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Microbes and Iron Minerals – A Love Story?

ANDREAS KAPPLER

Cluster of Excellence (EXC 3121): TERRA – Terrestrial Geo-Biosphere Interactions in a Changing World, University of Tübingen, Department of Geosciences, University of Tuebingen

Iron is the fourth most abundant element in Earth's crust, occurring across a wide range of environments - from soils and sediments to groundwater aquifers, hydrothermal vents, and permafrost. At the heart of iron cycling lies close, if complicated, relationship between microorganisms and iron minerals, one that shifts between formation and destruction depending on the redox conditions microbes exploit. Microorganisms that oxidize ferrous iron generate ferric iron minerals as a metabolic by-product, while iron-reducing microbes dissolve these same minerals to release ferrous iron.

I will first show how microbial iron oxidation and the resulting mineral precipitates can shield cells from harmful UV radiation, how this process can be harnessed for arsenic removal from contaminated groundwater, and how it contributed to the deposition of Banded Iron Formations on early Earth.

Turning to the reductive side, I will demonstrate how microbial reduction and dissolution of ferric iron minerals mobilizes arsenic into groundwater, and how the same process, occurring in thawing permafrost soils, liberates iron-bound organic carbon, fueling methane and carbon dioxide release - i.e. it destroys the "rusty carbon sink" that protects the organic carbon from transformation into greenhouse gases.

Finally, I will highlight mixed-valent iron minerals such as magnetite, which contain both ferrous and ferric iron and can be alternately reduced by iron-reducing bacteria and reoxidized by iron-oxidizing bacteria - effectively functioning as a rechargeable "biogeobattery" that stores and releases electrons within the subsurface.

Together, these examples reveal a microbe-mineral relationship that is as consequential for environmental health and climate as it is fundamental to Earth's geological record.