RADIOACTIVE HOT SPRINGS AS A MODEL GEOMICROBIOLOGICAL SYSTEM FOR EXOBIOLOGY STUDIES.
T. S. Magnuson[1], J. C. Rask[2], K. F. Bywaters[3], K. A. Counsell[1], J. A. Wilson[1], C. Puschak,[1] M. W. Swenson[1], and D. Viall[1], [1]Idaho State University, Pocatello ID, [2]NASA Ames Research Center, Moffett Field, CA. [3]USRA NPP, NASA Ames Research Center, Moffett Field, CA.

Introduction: Idaho harbors a multitude of unexplored hot springs and thermal areas, many of which have 'multi-extreme' characteristics such as temperature, salinity, and radioactivity [1]. The Worswick Thermal Area (Fig. 1) is a system comprising over 50 distinct sources, including sulfur-rich thermal waters, extreme temperature (80°C) and pH (9.0) conditions, and radioactivity levels 4-5 times above background [2]. Additionally, this system shows meter-scale variability in aqueous and mineral geochemistry, comparable to observations in Yellowstone thermal systems. The goals of our studies were three-fold: First, characterize the aqueous geochemistry of the systems, with emphasis on elemental composition and metal/sulfur determination, second, to isolate and characterize representative microbes that take part in iron, sulfur, and carbon transformation, and third, to determine the source(s) of radiation in the system by surveying individual thermal water sources and surrounding exposed minerals.

Materials and Methods: Aqueous geochemistry was conducted via ICP-MS on thermal waters from the most significant sources and channels. Radiation was measured in the field by use of a micro-R-meter, and both thermal streams and associated minerals were surveyed. Cultivation experiments utilized native hot spring waters as base medium, with carbon/electron donors and acceptors provided as amendments. Native biofilms and enrichments were analyzed by protein extraction and metaproteomic analysis.

Results and Conclusions: Potential sources of radioactivity include Thorium, Uranium, and Radon, and there is a correlation between temperature of spring and radioactivity, suggesting that radiation conditions vary among features and temperatures. Distinct total sulfur and iron gradients occurred along the outflow channel flowpaths, due to inputs from input from springs high in S and Fe. This correlates with occurrence of sulfidic sediments along outflow streams. Enrichments show activity in reduction of both soluble and mineral phase Fe substrates. Complex carbon sources were readily utilized by aerobic isolates. 16S rRNA gene analysis of isolates revealed thermophiles in the *Geobacillus*, *Bacillus*, and *Anoxybacillus* genera, related to isolates from other thermoalkaline springs and high-radiation regimes. Acetate- and Hydrogen-oxidizing, Fe-reducing consortia were also obtained, and demonstrated production of magnetite (a biosignature) when grown on solid-phase Fe minerals. Metaproteomic analysis of microbial mat extracellular material revealed c-type cytochromes and a variety of other proteins, representing potential mechanisms for extracellular Fe and S transformation in biofilms. Our investigations into this system have revealed a biogeochemistry that supports microbial metabolisms linked to carbon, iron and sulfur, abundant phototrophic microbial mats, and a variety of geomicrobiological processes carried out by a diverse microbial community, thus representing a new resource for research in astrobiology and exobiology.

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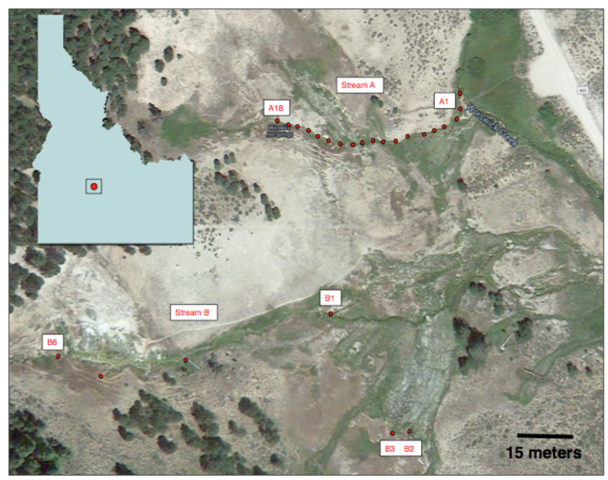

Figure 1. Location and layout of the Worswick Thermal Area, Idaho. Stream 'A' is the most radioactive, while stream 'B' has the highest overall sulfur concentration.

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[2] Rask, J. C., Bywaters, K. B., Magnuson, T. S., (2016) *Proceedings of the Sixth Mars Polar Science Conference, abstract 6110.*