

## **Experimental evaluation of the effect of CO<sub>2</sub>-fluid-rock interactions on the petrophysical properties of calcite-bearing sandstone.**

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It is well known that acidification of pore waters during CO<sub>2</sub> injection leads to dissolution of calcite. The effect that dissolution has on petrophysical properties is particularly relevant for calcite-bearing reservoir sandstones, in which rapid pore network evolution could compromise or reinforce the injection operation. In addition to hydrogeological considerations, the mechanical properties of the rock, e.g. shear and bulk modulus, may also be modified. The study of such mechanical changes resulting from fluid-rock interactions could improve the interpretation of time-lapse seismic surveys taken around CO<sub>2</sub> plumes.

Ideally, changes in petrophysical properties can be described as functions of the porosity alone. Unfortunately, classical “porosity-permeability” and “porosity-mechanical properties” relationships are not readily applicable when small scale heterogeneous processes modify the pore structure. Moreover, time scales of porosity evolution need to be clarified and also require experimentation. In this work, a flow-through reactor has been used to study the effect of fluid-rock interactions on the petrophysical properties of calcite-bearing sandstones. The experiments involved the injection of CO<sub>2</sub>-enriched brine into rock plugs (of 3.75cm diameter). The brine (1 Molar NaCl) was saturated with CO<sub>2</sub> at a pressure of 5 to 10 bars and room temperature. The resulting fluid is likely to reflect reservoir conditions away from the brine/CO<sub>2</sub> interface. Chemical changes to the fluid were monitored by means of time-lapse sampling and continuous pH recording. Porosity evolution along the length of the samples was investigated in-situ with CT scans produced during the course of the experiment and the permeability was computed using Darcy’s Law. Finally, sonic velocity measurements were performed in a triaxial cell before and after each experiment.

A series of experiments have been conducted on samples with an average grain size of 100 microns, a porosity of 30%, a permeability of 10mD and a calcite content of about 5% (in the form of dispersed grains). The data showed a quasi-instantaneous dissolution of the calcite even at low CO<sub>2</sub> concentrations (0.15 Molar) and with very high fluid interstitial velocities (1mm/s). This appears to validate use of the local equilibrium assumption for calcite dissolution, but care is still needed in larger, heterogeneous natural systems due to mineral accessibility considerations. More importantly, dissolution caused a porosity increase to 33%, and directly impacted the permeability and the rock strength in a way that would have been underestimated in reactive transport codes. The permeability increase ranged between 60 and 100% while widely used porosity-permeability relationships would predict 30 to 40%. The change in the rock strength is even more spectacular with a decrease of the shear and bulk moduli of 20% when empirical equations would give a negligible change.

The results demonstrate that reactive transport leads to changes in petrophysical parameters and that laboratory experiments can provide valuable insight into these changes. More experiments are planned to study different lithologies (in particular calcite-cemented sandstones). However, given the diversity of reservoir rocks, the results of this study indicate that it may sometimes be necessary to develop more sophisticated ways to incorporate chemical reactions into pore-scale fluid-flow models.