PARTIALLY DEVITRIFIED GLASS AS A COMPONENT OF THE MARTIAN SURFACE LAYER: THERMAL INFRARED EVIDENCE. W. H. Farrand[1], A. D. Rogers[2], S. P. Wright[3], and T. D. Glotch[2], [1]Space Science Institute, 4750 Walnut St., #205, Boulder, CO 80301, Farrand@spacescience.org, [2]Dept. of Geosciences, Stony Brook University, Stony Brook, NY, [3]Planetary Science Institute, Tucson, AZ.

Introduction: Two unresolved problems regarding the nature of the martian surface layer are: first, the identity of a component suggested by the Mars Global Surveyor Thermal Emission Spectrometer (MGS TES) that has been variously suggested as silica-rich glass or coatings [1,2], clays [3], or palagonite [4]. Second, the identity of an amorphous component that has been modeled in Mars Exploration Rover (MER) Mini-TES data [5] and identified in CheMin X-Ray Diffraction (XRD) data [6]. A common solution to these two mysteries could potentially be partially devitrified basaltic glass. Glass is an X-ray amorphous material that should have been formed in abundance an Mars through volcanic activity and through impacts.

We have examined natural basaltic glasses formed through hydro- and glaciovolcanic activity as well as basaltic impact melts from Lonar Crater in India. In this presentation, we discuss the nature of these glasses and how they might represent the missing component of the two mysteries noted above.

Volcanic and Impact Glasses: *Farrand et al*. [7-9] have discussed the visible/near infrared (VNIR) and mid-wave infrared (MWIR) reflectance and emissivity of relatively fresh and altered basaltic glasses produced both at a number of hydro- and glaciovolcanic centers in the western U.S.A. and in the basaltic impact melt from Lonar Crater. Specifically, with regards to the MWIR emissivity of these glasses, we have found that in even relatively fresh (black color, minimal VNIR hydration features at 1.9 and 6.1 μm, absent any ferric oxide absorption feature at 480 nm) samples the silica-stretching feature near 9.5 μm has changed from its pristine glass appearance. Previous studies such as that of [10] and in our work examining cut surfaces, the silica-stretching feature has a "U" shaped form centered near 10 μm. However, the spectra of undisturbed bulk samples of these glass-rich samples (**Fig. 1**), display a doublet with a narrow emissivity band with a minimum at approximately 9.5 to 9.6 μm (1052.6 to 1041.7 cm^{-1}) and a broader shoulder centered at approximately 10.9 to 11.3 μm (917.4 to 885 cm^{-1}). These features correspond to those identified in the glassy rinds of lava flows by *Crisp et al*. [11]. They attributed the 9.5 to 9.6 μm feature to the incipient development of sheets of silica tetrahedra and the 9.96 to 10.2 μm feature to the development of chains of silica tetrahedral. In [11] these features were attributed to a very thin (nominally only 1 to 2 μm thick) rind on the basaltic glass. As shown in **Fig. 2**, these incipient silica chain and sheet features are absent in cut surfaces of the glass-rich samples.

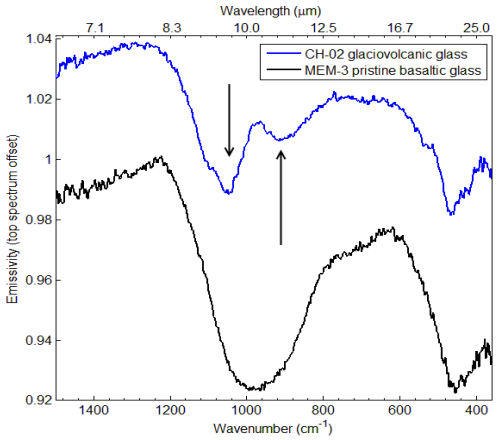

Fig. 1. Comparison of partially devitrified glaciovolcanic glass (CH-02) and lab pristine glass (MEM-3). Arrows indicate silica chain and sheet features.

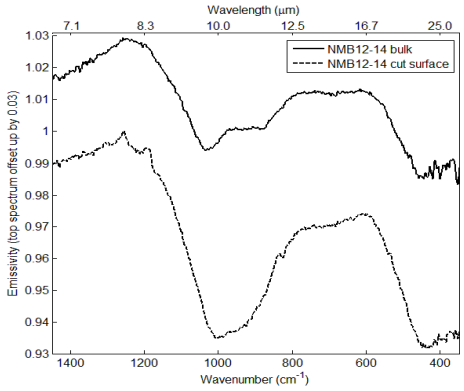

Fig. 2. Comparison of "as is" bulk glass-rich sample and cut surface left from thin section preparation.

Application to TES Data: *Rogers et al*. [12] divided martian dark regions into 11 spectral types. In linear deconvolution modeling of those spectral types those authors attributed 12 to 34% of the modal mineralogy to a "high silica phases" group (including amorphous silica, sheet silicates, high silica glasses, and zeolites). Examining 9 of those spectral types, using the same spectral library used by *Rogers and Christensen* [13], *Minitti and Hamilton* [14] used pristine laboratory produced glasses as components of a linear deconvolution library applied to TES spectra of surface types identified in [12,13]. They found that the pristine

glass spectra were not selected or required for the modeling of the TES surface spectral types.

Given what appears to be the relatively rapid development of the incipient silica chain and sheet features found in this study and by [11], these partially devitrified glass sample spectra are potentially a better representative of the glassy materials that could be present in the martian surface layer. We have used the NNLS deconvolution approach of [15] over the 1301 - 225 cm^{-1} (7.7 – 44.4 μm) spectral range with the same library used by [13, 14] with the addition of the natural hydrovolcanic glass spectra listed in **Table 1**. We find that these partially devitrified glass sample spectra can form up to nearly 40% of the N. Acidalia spectral type of [12] and constitute significant fractions of several of the other spectral type regions as well. Example measured and modeled TES spectra of the four summary groups of spectral types from [13] are shown in **Fig. 3**.

In the new modeling, the partially devitrified glass spectra are selected by the linear deconvolution for most of the modeled spectral types of [12]. However, the improvement in root mean square error using these new sample spectra is only marginally better than for modeling not including the glass sample spectra.

Sample	*Sampling Location*
NMB12-14 average	N. Menan Butte, Idaho
NMB12-14 cut face average	N. Menan Butte, Idaho
CH-02 average	Crazy Hills, Washington
PB13-011 average	Pavant Butte, Utah

Table 1. Glass-rich spectra in deconvolution library.

As noted above, in [13] the "high silica phases" group was modeled as accounting for significant fractions of the TES surface spectral types. In our modeling, using the partially devitrified basaltic glass sample spectra, the modeled amount of high silica phases goes down for all the spectral types (e.g., from 12 to 34% to 7 to 12%). We interpret the selection of the partially devitrified glass sample spectra over the high silica phases as a geologically reasonable result given the dominance of basaltic volcanism on Mars and the early history of explosive volcanism [e.g., 16] that there would be relatively more (partially devitrified) basaltic glass and less high silica materials.

Conclusions: The CheMin instrument on Curiosity has consistently found an X-ray amorphous component in samples analyzed to date [5]. At least part of this amorphous component could be partially devitrified glass such as has been discussed here. Our findings support those of *Horgan and Bell* [17] who, using VNIR OMEGA data, found a significant glass component in the northern plains of Mars, especially in northern Acidalia Planitia and Siton Undae. Earlier studies [1,2] had suggested that high silica glass might be present in these regions. However, using the partially devitrified glass sample spectra in the linear deconvolution, we find close to 40% devitrified *basaltic* glass in north Acidalia. The partially devitrified glass spectra are distinct from pristine glass in the silica stretching region near 10 μm; however, bands near 1 and 2 μm are unaffected by the incipient development of silica chain and sheet structures. Thus, the finding in [17] would be consistent with the presence of the N. Acidalia glass being partially devitrified in nature. Also, basaltic glass would be more consistent with the known basaltic character of Mars.

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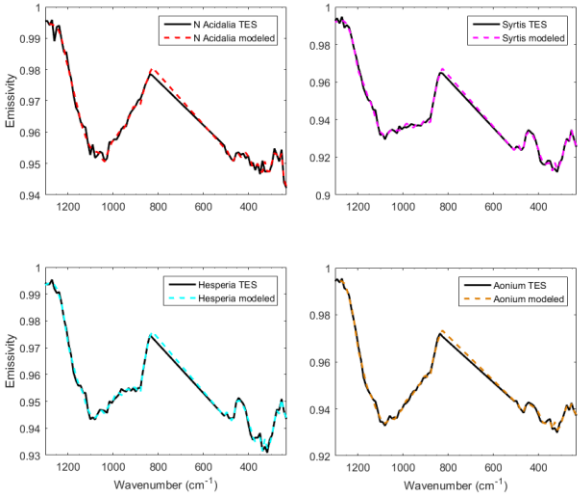

Fig. 4. Representative TES spectral types and modeled spectra using partially devitrified basaltic glass sample spectra in the deconvolution endmember library.