Siderophore and biofilm synthesis: effects on nutrient bioavailability and silicate dissolution

VAN DEN BERGHE, M.[1]*, WEST, A. J.[1], NEALSON, K. H.[1]

[1]Dept. Earth Sci., University of Southern California, 3651 Trousdale Pkwy, 90089, Los Angeles, CA, USA. (*correspondence: mdvanden@usc.edu)

As a limiting micronutrient, iron is critical to biological productivity, and thus regulates major global biogeochemical cycles, such as those of carbon and nitrogen. Yet iron's high biological demand is met with extremely low solubility and bioavailability in oxic environments. To adapt, many microorganisms synthesize siderophores to help improve its acquisition. How these ligands work to increase iron bioavailability from mineral phases remains unclear. Similarly, many bacteria form thick, redox-active biofilms on mineral surfaces in order to create micro-environments favourable for growth. The combined effects of siderophore and biofilm synthesis suggest active mechanisms of nutrient acquisition directly from mineral phases. A better understanding of these effects is needed to answer long standing questions about the biological controls on silicate weathering, the metabolic potential driving bacteria-mineral interactions, the limits of life in ocean and sub-surface environments as well as the coevolution of life and Earth.

Bacteria with disabled synthesis capabilities can isolate the effects of specific metabolic processes. Batch experiments were conducted using the bacteria *Shewanella oneidensis* and *Pseudomonas aeruginosa* in iron-deplete minimal media, amended with olivine as the sole source of iron. Experiments included wild types and siderophore synthesis gene deletion strains. Wild type strains showed no growth penalty, as a result of being able to acquire iron from induced olivine dissolution. The *Shewanella* deletion mutant strain showed a very pronounced growth penalty, resulting in an extended lag phase. Yet, when the same *Shewanella* deletion strain was provided with siderophores via filtrate from the wild type experiments, substantial and comparable growth to the wild type was observed. In contrast, the *Pseudomonas* siderophore deletion strain grew very thick biofilms on the olivine minerlas, and showed no growth penalty whatsoever. These results strongly suggest that siderophores as well as thick, redox active biofilms are effective mechanisms for bacteria to dissolve and acquire micronutrients directly from mineral phases. Ongoing research will quantify silicate dissolution rates related to this activity, and explore biofilm microenvironments.