

Mechanical response of polycrystalline rock during hydration reactions -Experimental investigation of reaction-induced stress and strain in CaSO<sub>4</sub>-H<sub>2</sub>O system-

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Dehydration and hydration reactions deep in the Earth control the water budget in the subduction zone system. Hydration reactions in particular, associate large solid volume changes. Such solid volume changes can induce large stress by the release of Gibbs free energy during the reactions, which can be larger than the strength of rocks and generate fracturing. However, whether the volume change in hydration reactions causes fracturing, enhance fluid flow and promote further hydration reactions, or it fills in the pores, reduces fluid flow and suppresses further hydration, is largely unconstrained. Here we explored mechanical responses of polycrystalline rock through hydration reactions  $\text{CaSO}_4 + 2 \text{H}_2\text{O} \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ .

Although the samples have high porosity ( $\phi = 20\text{-}35\%$ ), direct measurement of reaction-induced strain under constant load experiments revealed that reaction-induced bulk strain does occur under loadings of 0.01-10 MPa. The increase of loading enhances deformation mechanisms such as pressure-solution creep, and the amount of reaction-induced bulk strain decreases. Constant volume experiments revealed that reaction-induced stress increases linearly with reaction rate. These results suggest that the mechanical behavior during hydration reaction is primary controlled by the competition between the reaction rate and deformation rate.

Keywords: Reaction induced stress, Hydration reaction, Mechanical behavior