Center for Interacting Geo-processes in Mineral Carbon Storage (GMCS)
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Mission Statement*: To develop the fundamental science and engineering capability that will lead to realizing the full potential for the large-scale subsurface sequestration of CO2 via mineralization*

A promising technology for permanently storing CO2 is sequestration via mineral carbonation in subsurface mafic and ultramafic rocks, e.g., basalt and peridotite, which are abundant in the Earth's crust. While this approach theoretically has the capacity to outpace anthropogenic CO2 emissions, its full potential is held back by the lack of knowledge of the processes that drive carbon mineralization.

Recent pilot scale projects, based on injecting dissolved CO2 in fractured basalt, have indicated that appropriate engineering can create conditions for effective carbon mineralization. The success of such an operation hinges on achieving a sustained dissolution-precipitation reaction between the host rock and dissolved CO2, whose rate is mainly influenced by the chemical potential of the host rock and the pH of the CO2 charge. The extent of the reaction throughout the reservoir is controlled by the ability of the CO2 charge to flow through the rock mass, along the fracture network and into the surrounding pore spaces. In turn, this flow is controlled by how the volume change, induced by the mineralization, clogs pores – retarding flow – or creates a network of cracks – promoting flow. Arriving at an effective operation for CO2 mineralization requires that these reaction, flow, and fracture processes, occurring across multiple space and time scales, work in a positive feedback loop. The objective of the Center is to arrive at a comprehensive understanding of the key interacting and multi-scale processes (Figure 1) that are necessary to achieve a successful carbonation operation.

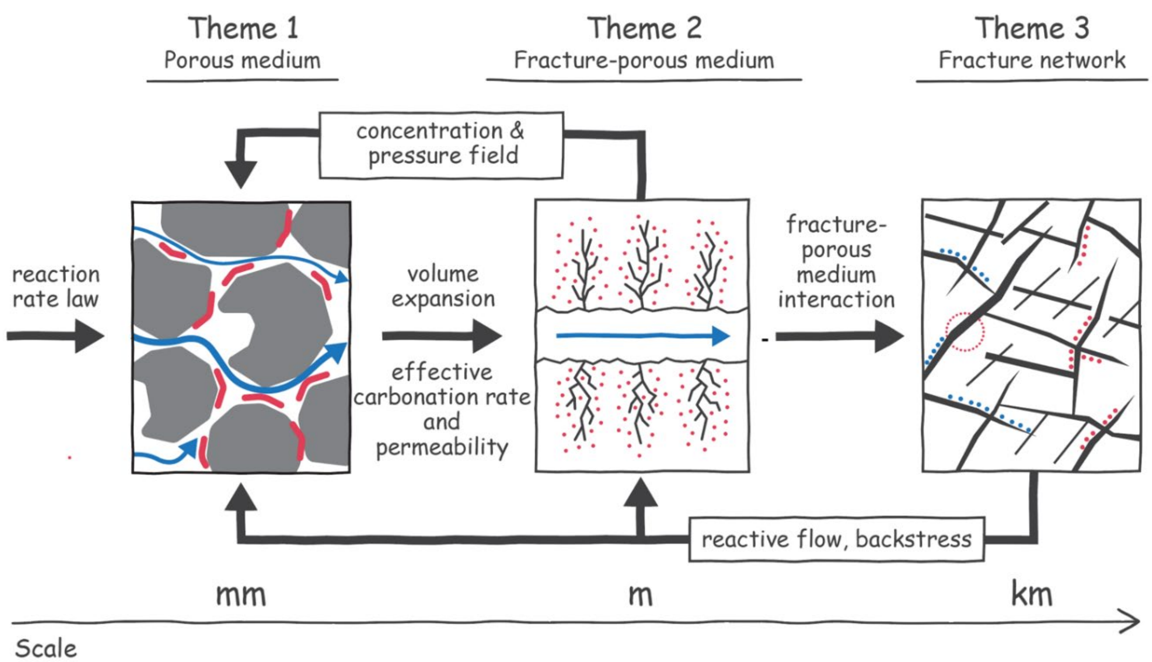

Figure 1. Interacting scales and processes in mineral carbon storage.

The Center will develop the mechanistic understanding of mineral carbonation in the subsurface by studying the reaction, flow, and fracture processes over three distinct scales (Figure 1):

(i) the porous medium scale (millimeter to decimeter) of the host rock, where the mineralization reactions and carbon storage takes place;

(ii) the fracture-porous medium scale (decimeter to meter), capturing an individual fracture from which the CO2 is delivered to the surrounding rock;

(iii) the fracture network scale (meter to kilometer) to describe how the CO2 charge is distributed within the reservoir by the natural or engineered fracture system.

Figure 1 illustrates the scales and processes of the theme domains together with their interconnections. The latter include research products and information that are passed not only from the small scales to larger scale but also from the large scales to smaller. Further note how each of these research themes is not restricted to a single knowledge domain. The threads of geomechanics, geochemistry, porous media transport, and sensing technology are tightly woven through each research theme. Knowledge about the key processes operating at each of these scales and the physics that bridge between the scales will be obtained through developing, adapting, and applying analytical and numerical modeling, physical experiments, and sensing techniques.

This intimate coupling and integration are necessary to provide answers to three fundamental overarching questions at the heart of the research efforts:

- *What are the key factors and processes that determine the evolving* CO_2 *mineralization rates (mass/time) in mafic and ultramafic rock masses?*
- *How do these factors and processes depend on the host rock lithology: mafic rocks (e.g., basalt) vs. ultramafic rocks (e.g., peridotite)?*
- *Once these factors and processes are identified and understood, how can the resulting models be deployed to generate hypotheses that can be tested at the scale of field operations?*

The successful outcome for sequestration of CO2 via mineralization will be measured by our ability to evaluate accurately the rate and amount of carbon that can be stored in a reservoir.

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