

Reactive transport modeling and experiments on dissolution of unsaturated rocks: role of water film and effect of surface roughness

T. YOKOYAMA¹ AND N. NISHIYAMA²

¹ Graduate School of Integrated Arts and Sciences, Hiroshima University, t-yokoyama@hiroshima-u.ac.jp

² National Institute for Materials Science, NISHIYAMA.Naoki@nims.go.jp

Weathering and soil formation near the ground surface often proceed under unsaturated condition. Whether reaction occurs at air-containing pore or not is important for considering overall reactivity of the rock. To explore this problem, water was passed through a core of Fontainebleau sandstone both under saturated condition and unsaturated condition (air occupied 60% of pore volume), and amounts of dissolution of Si were compared. The result showed that whole-rock dissolution rates of the two conditions were equal^[1]. This indicates the followings: (1) all surfaces of air-containing pores were wet with a water film (thickness: < 1 μm) and dissolved. (2) Si concentration in a water film was sufficiently lowered by diffusion in the film. On the other hand, similar experiments using Berea sandstone showed that the dissolution rate of Si under unsaturated condition was 1/2 of that under saturated condition. The two rocks are differing in roughness of mineral surfaces, α (Fontainebleau: $\alpha = 11$, Berea: $\alpha = 80$). A reactive transport model that addresses dissolution in a water film (Fig. 1a) revealed that overall dissolution rate decreases with increasing α (Fig. 1b), since the water film lengthens and Si concentration increases at greater α . The model predicts that average dissolution rates in a film are $\sim 0.9r_0$ (r_0 : rate constant) at $\alpha = 11$ and $\sim 0.4r_0$ at $\alpha = 80$, which confirms the experimental results.

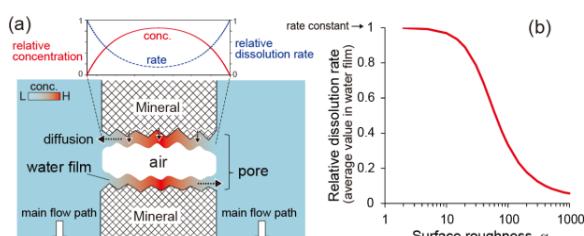


Fig. 1: (a) Schematic of a model of dissolution and diffusion in a pore wetted with a water film. (b) Calculated dissolution rate in a water film vs. roughness of mineral surface.

[1] Nishiyama and Yokoyama (2013) *Geochim. Cosmochim. Acta* **122**, 153–169.