

PUTTING THE 'HEME' IN HEMATITE: ELECTRON TRANSFER AT THE MINERAL-MICROBE INTERFACE

WIGGINTON, Nicholas S., Dept. of Geosciences, Virginia Tech, Blacksburg, VA 24061

Hematite ($\alpha\text{-Fe}_2\text{O}_3$) is one of the most ubiquitous metal-oxide phases on the near surface of the planet. Hemes are prosthetic subunits of proteins that contain an iron atom that acts as an electron carrier. Although the words 'hematite' and 'heme' share the same etymology (they both come from the Greek word, *haima*), they have another less obvious similarity; they are the terminal components of a complex series of redox reactions that occur between bacteria and minerals in the environment. In anoxic circumneutral pH waters, metal-reducing bacteria couple the reduction of ferric iron sites at hematite surfaces to the oxidation of an energy source. This biological electron transport pathway involves the localization of several heme-containing proteins to the cell's outer membrane, essentially creating a bioelectrical 'circuit.' Here, the organism acts as the electron source and the mineral serves as the electrode. Although we know that certain heme-proteins expressed by these microorganisms control the rate of iron reduction, the mechanisms of their enzymatic activity remain poorly understood. Characterizing the function and efficiency of such proteins will aid in our understanding of not only the reductive dissolution of natural oxides such as hematite, but of soluble environmental contaminants including certain heavy metals and radionuclides. Additionally, the net current passed through heme-proteins in these pseudo biological circuits (i.e. the transfer of electrons from a bacteria to a solid-phase electrode) has been harvested as potential new energy technology—microbial fuel cells.

My research focuses on two aspects of heme-protein interactions with minerals: 1) characterization of the 'tunneling' efficiency for outer-membrane heme-proteins in hopes of deducing probable electron transfer pathways to the hematite surface, and 2) quantifying the nanoscale limits of such reactions in terms of the protein's proximity to electron accepting sites in the crystal.