



Experimental approach reveals distinct mechanisms of biotite weathering under different chemical conditions.

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It is now well admitted that the presence in the soil of living organisms such as plant roots, bacteria and mycorrhizes enhances the weathering rate of soil minerals through the release of digesting agents. In particular, the release of protons, the production of organic acids and/or chelates like siderophores have been identified as reactants by which living organisms directly act on the mineral dissolution rate. In the present work, we adopted an experimental approach aimed at synthetically reproduces the actions of each these agents in order to test whether they lead to distinct and observable mechanisms of mineral weathering. With this view, we chose to investigate the behavior of boron isotopes during the weathering of biotite under different acidic conditions.

Boron has been chosen because it is a micronutrient necessary for the development of the vegetation and microorganisms and because it undergoes large isotopic fractionation during water/rock interactions that greatly helps to characterize to mechanisms in action. Biotite has been chosen as test mineral because it is a phyllosilicate made of an alternation of well-crystallized tetrahedral and octahedral sites and more reactive interlayers. It is also a mineral abundant in temperate acidic soils and contains significant amount of boron in its different crystallographic sites. In the present work we monitored the evolution of the boron isotopic composition of the solution in contact with biotite in the presence of HCl (as proxy for proton), citric acid (as proxy for organic acid) and siderophores. Each of those experimental conditions were tested at 20°C for about 37 days both at pH 3 and 4.5 with continuous water flow of 4mL/h. Measurements of major element concentrations (Si, K, Fe, Al, and Mg) as well as boron concentration and isotopic composition in outflowing solutions were performed at different stages of the experiments. Major elements and boron clearly reveal differences in reaction rates with respect to reactants and/or pH conditions tested. Mineral dissolution, whatever the reactant is, predominates at pH 3 and leads to near stoichiometric dissolution of the biotite. At pH 4.5, biotite in contact with citric acid gives similar results as for pH 3, but for experiments with protons and siderophores, the mineral transformation appears being the dominant reaction (vermiculitization), indicating a major contribution of the interlayer and a minimal contribution of the well crystallized sites. Boron isotopes show very contrasted behavior with respect to these two different processes: they give values close to the bulk biotite at pH3 and pH4.5 with acid citric confirming the previous inference of a stoichiometric dissolution, while a strong isotopic fractionation is observed during transformation reactions (values in outgoing solutions about 15 to 40 ‰ higher than mineral). From our experimental results, it is clear that the high B isotopic composition observed at pH4.5 is controlled by the biotite interlayer opening, but it is still not clear whether it reveals a heavy B pool in the interlayer or results from a large isotopic fractionation during B equilibrium after exposure of fresh interlayer surface to the surrounding solution.