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Bioelectrochemical Processes in Some of Earth's most Dynamic Aquatic Environments, and Implications for life on Ocean Worlds (Including Our Own)

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In 1988, scientists discovered that manganese- and iron-reducing bacteria use exogenous solid-phase metal oxides as oxidants for degradation of organic matter by shuttling electrons from central metabolism to outside the cell. These anaerobic microbes –known as dissimilatory metal reducing bacteria (DMRB)– were able to "breathe rust" and manganese oxides, using them as a terminal electron acceptor. This physiological process is called extracellular electron transport (EET), and can be broadly defined as a physiological capacity that enables electrons to be shuttled to or from extracellular metabolic substrates. We now know that these "EET-enabled" microbes influence a number of biogeochemical cycles. The microbial reduction and oxidation of minerals is globally relevant, and drives other elemental cycles, including the carbon cycle, which has significant consequences to our biosphere.

We study the ecological, physiological, and evolutionary aspects of EET among bacteria and archaea, with the overarching goal of understanding how this capacity confers fitness. Our overarching goal is to characterize the diversity and activity of EET-enabled microbes in Earth's most "extreme environments" such as the deep sea hydrothermal vents, as well as the extremely oligotrophic (food scarce) sediments beneath the mid-ocean gyres. To that end we have developed in situ bioelectrochemical systems at deep sea vents, deep-sea gas seeps, and deep-sea oligotrophic sediments. Subsequently, we have studied EET-capable microbes from those environments in the lab, to identify their ecological niche and to understand their contributions to iron, sulfur, nitrogen, and carbon cycling.

Here we will present an overview of our work at hydrothermal vents and hydrocarbon seeps, in which we studied the interactions between microbes (both EET and non-EET microbes) and their associated minerals. Much of our work has focused on understanding the role that microbes play in mineral precipitation (including mineral characteristics), the role of minerals in shaping microbial community structure, and equally important how electrochemical processes shape mineral precipitation, and the potential relevance to the origins of life.