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Effect of CO2-rich water injection on the hydromechanical properties of Pont Du Gard limestone

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CO_2 storage in deep geological formations (e.g., saline aquifers) is essential for global warming mitigation. Storage of large amounts of CO_2 in the saline aquifers results in acidification of the resident brine, inducing chemical reactions that change the pore structure of the host rock. Hence, the hydromechanical properties of the host rock are likely to alter, which affects the long-term injectivity and mechanical integrity of the reservoir.

To improve our understanding of the alteration of carbonate rocks after the injection of $CO_{2,}$ we have conducted percolation experiments under supercritical CO_2 conditions. CO_2-saturated water was injected at a constant rate of 0.15 mL/min through cylindrical core samples of Pont Du Gard limestone (diameter of 2.5 cm and length of ~5 cm) at 100 bar P_{CO2} and 60°C for 14 and 28 days. Fluid chemistry analyses were combined with X-ray microtomography imaging (XCMT) and porosity, permeability, and ultrasonic waves velocity (i.e., compressional and shear) measurements to assess the induced changes in rock properties.

Measured chemical parameters of the effluent solutions revealed rapid calcite dissolution correlating with 4% and 9.6% porosity enhancements for the 14-day and 28-day injections, respectively. Porosity enhancement affected mostly the inlet of the cores. Permeability increased by three orders of magnitude in both cases (from 10^{-14} to 10^{-11} m^2). XCMT images disclosed that the substantial increase in permeability coincides with the formation of large wormholes along the cores, likely controlled by their intrinsic heterogeneity. Ultrasonic waves velocity measurements under ambient conditions demonstrated that the observed alterations in the pore structures degrade the mechanical stiffness of the rock by up to 40%. Our findings provide insight into the key role of natural heterogeneity in the reactivity of the rock and in the resulting evolution of its hydromechanical properties during CO_2 storage.