SIZE-FREQUENCY DISTRIBUTIONS OF SMALL IMPACT CRATERS ON VESTA - IMPLICATIONS FOR SECONDARY CRATERING

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Introduction: Dawn is the first comprehensive mission designed to explore the two most massive main belt asteroids, Vesta and Ceres in detail [1]. To investigate size-frequency distributions (SFD's) of small impact craters on Vesta we make use of clear filter image data aquired by the Framing Camera (FC) during the Low Altitude Mapping Orbit (LAMO) with a resolution between 15 - 20 m/px. This allows us for the first time to study small craters and especially the potential of secondary cratering on a low gravity body in such detail.

Background: We depend on sub-kilometer impact craters as it is only these that occur in statistically significant numbers on fresh and/or small units (like recent mass wastings or fresh rayed craters) to determine their relative and absolute ages. By making use of small craters statistical robustness can increase but can become problematic in cases of contamination by unrecognized secondary background craters. On the other hand, very young surfaces should be free of background secondaries as far as possible. Thus for our investigation of the SFD of small impact craters we performed crater counts on the youngest surface units on Vesta, namely continuous ejecta blankets of rayed craters and analyzed its distant dependent change and distributions of secondary craters. Additionally, we compared our results with CSFD's measured on mass wasting deposits (i.a. within Licinia and Octavia crater), that were obviously formed during a short and distinct process. We are fully aware that ejecta blankets might exhibit self-secondary craters and that CSFD's must be interpreted carefully when deriving absolute model ages. Nevertheless, assuming a minimum impact velocity $v_{\min}$ required to form a crater ([2] for example calculated values for $v_{\min}$ for two cases on the icy moon Europa to be 150 - 250 m/s), we should observe the first secondaries at a certain distance from the primary crater, while its close vicinity should be relatively free of secondaries.

MPF and the lunar-like PF: Two approaches for dating surface units on protoplanet Vesta that differ in their Chronology Function (CF) and Production Function (PF) [4, 5, 6] are in concurrent use. While CF's of both systems are nearly identical for ages < 3 Ga using craters $\lesssim 1$ km [7], their PF's are far from being in agreement mainly due to different assumptions about the impacting projectile population. This is not only crucial when determining absolute ages of young surfaces since each PF predicts a different CSFD but for the analysis of CSFD's in regard to secondary contamination. For our analysis we use the latest revision of the lunar-like PF of [6] because it corresponds best with SFD's of small craters measured on units interpreted to be most likely free of secondary craters and that have not undergone post formation modification processes.

Cornelia: Centrally located at 9.36°S/225.68°E in the western region of Vestalia Terra, the 16.53 km in diameter Cornelia crater is the largest, fresh appearing impact crater on Vesta. It is primarily known for its unique interior, which exhibits various peculiar features such as pitted terrain [8], gully-like features [9, 10],

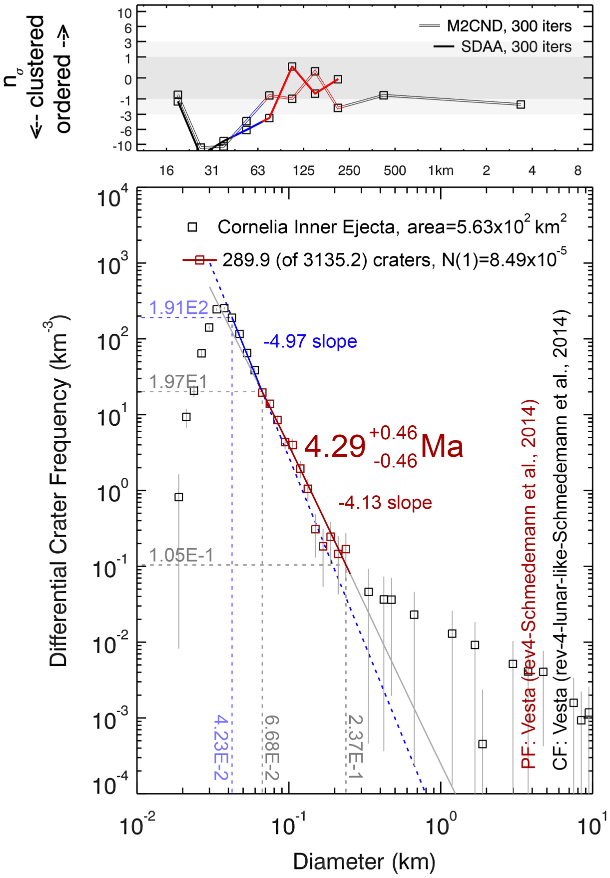

Figure 1: CSFD of a 1 primary crater radius wide ring around Cornelia. Red: Bins that follow the lunar-like PF. Blue: Diameter range where secondaries seem to dominate over primaries. As a consequence, the CSFD steepens towards smaller craters owing to an inverse size-velocity correlation of ejected fragments. The plot above shows the results of two seperate randomness analyses namely a *mean 2nd closest neighbor distance* (M2CND) and a *standard deviation of adjacent area* (SDAA) [3] to demonstrate the increase in spatial clustering towards smaller craters.

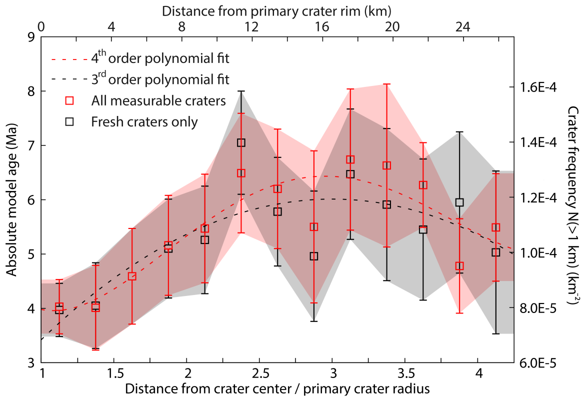

Figure 2: Derived N(1) values and theoretically derived ages for Cornelia's individual CSF measurement rings. Polynomial fits show an increase in age with distance, peaking at approx. 2.9 times the crater radius from the primary crater center

fine and distinct mass wasting lobes or bright and dark abledo material within the walls but also for its extensive, bright ray system and dark ejecta patches, visible in FC multispectral images [11, 12]. With a depth to diameter ratio of 0.28 it is much less degraded than the majority of craters on Vesta [13]. The fact that these features are almost in pristine condition and that the crater itself is virtually not degraded, which is by the way not very common on Vesta, support the assumption that Cornelia is one of the youngest craters at that size range, which has had the potential to produce certain amounts of secondaries that could have contributed to a local unrecognizable secondary population. In this case, Cornelia's fresh ejecta blankets should be least populated by any secondary craters with the exception of self-secondaries which enables us to investigate distant dependent changes of CSFD's.

Observations and Conclusions:

- Distributions of small impact craters ($\lesssim$ 1 km) investigated on units that are most likely not contaminated by secondary craters and that have not undergone considerable post formation modification processes on Vesta follow a lunar-like production function adapted to Vestan conditions.
- Radial CSFD analysis around Cornelia and many other fresh craters on Vesta show that power-law exponents of the small diameter end of the SFD's increase with distance to the primary crater rim. At the same time the characteristic steepening which is an indicator that the area exhibits more craters than predicted by the PF rapidly affects more and more larger craters (Fig. 3).
- Secondary craters only occur infrequently at least within one primary crater radius distance from the rim. Thus, precise dating of larger, fresh craters ($\gtrsim$ 3 km) using craters below 1 km in diameter is possible within this area (Cornelia's absolute model age of 4.29 Ma (Fig. 1) lies within the statistical error of the four innermost rings, see Fig. 2). Nevertheless, CSFD's should be interpreted with caution, especially when plotting cumulative distributions that include obvious background craters by which a potential secondary signature might be obscured.
- Secondary cratering on Vesta is possible. However, impact velocities must be slower than the escape velocity of the target body and higher than a certain minimum velocity required to produce an impact crater ($v_{min} < v_{sec} < v_{esc}$). Therefore the velocity interval and thus the percentage of ejected material that allows secondary crater formation is way much smaller compared to most other bodies that have been investigated in terms of secondary cratering.

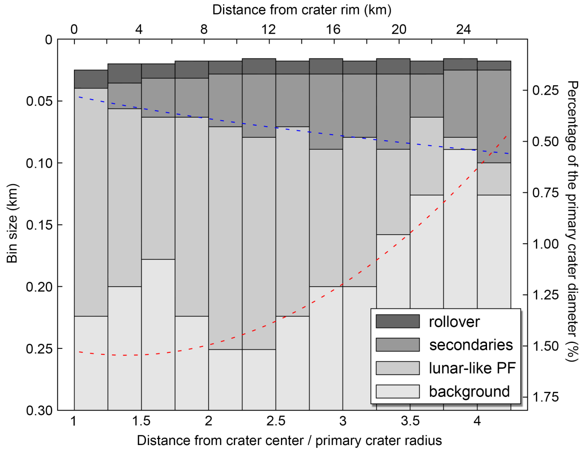

Figure 3: Distant dependent changes of fit ranges and secondary contaminated bins of CSFD's around Cornelia. Its ejecta as a measurement area was devided in 4.13 km (1/4 of Cornelia's radius) wide rings represented by the thirteen columns. Various colors represent different parts of the CSFD's resp. the bin sizes or diameter ranges affected by the rollover, the steepening when secondaries dominate over primaries and the size range that follows the predicted lunar-like PF [?]. The dashed blue line indicates the increase of the crossover diameter below which secondaries dominate over primaries with distance from the primary crater rim, whereas the dashed red line shows the increasing amount of shining through background craters.

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