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Modelling the combined effects of reaction-driven flow path modification and fracture propagation during carbon mineralization in poroelastic rock

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Here we present a novel approach to model hydro-chemo-mechanical responses in host rock formations during carbon mineralization. The framework integrates fluid flow, reactive transport in porous media, and phase-field fracture propagation modeling in poroelastic media (Clavijo et al. 2022). This integration is key to understanding the complex interactions between fluid flow, chemical reactions, and mechanical deformation in rock formations. The solution approach uses the geochemical package PHREEQC and the finite-element open-source platform, FEniCs. PHREEQC is used to calculate the localized chemical reactions, including mineral dissolution/precipitation. The flow path modification due to geochemical interactions is estimated from the reaction-induced porosity change. This information is then used to update the mechanical properties of the rock within a finite element model, allowing for a more accurate representation of the hydro-chemo-mechanical interactions. The proposed coupled model has been validated against previous numerical results and applied to a synthetic case exhibiting hydraulic fracturing enhanced with chemical damage. The model results suggest that ongoing chemical processes can accelerate mechanical failure and weaken the rock, forming fractures. This observation confirms the significant role of chemical reactions on the mechanical behavior of rock formations and should be considered in hydraulic fracturing operations. This new model can be applied to a wide range of underground CO_2 storage systems and other subsurface engineering problems. The ability to accurately model the complex interactions between fluid flow, chemical reactions, and mechanical deformation will be essential for understanding and mitigating the risks associated with these activities.

Clavijo, Santiago Pena, Mouadh Addassi, Thomas Finkbeiner, and Hussein Hoteit. 2022. “A Coupled Phase-Field and Reactive-Transport Framework for Fracture Propagation in Poroelastic Media.” *Scientific Reports* 12 (1): 17819. https://doi.org/10.1038/s41598-022-22684-1.