Novel techniques for investigation of the cell-mineral interface

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Mineral weathering is a fundamental process on the Earth's surface since it provides the biosphere with a number of elements essential for its existence. It has been revealed that many organisms are able to increase weathering rates and acquire the essential elements by dissolution of nutrient-bearing minerals [1], [2], [3].

One of the biggest challenges arising in biological-weathering studies is the necessity to analyse the reacted mineral species in order to determine whether the present microorganism(s) caused any structural and/or chemical alteration to the mineral surface. In our study, we focused on analytical techniques not requiring removal of organic material (microorganisms and their products) as it can be very demanding to identify a removal method that would be non-destructive to the mineral surface.

Colonisation and weathering of the mineral biotite by filamentous cyanobacteria (phototrophic oxygen-evolving bacteria) were studied under controlled laboratory conditions. The aim was to reveal whether the cyanobacteria cause any structural and/or chemical alteration to the biotite surface. We presume that alteration during the incubation period of three months will likely happen on a nanometer (nm) scale, thus making it extremely difficult to detect. Therefore, sensitive analytical techniques with nm scale resolution, such as SIMS depth profiling, HR-TEM imaging and STEM/EDX analysis were applied for investigation of the samples.

We concluded that TEM is the best available technique for analysis of cell-mineral interactions as it allows the actual interface to be imaged and analysed directly. Preliminary analysis indicates that there may be a slight depletion in Fe and Mg with respect to Si at the cell-mineral interface. Further investigation is required to draw clear conclusions.

[1] Hutchens *et al*. (2003) *Mineral. Mag.* **67**, 1157-1170. [2] Gadd (2007) *Mycolog. Res.* **111**, 3-49. [3] Kelly *et al*. (1998) *Biogeochemistry* **42**, 21-53.

Arsenic redox transformation by humic substances and Fe minerals

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Arsenic-contaminated environments (e.g. groundwater aquifers and rice paddy) affect about 1-2% of the world's population. Arsenic toxicity and mobility strongly depend on its interactions with iron minerals and humic substances via complexation but also via redox reactions. As(III) (arsenite) is generally considered to be more toxic and mobile than As(V) (arsenate). Understanding both microbiological but also chemical redox processes leading to As redox changes is necessary in order to predict the environmental behaviour of As.

In our experiments we studied the reactions of arsenite and arsenate with microbially and chemically reduced humic substances and model compounds for quinone moieties in humic compounds. Additionally, we quantified As(III) oxidation and As(V) reduction by abiotic Fe(III)-Fe(II) systems (e.g. goethite/Fe(II)) as well as by microbially reduced Fe(III) minerals (ferrihydrite and/or goethite). Speciation of dissolved, mineral-sorbed and humic bound-arsenic was determined by IC-ICP-MS and synchrotron based X-ray absorption techniques (XANES and EXAFS). Humic substance radicals were quantified by electron spin resonance (ESR). Iron minerals were identified and characterized by Moessbauer spectroscopy, X-ray diffraction and electron microscopy. Our results show that reactive iron mineral phases as well as microbially reduced humic substances can lead to both As(III) oxidation and As(V) reduction depending on the geochemical conditions. These results suggest that microbial transformation of both humic substances and iron minerals can lead to arsenic redox changes and thus influence arsenic toxicity and mobility.