

THERMAL EMISSION MEASUREMENTS OF FOIDITE ROCKS: POSSIBLE MARTIAN LITHOLOGIES. K. R. Stockstill-Cahill^{1,2}, P. G. Lucey¹, G. J. Taylor¹ and D. Blake³ ¹University of Hawaii at Manoa, HIGP, 1680 East-West Road, POST 602B, Honolulu, HI 96815, ²kstockst@higp.hawaii.edu. ³MS 239-4, NASA Ames Research Center, Moffett Field, CA 94035-1000

Introduction: A TES spectral study of low albedo (LA) deposits within the Amazonis Planitia of Mars revealed that the derived bulk composition of these deposits contain very low silica contents (Fig. 1), classifying some of the deposits as foidites [1]. A foidite is an igneous rock in which feldspathoid minerals constitute $\geq 60\%$ of the light-colored mineralogy; it is the inclusion of feldspathoids in place of feldspars that lowers the silica content of these silica-undersaturated rocks. Currently, the TES spectral library lacks spectra of feldspathoid minerals and so none were available for the spectral unmixing of these deposits. To assess the significance and effect of unmixing spectra of silica-undersaturated rocks without feldspathoid spectra, we conducted a subsequent thermal emission study of the Honolulu Volcanic (HV) series, which include samples ranging from foidite to basalt (Fig. 1).

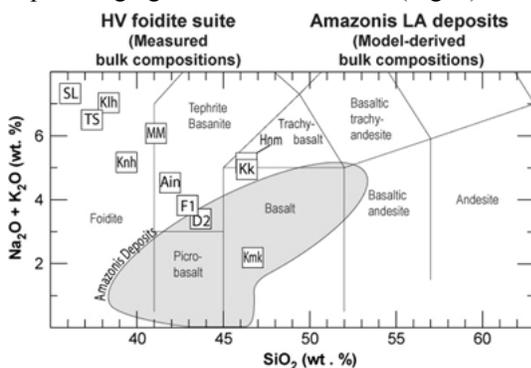


Figure 1: Laboratory-measured bulk compositions for the Honolulu Volcanics (squares) plotted against the model-derived bulk compositions for the Amazonis LA deposits (gray field).

Methods: We collected thermal infrared (TIR) spectra for the HV foidite samples using a Nicolet 470 FTIR spectrometer (currently at SWRI) following the method of [2] to derive emission spectra. Spectra 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 representative HV lab spectra and Amazonis LA deposit spectra, both with 10 cm^{-1} spectral sampling. (Samples/spectra were selected to represent the full compositional range displayed by the HV suite and Amazonis LA deposits.)

Foidite spectra were also modeled using the linear least-squares method [3] using the same spectral li-

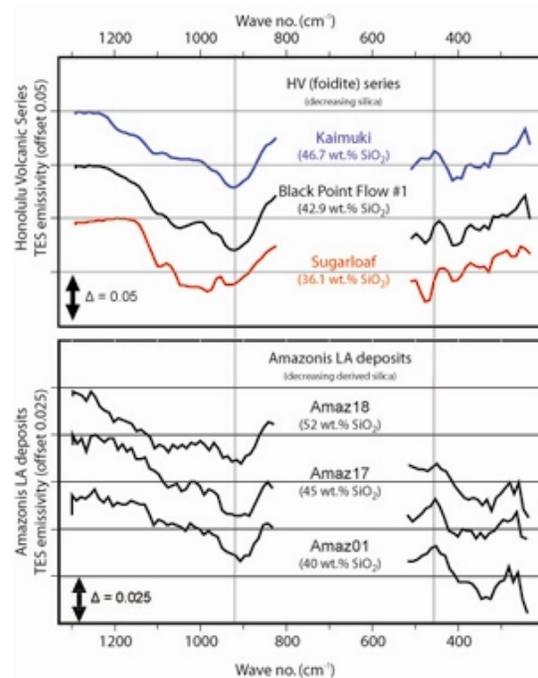


Figure 2: Representative spectra for the HV suite (top box) compared to representative spectra for the Amazonis LA deposits (bottom box). Note that the all spectra have a characteristic emissivity minimum ($\sim 910\text{ cm}^{-1}$) and peak ($\sim 450\text{ cm}^{-1}$), shown by vertical lines.

brary as used to model the Amazonis LA deposits. This approach fits the measured TES apparent emissivity spectrum using a spectral library mineral spectra (feldspar, pyroxene, olivine, oxide, and phyllosilicates) and glass spectra [1].

Equivalent bulk rock chemistries are derived by combining known electron microprobe-measured compositions (wt. % oxides) of the minerals in proportion to the abundances derived from the linear least squares model, providing a bulk composition in terms of oxide abundances [4-6]. Each deposit was assigned to a lithologic class using the total-alkali silica (TAS) diagram [7]. In general, derivation of bulk rock chemistry from linear least squares models and subsequent classification have been demonstrated to be accurate, especially when supplemented by comparisons to library rock spectra [4, 8]. The mineral abundances for each individual spectrum were converted to major oxide abundances, and the error propagated in quadrature, to calculate the standard deviations for the mean oxide abundances for a given crater.

XRD analysis was also used to determine mineral content for the most mafic rock. The diffraction pattern was quantified using Rietveld refinement [9]. This analysis allows determination of abundances of minerals present at levels greater than about 1 wt. %, and the abundance of silicate glass [10-11].

Results: Like the Amazonis LA deposits, TES spectral modeling of the HV series reveals a mineralogy that is dominated by mafic minerals (pyroxene, olivine) with lesser amounts of plagioclase feldspar. Visual inspection of the modeled spectra (gray spectra in Fig. 3) reveal passable fits for rocks containing lesser amounts of feldspathoids (e.g., Kaimuki, Kmk, and Black Point flow, F1, in Fig. 3) to very poor fits for rocks containing abundant feldspathoids (e.g., Sugarloaf, SL in Fig. 3). In fact, the models for the lowest silica rocks have very low quality fits, with large residuals between their measured and modeled spectra. Indeed, many of these rocks are melilite-bearing nephelinites, so the spectral library lacks mineral spectra of a significant mineral component.

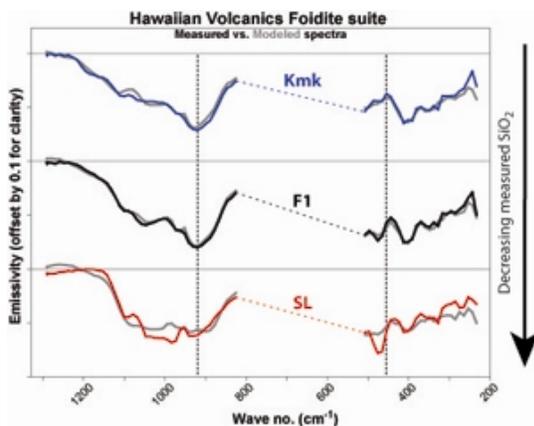


Figure 3: Measured (colored line) vs. Modeled (gray line) spectra for the HV series rocks. Three representative sample spectra (Kaimuki, Black Point Flow #1, & Sugar Loaf) are shown in bolder colored lines.

The poor fit is also apparent when we compare their model-derived bulk composition to their measured bulk compositions (Fig. 4). When modeled with a spectral library lacking feldspathoid minerals, the model-derived compositions in general have higher silica/lower alkali content from linear least squares models. Even samples that overlap the Amazonis LA deposits, such as Kaimuki and Black Point Dike #2 (Kmk and D2, respectively, in Fig. 4), show significantly different model-derived bulk compositions relative to their measured bulk composition. Clearly, a different mineral library is required to model feldspathoid-bearing, low silica rocks to obtain satisfactory model results with respect to spectral and compo-

sitional fits. Indeed, the XRD analysis confirm that the most mafic rock (Sugar Loaf) contains nepheline and leucite (Figure 5); lacking these major constituents would lead to poor spectral fits. If feldspathoid-bearing rocks/deposits exist on Mars, we would be unable to recognize them with the mineral spectra currently available to TES data users.

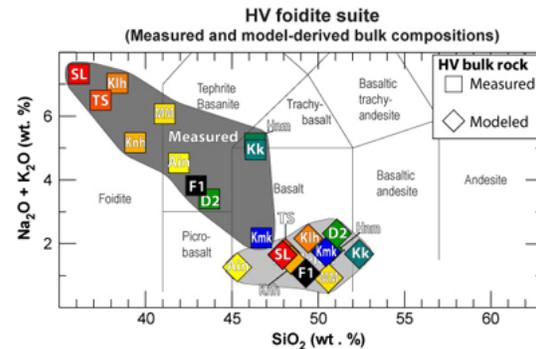


Figure 4: Measured (squares) vs. Modeled (diamonds) compositions for the HV series of rocks. The three representative samples are shown in red (Sugar Loaf), black (Black Point Flow #1) and blue (Kaimuki).

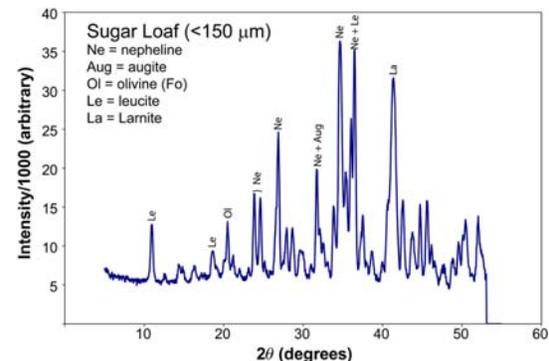


Figure 5: Diffractogram obtained by the Terra instrument for Sugar Loaf from HV series, with some of the major mineral peaks labeled.

References: [1] Stockstill-Cahill *et al.* (2007) *JGR*, 113, doi:10.1029/2007JE003036. [2] Ruff, S. W. *et al.* (1997) *JGR*, 102, 14899-14913. [3] Ramsey and Christensen (1998) *JGR*, 103(B1), 577-596. [4] Hamilton and Christensen (2000) *JGR*, 105(E4), 9717-9733. [5] Hamilton *et al.* (2001) *JGR*, 106, 14733-14746. [6] Wyatt *et al.* (2001) *JGR*, 106(E7), 14711-14732. [7] Streckeis (1978) *Neues Jahrbuch für Mineralogie*, 141, 1-14. [8] Dunn *et al.* (2007) *JGR*, 112, doi:10.1029/2006JE002766. [9] Bish and Post (1993) *Am. Min.*, 78, 932-940. [10] Sarrazin *et al.* (2002) *Planet. and Space Sci.*, 50, 1361-1368. [11] Sarrazin *et al.* (2005) *Powder Diffraction*, 20, 128-133.