NEW CRATER SIZE-FREQUENCY DISTRIBUTION MEASUREMENTS FOR TYCHO CRATER BASED ON LUNAR RECONNAISSANCE ORBITER CAMERA IMAGES. H. Hiesinger[1], C. H. van der Bogert[1], M. S. Robinson[2], K. Klemm[1], D. Reiss[1], and the LROC Team, [1]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany, [2]Arizona State University, Tempe, AZ, USA

Introduction: Tycho is a 102-km diameter impact crater on the lunar central nearside, located at 43.4°S and 11.1°E. Named after the Danish astronomer Tycho Brahe, it exhibits a prominent bright ray pattern that extends across large parts of the nearside. Tycho has a sharply sculpted crater morphology and its rays are superposed on most of the materials surrounding them, thus Tycho is interpreted as a young Copernican crater [1].

At the Apollo 17 landing site, about 2200 km away, secondary craters from Tycho presumably triggered a landslide on the slope of the South Massif. König [2] and Neukum and König [3] counted craters on the landslide and in the area of a cluster of craters (Central Cluster) on the Taurus-Littrow floor and compared these counts with counts made at Tycho. They found a good agreement between the ages and concluded that the landslide and the Central Cluster were very likely formed by Tycho ejecta.

Samples returned from the landslide revealed exposure ages of about ~100 Ma. Consequently, this age has been interpreted to represent the formation age of Tycho crater [e.g., 4-7]. The Central Cluster, interpreted as secondary craters from Tycho, also have exposure ages of ~100 Ma [4, 6], consistent with the idea that Tycho is a young Copernican crater of 100 Ma in age. From the exposure ages, Drozd et al. [7] concluded that Tycho is 109±4 Ma old. This age is identical to that of Guinness and Arvidson [8], and is similar to an exposure age of 96±5 Ma for the landslide and Central Cluster materials derived by Arvidson et al. [5]. However, Stöffler and Ryder [9] point out that the geological evidence for the South Massif landslide and the secondary crater cluster having formed due to distal ejecta from Tycho is equivocal.

From Lunar Orbiter V images, Strom and Fielder [10] argued for extensive multiphase volcanism in and around Tycho. Based on these images, they mapped and dated what they interpreted as lava flows, as well as "lakes" and the floor of Tycho crater. Based on their age estimates, the "lakes" and the floor exhibit about the same ages of ~160 m.y., whereas their "lava flows" just outside the northern rim of Tycho are ~320-400 m.y. old [10].

Tycho is an important anchor point for the lunar chronology, which allows us to determine absolute model ages for the entire lunar surface. Hence, it is crucial to have accurate crater size-frequency distribution measurements that can be correlated with the exposure ages measured for the Apollo 17 samples.

Data: For our study we made use of two image pairs collected by the Lunar Reconnaissance Orbiter Narrow Angle Camera (LROC NAC) [11], M104584909 and M1044570590. These images have a pixel size of 0.6 m, and allow us to date small areas such as individual impact melt ponds. The images were calibrated and map-projected with ISIS 3 and imported into ArcGIS. Within ArcGIS, we used CraterTools [12] to perform our crater counts. The crater size-frequency distributions (CSFDs) were plotted with CraterStats [13], using the crater-size standard distribution of [14] and the lunar chronology of [15]. This work yields absolute model ages (AMAs) for craters in the diameter interval of 10 m to 300 km [16]. The technique of CSFD measurements has been described extensively [e.g., 16-19]. For our crater counts we mapped several homogeneous areas on the ejecta blanket, the floor, and the smooth impact melt ponds. Particular attention was paid to avoid obvious secondary craters.

Results: We dated a total of seven different units at Tycho crater (Table 1.), including three individual smooth melt pools just outside the eastern rim of Tycho crater. Numerous melt pools at Tycho crater show extensional fractures, probably due to cooling and shrinking of the impact melt [20]. We also dated a melt pool inside Tycho, the central floor, and two areas on the proximal ejecta blanket.

Melt pool 1 is the smallest pool dated. The AMA of this pool is ~37 Ma (Fig. 1a). Melt pools 2 and 3 are much larger, with correspondingly larger numbers of craters. These pools yielded ages of ~35 and ~32 Ma

Table 1. *Size of counting areas, number of craters counted, N(1), and the absolute model ages (AMAs) for each Tycho unit.*

Location	Area (km^2)	Craters	N(1) ($x 10^{-5}$)	AMA (Ma)
Exterior Pool 1	3.72×10^{-2}	305	3.11	37
Exterior Pool 2	9.03×10^{-1}	763	2.92	35
Exterior Pool 3	1.53×10^{0}	3609	2.67	32
Interior Pool	1.35×10^{0}	6322	3.08	37
Crater Floor	8.58×10^{-1}	3590	3.08	37
Ejecta 1	2.17×10^{-1}	1848	9.18	110
Ejecta 2	8.11×10^{-2}	926	9.90	118

respectively (Fig. 1a).

In order to investigate potential differences in age between pools outside and inside the crater, we dated a fourth pool on the floor of Tycho crater for which we derived an AMA of ~37 Ma (Fig. 1b). We also dated a hummocky area of the Tycho floor, which yielded an AMA of ~37 Ma, contemporaneous with the melt pool ages (Fig. 1b). Thus, all investigated melt ponds inside and outside Tycho and the floor of Tycho show similar ages of 32-37 Ma. Crater counts performed in two areas on the proximal ejecta blanket revealed significantly older ages compared to the ages of the melt ponds and the hummocky floor. According to our CSFDs, ejecta area 1 is 110 Ma old; ejecta area 2 is 118 Ma old and basically of the same age as ejecta area 1 (Fig. 1c). Hence, there is a significant difference in ages of the ejecta blanket and the melt pools and floor material.

Discussion: Compared to ages of [10], for their "lakes" and "lava flows", our ages for the floor, the melt pools, and the ejecta blanket are significantly younger. However, our ejecta ages are in excellent agreement with the exposure ages of the Apollo 17 landslide and the Central Cluster. Similar to our findings, Strom and Fielder [10] observed differences in CSFDs between their "lava flows" and "lakes", which we interpret as ejecta material and impact melt pools. Such an interpretation is consistent with that of [20]. Strom and Fielder [10] concluded, that the age differences are best explained by extensive multiphase volcanism post-dating crater formation. Similar differences have been observed for melt pools and ejecta of Jackson crater [21] and Copernicus crater [22]. However, van der Bogert et al. [21] argue that strength differences between the target materials cause larger crater sizes on the weaker ejecta blanket compared to the more coherent melt pools.

Conclusions: From our CSFD measurements performed for melt pools inside and outside Tycho crater, the hummocky crater floor and two areas on the proximal ejecta blanket, we conclude: (1) all melt pools exhibit a similar absolute model age of about 32-37 Ma; (2) the melt pools show the same age as the hummocky floor of Tycho; (3) both areas on the ejecta blanket appear to be roughly 2-3 times older than the melt pools and the floor, and this might have to do with different target properties as suggested by [21]; (4) the absolute model ages for the ejecta areas are in excellent agreement with exposure ages of the landslide and the Central Cluster at the Apollo 17 landing site.

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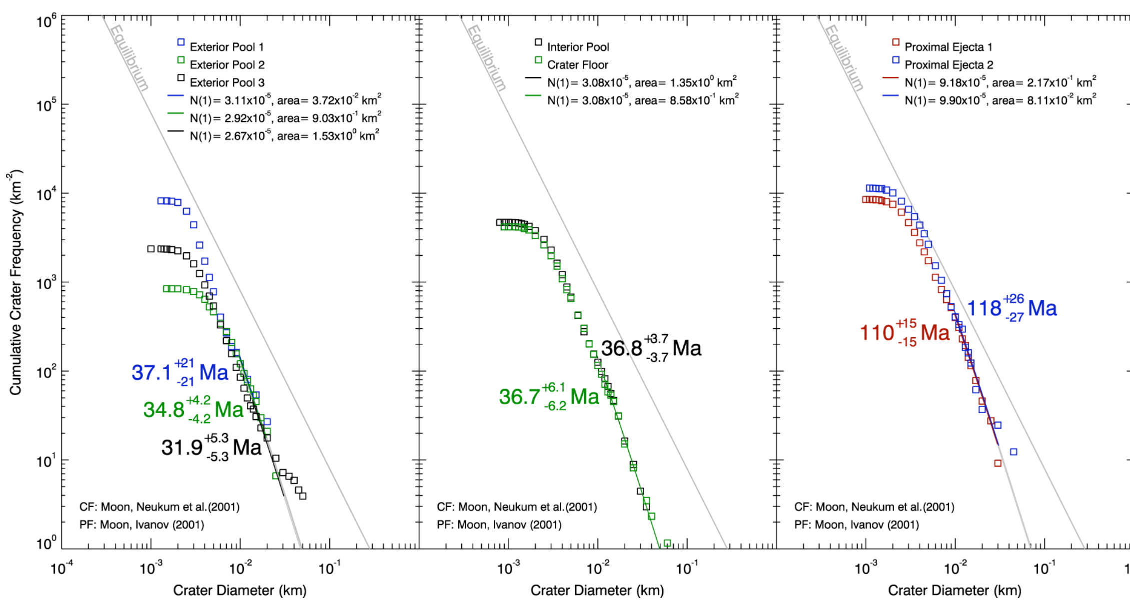

Figure 1. *CSFDs of (a) exterior melt pools, (b) an interior melt pool and the crater floor, and (c) the proximal ejecta blanket of Tycho crater.*