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Microbial siderophores increase olivine dissolution rates by shunting Fe and Mg into biomass

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Enhanced weathering of olivine is an active area of research for carbon dioxide removal (CDR). Previous research has shown that siderophore-producing microbes can actively extract and utilize mineral-sourced Fe, but these findings have largely focused on geobiological processes, and have yet to be extrapolated to CDR-focused studies quantifying the effect of siderophore-producing microbes on mineral dissolution rates. To fill this gap, we conducted experiments aimed at measuring olivine dissolution rates in Fe-limited media with a) siderophore-producing bacteria (*Shewanella oneidensis*), b) a gene-deletion mutant strain of *S. oneidensis* incapable of producing siderophores, and c) abiotic control solution. The commercially available siderophore desferrioxamine B was added across a range of low, environmentally-relevant concentrations to the mutant bacteria and abiotic solutions. At the same level of desferrioxamine addition, the mutant experiments had up to 10x higher dissolution rates (based on dissolved Si) compared to the abiotic experiments, and matched dissolution rates in the wild type experiments at only 50 μM desferrioxamine addition. Analysis of total and dissolved metals in the biotic experiments revealed that both Fe and Mg accumulated in the solid, and not dissolved phase, in line with microbial biomass growth. We conclude that microbes use siderophores to transfer metals from olivine to biomass, thereby freeing siderophores for reuse. This recycling results in higher effective siderophore concentrations in biotic vs abiotic conditions, leading to higher mineral dissolution rates. These findings suggest that using siderophore-producing microbes in engineered CDR systems may be an effective method to achieve higher dissolution rates. These results may also inform monitoring efforts for enhanced weathering projects, since dissolved phase measurements may not fully capture rates of metal release from dissolution.