Biomineralization of Mn oxides by Mn(II)-oxidizing bacilli from an extreme environment

S. MAYANNA[1]*, C. L. PEACOCK[2], V. CIOBOTA[3], V. K. B. NARAYANA[3], E. KOTHE[4], P. RÖSCH[3], J. POPP[3,5] AND G. BÜCHEL[1]

[1]Institute of Geosciences, Friedrich-Schiller-University Jena, Germany
(*Correspondence: sathish.mayanna@uni-jena.de)
[2]School of Earth and Environment, University of Leeds, UK
[3]Institute of Physical Chemistry, Friedrich-Schiller-University Jena, Germany.
[4]Institute of Microbiology, Friedrich-Schiller-University Jena, Germany
[5]Leibniz-Institute of Photonic Technology, Jena, Germany

Biogenic Mn oxides are produced via the microbial oxidation of Mn(II) and are ubiquitous in the environment. They are extremely efficient oxidants and sorbents, and as such they control the mobility of trace metals, and impact on the cycling of carbon and flow of electrons in the subsurface. To better understand the formation of biogenic Mn oxides and their role in elemental cycling, we have studied the former uranium mining site, Ronneburg, Germany. Here soil geochemistry is unfavorable for abiotic Mn oxide formation, due to its acidic pH, low carbon content and high heavy metal loads, which makes it an extreme environment for microbial activity. Despite these conditions, the study site is rich in poorly crystalline Mn(III/IV) oxides most closely resembling the abiotic phyllomanganate δ-MnO_2. We have identified and isolated *Bacillus* sp. GH_P2_28 and *Brevibacillus* sp. GH_P2_27, present as metabolically dormat spores, that we then cultured to produce biogenic Mn oxides in the laboratory. Our products were characterised by electron microscopy and synchrotron spectroscopy techniques. In agreement with previous studies on biogenic Mn oxide products of different Mn(II)-oxidizing strains, we identified very poorly crystalline δ-MnO_2-like products. Our Mn oxides enrcusted the *Bacillus* sp. and *Brevibacillus* sp. bacterial spores showed unique morphological and mineralogical features that were specific to each strain, including an enrichment of Mn(III) in *Brevibacillus* sp.. In light of our work, it appears that dormant spores of Mn(II)-oxidizing bacteria are still able to catalyse Mn(II) oxidation and that Mn(II)-oxidizing bacteria in general possess species-specific mechanisms for this phenomenon. This necessitates further work on the microbial mechanisms of Mn(II) oxidation and mineralization by spores, and a new assessment of the role and functions of dormat spores in the environment.