Geophysical Research Abstracts, Vol. 9, 05948, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-05948

Nanometer-scale study of biomineralization and basaltic glass weathering by anaerobic iron-oxidizing bacteria.

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The weathering of seafloor basalts may have a significant impact on the geochemistry of the oceanic crust and of seawater. It may also influence the Earth climate on geological timescale by providing a sink for atmospheric CO_2 through carbonatization reactions. Recently, an abundant and highly diverse microbial fauna, including iron-oxidizing bacteria, has been identified in the oceanic crust. Hence, it has been proposed that microorganisms - and particularly iron-oxidizing bacteria – have a significant impact on the weathering of seafloor basalts. We studied the mineral products formed by anaerobic iron-oxidizing bacteria cultured in the laboratory with and without basalt glass in order to evidence potential mineralogical signatures of their activity.

Iron-oxidizing bacteria, coupling iron oxidation with nitrate reduction were cultured under anoxic conditions. Iron was provided as dissolved Fe^{II} or as Fe^{II}-bearing phases, including powders of Mid Ocean Ridge Basalt glass. The texture, structure and chemistry of biominerals formed through Fe^{II} bio-oxidation and of the secondary phases resulting from glass weathering were investigated at the nanometer scale by a combination of microscopic and spectroscopic tools, including Transmission Electron Microscopy (TEM) and synchrotron-based Scanning Transmission X-ray Microscopy (STXM). TEM observations were conducted on ultrathin sections to characterize Fe-bearing phases and analyze their connection with microbial ultrastructures. X-ray Energy Dispersive Spectroscopy analyses showed that minerals forming on the bacterial cells have different chemical compositions compared with minerals precipitating in the solution. STXM analyses on the same samples provided information on the speci-

ation (type of bonding and redox state) of both carbon and iron at the 20-nm scale. An intimate mixture of organic carbon species, carbonates and iron-rich minerals resulting from bacterial activity could be evidenced.

This approach sets a unique methodological framework that will allow to assess both in laboratory cultures and in natural samples the various mineralogical transformations triggered by iron-oxidizing bacteria at the submicrometer scale.