Nanoscale environments associated with bioweathering of a Mg-Fe-pyroxene

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Microorganisms are believed to create microenvironments leading to reaction products not predictable from equilibrium thermodynamics and to unique biomineral morphologies. Unambiguous evidence for such environments is, however, rare in natural samples. We characterize in this study the bioweathering products on a Fe-Mg-orthopyroxene reacted for 70 years under arid conditions in the presence of a filamentous microorganism. An electron transparent cross section of the interface between a single microorganism and an orthopyroxene grain was prepared with a focused ion beam-SEM system and was examined by scanning transmission x-ray microscopy and spectromicroscopy at the sub-40-nm scale, coupled with transmission electron microscopy. A 100 nm deep depression was observed in the orthopyroxene adjacent to the microorganism, suggesting enhanced dissolution of the pyroxene mediated by the microbe. Our measurements reveal an amorphous Al-rich layer beneath the microorganism, calcium carbonates of unique morphology intimately associated with polysaccharides adjacent to the microorganism, and regions surrounding the microorganism with different iron oxidation states. Our results confirm the presence of different microenvironments at this microorganism-mineral interface and provide unique nanometer-scale views of microbially controlled pyroxene weathering products.

Scanning electrochemcial microscopy (SECM) studies on microbial metal respiration using Pt/Hg amalgam microelectrodes

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The bioavailability and *in-situ* detection of dissolved chemical species such as Mn^{2+} and Fe^{2+} is attracting increasing interest for understanding the environmental and geological chemical reactions at the microbe-mineral interface. A versatile and promising tool for the investigation metal distributions at a microscopic scale is scanning electrochemical microscopy (SECM) in combination with square wave voltammetry (SWASV) performed at platinum/mercury amalgam microelectrodes [1].

In this contribution, we present the application of Pt/Hg amalgam electrodes in SECM detecting and imaging redox activity of iron-reducing proteins separated from *shewanella* species in native agarose gels. SECM enables for the first time a spatially resolved direct read-out of redox activity from proteins, which can not be easily stained. SECM approach curves to the gel were performed positioning the electrode in close proximity above the protein bands after calibration of the Pt/Hg microelectrodes in bulk solution for the targeted analytes (Fe^{2+}, Mn^{2+}). First SECM data on the determination of spatially resolved Mn^{2+} and Fe^{2+} concentrations produced by microbial protein bands in a gel buffered at mildly acidic conditions with Pt/Hg microdisk electrodes will be presented. Recently, we combined atomic force microscopy and electrochemical microscopy by integrating micro- and nanoelectrodes into an AFM cantilever [2], which will in future be applied to the determination of bacterial redox activity with high lateral resolution.

References

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