A GLOBAL MAP OF HIGH-SILICA PHASE MINERALOGY ON MARS. R. J. Smith[1], B. Horgan[2], S. W. Ruff[1], and P. R. Christensen[1], [1]Arizona State University (rebecca.jean.smith.1@asu.edu), [2]Purdue University.

Introduction: Much of the northern plains of Mars, and especially the north polar dune sea Siton Undae, exhibit iron absorption bands and concave-up spectral slopes that are consistent with spectra of acid-leached iron-bearing glass in the near-infrared (NIR) [1-2]. Natural and laboratory acid-leached basalt glass both show an enrichment of silica on their surfaces, which can be detected in thermal-infrared (TIR) analyses [3-6]. The outstanding question then, is whether the TIR spectral character of the northern plains and polar regions are also consistent with acid-leached glass.

TIR mineralogical investigations have generally ignored the north polar region of Mars (> 65° N) due to low surface temperatures which decrease the signal-to-noise-ratio (SNR) [7-10]. However, [11] did map this region, and found that it contained high abundances of both plagioclase and high-silica phases (sheet silicates and/or high-silica glass). Here we attempt a more in-depth study of this region to determine whether it is spectrally consistent with acid-leached glass.

Furthermore, we present the preliminary results of a new global product that maps the position of the emissivity minimum in the range of 1068 cm^{-1} to 1121 cm^{-1}, which is sensitive to tetrahedral Si-O stretching in high-silica phases (defined in this study as: ~0.4 < Si/O < 0.5). High-silica phases are detected in most low albedo regions in abundance of 15-20%, with higher abundances in the northern plains and polar regions [9,11]. Yet the mineralogy of these phases is poorly contrained. The Si-O stretching emissivity minimum has been shown to be directly related to Si/O ratio and polymerization [12]. Thus, this map can be used to help constrain the mineralogy of the dominant high-silica phase(s) in an area. This map does not determine the presence of these phases, as other minerals have weak absorbtions in this spectral range. However, we can assume that this spectral range is dominated by high-silica phase(s) in regions where they are found in significant abundance (> 15%).

Methods: The emissivity minimum map was genereated by first selecting atmospherically adjusted Thermal Emission Spectrometer (TES) data [13] by restricting: lambertian albedo < 0.15, surface temperature > 255 K, dust opacity < 0.25, ice opacity < 0.1, emission angle < 30°, and HGA and solar panel motion = 0 °/sec. TES data for latitudes below 60° N were also constrained to orbital counts (OCK) 1563-7500, because of an instrument anomaly past this orbital period that caused a sporadic minor feature in data at ~1000 cm^{-1} [11]. However, we chose to allow data from later orbits for the regions above 60° N in order to increase the number of viable TES spectra. All spectra from OCKs > 7500 were visually inspected for this spectral feature to ensure it would not affect the results.

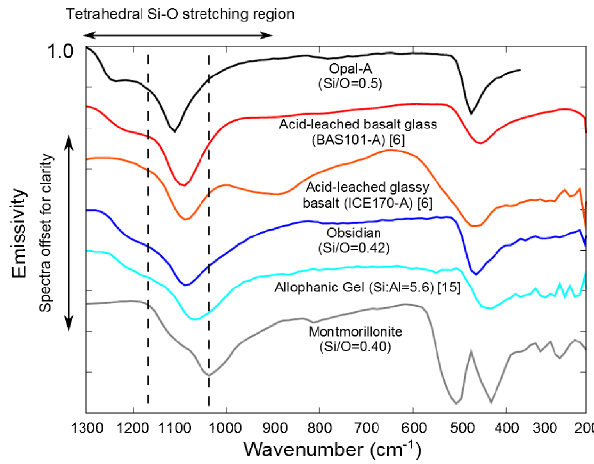
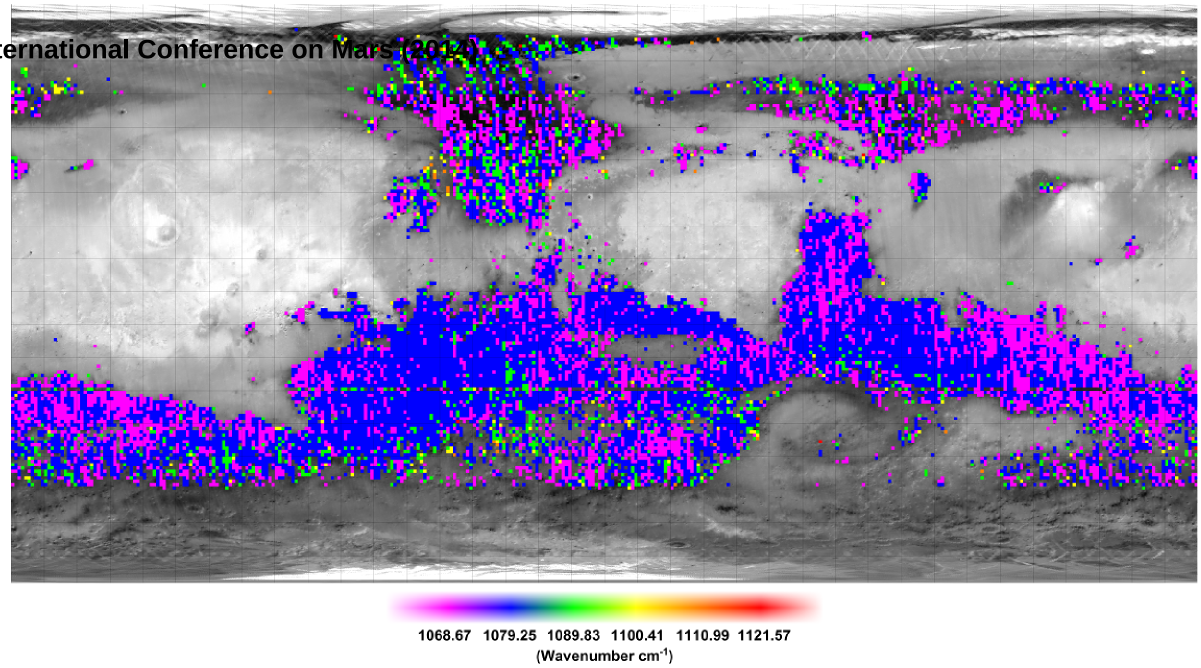


Figure 1. Plot showing TIR laboratory spectra of high-silica phases at TES resolution (10 cm^{-1} sampling). Dotted lines indicate the region over which the emissivity minimum was calculated for each TES spectrum.

The TES spectra used in this study were atmospherically adjusted using a linear least-squares fitting algorithm to model the measured spectrum using surface and atmosphere components [13]. The difference between the measured and modeled spectra is recorded in the root-mean-square (RMS) error, and a low RMS error is generally taken to indicate a more accurate surface-atmosphere separation.

The main CO_2 absorption region (508–825 cm^{-1}) was removed from the selected TES spectra, and a boxcar filter (length=3) was applied to each spectrum in order to smooth high-frequency features, retaining the general spectral shape. Each spectrum was then run through a simple algorithm to find the emissivity minimum in the Si-O stretching region of high Si/O material (1068.67 cm^{-1} to 1121.57 cm^{-1}) (Fig. 1). The emissivity minima were binned at 1 ppd, colorized, and plotted over the TES albedo map [14]. The RMS error associated with each surface emissivity spectrum was also binned and mapped in the same manner.

Discussion: Laboratory samples of basalt glass weathered in low pH acid have TIR spectra dominated by a shape similar to opal-A, but with an emissivity minimum (1100 cm^{-1} and 1095 cm^{-1}) closer to obsidian (1087 cm^{-1}) than opal-A (1115 cm^{-1}) [5-6] (Fig. 1). Preliminary results from this study show that the north



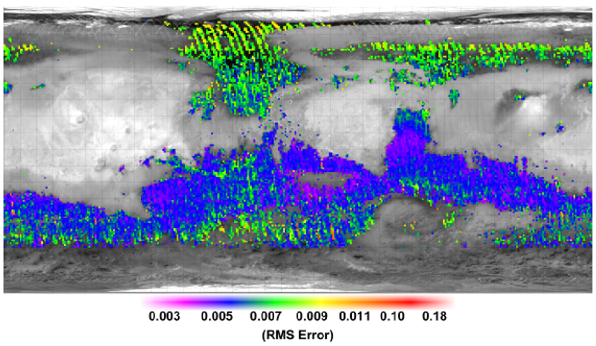


Figure 2. (Above) Emissivity minimum map over TES global albedo map [14], centered at 0 N, 0. (Left) RMS error associated with surface-atmosphere separation.

polar region predominantly displays spectra with emissivity minima between ~1080 cm^{-1} to 1100 cm^{-1} (blue/green/yellow in Fig. 2 top), and thus contains some of the most polymerized high-silica phases on the planet. Therefore, based on this metric, the north polar region appears to be most spectrally consistent with obsidian and acid-leached glass in the TIR (Fig. 1). Elsewhere, emissivity minima are generally less than 1090 cm^{-1}.

North Acidalia and Solis Planum are also known to contain a significant abundance of high-silica phases, and have similar spectral shapes [e.g. 8,11,15]. Our map shows these regions as being dominated by phases with an emissivity minimum ~1070 cm^{-1} (pink in Fig. 2 top), which is consistent with allophanic gel (Si/Al=5.6). This supports the findings of [15] under the assumption that the main contributors to a surface emissivity spectrum in the mapped range are high-silica phases.

The RMS error in the north polar region is also greater than that over much of the rest of Mars (Fig. 2 bottom) with the majority of values between 0.003 and 0.008. While an RMS error of ~0.0045 is generally considered acceptable, high RMS values do not necessarily equate to a poor atmospheric correction over the entire spectrum. A high RMS can sometimes be attributed to a large error over a small wavelength region [11]. The high RMS values in the north polar region indicate the need for further investigation.

Conclusion: Preliminary results from our global high-silica phase emissivity minimum map suggest that the north polar region of Mars is spectrally consistent with acid-leached glass in the TIR, supporting the findings of [1-2] in the NIR. Additionally, our map highlights many of the regional variations identified in previous global maps [7-10] such as the spectral difference between Northern and Southern Acidalia, as well as the spectral similarity between high-silica phase(s) in Northern Acidalia and Solis Planum [9,15]. This map can be used to gain insight into the mineralogy of the dominant high-silica phases present on Mars.

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