

Comparison of the mechanisms and kinetics of biotite dissolutions between oxic and anoxic conditions

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Mineral-water-atmosphere interactions under anoxic conditions are not well known although they are important for better understandings of atmospheric evolution in the Precambrian and modern weathering deep in the subsurface. Dissolution experiments of rock-forming minerals under anoxic conditions give us much information to interpret the natural mineral-water-atmosphere interactions under these conditions. For decades, numerous dissolution experiments have been conducted under oxic conditions, i.e., under present atmosphere, while little has been known for the dissolution under anoxic conditions. Therefore, we carried out dissolution experiments under oxic conditions and anoxic conditions using biotite, one of the most common rock-forming minerals, and compared the dissolution behaviors of biotite between oxic and anoxic conditions to evaluate the effects of dissolved oxygen on biotite dissolution. For the oxic conditions, a dissolution rate of biotite was measured under ambient air (dissolved oxygen in solution : around 8 ppm) using a flow-through reactor at 25 degree C and pH 6.9. For the anoxic conditions, a similar experiment was conducted in the glove box filled with an Ar gas where the concentration of dissolved oxygen in solution was kept under 0.001 ppm. Biotites after the experiments were reacted with dithionite-citrate reagents to evaluate the amounts of secondary-formed hydrous Fe(III) oxides.

The measured release rates of Si under anoxic conditions were 3~4 times faster than those under oxic conditions. The release rates of Fe were approximately one order of magnitude slower than those of Si throughout the experiment under oxic conditions. On the other hand, under anoxic conditions, the release rates of Fe and Si became congruent after 65 days of reaction. The different behavior of Fe between oxic and anoxic conditions may be attributed to the different rates of oxidation from Fe(II) to Fe(III) in solution. More Fe(II) released from the biotite was oxidized by dissolved oxygen and was precipitated as secondary minerals under oxic conditions compared with that under anoxic conditions. The results of dithionite-citrate treatment also suggest that more Fe(III) was precipitated under oxic conditions than under anoxic conditions. Si was also extracted by dithionite-citrate treatment and the amount under oxic conditions was larger than that under anoxic conditions. Because hydrous Fe(III) oxides such as ferrihydrite are known to adsorb Si dissolved species, co-precipitation with hydrous Fe(III) oxides is one possibility for the different release rates of Si between oxic and anoxic conditions.