WORSWICK HOT SPRINGS: A RADIOACTIVE HYDROTHERMAL FIELD SITE.

J. C. Rask[1], K. F. Bywaters[2], and T. S. Magnuson[3], [1]NASA Ames Research Center, Moffett Field, CA, 94035, jon.c.rask@nasa.gov, [2]Honeybee Robotics, Altadena, CA 91101, [3](Deceased) Formerly of the Department of Biological Sciences, Idaho State University, Pocatello, ID, 83209.

Introduction: We report on a systematic characterization of the environmental conditions at Worswick Hot Springs, a hydrothermal system in Idaho, USA. (Figure 1).

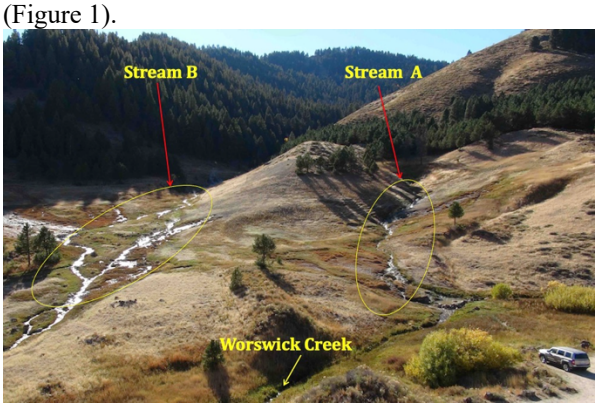

Figure 1. The Worswick Hot Springs field site.

Because localized "hot spots" of elevated radiation and biofilms are easily accessible, various biological studies of radiation resistance and biosignature formation are possible, making this fieldsite relevant for analog field studies that consider microbiology, geochemistry, and ionizing radiation. In addition to Worswick being a natural radiation biology laboratory that may also be relevant for space biology applications, we assert that these unusual environmental conditions may inform us about locations on Mars that are also enriched in radioactive elements and their potential for hosting biosignatures.

Methods: We carried out repeated temperature and radiation measurements at the same hot spring locations to observe the system over time (Figure 2). *Radiation:* A Bicron Micro Analyst micro-r-meter (Bicron NE, Saint-Gobain Industrial Ceramics, Inc.) capable of sensing x-rays and gamma-rays (0-5000 µR/hr), was used to gather radiation data at twenty-four locations around and above the region of the two main stream channels. *Water Temperature:* A digital hand-held infrared thermometer (Oakton WD-39642-00 Mini-Temp Tester) was used for all measurements. *ICP-MS aqueous geochemistry:* Water samples were analyzed at the ISU Center for Archaeology, Materials and Applied Spectroscopy (CAMAS).

Results: We have discovered localized areas of elevated radiation that are approximately 4 to 5 times greater than background radiation, and we have observed that both radioactivity and temperature of the spring waters vary over time. ICP-MS reveal the presence of thorium and uranium, which are correlated with elevated radioactivity. Several point sources of elevated radioactivity have been identified in both Stream A and Stream B.

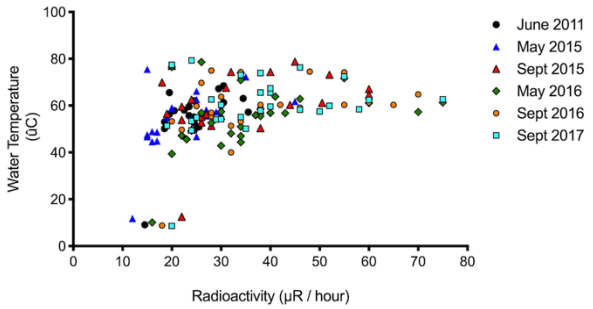

Figure 2. Radioactivity and water temperature data from Worswick. Background radiation and upstream cold stream temperature measurements appearing in the lower left serve as a baseline.

Summary: We have been unable to find a record that documents the presence of radioactivity around Worswick Hot Springs, despite detailed characterization of its waters and local hydrothermal systems [1]. We believe our work represents the discovery of radioactivity at Worswick Hot Springs. A correlation between temperature and radioactivity may exist at Worswick, and the aqueous geochemistry results indicate that thorium and uranium are likely sources of the radioactivity.

With regard to radioactive hot springs as a model geomicrobiological system for exobiology studies, we assert that elevated radioactivity in a hot spring on Earth serves as an analog environment for hot springs on other planetary bodies with thinner atmospheres and elevated levels of radiation on their surfaces [2][3]. For example, thorium enriched areas of Acidalia Planitia on Mars occur in an area that contains more than 40,000 circular mounds with associated lobate and flow-like features, which suggests possible widespread and extensive mud volcanism [4]. A study of the habitability of these features as it relates to in situ radionuclides is warranted, and may prove useful in regard to site selection criteria for future life detection missions.

Acknowledgements: This work was supported by the NASA Exobiology and Evolutionary Biology Program Element, and thank John V. Dudgeon for ICP-MS analyses.

References: [1] Mariner, R.H., et. al. (2006) *Geoth*. 35(1):3-25. [2] Rask, J.C., et.al., (2016) Sixth Mars Polar Sci Conf, 6110. [3] Ruff, S. W., Farmer, J., (2016) Ncomms, 7:13554. [4] Oehler DZ, Allen CC, (2010). Icarus. Aug 1;208(2):636-57.