HYDROTHERMAL MINERAL PRECIPITATES AS HABITABLE ENVIRONMENTS: A SYNERGISTIC IMAGING, RAMAN, AND LIBS APPROACH TO EXPLORING UNDERWATER CHIMNEY MATERIALS. P. Sobron[1], L. M. Barge[2], M. J. Russell[2], R. Price[3], T. Schneiderman[4], K. Takai[5], M. Yamamoto[5]. [1]SETI Institute Carl Sagan Center, [2]Jet Propulsion Laboratory, California Institute of Technology, [3]Stony Brook U., [4]Ohio State U., [5]JAMSTEC. Contact: psobron@seti.org

Introduction: Hydrothermal mineral precipitates can serve the following functions with respect to habitability at seafloor interfaces: they can 1) concentrate the organics, phosphates and other biologically relevant components exhaling from the subsurface; 2) can catalyze redox chemistry; and 3) serve as electron donors/acceptors for life, transfering electrons directly to/from minerals in the matrix from cell to cell. In order to understand the energetic environment in a hydrothermal system, techniques are needed that are capable of analyzing minerals as well as their elemental compositions rapidly and without altering the sample.

Analytical Approach: We have identified a highly synergistic suite of techniques capable of such integrated rapid, *in situ* mineralogical and geochemical characterizations: Visual Micro-Imaging (VMI) + Laser Raman spectroscopy (LRS) + laser-induced breakdown spectroscopy (LIBS). VMI provides high-resolution visible imagery of targets and self-location information to precisely synchronize/coordinate the pointing of the spectroscopic sensors. LRS analyzes energy shifts of laser-excited molecules, identifies mineral phases by their vibrational modes, and detects fluorescence of organics. LIBS ablates material to form a plasma, observes atomic emission lines, and derives elemental abundance. Using these techniques, we describe the laboratory characterization of returned deep-sea black smoker and alkaline chimney materials.

Results and Implications: Fig. 1 shows five representative datasets of black smoker samples Oki-1 and Oki-2 [1] recorded on different regions. The LRS data are consistent with sulfides containing variable amounts of iron and other metals, *e.g.* Zn, Ni, and Mn. LIBS data detect these metals and constrain their relative abundance. The synergistic use of VMI, LRS, and LIBS determines the presence of sphalerite, isocubanite, chalcopyrite, and other polymetallic sulfides as well as sulfur, anhydrite, and gypsum. Our results demonstrate the feasibility of using VMI+LRS+LIBS for characterizing the mineralogy of seafloor hydrothermal systems. These techniques offer a strategic advantage for the exploration of deep-ocean hydrothermal systems on Earth and other planets related to biogeochemistry and origin-of-life research.

Reference: [1] Sobron et al 2014 *GeoRaman* abs. 5102.

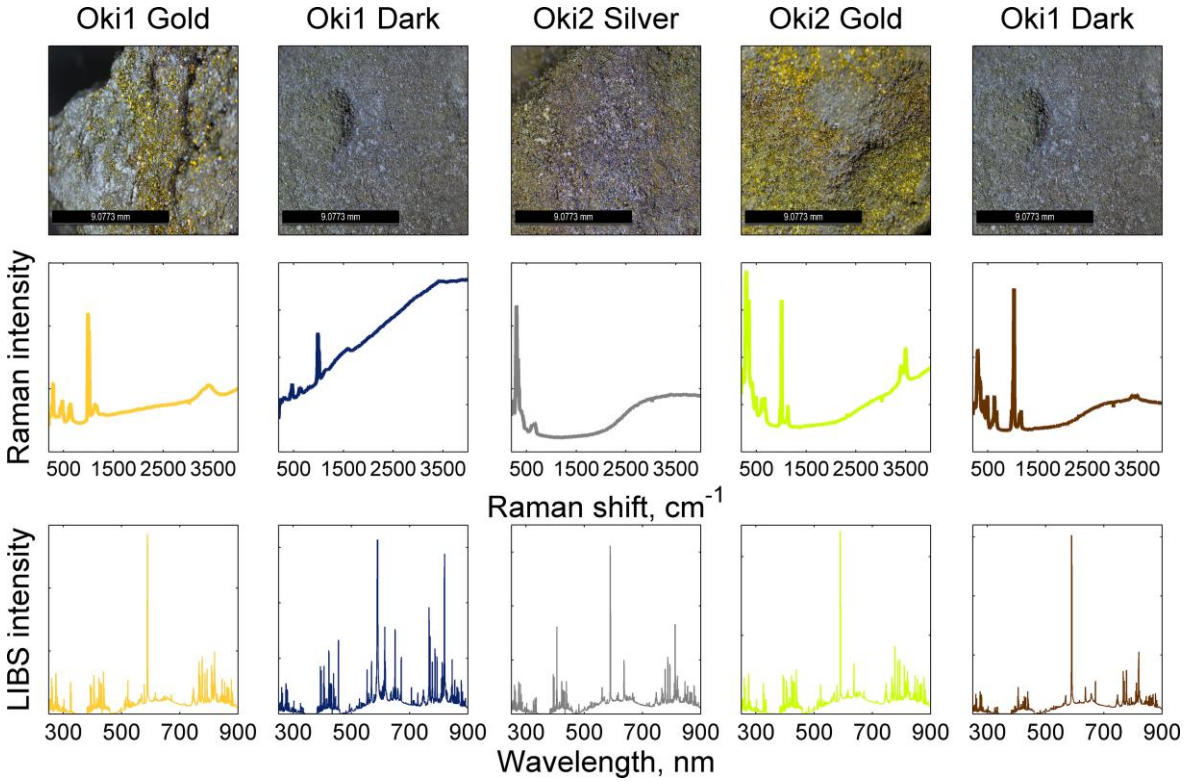

Figure 1. Co-registered VMI, LRS, and LIBS datasets of black smoker materials. VMI are 100ms exposures. LRS are <30s exposures. LIBS are <1s exposures. Spectra are intensity-scaled for visualization purposes. The analyzed areas are in the the center of the VMI. Laser spot diameter is 50 and 200 µm for LRS and LIBS, respectively.