GLOBAL DISTRIBUTION OF THERMALLY DISTINCT CRATER EJECTA ON MARS AND GEOLOGICAL IMPLICATIONS. L. M. Garofalo and A. D. Rogers[1], [1]Stony Brook University, Stony Brook, NY, USA, Deanne.Rogers@stonybrook.edu

Introduction: The Mars Odyssey Thermal Emission Imaging System (THEMIS) provides a unique view of Martian surface properties, with a capability for nighttime imaging of thermal radiance at 100 m/pixel spatial resolution [1]. At night (~5 am), thermal variations on the surface are largely controlled by the physical properties (e.g. particle size, induration) of the upper few centimeters of surface materials, whereas factors that dominate daytime radiance, such as albedo or topography, are insignificant [e.g. 2].

Nighttime thermal imaging has proven extremely useful for identifying impact ejecta that is, in many cases, otherwise indistinguishable in visible imagery or laser altimetry [3-7]. These studies used nighttime imaging to: find and identify rayed craters on Mars [3-4], map the contributions of impact ejecta to intercrater plains surfaces [5], locate potentially “fresh” craters for spectral and compositional characterization [6], and demonstrate possible regional differences in target material properties [7]. Despite the previously demonstrated utility and potential science applications of identifying thermally distinct crater ejecta, the factors that contribute to their formation and preservation remain unclear. For example, [6] interpreted them as relatively fresh craters, whereas [7] interpreted the presence of thermally distinct ejecta in terms of distinct target material strength. In reality, probably both factors contribute to their formation and preservation, and regional variations in the dominant factor may exist.

In this work, we conducted a global and systematic survey of thermally distinct crater ejecta on Mars, with the goal of trying to understand the factors that contribute to their formation and preservation. We documented their locations, “thermophysical facies” [4], diameters [8], degradation states [8], map unit ages [9-10], and the thermophysical map units [11] that they are contained in.

Methods: The global THEMIS nighttime radiance mosaic [12] was systematically examined in 10 x 10° regions, at a spatial resolution of 64 pixels-per-degree (ppd). Crater ejecta that could be visually distinguished from background surfaces were marked. Whether the ejecta exhibited a higher or lower thermal radiance than background materials was noted. Note that the radiance mosaic consists of individually stretched images, and thus cannot be used for quantitative measurements. However, it may be used for identifying relative differences in thermophysical properties. Crater diameters and degradation states for all thermally distinct craters were retrieved from the Robbins et al. [8] crater database, and map unit ages were retrieved from [9-10]. Finally, thermophysical map units were defined by [11] using the global 2-D histogram of thermal inertia vs. albedo values, derived from TES data. Using the thermal inertia-albedo ranges defined by [11], the TES-based thermophysical map unit for each thermally distinct crater ejecta was retrieved.

Results: The global distribution of thermally distinct craters is shown in **Figure 1**. There are 952 craters, categorized into four groups: cooler than surroundings (50%), warmer than surroundings (35%), both warm and cool facies within the ejecta (4%) and thermally distinct ejecta margins only (11%). Examples from each of these groups are shown in **Figure 2**.

The range of crater diameters with thermally distinct crater ejecta is 1-77 km, with most craters falling between 4-10 km (**Figure 3).** Diameter frequency distributions for each of the four ejecta groups was compared. No statistical difference between the “warm” and “cool” populations were observed (Student’s t-test P-value = 0.78); however the “margin-only” crater diameter distribution is shifted to a higher range of diameters with >99% confidence.

Thermally distinct ejecta are contained in map unit ages that are overwhelmingly Hesperian-aged or younger, with 44% Hesperian, 30% Amazonian, and 25% Noachian, even though Noachian terrains contain a much higher proportion of craters in general [9-10].

Thermal inertia (TI)-albedo units [11] for the crater ejecta show ~5% in class “A” (low TI, high albedo, interpreted as dust deposits), ~54% in class “B” (high TI, low albedo, sand/rocks), ~37% in class “C” (high TI, moderate albedo, duricrust), and <5% in other classes. The proportions of each class found by [11] for all surfaces are ~19% class A, ~36% in B and ~23% in C. Thus there is a slight preferential association of thermally distinct crater ejecta with classes B and C, relative to A, but in general, the distribution of thermally distinct crater ejecta between thermophysical map units is not extremely different from the global population.

Approximately 80% of all thermally distinct craters were categorized with degradation states of “3” or “4” by [8], corresponding to less degradation than the global population (only ~37% of the ~50,000 craters with recorded preservation state are categorized as 3 or 4 [8]). This is to be expected, given that one of the major factors in assigning preservation state is the presence of crater ejecta [8]. No statistical difference in degradation state between each of the ejecta groups was found.

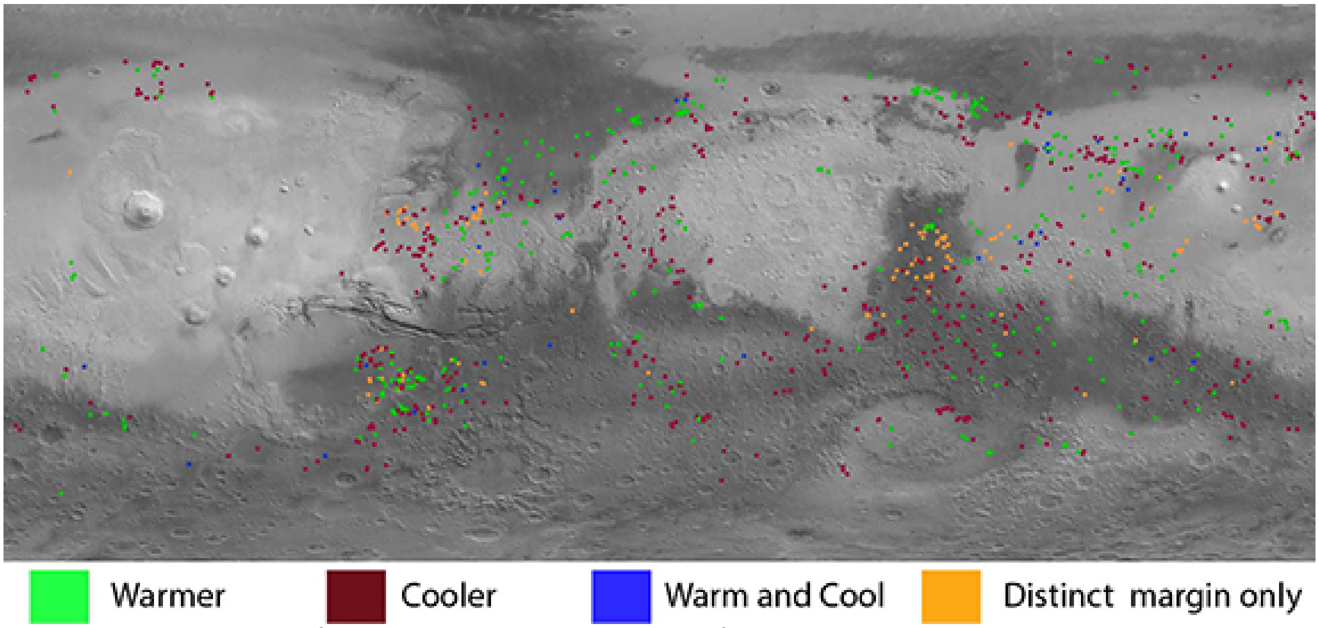

Figure 1. Global distribution of thermally distinct crater ejecta, detected from THEMIS nighttime radiance images. Craters were categorized into four groups based on thermal contrast with surrounding material (see **Fig. 2** for examples).

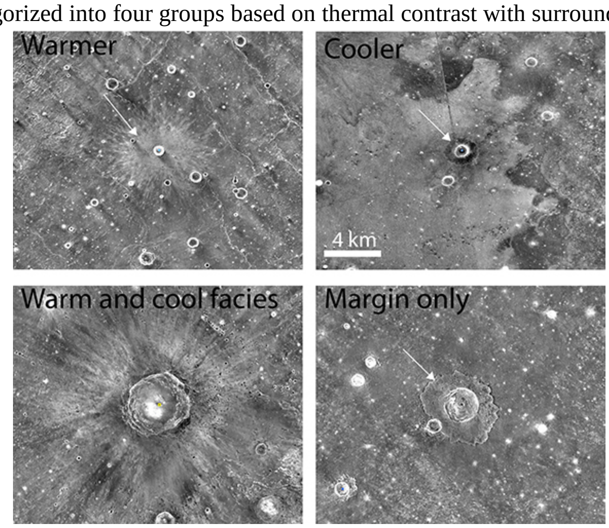

Figure 2. Examples of ejecta categories in this work: warmer than surroundings, cooler than surroundings, both warm and cool ejecta facies present, and craters with thermally distinct margins only. Scalebar applies to all panels.

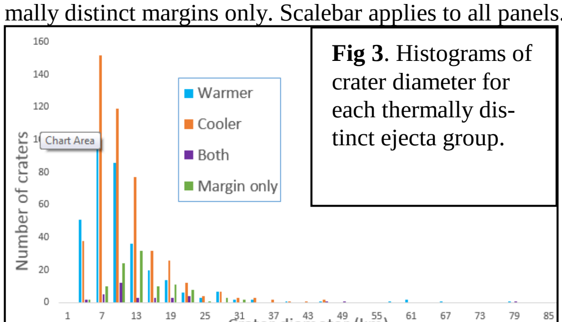

Fig 3. Histograms of crater diameter for each thermally distinct ejecta group.

Discussion: A major finding is that the global distribution of thermally distinct ejecta is not random. This indicates spatial control by one or more processes/factors. Target material and map unit age do show some control over the distribution, as distinct crater ejecta are disproportionately low in very high albedo, low thermal inertia surfaces and in Noachian aged surfaces. Sharp transitions in spatial density and/or type of thermally distinct ejecta are observed in many locations; for example, the northern extent of distinct ejecta in Acidalia Planitia corresponds with the southern margin of the Vastitas Borealis formation. As another example, Syrtis Major shows a dominance of the "margin-only"-type ejecta, whereas Tyrrhena Terra to the south lacks this type of ejecta. Though there are appear to be regions where each group is more dominant, a clear *global* pattern in dominant groups is not evident.

Future work will focus on quantifying thermal inertia values for each ejecta field, deriving compositional properties (as in [6]), and examining spatial/regional clustering of crater ejecta types within each age and thermophysical unit. This work will contribute to understanding the potential use of thermally distinct ejecta as indicators of target properties, crater preservation, and/or resurfacing (burial or erosion) history on Mars.

References: [1] Christensen et al., (2004) Space Science Rev., 110, 85-130 [2] Kieffer et al. (1977), JGR, 82, 4249-4291 [3] McEwen et al. (2005), Icarus, 176, 351-381 [4] Tornabene et al. (2006), JGR, 111, E10006 [5] Rogers et al. (2009), Icarus, 200, 446-462 [6] Rogers, (2011) *EPSL, 301*, 353-364 [7] Bandfield et al. (2013), Icarus, 222, 188-199 [8] Robbins et al. (2012), JGR, 117, E05004 [9] Greeley and Guest (1987) UGSS Misc. Invest. Ser. Map, I-1802-B [10] Tanaka and Scott (1986) USGS Misc. Invest. Ser. Map, I-1802-A [11] Putzig et al. (2005), Icarus, 173, 325-341 [12] Edwards et al., (2011), JGR, 116, E10008.