GEOLOGIC FEATURES IN NEW TES THERMAL INERTIA-ALBEDO UNITS DERIVED FROM UNSUPERVISED CLASSIFICATION.

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Introduction: Maps of thermal inertia-albedo units have been demonstrated to provide information on the distribution of surface materials on Mars [1,2]. Previous work has used deterministic methods to threshold the dominant values in thermal inertia and albedo from the Thermal Emission Spectrometer (TES), producing a map of 7 thermophysical units [2]. The units were interpreted as mixtures in various proportions of principal surface components dust, bedrock and ice. The use of deterministic methods to define threshold captures important information from the thermal inertia and albedo data but discards potentially significant patterns and can introduce biases. An alternative is to use unsupervised classification algorithms, which are not biased towards the most distinctive thermal inertia and albedo information. We have utilized unsupervised classification algorithms to identify martian surface features, at multiple cluster resolutions, and found substantial structure in medium-high thermal inertia materials that were not seen in previous works. As part of an ongoing analysis of the classes produced by the classification algorithm, here we present some correlations between geologic surface features and the new class boundaries. Our mapping of surface materials is consistent with the locations of high latitude ice, the boundaries of some geologic units, and suggests the presence of low-latitude ice-cemented terrain.

Methods: Unsupervised classification is broadly used in the interpretation of terrestrial remote sensing and involves using a clustering algorithm to group pixels that have similar values in each measurement parameter. The algorithms used here were isodata and maximum likelihood [3,4] (see detailed methodology therein). They provide a complete partitioning of the data space into non-overlapping Gaussian distributed classes, with the maximum number of classes N specified by the user. A number of N values were applied, with N > 10 found to decrease the coherency of the spatial patterning. Here some results for N = 10 will be discussed. The classes were mapped and interpreted as mixtures of dust, sand, duricrust, bedrock and ice on the Martian surface through comparing the thermal inertia and albedo distribution within each class to the known behaviour of different grain sizes on Mars (eg. [5-8]). One approach for assessing the validity of the classes produced by the classifier is through examining their relationship to martian surface features, such as geology, location of sand dunes, and near-surface ice. The results of comparisons to the GIS-ready vector datasets of geologic contacts [9] and dunes > 1 km^2 [10] (likely incomplete for dune fields < 10 km^2) are shown below.

Results: Major geologic structures such as Valles Marineris, Olympus Mons, and a number of large impact craters are clearly delineated in our thermophysical map, suggesting a broad correlation between the classes and martian geology. For example in Figure 1, the boundary between the light and dark green classes is located near the boundary between the low viscosity lava flows of the 'ridged plains unit' and the volcanic flows of the 'syria planum formation' in the geologic map [9], suggesting the map may be used to resolve different types of lava flows.

Many impact craters with diameter over 50 km are distinguished in the thermophysical map, identified by concentric circular structures of thermophysical units that contrast with the units dominating the surrounding terrain. This is consistent with observations of distinct high thermal inertia impact ejecta surrounding many martian craters [1].

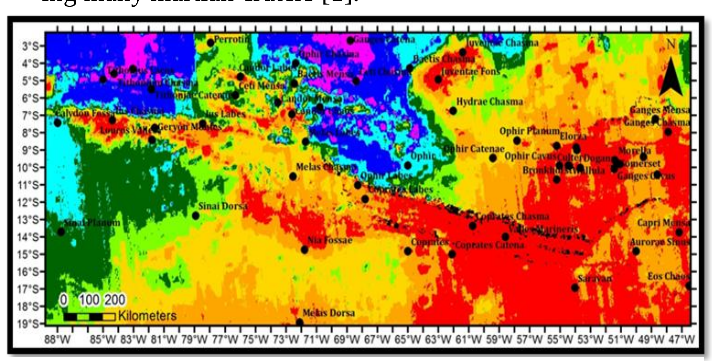

Figure 1: Valles Marineris canyon system in the thermophysical classification map. Noctis Labyrinthus, Ius Chasma, Candor Chasma, Coprates Chasma and Melas Chasma are clearly delineated in the thermophysical map.

The thermophysical units produced here may be sensitive to geologic terrain age, as the borders between Noachian, Hesperian and Amazonian units are closely matched by class boundaries. Comparing the classes to geologic polygons with designated terrain age in

Figure 2, reveals that each class is comprised of terrain of all surface ages, but there is a clear mapping from surface age to thermophysical unit.

Several thermophysical classes were interpreted as being dominated by sand. If correct, the location of the classes should be correlated with dune fields. 95 % of total mapped dune area [9] was found to occur in the aforementioned classes. This strong correlation between large dune occurrence and the class terrain provides strong supporting evidence for these surfaces being sand dominated. In comparison, the remaining classes showed few medium-large dunes.

Two classes were interpreted as dominated by water ice with varying dust coverage. The spatial locations of these classes is consistent with observations of shallow subsurface water ice [11,12]. The interior of Korolev crater shows water ice and ice-related morphologies [13,14]. In Figure 3 Korolev crater in our thermophysical map is filled by one of the classes interpreted to be surface/shallow water ice (in purple). Some localized low-latitude occurrences of this purple class may be possible locations of shallow water ice.

Conclusions: The thermal inertia-albedo classes produced by unsupervised classification provide important insights into how past fluvial and aeolian processes have distributed materials and sorted grain sizes on the Martian surface. The correlations between the new martian thermophysical map and independent observations of the surface reinforces the interpretation of classes and strengthens the validity of the dataspace partitioning. Detailed analysis and comparison to the mineralogy and geologic context of each class is ongoing.

References: [1] Mellon, M.T. et al. (2000) *Icarus, 148*, 437; [2] Putzig, N.T. et al. (2005) *Icarus, 173*, 325; [3] Jones, E.G., et al. (2011) *ASSC Proceedings, 10*, 145; [4] Jones, E.G., et al. (2011) *LPSC, 42*, abstract 1093; [5] Christensen, P.R. (1986) *J. Geophys. Res., 91*, 3533; [6] Jakosky, B.M. (1986) *Icarus., 66*, 117; [7] Jakosky, B.M. and Christensen, P.R. (1986) *J. Geophys. Res., 91*, 3547; [8] Presley, M.A. and Christensen, P.R. (1997) *J. Geophys. Res., 102*, 6551; [9] Skinner, J.A. et al. (2006) *LPSC, 37*, abstract 2331; [10] Hayward, R.K. et al. (2008) *Planetary Dunes Workshop*, 7013; [11] Boynton, W.V. et al. (2002) *Science, 297*, 81; [12] Mitrofanov, I.G. et al. (2002) *Science, 297*, 78; [13] Burr, D.M. et al. (2009) *Planet. Space Sci. 57*, 541; [14] Brown, A.J. et al. (2007) *LPSC, 58*, abstract 2308.

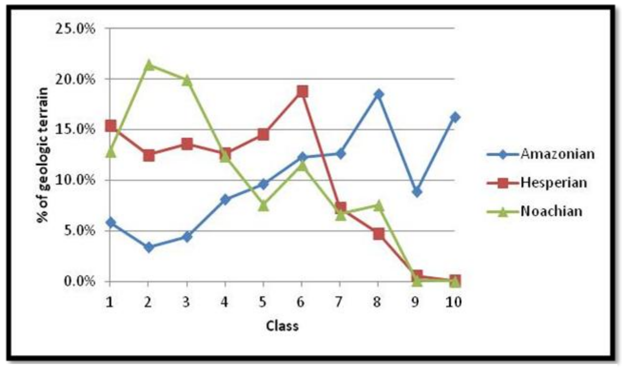

Figure 2: Relationship between terrain age and thermophysical units. For each geologic epoch percentages are calculated as the total surface area of terrain that falls within each class, out of the total global area of terrain of that epoch.

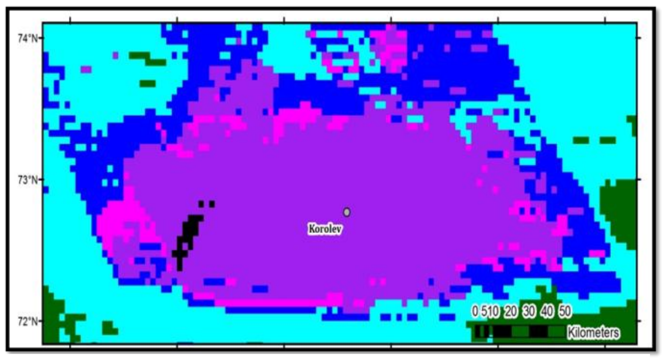

Figure 3: Korolev crater in the thermophysical map. Crater diameter is ~ 84 km.