Thermal and Near-Infrared Analyses of Central Uplifts of Martian Impact Craters. Cong Pan[1], A. Deanne Rogers[1], and J. R. Michalski[2], [1]Stony Brook University, Department of Geosciences, 255 Earth and Space Science Building, Stony Brook, NY, 11794-2100, panconggeosciences@gmail.com, [2]Planetary Science Institute, 1700E Fort Lowell RD STE 106, Tucson, AZ, 85719

Introduction: Insight into Martian igneous compositions may be gained by studying impact craters, which are natural probes into the Martian subsurface [1]. Particularly, the central uplift (CU) of an impact crater exposes rocks from the subsurface. A recent study [2] presented a planetwide survey of CU compositions (focusing on CUs with a lack of evidence for alteration) using CRISM VNIR data. This study complements that work by presenting a global survey of CUs that are spectrally distinct in THEMIS thermal infrared (TIR) data. The TIR spectral range is sensitive to mafic minerals as well as plagioclase which is a major mineral on Martian surface [3], anhydrous silica/sulfate, or poorly crystalline silicates. This paper presents a global thermal (THEMIS) and near-infrared (CRISM) spectral study of low-albedo central uplifts of Martian impact craters with diameter between 20-143 kilometers. It will help to understand processes that contributed to crust formation and evolution, as well as magnitude and style of surface weathering.

Data: We investigated THEMIS Decorrelation stretch (DCS) and CRISM (where available) summary parameter images covering impact craters with central peaks and diameter larger than 20 kilometer globally, using the crater database of [4] and [5]. Within this set of craters, CUs containing units that are spectrally distinct from the plains that surround the crater were identified by THEMIS DCS image and CRISM product indices were identified, and well-exposed and preserved CUs were prioritized using visible (THEMIS VIS, CTX, MOC and HiRISE) and daytime/nighttime THEMIS IR data. Thermal infrared spectra of CUs were derived from THEMIS and TES (where available) data. High resolution CRISM data were used to search for secondary minerals (e.g., clay, sulfate and carbonate) and primary minerals (olivine and pyroxene).

Method: THEMIS spectral unit mapping similar to [6] was used to determine the distribution of distinct units. Scene-derived endmembers was used to model surface emissivity for the crater and surroundings using linear least squares minimization. Both CRISM targeted and multispectral images were used to map spectrally distinct units. THEMIS surface spectra from spectrally distinct CU units were classified as Surface Type1 (ST1) [7], Surface Type2 (ST2) [7] or olivine rich basalt or "other" (**Figure1**) based on their spectral shape. **Figures 1-3** demonstrate how CU units were classified using THEMIS and CRISM data. Because the multispectral THEMIS data does not allow for detailed analysis of basalt composition, the THEMIS-derived classifications were further characterized using CRISM data. For example, for two units classified as ST1 in THEMIS data, one may show only an enrichment in low-Ca pyroxene (LCP) in CRISM data, and another may show a mixture of LCP and high-Ca pyroxene (HCP). Using THEMIS and CRISM together, we can classify these as different units despite similarity at THEMIS spectral resolution. We then map the global distribution of places where each THEMIS-CRISM unit type is exposed.

Result: There are 41 craters with spectrally distinct units (**Figure 4**). Seven have only a single unit in the CU, where as and 34 have 2 or more units in the CU. In most cases, the spectral and compositional indicators derived from thermal and near-infrared data are consistent. Inconsistencies can be attributed to differences in spatial resolution and/or mineral sensitivities between data sets. Derivation of THEMIS-CRISM units is ongoing, however **Figure5** shows the distribution of one THEMIS-derived unit type: "olivine-rich". This unit type appears similar to an olivine basalt in THEMIS. Olivine-rich units are found primarily in the cratered highlands, and interestingly, are absent from certain regions of the cratered highlands (e.g. Terra Sirenum). CRISM data will be used to determine similarities/differences in mafic mineral assemblage between these exposures.

Discussion: As described by Skok et al. [2], the locations of spectrally unique CUs cluster regionally. Our distribution differs slightly from that of Skok et al. [2] because they limited their data set only to craters which lack evidence of alteration minerals. Spectrally unique CU units are primarily found in the southern highlands, with many clustered near Hellas and Argyre.

Skok et al [2] reported numerous detections of monomineralic lithologies, for example pure olivine, or pure pyroxene units.We did not observe any THEMIS-derived surface spectra that are consistent with pure olivine or pyroxene. This may be due to differences in spatial resolution and/or to inclusion of plagioclase or poorly crystalline alteration phases that are not easily detected in CRISM data. Detail regional analysis will help to further constrain the formation of subsurface. For example, it may help to understand whether the subsurface of craters in the rim of Hellas were formed by layered mafic intrusion, exposed volcanic, impact melt, exposed materials brought up from formation of Hellas Basin or all of above.

Future work: THEMIS-derived units will be characterized and subdivided using CRISM data. The distributions of THEMIS-CRISM-derived units will be mapped globally and compared with global compositional maps [e.g 3]. Distributions of exposed subsurface compositions will be examined for regional trends. We will expand our detailed analyses to thermal inertia and geomorphology of these craters to further constrain the subsurface formations.

References: [1] French B. M. (1998) LPI. [2] Skok J. R. et al. (2012) *JGR*, *117(E11)*, E00J18. [3] Rogers A. D. et al. (2007) *JGR, 112(E1)*, E01003. [4] Barlow N. J. et al. (2000) *JGR*, *105(E11)*, 26733. [5] Robbins S. J. and Hynek B. (2012) *JGR*, *117*, E05004. [6] Bandfield J. L. et al. (2004) *JGR*, *109(E10)*, E10008. [7] Bandfield J. L. et al. (2000) *Science*, *287*, 1626-1630.

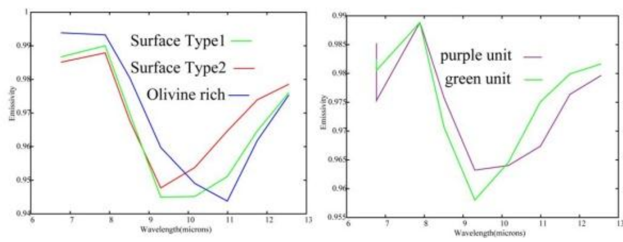

Figure 1 Left: THEMIS unit types (excluding “other”, which is variable). Right: example of THEMIS derived spectra for crater in Figure 2. Purple unit is consistent with ST1 while green unit is consistent with ST2

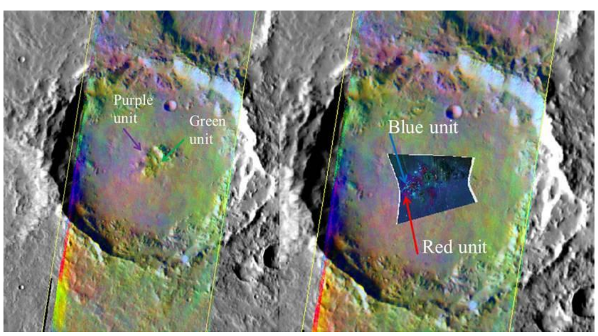

Figure 2 Left: THEMIS DCS (bands 8-7-5 as red-green-blue) image shows purple unit in the peak and distinct from other material from the peak (green unit).Right: CRISM mafic mineral stretch map from PDS: red is OLINDEX; Green is LCPINDEX and blue is HCPINDEX. The unit mapped as ST1 in THEMIS (Left) is dominated by intimately mixed LCP and HCP, with isolated outcrops of olivine. The unit mapped as ST2 is dominated by LCP in CRISM.

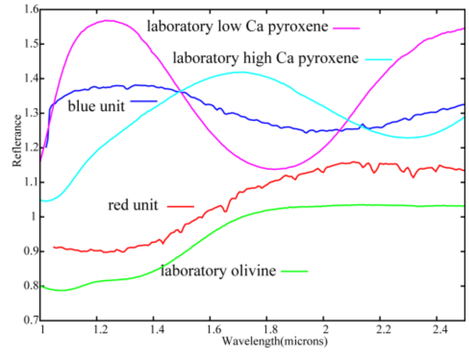

Figure 3 I/F spectra (ratioed to spectrally neutral surface) derived from CRISM showing red and blue units. The red unit is consistent with laboratory olivine. The blue unit is consistent with mixture of LCP and HCP.

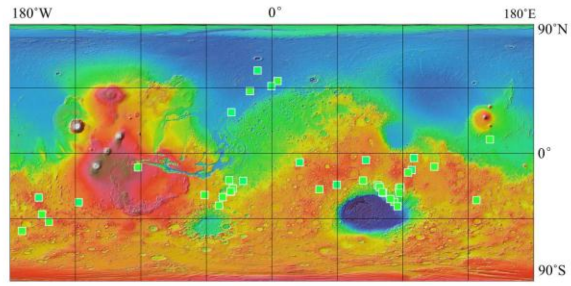

Figure4 Distribution of all craters with spectrally distinct CU surfaces in THEMIS data.

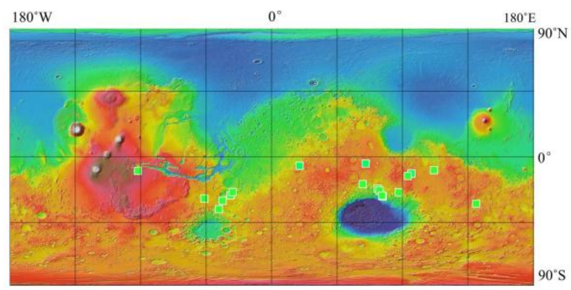

Figure 5 Distribution of craters classified into the “olivine-rich” rock type using THEMIS data. All the craters are in the sorthern highlands and many of them are clustered close to impact basin Hellas or Argyre. The absence of hydrated minerals in CRISM images from these units suggests that the they exposed relatively unaltered subsurface materials.