Effects of chemical alteration on mechanical properties of a limestone investigated by multi-scale full field measurements

L. Zinsmeister 1, 2, J. Dautriat 1, M. Bornert 3, E. Rosenberg 4, N. Gland 1, J. Raphanel 2, A. Dimanov 2

1 IFP Energies nouvelles, 1 & 4 Av. de Bois Préau, 92852 Rueil-Malmaison Cedex, France.
2 École Polytechnique, 91128 Palaiseau, France.
3 Laboratoire Navier, École des Ponts ParisTech, 664 Av. Blaise Pascal, 77455 Champigny sur Marne, France.
4 Laboratoire Link, Ecole des Ponts ParisTech, 664 Av. Blaise Pascal, 77455 Champigny sur Marne, France.

Introduction: CO2 geological storage is considered as the most effective way to prevent CO2 release into atmosphere and to reduce consecutive greenhouse effect. Underground CO2 injection implies geochemical reactions between the reactive brine and in situ geological formations, leading to modification of their petrophysical and mechanical properties. In the Paris basin, region of low seismic activity, the Digger formation is considered as a good candidate for CO2 sequestration, because it offers good petrophysical properties for injection (porosity, permeability) and an appropriate geological structure (impenetrable cap rock) in order to prevent gas leakage. In order to mimic experimentally the alteration effects of CO2 injection on the reservoir rock microstructure, we applied Retarded Acid Treatment (RAT) on the Lavoux limestones. This protocol insures a homogeneous alteration of the sample (Egermann et al., 2006; Radilla et al., 2010).

The impact of the alteration of an oolitic limestone is investigated in terms of petrophysical properties, through porosity and permeability measurements, completed by many observations of the microstructural changes. Furthermore, DIC method is applied to study the alteration effects on mechanical properties of this limestone, from the macroscale to the microscopic scale by combining optical and SEM imaging of untreated compressed samples.

3. Observations of the alteration on the microstructure:

Figure 4: Sequence of optical (a) and SEM pictures (b) showing the evolution of a fracture on a sample, observed during loading in uniaxial compression of a sample. The natural fractures of the rock sample are oriented perpendicularly to the loading axis. After 5 MPa, the crack propagated in the late stage of loading (15 MPa).

Figure 5: SEM pictures showing the evolution of the fracture observed in Figure 4. The fracture is oriented perpendicularly to the loading axis. After 5 MPa, the crack propagated in the late stage of loading (15 MPa).

Figure 6: Stress-strain curves obtained from (a) classical Uniaxial Compressive Strength experiments and (b) indirect from DIC computations at the macroscale.