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Hydrogeochemical Modeling of Opalinus Clay: Insights from CO2 Injection Experiments at Mont Terri Rock Laboratory

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Within the context of CO_2 injection, understanding the properties of potential caprocks, particularly clay-rich ones such as Opalinus Clay and their potential evolution is crucial for safe and effective carbon capture and storage (CCS) initiatives. This study presents hydrogeochemical models developed to investigate interactions between groundwater, Opalinus Clay caprock and CO_2, focusing on chemical evolution under varying pCO_2 levels across different layers of the clay.

Utilizing a comprehensive dataset derived from CO_2 injection experiments conducted at the Mont Terri Rock Laboratory and published pore water chemistry of Opalinus Clay, hydrogeochemical models of a potential reservoir and caprock system were constructed employing PHREEQC and CHESS geochemical modeling softwares. These models were designed to simulate and comprehend the intricate processes governing groundwater-CO_2-rock interaction within the reservoir-caprock interface and through the stratified layers of Opalinus Clay.

The models aimed to elucidate the chemical evolution of the groundwater as it interacts with the Opalinus Clay under different pCO_2 conditions. By considering variations in pCO_2 levels representative of potential CCS scenarios, the simulations provided insights into the geochemical alterations occurring within the caprock and their implications for its integrity over time.

The findings of these hydrogeochemical models offer valuable insights into the potential consequences of CO_2 injection into reservoirs whose caprocks are formed of Opalinus Clay, informing risk assessment and mitigation strategies for CCS applications. Moreover, these constructed hydrogeochemical models not only serve as a crucial foundation for comprehending the intricate thermal-hydro-mechanical-chemical (THMC) coupling mechanisms within caprocks like Opalinus Clay but also contribute to a deeper understanding of the complex interplay between pore water chemistry, rock properties, and varying pCO_2 levels, essential for ensuring the long-term security and effectiveness of subsurface CO_2 storage.