The nature and origin of Mars' intercrater plains: New insight from THEMIS. A. D. Rogers[1], O. Aharonson[1], J. L. Bandfield[2], and P. R. Christensen[2]. [1]California Institute of Technology, MC 150-21, Pasadena, CA 91125 USA, [2]Arizona State University, Campus Box 876305, Tempe, AZ 85287 USA. drogers@gps.caltech.edu

Introduction: The nature and origin of highland intercrater plains on Mars have been somewhat enigmatic since the Mariner era [1-3]. Long-standing questions about these areas include the relative amount of resurfacing by impact, volcanism, sedimentation, and fluvial action [3]. For example, what proportion of the exposed surface area is impact debris? Are the plains surfaces primarily volcanic in origin, or consolidated sediments? High-resolution spectrometers and imagers have provided new insight into the origin of these ancient surface materials. In this work, we examine the composition, morphology and thermophysical properties of intercrater plains with THEMIS, TES and MOC data in an initial effort to revisit these basic questions. Additional insight to be gained from this study is whether regional compositions observed by TES [4,5] are due to materials of a uniform regional mineralogy, or to a mixture of geologic units with differing compositions. And if the compositions differ, what processes are responsible?

Presently, our study region is limited to 10-60 °E, 15-35°S, which is generally northwest and west of Hellas Basin. Our study area covers the following major map units of [6]: Npl1, Npl2, Nplr, Nplh, Npld, Nple, and Hpl3.

Thermal inertia and geology: THEMIS nighttime imagery shows that the intercrater plains of Mars commonly contain significant areal exposures of high thermal inertia (TI) surfaces relative to surroundings (Fig. 1). Quantitive TI values were measured from some of these nighttime-warm surfaces; values were typically >500 $Jm^{-2}K^{-1}s^{-1/2}$, with some as high as 1200 $Jm^{-2}K^{-1}s^{-1/2}$. These values are consistent with sufaces dominated by blocky materials or bedrock. For many of these exposures, lower-inertia ejecta blankets from nearby craters (~40-80 km diameter) overlie the high-TI surface (Fig. 1). However, in other cases, the high-TI surfaces appear to border crater rims of similar diameter, suggesting that the high-TI unit overlies the preexisting ejecta of that crater. These relationships are in many cases difficult to observe in visible imagery, and demonstrate the utility of using thermal infrared data for understanding the relative contribution of impact materials to intercrater plains units. Low-TI materials that are not clearly part of an ejecta blanket are hereafter loosely referred to as "undifferentiated units".

The high-TI surfaces (relative to surrounding terrain) have an apparently resistant morphology. No channels or yardangs are observed within the high-TI units, however in at least one example, the high-TI unit appears to truncate dissected plains. Resistant linear ridges that may be exposed dikes or inverted channels are observed in some of the high-TI units. The high-TI units are commonly superposed by lower-inertia patches of material that are not associated with crater ejecta. The high-TI unit is usually lighter-toned than surrounding lower-inertia plains in visible imagery (Fig. 1). Quantitative TES albedo values are difficult to retrieve over these small areas because of subpixel mixing, however in general they range from 0.12-0.16 and are still low in albedo relative to Martian dust covered regions.

Composition: Bandfield et al. [7] applied decorrelation stretches to daytime THEMIS IR images using three band combinations displayed as red-green-blue: 8-7-5, 9-6-4, 6-4-2; here these are referred to as "3-panel images". The high-TI unit discussed above exhibits a consistent DCS color combination in the 3-panel images: magenta in 8-7-5, magenta in 9-6-4, and green in 6-4-2. The surrounding undifferentiated lower-inertia units are usually green-green-pink in these plots. Materials that are clearly ejecta blankets in the nighttime imagery (see above) are indistinguishable from the undifferentiated units, within the THEMIS spectral range. In addition to the high-TI unit and the undifferentiated plains/crater ejecta units, a third spectral unit (light blue, light green, yellow in 3-panel images) is sometimes found overlying either of those units (Fig. 2, "LT"). It exhibits a lower TI and lighter tone than the high-TI unit, and appears to exist independently of the plains and high-TI units.

TES spectra were extracted from 3 of the high-TI surfaces and surrounding plains. For the areas examined, there is a consistent trend in derived mineralogy in which the high-TI units exhibit low plagioclase/pyroxene ratios relative to the surrounding plains and impact ejecta. Excluding the small orthopyroxenite detections in Vallis Marineris [8], the areas examined exhibit the lowest plagioclase/pyroxene ratios observed to date in TES data, and are well within the range measured from basaltic shergottites (~0.4-0.9 [9]). In addition, in every case, low-Ca pyroxene is modeled as the dominant pyroxene. This differs from regional scale TES-derived mineralogy of highlands units [4,5]. The LCP:HCP ratios are also within the range measured from basaltic shergottites (1:1 to 18:1, summarized in [5]). Few TES spectra are available from the third spectral unit, therefore a mineralogy was not derived. Additional techniques and datasets will be required to constrain the mineralogy of this unit. Future work will also include examining TES spectra from other high-TI regions in our study area.

Stratigraphy: There are few places where the contact between the high-TI unit and the undifferentiated plains can be positively identified as erosional or depositional in nature, however in those few examples, the morphology (i.e., apparent onlap margins) suggests that the high-TI unit superposes the undifferentiated plains rather than being exposed from beneath by erosion. Ejecta from small (~3-5 km) impact craters found within the high-TI unit have similar spectral properties to the surrounding undifferentiated plains (Fig. 2), whereas ejecta from smaller craters (<1 km) do not appear spectrally distinct from the high-TI unit. This suggests that the high-TI unit in those areas is thinner than the depth of the shallowest crater that excavates plains-like material, i. e. ~300-500 m.

Discussion: Numerous intercrater plains areas within the study region contain high-TI units within otherwise-undifferentiated plains (spectrally and thermophysically). The similarity in spectral properties and morphology of these discontinuous exposures suggest a similar origin for these high-TI units despite the large area over which they are dispersed. As discussed above, there are areas where craters of similar size to those found in the undifferentiated plains have produced ejecta blankets that clearly overlie the high-TI unit. These ejecta patterns appear well-preserved implying that little erosion or deposition has occurred in these areas since those impacts occurred.

We have begun to examine high-TI units outside the study area to determine if they have similar spectral properties. High-TI plains units south of our study region were noted by [10]. We found that the southern units commonly have a different color combination (orange, pink, blue) in the 3-panel images than those in our study region. TES spectra from those units show the southernmost high-TI units do not have the low plag/pyx ratios which primarily characterize the high-TI units to the north. In addition, there is a suggestion of slightly higher high-silica phase abundance and lower olivine abundance in the southernmost high-TI units, however that result must be further validated with additional datasets and analysis.

Conclusion: The high-TI units exhibit a different morphology and composition than impact ejecta that overlies them, thus from this work we are able to identify portions of the intercrater plains that clearly were not emplaced by impact processes. Volcanic, subaqueous sedimentary, and subaerial sedimentary hypotheses for the origin of the high-inertia unit are currently being evaluated based on mineralogy, geomorphology, and context. The high-TI unit and surrounding plains have differing compositions, indicating that a mixture of local-scale geologic units are contributing to the regional composition derived with TES data [4,5]. Preliminary examination of relatively high-TI units outside the study area suggests regional differences in mineralogy exist between these components of the intercrater plains.

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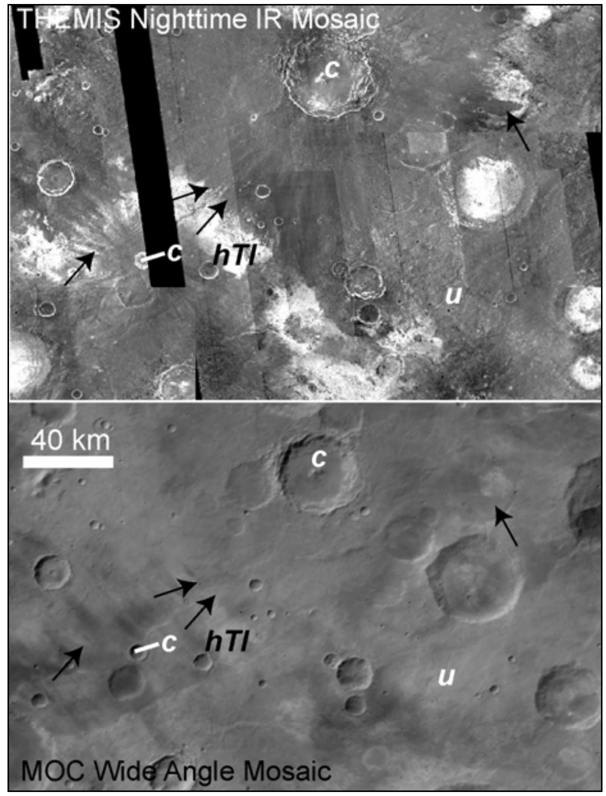

Figure 1. Example of intercrater plains. "hTI" is a typical high-TI area within the intercrater plains. "c" designates craters whose ejecta clearly overlie the high-TI unit. "u" shows a typical area of low-TI material that is not obviously crater ejecta, loosely designated as "undifferentiated". Arrows point to ejecta margins.

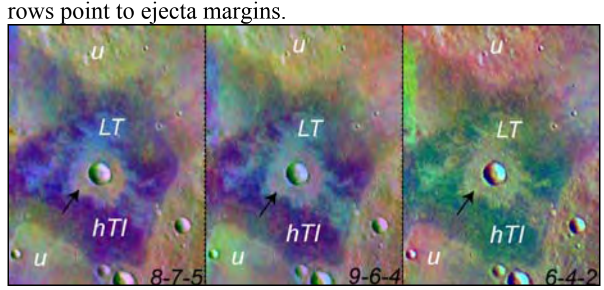

Figure 2. Labeled 3-panel image [7, 11] of intercrater plains area showing the spectral characteristics of the units discussed. "LT" is the third spectral unit that is sometimes found in the intercrater plains. Arrow points to ejecta that is spectrally similar to surrounding plains, suggesting that hTI is a thin layer.

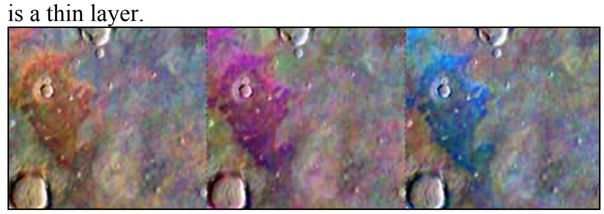

Figure 3. 3-panel image [7,11] for a high-TI unit south of the study area. The differences between Figs. 2 and 3 illustrate regional variations in mineralogy of these high-TI units.