Composition of the martian crust: Spectral classification of deep-seated and subsurface lithologies in impact craters using MGS-TES and Odyssey-THEMIS. L.L. Tornabene. University of Tennessee, Planetary Geoscience Institute, 306 Earth and Planetary Sciences Bldg., Knoxville, Tennessee 37996.

Introduction: Previous to the Mars Odyssey's Thermal Emission Imaging System (THEMIS) inadequate spatial resolution of compositionally oriented remote sensing missions, coupled with a lack of large-scale tectonic exposures of subsurface materials, have limited our understanding of the martian crust. By utilizing the high-spatial resolution of THEMIS (~100 m/pixel, with 10 spectral bands between 14.9-6.8 µm or ~672- 1474 cm^{-1}) with the high-spectral resolution of Mars Global Surveyor's Thermal Emission Spectrometer (TES) (~ 3 x 6 km/pixel, with 143 spectral bands between 6-50 µm or ~200-1600 cm-1), subsurface and deep-crustal compositions can be mapped and identified via impact excavated materials in and around craters. Prior results from remote studies of lunar impact structures suggest that a similar study of martian craters maybe successful towards revealing the composition of the martian subsurface, both on a regional and global scale [1].

Some of the most prominent questions and issues that may be addressed by such a survey are:

- In addition to lateral variations, are there vertical variations in the composition of the martian crust?
- Can small impact craters (D > 7 km) yield information about the composition of the crust in dust-mantled regions?
- What is the average composition of the martian crust? What are its most common mineral assemblages?
- Is the compositional nature of the crustal dichotomy only a surface artifact, or can it be traced into the subsurface and deeper? Is there any correlation between the inferred thicknesses of the martian crust and the compositions of central uplifts within craters?
- Are SNC compositions consistent with lithologies from the subsurface and deeper? How representative of the martian crust are the SNC meteorites? Should SNCs be used as a basis to estimate bulk planet compositions and structure?
- Is there any correlation between rampart craters and composition in the sense that water may have influenced the formation of these features?
- What is the origin of the crust and by what petrologic mechanisms was it formed? (i.e. Was it formed by a magma ocean? As a sequence of layered igneous intrusions? Or, by overlapping localized plutonic injections?)

Methods: Impact craters with complex morphologies (generally, D > 7 km on Mars) will primarily be utilized in this study due to the spatial limitations of THEMIS and because they can uplift and expose deep-crustal and shallow-crustal materials. Complex craters commonly have morphological features such as central peaks, or peak rings, which are composed of coherent lithologies tapped from deep-seated crustal components uplifted during the excavation and final modification stage of an impact event. Near-surface crustal components can be observed as coherent rocks within the exposed crater walls and possibly from both ejecta and autochthonous crater-fill deposits. Such observations have been substantiated in both terrestrial and lunar craters and are a basis on which this research is supported. Martian impact craters will be chosen for this study primarily from relatively dust-free regions with characteristics such as presence of a central peak or peak ring, preservation, and low albedo units with high thermal inertia (See example in Figure 1). Craters less than 7 km in diameter, those bearing a simple crater morphology, will be assessed in notoriously dust cover regions to see if exposures in crater walls have a low-albedo and a high-thermal inertia.

Crater "spectral units" will be defined via THEMIS mapping and their spatial relationships will be compared with crater morphological features present. Averaged crater spectra will be extracted from spectral maps generated by linking THEMIS and TES, where spatially possible. These THEMIS and TES spectra from crater units will then be compared with lab-collected thermal emission spectra and globally representative TES spectra, such as Sytis-type and Acidalia-type surfaces, to make a preliminary qualitative classification. Next, lab-collected spectra from infrared spectral libraries will be used as an output for a linear deconvolution algorithm to constrain quantitatively the modal mineral abundances for crater spectral units. These derived mineral modes will be cast into lithologic classes based on classification schemes for volcanic and / or plutonic rocks where applicable. Once lithologic classes are assigned to crater spectral units, data from the Mars Crater Database (MCD) and the Mars Orbiter Laser Altimeter (MOLA) will be used to constrain the dimensions of crater spectral units and to determine the apparent diameter for each crater, which will then be used to estimate original crater depths from crater-scaling laws. Because planetary crusts are not consistent in thickness, depths associated with excavated crater units, especially from deep-seated materials in central peaks, lack geological context and may limit geologic interpretations. Therefore, the lithologic data for crater spectral units with their estimated depths of excavation will be used to construct proximate stratigraphic columns. These will then be compared with a martian crustal thickness model to assess what level of the crust has been sampled and to assess pre-impact surface modifications by crustal thickening and thinning. The proximate stratigraphic columns, in conjunction with the crustal thickness model, will be used to interpret lateral and vertical variations in the composition of the martian crust on a global and regional scale. The results of this study may help us better understand the composition, origin, and evolution of the martian crust.

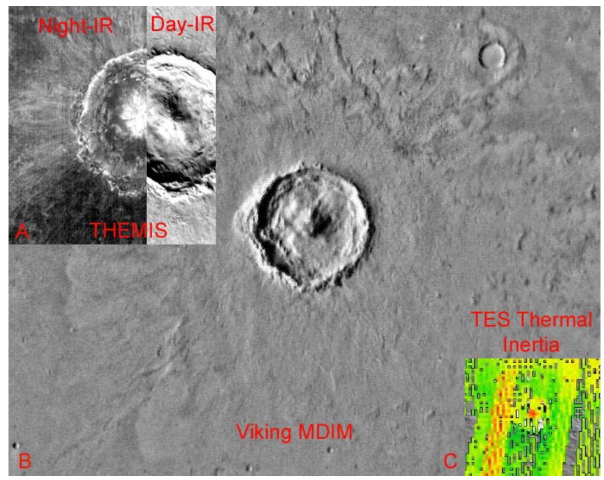

Figure 1. MCD crater 04SC-73 D=29.1 km. A) THEMIS band 9 nighttime (**I05875006**) and daytime (**I01175006**) brightness temperature images. The nighttime image ranges from 179.6K (darker surfaces) to 197.1K (brighter surfaces), while the daytime image ranges from 199.9K (darker surfaces) to 236.0K (brighter surfaces). **B)** Viking MDIM image of crater 04SC-73 exhibiting a low albedo central peak. **C)** TES derived thermal inertia showing that the central peak is distinct and has a relatively high thermal inertia with respect to its surroundings.

References: [1] Tompkins, S. and Pieters, C. M. (1999) Meteoritics, 34 (1): 25-41.