A STUDY OF RAMPART CRATERS IDENTIFIED FROM MCC AND THEMIS IMAGES, INFERENCE ON ICY SUBSTRATE DURING IMPACT.

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Introduction: Images captured by Mars Colour Camera (MCC) onboard Mars Orbiter Mission [1] show presence of three Rampart craters with lobate ejecta rims in the Thaumasia Planum (Fig. 1). Rampart craters reflect subsurface permafrost and flow of subsurface volatiles which are responsible for the lobateness of the ejecta rims [2]. This work intends to get an idea of the subsurface ice and volatiles by analyzing the morphology of the ejecta blankets of the craters. For convenience the largest, intermediate and the smallest craters, in the images, are referred as crater 'L', 'M' and 'S' respectively (Fig. 1,3).

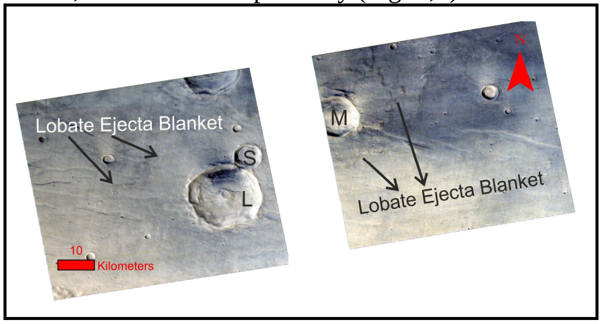

Figure 1: Craters L, M and S with lobate ejecta blankets shown in Mars Colour Camera images. (MCC_MRD_20150219T134300347_D_D32_V3, MCC_MRD_20150219T134240347_D_D32_V3).

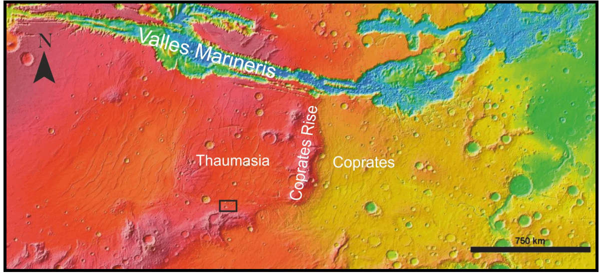

Figure 2: MOLA DTM [3] image showing area of present study in black rectangular box.

Geological Setup of the Area of Study: The area of study (Fig. 2) is a young volcanic terrain [4] covered by basaltic flow which might have extruded through a system of dykes served as feeders for the olivine-enriched flood basalts originated from a hypothesized "plume" of molten rock rising from deep in the Martian mantle that fed the whole Tharsis area [5]. The area is punctuated by complicated systems of grabens and wrinkle ridges of different trends. Majority of the grabens are roughly trending E-W, while the most prominent set of wrinkle ridges trend ~N-S.

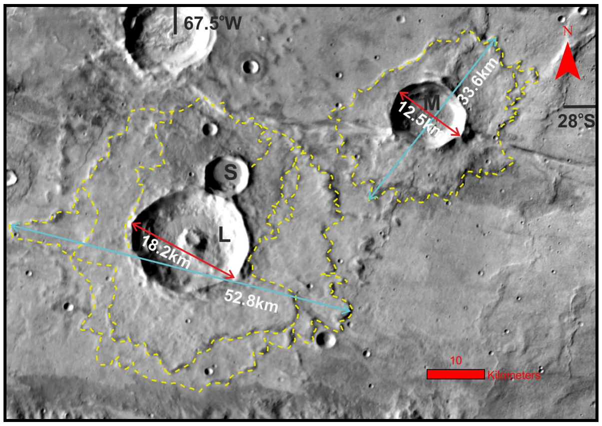

Figure 3: The Rampart Craters illustrated with the maximum diameter of the ejecta blankets (in blue) and the maximum diameter of the crater rims (in red). (THEMIS Daytime IR Global Mosaic [6])

Rampart Craters: Rampart craters display ejecta layer with a low ridge along its outer edge which is lobate shaped, reflecting the movement of material along the surface. Breaks in outward convexity of the ejecta margin indicate flow diversion at obstacles. The mudflow like ejecta reflects that the impact was powerful enough to penetrate to the level of the subsurface ice and also to melt or boil the subsurface water producing the distinctive pattern of material surrounding the crater [7, 8].

The Rampart craters with single layered ejecta (SLE) do not have a large spatial extent of the ejecta blanket possibly because the impact cannot penetrate through the entire icy layer (Ice-cemented Regolith) [8].

Double layered ejecta (DLE) and multi layered ejecta (MLE) have two or more layers of ejecta blanket respectively. These are mostly concentrated between the 40°N and 40°S latitudes of Mars. Evidences suggest that impacts penetrating through an entire icy layer (ice-cemented regolith) and thereby hitting a rocky layer (ice-free regolith) underneath a comparatively thinner icy layer are responsible for DLE and MLEs [8].

To get an idea regarding the subsurface volatile content or the thickness of the icy layer a parameter known as the Ejecta Mobility (E.M.) Ratio is usually calculated. Ejecta mobility corresponds to the ratio of maximum diameter of the ejecta blanket (EBD) to the maximum diameter (D_R) of the crater rim [9]. E.M. values are usually higher in the higher latitudes.

The craters and their ejecta blanket(s) are identified and required parameters are measured on THEMIS Daytime IR mosaic as in this image a complete view of the craters and ejecta layer (s); e.g., the crater 'L' is an MLE whereas crater 'M' is an SLE (Fig. 3).

Crater	**EBD (km)**	**D_R (km)**	**E.M.**	**D_T (km)**	**D_E (km)**
L	52.8	18.2	2.9	13	1.3
M	33.6	12.5	2.69	9.86	0.99

Table 1: Values of morphometric parameters of the studied craters. EDB=maximum diameter of ejecta blanket, D_E = excavation depth, D_R= rim-to-rim diameter of the crater, E.M. = ejecta mobility D_T = transient cavity diameter.

E.M. values in the case of crater L is found to be 2.9 while in the case of M, it is 2.69 (Table 1). E.M. values for crater S wasn't calculated individually since its ejecta layer is ambiguous. The excavation depth of the craters are estimated following the formulae D_E = 0.1 D_T [10, 11] and $D_T = D_{SC}^{0.15 \pm 0.04} + D_R^{0.85 \pm 0.04}$ [12] where D_E = excavation depth, D_T = transient cavity diameter, D_{SC}= diameter of simple-complex crater transition (considered ~6km for Mars) and D_R= rim-to-rim diameter of the crater (Table 1). The average values of D_E for craters L and M are ~1.3km and ~1km respectively.

Discussion: The E.M. values expected in the Thaumasia region are between 2 to 3 [8]. Therefore, the EM values of the studied craters are consistent with the values found by earlier works [8] which states that young lava plains of Tharsis exhibit craters with low density of fluidized ejecta.

As crater L is an MLE, the impact possibly had penetrated beyond the lower boundary of the icy substrate whereas in case of crater M the impact possibly could not penetrate down to that level. Therefore, it can be envisaged that the bottom of the icy substrate layer was above 1.3km but not above 1km below the Martian surface in the area of study. This value is consistent with the global variation in Martian cryosphere depth [8]. Craters L and M are thus indications of thinner subsurface permafrost in the area of study during the impact events.

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