

**CHARACTERIZING HAWAIIAN BASALTIC HYDROTHERMAL ALTERATION USING FIELD PORTABLE AND LABORATORY TECHNIQUES.** K. E. Young<sup>1,2</sup>, M. H. Yant<sup>3</sup>, A. D. Rogers<sup>3</sup>, C. A. Evans<sup>4</sup>, J. E. Bleacher<sup>2</sup>, A. McAdam<sup>2</sup>, and T.D. Glotch<sup>3</sup>, <sup>1</sup>CRESST/University of Maryland, College Park, MD, 20742; <sup>2</sup>NASA Goddard Space Flight Center, Greenbelt, MD, 20771; <sup>3</sup>Stony Brook University, 255 Earth and Space Sciences Building, Stony Brook, NY, 11794-2100; <sup>4</sup>NASA Johnson Space Center, Houston, TX, 77058; corresponding author email: Kelsey.E.Young@nasa.gov

**The RIS<sup>4</sup>E Field Team:** The Remote, In Situ and Synchrotron Studies for Science and Exploration (RIS<sup>4</sup>E) team is a node of the Solar System Exploration Research Virtual Institute (SSERVI), led out of Stony Brook University. While RIS<sup>4</sup>E as a whole focuses on numerous aspects of the exploration of the Moon and small bodies, Theme 2 (the field team) specifically investigates the integration of field portable instruments into planetary field geology [1,2]. Through fieldwork at the December 1974 (D1974) flow at Kilauea Volcano, HI, we are conducting fieldwork that combines data products from a variety of field instruments and is designed to characterize the morphology, chemistry, and mineralogy of the D1974 flow.

**Field Instrumentation:** The RIS<sup>4</sup>E team selected field instruments designed to answer a variety of science questions. To look at chemistry and mineralogy, we deployed a portable x-ray diffraction instrument (XRD) [3], a handheld x-ray fluorescence (hXRF) spectrometer [4], and an infrared spectral camera [5, this meeting]. To look at flow emplacement and morphology, we deployed a portable light detection and ranging (LiDAR) instrument [6] and a kite-based imaging system [7] to provide context. In this study we focus only on data taken with the hXRF as well as laboratory thermal- and visible/near-infrared data.

**The Field Site:** The D1974 flow is located in the southwest rift zone on the Kilauea Volcano. It erupted over eight hours in a series of en echelon fissures on December 31, 1974. The flow was emplaced over previously-existing flow topography and was constrained by a fault system to the southwest. It has been established as a good planetary analog due to its composition, climatic conditions, alteration products, and flow morphology and emplacement style [8]. While the RIS<sup>4</sup>E team seeks to use our chosen instrument suite to address a variety of science questions, this study specifically will focus on the nature of hydrothermally-altered basalt found within the study area.

**The Solfatara and Hawaiian Fumarolic Alteration:** A number of studies have centered around various alteration products that form in the Hawaiian volcanic environment [9,10,11]. The D1974 study area contains several examples of hydrothermally-altered basalt found around degassing fumaroles. The resulting alteration products are similar to certain sulfur- and

silica-rich alteration sites on the martian surface. Several potential formation processes for these alteration products have been discussed [i.e. 9,10, etc.], including local leaching and dissolution, precipitation, and general alteration as a result of local environmental conditions (i.e. the active Kilauea plume lies predominantly directly over the D1974 flow). Our study builds off this previous work. Here we highlight results from one of our field instruments as well as show preliminary laboratory spectral data from samples taken from hydrothermally-altered basaltic outcrops at the D1974 flow (Figure 1).



**Figure 1:** Field photos showing examples of hydrothermally-altered basalt at the D1974 flow.

**Solfatara Data:** Data was taken on a number of samples analyzed from the area surrounding the hydrothermally-altered degassing vent. Thirteen sites were chosen for analysis with an Olympus DELTA handheld x-ray fluorescence analyzer. The degree of alteration varied widely over the site of interest, as shown by the diverse surface textures and visual properties in Figure 1. The data are shown in Figure 2. Thermal infrared and visible/near-infrared (TIR and VNIR, respectively) spectral data were obtained at Stony Brook University and the results are shown in figures 3 and 4 below [12,13].

**Figure 2 (below):** Handheld x-ray fluorescence (hXRF) data taken from 13 Hawaiian altered basalt samples. Sample clustering is as follows. Group 1: HI\_15\_Solf\_002\_3, HI\_15\_Solf\_003\_2; Group 2: HI\_15\_MHY\_001, HI\_15\_MHY\_002a, HI\_15\_MHY\_003, HI\_15\_MHY\_005, HI\_15\_MHY\_006, HI\_15\_MHY\_007a, HI\_15\_Solf\_003\_3; Group 3: HI\_15\_SOLF\_001\_1, HI\_15\_SOLF\_001\_2, HI\_15\_SOLF\_002\_1, HI\_15\_SOLF\_002\_2. These

groupings were determined using a minimum distance clustering algorithm on the handheld XRF data.

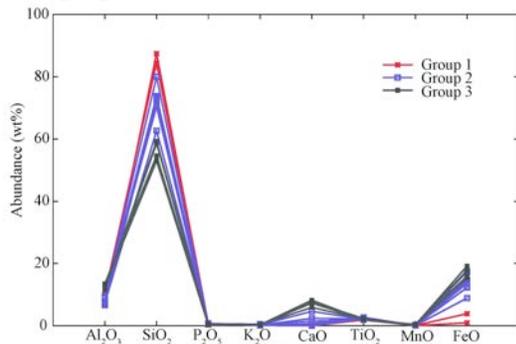


Figure 3 (below): Laboratory TIR Results [12,13].

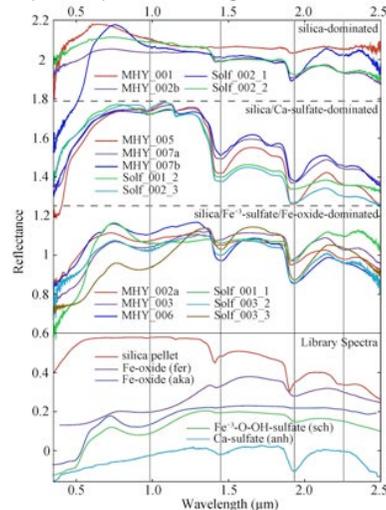
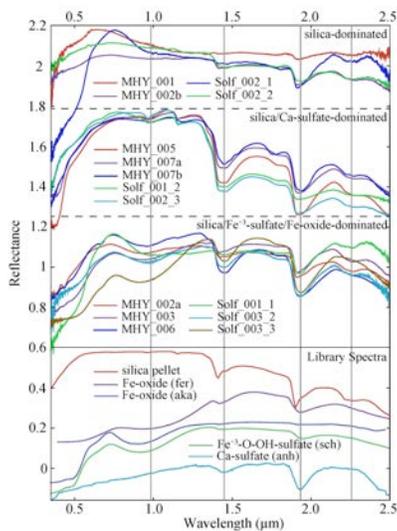


Figure 4 (below): Laboratory VNIR Results [12,13].



**Discussion:** As shown in Figures 2, 3 and 4, the classification of hydrothermally-altered materials at the D1974 site by all three techniques is not well-correlated across the methodologies. While all three

techniques highlighted a strong Si signature (which is expected in this type of volcanic environment), they did not detect similar groupings within the analyzed samples. This could be due to differences in the spatial resolution and sensitivity in each technique. The XRF has a negligible penetration depth, making it very susceptible to detecting changes in the surface chemistry of a sample of interest. These alteration sites have high variability in elements such as Al, Ca, Ti, and Fe. While the hXRF can resolve these small differences, they are harder to detect at the IR wavelengths. This suggests that each instrument and technique can perhaps inform us about a range of processes taking place in these alteration environments. Developing an instrumentation suite that is capable of interrogating both the bulk rock composition as well as more localized differences in alteration products is important in the exploration of these hydrothermally-altered terrains.

**Moving Forward with RIS4E:** As the hXRF data show wide variety in the element chemistry at these hydrothermally-altered locations, more analyses are needed to fully understand the chemical diversity at this field site. Additionally, we seek to develop an ongoing and better understanding of how techniques like XRF, TIR, and VNIR can interact together to form a complete picture of an analog field site. These data will also be integrated with XRD and SEM (scanning electron microscope) data in an attempt to link mineralogy to some of this small scale chemical variability. Additional fieldwork will take place, both at the D1974 flow as well as at the Potrillo Volcanic Field, NM, where complex xenoliths will add new layers of chemical complexity designed to test the limits of our instrumentation suite.

**References:** [1] Glotch T. D. et al. (2015) *Lunar Planet. Sci. XLVI*, Abstract #2178. [2] Young K. E. et al. (2015) *AGU 2015*, Abstract #P44A-06. [3] McAdam A. et al. (2015) *AGU 2015*, Abstract #P31A-2034. [4] Young K. E. et al. (2015) *Lunar Planet. Sci. XLVI*, Abstract #1658. [5] Ito G. (2016) *Lunar Planet. Sci. XLVII*, this meeting. [6] Whelley P. et al. (2015) *AGU 2015*, Abstract #P31A-2050. [7] Scheidt S. et al. (2015) *AGU 2015*, Abstract #P42A-08. [8] Young K. E. et al. (2015b) *AGU 2015*, Abstract #P31A-2049. [9] Minitti M. E. et al. (2007) *Jour. Geophys. Res.*, *112*, E05015. [10] Seelos K. D. et al. (2010) *Jour. Geophys. Res.*, *115*, E00D15. [11] Chemtob S. M. (2010) *Jour. Geophys. Res.*, *115*, E04001. [12] Yant M. H. et al. (2015) *AGU 2015*, Abstract #P31A-2052. [13] Yant M. H. et al. (2016) *in preparation*.