

AN INTEGRATED ANALYSIS OF MARTIAN SURFACE COMPOSITIONS USING NEAR INFRARED THROUGH THERMAL INFRARED SPECTROSCOPIC DATA. J. L. Bandfield¹, L. C. Mayorga¹, C. S. Edwards², and T. D. Glotch³, ¹Department of Earth and Space Sciences, University of Washington, Seattle (joshband [AT] u.washington.edu) ²School of Earth and Space Exploration, Arizona State University, ³Department of Geosciences, Stony Brook University.

Introduction: A great deal has been learned about the composition of the martian surface using orbital and in-situ spectroscopy. Significant advancements have been made possible by recent measurements from the Thermal Emission Spectrometer (TES), Thermal Emission Imaging System (THEMIS), Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA), Miniature Thermal Emission Spectrometer (mini-TES), and Compact Reconnaissance Imaging Spectrometer for Mars (CRISM). Because of the complicated nature of the instruments, datasets, and analysis techniques, studies have typically focused on a single wavelength region. Despite this complication, several martian compositional studies have included an analysis of both reflected and emitted light spectroscopy [1-3].

The incorporation of both visible/near-infrared (VNIR) and Thermal Infrared (TIR) datasets into surface compositional analysis can provide highly complimentary information based on the unique sensitivities of the two wavelength regions. In general, VNIR measurements (defined here as roughly 0.3-3 μ m wavelengths) are highly sensitive to mineralogies that contain transition metals and various forms of hydration. In some situations, sensitivity can be extremely high (<1-2% by volume). TIR spectroscopy is generally sensitive to the bulk composition as most rock forming minerals have absorptions in this wavelength region (~5-50 μ m). The purpose of the work presented here is to begin to explore the combined wavelength regions in a systematic fashion in order to provide a more coherent picture of martian surface compositions. We present a number of specific surfaces that have been addressed in previous studies.

Variable Lava Compositions in Nili Patera: TIR data has been used to identify compositions in Nili Patera that are consistent with olivine-rich basalts and dacitic lavas [4]. Based on OMEGA data, 1 identified spectral slopes present on the high-Si unit and concluded that it was consistent with glassy coatings instead of a high-Si composition. High spatial resolution CRISM data shows that the distribution of negative spectral slopes are not correlated with the high-Si TIR unit and are most clearly present on parts of the olivine basalt unit. The presence of olivine is highly correlated between the VNIR and TIR measurements and the shallowest olivine absorptions are coincident with the TIR high-Si unit. Minor 1 and 2 μ m absorp-

tions are present on the hi-Si surface, indicating the presence of small amounts of pyroxene, consistent with an intermediate volcanic composition.

The more detailed VNIR data support the initial conclusions of 4. In addition, the variable spectral slopes present within the CRISM scene are likely indicating the presence of some form of coating on the surface materials. However, the variable phase angle of the observations within the CRISM scene make it difficult to compare surfaces without properly accounting for the effects of atmospheric aerosols.

Quartzofeldspathic-Hydrated Silica Surfaces: Surfaces composed primarily of quartz and feldspar have been identified northwest of Syrtis Major [5-6]. Hydrated silica has been identified with CRISM data in the same regions [7] and close examination shows that it is coincident with the TIR quartzofeldspathic unit (Figure 1). Hydrated silica has features in the TIR that are distinct from quartz and it is not present at detectable concentrations in the TIR data.

Based on the CRISM data, 7 concluded that it was not possible for the surfaces to be granitic in composition. However, the lack of mafic minerals in the bulk composition supports the analysis of 5 and 6 in that the composition may be altered, but must have originally started as a highly differentiated igneous body. Although K-feldspar and silica phases can be produced from mafic compositions, weathering and alteration processes do not efficiently create bulk compositions dominated by quartz and plagioclase.

The hydrated silica features that are present in this region are consistent with those of lightly altered granitic rock surfaces. However, the presence of phyllosilicate and zeolite compositions in the same vicinity and indications of formation at depth indicate clear potential for hydrothermal alteration. Although speculative, the association of hydrothermal systems with granitic bodies on Earth is an interesting possible formation mechanism for these compositions.

High Silica Surfaces in Hellas Basin: Surfaces with up to 80% high-Si phases have been identified in western Hellas Basin [8]. In contrast to the quartzofeldspathic surfaces discussed above, the TIR data indicates that the surfaces are dominated by amorphous Si rich phases.

Inspection of CRISM multispectral survey data shows hydrated silica absorption features that are coincident with the high-Si TIR spectral unit. The

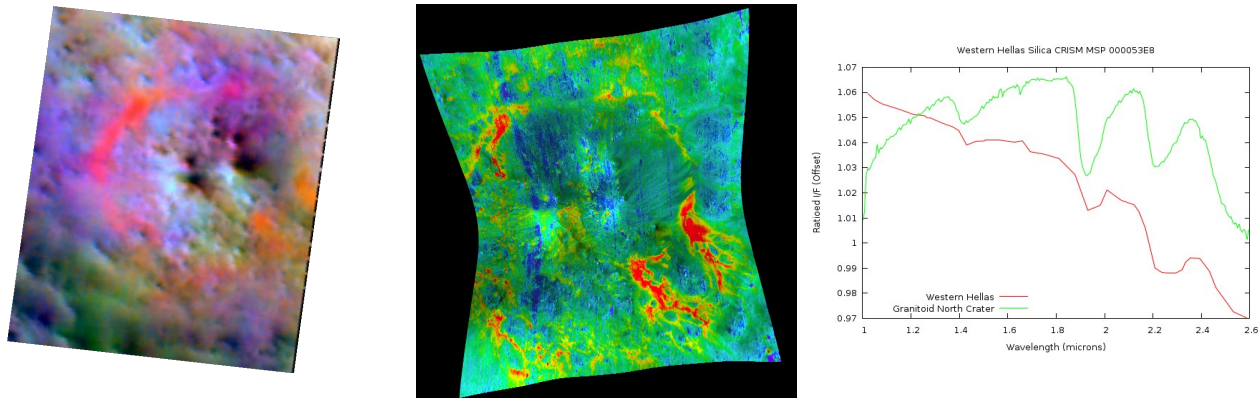


Figure 1. THEMIS band 654 decorrelation stretch image (left) CRISM 2.25 μ m band depth image (center) and CRISM spectra from surfaces containing hydrated silica features (right). The images are centered near 66 E, 20 N. The red spectrum is from CRISM multispectral data of western Hellas Basin and the green spectrum is from the hydrated silica surfaces shown in the center image.

CRISM data helps confirm the aqueous origin for the surfaces and the specific shape of the hydrated silica absorption is distinct from the hydrated silica present northwest of Syrtis Major, which may indicate a unique formation environment [e.g. 9].

Potential Chlorides in the Southern Highlands:

Low emissivity surfaces resulting in spectral slopes have been identified in TIR data of Noachian age southern highlands [10]. This relatively unusual property is characteristic of chloride minerals.

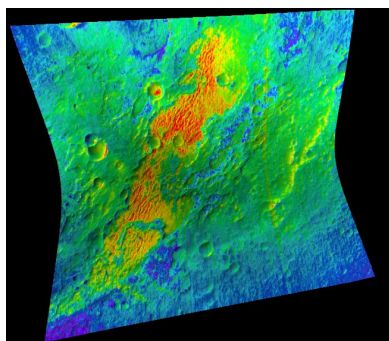


Figure 2. THEMIS band 875 decorrelation stretch image (top) and CRISM infrared slope intensity image (bottom) centered near 216 E, 33 S. The regions are marked by TIR negative slopes and positive SWIR slopes. This surface is similar to the type purported chlorides of Osterloo et al. (2008).

material is relatively pure and does not contain other minerals that are often associated with chloride materials, such as sulfates.

Olivine and Phyllosilicates in Nili Fossae: Qualitatively, olivine-rich surfaces are highly correlated and show similarities in absorption band intensity in the TIR and VNIR data. Nili Fossae has been well documented as a region of high olivine abundances in both wavelength regions [e.g. 11-12].

A variety of other compositions, particularly phyllosilicates, have been identified in the Nili Fossae region in VNIR data [e.g. 13-14]. Reexamination of coincident THEMIS data shows that the regions with phyllosilicates coincide with regions that contain high concentrations of high-Si phases. However, other surfaces are present in the region with high-Si phases that do not show phyllosilicate or other hydrated mineralogy absorption features.

References: [1] Kanner, L.C. et al. (2006) *LPSC XXXVII*, Abstract #1648. [2] Wyatt, M.B. (2007) *7th Intl. Conf. Mars*, Abstract #3402. [3] Rogers, A.D. et al. (2008) *J. Geophys. Res.*, in press. [4] Christensen, P.R. et al. (2005) *Nature*, 436, 504-509. [5] Bandfield, J.L. et al. (2004) *J. Geophys. Res.*, 10.1029/2004-JE002290. [6] Bandfield, J.L. (2006) *Geophys. Res. Lett.*, 10.1029/2005GL025559. [7] Ehlmann, B.L. et al. (2007) *7th Intl. Conf. Mars*, Abstract #3270. [8] Bandfield, J.L. (2008) *Geophys. Res. Lett.*, 10.1029/2008GL033807. [9] Swayze, G.A. et al. (2007) *7th Intl. Conf. Mars*, Abstract #3384. [10] Osterloo, M.M. et al. (2008) *Science*, 319, 1651-1654. [11] Hamilton V.E. and P.R. Christensen (2005) *Geology*, 33, 433-436. [12] Mustard, J.F. et al. (2005) *Science*, 307, 1594-1597. [13] Poulet, F. et al. (2005) *Nature*, 438, 623-627. [14] Mustard, J.F. et al. (2008) *Nature*, 454, 305-309.