Experimental tests of universal metal adsorption behavior for bacteria

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In order to apply surface complexation models of metal-bacteria adsorption reactions to realistic geologic systems, it is important to determine if proton and metal adsorption behavior is species-specific or if commonalities exist between species. A number of studies have noted similar adsorption behavior among individual bacterial species and among mixtures of bacterial species. Here, I summarize experimental evidence for, and against, universal adsorption behavior.

A large number of gram-positive and -negative bacterial species and consortia exhibit similar bulk proton and metal adsorption behaviors. Borrok *et al.* (2005) applied a discrete site, non-electrostatic model to the available published potentiometric titration data from 36 bacterial species and consortia, and found the resulting model parameters (sites, site concentrations) to be similar for all of the species. In this talk, I will compare our results of EXAFS studies of Cd adsorption onto bacterial consortia to those involving single bacterial species. The results, too, are remarkably similar. The consortia exhibit the same limited number of binding sites as pure strains of bacteria, suggesting that commonalities in bulk adsorption behavior are likely caused by commonalities in proton and metal binding mechanisms between species.

Not all bacterial species exhibit similar adsorption behaviors. Borrok *et al.* (2004) noted enhanced Cd adsorption onto bacterial consortia grown from hydrocarbon-contaminated soils. In addition, we have recently measured proton, Cd, and Pb adsorption onto a range of bacteria that are extremely diverse genetically. Known bacterial species are classified from Section VI to Section XXXIII in Bergey’s biological classification scheme. Here, I report on studies of five species of bacteria, ranging from a Section VIII species to a Section XXX species, and the species also inhabit a wide range of extreme habitats. Most of the species studied exhibit similar proton and metal adsorption behaviors. However, the acidiphilic species exhibits a markedly different behavior, suggesting that significant exceptions to the typical bacterial adsorption behavior do exist. This study demonstrates that a wide range of bacteria exhibit similar proton and metal adsorption behaviors, and that a single set of averaged acidity constants, site concentrations, and stability constants for metal–bacterial surface complexes yields a reasonable model for the adsorption behavior of many of these species.

Post-entrapment Li isotope fractionation in melt inclusions from Volcán Jorullo, Mexico

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Trace element concentrations and Li isotope ratios have been analyzed in olivine-hosted melt inclusions sampled in tephras from Volcán Jorullo, a monogenetic cinder cone in the Michoacán-Guanajuato Volcanic Field, Mexico. The melt inclusions range from basalt to basaltic andesite in composition. Lithium concentrations range from 2 ppm in the most primitive inclusions to 12 ppm in the most evolved. Some of the lava flows from Jorullo contain abundant granitic xenoliths, and most contain plagioclase xenocrysts, suggesting that the lavas have assimilated some amount of crustal material. Lithium concentrations in the lava flows are ~10 ppm, while the Li concentration in a granitic xenolith is ~20 ppm. One interpretation is that the melt inclusions containing ~2 ppm Li represent the primitive melt, while the higher Li in the more evolved melt inclusions and the lava flows results from assimilation of high-Li granitic country rock.

The δ^7Li in the melt inclusions ranges from typical arc lava values of 1.1‰ in the most primitive (low-Li) melt inclusions to extremely light values as low as -9.2‰ in the more evolved (high-Li) melt inclusions. This is in distinct contrast with the δ^7Li of ~3.6‰ in the basaltic lava flows and ~12‰ in the granitic xenoliths. With no direct source of light Li, it is clear that some post-entrapment process must be responsible for fractionating Li in the melt inclusions. We propose a model whereby Li is added to the magma by assimilation of Li-rich country rock *following* the initial entrapment of melt inclusions. Assimilated Li then enters the melt inclusions by diffusion through olivine. The process of diffusion simultaneously increases the Li concentrations in the melt inclusions and decreases the δ^7Li, because the added Li is enriched in ^{6}Li due to its faster diffusion rate. With improved understanding of the rates of Li diffusion and isotopic fractionation in olivine, the Li isotope variations in the Jorullo melt inclusions could serve as a useful indicator of the timing of crustal assimilation prior to eruption.