Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.7658

Laboratory measurements of the hydraulic-geochemical-mechanical properties of a limestone during injection of CO_2-rich water under CO_2 supercritical conditions

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Deep saline aquifers are target repositories for underground storage of CO_2 as a viable choice to mitigate the increasing atmospheric concentrations of CO_2. However, the injection of CO_2 into the underground disturbs the initial equilibrium conditions in the reservoir rock. The interaction between CO_2-saturated brine and the host rock causes alterations in the rock hydraulic, geochemical and mechanical properties. These alterations that likely affect the CO_2 injectivity and mechanical integrity of the reservoirs need to be evaluated at different scales starting from the laboratory.

A preliminary percolation experiment was conducted to evaluate the changes in hydraulic properties of a Pont du Gard limestone core (2.5 cm in diameter and length) during CO_2-rich water injection at a flow rate of 0.1 mL min^{-1} under supercritical CO_2 conditions ($P_{Total} = P_{CO2} = 80$ bar and 40 ºC). After 48 h, the average porosity and permeability of the core increased from 10% to 13% and from $2.5 \cdot 10^{-14}$ m^2 to $5 \cdot 10^{-14}$ m^2.

1D scoping reactive transport simulations for a 5-cm long core at $P_{CO2} = 100$ bar and 60 ºC show that the injection of the CO_2-rich water leads to a strong dissolution of calcite and a marked porosity increase along the core after 300 h (Fig. 1a).

In the next step, a percolation experiment ($P_{CO2} = 100$ bar, 60 ºC, 0.1 mL min^{-1}) will be performed. Changes in solution composition, mineral content, and porosity will be analyzed (Fig. 1b). In addition, changes in the propagation velocities of compressional (P) and shear (S) seismic waves along the core will be quantified. The initial velocities before injection have already been measured ($V_p = 2634$ m s^{-1}, $V_s = 1666$ m s^{-1}).

The main goal of the study is to combine modeling and experimental results to quantify the coupling between the changes in (1) porosity and pore structure, (2) mechanical properties (stiffness), and (3) hydraulic properties (permeability) caused by the injection of CO_2.

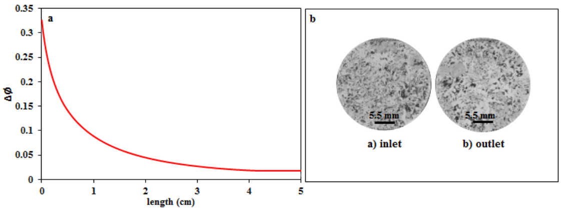

Figure 1. Porosity variation along a 5 cm long core after 300 h of injection (a); X-ray microtomography images of the inlet and outlet parts of the core before injection (b).