THE EFFECT OF WEATHERING AND OUTCROP VARIABILITY ON THERMAL INFRARED MULTISPECTRAL REMOTE SENSING DATA: A COMPARATIVE STUDY IN GILA BEND, AZ.

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Introduction: Thermal Infrared spectroscopy (TIR) constitutes a powerful diagnostic tool for compositional analysis of geological materials on planetary surfaces. The quantitative mineralogy of a sample can be determined from laboratory spectra using a linear deconvolution process [1]. The same approach can be applied to remote sensing data but the method is severely hindered in the case of multispectral data, as the number of end members that can be used in the deconvolution is limited to the number of bands available. Although numerous studies have been conducted to characterize the effect of weathering on TIR laboratory spectra [2,3,4], the quantification of that effect on remotely sensed data is still poorly understood, and identification of alteration products from orbital data remains a challenge to this day. Correct identification of weathering products, their abundance and distribution, are of crucial importance in characterizing the geologic history and environmental conditions on Mars. A proper quantification of the effect of weathering on remote sensing data must come from field studies where laboratory spectra of natural samples are compared with airborne or orbital images [e.g. 5].

Approach: This study focuses on two lithological units from the Gila Bend region in Arizona: a rhyolite from the Precambrian basement and the Warford Ranch shield volcano, a basaltic unit from the Pliocene Sentinel-Arlington Volcanic Field [6]**.** Caliche, a light-colored carbonate rock typical of desert environments, is present in various amounts throughout the field area. We collected natural samples from both types of igneous lithologies in an attempt to compare TIR spectra at 3 different resolutions: a) laboratory spectra taken on individual samples with hyperspectral resolution (~2 wavenumbers); b) 6-point spectra from Thermal Infrared Multispectral Scanner (TIMS) imagery taken at meter-scale spatial resolution; and c) 5-point spectra from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery taken with a 90x90 m²/pixel spatial resolution. The laboratory spectrometer offers the most ideal conditions, sampling individual and uniform rock surfaces and minimizing the effects of atmospheric CO_2 and H_2O. But it fails to incorporate the diversity that can be observed in a natural outcrop. TIMS, with a pixel size of ~2m samples radiated energy from the soil and various types of rock fragments, possibly with different levels of weathering. One level of spatial resolution down, ASTER, with a pixel size of 90 m, likely samples radiated energy from in-situ outcrops as well as rock fragments.

We adopted a systematic approach, sampling various outcrops within each unit, and sampling all the different types of rock fragments present on each outcrop in an effort to accurately recreate the TIR signature of individual pixels in the remote sensing data. The laboratory spectra were degraded to TIMS and ASTER resolutions (Figure 2) and combined in various ways to be used as end-members in a deconvolution of the scenes. Three sets of end-members were used: (1) the fresh surfaces of individual rock samples, (2) variably weathered surfaces of each rock unit (fresh, varnished, heavily weathered, etc.), (3) 'outcrop' spectra reconstructed from the individual constituents found in the outcrop, weighted with their areal abundances

Results: A first analysis of the data set shows discrepancies between the instruments. Features that are clearly identifiable in TIMS data are much less prominent in ASTER data, mostly due to a missing band in ASTER spectra caused by an atmospheric ozone absorption feature. The Si-O stretching absorption features for rhyolite and basalt occur in two separate bands for TIMS, but in the same band for ASTER (Figure 2). This makes the identification of weathering products in ASTER data much more difficult. When comparing spectra extracted from individual pixels to the degraded laboratory spectra, we found significant differences between the measured and expected spectra (Figure 3). We found that both weathering and outcrop variability affect the TIR spectra of multispectral remote sensing data in similar ways, making it challenging to distinguish bedrock heterogeneity from weathering. Our results emphasize the need for more ground-truthing studies on Earth if we are to ever truly understand the remote sensing data on other planetary bodies.

References: [1] Ramsey M. S. and Christensen P.R. (1998) JGR, 103, 577-596. [2] Christensen P.R. and Harrison T.S. (1993) JGR, 98(B11), 19819-19834. [3] Kraft, M.D. et al. (2003) GRL, 30(24), 2288, doi:10.1029/2003GL018848. [4] Michalski J.R. et al. (2006) EPSL, 248, 822–829. [5] Michalski J.R et al. (2004) JGR, 109, E03007. [6] Cave S. and Greeley R. (2004) J. Arizona-Nevada Academy of Science*,* 37(2), 105-110.

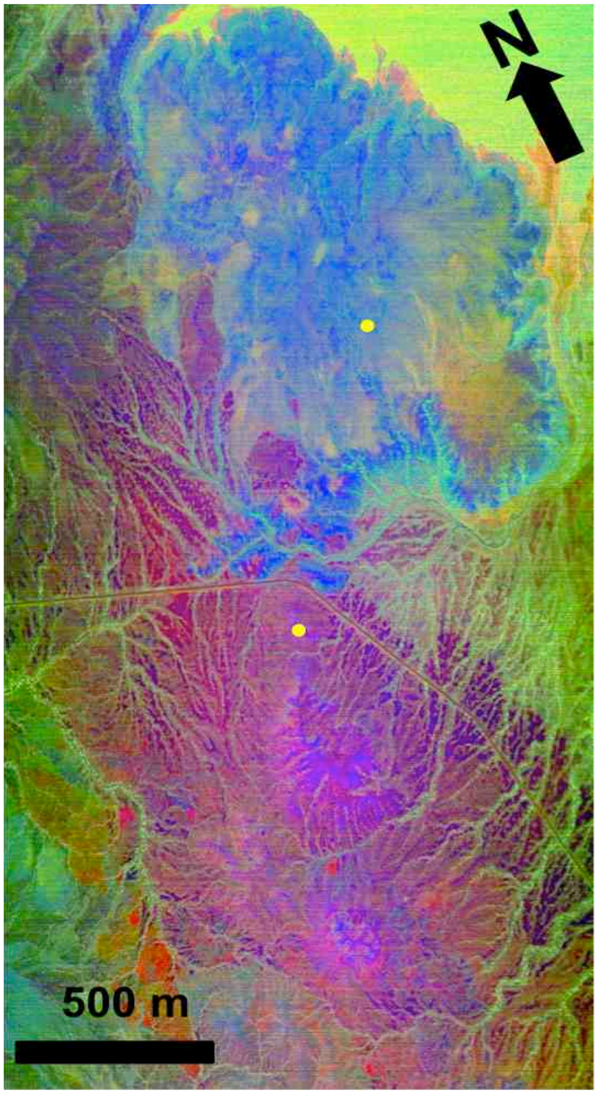

Figure 1: Decorrelation stretch of the TIMS image (bands 5-3-1 as R-G-B, respectively) showing the different units sampled in this study. The purple shades are rhyolite, the blue shades are basalt and the green shades represent caliche. The yellow dots represent samples whose spectra are shown in Figure 2.

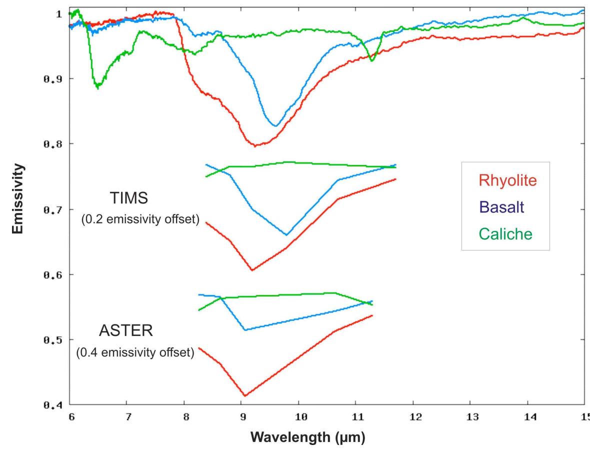

Figure 2: Laboratory emissivity spectra of 3 rock samples from the area around Warford Ranch shield volcano: a rhyolite (red), a basalt (blue) and a piece of *caliche* (green). These represent the 3 major colors seen in the decorrelation stretch in Figure 1. Also shown are the spectra degraded to TIMS (0.2 offset in the y-direction) and ASTER (0.4 offset) resolutions.

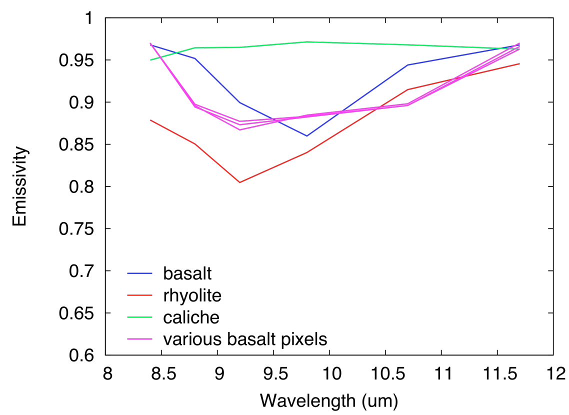

Figure 3: Emissivity spectra extracted from individual pixels from the basaltic unit in the TIMS image (in pink), compared with degraded laboratory spectra of the three main rock units present in the scene: rhyolite (red), basalt (blue), and caliche (green).