Mineral-microbe interactions in Fe-oxidizing bacteria

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Microorganisms are abundant and ubiquitous in Earth's surface environments where their surfaces influence mineral dissolution and precipitation reactions and biogeochemical cycling from nano- to planetary-scales. Microbial surfaces are the interface through which microorganisms interact with each other and their external environments. These surfaces provide the basis for phage and antigen recognition as well as sites for solute adsorption and mineral templating. In many natural and engineered ecosystems, microbial surfaces represent the largest potential sorbents for dissolved cations and they thus play key roles in controlling metal mobility. At the same time, surfaces lower barriers to nucleation and are thus vital in driving mineral precipitation. Not all microorganisms and their surfaces are created equal, however, and nuanced differences in the molecular structure of the outer-membrane can have far reaching influences on microbial surface chemistry and its interaction with the environment. Two species - *Chlorobium ferrooxidans* and *Chlorobium phaeoferrooxidans* - of photosynthetic iron oxidizing bacteria, with more than 99% identity in their 16S rRNA genes have less than 75% identity in their genomes at the nucleotide level. This genomic degeneracy gives rise to a number of physiological differences that ultimately contribute to benthic and pelagic habitat preferences, respectively. A key difference between the two organisms is the surface densities of cation binding carboxyl functional groups. This leads to different metal binding capacity and distinctive cell surface biophysical properties that enable niche differentiation. Fitting to its benthic lifestyle, *C. ferrooxidans* associates with its iron metabolites. *C. phaeoferrooxidans*, by contrast, repels these metabolites, enabling it to remain buoyant in pelagic habitats. Because these molecular-scale interactions control association of cell biomass to mineral metabolites they ultimately control coupled carbon and iron cycling, In Precambrian iron-rich oceans, these interactions likely influenced the deposition of banded iron formations and the evolution of the ocean-atmosphere system.