A THERMAL EMISSION STUDY OF HAWAIIAN FOIDITE ROCKS AND COMPARISON TO TES DATA OF MARS.
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Introduction: Recent work suggests that some deposits on Mars may have low silica contents that classify them as foiditic rocks [1, 2]. Currently, the ASU spectral library does not include spectra of feldspathoid minerals or foidite rocks. This paper presents thermal infrared spectra of silica-undersaturated rocks, including foidites, from the Honolulu Volcanic (HV) suite. This will allow us to compare spectra of deposits with derived bulk composition of foidites to lab spectra.

Background: We studied low albedo (LA) deposits in the floors of craters within the Amazonis Planitia region using infrared data from Mars Global Surveyor Thermal Emission Spectrometer (TES) [2]. These deposits are found within subdued to sharp-rimmed craters that impacted into proposed thick basaltic lava flows from Olympus Mons that flooded the region and were subsequently eroded by aeolian processes [3]. Their presence in a relatively dusty region may reveal information about the underlying rock composition. TES spectral modeling of the LA deposits reveal a mineralogy that is dominated by mafic minerals (pyroxene, olivine) with a derived bulk chemistry that ranges from ultramafic to mafic (~40-52 wt. % SiO_2) in composition [2]. These bulk compositions are comparable to some Martian lithologies, but represent some of the lowest silica contents identified on Mars. In fact, some LA deposits have derived bulk compositions with silica and alkali contents low enough to classify them as foidite rocks. The inclusion of feldspathoids in place of feldspars that the silica content of foidite rocks.

Examination of the LA deposit models revealed that their low silica content resulted from magnetite abundances (15-25%) higher than expected for mafic or ultramafic rock (<5%). However, magnetite might be erroneously modeled if there were slight errors in the temperature determination used to convert TES data to emissivity (perhaps due to mixing of disparate surface temperatures in regions where cold dusty areas are adjacent to warmer LA deposits) [1, 2]. Even when magnetite is removed from the models entirely, the bulk compositions of LA deposits still overlap into the foidite field [1, 2].

For deposits with such low silica contents, it would be appropriate to compare their spectra to terrestrial foidite spectra and to model their mineral abundances using library feldspathoid spectra in addition to (or in place of) feldspars.

Samples: The HV suite includes small volume, late-stage vent eruptions along rifts cutting the Koolau tholeitic shield on Oahu, Hawaii [4]. The HV rocks includes alkali olivine basalt, basanite, nephelinite and nepheline melilitites derived by partial melting of a garnet lherzolite source [4] and all rocks are undersaturated with respect to silica [5]. The samples for this study were selected to represent the full compositional range, varying from 36.1 to 46.1 wt. % SiO_2 (average = 41.4 wt. % SiO_2) as shown in Figure 1.
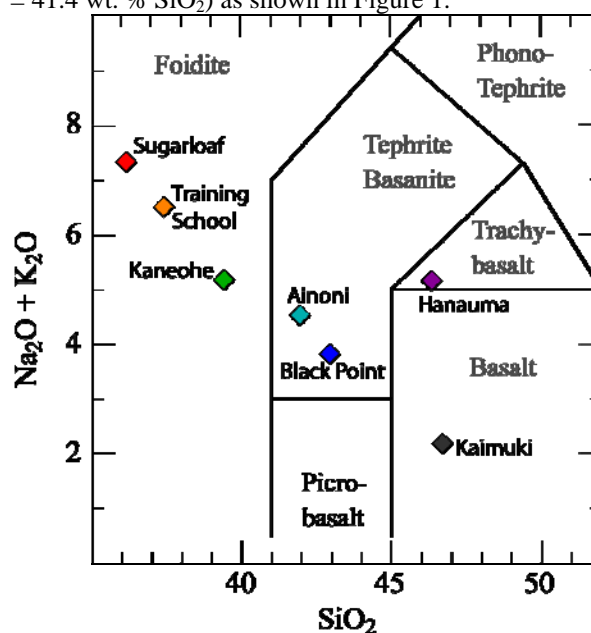

Figure 1: HV foidite measured compositions from this study [6] plotted on a total-alkali silica (TAS) diagram.

Methods: We collected thermal infrared (TIR) spectra for the HV foidite samples using the University of Hawaii's Nicolet 470 FTIR spectrometer following the method of [7] to derive emission spectra. Data were acquired at 2 cm^{-1} spectral sampling and convolved to the 10 cm^{-1} spectral sampling of TES for comparison to LA deposit spectra of foiditic composition. Figure 2 displays laboratory spectra for six of the foidite samples.

Foidite spectra were then modeled via the linear least-squares method of [8] to identify mineral composition. This approach fits the measured TES apparent emissivity spectrum using a spectral library mineral spectra (feldspar, pyroxene, olivine, oxide, phyllosilicates) and glass spectra that were previously used to model the LA deposits [2].
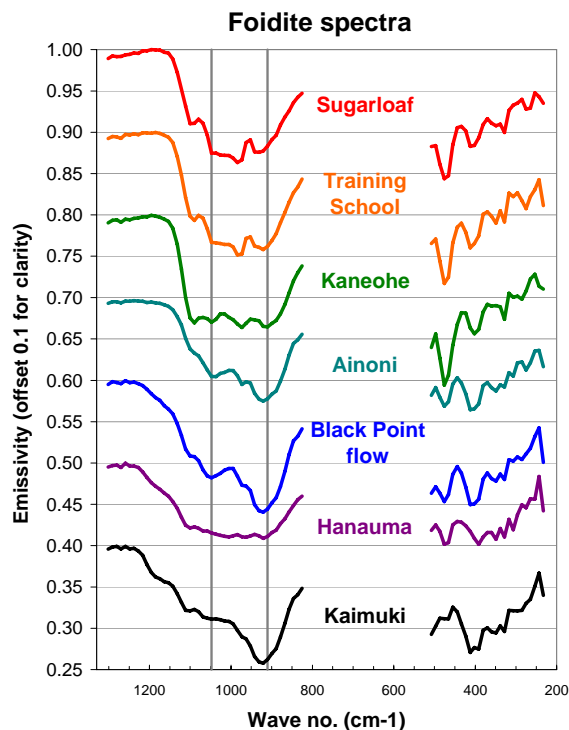
Foidite spectra

Figure 2: Lab emissivity spectra of HV foidite samples (increasing wt.% SiO$_2$ from top to bottom). Vertical lines indicate spectral absorptions of LA deposits.

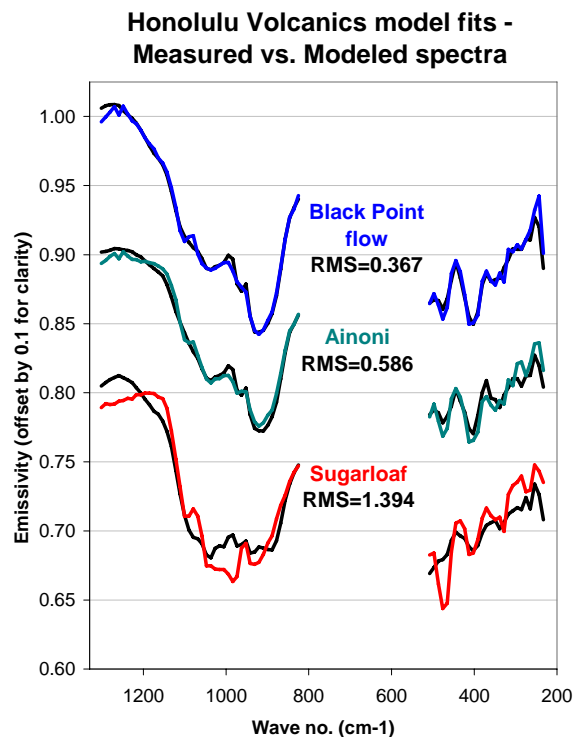## Honolulu Volcanics model fits - Measured vs. Modeled spectra

Figure 3: Measured spectra (color) vs. modeled spectra (black) for three samples with the best (Black Point flow), average (Ainoni) and worst (Sugarloaf) fits.

Results: Spectra of the HV suite are shown in Figure 2. Some of the higher silica rocks have spectra that resemble spectra of the Amazonis LA deposits surface spectrum, including two main absorptions located at ~997 and 1147cm^{-1} (vertical gray lines in Fig. 2). The best fits occur for rocks that overlap with the compositional field of the LA deposits (e.g., Black Point flow).

Like the Amazonis LA deposits, TES spectral modeling of the HV suite reveals a mineralogy that is dominated by mafic minerals (pyroxene, olivine) with lesser amounts of plagioclase feldspar. In addition, the pyroxene component is dominated by clinopyroxene variety. The models have RMS errors ranging from 0.367 to 1.394 (average RMS=0.811 ± 0.440). Samples with compositions that overlap the LA deposit compositions (Kaimuki and Black Point flow) have lower RMS errors (0.473 and 0.367, respectively). Samples with have the lowest silica (i.e., Sugarloaf and Training School) have very high RMS errors (1.394 and 1.367, respectively).

Discussion: Visual inspection of the modeled spectra reveal passable fits for some rocks (e.g., Black Point flow) to very poor fits for other rocks (e.g., Sugarloaf) as shown in Figure 3. In fact, the models for the lowest silica rocks have very low quality fits, with large residuals between their measured and modeled spectra (Fig. 3). Indeed, these rocks are melilite-bearing nephelinites, so the spectral library lacks mineral spectra of their dominant component. Clearly, a different mineral library is required to model such low silica rocks and satisfactory model fits probably require feldspathoid (or other) minerals. More importantly, knowledge of the TIR spectral shape of foidites and feldspathoid minerals might allow us to identify this unique rock on Mars in TES data.

Future work: Additional mineral libraries will be constructed in an attempt to improve the model spectral fits of foidite spectra. We will evaluate the need for acquiring spectra of feldspathoids for the TES spectral library to improve the spectral model fits of the HV suite and the Amazonis LA deposits.

References: [1] Schneider & Hamilton (2006) *JGR, 111, doi:10.1029/2005JE002611.* [2] Stockstill-Cahill *et al.* (2007) *JGR, accepted.* [3] Morris & Dwornik (1978) *I-1049 (MC-8).* [4] Clague & Frey (1982) *J. Petrology, 23,* 447-504. [5] Macdonald *et al.* (1983) *Volcanoes in the Sea: The Geology of Hawaii,* 528 pp. [6] Fekiacova *et al.* (2007) *EPSL, 261,* 65-83. [7] Ruff, S. W. *et al.* (1997) *JGR, 102,* 14,899-14,913. [8] Ramsey & Christensen (1998) *JGR, 103 (B1),* 577-596.