COLLABORATIVE RESEARCH: Characterization of Microbial Transformations in Basement Fluids, from Genes to Geochemical Cycling

Intellectual Merit

Current estimates suggest that the volume of ocean crust capable of sustaining life is comparable in magnitude to that of the oceans. To date, we have little understanding of the composition or functional capacity of microbial communities in the subseafloor, or their influence on the chemistry of the oceans and subsequent consequences for global biogeochemical cycles. This proposal focuses on understanding the relationship between microbial communities and fluid chemistry in young crustal fluids that are responsible for the transport of energy, nutrients, and organisms in the crust. Specifically, we propose to couple microbial activity measurements, including autotrophic carbon, nitrogen and sulfur metabolisms as well as mineral oxide reduction, with quantitative assessments of functional gene expression and geochemical transformations in basement fluids. Through a comprehensive suite of *in situ* and shipboard analyses, the proposed research will yield cross-disciplinary advances in our understanding of the microbial ecology and geochemistry of the subseafloor biosphere. The focus of the effort is at North Pond, an isolated sediment pond located on ridge flank oceanic crust 7-8 million years old on the western side of the Mid-Atlantic Ridge. North Pond is currently the target for drilling on IODP expedition 336, during which it will be instrumented with three subseafloor basement observatories. The proposed work will leverage this opportunity for targeted and distinct sampling at North Pond on two German-US research cruises to accomplish our three main objectives:

1. to determine if different basement fluid horizons across North Pond host distinct microbial communities and chemical milieus and the degree to which they change over a two-year post-drilling period.

2. to quantify the extent of autotrophic metabolism via microbially-mediated transformations in carbon, nitrogen, and sulfur species in basement fluids at North Pond.

3. to determine the extent of suspended particulate mineral oxides in basement fluids at North Pond and to characterize their role as oxidants for fluid-hosted microbial communities.

Specific outcomes include quantitative assessments of microbial activity and gene expression as well as geochemical transformations. The program builds on the integrative research goals for North Pond and will provide important data for guiding the development of that and future deep biosphere research programs. Results will increase understanding of microbial life and chemistry in young oceanic crust as well as provide new insights into controls on the distribution and activity of marine microbial communities throughout the worlds oceans.

Broader Impacts

There are no data about microbial communities in ubiquitous cold, oceanic crust, the emphasis of the proposed work. This is an interdisciplinary project at the interface of microbial ecology, chemistry, and deep-sea oceanography with direct links to international and national research and educational organizations. It leverages on a long-term collaboration between the PIs and collaborators in both the US and Germany, including the recently formed NSF Science and Technology Center entitled “Center for Dark Energy Biosphere Investigations” (C-DEBI) and the NSF Research Coordination Network focused on the deep biosphere. Our work on microbially-mediated geochemical transformations in basement fluids is both attainable and timely, and methods development and results from this work will complement current and future microbial and geochemical investigations on the Juan de Fuca Ridge as part of both IODP and the OOI Regional Scale Node. Our public outreach effort will utilize The Zephyr Education Foundation’s unique marine science program to incorporate a short educational module focused on marine microbiology that will be tailored to the grade levels 7 through college. The module will emphasize the importance of marine microbes to environmental sustainability, human health, and the origin and evolution of life on our planet. The proposed work will also support the research and career development of one graduate student, one undergraduate student, and two postdoctoral researchers. We will strongly encourage our students and postdocs to engage with the larger community of researchers interested in deep biosphere microbiology and chemistry through emerging and existing NSF programs.