NEW DETERMINATION OF CRATER SIZE-FREQUENCY DISTRIBUTION VARIATION ON CONTINUOUS EJECTA DEPOSITS: RESULTS FROM ARISTARCHUS CRATER. M. Zanetti[1], B. Jolliff[1], C. H. van der Bogert[2], and H. Hiesinger[2] [1]Department of Earth and Planetary Sciences & McDonnell Center for the Space Sciences, Washington University in St Louis, One Brookings Drive, St. Louis, MO 63130; [2]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm Str. 10, 48149, Münster, Germany.

Introduction: Crater distributions on proximal ejecta blankets of Copernican-age impact craters analyzed for the purpose of relative age dating are complicated by many factors [1-6]. Previous measurements have shown that crater size-frequency distributions (CSFDs) can vary as a function of count-area size, diameter-range of craters counted, distance from crater rim [2], target properties [4-6], topographic effects, image resolution, effects of secondary craters [7-10], and possibly the effect of late-arriving ejecta [1, 2].

Understanding the causes of the discrepancies in CSFDs of small craters on ejecta surfaces is important to ensure appropriate use of CSFDs for derivation of absolute model ages and understanding their limitations [9]. To address the issue of CSFD variation and potential biases introduced by count-area selection and summation of many smaller count areas [3,9], we have done a comprehensive count of craters on the proximal ejecta blanket of Aristarchus Crater (42 km diameter) supplementing our LRO NAC and WAC image base [11] with Kaguya Terrain Camera Data [12] for comparison to previous work using a series of equal-area radial counts with LRO-NAC images [2]. We subdivided the ejecta blanket into different count areas to investigate variations in derived absolute model age (AMA) with distance from the crater rim, and we compare these results to the ejecta blanket as a whole. We present the AMA results of the proximal ejecta blanket as a single contiguous unit and also binned into radial rings to assess variation in crater density with increasing distance from the crater rim. We interpret the results as evidence for the over-production of small craters relative to the expected primary crater production, and that self-secondary impacts are an important part of the cratering process.

Methods: The proximal ejecta blanket, defined as the region between the crater rim and the onset of hummocky hills at approximately one crater radius [13,14], was mapped in ArcGIS. Over 38,000 craters were counted on the ejecta blanket using CraterTools [15]. We focused on craters >35 m, but all statistics are based on craters >60 m diameter. The count dataset was subdivided into 4 radial rings spaced at 5 km intervals from the crater rim (0-5, 5-10, 10-15, and 15-20 km). CSFD statistics and AMA isochrons were fit using CraterStats [16], and the production and chronology functions of Neukum et al. [17]. CSFDs were further subdivided by isochron fitting to different crater diameter ranges (60–100, 100–200, 200–300, >300 m) for each of the rings to examine AMA variation dependence on crater size.

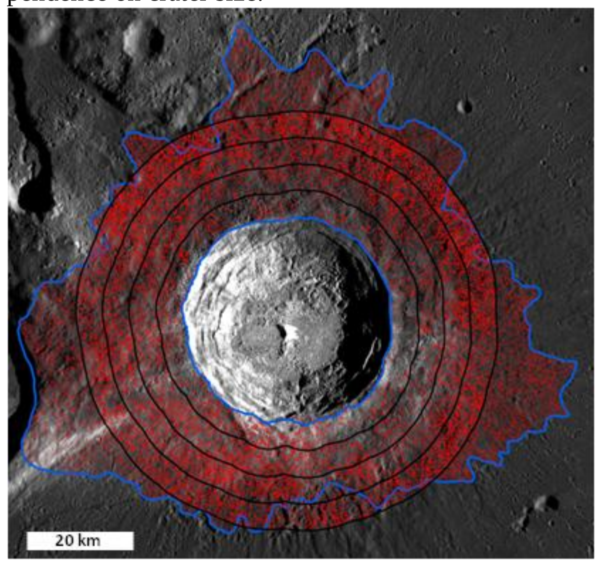


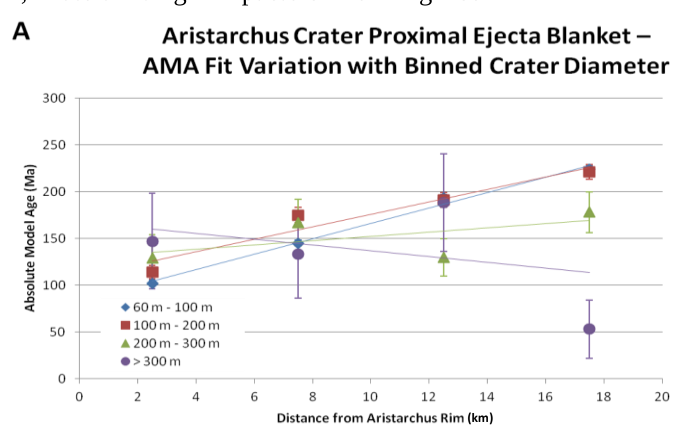
Figure 1: Count areas at the 42 km diameter Copernican-aged Aristarchus Crater. Blue line represents the edge of the proximal, continuous ejecta blanket. Black lines are radial ring count areas spaced at 5 km intervals from the crater rim.

Results: Results for the proximal ejecta (blue line in Fig 1) and radial ring (black lines) count areas are summarized in Table 1. The entire proximal ejecta count results in an AMA of ~189 Ma. Summing the radial ring counts results in a slightly younger apparent AMA of ~176 Ma. These ages are similar to previous estimates (i.e., 130–180 Ma, [16]; ~174 Ma, [17.]). However, the radial rings display a pronounced linear trend of increasing apparent-AMA with increasing distance from the crater rim, opposite to a radial trend shown in small (1 km^2) equal-area counts done previously at 4 Copernican-aged craters [2]. Analyzing the counts using subdivided crater diameter bins yields the following results: in the smallest crater diameter bin (60–100 m), the linear increase in age with distance from the rim is consistent, with the smallest crater bin yielding an age close to the best fit isochron for the entire CSFD. Larger crater diameter bins (100–200 m, and 200–300 m) show more variation, and the largest diameter bin (>300 m) shows the most variation, but also has the poorest count statistics.

Discussion: Our results indicate that AMAs on the ejecta blanket of Aristarchus Crater systematically change with distance from the crater rim, and depend on the crater diameter range for which the AMA isochrons are fit (Fig 2). The most distal ring has a greater small-crater (60-100 m) density than inner rings. Each of the radial ring CSFD counts is best fit in the 60–200 m size range, and these diameter bins control the derived best fit AMA for the entire count area. Greater numbers of craters in these size bins drive the AMA to an apparently older value. The CSFD curves for the radial rings and the entire proximal ejecta blanket can typically be fit over a wide-range of crater diameter bins, but large-crater-size bins commonly fall below the best fit isochron (e.g. green isochron in Fig 2b). This could either be due to removal of the large (>200 m) craters on the ejecta blanket; or conversely the small crater production (<200 m), especially in the more distal 15 and 20 km rings, may be inflated. Larger craters (>200 m) are more likely primary impacts, as they are randomly distributed around the ejecta blanket, and are large enough to be in the gravity-dominated cratering regime [5,6]. The systematic radial trends in the counts and the lack of young, nearby craters to produce clusters and chains indicate that the inflated AMA and crater densities in the distal rings cannot be caused by external secondary fields.

The formation of the proximal ejecta blanket of a crater has traditionally been interpreted as the emplacement of an ejecta curtain that homogenously resurfaces the area within ~one crater radius [13,14] and could thus be used to record the time of the impact. We interpret the small-crater densities in the distal rings of the proximal ejecta blanket to reflect the effect of small, late-arriving impactors forming self-secondary craters [20] during the Aristarchus crater-forming event, which produce a greater number of small craters in the distal portions of the proximal ejecta blanket. It may thus be the case that the small-crater densities give information about the fundamental process of ejecta blanket emplacement, while larger primary craters on the proximal ejecta blanket are useful for conventional derivation of AMAs. Accordingly, our assessment of the age of Aristarchus Crater based on craters >200 m would be ~150 Ma. This is in agreement with previous estimates, and with stratigraphic relationships of crater rays between Copernicus and Tycho craters.

References: [1] Plescia, J.B. et al. (2011), LPSC XLII, #1839. [2] Zanetti, M. et al. (2012), LPSC XLIII, #2131. [3] Hiesinger, H. et al. (2012), JGR, 117, E2 [4] van der Bogert, C.H. et al. (2010), LPSC XLI, #2165. [5] van der Bogert et al., (2013) LPSC XLIV #1942. [6] K. Wuenneman et al., (2012), LPSC 43 #1805. [7] Xaio and Strom (2012) Icarus 220, p254-267. [8] McEwen and Bierhaus, (2006), Annual Review of Earth and Planetary Science, 32, 535-567. [9] van der Bogert et al., (2012), GSA annual meeting, #202-6 [10] S. Werner, et al., (2009), Icarus 200, 406-417 [11] Robinson et al., (2010) Space Sci Rev 150: 81–124 [12] Haruyama J. et al., (2008). EPS, 60, 243-255. [13] Schultz, P.H. (1976), Moon Morphology, p. 641. [14] Oberbeck (1975) Reviews of Geophysics, 13, 2, p337-362 [15], CraterTools: Kneissl et al., (2010) PSS, PSS, 59, 1243-1254. [16] CraterStats: Michael and Neukum, (2010), EPSL, 2010, 294, 223–229 [17] Neukum et al., (2001) Space Sci. Review, 96, 55-86. [18] Neukum and König (1976) LPSC 7, 2867-2881. [19] Zanetti et al., (2011), LPSC 42, #2330.[20] Shoemaker, E.M. et al. (1968), Surveyor 7 Mission Report, 2, 32–1264, pp. 9–76.



Region	Count Area (km²)	# of Craters Counted	Best Fit AMA (Ma)	Fit Range	# of Craters Fit
5 km Ring	712	2551	105 +/- 3.4	60 m - 600 m	933
10 km Ring	865	5337	153 +/- 3.7	60 m - 500 m	1706
15 km Ring	1021	8811	190 +/- 3.7	60 m - 700 m	2599
20 km Ring	1177	12387	223 +/- 3.7	60 m - 350 m	3631
All Rings Summed	3775	29054	176 +/- 1.8	60 m - 300 m	8884
All Proximal Ejecta	4910	38311	189 +/- 1.7	60 m - 600 m	12235

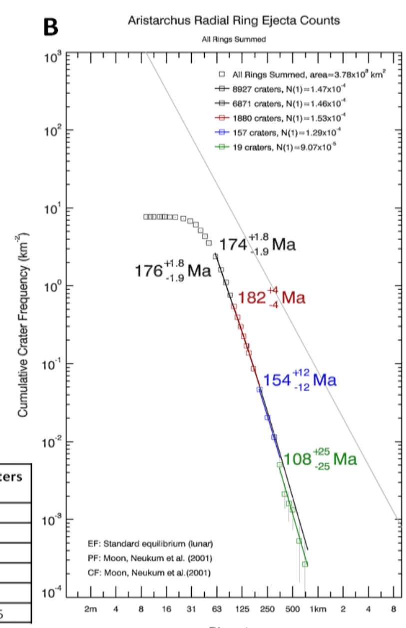


Figure 2: A) Graph of AMA isochron fit variation using different diameter bins. B) Example CSFD using the sum of all radial rings with AMA isochrons fit to different crater diameters. Note the poor fit of the largest craters counted.
Table 1: Crater counting statistics for the proximal ejecta blanket and radial rings at Aristarchus Crater.