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Long-Term Mineral Trapping of CO₂ in Aquifers and Reservoirs: Integration of Thermodynamics and Kinetics in Reservoir Engineering and Geological Simulations

One of the mechanisms expected to increase the capacity of sequestration offered by permeable rocks with respect to CO₂ is mineral trapping of the gas molecule to form carbonates. The host rock must contain one or several precursor minerals capable of being dissolved in presence of the interstitial water enriched in CO₂, and capable of providing elements that can be incorporated into carbonates (e.g., Ca, Mg, Fe).

A variety of minerals can be a priori considered as possible precursors in such a process: sulfates, volcanogenic silicates, detrital mica phases such as biotite, diagenetic clay minerals such as glauconite or chlorite, etc. The presentation aims first at giving a geochemical insight into the capacity of these minerals to be de-stabilized by a formation water acidified by CO₂. From a synthesis of published data it investigates : i) the stability domains of the considered minerals with respect to carbonates in the ranges of temperature, pressure and water composition relevant to the situations of CO₂ storage ; ii) the kinetic rates involved in the dissolution and precipitation mechanisms.

The second objective of the present work is to integrate the preceding results into reservoir engineering and geological modeling (using the Diaphore model) that simulates: i) the multi-phase flow pattern and the dissolution of CO₂ during the injection period; ii) the risk of porosity occlusion by carbonate cementation close to an injection well ; iii) the long-term reactivity of the geological system when the injection is over, in static conditions or, in contrast, in presence of a natural hydrodynamism.