American Mineralogist, Volume 83, pages 1551–1563, 1998

Experimental observations of the effects of bacteria on aluminosilicate weathering

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ABSTRACT

Mineral dissolution experiments using batch cultures of soil and groundwater bacteria were monitored with solution chemistry and various microscopic techniques to determine the effects of these organisms on weathering reactions. Several strains of bacteria produced organic and inorganic acids and extracellular polymers in culture, increasing the release of cations from biotite (Si, Fe, Al) and plagioclase feldspar (Si, Al) by up to two orders of magnitude compared to abiotic controls. Microbial colonies on mineral grains were examined by cryo-scanning electron microscopy (cryo-SEM), confocal scanning laser microscopy (CSLM), and epifluorescence microscopy. Bacteria colonized all mineral surfaces, often preferentially along cleavage steps and edges of mineral grains. Low-voltage high-resolution cryo-SEM of high-pressure cryofixed and partially freeze-dried colonized minerals showed many bacteria attached by extracellular polymers of unknown composition. These biofilms covered much larger areas of the mineral surfaces than bacterial cells alone. Mineral surfaces where bacteria and extracellular polymers occurred appeared more extensively etched than surrounding uncolonized surfaces. CSLM was used to observe microbial colonization of biotite and to measure pH in microenvironments surrounding living microcolonies using a ratiometric pH-sensitive fluorescent dye set. A strain of bacteria (B0693 from the U.S. Department of Energy Subsurface Microbial Culture Collection) formed large attached microcolonies, both on the outer (001) surface and within interlayer spaces as narrow as 1 μm. Solution pH decreased from near neutral at the mineral surface to 3–4 around microcolonies living within confined spaces of interior colonized cleavage planes. However, no evidence of pH microgradients surrounding exterior microcolonies was noted.