CRATER SIZE-FREQUENCY DISTRIBUTION (CSFD) MEASUREMENTS OF WOLF CRATER AND ITS ADJACENT AREA USING TERRAIN MAPPING CAMERA (TMC) AND NARROW ANGLE CAMERA (NAC) DATASETS. Mayank Bishwari, Monika Bansal and Mamta Chauhan*, Banasthali Vidyapith, Rajasthan, India (geologymamta@gmail.com)

Introduction: Wolf crater, located in the south-central section of Mare Nubium and centered at 16.6°W and 22.7°S, is a highly evolved non-mare volcanic feature [1]. It has also been identified as thorium anomaly [2].This highly degraded and irregular volcano is flooded and surrounded with basaltic flows. In order to determine the chronology of emplacement of the various volcanic units present, calculation of their relative and absolute model ages (AMAs) is essential. We have used high-resolution datasets to estimate the AMAs of these units present/regional events that occurred at and near wolf crater utilizing crater size-frequency distribution (CSFD) technique [3, 4].

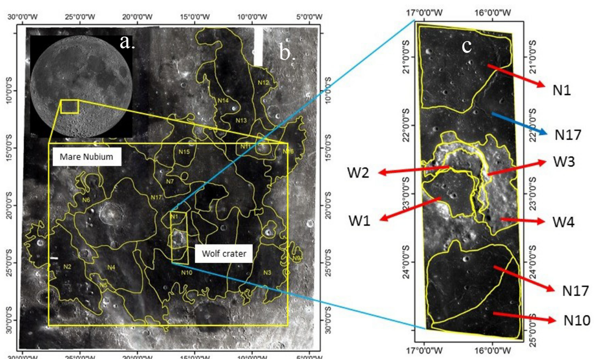

Figure 1. **a**. Mare Nubium area as highlighted on the lunar glode **b.** Chandrayaan-1, M^3 mosaic of Mare Nubium showing delineated basaltic units (N1-N17) along with the present study area and **c.** various volcanic units considered for CSFD analysis as outlined in yellow colour and indicated by red arrows on TMC strip.

Datasets and Methodology:
The present work has mainly utilized data from Terrain Mapping Camera (TMC) from ISRO's Chandrayaan-1 mission with spatial resolutions of 5m. Also, data from Narrow Angle Camera (NAC) onboard NASA's Lunar Reconnaissance Orbiter (LRO) mission having a spatial resolution of 0.5-2 m/pixel has been used. The advantages of TMC datasets includes full coverage of the area while better resolution of NAC data aids in recognizing the highly degraded crater which are otherwise unrecognizable on TMC data. To measure CSFD, total seven areas with homogenous counts were selected out of which three represents N1, N10, N17 units of [5] from Mare Nubium (Fig. 1).The other four represents the internal basaltic area of wolf crater,W1; its slope area, W2 and wall area W3 both towards east, and an eastern high-albedo unit W4 (Fig. 1c). For analysis all the primary craters present down to a minimum diameter size were considered. Crater counting and analysis is carried out using CraterTools [6] and CraterStats [7] in ArcGIS. The obtained CSFDs were plotted using pseudo-log binning and the AMA's were fit both in cumulative form (CumF) as well in differential form (PDF) using Poisson timing analysis of the unbinned datasets [3,7,8].The obtained results are compared with previously estimated ages for N1, N10 and N17 units (Table 1a, Fig. 2). While for the remaining four areas, AMAs estimation have been done for the first time using the same approach and technique (Table 1b, Fig.3).

Results: The best cumulative fit results corresponding to basaltic units N1, N10, N17 are presented in Table 1 a and 1b and Figure 2a-f.

Table 1a: The derived absolute model ages (AMAs) for cumulative fits (CumF) and Poisson differential fits (PDF) for N1, N10 and N17 basaltic units using TMC datasets:

Unit	CumF/Error bar	PDF/Error bar	[5]
N1	µ3.59+0.063/-0.11 Ga	µ3.37+0.16/-0.42 Ga	3.67 Ga
N10	µ3.51+0.14/-1.7 Ga	µ2.28+0.81/-0.95Ga	3.48 Ga
N17	µ3.27+0.16/-0.58 Ga	µ2.71+0.43/-0.55 Ga	2.77 Ga

Table 1b: The derived AMAs for CumF and PDF for N1, N10 and N17 units using NAC datasets:

Unit	CumF/Error bar	PDF/Error bar	[5]
N1	µ3.60+0.061/-0.10 Ga	µ3.37+0.16/-0.42 Ga	3.67 Ga
N10	µ3.52+0.14/-1.7 Ga	µ2.28+0.81/-0.95 Ga	3.48 Ga
N17	µ3.19+0.19/-0.62 Ga	µ2.92+0.34/-0.51 Ga	2.77 Ga

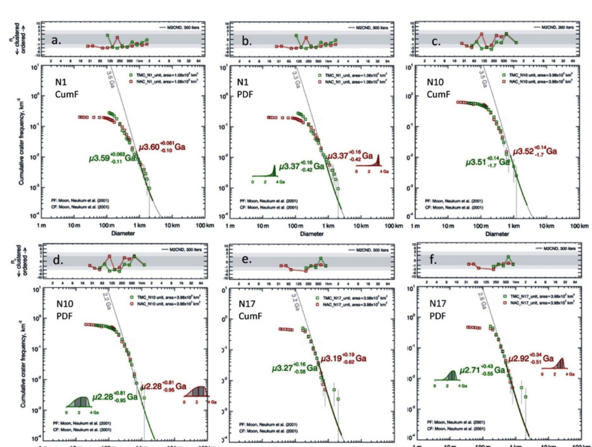

Figure 2: Respective CumF and PDF for count area, N1 (a. and b.) N10 (c. and d) and N17 (e. and f) of Mare Nubium. TMC's count area are green in colour while NAC's count area indicated by red colour.

The best cumulative fit results obtained for W1-W4 are presented in Table 2 a and 2b and Figure 3a-h.

Table 2a. The derived AMA's for CumF and PDF for basaltic unit W1 and volcanic units, W2-W4 using TMC datasets:

Units	CumF/Error bar	PDF/Error bar
W1	µ3.61+0.081/-0.19 Ga	µ2.51+0.61/-0.76 Ga
W2	µ3.47+0.13/-0.83 Ga	µ2.89+0.51/-0.83 Ma
W3	µ3.55+0.010/-0.94 Ga	µ2.86+0.52/-0.83 Ga
W4	µ3.68+0.057/-0.093 Ga	µ3.38+0.21/-0.63 Ga

Table 2b. The derived AMA's for CumF and PDF for basaltic unit W1 volcanic units, W2-W4 using NAC datasets:

Units	CumF/Error bar	PDF/Error bar
W1	µ3.61+0.081/-0.19 Ga	µ2.51+0.61/-0.76 Ga
W2	µ3.47+0.13/-0.83 Ga	µ2.89+0.51/-0.83 Ma
W3	µ3.49+0.013/-1.1 Ga	µ2.55+0.07/-0.89 Ga
W4	µ3.73+0.050/-0.076 Ga	µ3.58+0.094/-0.20 Ga

Here, W1: basaltic unit inside the wolf crater
W2: eastern slope surface of wolf crater wall
W3: eastern wall of wolf crater
W4: eastern side high-albedo unit

Discussions: The results obtained from the cumF using TMC and NAC data are consistent with the ages given by [5] for N1, N10 and N17 basaltic units of Mare Nubium. However, AMA's estimation of these units using PDF calculation [8] shows slight young ages than [5] from the same datasets.The reason could be due to consideration of empty bins in case of poisson's calculation [8,9]. The N17 unit yields different age from that of [5]. There is a possibility that the representative area for N17 unit selected by [5] was near to Bullialdus crater and its crater count may have been modified by its impact. It could therefore, may not be representative for the whole extent of N17 unit. The representative area selected for the present N17 unit for CSFD, lies towards the south of Wolf crater. It seems highly degraded and may even suggest the possibility of a totally different unit within N17 unit. AMA's calculated for previously unreported areas are also showing similar trends and the obtained PDF are showing younger ages (Table 2a and 2b). The overall results obtained from the present study indicates that the internal basalts of the wolf crater (W1 unit) are relatively older than the surrounding basaltic units (N1, N10 and N17 units). It indicates emplacement of basalt inside the wolf crater took place before the flooding event in the surrounding area. Also, the derived age for high-albedo unit (W4), possibly a volcanic dome, gives an age older than the internal basalts suggesting it to be the first surficial feature to have formed in the sequence. The age estimated for the slope area of the wolf crater wall may have large error margin as it is postulated by [5] that craters at slope surface may have faster degradation rates than normal because of mass wasting and other factors, so they may not follow the production and chronology curve trend as they should, resulting in somewhat additional error margins.

References: [1] Greenhagen B.T et. al. (2017) *LPS XLVIII,* #2597. [2] Lawrence D.J. et al. (2007) *GRL*. ***34***, L03201. [3] Neukum G. et. al. (2001) *Space Sci. Rev.,* 96, 55-86. [4] Neukum G. (1983) thesis, *Univ. of Munich*. 186 p. [5] Hiesinger H. (2003) *JGR*, 180, E7, 5065 [6] Kneissl T. et al. (2010) *Planet. Space Sci*.,10.1016/j.pss.2010.03.015. [7] Michael G. & Neukum G. (2010) *EPSL*, 294, 223-229. [8] Michael G.G. (2016) Icarus 277, 279-285 [9] Hiesinger H. (2012) *JGR* 117 E00H10.

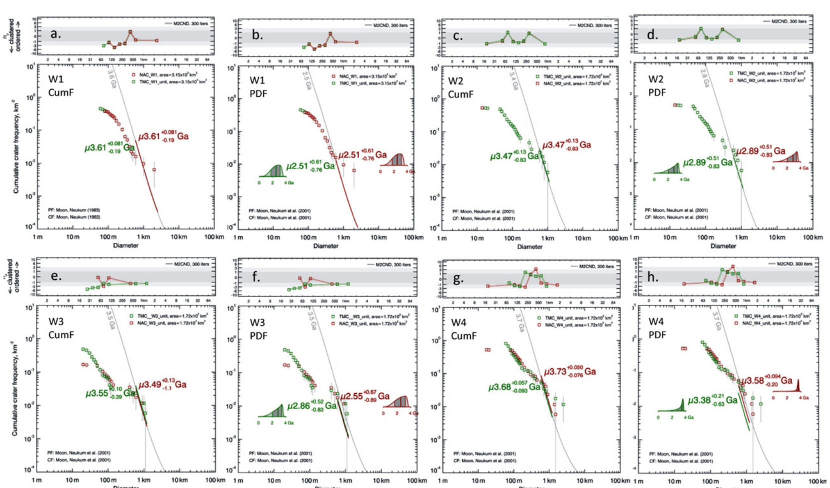

Figure 3: Respective CumF and PDF for count area W1 (a and b), W2 (c and d), W3 (e and f), W4 (g and h) of Wolf crater. TMC's count area are green in colour while NAC's count area are indicated by red colour.