Structure of bacterial multiheme cytochromes at the microbial-mineral interface

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Electron transfer by dissimilatory metal-reducing bacteria (DMRB) is facilitated by a series of *c*-type cytochromes associated with the bacterial cell envelope. The outer membrane protein OmcA is located on the cell surface of the dissimilatory metal reducing bacterium *Shewanella oneidensis* MR-1 [1, 2]. This 85 kDa decaheme *c*-type cytochrome functions as a terminal reductase that relays electrons generated by the bacteria's metabolism to extracellular acceptors that include solid metal oxides such as hematite (α-Fe_2O_3) [3]. The solution structure of OmcA was determined by small angle X-ray scattering (SAXS) and its interaction with hematite was revealed by neutron reflectometry (NR). SAXS results showed that OmcA is a monomer that adopts a flat ellipsoidal shape with a dimension of 34×90×65 Å. Changes in redox state affect OmcA conformation. In addition, OmcA interacts with small organic ligands known to act as electron shuttle molecules, such as flavin mononucleotide (FMN), resulting in the formation of higher molecular weight assemblies. A model system, developed to study the interaction of OmcA with hematite using NR, shows that OmcA forms a well-defined monomolecular layer on hematite surfaces. This allows OmcA to preferentially interact with hematite in a conformation that appears to maximize its contact area with the mineral surface. Overall, these results provide a structural basis for OmcA mediated redox processes by providing novel insights into its molecular structure and interaction with insoluble hematite and small organic ligands.

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Analysis of samples from regolith in the Moon's South Pole-Aitken Basin

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The Moon's South Pole-Aitken Basin is a high-priority target for sample return because of the potential to (1) determine the chronology of the basin and thus test the impact cataclysm hypothesis, (2) determine composition and lithology of basin materials and thus test models for the origin, evolution, and diversity of the lunar crust, (3) measure incompatible-element signatures (i. e., KREEP) to test models for the mechanism and scale of lunar differentiation and infer its link to thermal evolution, and (4) determine the chemistry, mineralogy, and chronology of basaltic components to assess lunar far-side volcanic history and mantle composition. These objectives link also to processes beyond just the Moon: they relate to dynamics in the early Solar System, impact history of the inner solar system, differentiation and evolution of the terrestrial planets, and origin and evolution of life on Earth.

To achieve these objectives requires collection of the right samples. We expect that lunar regolith in appropriately selected sites in the interior of the SPA Basin will provide the right samples via small rock fragments and regolith fines. Impact-mixing processes generate a wide diversity of materials in lunar regolith. Apollo samples show that materials derived from local geologic formations dominate, but components originating from great distances occur in all samples, e.g. basalt and volcanic glass in Apollo 16 regolith. Although in lunar regolith, <1 mm fines dominate, a significant fraction consists of small rock fragments (mm to cm). For typical, fine-grained samples, small rock fragments (e.g. >3 mm) commonly represent well the larger rocks from which they derive. For coarser-grained rocks, mineral chemistry determined by electron- and ion-microprobe methods, petrographic analysis, and trace-element geochemistry can relate different fragments of the same lithology. Addressing the full suite of science objectives requires integrated and well-coordinated analyses of these rocks by multiple geochemical, isotopic, and microbeam methods. Existing analytical methods are sufficient to do these analyses, but advances leading to capabilities to analyze increasingly smaller masses will help to maximize science return from such samples.