Pore-scale heterogeneity of solute distribution as evaluated by sequential pore water extraction

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While many numerical simulations of reactive transport processes have visualized pore-scale heterogeneities of solute distribution, it is usually not easy to directly observe solute distribution in pores by experimental approaches. In this study, a sequential pore water extraction technique was applied to experimentally obtain information of pore-scale solute distribution. When gas pressure is exerted on the bottom surface of a wet rock core, pore water is expelled to the top surface (Fig. 1a). The radius of the pore (r) from which water is expelled can be correlated to the pressure difference between the top and bottom of the sample (ΔP) as follows: $r > 2\gamma\cos\theta/\Delta P$, where γ is the interfacial tension and θ is the contact angle (assumed to be 0°) [1]. Hence, pore water is first expelled from the largest pores when ΔP is small, and water in smaller pores is progressively expelled as ΔP is increased [2]. In the experiment, ultrapure water was initially passed through a Berea sandstone core to induce dissolution in the pores (flow-through reaction), then pore water was extracted for each pore size and analyzed. Plot of solute concentrations vs. pore radius (Fig. 1b) showed that the concentrations increased with decreasing pore radius and that the concentration variations of Ca, Mg, and Na were greater than that of Si. A reactive transport modeling of the flow-through reaction suggested that the flushing efficiency of solute decreases with decreasing pore radius, which can be a major cause of the observed concentration variations.

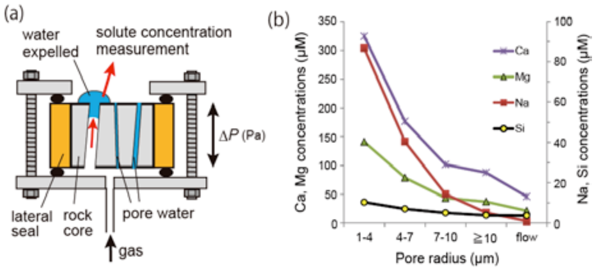

Figure 1: (a) Schematic of pore water extraction technique. (b) Solute concentrations plotted against pore radius.

[1] Yokoyama & Takeuchi (2009) *J. Geophys. Res.* **114**, B02201. [2] Nishiyama et al. (2012) *Water Resour. Res.* **48**, W09556.