SPECTROSCOPY OF IMPACT MELTS – RESULTS FROM LUNAR CRATER TYCHO D. Dhingra and C. M. Pieters, Dept. of Geological Sciences, Brown University, Providence, RI 02912 (deepak_dhingra@brown.edu)

Introduction: Impact melts are a common component at craters on planetary surfaces, especially where processes of erosion are least active (such as the Moon). As a result, the character and distribution of impact melts provide clues for understanding planetary surface evolution. Extensive studies by earlier workers have shed light on the formation and evolution of impact melts [e.g. 1, 2]. However, most of the studies, especially in the lunar context, have been focused on morphological aspects. Very few studies [e.g. 3, 4] have explored the spectral domain which expands the scope by providing compositional information.

Recent availability of high spatial and spectral resolution datasets from various instruments on multiple missions sent to the Moon, provide an opportunity to study impact melts in a lot more integrated way than was earlier possible. We have initiated a global survey of impact melts focusing primarily on the compositional properties as derived from reflectance datasets [5]. At the same time, we supplement our observations with high spatial resolution data in order to understand the geological context better.

Here, we discuss the character of impact melts observed at crater Tycho as an example of the spectral diversity that can be expected in impact melts. We have used Chandrayaan-1 Moon Mineralogy Mapper (M^3) data (corrected for photometry and thermal contributions) [6] in conjunction with Kaguya Terrain Camera (TC) data [7] in this work.

Impact Melts at Crater Tycho: Tycho is a relatively young 86 km diameter, complex impact crater in the lunar nearside highlands with an extensive bright-ray system and a dark halo around its rim, believed to be due to the presence of impact melts. The interior of Tycho (walls, floor and central peaks) also contain deposits of impact melt. Though Tycho is located in the highlands, it shows signatures of high-Ca pyroxene-bearing lithology at number of locations [8]. Since this highland composition is uncommon, it has been suggested that Tycho excavated a pluton with gabbroic affinity. Alternative explanations in the form of post-crater volcanic activity have also been proposed [9,10]

M^3 Observations – Regional Scale: The spectral diversity at the crater indicates the presence of high-Ca pyroxene rich lithology (Fig. 1), in agreement with previous analyses. Although crystalline anorthosite has also been reported in the central peak [11], we haven't detected it yet with M^3, perhaps due to occurrence of the deep shadows in the area.

The high spectral resolution of M^3 suggests a different composition of the eastern wall which displays prominent 1 and 2 µm absorptions at much longer wavelengths than other locations studied within the crater so far. It is however yet to be ascertained if target heterogeneity is the cause of this variation.

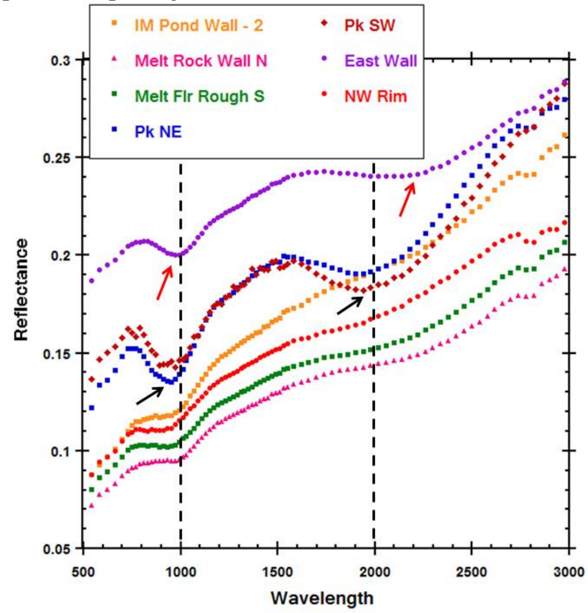

Fig. 1 Spectral diversity observed at crater Tycho. Most of the spectra display similar 1 and 2 µm absorption band centers. Black arrows mark the well-defined absorptions at the central peaks. The purple spectra from eastern walls (marked with red arrows & offset for clarity) is notably different with longer 2 µm absorption and thus more Fe and Ca-rich pyroxenes.

M^3 Observations – Local Scale: Apart from the crater scale observations, local variations in the character of the impact melts were also observed emphasizing the heterogeneity at small spatial scales. Two melt patches on the floor (rough and smooth) located northeast of the central peaks (Fig. 2c) show a difference in their spectral character (Fig. 2e). While the smooth patch (solid purple line marked with black arrow) has very weak 1µm absorption and no 2 µm absorption, the rough patch (dotted purple line marked with black arrow) has relatively strong 1 and 2 µm absorptions.

Impact melts sampled at various locations were also compared with the rocks on the central peaks (Fig. 2d and e). It can be observed that the rocks (shown in orange) show variation in their mineralogy in terms of short and long wavelength 1 and 2 µm absorptions (green arrows indicate one such variation). Similar variations are also observed amongst the sampled impact melts (spectra shown in purple and marked with red and black arrows). We suggest that such differences in impact melts could be due to multiple causes: variable crystallinity (proportion of glassy to crystalline material), different clast fraction, potential melt differentiation, or even target heterogeneity coupled with inefficient mixing of melts.

Conclusions & Future Work: The observed spectral diversity amongst impact melts suggests that their compositional attribute is a rich source of information for determining possible target composition, efficiency of melt mixing during formation as well as their relative cooling rates (determined from their crystalline/glassy character). In certain cases (as in case of smooth vs rough impact melt), there also seems to be an observable link between the morphological form and the composition.

Similar integrated spectral and spatial studies of impact melts at several other craters (including Copernicus, Aristillus, King and Eratosthenes) are underway. Future studies would aim at looking at the common characteristics of impact melts as well as the most important causes of their variations.

References: [1] Howard and Wilshire (1975) *J. Res. U.S. Geol. Surv.*, **3**, 237-251 [2] Hawke B.R. and Head J.W.(1977) *Impact and Explosion Cratering, edited by D.J. Roddy et al., Pergamon, NY*, p 815-841 [3] Smrekar S. and Pieters C.M. (1985) *Icarus*, **63**, 442-452 [4] Tompkins and Pieters (2010) *MAPS*, **45**, 1152-1169 [5] Dhingra D. and Pieters C.M. (2011) *LEAG Meeting, Houston*, Abs#2025 [6] Pieters, C. M. et al. (2009), *Curr. Sci*, **96**, 500-505 [7] Haruyama et al. (2008) *EPS*, *60*, 243-255 [8] Pieters C.M. (1986) *Rev. Geophys.*, **24**, 557-578 [9] Strom R. and Fielder G. (1968) *Nature*, **217**, 611-615 [10] Chauhan P. et al. (2011) 42nd LPSC, Houston, Abst. #1341 [11] Ohtake M. et al. (2009) *Nature*, **461**, 236-241

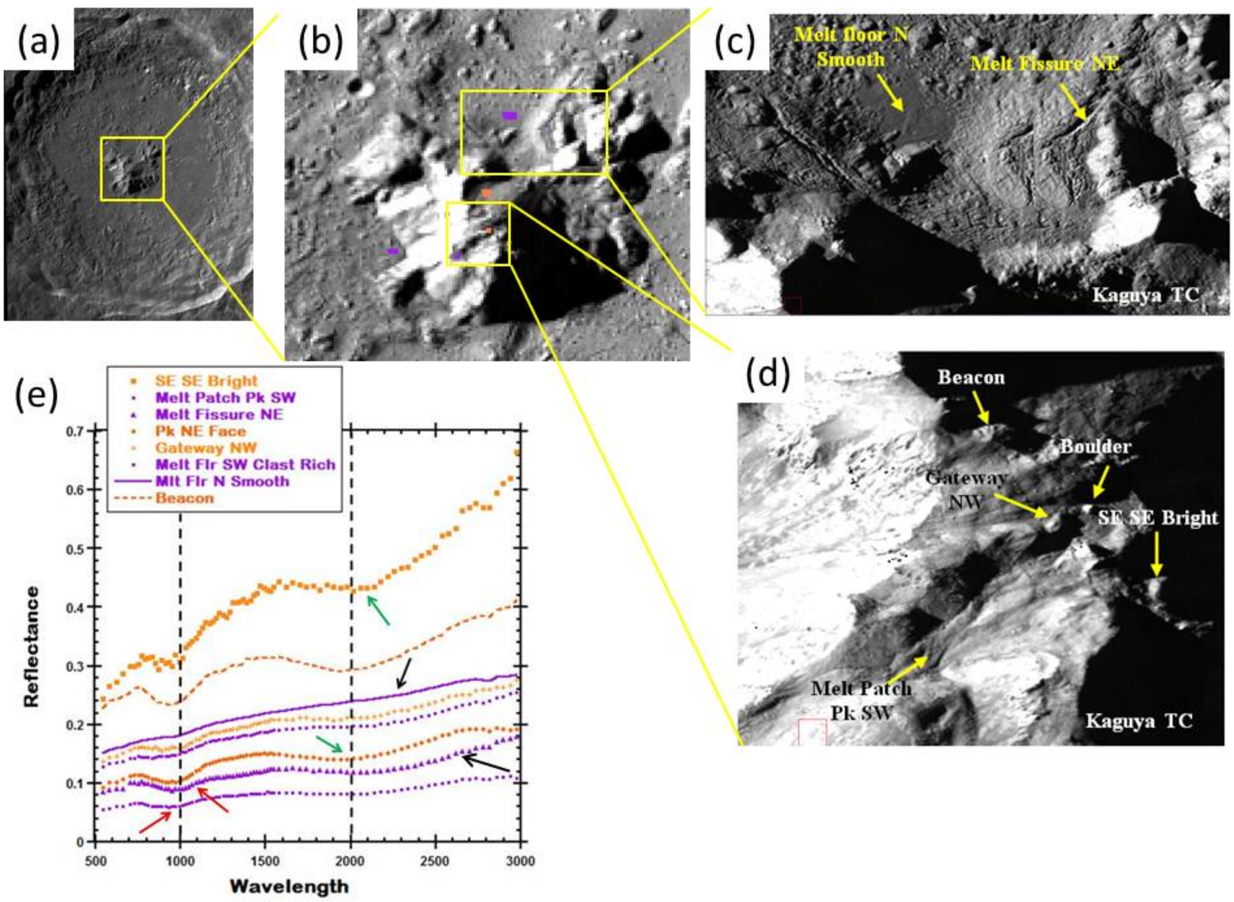

Fig. 2 Spectral variations among impact melts and rocks, supplemented by their geological context. (a) Kaguya TC context image of Tycho crater (b) M^3 image showing sampled regions. (c) Kaguya TC image showing the smooth and rough impact melt exposures on the floor, (d) Kaguya TC image showing sampled impact melt and rock boulders on the central peak (e) M^3 spectra of the sampled locations. Note the difference in spectral character of smooth melt (purple solid line marked with black arrow) and rough melt (purple dotted line marked with black arrow). The green arrows point to the relative difference in 2 µm band for the central peak rocks. Spectra are offset for clarity.