

# Deformation behaviour of a Carbonate Clay subjected to calcite and dolomite dissolution in acidic environment

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**Keywords:** acidic exposure tests, caprock, chemo-hydro-mechanical processes, CO<sub>2</sub> storage, dissolution of carbonates.

In CO<sub>2</sub> storage operations the containment of the stored fluid is ensured by caprocks, typically evaporites or clayey rocks. A comprehensive study of the sealing capacity of caprocks requires evaluating their threshold capillary pressure (e.g. Vespo et al., 2024), their mechanical strength (e.g. Rutqvist 2012) and the impact of the geochemical interactions on their mechanical behaviour (e.g. Ciancimino et al., 2025). Chemical interactions between the injected CO<sub>2</sub> and the caprock can modify the sealing rock's internal structure and mineral content. Consequently, these changes may lead to alterations in its fabric and hydro-mechanical properties.

The goal of this study was to investigate the effects of the geochemical and geomechanical processes on a Carbonate Clay, traced back to a typical carbonate-clay caprock, due to the exposure to acidic solution. This material is noteworthy for comprising over 50 % carbonates, a factor that becomes critical when considering the potential acidification of the pore fluid by CO<sub>2</sub>.

Titration tests allowed to analyse the geochemical equilibria between the solid phase and increasing quantities of H<sup>+</sup>, as well as the role played by each carbonate species on the overall buffer capacity of the material. It was deduced how the material was able to buffer the pH as long as carbonates remained in the solid phase, which were subject to dissolution according to their binding energy (details reported in Vespo 2024). The tests' results were used to validate a reactive transport geomechanical model, through which it was possible to determine the reactive surface area and the equilibrium constant characteristic of the calcite and dolomite constituting the material.

Long-term exposure experiments with a 10<sup>-3</sup> M HCl solution, pH equal to the one following the dissolution of CO<sub>2</sub> in the pore fluid, were conducted to assess the geomechanical impact of prolonged exposure on reconstituted Carbonate Clay specimens (details reported in Vespo 2024). These tests were performed under oedometer constant stress conditions. To investigate the influence of transport mechanisms, two distinct exposure methodologies were implemented: one based on H<sup>+</sup> diffusion from the oedometer basin into the specimen (exposure time: 329 days), the other on the advective flow of the solution through the specimen (exposure time: 184 days).

The results highlighted the important role that the transport mechanism, exposure times and concentrations have on the geochemical interactions with the solid phase, and in particular the increased dissolution of carbonates and related microstructural variation in presence of advective flow. Furthermore, the correlation between the amount of dissolved carbonates and deformations due to chemical reactions was determined using a reactive transport geomechanical model.

## References:

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