Thermophysical Characteristics of Lava Flows South of Arsia Mons

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Introduction

Significant mantling of the Martian surface by dust and sand (e.g., in the Tharsis region) negatively influences the ability to investigate the underlying bedrock remotely [1]. Eolian deposits may be locally derived and preserve signatures of the underlying bedrock; however, global homogenization commonly hinders accurate interpretation [2-3]. Using datasets with different spatial and spectral resolutions may allow interpretations of surface features previously considered too extensively mantled for spectral studies. Higher resolution imaging datasets such as HiRISE and CTX are used here to characterize surface formations, whereas lower resolution thermal remote sensing data provide information about composition and particle size.

Location

Arsia Mons is the southernmost of the Tharsis shield volcanoes and exhibits a summit caldera and two main flow aprons originating from the NE and SW flanks [4-5]. The study area is located in the SW apron in Daedalia Planum (figure 1). This region was selected for its extensive lava flow field, coverage by multiple datasets, and recent flow field mapping [6-9]. Previous studies suggest that this area is predominantly basaltic in composition and has a Thermal Emission Spectrometer (TES)-derived albedo of roughly 0.22-0.24 and a dust cover index of 0.94-.97 [10-11]. However, analysis of CTX and HiRISE images suggest the presence of non-mantled outcrops of lava that are distinct from the mantling material [12].

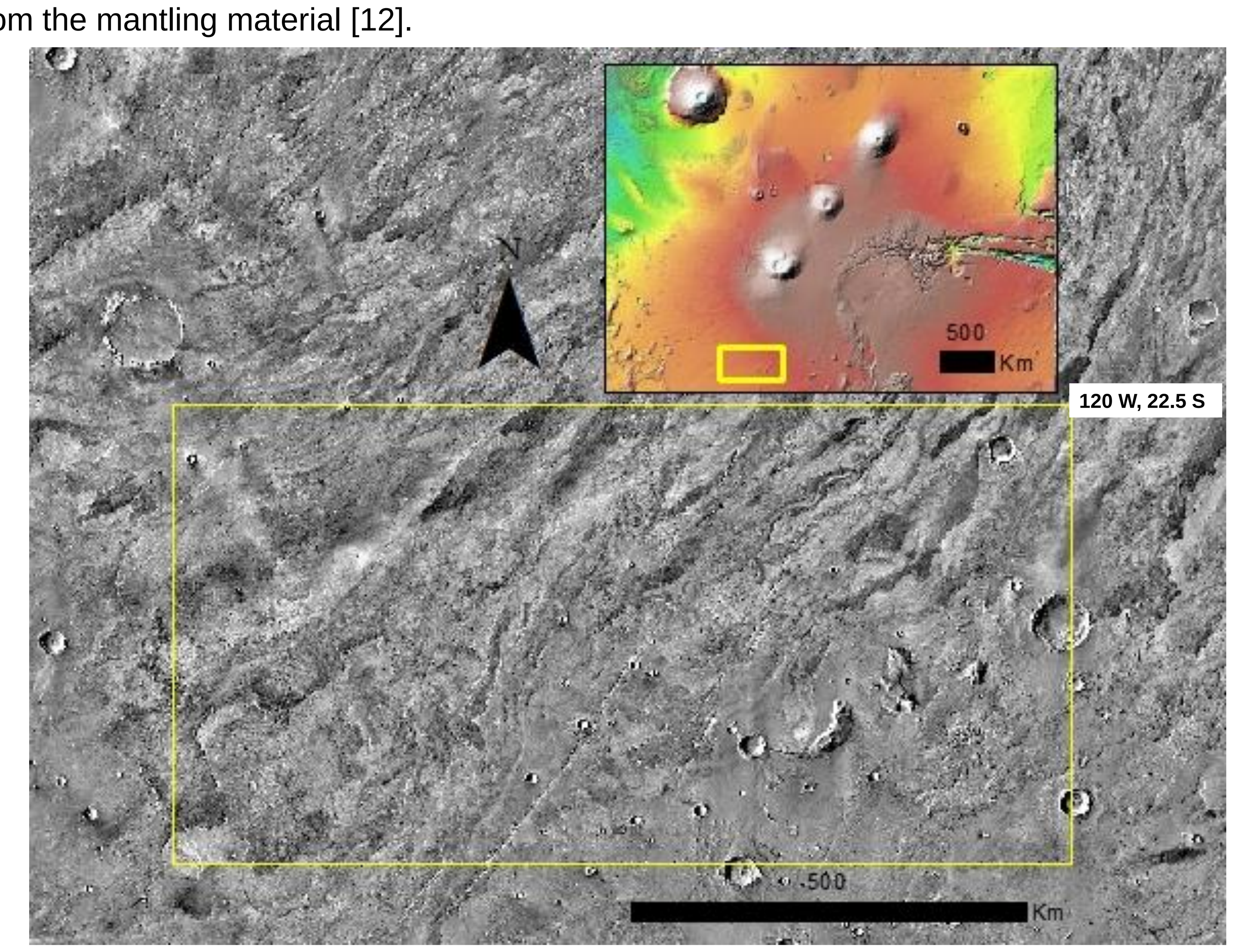


Fig. 1. THEMIS IR daytime temperature composite of the study area (yellow outline) in the Daedalia Planum region located SW of Arsia Mons. MOLA color map inset for context shows the location of the Tharsis study site.

Datasets

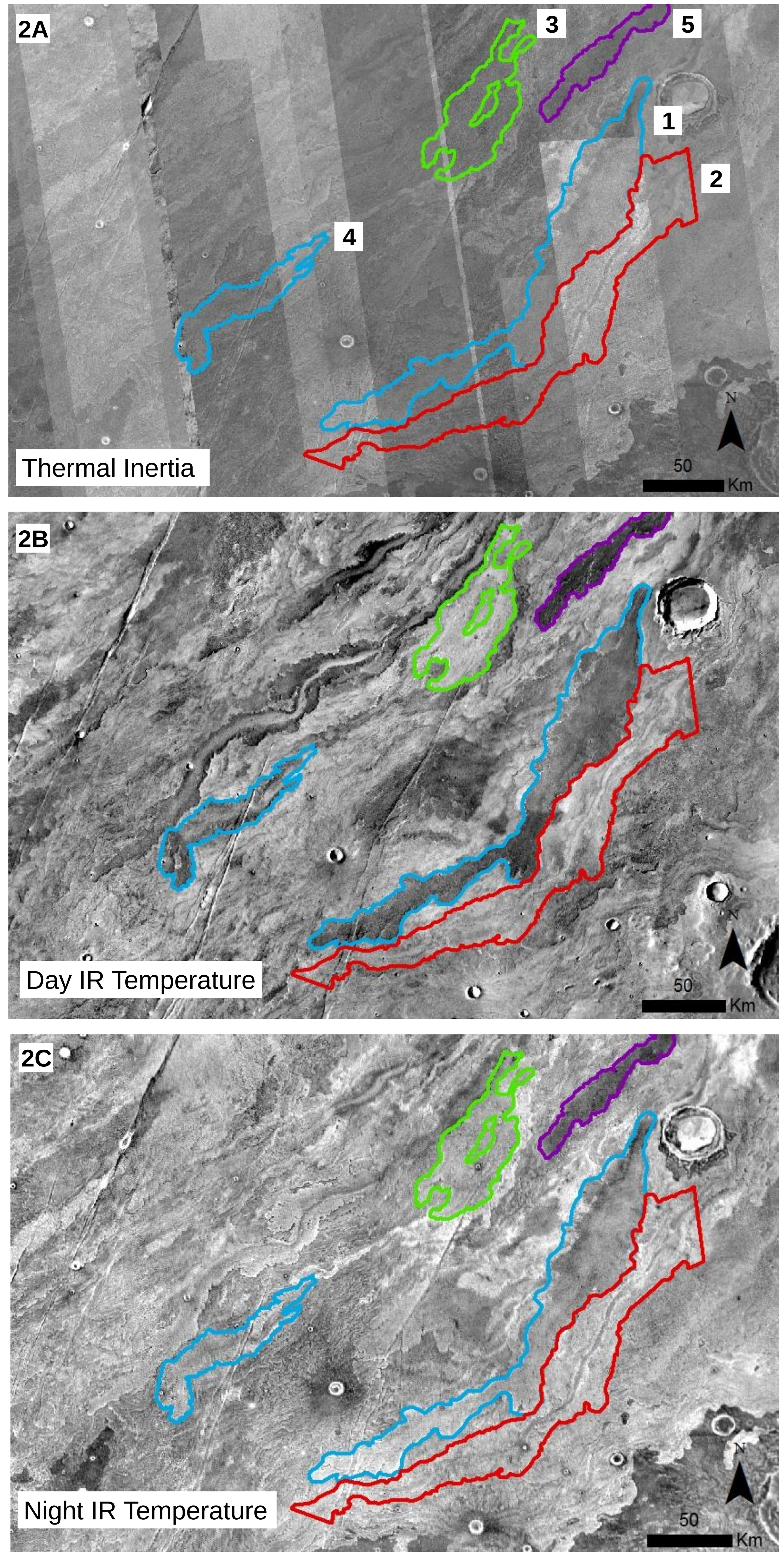
Lava Flow Boundaries and Surface Textures	• MRO High Resolution Imaging Science Experiment (HiRISE) • MRO ConTeXt Camera (CTX)
Thermophysical Properties	• Thermal Emission Imaging System (THEMIS) IR Temperature Day and Night • THEMIS Derived Thermal Inertia • Thermal Emission Spectrometer (TES) Dust Cover Index

Specific limitations were placed on the Thermal Emission Imaging System (THEMIS) infrared (IR) database search to ensure the best quality data would be selected. The following criteria were used:

(1) acquired within the last 600 sols from August 2014
(2) contained all 10 bands
(3) collected between the local hours of 2:00-6:00 (night) and 15:00-18:00 (day)
(4) surface temperature of 225-350 K for day acquisitions

Thermal inertia (TI) derived from THEMIS IR night data were compared with THEMIS IR day data to determine the thermophysical response of the identified flows over a diurnal cycle (figures 2-3) [13-14]. Additionally, in order to assess compositional variability to the flow material, different channels from THEMIS IR data were compared (6-4-2, 8-7-5, and 9-6-4). CTX and HiRISE images were used to identify individual flows, determine local flow superposition relationships, and examine surface textures and morphology.

Comparison of Thermophysical Properties



Figs. 2-4. [2A] Thermal Inertia derived from THEMIS IR night [13], [2B] THEMIS IR day temperature, and [2C] THEMIS IR night temperature. These flows are located in the upper right quadrant of the study area shown in figure 1. The colors of outlined flows correspond with the four categories defined in the procedure section.

Methods

Analyses of the thermophysical characteristics of the Arsia Mons lava flow field show a significant, and unexpected, degree of TI and THEMIS IR temperature variability. Some flows display a significantly higher thermal inertia compared to adjacent flows, which is indicative of a surface that is blockier, less mantled, and/or higher density. This variability could suggest the presence of different particle or block size distributions, linear mixing of mantling and lava outcrops, and/or different flow emplacement processes and ages. To investigate these possibilities, four categories were defined based on the response in THEMIS IR day and night temperature data (figures 2-4). The average thermal inertia, IR day temperature, and IR night temperature values were calculated for each image and used to identify flows with above and below average data. Neighboring flows were then compared to quantify variations in response.

Categories	IR Day Temperature	IR Night Temperature	Flow IDs
A	High	High	Flow 2
B	High	Low	Flow 3
C	Low	High	Flow 1 and Flow 4
D	Low	Low	Flow 5

Region of Interests (ROIs) were defined with a standardized area [3km x 3km], constrained by the smallest flow, to analyze the thermal inertia and temperature response of the flows. For neighboring flows (such as flows 1 and 2), the ROIs were placed next to each other within the same THEMIS image (figure 5). Additionally, flow boundaries were used to help constrain the placement of the ROIs [9]. Statistical analysis of the ROIs was completed in order to understand the differences between the flows to hopefully provide information about emplacement processes in this region.

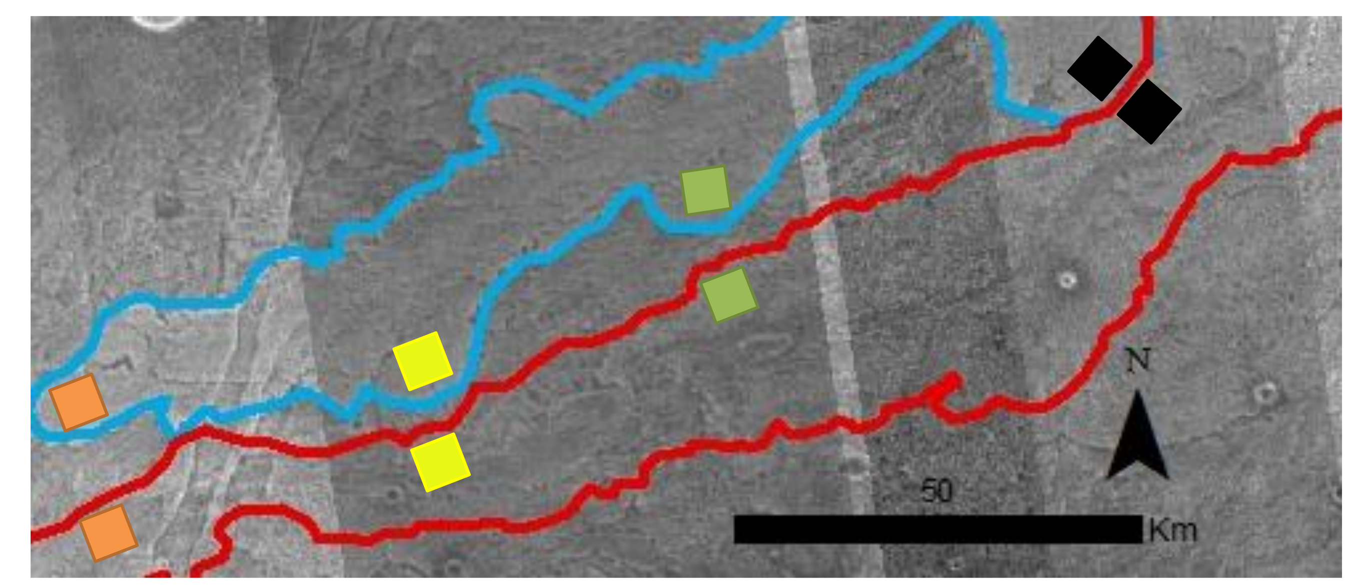


Fig. 5. ROIs, with colors corresponding to figure 6, in flows 1 (blue) and 2 (red) on thermal inertia images.

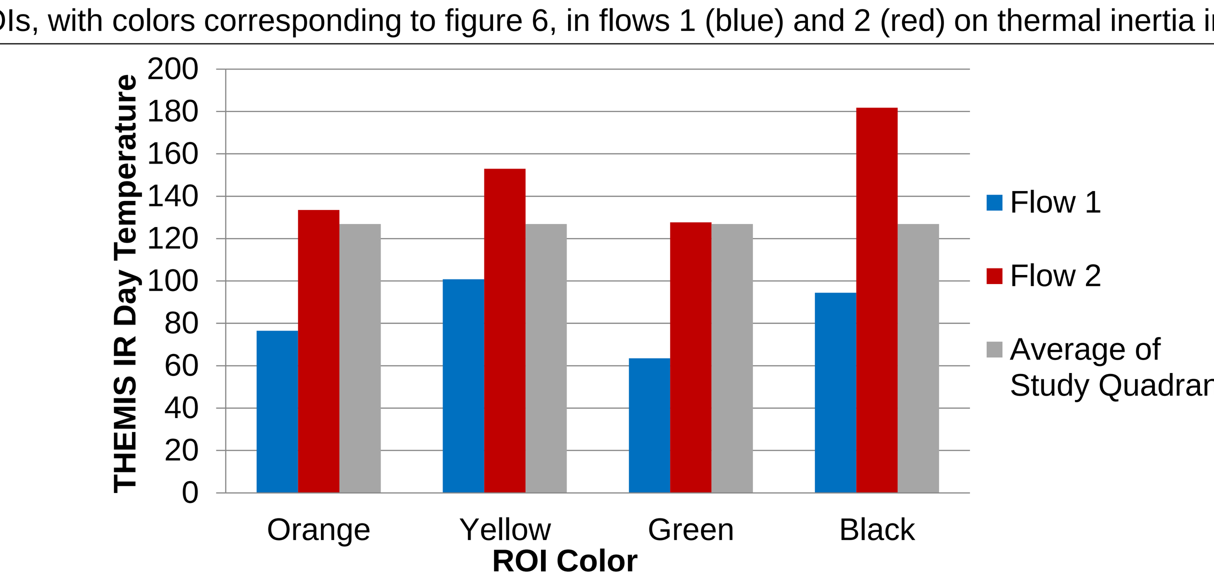


Fig. 6. THEMIS IR temperatures of ROIs along flows 1 and 2.

Results and Future Work

Preliminary results quantified the variation between neighboring flows such as those in figures 5 and 6, for example. The average IR day temperature for neighboring ROIs both lie in the respective second standard deviations (in opposite directions) away from the regional average. However, IR night temperature for the ROIs both lie in the respective first standard deviation from the regional average. Additionally, whereas the thermal inertia for flow 2 is always less than the value for flow 1, the variation between the two flows is not as pronounced as the differences in IR day and night temperature.

Analyses of thermophysical properties suggest the presence of numerous flow types. Continued investigations of TI, day IR temperature, and night IR temperature will be used to characterize regional trends across the flow fields, as well as variations between and within individual lava flows. Comparing properties of these flows and investigating changes along a flow will constrain how the emplacement process may have changed over time and provide insights on how these volcanic processes deviate from similar terrestrial flows.

Acknowledgements

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