MARS ANALOGUE FIELD STUDIES AT HAWAI'I: USING BULK CHEMISTRY TO DISENTANGLE IGNEOUS, SEDIMENTARY, AND ALTERATION PROCESSES. J. A. Berger[1*], M. E. Schmidt[2], D. W. Ming[1], R. V. Morris[1]. [1]NASA Johnson Space Center, Houston, TX, USA; [2]Brock University, St. Catharines, ON, CAN; *jeffrey.a.berger@nasa.gov.

Introduction: Unraveling the varied geologic processes recorded in martian rocks and soils is a challenge for Mars rover missions. To improve our interpretations of Mars rover data, we have conducted analogue field studies at Kohala and Maunakea*, Hawai'i. The two volcanoes are comprised of rocks with compositions similar to the martian surface and analogous geologic processes have occurred on Hawai'i [e.g., 1-3]. We present selected results and discuss the implications for interpreting Mars rover data.

Methods: Multiple site visits to the Maunakea summit were conducted over 1995-2000, and volcanic materials altered by acid-sulfate and hydrothermal processes were sampled [1]. A field campaign at Kohala and Maunakea was carried out in 2015 to collect unaltered lavas, weathering profiles, and glacial, aeolian, alluvial, and fluvial sediment. Our approach was to sample materials that recorded igneous evolution, sedimentary sorting and/or mixing, and the elemental gains and losses and mineralogical changes that can occur with alteration of the igneous parental rock. We present one of multiple analytical techniques employed: XRF elemental analyses that are comparable with the APXS instruments on the MER and MSL rovers and PIXL on the Mars 2020 rover.

Results and Discussion: The unaltered (parent) samples cover the full range of igneous compositions observed at Kohala and Maunakea [4]. We use these parent compositions to evaluate relative changes caused by chemical alteration and sedimentary processes.

Chemical alteration: Hydrolytic alteration due to surface water is common on Hawai'i, as typified by weathering profiles (Fig. 1a). Mildly acidic water (pH ~6.5) dissolves material, removing soluble elements and leaving insoluble elements in the residue. The solubility of elements changes under acid-sulfate conditions (Fig. 1b). The resulting element ratio patterns are distinct and diagnostic for the type of alteration, which can be used to identify similar processes on Mars.

Sedimentary mixing: Sediment on the southwest flank of Maunakea preserves the composition of the parent volcanics (Fig. 2). At elevations >3000 m, the higher Al/Ti of the younger volcanics is reflected in the sediment. Sediment below outcrops of older basalt reflects the mixing of material with high Al/Ti and low Al/Ti together to form deposits with intermediate Al/Ti. On Mars, physical sedimentary mixing can act in a similar manner to create intermediate compositions that may not occur in igneous systems. This concept is useful because rovers do not necessarily encounter the parent material directly; knowing how relevant processes operate on Earth can enable inferences about martian sedimentary source regions from limited data.

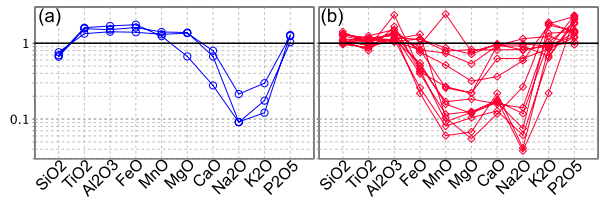

Figure 1: *Oxide ratio plots for (a) a hydrolytic weathering profile and (b) acid-sulfate altered tephra. Oxides are normalized by the unaltered parent material so that element gains and losses are higher and lower than 1, respectively.*

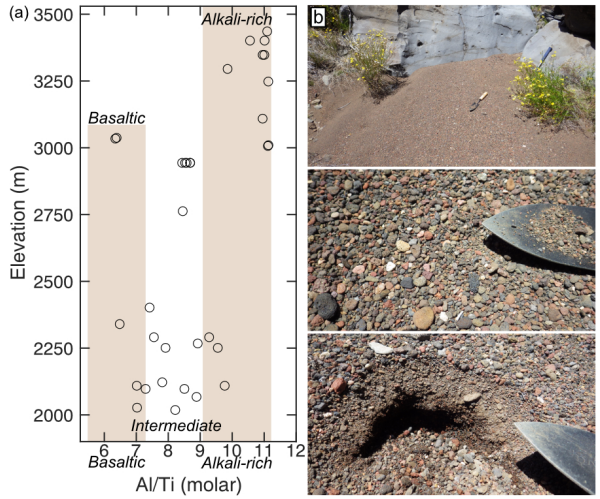

Figure 2: *(a) Al/Ti of sediment at different elevations on the southwest flank of Maunakea. Outcrop of the older basaltic parent (lower Al/Ti) and younger alkali-rich parent (higher Al/Ti) are indicated by shading. (b) Representative sand/gravel sediment deposit on Maunakea.*

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References: [1] Morris et al. (2000) *JGR, 105, E1*, 1757-1817. [2] Stolper et al. (2013) *Science, 341, 6153,* 1239463. [3] Berger et al. (2020) *Icarus, 345,* 113708. [4] Wolfe et al. (1997) *USGS* (1557) 1-129.

* The single word spelling is recommended by UH Hawaiian language experts.