CHARACTERIZING LITHIFIED BEDFORMS ON MARS USING THERMOPHYSICAL AND COMPOSITIONAL ANALYSES. A. R. Weintraub[1], C. S. Edwards[1], M. F. Chojnacki[2], L. A. Edgar[3], L. K. Fenton[4], [1]Dept. of Astronomy and Planetary Science, Box 6010, Northern Arizona University, Flagstaff, AZ, arw366@nau.edu; [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, [3]USGS, Astrogeology Science Center, Flagstaff, AZ, [4]Carl Sagan Center, SETI Institute, Mountain View, CA.

Introduction: The surface of Mars is scattered with bedforms generated through aeolian and fluvial processes. Orbital studies have revealed these features are similar to classic aeolian dunes, as well as solid-rock bedforms [1]. While cross bedding and the presence of terrestrial dunes are ubiquitous in the rock record on Earth, fully-preserved bedforms, hereafter called paleobedforms, are much less common. On Mars, these lithified dunes are found in a wide variety of geographic locations indicating diverse formational histories [2]. Paleobedforms are distinct from active dune fields identified on Mars. Evidence include: 1) The presence of meteorite impacts found within the dunes; and 2) The various degrees of degradation found across different paleobedform fields which indicate the break-down of solid rock [3].

The formational histories and cementing agents for these paleobedforms are poorly understood. We aim to classify and characterize compositional and thermophysical relationships between paleobedform fields across Mars with the goal of differentiating between a fluvial and an aeolian genesis. Specifically, we use a thermal model known as KRC [4] to determine the thermal inertia of the surface as a proxy for the grain size and potential cementation of these features. Infrared spectroscopy will be used to identify absorption features indicative of hydrated minerals that might have been generated during formation or induration.

An initial global survey using High Resolution Imaging Science Experiment (HiRISE; [5]) data revealed a wide distribution of candidate paleobedforms – 43 total paleobedform sites were identified with high confidence from a list of several hundred candidates [3]. Eight sites have undergone thermophysical analysis, and two sites have had compositional investigations. Trends and relationships among paleobedform fields will be studied once thermal inertia has been modelled and composition has been identified for all 43 sites.

Thermophysical Analyses and modeling: Thermal inertia can be thought of as the tendency of a material to retain its heat over the course of a day. This is represented as $I = \sqrt{\rho \kappa c}$, where ρ is density, κ is thermal conductivity (the dominant parameter for thermal inertia on Mars), and c is specific heat [6]. A material with low thermal inertia, sand, changes its temperature quickly, due to the low surface contact area between the small grains. High thermal inertia, rocky materials, retain their heat for longer periods of time, where heat is allowed to flow easily throughout the entire material.

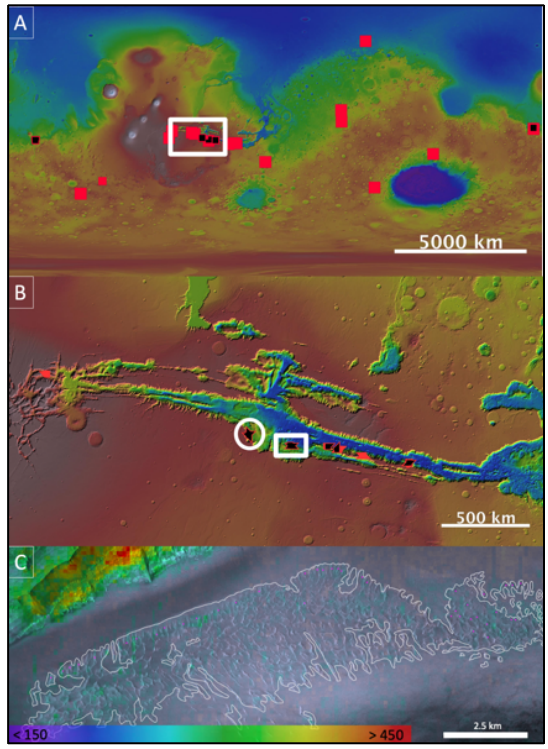

Figure 1: A) This map depicts the 43 paleobedform sites for this investigation (JMARS; [7]). Black dots are sites where thermal inertia values were derived and red dots are sites where values have not been derived. White squares are zoomed in areas within the figure. B) and C) Colorized HRSC/MOLA Blended DEM maps for regional context. B) includes a white circle depicting the location of Figure 2. C) The white outline shows the region identified as a paleobedform field in Melas Chasma. Average thermal inertia of 40 individual paleobedforms in field = 235.16 thermal inertia units (TIUs), standard deviation = 14.78 TIUs. Notice how paleobedforms resemble traditional aeolian dunes.

Thermal inertia is diagnostic of a particular surface and can be used as a proxy for effective grain size [8]. In the case of paleobedforms, thermal inertia is also valuable because it can be used to interpret the degree of lithification of the dunes into solid rock [8]. This will shed light on whether the features represent a fluvial or aeolian origin.

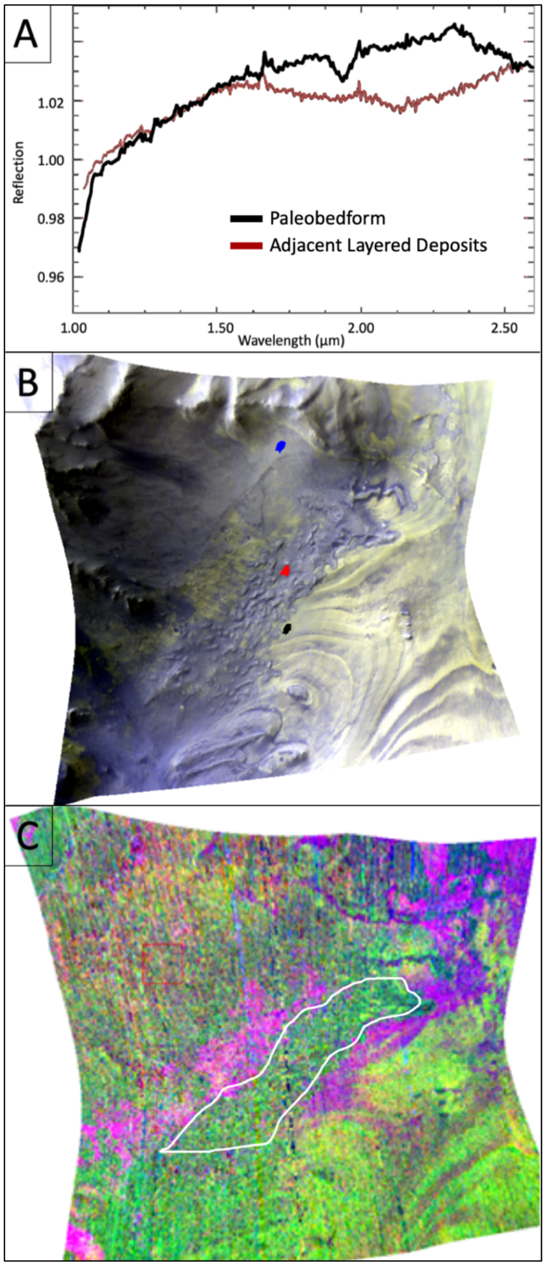

Figure 2: A) CRISM spectra for paleobedforms and layered deposits (bottom right of C, alternating green and magenta stripes) in southwest Melas Chasma, white circle in Figure 1B. The red spectrum, suggesting a pyroxene mineral, represents the ratio between the paleobedform (red polygon in B; 131 pixels) and a bland region with low spectral contrast (blue polygon in B; 142 pixels). The white spectrum (A), suggesting a 1.9 hydrated mineral feature, is the ratio of the layered deposit region (white polygon in B; 121 pixels) and the same bland region. B) The locations of the ROIs are overlaid on a projected and atmospherically corrected CRISM stamp FRT0000A3E9_07_IF164L_TRR3. C) CRISM parameter map depicting hydrated minerals in the paleobedform field (thin white line).

Thermal inertia is derived using the thermal numerical model known as KRC [4]. Surface brightness temperatures obtained from nighttime images (3 – 6 AM) from the Mars Odyssey's Thermal Emission Imaging System (THEMIS; [9]) was used as input parameters along with elevation, slope, and albedo from the HRSC/MOLA Blended DEM. Figure 1C illustrates an HSV image from the Context Imager onboard the Mars Reconnaissance Orbiter [10] colorized with thermal inertia values from paleobedforms derived using KRC. This figure demonstrates how individual paleobedforms have slightly higher thermal inertia than adjacent units.

Compositional Analysis: The compact Reconnaissance Imaging Spectrometer for Mars (CRISM; [11]) was used to determine the spectral signatures and mineralogy for the paleobedform fields. Parameter maps and individual spectra were collected where available. Lower-resolution multispectral survey mode was utilized if high-resolution targeted mode from CRISM data were unavailable. Polygonal ROIs were made encompassing the individual debris-free paleobedforms and its immediate surrounding terrain, which we deemed to be representative of an individual paleobedform.

Spectral math was then performed using ENVI version 5.5 [12] by dividing the ROI by a larger, spectrally bland region covering the same columns (Figure 2 B). This is done to ensure the two areas do not have differing CRISM columnar artifacts. Figure 2C depicts a mineral parameter map following Viviano-Beck et al. [13]. Yellow-green regions indicate monohydrated sulfates and magenta indicate polyhydrated sulfates.

Results and Future Work: Figure 1C depicts raised thermal inertia within the paleobedform field as compared to the adjacent terrain. Figure 2C illustrates a paleobedform field compositionally distinct from adjacent units. Together, these data imply a distinct mineralogical and thermophysical signature from paleobedform fields, thus justifying continued studies. This includes completing thermal modelling, collecting compositional data, and performing statistical analyses.

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