Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36616

Evaluating biotic and abiotic mechanisms of manganese oxide precipitation in porous environments

ELEANOR C. FADELY[1], GAITAN GEHIN[1], SHARON E. BONE[2], NICHOLAS P. EDWARDS[3], SAMUEL M. WEBB[4] AND JASQUELIN PEÑA[1,5]

[1]University of California Davis
[2]Forschungszentrum Jülich GmbH
[3]Stanford Synchrotron Radiation Lightsource
[4]SLAC National Accelerator Laboratory
[5]Lawrence Berkeley National Laboratory

Microbial manganese (Mn) oxidation drives key soil biogeochemical processes. The resulting Mn(III, IV) oxides react readily with organic and inorganic constituents, influencing nutrient cycling and contaminant mobility. However, biogenic Mn oxides can also oxidize aqueous Mn(II), which can lead to an increase in solid-phase Mn(III) content and a decrease in mineral reactivity. We hypothesize that in porous environments experiencing fluid flow and Mn(II) flux, Mn oxidation is initially enzymatic, followed by mineral-surface mediated sorption and oxidation of Mn(II).

Here, we integrate molecular microbiology tools and geochemical measurements with a microfluidic system to investigate pore-scale mechanisms of Mn oxide precipitation. Using two fluorescent-tagged bioreporter strains of *Pseudomonas putida* GB-1, we evaluate the timing and spatial distribution of bacteria expressing *mnxG* and *mcoA,* the genes encoding two Mn oxidases in this organism. We further assess the relative contribution of each enzyme to Mn oxide precipitation kinetics and total mineral mass using single gene knockout strains. Finally, we quantify the proportion of Mn(II), Mn(III), and Mn(IV) in the pore space over time with micro-X-ray fluorescence mapping and X-ray absorption spectroscopy.

Our preliminary findings show that while the expression of *mnxG* and *mcoA* follows distinct patterns within the pore space, both genes are needed to produce comparable Mn oxide mass, suggesting a role for both enzymes in dynamic environments. Concurrently, we observe that the proportion of Mn(III) to Mn(IV) increases substantially over time near the reactor inlet, consistent with oxidation of influent Mn(II) by nascent mineral particles. By combining multimodal biological and geochemical approaches, we provide a data-driven conceptual model for coupled biotic-abiotic Mn oxidation, advancing our fundamental understanding of mineral precipitation and reactivity in soils.