DECOUPLING LAVA FLOW COMPOSITION AND EMPLACEMENT PROCESSES FROM EOLIAN MANTLING DEPOSITS USING THERMAL INFRARED DATA. Michael S. Ramsey[1], David A. Crown[2], and Mark A. Price[1], [1]Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260; [2]Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719; mramsey@pitt.edu.

Introduction: Sediment/regolith history, mobility, and its mantling of the underlying bedrock are important topics for Mars science. Eolian processes significantly influence Mars and cover many bedrock surfaces with sand and dust [1]. These eolian deposits can be derived locally and therefore retain the chemical/spectral signatures of the underlying rocks [2], or more commonly it becomes globally-homogenized obscuring the surface below and hindering accurate identification from orbit [3]. Although not as pervasive on Earth, surface mantling can also arise from a variety of processes (e.g., eolian reworking, pyroclastic airfall).

In order to better understand the volcanic history of the SW Arsia Mons flow field and aid in geologic mapping, the compositional and thermophysical properties of these flows are being examined using thermal infrared (TIR) data from the Mars Odyssey Thermal Emission Imaging System (THEMIS) and the Mars Global Surveyor Thermal Emission Spectrometer (TES) [4,5]. Complementary work is focused on terrestrial analogs and advanced image processing techniques in order validate the approach and ultimately to decouple the spectral contribution of the mantling from that of the underlying lava flows for both terrestrial and planetary applications.

Locations: Arsia Mons (9.5°S, 239.5°E) is the southernmost Tharsis shield volcano, rising more than 11 km above the surrounding plains and having a well-developed summit caldera [6,7]. Two large lava flow aprons extend from alcoves on the NE and SW flanks and postdate the main shield. The SW apron has an average slope of 0.6° with flows that exhibit a wide range of morphologies, surfaces, textures, and degrees of eolian mantling [7,8]. A series of lava flows on the SW apron (near 22.5°S, 238.0°E) have unusual thermophysical characteristics and new findings show that these flows are relative young (~100 My) [9]. This is also the same region of Mars with some of the largest meter-scale roughness on the planet [10].

The silicic flow and dome surfaces of the Mono Craters/Domes (MCD) in east-central CA formed within the last 1,000 years. Some are mantled in places by fine-grained pyroclastic airfall deposits of similar composition from younger explosive activity [11]. They provide an excellent process-analog for the Martian flows. Fundamental to the formational processes is the block size distribution, which has been shown to reflect the balance between lava emplacement (extrusion rate) and cooling-derived deformation, and is also representative of the lava type/composition [12]. Extracting these parameters is difficult in cases where the flow surfaces are mantled

Flow Field Mapping. The SW Arsia flow field exhibits small vents, channels, and lobe margins. Two distinct flow types have been documented: (1) blockier, higher albedo, rugged flows and (2) smoother, lower albedo flows [5,8]. CTX and HiRISE images reveal that both flow types are partially mantled by eolian infill that covers up to 50% of the blockier flows. In addition, TES thermal inertia and albedo values indicate that a low to moderate amount of dust cover is also present in this region. Despite this, we have identified TIR spectral variations of these flows (Fig. 1) as well as every style of albedo/thermophysical variability at the individual flow scale [5]. For example, some flows show no temperature inversion between day and night TIR data, which is likely the result of an albedo-dominated influence of radiant temperature and also indicates the presence of surface dust (Fig. 2), whereas adjacent flows show temperature inversions between day and night data.

Analysis of spaceborne TIR data of the MCD shows considerable spectral variability, which corresponds well to areas of high thermal inertia. High spatial resolution images indicate that these regions are less pervasively mantled. Mantled areas will be investigated during a series of field campaigns over the next three years in order to precisely map the depth and extent of these deposits and document the block size of the underlying flows.

Results. The thermal IR imager on THEMIS consists acquires data in 10 spectral channels centered between 6.8 and 14.8 µm with a spatial resolution of 100 m. The IR data examined have all been acquired over the past year during a period of higher data quality due to earlier local overpass times and subsequently higher surface temperatures. The images were atmospherically-corrected using previously-collected Thermal Emission Spectrometer (TES) data. The apparent surface emissivity shows variations both between the flow types as well as between flow levees and central channels (Fig. 1). Some of this variability may be related to micron-scale surface roughness of the flows, but compositional changes in the flows also must contribute [4,5].

The TIR instrument that is part of the ASTER sensor acquires data at 90 m/pixel resolution in 5 bands between 8 and 12 µm, making it a good proxy for THEMIS IR data. A day/night TIR pair separated by ~30 hours was acquired in July, 2011 and used to derive the apparent thermal inertia of one of the larger flows at the MCD (Fig. 3). Of interest is whether this approach together with spectral variation derived from super-resolution of the data correspond to the known mantled areas. Initial examination appears to show that to be the case; however, these areas will be validated during the field-based data collection.

Conclusions: The general objective of our ongoing terrestrial research is to more accurately quantify blocky, mantled, and eroded lava surfaces using a combination of field measurements and remotely-acquired datasets. Most important is understanding how eolian overprinting of lava surfaces can be spectrally removed in order to more accurately map the underlying composition, morphology, and extent of the flows. This knowledge will then be adapted for improved interpretations of planetary flow surfaces.

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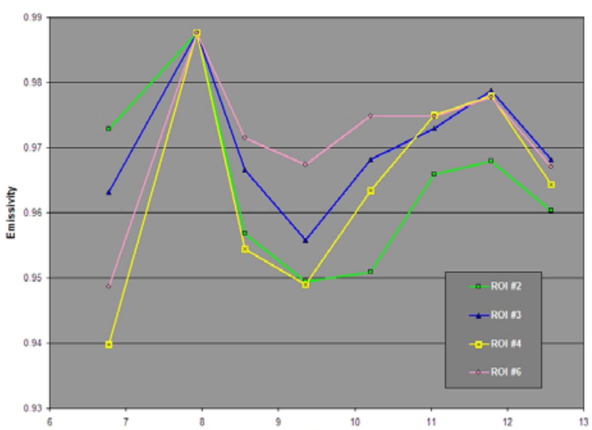

Figure 1. THEMIS IR emissivity spectra extracted from several regions of interest on Arsia Mons lava flows (see Fig. 2). Note the shift in the main absorption feature between 9 – 10 microns from ROI #2 (green) and ROI #4 (yellow). This shift indicates a change in the composition and is independent of the eolian mantling in the region.

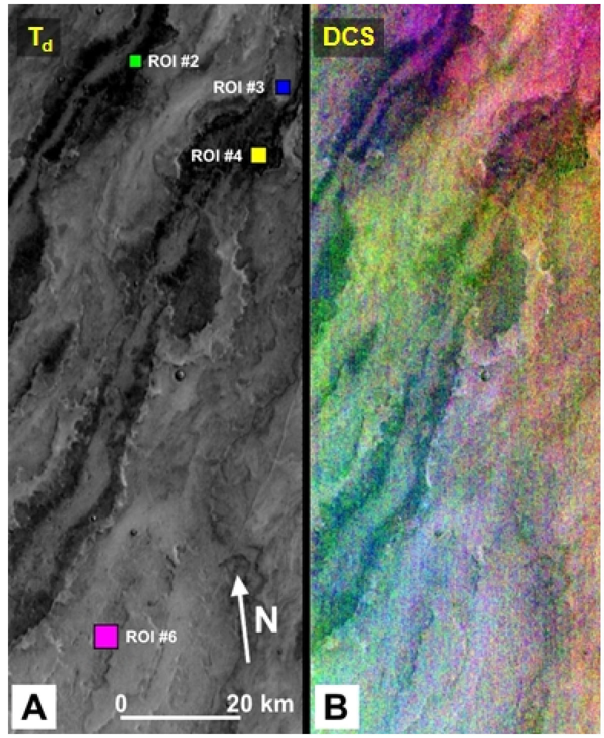

Figure 2. THEMIS daytime temperature image (I07370003) of the prominent flows south of Arsia Mons. [A] Temperature image with darker regions corresponding to the rugged levees of the higher albedo flows. [B] DCS image of bands 9/7/6 in R,G,B (respectively) showing color (compositional) variability.

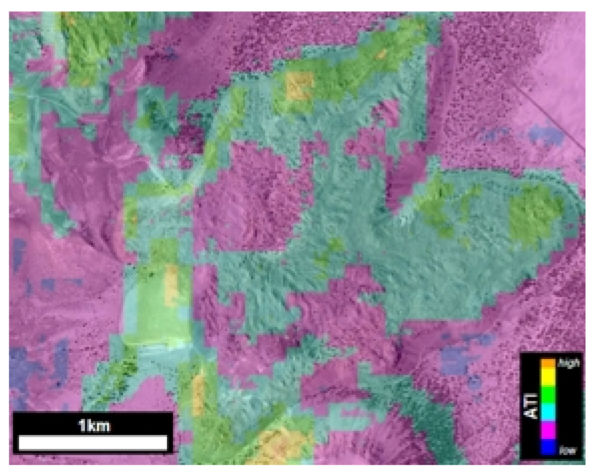

Figure 3. ASTER-derived apparent thermal inertia (ATI) image of the North Coulee flow in the MCD chain. The day/night TIR data were used to create the image, which was overlain on a Google Earth high resolution visible image. Areas of low to moderate ATI values (magenta) correspond to regions of the greatest pyroclastic mantling.