反応誘起応力による地殻応力発生と浸透率発展：MgO-H_2O系での測定
Experimental investigation of reaction-induced stress and permeability evolution in MgO–H_2O system

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Crustal and mantle hydration reactions at subduction zones accompany large solid volume change as much as several vol.% to several tens of vol.%. Such large solid volume change can generate stress and fractures, accelerate reactions and fluid migrations (e.g., Kelemen and Hirth, 2012), and potentially influence the fluid transport in the crust and mantle (e.g., Jamtveit et al., 2000). Field observations of serpentinization and peridotite carbonation suggest fracture generation and permeability enhancement by such “reaction-induced stress” (e.g., Jamtveit et al., 2008; Plumer et al., 2012). However, the permeability enhancement during hydration reaction have not been reproduced by experiments, and the mechanisms and conditions of permeability enhancement by volume-increasing reactions remain largely unknown.

To understand the controlling mechanisms of fluid flow during hydration reactions, we show one of the first experimental trial to measure the permeability evolution during hydration reactions. We use MgO–H_2O system, where periclase (MgO) react with H_2O to produce brucite ($Mg(OH)_2$). The reaction involves solid volume increase of as much as +119%. Our earlier experiments have revealed that the reaction-induced stress in this system are controlled by the competition of reaction rate and stress-dependent deformation rate, and exceeds ～40 MPa in this system which well exceeds the tensile strength of crustal rocks.

In this presentation, we have conducted flow thorough experiments to reveal the permeability evolution during hydration reactions. Experiments were conducted with sintered MgO with 4–14 vol.% porosity, under 100–300˚C with 5–50 MPa confining pressure and 5–15 fluid pressures. Preliminary experiments showed rapid permeability decrease in 2–3 orders, and finally the stainless sleeve broke by the reaction-induced expansion. The rate of permeability decrease is a function of the confining pressure, suggesting that the deformation of the reactant (brucite) has significant control over the permeability evolution during hydration reactions. We will present further experiments with various reaction rate/deformation rate ratios, and discuss the controlling factors of permeability enhancement/reduction during hydration reactions.

[References]
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