EVALUATING THE EXTENT OF IMPACT MELT ON CENTRAL PEAKS OF LUNAR COMPLEX IMPACT CRATERS [1]Rajani. D. Dhingra, [2]Deepak Dhingra and [2]Lynn Carlson, 218, Waterman Street, Providence, RI 02906, USA. Email: rhapsodyraj@gmail.com, Geological Sciences, Brown University, Providence, USA

Introduction: Impact craters are circular (sometimes elliptical) depressions on the surface of a planetary body that are formed by hyper-velocity impacts of other rocky bodies (asteroids, comets etc.). The central peaks of impact craters on the Moon have been studied widely [e.g. 1] because they excavate material from deeper depths and hence act as probes to understand the lunar subsurface mineralogy.

With the recent availability of high spatial resolution imagery [e.g. 2, 3], central peaks of impact craters have been observed to be covered by impact melt to various extents at different craters [e.g. 4, 5, 6]. The pristine character of the central peaks is therefore undoubtedly modified (to various extents) and could have a bearing on the mineralogical identifications that have been made. It is hence important to map the extent of impact melt on the central peak regions so that such areas can be dealt with separately during analysis of the peaks and subsequent interpretation of the lunar subsurface mineralogy. A separate set of studies [e.g. 7, 8, 9] are evaluating the mineralogy of impact melt deposits on the Moon and its implications for crustal diversity.

Objectives: The objectives of this study are to map the extent of impact melt on central peaks, evaluate if the coverage area of melt is significant and determine if there is any discernable slope control (range of slopes defining a threshold) on the retention of the impact melt deposits. The latter, in conjunction with parameters such as viscosity of the melt, might affect the melt volume that stays on the peak and could be identified. However, there might be local depressions on the peak where such slope control will not be directly relevant.

Data & Methodology: We have used data obtained by the Terrain Camera (TC) onboard SELENE (Kaguya) mission [e.g. 2] for our analysis presented here. TC data with a spatial resolution of 10 m/pixel was used to visually identify and map the extent of impact melt deposits on the central peaks of impact craters, guided by their morphological expressions such as flow lobes, cooling cracks, smooth ponded material etc. (Fig. 1). Many of these observations were further verified using the data from Narrow Angle Camera (NAC) [e.g. 3] onboard the Lunar Reconnaissance Orbiter (LRO) with a spatial resolution of 0.5-1 m/pixel.

Once identified, the central peaks and impact melt deposits on the peaks were mapped in ArcGIS (ver. 10.2, ESRI, Inc.) to estimate the proportion of melt area compared to the total peak area. The DEMs available from TC data were used to generate slope maps for the peak regions. Subsequently, the slope information of the peak region covered with impact melt was extracted to obtain the dominant slopes at which melt deposits commonly occur. The estimated impact melt cover is a conservative assessment as only those areas were mapped which displayed distinctive evidence of melt. As discussed below, several factors affect impact melt detection and therefore the actual areal extent is likely larger than reported here.

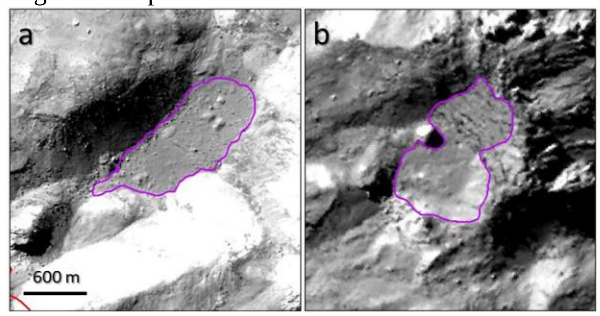

Fig. 1 Various morphological forms of impact melt at crater Tycho (mapped with magenta outline) (a) Smooth ponded material (b) Cooling cracks in an otherwise smooth material.

Results: Preliminary results from the analysis of central peaks of 5 impact craters are presented here (Table 1). Impact melt deposits (mapped so far) appear to cover a small proportion of the central peak area. The average melt area to peak area ratio for the analyzed craters is 0.031. The average slopes on which the melt commonly occurs on the peak ranges around 25^0. The melt features were observed at low to moderate slopes with the minimum slope being 16^0 and maximum being 36^0. The central peak of Jackson crater (22.04° 196.68°, 71 Km diameter) has the highest areal extent of impact melt (Fig. 2) while the central peak of Theophilus crater (-11.45° 26.28°, 99 Km) does not show any observable evidence of impact melt deposits thus far.

Discussions: Identification of impact melt deposits depends upon morphological form of melt, its spatial extent, illumination conditions, age of the crater (older age leads to greater degradation of features and therefore difficulty in identification) and later modification (such as crater filling by volcanism, ejecta coverage from later formed craters). All these factors need to be considered while searching for melt deposits and define the degree of uncertainty of the analysis.

Jackson (Fig.2) has the highest central peak area and the largest melt covered area as well. Theophilus has an equally large central peak area but no noticeable impact melt could be traced. While the lack of melt on peaks of Theophilus might just be a natural case, the relative age difference between the two craters could also be one of the contributing factors.

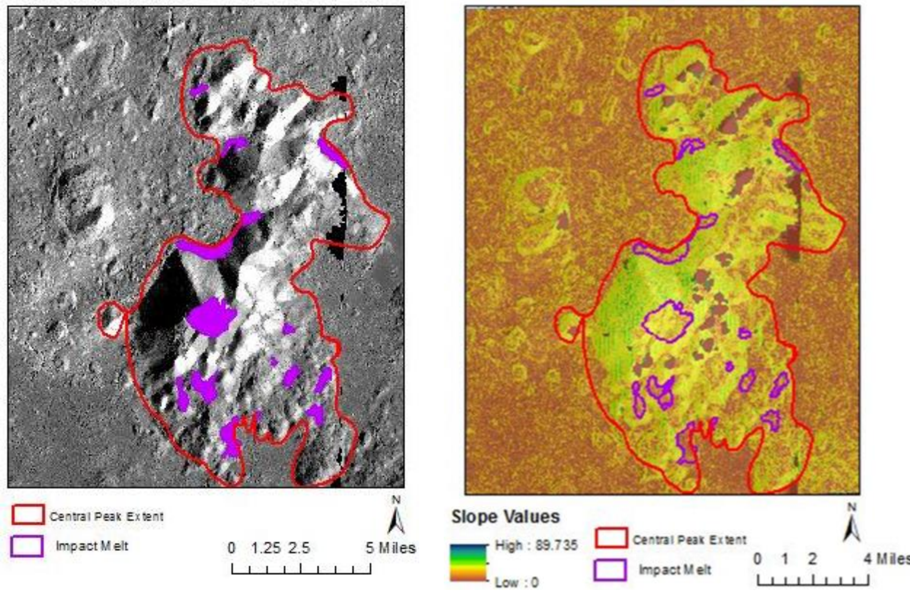

Fig.2: Impact melt mapping and analysis of crater Jackson using Kaguya Terrain Camera (TC) data. (a) Impact melt deposits (in magenta) mapped on the central peak (outlined in red) (b) Slope map of the peak region derived from TC DEM. The mapped melt deposits are outlined (in magenta) to show the respective slope values in those regions.

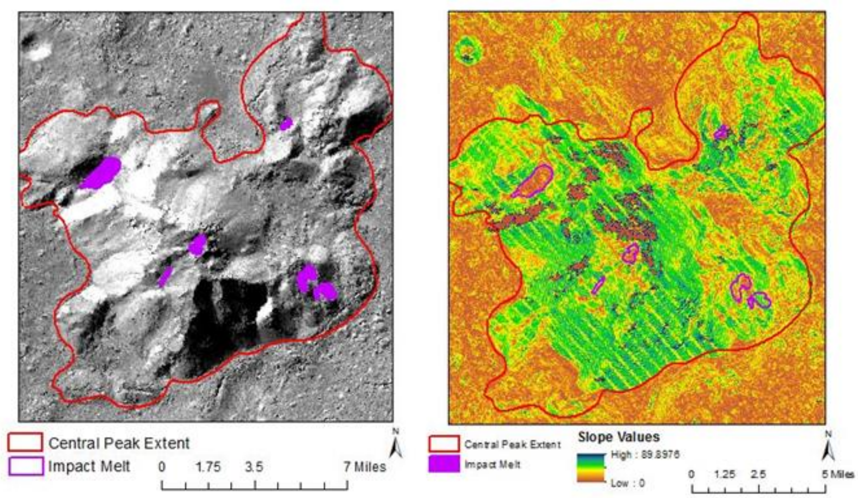

Fig. 3: Impact melt mapping and analysis of crater Tycho using Kaguya Terrain Camera (TC) data. (a) Impact melt deposits (in magenta) mapped on the central peak (outlined in red) (b) Slope map of the peak region derived from TC DEM. The mapped melt deposits are outlined (in magenta) to show the respective slope values in those regions.

Crater Name	Diameter (km)	Relative Age	Peak Area (km^2)	Total Melt Area (km^2)	Proportion	Average Slope (degree)
Tycho	86	Young	174.75	2.77	0.015	16.08
Jackson	71	Young	234.16	16.14	0.068	14.8
Copernicus	96	Young	56.59	1.36	0.024	36.91
Aristillus	54	Older	52.15	0.97	0.018	25.50
Theophilus	99	Old	134.17	0.00	Nil	34.74

Table 1 Summary of the analysis carried out at 5 complex craters showing crater information and melt proportion on the central peaks relative the central peak area. The coverage of impact melt on average is very low.

Jackson is a young Copernican age crater (~1 b.y.) and hence less altered whereas Theophilus is a relatively older crater of Eratosthenian age (1-3.2 b.y.).

Another Copernican aged crater Tycho (-43.29° 348.78°, 86 km) (Fig. 3) supports this age dependence hypothesis and displays distinct evidences of impact melt on its central peak (and elsewhere).

Summary: Preliminary analysis of impact melt occurrence on the central peaks suggests that only a small area of the peak region seems to be covered with impact melt. Detailed studies are currently in progress and the results from the same would be presented.

References: 1. Tompkins S. and Pieters C.M. (1999) *Meteorit. and Planet. Sci.*, **34**, 25-41 [2] Haruyama J. et al. (2008) *Earth, Planets, Space*, **60**, 243-255 [3] Robinson et al. (2010) *Space Sci. Rev.*, 150, 81-124 [4] Ohtake et al. (2009) *Nature*, **461**, 236-240 [5] Dhingra et al. (2011) *LEAG Meeting*, Abst#2025 [6] Kuriyama et. al (2013) *44th LPSC*, Abstract#1402 [7] Dhingra et al. (2012) *39th COSPAR Assembly*, Abst.# B0.1-0034-12 [8] Dhingra et al. (2012) *NASA Lunar Science Forum* [9] Dhingra et al. (2013) *GRL*, **40**, 1-6