REVISED CRATER SIZE-FREQUENCY DISTRIBUTION MEASUREMENTS AT THE APOLLO 14 LANDING SITE. D. Borisov[1], H. Hiesinger[1], W. Iqbal[1], and C. H. van der Bogert[1], [1]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, D-48149 Münster, Germany (contact: d.borisov@uni-muenster.de).

Introduction: In [1], crater size-frequency distribution (CSFD) measurements of the Apollo 14 landing site were reported in conjunction with a well-constrained crystallization age of impact melt rock 14310 using Pb-Pb, Rb-Sr, Lu-Hf, and Sm-Nd isotopic systems, in an attempt to constrain the 'A14/Fra Mauro Formation (FMF)' calibration point on the lunar cratering chronology function [2-5]. Here, we investigate the CSFDs in more detail based on additional measurements on Lunar Reconnaissance Orbiter (LRO) Narrow Angle Camera (NAC) and Wide Angle Camera (WAC) images. Using the data presented here and in [1], our study aims to constrain the cumulative crater-frequency $N(1)$ and the absolute age of the Fra Mauro Formation, i.e. the Imbrium basin, using both laboratory and remote-sensing techniques.

Apollo 14 Landing Site: The Apollo 14 landing site is situated about 600-800 km south of the Imbrium basin within the Fra Mauro Formation (FMF), which is interpreted to represent megabreccia formed during the Imbrium basin formation event (e.g., [6]). The landing site was originally chosen to sample ejecta blocks that were excavated by the very young Cone crater and interpreted to unambiguously represent the FMF [6]. The original CSFD measurements yielded an $N(1) = 3.7 \pm 0.7 \times 10^{-2}$ km^{-2} [2], while the currently accepted isotopic age range for the Imbrium basin is 3.91-3.94 Ga based on Secondary Ion Mass Spectrometry (SIMS) Pb-Pb dating on accessory minerals of impact melt rocks, recently summarized in [7].

Geological Mapping and CSFDs: A geological map (1:1,500,000) of the FMF was prepared and is shown in Fig. 1. CSFDs were measured on the LRO WAC mosaic using the same count area as [2] (Fig. 1, red area), as well as a new count area, defined to cover the largest area with homogenous geology and topography within the newly remapped FMF (Fig. 1, yellow area). The results yielded a mean cumulative crater frequency of $N(1) = 4.40 \pm 0.09 \times 10^{-2}$ km^{-2} (Fig. 2), using the production and chronology functions of [3], and are concordant with the original study [2]. An inferred absolute model age (AMA) of 3.94 Ga agrees with the most recent isotopic age estimate of the Imbrium basin [7].

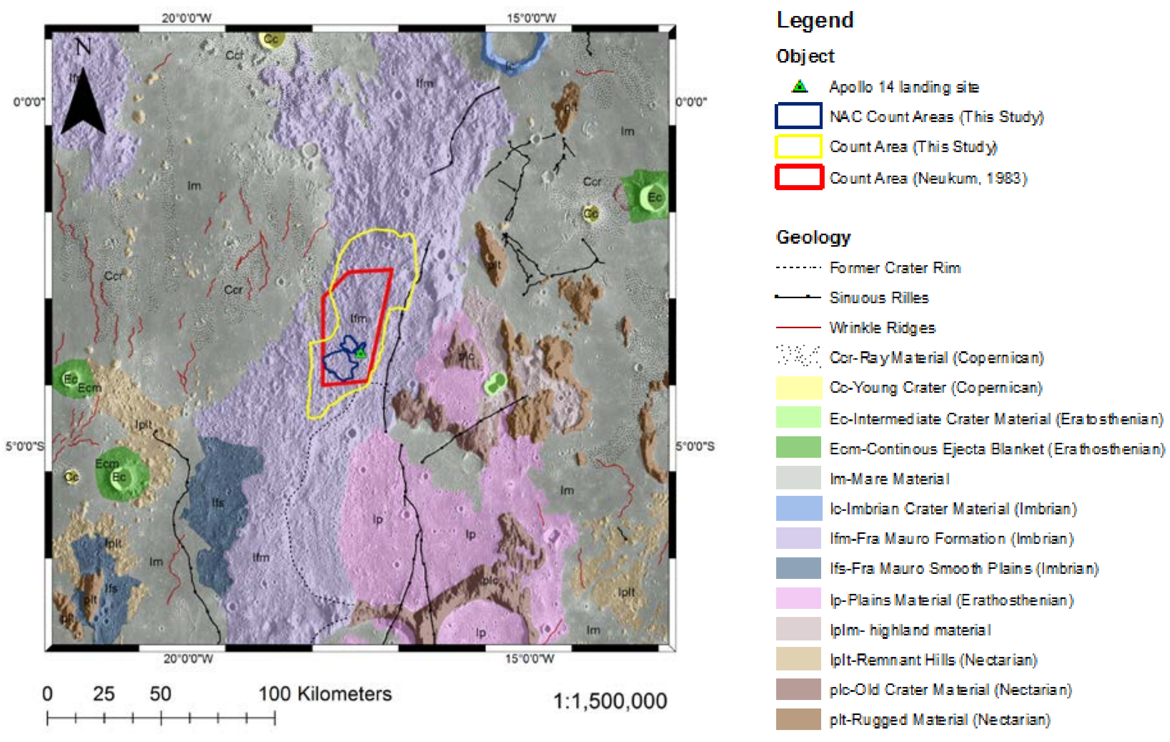

Fig. 1: *New geological map of the area around the Apollo 14 landing site (1:1,500,000).*

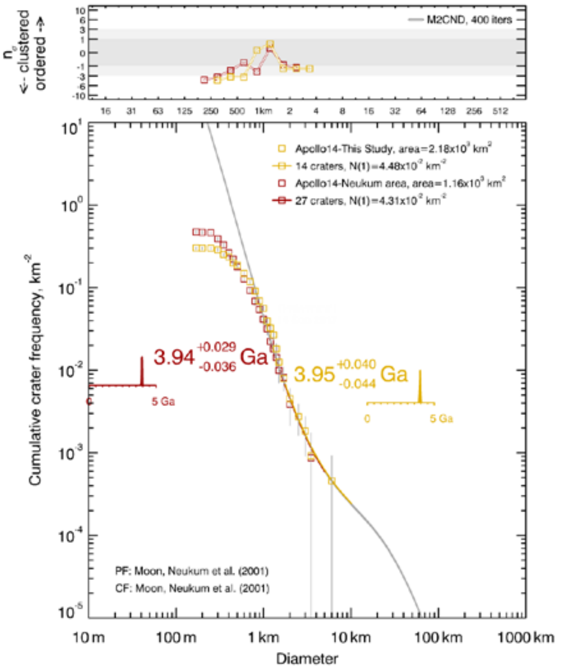

***Fig. 2:** CSFD measurements based on the LRO WAC mosaic for the original count area by [2] (black), compared with a newly defined count area on the Fra Mauro Formation on the basis of our new geological map (red).*

To investigate the distribution of small craters on the FMF, LRO NAC and Kaguya images with a pixel size of ~1 m/pixel and ~10 m/pixel were analyzed. Currently, only one Digital Terrain Model (DTM) exists at this scale for the FMF and, thus, only one detailed NAC CSFD measurement can be performed for the FMF using topographical data to more precisely identify old degraded crater rims (Fig. 3; black). The count area was selected to avoid steep slopes, which might affect the CSFD measurements [8, 9]. A cumulative crater frequency of $N(1) = 2.27 \times 10^{-2}$ km^{-2} was determined. To test and validate this observation, two further NAC count areas were focused on measuring craters with diameters of >200 m, because craters below that size are in equilibrium. The results show that all NAC count areas combined yield a total $N(1) = 4.43 \times 10^{-2}$ km^{-2} (Fig. 3; blue).

Discussion: The variations of the CSFDs based on NAC data are most likely because many old and small craters in this area are heavily degraded and often do not have well-defined crater rims, which makes crater diameter determinations difficult. Additionally, target property effects, such as the relatively high porosity of the FMF [10, 11], which particularly affect small craters, might be partially responsible for the measured deviations. Thus, it is reasonable to assume that a better approximation of the $N(1)$ for the FMF is given by the WAC count areas, which encompass craters larger than those affected by strength-scaling effects and generally have higher statistical significance. Based on these data and the various isotopic data collected in the last 10 years [7], we conclude that the FMF has an $N(1) = 4.40 \pm 0.09 \times 10^{-2}$ km^{-2}, which is correlated to an absolute age of 3.91-3.94 Ga. Overall, these data are more precise, but still concordant with the pioneering studies [2, 3], which supports the current position of the A14 calibration point on the lunar chronology function.

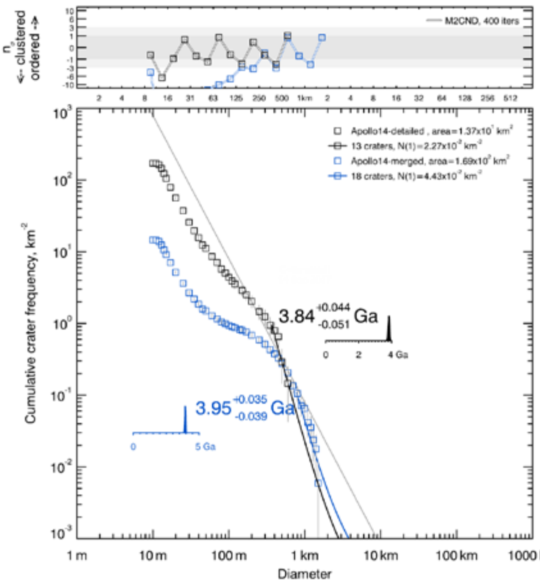

***Fig. 3:** CSFD measurments based on LRO NAC and Kaguya images, and a NAC DTM for a count area directly at the Apollo 14 landing site (black), and for a merge of three NAC count areas on the FMF focusing on craters >200 m (blue).*

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References: [1] Borisov et al. (2018) *LPS XLVIV*, Abstract #1933. [2] Neukum (1983) Habilitation thesis, University of Munich. [3] Neukum et al. (2001) *“Chron. and evol. of Mars.”, Springer Netherlands, 2001*, 55-86. [4] Hartmann and Neukum (2001) *“Chron. and evol. of Mars.”, Springer Netherlands, 2001*, 165-194. [5] Stöffler et al. (2006) *Rev. in Min. and Geochem.*, 60, 519-596. [6] Swann et al. (1977) *“Geology of the Apollo 14 landing site in the Fra Mauro highlands.", Washington: US Govt. Print. Off.* [7] Bottke and Norman (2017) *Annu. Rev. Earth Planet. Sci.*, *45*, 619-647. [8] Basilevsky (1976) *Proc. Lunar Sci. Conf. VII*, 1005-1020. [9] Meyer et al. (2016) *DPS XLVIII*, Abstract #223.04. [10] Kiefer et al. (2012) *Geophys. Res. Lett.*, *39*. [11] van der Bogert et al. (2017) *Icarus*, *298*, 49-63.