Unveiling the evolution of mineral precipitates and porous rock geometry during CO_2 injection into sandstone and basalt storage reservoirs

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Background: Geosciences, Experimental physics, Fluid dynamics/mechanics
Available projects: 2
Preferred project period: 01.04.2024 – 30.06.2024

Project Outline:

Introduction:

Crystal nucleation, precipitation, and growth during a reactive fluid flow and solute transport are critical in many natural and industrial systems. Mineral growth is a prime example where (geo)chemical reactions give rise to geometry evolution in porous media. The precipitation reactions can reduce porosity, alter pore space connectivity, modify tortuosity, deteriorate permeability, and change the fluid flow and solute transport. Additionally, precipitation reshapes the available surface area for growth, leading to changes in the system's reactivity, reaction progress, and reaction rates. The intricate nature of this reactive transport process poses a challenge, demanding the integration of flow, transport, and chemical processes characterized by disparate temporal and spatial scales. Grasping, regulating, and predicting these multifaceted interactions necessitate a nuanced understanding of the coupling dynamics.

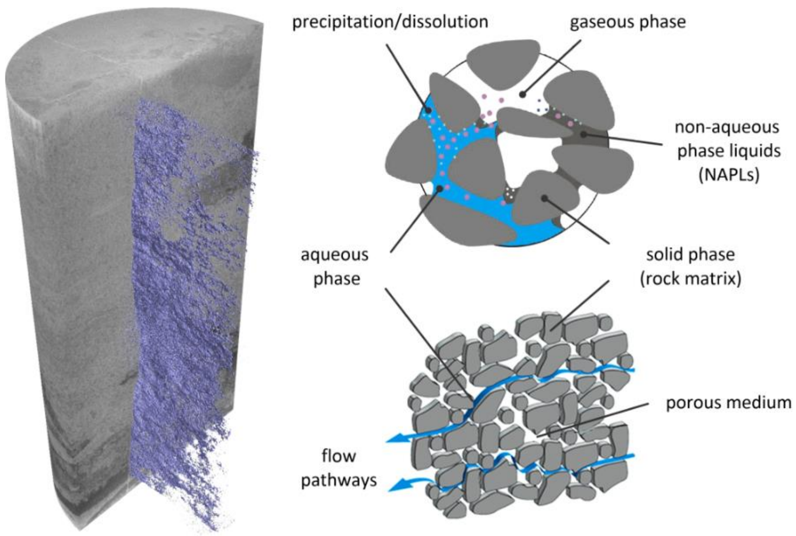

Figure 1. The flow of reactive fluids and solute transport lead to fluid-rock interactions and dissolution–precipitation events inside the porous medium.

Research Objectives:

Driven by the crucial need to understand precipitation dynamics and growth within geo-environmental systems, this research employs an experimental approach to delve into the CO_2-induced evolution of geometry and mineral precipitation within sandstone and basalt rocks. Our laboratory endeavors involve a spectrum of experimental setups meticulously designed to discern precipitation patterns, locations, and timings within the porous medium. This investigation spans various solutes (dissolved salts), pH/alkalinity and temperature-pressure conditions, mirroring the complexities inherent in Carbon Capture and Storage (CCS) operations within saline aquifers, as well as carbon mineralization processes in mafic/basaltic rocks.

Research Scope:

In our experiments, candidates undergo training in utilizing various tools, including mineral surface scale, microfluidics, sandboxes, and hele-Shaw cells, to conduct experiments in static and dynamic flow conditions. This training equips them to explore synthetic and natural substrates, as well as porous media geometries impacted by CO_2-induced mineral precipitation and growth. The primary objective is to unravel the underlying physics, evolution dynamics, and governing factors operating at the pore-scale and meso-scale, thereby formulating implications for macroscale flow and transport. Our approach involves deploying an array of advanced surface characterization techniques to examine pre- and post-experiment surface conditions.

Opportunities for Candidates:

Candidates engaging in this research will undergo comprehensive training and assume responsibilities for developing essential tools for the study, addressing open questions, adhering to overall objectives, and compiling detailed reports or manuscripts to present their findings. Through active involvement and supervisor guidance, candidates will immerse themselves in cutting-edge research, gaining proficiency in advanced experimental and analytical techniques in high demand for further career development. This dynamic engagement offers a chance to delve into reactive transport studies and become integral members of a vibrant, curiosity-driven research group. Collaborating closely with supervisors, candidates will contribute to disseminating project outcomes through conference proceedings and peer-reviewed articles.

This project serves as a valuable opportunity for candidates to initiate their exploration and mastery of techniques relevant to the study of fluid flow and reactive transport processes, with applications spanning subsurface storage, geoenergy and hydrocarbon resources, geothermal energy, waste disposal, and environmental studies.