the history of the deformation and the localisation processes during the compression. This technique was applied on both intact and altered materials and at different scales of observation: (i) cm-scale samples were compressed in a classical load frame and imaged by optical devices, (ii) mm-scale samples were loaded with a mini compression rig fitted within a Scanning Electron Microscope.
At the macroscale and for the intact sample, a diffuse accommodation of the deformation is observed during the elastic regime, followed by sudden failure propagation after the peak stress. Conversely, the altered samples exhibit much stronger deformation levels, related to strain localization events. The latter result in locally non monotonous stress-strain curves well before macroscopic failure. At the microscale and for the intact sample, the deformation is mostly accommodated within the inter-granular pores. In contrast, the altered samples show a gradual damage, characterized by nucleation at the grain contacts and propagation of microcracks within the grains. The DIC results suggest that besides the overall increase of porosity, the dissolution processes enhance the local heterogeneities of the porous network, which phenomenon further increases the weakening of the materials.