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Aquifer-CO2 leak project. Impact of CO2-rich water percolation in porous limestone cores: simulation of a leakage in a shallow carbonate freshwater aquifer

DAVID SEGURA, ADRIAN CEREPI AND CORINNE LOISY
Univ. Bordeaux, CNRS, Bordeaux INP, EPOC, UMR 5805
Presenting Author: dsegura@bordeaux-inp.fr

Carbon capture and storage is a promising technology for reducing greenhouse gas emissions. The most important aspects for CCS success are long term trapping of CO_2 and assurance that the environmental impact is negligible. Leakage of CO_2 into overlying aquifers constitutes a major concern, especially in the case of carbonate aquifers. We investigated the impact of a CO_2 leakage by performing Laboratory experiments at the core scale. The laboratory scale approach facilitates the investigation of the evolution of water-rock interactions and the petrophysical changes, as the transport conditions are simplified and determined by the experimental setting.

To evaluate the impact of a leakage at different conditions, we simulated one by injecting CO_2-rich freshwater into two porous carbonate cores (boundstone and grainstone textures) at different dissolved CO_2 concentrations (700 and 1400 mg/L), salinities (0 and 5 g/L of NaCl) and flow rates (0.5 and 1 ml/min) in a total of 5 consecutive experiments for sample. All five experiments were made at near-surface pressure and room temperature. The impact was studied by comparing the petrophysical properties of our samples and the injected water physicochemical parameters before, during and after percolation.

We observed that the dissolution increased the porosity as well as the cementation factor, it also decreased the specific surface area. The permeability increased during the first three experiments and decreased during the last two experiments. during all experiments, the outlet water was nearly at equilibrium with calcite. Lastly, a significant increase in electrical conductivity and dissolved Ca^{2+} and HCO_3^- concentrations was observed.

We found that increasing inlet CO_2 concentrations, salinities and flow rates encourages dissolution significantly. We conclude that the transport of fine particles, and the consequent pore clogging, produced the permeability drop during the last experiments. The transport of particles was also responsible for a significant increase in total porosity, especially in the boundstone core sample. The calculated Damköhler numbers indicate that the reactions were mostly transport-controlled, in accordance with near-equilibrium at the outlet.