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

Dipayan Dasgupta[1]*, Keyur De[1, 2], Abhik Kundu[1], Nilanjan Dasgupta[2]

[1]*Department of Geology, Asutosh College, Kolkata, West Bengal, India (dipayan14@gmail.com),*

[2]*Department of Geology, Presidency University, Kolkata, West Bengal, India.*

1. Introduction

Images captured by Mars Colour Camera (MCC) onboard Mars Orbiter Mission [1] show presence of 2 Rampart craters with lobate ejecta rims in the Thaumasia Planum (**Figure 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. Here the larger and smaller craters are referred as crater 'L' and 'M' respectively (**Figure 1,3**).

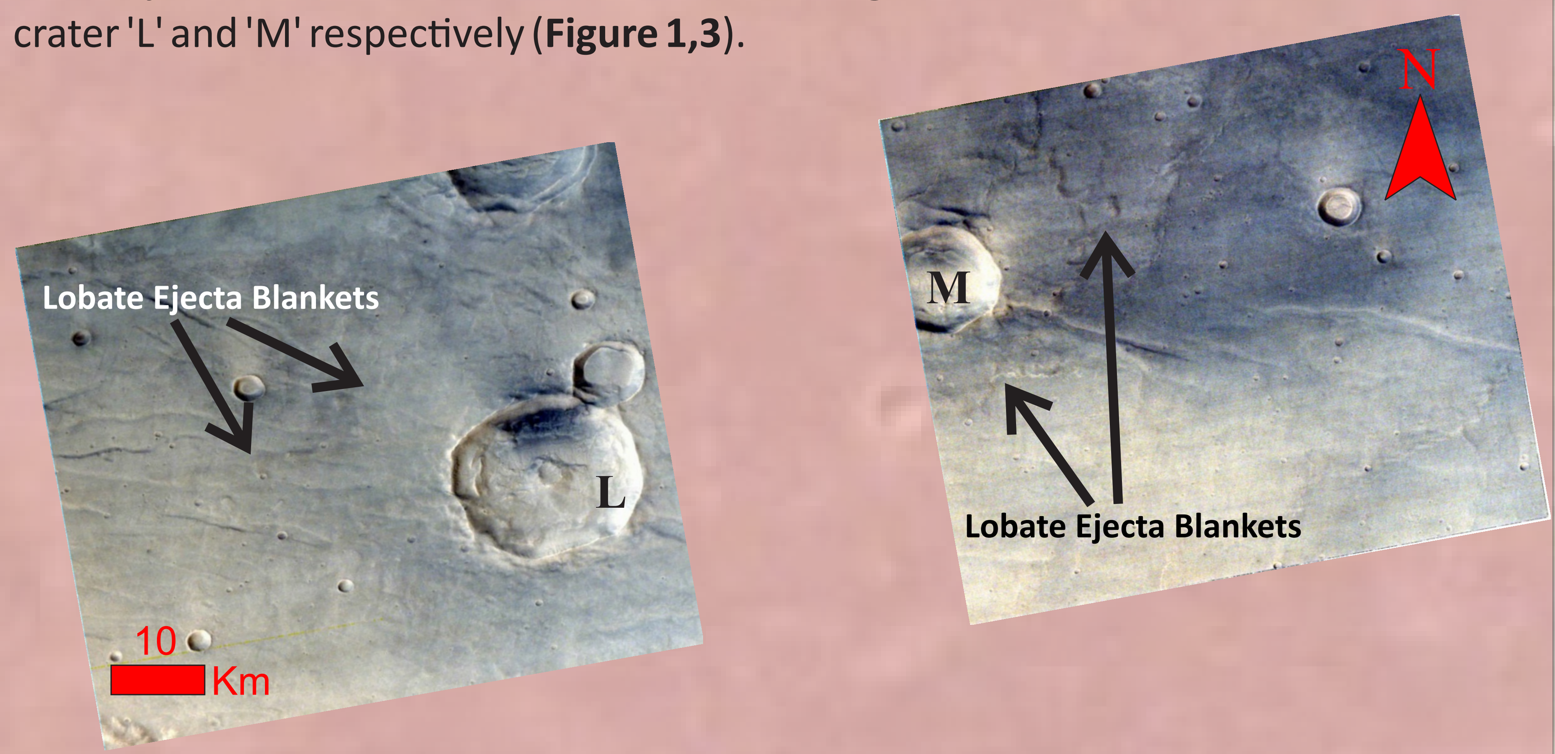

Figure 1: Craters L and M with lobate ejecta blankets shown in Mars Colour Camera images (MCC_MRD_20150219T134300347_D_D32_V3, MCC_MRD_20150219T134240347_D_D32_V3).

2. Geological Setup of the Area of Study

The area (**Figure 2**) is a young volcanic terrain [4] covered by basaltic flow which might have extruded through a system of feeder dykes. The olivine-enriched flood basalt is suggested to have originated from a hypothesized "plume" that fed the whole Tharsis area [5]. The area is punctuated by complicated systems of graben and wrinkle ridges of different trends. Majority of the graben are almost E-W, while the most prominent set of wrinkle ridges trend ~N-S.

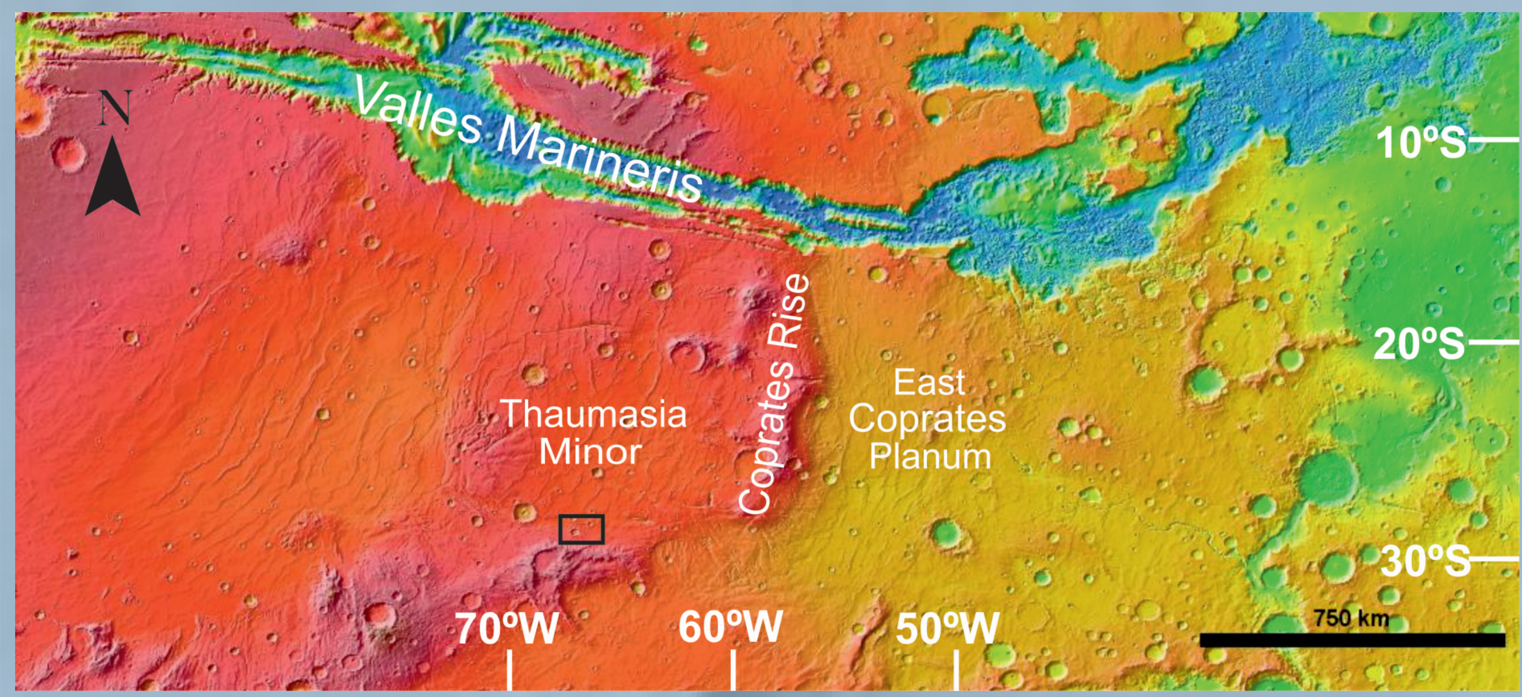

Figure 2: MOLA DTM [3] image showing area of present study in black rectangular box.

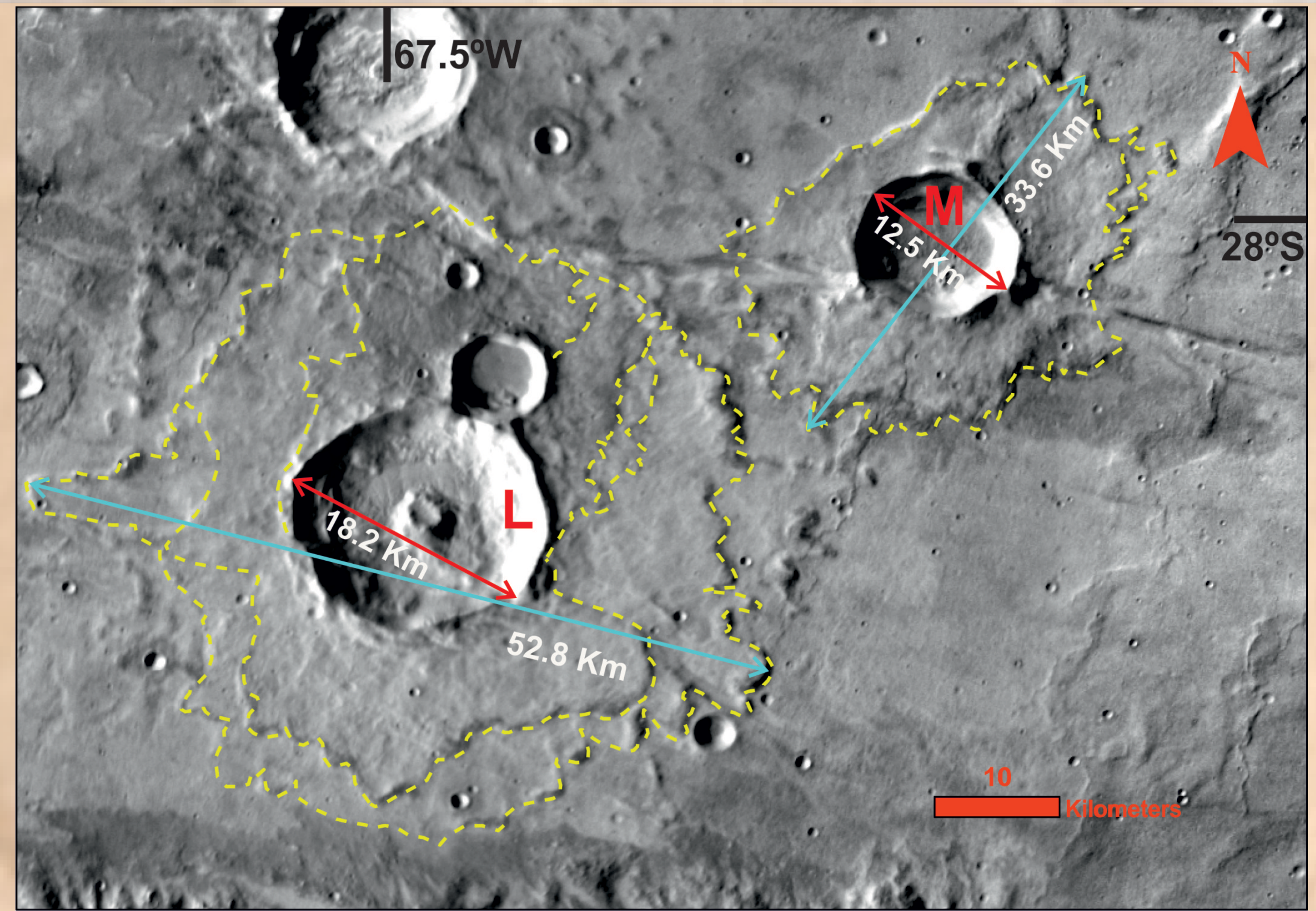

Figure 3: The Rampart Craters illustrated with the maximum diameter of the ejecta blankets (in blue) and the maximum diameter of the crater rims (in red) and sinuous ejecta blankets (in yellow). (THEMIS-IR Daytime Global Mosaic [6])

3. Rampart Craters

- Outer edges of ejecta layers are lobate shaped with a low ridge along its boundary, reflecting the movement of material long the surface. Breaks in outward convexity of the ejecta margin indicate flow diversion at obstacles. The mudflow like ejecta reflects strong impacts which penetrating the subsurface ice and melts or boils the subsurface water producing the distinctive pattern of material surrounding the crater [7, 8].
- The Rampart craters with Single Layered Ejecta (SLE) have a single ejecta blanket possibly as impact cannot penetrate through the entire icy layer [8]. Double Layered Ejecta (DLE) and Multi Layered Ejecta (MLE) have two or more layers of ejecta blanket respectively whereby the impacts penetrate through an entire icy layer and thereby hitting a rocky layer below it (**Figure 4**) [8].

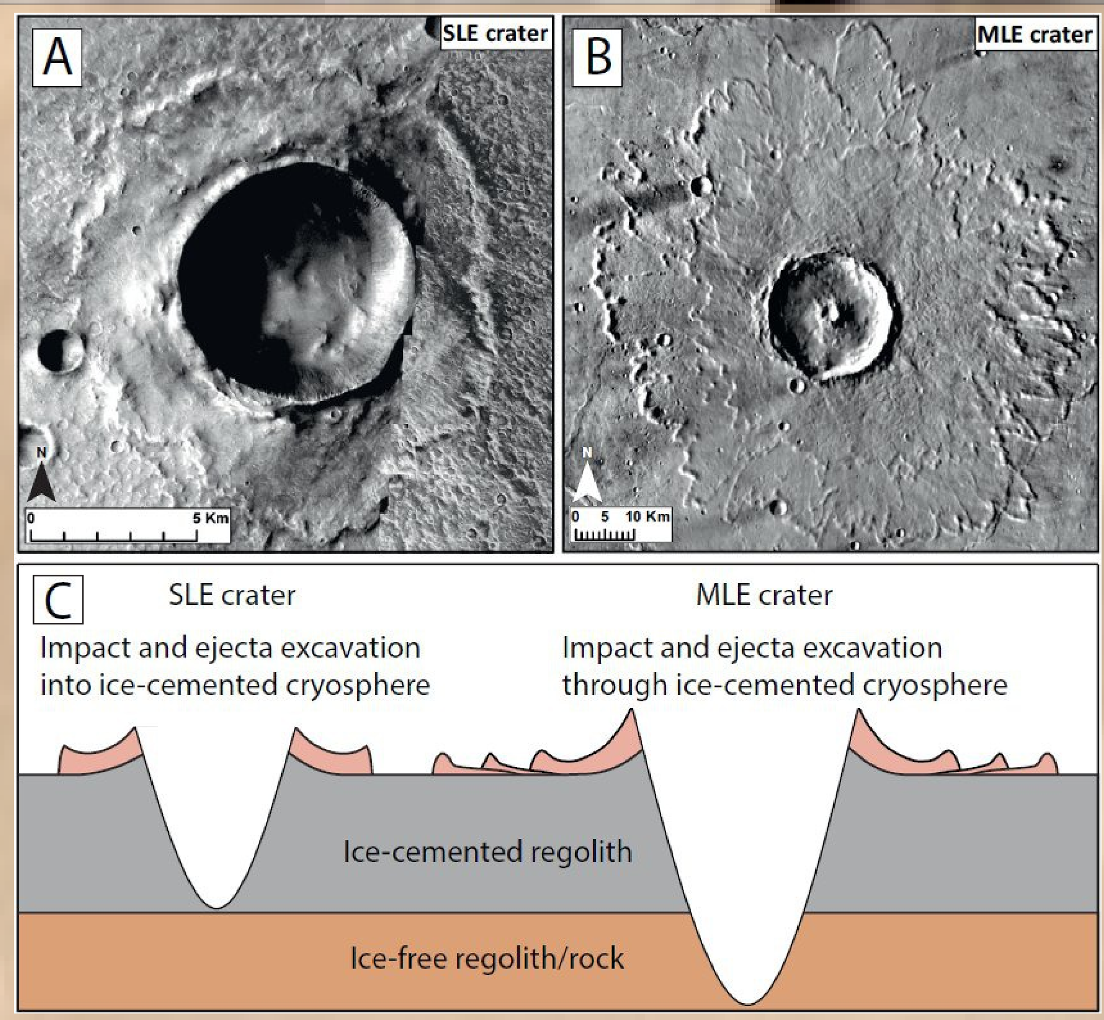

Figure 4: Martian impact craters interpreted to form in the ice-cemented cryosphere (A) SLE crater, 7.2 km diameter; 2.76 °N, 74.5 °E; THEMIS VIS V26756014, (B) MLE crater, 21 km diameter; 5.9 °N, 70.53 °E; THEMIS IR day global mosaic, (C) Simplified target structure for SLE and MLE craters. SLE craters are interpreted to excavate within the ice-cemented cryosphere, while MLE craters are interpreted to excavate below the ice-cemented cryosphere (Figure 4A, B and C (redrawn) are taken from Figure 2 of Weiss and Head, 2017).

- 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 which corresponds to the ratio of maximum diameter of the ejecta blanket (EBD) to the maximum diameter (D_R) of the crater rim [9]. The craters and their ejecta blanket(s) are identified and parameters measured on THEMIS-IR Daytime mosaic. 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**).
- The excavation depth of the craters is estimated following the formulae $D_E=0.1\ D_T$ [10, 11] and $D_T=D_{SC}^{0.15\pm0.04} + D_R^{0.85\pm0.04}$ [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.

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.

4. Discussion

The E.M. values expected in the Thaumasia region are between 2 to 3. Therefore, the EM values of the studied craters are consistent with the values found by earlier works [9] 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.

References

[1] Arya, A. S. et al. (2015), Current Science, 109, 6, 1076-1086. [2] Carr, M. H. et al. (1977), Journal of Geophysical Research, 8.2, 4055-4065. [3] Smith D. et al. (2003) Mars Global Surveyor Laser Altimeter Mission Experiment Gridded Data Record. NASA Planetary Data System, MGS-MMOLA-5-MEGDR-L3-V1.0. [4] Christensen, P. R., et al. (2004), Space Science Reviews 110(1-2), 85-130. [5] Scott, D. H. and Tanaka, K. L. (1986), Geological Survey (US). [6] Flahaut, J. et al. (2011), Geophysical Research Letters, 38, L15202, doi:10.1029/2011GL048109. [7] Kieffer, H.H. et al. (1992), Mars. University of Arizona Press. ISBN 978-0-8165-1257-7. [8] Weiss, D. K. & Head, J. W. (2017), Icarus, 288, 120-147. [9] Costard, F. M. (1989), Earth, Moon, and Planets, 45(3), 265-290. [10] Croft, S.K. (1980), Lunar and Planetary Science Conference XI, pp. 2347–2378. [11] Melosh, H.J. (1989), Oxford University Press. [12] Croft, S.K. (1985), Journal of Geophysical Research, 90 (S02), C842.

Background Image: MCC image MCC_MRR_20150423T072908124_G_D32

Acknowledgement

MOM-AO research grant by ISRO is acknowledged.