SEARCHING FOR BASALTIC TO INTERMEDIATE IGNEOUS GLASSES IN MARTIAN SURFACE MATERIALS. M.E. Minitti[1] and V.E. Hamilton[2], [1]Center for Meteorite Studies, School of Earth and Space Exploration, Arizona State University, Box 872504, Tempe, AZ, 85287-2504 (minitti@asu.edu), [2]Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO 80302 (hamilton@boulder.swri.edu).

Introduction: Martian geomorphology is rich in volcanic landforms [e.g., 1] and spectroscopic data across visible, near infrared and thermal infrared wavelengths indicates that Mars is largely a basaltic planet [e.g., 2,3,4]. Among the components that remote sensing and landed instruments have found are a variety of amorphous phases [e.g., 3,5]. Given these observations, it is reasonable to hypothesize that intermediate to basaltic glasses exist in Martian surface materials. To test this hypothesis, we created a suite of glasses (two basalts, two andesites, one dacite), obtained their thermal infrared spectra, and deconvolved regional Martian Thermal Emission Spectrometer (TES) spectra with a spectral library containing the glasses.

Experimental and Analytical: The experimental technique used to create the glasses was described in [6]. The major element compositions of the glasses (Table 1) were measured on the JEOL JXA-8600 electron microprobe at Arizona State University using a 15 kV, 10 nA, 10 μm defocused beam. The thermal infrared spectra of glasses (Fig. 1) were obtained from 200-4000 cm^{-1} at 2 cm^{-1} spectral sampling using a ThermoElectron Nexus 470 FTIR interferometric spectrometer in thermal emission mode at the Hawai'i Institute of Geophysics and Planetology [7]. We added the glass spectra to spectral library of [8] and deconvolved nine regional TES spectra of [9]. We based our spectral library on that of [8] because of its comprehensive nature and it allowed us to compare our results with those of [8] to establish the presence and importance of the glasses in Martian spectra. We deconvolved the regional spectra at TES spectral resolution (20 cm^{-1}) between 305-1302 cm^{-1} excluding the region of the CO_2 atmospheric absorption.

To deconvolve the regional spectra, we employed the nonnegative least squares (NNLS) technique of [10]. The NNLS technique not only calculates the root-mean-square (rms) error associated with a fit, it yields the uncertainty on the abundance of each library spectrum used in the deconvolution solution. Uncertainties on the abundances of groups of phases (e.g., pyroxenes, feldspars) can also be determined. To take advantage of the group error analysis capability, we separated the library spectra into seven groups: plagioclase, low-calcium pyroxene (LCP), high-calcium pyroxene (HCP), olivine, high silica phases (includes silicic glasses, opals, zeolites, clays and micas), other (includes carbonates, sulfates and oxides) and the new glasses (Table 2). The NNLS technique (and similar approaches [e.g., 11]) has also proven to produce stable solutions when the number of spectra in the library approaches the number of bands in the spectra [10].

Results: The modeled spectra produced by the deconvolution solutions fit the regional spectra with reasonable rms errors (Table 2). The deconvolved mineralogies are the same (to within the error) as those derived by [8] and none of the nine surfaces are modeled with the intermediate to basaltic glasses (Table 2).

Assuming that the basaltic and volcanic nature of Mars is consistent with the presence of intermediate to basaltic glass, the lack of such glasses on a regional scale must be explained. Glass is susceptible to aqueous alteration in terrestrial Mars analog settings [e.g.,

Table 1: Intermediate to basaltic glass compositions

	1	2	3	4	5
SiO_2	49.95 (0.22)	50.75 (1.05)	58.92 (0.85)	57.56 (0.62)	67.82 (0.60)
Al_2O_3	7.40 (0.02)	12.43 (0.18)	15.43 (0.70)	11.30 (0.41)	11.71 (0.39)
MgO	7.13 (0.05)	6.17 (0.09)	3.78 (0.32)	1.12 (0.08)	0.92 (0.04)
FeO	19.36 (0.18)	13.94 (1.30)	6.95 (0.52)	15.26 (0.34)	8.02 (0.37)
CaO	10.99 (0.02)	9.53 (0.11)	7.20 (0.43)	7.49 (0.15)	4.47 (0.16)
Na_2O	1.50 (0.04)	2.38 (0.27)	2.72 (0.27)	2.71 (0.19)	4.31 (0.09)
K_2O	0.38 (0.01)	0.51 (0.06)	2.02 (0.16)	1.54 (0.05)	1.57 (0.07)
TiO_2	1.00 (0.09)	2.15 (0.10)	1.03 (0.11)	0.52 (0.09)	0.66 (0.07)
P_2O_5	0.70 (0.08)	0.31 (0.06)	0.51 (0.08)	1.47 (0.06)	0.26 (0.11)
MnO	0.48 (0.06)	0.15 (0.04)	0.11 (0.07)	0.18 (0.07)	0.28 (0.08)
Total	98.87	98.34	98.66	99.16	100.02

±1σ standard deviation in parentheses
1=Martian meteorite basalt proxy; 2=TES basalt proxy, 3=TES andesite proxy; 4=Andesite glass (from [12]); 5=Dacite glass (from [12])

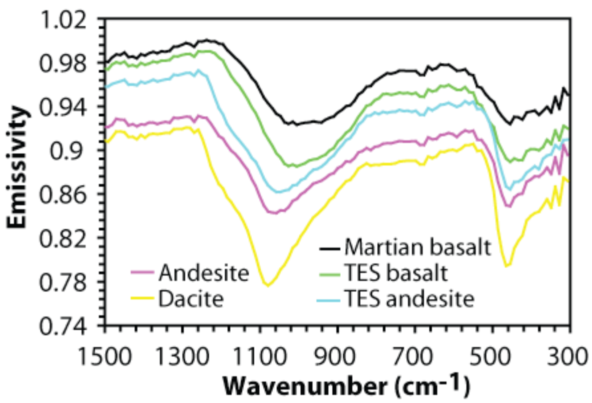

Fig. 1: Synthetic igneous glass spectra. The spectral shape of the glasses is largely controlled by SiO_2 content (Table 1).

13,14]. The phases in the high silica phase group are among those that form from aqueous alteration of glass [e.g., 15,16]. It is possible, then, that the high silica phase group represents materials replacing intermediate to basaltic glasses on Mars. The most abundant high silica phase that appears in the devonvolution solutions for each surface is zeolite. Zeolite has been hypothesized to exist on Mars [e.g., 15, 17] and to serve as a water carrier at mid-latitudes [18]. The presence of zeolite in Martian dust is suggested by TES data [19] and zeolite has been detected in a few areas in visible and near infrared data [e.g., 20]. If zeolite is not specifically the phase replacing intermediate to basaltic glass on Mars, something that has zeolite-like spectral character must explain the contribution of the high silica phase group to the deconvolution solution. [21] showed that the deconvoltuion of thermal infrared spectra of allophane-bearing palagonites used phyllosilicate spectra in the solutions when allophane spectra were not available in the library. Phyllosilicates were used because they served as the closest spectral match to the allophane. Zeolite in this study may be playing the same role that phyllosilicates played in [21]. Ultimately, the spectral shape and band positions of the combined high silica phases that are included in the deconvolution solutions help constrain the spectral character of the material that is present. The phase potentially replacing intermediate to basaltic glass on Mars must be more silica rich than glasses of this study (which have broader features at longer wavelengths) but less silica rich than glasses that have appeared in spectral libraries of previous studies [e,g., 3] (which have narrower features at shorter wavelengths).

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Table 2: NNLS deconvolution results for regional spectra with library spectra divided into mineral/phase groups

	Syrtis	Tyrrhena	Hesperia	Cimmeria	Sirenum	Aonium	Meridiani	Solis	North Acidalia
Plag.	28 (9)	24 (6)	21 (8)	26 (7)	28 (9)	34 (10)	26 (9)	25 (11)	35 (10)
LCP	6 (6)	17 (4)	12 (9)	16 (7)	10 (6)	5 (8)	9 (8)	16 (9)	18 (12)
HCP	30 (5)	19 (4)	21 (7)	18 (4)	19 (4)	21 (5)	20 (5)	8 (6)	2 (7)
Olivine	5 (3)	12 (3)	9 (3)	9 (3)	5 (2)	1 (2)	10 (3)	3 (3)	0 (4)
High-Si phases	14 (5)	13 (3)	17 (4)	14 (6)	21 (6)	17 (4)	17 (9)	25 (6)	29 (10)
Others	18 (3)	17 (3)	19 (3)	17 (3)	16 (3)	22 (3)	18 (3)	24 (6)	16 (10)
New glasses	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
RMS error	0.140	0.110	0.110	0.120	0.120	0.110	0.120	0.090	0.130

Values in parentheses are uncertainties on the abundances of the phase group