Thermophysical and Spectral Variability of Arsia Mons Lava Flows. Michael S. Ramsey[1] and David A. Crown[2], [1]Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260, mramsey@pitt.edu; [2]Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719, crown@psi.edu.

Introduction: Arsia Mons (9.5°S, 239.5°E) is the southernmost of the Tharsis shield volcanoes and the second largest volcano by volume on Mars. It is more than 9 km higher than the surrounding plains with a well-developed summit caldera [1-3]. Two large lava flow aprons extend from alcoves on the NE and SW flanks and postdate the main shield [4-5]. The SW apron has an average slope of 0.6° with a well-developed flow field [4]. The flows exhibit a wide range of flow surfaces, textures, and degrees of eolian mantling [6].

The research here focuses on a series of lava flows on the SW apron (near 22.5°S, 238.0°E) that have a multitude of textures and unusual thermophysical characteristics. The local slopes are less than 0.3°; however, the small-scale RMS roughness has been modeled using the thermal infrared (IR) emissivity spectra to be as large 15° [7]. Our past studies have utilized the Mars Odyssey (MO) Thermal Emission Imaging System (THEMIS) visible (VIS) camera, and the Mars Reconnaissance Orbiter (MRO) Context Camera (CTX) and High Resolution Imaging Science Experiment (HiRISE) to examine small-scale flow development as well as the degree of mantling [6]. This new work now incorporates data from the THEMIS IR system to extract the surface composition and thermophysical variability of these flows (Fig. 1).

Flow Field Mapping. The SW Arsia flow field exhibits small vents, channels, and flow lobe margins [6]. Morphometric parameters (e.g., length, width, thickness, sinuosity, etc.) for individual flow lobes were used to document the development of channel and levee systems and the differences between higher albedo, more rugged flows and lower albedo smoother flows, as well as to provide a general characterization of flow field properties. CTX images revealed small-scale characteristics of the lava flow surfaces and new insights into flow emplacement processes, useful for understanding the styles and diversity of volcanism [6,8]. HiRISE images provided cm-scale characterizations to derive the percentage of exposed bedrock and mantling deposits and to detect boulders and small impact craters.

THEMIS. The thermal IR imager on THEMIS consists of an array of uncooled microbolometer detectors with 10 spectral channels centered between 6.8 and 14.8 µm with a spatial resolution of 100 m [9-10]. The first two channels are duplicated for better signal to noise and the tenth channel is used to determine atmospheric opacity [9]. The IR data presented here (I07370003) were acquired with all 10 bands at Ls = 240 and a local solar time of 17:06:11. The data were atmospherically-corrected using previously-collected data from the Thermal Emission Spectrometer (TES) and separated into brightness temperature and apparent surface emissivity [10]. The derived scene temperatures ranged from 240 to 283 K with a maximum dust opacity of 0.34.

Results. Rugged levees commonly have daytime temperatures ~4° lower than the warmer channels and the surrounding lower albedo flows, indicating a higher thermal inertia (Figs. 1-2). The TES-derived albedo (0.24-0.26) and dust cover index (0.95-0.97) predict moderate levels of dust cover for the region [11]. Some flows show no temperature inversion between day and night IR data, which is likely the result of an albedo-dominated influence of radiant temperature also indicating the presence of surface dust. Typically, such regions are not conducive for surface emissivity analysis; however, the thermophysical diversity evident on the smaller-scale prompted us to examine the spectra further. Some flows did have a lower dust cover index and did show the expected day-night temperature behavior, indicating that dust cover is not uniformly thick.

Regions of interest (ROIs) were extracted over 16 THEMIS IR pixels in 26 different locations. These were chosen to compare the: 1) rugged and smooth flows, 2) down flow changes, and 3) variability between the levees and channels. Emissivity spectra from these ROIs contained significant diversity with the largest variation occurring between the rugged flow levees and the surrounding smoother flows (Fig. 3). The smoother flows had spectra that were ~50% shallower with the strongest absorption at 9.3 µm, whereas the rougher (less mafic?) flows commonly had an absorption at 8.5 µm. The rugged flow spectra also had a negative slope toward longer wavelengths, evidence of subpixel thermal heterogeneity due to significant surface roughness [7]. These spectra were corrected using a simple linear slope fitting approach. The observed spectral differences do not appear to be a linear combination of the two flow type spectral end-members. This would be expected if the partial eolian mantling on the rugged flows is derived from the smooth flows. The morphological and spectral differences likely indicate different emplacement histories and possibly compositions (Fig 3) .

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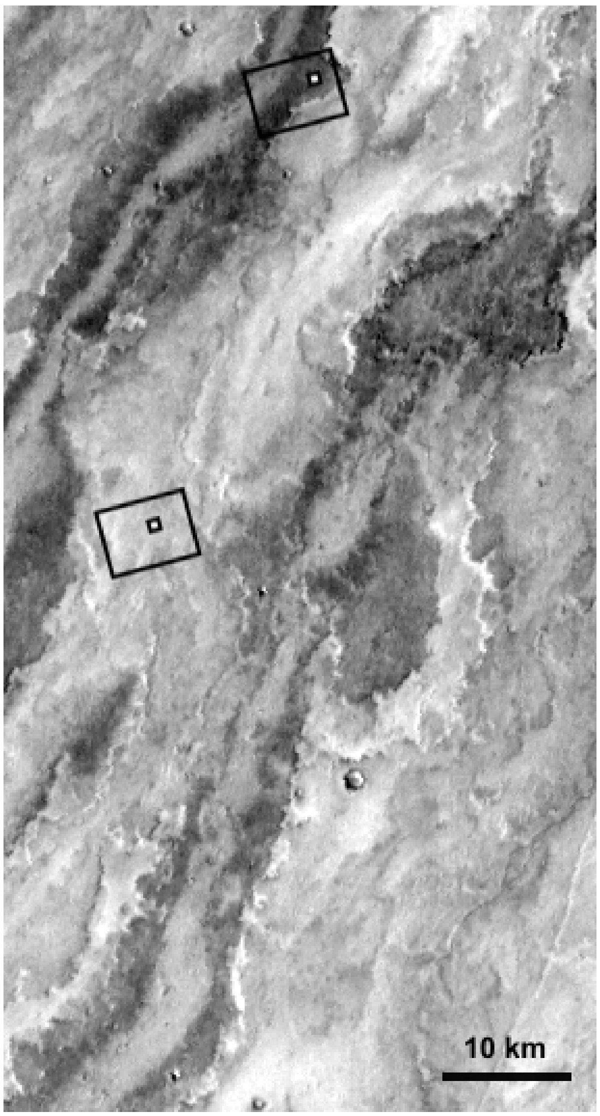

Figure 1. THEMIS daytime temperature image (I07370003) of two prominent flows south of Arsia Mons. The lower temperatures correspond to the rugged levees of the higher (visible) albedo flows. Black boxes indicate the regions shown in Fig. 2.

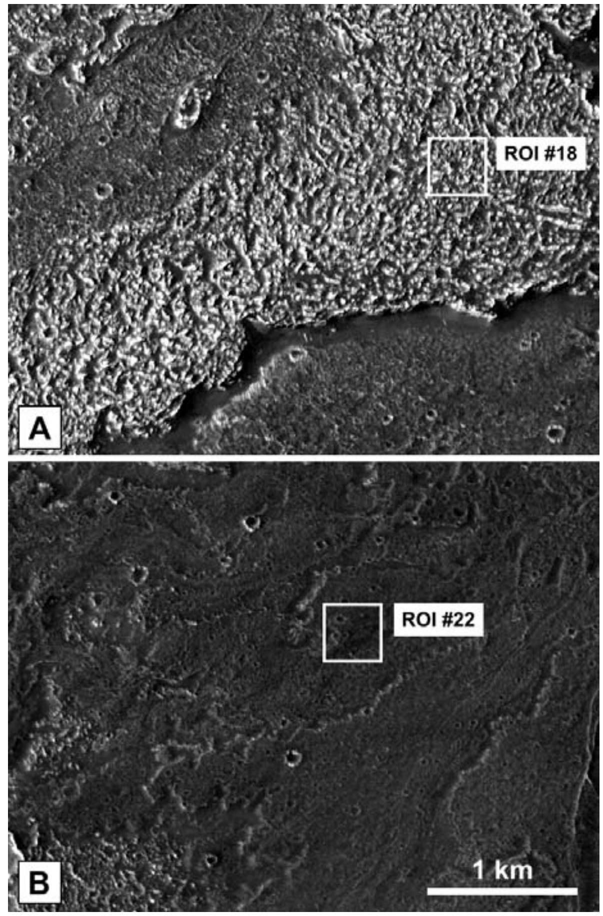

Figure 2. CTX image (P05_002856_1568_XI) of the Arsia Mons lava flows (5.13 m/pixel). The white boxes (0.16 km^2) indicate the regions of interest (ROI) from which the THEMIS IR spectra were extracted (Fig. 3). (A) Higher albedo flow with rugged levees. (B) Lower albedo flow fields containing narrow channels and diffuse terminations. These flows commonly embay the brighter flows in this region.

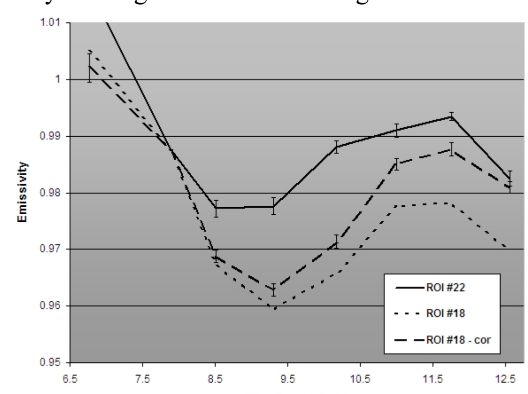

Figure 3. Emissivity spectra extracted from the boxes shown in Fig. 2. ROI #18 (dotted line) from the rugged flow shows evidence of sub-pixel thermal heterogeneity. A simple correction has been applied (dashed line). This spectrum is still quite distinct (and possibly less mafic) from that of the darker flows (ROI #22). Error bars denote 1σ deviation of each ROI.