CHARACTERISTICS OF CRATERS WITH MULTI LAYERED EJECTA IN THE EQUATORIAL REGION OF MARS.

Vijayan S., Rishitosh K. Sinha and S.V.S. Murty, PLANEX, Physical Research Laboratory, Ahmedabad – 380 009, India. (vijayan@prl.res.in)

Introduction: Martian impact craters often have distinct ejecta patterns which distinguishes them from other planetary craters. Among them, the multi layered ejecta (MLE) craters are dominant on the equatorial region of Mars. The suggested formation for such layered ejecta craters are interrelated to several aspects such as volatile rich surface [1], thin atmosphere [2], and a combination of both of these etc. Although the formation process is explained by different theories, characterizing the MLE over their dominant equatorial band will provide a unique diagnostic about their target properties and their morphological variations.

Observations: Our analysis focuses on the morphology of inner and outer region of the MLE craters. In addition to analyzing the ejecta morphology, the MLE inner floor morphology is also taken into account in this study, which helps to distinguish the different types within the MLE. The MLE on the equatorial region is analysed for morphological similarities and differences, their location, etc., using THEMIS and MRO-CTX images. Fig. 1. shows the distribution of MLE craters on the northern and southern equatorial region (within 30˚ N - 30˚ S) of Mars, chosen for this study.

MLE Inner Morphology: The MLE craters observed in this study broadly fall into four types as:

With Central Peak: The most dominantly observed MLE craters in this study that are equally distributed in both the hemispheres.

With Central Pit: The probable formation processes for the cenral pit are given in [3,4] indicating a key role of volatiles. However, pit also results due to weak target material [5]. In this study, some cluster of craters are observed in the volcanic provinces (like Tharis- and Syris Major–regions). These craters are younger than the last episodic lava flows indicating the later stage formation.

With Summit Pit: The second dominant type observed within MLE craters. The peak summit are with a raised peak and pit at the centre [3].

With Flat Floor: This type incorporate MLE with infilled- and bowl shaped -craters. They are observed sparsely on both the hemispheres with altered inner morphology, but their associated MLE is not much altered. The infilling of floor is likely an after effect of the impact process, where the original apparent crater floor morphology would be altered during such infilling processes.

The observation of inner morphology of MLE craters clearly reveal their different formation mechanisms, however, the overall build up of morphology depends upon their target rock characteristics. The central peak and summit pit crater diameters are relatively higher than the other crater types. Even the inner crater morphology differs significantly, they are all bound by multil layered ejecta. In this study, possible correlation and association among inner and outer morphology was analyzed and reported.

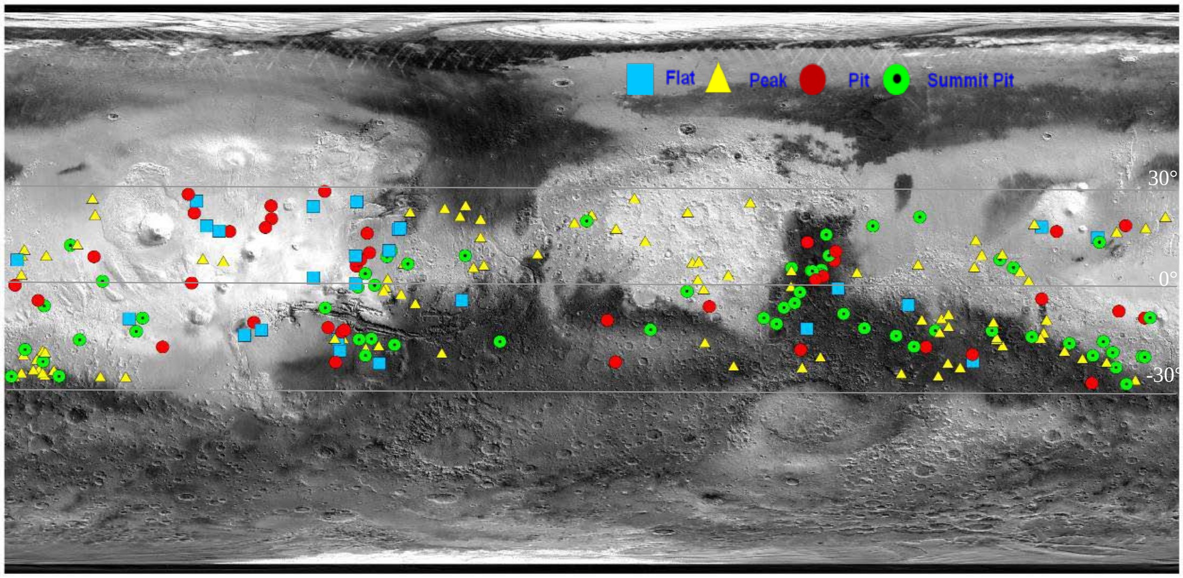

Fig. 1. Preliminary mapping of MLE craters on the equatorial region with their specific floor morphology overlaid on the TES albedo map.

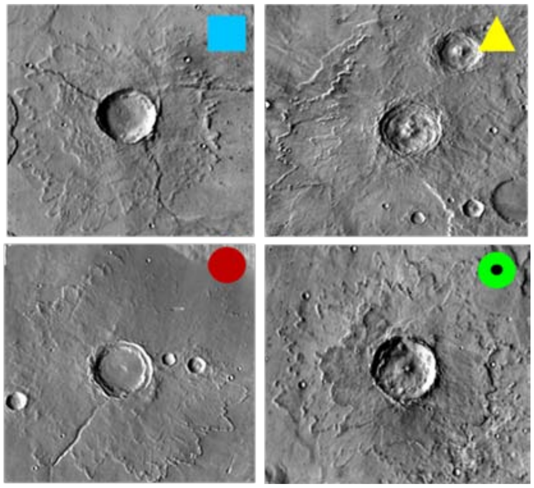

Fig. 2. MLE craters with different inner floor morphology as flat, peak, pit and peak summit, the symbols are same as described in Fig.1.

MLE outer morphology: The outer morphology tends to be the ejecta distribution that bear multiple patterns of lobate flows away from the crater rim. The ejecta mobility (EM), defined as the ratio of average extent of ejecta blanket from crater rim to the crater radius [6], is computed for all the craters and accordingly analysed. Out of the four observed types, the MLE with central peak morphology tend to have average higher ejecta extent in both the hemisphere (Fig. 3). It is higher than the pit and summit pit craters, which are originally supposed to be enriched in volatile materials. On the northern hemisphere, the maximum EM was obtained as 2.6 for a crater (dia. ~92 km) located on the resurfaced region. Similarly, for the southern hemisphere, it was 2.8 for a crater (dia. ~50 km) located on the Tyrrhena volcanic provinces. Although the southern hemisphere crater was much smaller in size and formed in a volcanic terrain, their EM was much higher. One of the causes for this significant difference is the target surface variation, which would have certainly played a considerable role in ejecta formation. The Tyrrhena volcanic region was not active in the last ~1Ga, suggesting that the crater might have formed after this time scale. The EM infers that there might be other possible source (other than crater size) for such ejecta distribution among the resurfaced and volcanic terrain. Distinguishing the MLE formed on recent volcanic terrain (e.g. Tharsis), older terrain (southern highland) and resurfaced northern region will give further evidence for their distinct variations, which is under progress. The MLE craters in these landforms can act as a key to unravel their target medium properties, volatile sources and prevailing conditions during their formations.

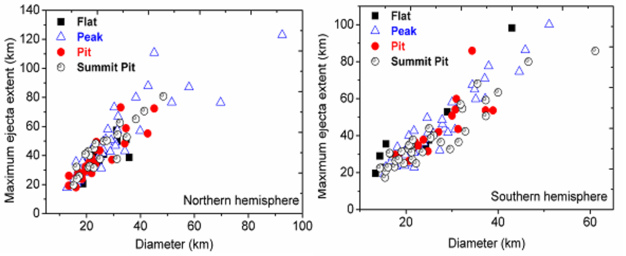

Fig. 3. Maximum ejecta extent for all the four crater types of MLE.

Discussion: Though the MLE crater formations are found around the volatile rich surface [1], out of the four different crater templates observed for hosting MLE's, the central pit craters are much closer to this theory. But from our preliminary investigations, it was inferred that the pit craters EM and maximum ejecta extent are comparatively smaller than the central peak and summit pit craters. The role of larger diameter in the types may be one of the causes for such high mobility. However, the other possible causes may relate to enrichment in the volatile materials for these two crater types for such a high ejecta mobility.

The main correlation observed between four craters types on equatorial region is the common source for layered ejecta. It may be volatile or subsurface ice or thin atmosphere, but it is clearly evident that the sources have spanned over large and different time scales in Martian history. The MLE craters possibly reveal about the past environment conditions, like presence of volatile in the target surface and the rough nature of the target surface. The former may have a substantial effect on ejecta deposits, whereas the later may control the inner morphological variations over craters. The correlation between them is inevitable, because the formation reveals the conditions prevailing during that time period.

Conclusion: Many MLE craters are observed on the recent volcanic terrain like Tharsis which are active till the last ~0.5Ga. Similarly, MLE's observed over the southern highland region clearly indicate their formation spanning over a longer time scale in the Martian history. Further study on location based distribution will reveal the past environment and the history of Mars during those periods.

References:[1] Mouginis Mark, P. (1981) *ICARUS*, 45, 60. [2] Schultz (1992), *JGR*, 97, E7. [3] Wood C.A. et al. (1978) *LPSC* IX, 3691-3709. [4] Croft S.M. (1981) *LPSC* XII, 196-198. [5] Passey Q.R. and E.M. Shoemaker (1982) *Satellites of Jupiter*, UAZ press, 379-434. [6] Barlow, N.G. (2006), *MAPS*, 10,1425-1436.