NEW INSIGTHS INTO THE CRATER AND BOULDER DISTRIBUTIONS ACROSS THE APOLLO 17 REGION.

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Introduction: The heterogeneous geologic setting of the Apollo 17 exploration region allows for a detailed analysis of the distribution of small craters (<100 m diameter) across a diverse range of target surfaces, along with their statistical size-frequency variations. The aim is to better understand crater morphology evolution and explore possible correlations with the local geology. A subsidiary aim is to characterise the relationship between the larger valley craters, broadly clustered into a central and a northern group, and which may or may not have a common origin.

Method and data: I used two Narrow Angle Camera (NAC) image pairs [1] with similar average pixel size (1.43 m) but different incident illumination angles, ~57° (M104311715LRE, basemap, Fig. 1), and ~81° (M101949648LRE), to detect morphological features of interest.

42,090 craters larger than 5 meters were marked over a total surveyed surface area of 400 km^2, 53% of which are mare units (Fig. 1, 'M*'). 79% of all craters were found on the valley floor (density, 160 craters km^{-2}) against a lower observed density of 47 craters km^{-2} on slopes and upland surfaces ('H*').

Cluster craters ejecta. Both the Central and Northern crater clusters have been linked to the distal impact event Tycho. These relatively large craters (~600 m) have produced overlapping ejecta aprons of varying thickness that would have reset the small crater population radially at a decreasing depth away from the impact centre [2]. In principle, the craters' interior would also retain a record of small impacts subsequent to excavation of the main crater, although these will have been modified at a greater rate than small craters outside the rim of the large crater as a result of burial by slumping of crater wall materials. Therefore, to further investigate these local trends, I have focused on the following crater populations: (i) those within the larger cluster craters ('Lucch_in'); (ii) inside a >5 m thick ejecta blanket ('Lucch_5'); (iii) and those down to a modelled one meter thickness ('Lucch_5_1'), based on the equations of [2].

DEMs. I have also utilised custom-made Digital Elevation Models of the area under investigation [3] to determine the depth-to-diameter ratio of the largest craters for comparison with earlier estimates [i.e., 4]. The results are mapped on Fig. 1.

Boulders. Finally, both single boulders and boulder clusters were mapped (Fig. 2R).

Results: DEM-derived topographic profiles reveal significant differences in d/D ratios amongst the larger craters (Fig. 1). Those with low d/D ratios appear to be typical of the whole valley region (average d/D ~0.10), with the shallowest craters found adjacent to the North Massif. This is not direct proof of a separate genesis, since the northern craters were excavated on less consolidated soil (mostly colluvium) and thereafter partially infilled by talus from the nearby slopes, as shown by DEM profiles. The central cluster craters are somewhat deeper with d/D >0.12; they are also highly fractured and populated by many rocks and boulders. The North Massif slope close to the Wessex Clef and above stations 6 and 7 (Fig. 2R), shows evidence of an impact that caused localised fracturing of the cliff face and the production of many boulders and rolling tracks, although no large primary crater is observed on the proposed target. If we hypothesize the impact to be related to the high d/D ratio craters (Steno, etc.), then boulders sampled at stations 6 and 7, with exposure ages in the range of 20-30 Ma, might constrain the time of impact [5].

The cumulative crater frequency slope of all small craters surveyed interior to the large cluster craters, fits the 15 ± 4 Ma isochron closely ('Lucch_in', Fig. 3, top). This could be variously interpreted as: 1] a local resurfacing event around 15 Ma; 2] the actual time of formation of the large craters; 3] a result of the mechanical properties of the less consolidated materials in the large crater's interiors, which would retain small crater signatures for this length of time and no longer; 4] the crater Production Function (PF) for craters <100 m should be recalibrated (assuming the age estimate of ~100 Ma for the primary impact to be correct).

The Cumulative Crater Frequency (CCF, Fig. 3) plots suggest that small crater statistics (<30 m) are strongly dependent on the terrain type; in particular they appear to describe four types of terrain: highland ('H'), older mare ('M1' and 'M2'), moderately 'refreshed' by secondary influxes ('M3'), and highly modified ('M4' and 'M5'). The ratio of <30 m against <20 m bin are >1 for 'H', 'M1', and 'M2' and <1 for 'M3', 'M4', and 'M5'. It seems that the relatively recent mechanical reworking that has affected the central region of the valley has produced a rejuvenation of the sub-20 m crater population, pointing to a preferential time-dependent obliteration of small craters of these sizes in the unaffected areas. If we take 100 Ma as the upper limit of a recent local remantling event (or even

20 Ma, as proposed in this work), we see a reduction between 10 to 20% in <20m crater fraction within this timeframe.

Conclusions: d/D profiles, boulder tracks, isotopic data, and localised size-frequency distribution of small craters, point to two major surface modification events in the valley, particularly in the central area. These would be mechanical in origin, not igneous, and linked to the arrival of secondary products from major distal impacts. Tycho's ejecta have been linked to many of the prominent surficial expressions across the region, including the Light Mantle area, with an age estimate of around 100 Ma [e.g., 6]. Here we have found evidence of a second, more recent secondary episode, probably originating from the south that excavated the deeper central craters along with considerable mass mobilisation on the southern slopes of the North Massif. This event is assigned an age estimate of around 20 Ma.

References:

[1] Robinson, M.S. et al. (2005) *LPS XXXVI*, abstract #1576. [2] McGetchin T.R. (1973) *Earth Planet. Sci. Lett. 20, 226-236*. [3] Moratto Z.M. et al. (2010) *LPS XLI*, abstract #2364. [4] Lucchitta, B.K. (1979) *Icarus 37*, 46-50. [5] Crozaz, G. et al. (1974) LPSC Vol 5, 157. [6] Stöffler D. and Ryder G. (2001) *Space Sci. Rev.s 96*, 9-54.

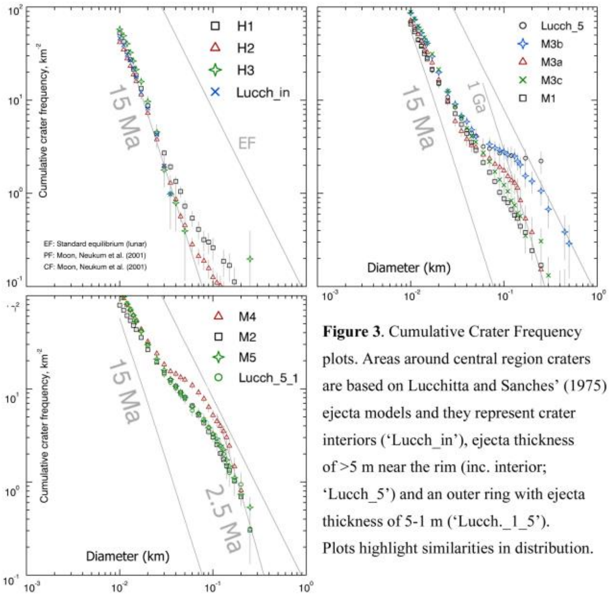


Figure 3. Cumulative Crater Frequency plots. Areas around central region craters are based on Lucchitta and Sanches' (1975) ejecta models and they represent crater interiors ('Lucch_in'), ejecta thickness of >5 m near the rim (inc. interior; 'Lucch_5') and an outer ring with ejecta thickness of 5-1 m ('Lucch._1_5'). Plots highlight similarities in distribution.

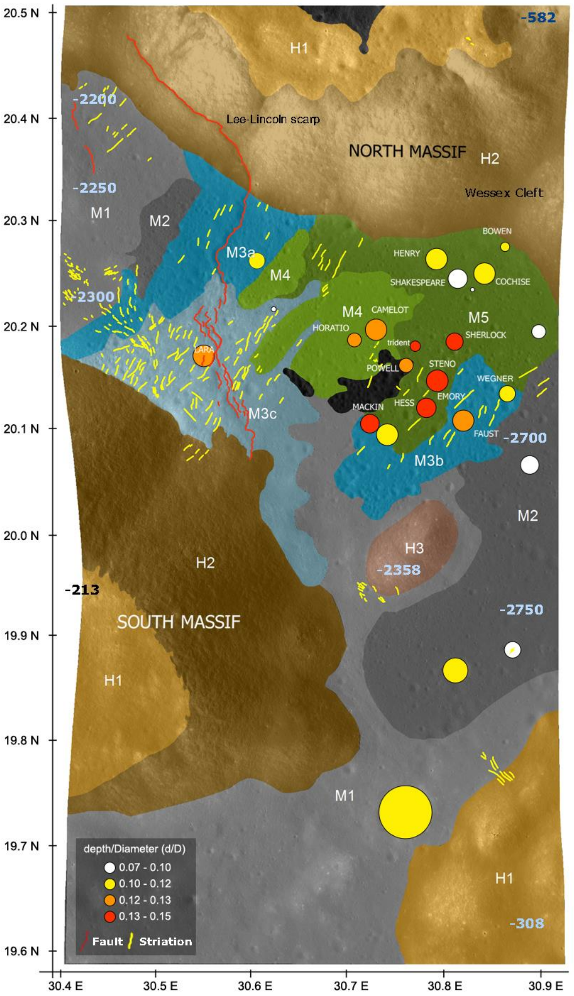
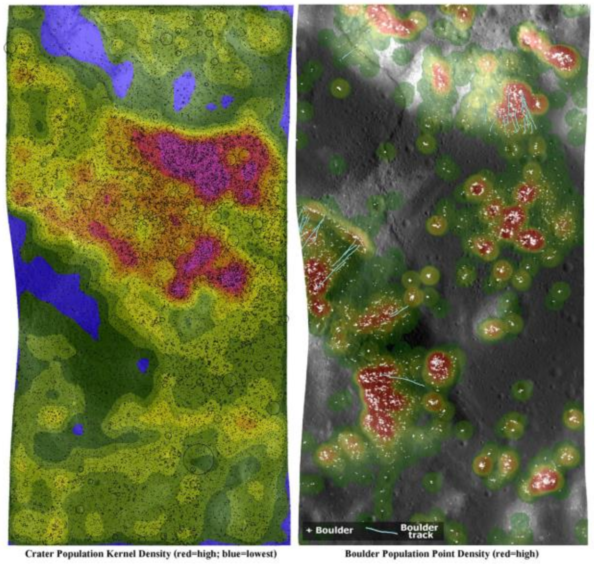


Figure 1. Geomorphologic units (M*=mare, H*=highilands). d/D of selected larger craters. Figures indicate topographic hights.



Crater Population Kernel Density (red=high; blue=lowest)

Boulder Population Point Density (red=high)

Figure 1. 2L, crater population density kernel map; **2R**, boulder kernel density map. Both red=highest, green=lowest. ESRI ArcMap tool.