

Chemical weathering rates of rhyolite: comparison of field and laboratory experiments with a model calculation

Tadashi Yokoyama[1]

[1] Dept. Earth and Planetary Science, Univ. Tokyo

Chemical weathering (rock dissolution and clay mineral formation) rates of rocks are essential parameters for modeling of geochemical systems. In the present study, dissolution rates of rhyolites from Kozushima, Japan, were determined from field based study and laboratory experiments. To determine a dissolution rate in the field, four porous, glass-dominated rhyolites, different in eruption ages (1.1-, 1.8-, 26-, 52-ka) and extent of weathering, were investigated. The analyses of the four rhyolites revealed that about 17% of SiO₂ decreased during weathering of 52,000 years. The dissolution rate, 6E-19 mol/cm²/sec, was obtained by dividing the amount of the SiO₂ decrease by the reaction time and reactive area determined by BET method. For the comparison of laboratory rates with the field rate, flow-through type dissolution experiments were conducted. Dissolution experiments have been usually performed using powdered samples. In the present study, in addition to powdered rhyolites (53-106 micrometer), rhyolite blocks (diameter: 2.6 cm, height 8 cm) were used to simulate the field conditions as closely as possible. The rates at 20 degree C and pH=6-7 were 5E-17 and 5E-18 (mol/cm²/sec) for powdered rhyolite and rhyolite block, respectively. The main mechanisms of the transport of dissolved ion inside rocks are the flow of water and the diffusion of ion in the water. In the case of the experiment using rhyolite block, it is presumed that pore water inside the block is almost stagnant and dissolved ion is transported mainly by diffusion. To evaluate the diffusivity of ion in pore water, through-diffusion experiments were performed for the rhyolite samples, and diffusion coefficients of 8E-8 to 2E-7 cm²/sec were obtained. To analyze field and laboratory results organically, the rhyolite dissolution was simulated by a coupled one dimensional dissolution-transport model using the experimental results. The calculation to simulate the block experiment (assuming no flow of pore water) revealed that ion concentration rapidly increases with depth in the block and reaches an equilibrium concentration at depths of 3 to 5 mm. In fact, analyses of the rhyolite pore water extracted by centrifugation confirmed slow transport and resultant high ion concentrations in the pore water. The calculated average dissolution rate of rhyolite block is 4E-18 to 6E-18 mol/cm²/sec, which agrees well with the experimental result. Consequently, the slow dissolution rate of rhyolite block (both in the field and laboratory) is mainly attributable to the high ion concentrations maintained in the rhyolite pore water, although part of the discrepancy of the dissolution rates between field and laboratory experiments could stem from the difference of glass surface condition. The results in the present study demonstrate that the dissolution of rock block is 'transport controlled', while that of the rock powder is 'surface-reaction controlled'.