Morphometric and rheological analysis of an effusive dome in Marius Hills using Chandrayaan-1 TMC DATA. **A.S. Arya*, Guneshwar Thangjam, R.P.Rajasekhar, Ajai, B. Gopala Krishna, Amitabh, A.S. Kiran Kumar, R.R. Navalgund ,** Space Applications Centre, Indian Space Research Organization, Ahmedabad–380 015 (India), draryaas@gmail.com*

Introduction: The lunar volcanism is vital for understaning and re-constructing the litho- stratiagraphic history of Moon and the processes involved.

The Mare emplacement on Moon is believed to be associated with major impact basins. However, the Mare within the Oceanus Procellarum (OP) does not correspond to any known impact structure thus providing an opportunity to understand the endogenic volcanism on Moon in pristine primary form. The edifices and constructs of igneous extrusion lies in the Marius Hill (MH) region of the Oceanus Procellarum, in the form of volcanic domes, cones & rilles[3].

MH is an area of high interest because it contains approximately half of the Moon's known volcanic domes/ cones. These volcanic constructs have been traditionally studied using Telescope based photoclinometry / shadow shading, LO (Lunar Orbiter) data, Clementine data etc.

Recently , high resolution satellite data with stereo vista capabilities (Chandryaan-1, LRO etc.) have returned spectacular scientific data with enhanced morphometric and planimetric accuracies. One such volcanic construct - an effusive dome, located in the south of Rima Gallelaea, near the contact of Imbrian and Eratosthenian geological units is taken for the present study. The broad research interest is to study the episodic character of the endogenic volcanism on Moon through morphometry, rheology and CSFD techniques and understand the chronology of the Domes/ Cones vis .a vis. in the backdrop of MH plateau

Data used and Methodology: Mosaic of imageries from Chandrayaan-I Terrain Mapping Camera (TMC) ortho-images and TMC-DEM of orbit numbers 798 (Jan 13, 2009) and 1130 (Feb 10, 2009) acquired from an orbital altitude of 100 km has been used. TMC data provides 5 m sampled spatial resolution and altitude data of 12 bit digitization , push-broom mode in the panchromatic spectral band of 0.5–0.75 m with a stereo view in the fore, nadir and aft directions of the spacecraft movement with a base to height ratio of one {1}. The ortho-image and digital elevation model [8] generated from its stereo pair enables to better study the deatiled morphometry, rheology, surface age and dike geometry accurately.

Morphometry : The 2D orthoimage does not show the dome appreciably, however a short rille is seen in the centre of the mosaic (fig 1). A contour map prepared from the DEM (fig 2) suggests the existence of the dome.

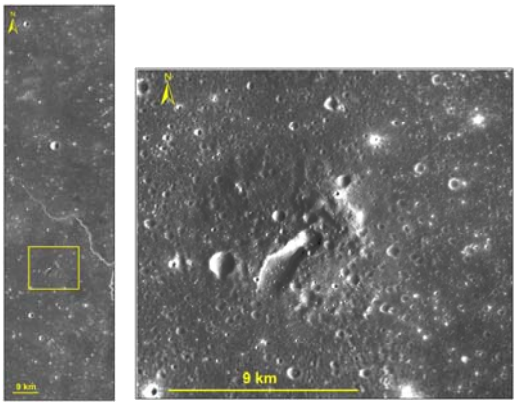

Fig. 1. TMC view of the dome, the mosaic of TMC orbit numbers 1130 and 798.

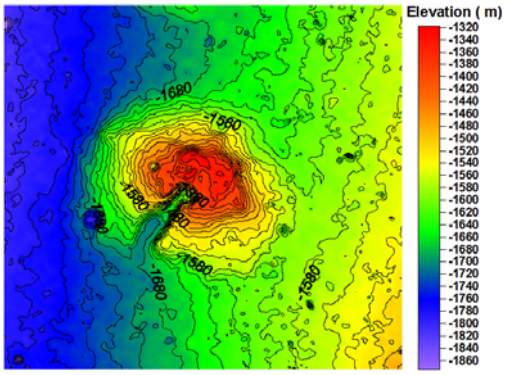

Fig. 2. Contour map draped over the DEM of the study area, generated using the TMC stereo data

A three dimensional exaggerated (2x) perspective view (fig 3), clearly shows the dome with an effusive vent in the centre which appears like a rille fed by the effusion from the Dome.

The morphometric parameters of the dome estimated from TMC DEM are as follows :

D, Diameter	ζ , flank slope	H, height	V, volume
10.4 km	3.77^0	344m	8.45 km^3

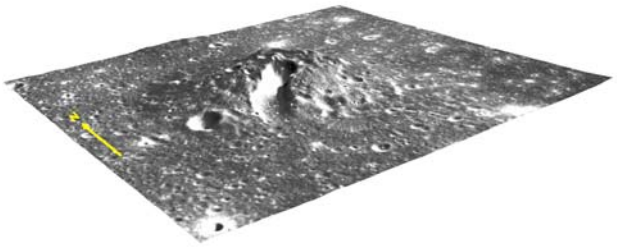

Fig. 3. Perspective view of the study area(vertical exaggeration 2x). The image width along E-W is 18 km.

Rheology : For rheological analysis, quantitative treatment of dome forming eruptions [2][3][4][5] is adopted, the value of lava density, ρ=2800kg/m^3 is adopted which is more apt for the MH basalts as against the previous assumption of ρ=2000kg/m^3 which hold true mainly for highland domes. The conditions for analysis are not directly applicable for Marius Hills domes, since the nature of the volcanism in Marius Hills is not monogentic and it is believed to be multi-phase eruption. Thus, the rheologic parameters were estimated under the assumption that the volcanic edifice is composed of two layers of maximum thickness *h*/2 inferring from the DEM[3]. Accordingly, the two layers are designated as lower layer and upper layer with D_l and D_u as diameters of the respective layers.

Layer name	Yield strength, τ, Pa	Viscosity, η , Pa s	Effusion rate, E, m^3s^{-1}	Duration of effussion, T, years
Lower	$8.38x10^3$	$1.56x10^6$	109.54	1.41
Upper	$1.66x10^4$	$8.01x10^6$	28.05	1.41

Layer name	Diameter, Km	Height, m	Flank slope, degree
Lower	D_l=10.4	172	1.89
Upper	D_u = 5.3	172	3.74

Surface Age Dating : Well established crater counting and surface age dating (CSFD) technique has been applied to determine the surface ages of the Dome (3.6 Ga) and the surrounding Mare plains (3.17 Ga).

Dike Geometry : The dike parameter estimations are also attempted considering the conditions [2][3][4][5][7] The dike width and length (depth) are found ranging from 51-100m and 169-183 km respectively.

Results & Discussion: The morphometry suggests that this edifice could be a small shield volvano, analogous to Terrestrial Hawaiin shield volvanos.

Rheologically, the terrestrial equivalents of such a multi-layered set up of a dome would suggest compositional changes or changes in magma temperature / explosivity between the layers. The estimated rheological arrangement suggests there was either increase in temperature with a decrease in gas content or decrease in silica content from lower to upper layer emplacement of the dome.

The surface age dating suggests that the Dome is older than the surrounding MH plain and was emplaced during upper Imbrian period while the surrounding area was re-surfaced during the lower Eristothanian period. The chronological and morphological difference between the two indicates the compositional variations between the two volcanic episodes. This establishes the episodic characteristic of the Mare basalts in OP and again churns up the debate on a possible magamatic differentiation of Mare basalts in OP, as believed by some.

For this particular dome, the depth (169-183 Km) and width (51-100 m) of the feeder dike suggests that the source magma chamber was in the lower mantle

The analysis of one construct is not sufficiant to conclude or localize the depth of the magma source, however, it certainly gives an idea about the mechanism, composition-variation and thermal conditions prevailing in part of MH. This is a preliminary investigation . A systematic , comprehensive and detailed study of the remaining domes and volcanic features in Marius Hills is initiated. TMC data has been found extremely useful and accurate in estimating the morphometric-, rheological- , chronological- parameters and estimation of the depth of source magma.

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