Dissimilatory iron reduction in the hyperthermophilic Archaea Pyrobaculum

Lawrence Frederick Feinberg, *University of Massachusetts - Amherst*

Abstract

Dissimilatory iron-reduction in hyperthermophilic (T_{opt} > 80°C) Archaea appears to be a ubiquitous, conserved, and possibly ancient metabolism that remains largely unknown. This investigation sought to understand the physiological and ecological context for iron respiration by the hyperthermophilic *Pyrobaculum* which are commonly found in terrestrial hydrothermal environments. Iron respiration in *Pyrobaculum* is differentiated from Bacteria by the lack of polyheme *c*-type cytochromes common for the mesophiles *Geobacter* and *Shewanella* , representing a novel model system for studying iron-reducing microorganisms. The overall change in protein pattern and abundance coupled with specific activities of respiratory enzymes such as the nitrate reductase and ferric reductase support the notion that iron respiration in *Pyrobaculum* is a regulated process. In *Pyrobaculum*, the mechanism for electron transfer to insoluble iron oxides seems to vary as *P. aerophilum* and *P. arsenaticum* could reduce iron oxide hydroxide when sequestered by semi-permeable dialysis membrane tubing while *P. islandicum* and *P. calidifontis* required direct contact with iron oxide hydroxide. Iron-grown membrane fractions of *P. aerophilum* only were capable of enzymatic oxidation of the reduced soluble quinone analog 2,6-anthrahydroquinone disulfonate (AHDS), while iron-grown membranes from *P. islandicum* did not show this activity. This suggests that although the ability to reduce iron oxide hydroxides to generate energy is highly conserved within *Pyrobaculum* , the strategies may not be. *Pyrobaculum* species are metabolically diverse microorganisms capable of iron, sulfur, thiosulfate, nitrate, and microaerophilic respiration. To understand how anaerobic respiration and the environment may interact, a range of Eh and pH values were investigated to determine their effect on growth rates in *Pyrobaculum*. Growth rates on sulfur compounds were highest at slightly acid pHs and highly reduced (< -420 mV)

conditions while growth rates on nitrate and iron were highest at neutral to slightly basic pHs and more oxidized (> -210 mV) conditions. Almost all known hyperthermophiles in pure culture to date have been isolated with an electron acceptor other than Fe(III). Therefore, it seems likely that a better understanding towards the diversity, physiology, and biogeochemistry of these hydrothermal microbial communities is likely to be gained by directly isolating hyperthermophiles using Fe(III). Two novel microbes were isolated, purified, and characterized during the course of this study from differing hydrothermal sediments. The first organism originated from a deep-sea hydrothermal vent from the northeast Pacific Ocean and is an obligate iron-reducing autotroph named *Geogemma pacifica*. The second organism investigated was named *Pyrobaculum* strain SP4 and was isolated from the Caribbean island, St. Lucia. These isolates support the notion that dissimilatory iron reduction is common in these environments and further expands the known locations where *Pyrobaculum* species have been isolated thus far. ^

Subject Area

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