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鉱物-水界面と水-空気界面の電気二重層相互作用に基づく地質媒体中の水膜厚さの評価
Estimation of water film thickness in geological media based on electric double layer interactions

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Water film plays an important role in mineral-water interactions and mass transport in geological media under water-unsaturated conditions (Nishiyama and Yokoyama, 2013, Geochim. Cosmochim. Acta). To quantify such reactive-transport in water film, the understanding of the properties of water film is essential. Water film is retained on grain surfaces due to the action of electric double layer force associated with the compression of diffuse layers developed from mineral-water and water-air interfaces. In this study, we focused on the thickness of water film and developed a model to estimate the thickness taking into consideration the effect of ion concentration, pH, and electric double layers overlapping.

The surface charge density and electric potential at mineral-water and water-air interfaces depend on the amount of adsorption-desorption of proton and ions. When two diffuse layers developed from the opposite interfaces overlap, the concentration of ions in diffuse layers changes and consequently the adsorption-desorption reactions at the interfaces achieve a new equilibrium state. To take into account this process, we used a triple-layer model and a double-layer model to numerically solve the Poisson-Boltzmann equation describing the ion distribution in diffuse layer between the interfaces. We considered water film on quartz grains and calculated water film thickness as a function of pH and ion concentration. The results show that water film thickens with decreasing ion concentration and increasing pH. The model presented in this study allows film thickness to be estimated as a function of mineral type, ion concentration, and pH. Such model would be useful for considering the reactive-transport under unsaturated conditions including the geological storage of carbon dioxide and soil formation.

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