

Ion concentration profile near water-mineral interface as revealed by centrifugation

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When a porous media is saturated with an aqueous solution, surface charges emerge at the pore wall due to dissociation and adsorption of proton, anion/cation, etc. If the pore wall is negatively charged, cation (or anion) concentration gradually increases (or decreases) as approaching the pore wall. The ion concentration profiles near water-solid interface should reflect an electric double layer. Since a water-solid interface is the place where dissolution and precipitation occur, the ion concentrations near the solid surface provide information on dissolution and precipitation. However, the thickness of an electric double layer is as thin as less than 1 micrometer depending on solution composition, and direct observation of the ion concentration profiles in such a thin water layer is quite difficult.

In this study the composition of pore water in a glass-dominated porous rhyolite (porosity: 21%; pore radius: about 4 nm - 0.5 mm) was studied. To evaluate the composition of pore water, a water-saturated rhyolite block was immersed in an aqueous solution of 50 micromole/L of lithium iodide for a week, and the pore waters were centrifugally extracted with increasing centrifugal force in incremental steps. The analyses of the pore waters revealed that the concentrations of cations (Li^+ , Na^+ , and Ca^{++}) increase and those of I^- and Si decrease with increasing centrifugal force. Of these elements, Na^+ , Ca^{++} , and Si dissolved from the rhyolite during one week's immersion. As increasing centrifugal force, it is presumed that water comes out in the order of larger pores to smaller pores or that the thickness of water near pore wall gradually decreases. In either case, the composition of extracted water gradually shifts to those at the water-solid interface (note that the volume fraction of the electric double layer is larger for smaller pore). The increases in the cation concentrations at higher centrifugal force show that the cations are concentrated at the negatively charged pore wall. The decreases in Si and I^- concentrations at higher centrifugal force imply that some Si is in the form of anions such as $\text{SiO}(\text{OH})_3^-$ and $\text{Si}_4\text{O}_6(\text{OH})_6^{--}$. This is contrast to the presence of electrically neutral $\text{Si}(\text{OH})_4$ as a dominant aqueous Si species which is thermodynamically equilibrated with bulk pore water (pH=6-7). These results indicate that the centrifugation technique provide useful information on the composition of the solution near water-solid interface.