THE LUNAR BASIN SEQUENCE BASED ON ABSOLUTE MODEL AGES DERIVED VIA BUFFERED NON-SPARSENESS CORRECTION: IMPLICATIONS FOR IMPACTOR POPULATION(S). C. Orgel[1] (orgel.csilla@fu-belin.de), G. Michael[1], C. I. Fassett[2], C. H. van der Bogert[3], C. Riedel[1], T. Kneissl[1], H. Hiesinger[3]. [1]Freie Universität Berlin, Department of Planetary Sciences, 12249 Berlin, Malteserstrasse 74-100, Bldg D, Germany. [2]NASA Marshall Space Flight Center, Alabama, USA; [3]Westfälische Wilhelms-Universität, Münster, Germany.

Introduction: The Moon has the best preserved impact record in the inner Solar System due to the absence of an atmosphere and the extremely low rates of surface modification. The lunar cratering record has long been used by the planetary community to determine relative and absolute surface ages [1, 2] and provides valuable information about the late accretion history of the inner Solar System. Crater size-frequency distributions (CSFDs) have been used to define the lunar "production function" (PF) [2], which describes the population of craters on the Moon's surface. Neukum's approach assumes that the PF remained unchanged, but this is debated [3-8]. If the PF has not changed, this could suggest the Moon had only one impactor population, or that multiple populations had the same size-frequency distribution.

Methods: We used the new CSFD method, the buffered non-sparseness correction (BNSC) [9] to revisit the characteristics of the impactor population(s). The new technique accounts for the fact that smaller craters on highly cratered surfaces have been previously undercounted with respect to their true accumulation due to their obliteration by larger craters and their ejecta blankets. Each crater is referenced to an area excluding regions in the study area that have been resurfaced by larger craters, thus the reference area becomes smaller for correspondingly smaller crater sizes. The new method also uses buffered crater counting (BCC), which includes all craters overlapping the counting area with a buffer, but whose center is located outside of the region of interest [6, 10]. In this study we took the region affected by ejecta to be 1 crater radius radial from the crater rim. This removes the region obliterated by the craters and the thickest part of the ejecta. We could increase the area removed to be more certain, but at the cost of further decreasing the counting statistics. To allow direct comparison of our corrected CSFDs with the BCC-only results of [6], we used their crater measurements along with their geologic mapping. The crater measurements are based on the lunar crater catalog and contains all impact craters with diameters ≥20 km [5]. Additional craters beyond that database were included from younger surfaces [6]. We represent the CSFDs using 2 different approaches: (1) BCC -- as done by [6], and (2) the new approach BNSC (Figure 1). We derive the N(20) values and the absolute model age of each basins and compare them results with [6].

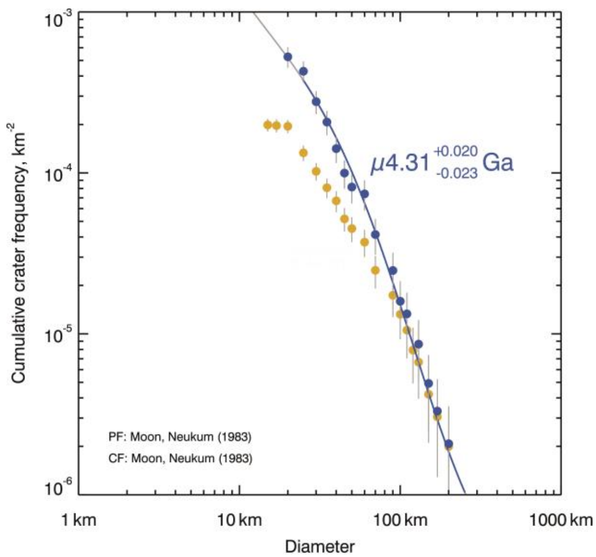

Figure 1. The CSFD and absolute model age fit for Nubium Basin using the BNSC (blue filled circle) and the BCC (yellow circle) CSFD techniques. The BNSC data shows that the smallest crater bins are corrected to higher crater frequencies when accounting for crater non-sparseness.

Results: The crater frequencies given by the BNSC technique correct the frequencies of smaller craters to larger values, seen as upward-shifted crater frequencies in the CSFD with respect to those derived from the BCC technique alone (Figure 1). Our results show that the crater frequencies increase by a factor of 24% compared to [6]. The shift is due to the corrected reference areas, namely that the density of smaller craters becomes higher in the correspondingly smaller reference areas when areas resurfaced by larger subsequent craters have been removed. The magnitude of this correction grows systematically larger for older surfaces, such as Pre-Nectarian and Nectarian basins. However, there is little to no effect of the BSNC technique on Imbrian basins, because craters are sparse on these younger surfaces.

As a result of the improved CSFDs, our derived N(20) crater frequencies for the individual lunar basins are different than [6], which in turn changes the basin sequence significantly. The differences in stratigraphic position increase on surfaces with higher crater densities/ages (Pre-Nectarian-aged and Nectarian-aged), since these surfaces require the largest BNSC corrections. The relative stratigraphies from previous studies [6, 11, 12] disagree in a few cases with our basin sequence based on our new absolute model ages. However, our measurements are made from a broader crater size-range and are likely more robust than establishing basin sequence based on N(20) values alone (Table 1).

Basin	Period	Absolute Model Age µ (Ga)
South Pole-Aitken	PN	4.31±0.019,-0.021
Nubium	PN	4.31±0.020,-0.023
Birkhoff		4.29±0.035,-0.047
Ingenii		4.28±0.035,-0.047
Amundsen-Ganswindt		4.26±0.038,-0.052
Cruger-Sirsalis		4.26±0.032,-0.041
Smythii		4.26±0.016,-0.018
Fitzgerald-Jackson		4.26±0.044,-0.063
Schiller-Zucchius		4.24±0.038,-0.052
Dirichlet-Jackson		4.23±0.022,-0.026
Coulomb-Sarton		4.23±0.025,-0.030
Poincare		4.23±0.031,-0.040
Serenitatis		4.22±0.027,-0.033
Lorentz		4.20±0.029,-0.036
Nectaris	N	4.17±0.012,-0.014
Grimaldi		4.14±0.033,-0.044
Freundlich-Sharanov		4.14±0.019,-0.023
Apollo		4.14±0.024,-0.029
Mendeleev		4.13±0.044,-0.064
Planck		4.13±0.038,-0.053
Mendel-Rydberg		4.13±0.022,-0.026
Korolev		4.11±0.021,-0.025
Humorum		4.09±0.023,-0.027
Hertzsprung		4.09±0.030,-0.037
Moscoviense		4.09±0.020,-0.024
Humboldtianum		4.08±0.026,-0.032
Crisium		4.07±0.016,-0.018
Imbrium	I	3.87±0.035,-0.046
Schrödinger		3.86±0.025,-0.030
Orientale		3.81±0.0081,-0.0085

Table 1: Derived absolute model ages of lunar basins using the buffered non-sparseness correction, ranked by model age. The model ages quoted for each basin with the respected µ-notation do not include the systematic uncertainties in the chronology model.

To investigate the nature of the impactor population(s), we plotted the summed CSFDs of the Pre-Nectarian-aged basins (excluding South Pole-Aitken Basin (SPA)), Nectarian-aged basins (including Nectaris), and Imbrian-aged basins (including Imbrium) on a relative crater frequency plot (R-plot) as was done by [6]. Our results show that the shape of the CSFD is in fact unchanged, and thus consistent with one impactor population or multiple populations that have the same size-frequency distribution (Figure 2).

Conclusions: The BNSC technique makes a significant difference in accounting for crater densities on highly cratered surfaces. In contrast to previous studies [3, 5, 6], which show a change in the shape of the CSFDs for the lunar periods, our results indicate no change in the shapes and thus, no evidence for a change in impactor population between the lunar periods.

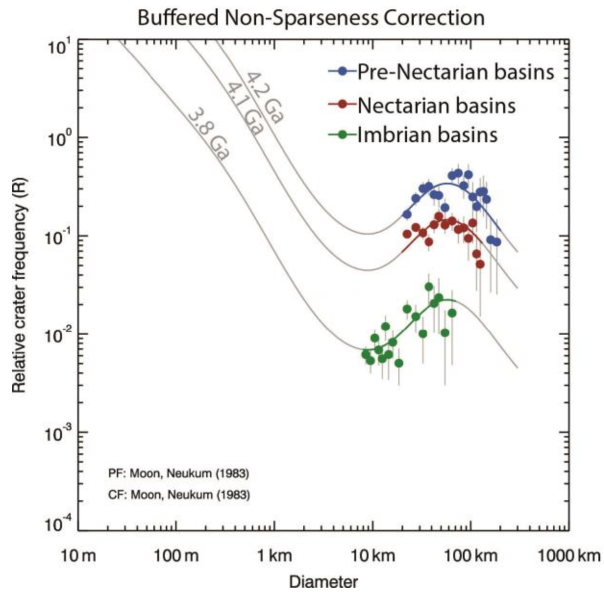

Figure 2. Summed crater size-frequency distributions for pre-Nectarian-aged basins (excluding SPA), Nectarian-aged basins (including Nectaris) and Imbrian-aged basins (including Imbrium). The shape of summed CSFDs of respective ages are similar using the BNSC method. This suggests one impactor population or multiple populations with the same size-frequency distribution formed all the lunar basins.

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