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Formation and Reactivity of Biogenic Iron Minerals

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RESULTS TO DATE: Dissimilatory iron-reducing bacteria (DIRB) play an important role in regulating the aqueous geochemistry of iron and other metals in anaerobic, non-sulfidogenic groundwater environments; however, little work has directly assessed the cell surface electrochemistry of DIRB, or the nature of the interfacial environment around individual cells. The electrochemical properties of particulate solids are often inferred from titrations in which net surface charge is determined, assuming electroneutrality, as the difference between known added amounts of acid and base and measured proton concentration. The resultant titration curve can then be fit to a speciation model for the system to determine pKa values and site densities of reactive surface sites. Moreover, with the development of non-contact electrostatic force microscopy (EFM), it is now possible to directly inspect and quantify charge development on surfaces. A combination of acid-base titrations and EFM are being used to assess the electrochemical surface properties of the groundwater DIRB, Shewanella putrefaciens. The pKa spectra and EFM data show together that a high degree of electrochemical heterogeneity exists within the cell wall and at the cell surface of S. putrefaciens. Recognition of variations in the nature and spatial distribution of reactive sites that contribute to charge development on these bacteria implies further that the cell surface of these Fe(III)-reducing bacteria functions as a highly differentiated interfacial system capable of supporting multiple intermolecular interactions with both solutes and solids. These include surface complexation reactions involving dissolved metals, as well as adherence to mineral substrates such as hydrous ferric oxide through longer-range electrostatic interactions, and surface precipitation of secondary reduced-iron minerals.

DELIVERABLES: I. Sokolov, D.S. Smith, G.S. Henderson, Y.A. Gorby, and F.G. Ferris. Cell Surface Electrochemical Heterogeneity of the Fe(III)-reducing Bacteria Shewanella putrefaciens. Submitted to Environmental Science and Technology (May 2000)

N. Parmar, Y.A. Gorby, T.J. Beveridge, and F.G. Ferris. Formation of Green Rust and Immobilization of Nickel in Response to Bacterial Reduction of Hydrous Ferric Oxide. Submitted to Geomicrobiology Journal (June 2000)