Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 649

Microbial Reduction of Iron in Hot Environments: Implications for the Geochemistry of Ancient and Modern Environments

Derek Lovley (dlovley@microbio.umass.edu)[1], **Kazem Kashefi**, **Jason Tor**, **Madeline Vargas**[2] & **Anna-Louise Reysenbach**[3]

[1] Department of Microbiology, University of Massachusetts, Amherst, MA 01003, USA
[2] Department of Biology, College of the Holy Cross, Worcester, MA 01610, USA
[3] Department of Environmental Biology, Portland State University, Portland, OR 97201, USA

The ability of micro-organisms to conserve energy to support growth from the oxidation of organic compounds or hydrogen with the reduction of Fe(III) to Fe(II) is one of the most recently recognized forms of microbial respiration. However, recent studies have suggested that microbial Fe(III) reduction may have been one of the first types of respiration on early Earth. Evaluation of a broad diversity of hyperthermophilic Archaea and Bacteria demonstrated that all of these organisms had the ability to couple the oxidation of hydrogen to the reduction of Fe(III). A representative of the Bacteria, *Thermotoga maritima*, and of the Archaea, *Pyrobaculum islandicum*, that were evaluated in more detail were found to conserve energy to support growth from this metabolism. The finding that all of the extant micro-organisms that are believed to be most closely related to the last common ancestor(s) of modern organisms have the ability to couple hydrogen oxidation to Fe(III) reduction suggests that the last common ancestor(s) had the ability to use Fe(III) as an electron acceptor. This conclusion is in accordance with previous studies that have suggested that hydrogen and Fe(III) oxide were abundant on pre-biotic Earth and the suggestion that life evolved from inorganic membranes which catalyzed the oxidation of hydrogen coupled to Fe(III) reduction. All of the hyperthermophilic micro-organisms converted large quantities of Fe(III) oxide to magnetite. This microbial production of magnetite formation provides a potential mechanism for the accumulations of magnetite in ancient formations. Furthermore, the magnetite was similar in morphology to the magnetite that has been recovered from deep below the Earth's surface, which has been proposed to provide evidence for a deep, hot biosphere. Studies with *P. islandicum* demonstrated that some hyperthermophiles can substitute other metals for Fe(III) as an electron acceptor for hydrogen oxidation. For example, *P. islandicum* reduced U(VI) to U(IV), precipitating the reduced uranium as uraninite. This demonstrates that microbial U(VI) reduction may readily account for the reductive precipitation of uranium deposits at temperatures up to 100ºC. *P. islandicum* also reduced ionic gold to the metallic state, depositing gold from solution. This provides a novel enzymatic mechanism for the generation of some gold deposits. Other heavy metals, some of which are generally considered to be toxic to micro-organisms, were also reduced.

The ability of hyperthermophiles to oxidize organic compounds with the reduction of Fe(III) was also evaluated. In anaerobic environments that are at moderate temperatures, such as aquatic sediments and the shallow subsurface, complex organic matter is anaerobically oxidized to carbon dioxide via the co-operative activity of microbial food chains. It has been questioned whether hyperthermophilic microbial communities have a similar ability to close the carbon cycle by completely oxidizing complex organic matter back to carbon dioxide because no hyperthermophiles have previously been described that can oxidize many of the most important organic intermediates, such as acetate, aromatic compounds, and long-chain fatty acids. However, hyperthermophilic isolates recovered from several hot microbial ecosystems were found to conserve energy to support growth by oxidizing these compounds to carbon dioxide with Fe(III) serving as the sole electron acceptor. These included micro-organisms not previously described, as well as *Ferroglobus placidus*, a hyperthermophile that was previously known for its ability to anaerobically oxidize Fe(II). These results demonstrate that anaerobic oxidation of complex organic matter to carbon dioxide, as previously described in cooler environments, is possible in hot microbial ecosystems.

These findings have implications for the geochemistry of modern, metal-rich hot environments associated with both marine and terrestrial hydrothermal zones and for the possibility of a deep, hot biosphere on Earth and other planets. Furthermore, ongoing studies on the biochemical mechanisms for the reduction of Fe(III) and other metals by these hyperthermophiles may provide additional insights into the role of Fe(III) reduction in the evolution of the earliest electron transport chains in microorganisms.