UNIVERSITY of HOUSTON

CULLEN COLLEGE of ENGINEERING
Department of Civil & Environmental Engineering

Distinguished Lecture Series

Jeremy B. Fein, Ph.D.
University of Notre Dame

Using Surface Complexation Modeling to Quantify Metal Adsorption and Bioavailability to Bacteria in Geologic Systems

Monday, January 28, 2013
10:30 to 11:30 AM
Seminar Room D3 W122

Abstract

Determining the controls on metal adsorption and bioavailability is crucial in order to understand the geomicrobiology of geologic systems with high metal concentrations, such as acid mine systems or contaminated soils, and in order to optimize bioremediation strategies aimed at remediating those types of systems. The key to improved models of all of these geomicrobiological processes is the ability to quantitatively model bacterial metal adsorption and bioavailability. Metal adsorption onto bacterial cell walls represents the first interaction of a metal with the cell, and for this reason we hypothesize that accessibility of the metal to the cell is directly related to, and can be predicted by, cell wall metal speciation.

In the research that will be discussed, we test the hypothesis that bacterial surface speciation and concentration of heavy metals controls the bioavailability of those metals. Previous models of metal bioavailability (e.g., the Biotic Ligand Model) characterize metal binding onto a wide range of organisms using a generic, unspecified metal-binding biotic ligand that does not account for the many complexities of metal adsorption reactions onto biological surfaces. These models often fail because of these overlooked complexities in adsorption reactions. Over the past 15 years, we have learned much about the mechanisms involved in metal binding onto bacterial cell walls, and have developed quantitative surface complexation models based primarily on x-ray absorption spectroscopy and bulk adsorption measurements. In this presentation, I will review my group's work to improve surface complexation models of bacterial metal binding, and to use those models to quantify the controls on the bioavailability of aqueous metals to bacteria. We have shown that bacterial chemotactic response and the enzymatic reduction of U(VI) are two examples of adsorption-controlled processes. The extent and rate of both of these processes can be directly related to the concentration of metal adsorbed onto the bacterial cell wall. Therefore, improving the sophistication and accuracy of surface complexation models of metal adsorption onto bacteria will lead to improved quantitative models of bacterial processes in realistic complex systems.

About the speaker

Professor Jeremy B. Fein received an M.S. in Geochemistry from Northwestern University in 1986 and a Ph.D. in Geochemistry, from Northwestern University in 1989. He joined the University of Notre Dame Department of Civil Engineering and Geological Sciences in 1996, where he is currently a professor.

The objective of Professor Fein's research is to use experimental data to construct quantitative thermodynamic and kinetic models of mass transport in bacteria-water-rock systems. These models are used to quantify heavy metal and radionuclide mobilities in systems of geologic and/or environmental interest, such as contaminated groundwater aquifers and oil-field reservoirs. His experimental work includes studies of bacteria-water-mineral interactions as well as measurements of the thermodynamic stabilities of radionuclide-bearing mineral phases.

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