END MEMBER ANALYSES OF SPACEBORNE THERMAL INFRARED DATA OF METEOR CRATER, ARIZONA AND APPLICATION TO FUTURE MARS DATA SETS S. P. Wright and M. S. Ramsey, Image Visualization and Infrared Spectroscopy (IVIS) Laboratory [http://ivis.eps.pitt.edu], Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260-3332, ShawnWright@pittsburghpanthers.com.

Introduction: Thermal infrared data from the **A**dvanced **S**paceborne and **T**hermal **E**mission and Reflection **R**adiometer (ASTER) is used to identify the distribution of three lithologies within the ejecta blanket of Meteor Crater, Arizona. This is possible because thermal infrared (TIR) data have been shown to add linearly and thus be easily interpretable [1]. As all small, simple impact craters are initially created with the same morphology, this has many applications to new data from the **Th**ermal **Em**ission **I**maging **S**ystem (THEMIS) currently in orbit at Mars and will use the premise of Ramsey [2] concerning the use of terrestrial multispectral images as proxies for thermal infrared data sets of Mars.

Background: Non-degraded, small impact craters outnumber large craters on unmodified planetary surfaces and are of younger age. Younger impact craters will have less erosion, a well-preserved ejecta blanket, and less dust at the surface, making them excellent sites for thermal infrared (TIR) observations of the surface composition. Of further interest is being able to identify inner-crater stratigraphy and the distribution of those units in the ejecta blanket in order to infer the geology and local climatic conditions of the region before and after crater formation.

ASTER TIR images are used as a proxy for upcoming THEMIS data by extracting emissivity spectra of the lithologic units representing the Meteor Crater rim and ejecta blanket. ASTER TIR has a comparable spectral resolution and spatial resolution (90 meters) to that of THEMIS TIR (100 meters). In order to test methodologies to be used with THEMIS data, image end member deconvolutions are performed using ASTER TIR spectra of the Meteor Crater ejecta blanket. Additionally, hand samples will be collected during field work (summer 2002) and the emission spectra of each lithology will be used as sample end members. The sample end member analysis will be compared to the image end member analysis to validate the image end member analysis.

It should be noted that any comparisons between Meteor Crater and a martian impact crater will be strictly a comparison concerning morphology and the geologic process of impact cratering. The sedimentary lithologies found at Meteor Crater are not likely to be found on the surface of Mars and therefore not in any martian crater or ejecta blanket. However, as all small, simple impact craters are initially created with the same morphology, martian impact craters should show a similar pattern of the distribution of ejecta, which will be deposited in inverse stratigraphic order with respect to the pre-impact stratigraphy. An objective of the project is to attempt to quantify this relationship for select small, simple impact craters. In addition to stratigraphy, other crater properties of Meteor Crater will be investigated to determine if these properties can be identified by TIR remote sensing.

It has been shown that an image end member deconvolution using the thermal infrared wavelengths can be used to identify the lithologies distributed in the Meteor Crater ejecta blanket [3]. However, the airborne Thermal Infrared Multispectral Scanner (TIMS) and its 4 meter spatial resolution was used in the earlier study. Still in question and what this project seeks to answer is if THEMIS data sets, with 100 meter spatial resolution, can be used to identify the lithologic members of small, simple impact craters on Mars. ASTER, rather than TIMS, will be used in this study due to the comparable spatial resolution to THEMIS over the TIR wavelengths. The ASTER image end member analyses will be compared to the earlier TIMS image end member deconvolution for validation.

Study Site: Meteor Crater, Arizona is located in semi-arid north-central Arizona and is estimated to be 49,000 to 50,000 years old, making it one of the most recent and well-preserved impact sites on Earth [4]. The simple, bowl-shaped crater is 180 meters deep and 1.2 km in diameter, with an eroded rim standing 30-60 meters high [5]. The local geology consists of three flat-lying sedimentary members with known lithologies and contrasting spectral signatures. The oldest unit sampled by impact is the Permian Coconino Sandstone. Above the Coconino are the Permian Kaibab Limestone and a thin veneer of the Triassic Moenkopi Formation. The crater rim and ejecta blanket consists of the same lithologies as described above, but inverted due to impact. Within the ejecta blanket, the units are preserved up to 1.2 km (or 2 crater radii) away. Additionally, the ejecta blanket has a noticeable wind-streak to the northeast due to climatic conditions since crater formation.

Meteor Crater has been described as a perfect example of a well-preserved, simple impact crater by many geologists [3,4,5,6,7]. Meteor Crater is convenient to use for remote sensing applications and associated ground-truthing with on-site field research. The amount of previous work, mineralogical contrast between the units [8], low amount of erosion since crater formation [3,7] due to a semi-arid environment and young age, and the mixing of the ejecta make Meteor Crater the logical choice to be an analog for similar craters on the martian surface.

Instrumentation: ASTER is a multispectral imager on the Terra spacecraft and has been operational since October 2000. ASTER has fourteen bands from the visible to the thermal wavelengths, including five in the TIR at 90 meter spatial resolution and three in the visual and near infrared (VNIR) wavelengths at 15 meter resolution [9]. ASTER's TIR bandwidths range from 8.13 μm to 11.65 μm.

THEMIS is a multispectral instrument on the Mars Odyssy orbiter and operates over nine bands from 6.5 μm to 14.5 μm. THEMIS also has five bands in the VNIR wavelengths at 20 meter resolution [10]. The release of a portion of THEMIS data representing a small (3%-4%) fraction of the martian surface is tentatively set for October 2002.

Conclusion and Application to Mars: The results of the study will lead to a greater understanding of THEMIS TIR data of young, small, simple impact craters.

THEMIS TIR data sets of the martian surface will yield the emissivity of each pixel at the highest spatial resolution ever collected of the martian surface [10]. Because a sample end member analysis cannot be performed, the limits of an image end member analysis must be known. An image end member analysis could reveal the distribution of various lithologies within the ejecta blanket and mineral spectral libraries can be used to extract the mineralogical content of each lithology. Impact craters on Mars will be chosen to be examined using THEMIS TIR data based on 1) age, as young impact craters will have less erosion and dust, 2) size and shape, as this study concerns what can be learned from the study of small (<3-4 km diameter), simple craters, and 3) the TIR spectra, as the impacted area requires spectrally different stratigraphy.

References: [1] Ramsey and Christensen, *JGR 103*, pp 577-596, 1998. [2] Ramsey, *Mars Infrared Spectroscopy Workshop* (ext. abstract), pp 2016, 2002. [3] Ramsey, *JGR (in press)*, 2002. [4] Shoemaker, et al., *Guidebook to the Geology of Meteor Crater, Arizona*, 1974. [5] Roddy, *LPSC IX*, pp 3891-3930, 1978. [6] Garvin, et al., *LPSC XX* (abstract), pp 333-334, 1989. [7] Grant and Schultz, *JGR*, *98*, pp 15033-15048, 1993. [8] Ramsey and Christensen, *TIMS Workshop, JPL Publ. 92-14* (ext. abstract), pp 34-36, 1992. [9] Abrams, *Int. Jour. of Rem. Sens., Vol. 21*, pp 847-859, 2000. [10] Christensen, et al., *Mars Mission Workshop*, pp 16-18, 1999.