SIZE-FREQUENCY DISTRIBUTIONS OF KM TO SUB-KM SIZED IMPACT CRATERS ON CERES A. Neesemann[1], T. Kneissl[1], N. Schmedemann[1], S.H.G. Walter[1], G.G. Michael[1], S. van Gasselt[1], H. Hiesinger[2], R. Jaumann[3], C. Raymond[4], C.T. Russell[5] [1]Freie Universität Berlin, Inst. of Geological Sciences, Planetary Sciences and Remote Sensing Group, Malteserstr. 74-100, 12249 Berlin, (Germany); adrian.neesemann@fu-berlin.de; [2]Inst. für Planetologie, Westfälische Wilhelms-Universität, Münster, Germany; [3]German Aerospace Center (DLR), Inst. of Planetary Research, Berlin, Germany; [4]JPL, Caltech, Pasadena, CA, USA; [5]Inst. of Geophysics and Planetary Physics, Dept. of Earth and Space Sciences, University of California, Los Angeles, CA, USA

Introduction: Since March 5, 2015, NASA's Dawn spacecraft [1-2] is acquiring data successively increasing in detail of the dwarf planet Ceres while descending to lower orbits. At present, Dawn orbits Ceres in the Low Altitude Mapping Orbit (LAMO), mapping its surface at a resolution of up to ~35 mpx^{-1}. This high resolution image data finally allows us to identify and measure, as precise as possible, the diameters of sub-km impact craters and thus to investigate the stratigraphic position even of relatively small geomorphologic units.

Background: Ceres exhibits a variety of exceptionally fresh appearing surface features such as impact related fossilized lobate flows, crater interior smooth plains or fresh ejecta blankets, often only about a few thousand km^2 in size. Many of these features show no or only few superposed craters in ~130 mpx^{-1} Framing Camera (FC) High Altitude Mapping Orbit (HAMO) data, suggesting relatively young formation ages. One of the most prominent of these features is a cluster of bright spots, which is also the brightest surface on Ceres [3], located within the 83.8 km Occator crater at 19.8°N/239.6°E (Fig. 1). The crater interior smooth plains exhibit subtle multiple flow lobes which seem to emanate from the bright spots. In many areas, flows form a sharp boundary and superpose collapsed crater wall material indicating some form of post-Occator-formation activity. Initial visual inspection of FC LAMO data already shows that crater densities appear to be much higher on Occator's proximal ejecta than on its interior smooth plains. This, however, can be interpreted in different ways.

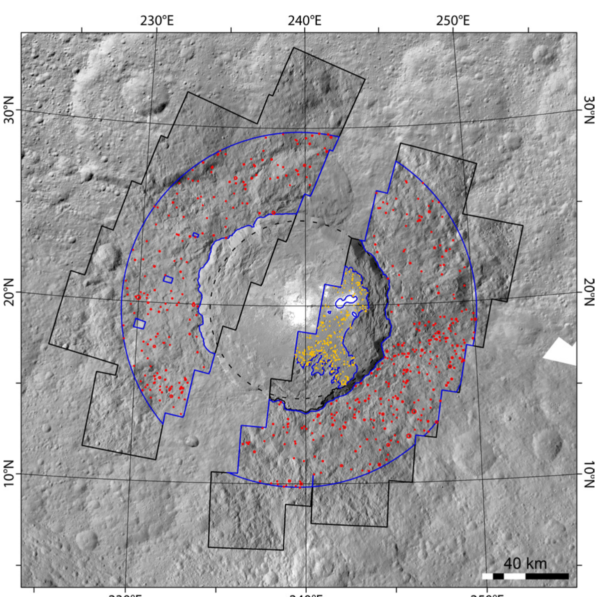

Figure 1: FC HAMO image mosaic superimposed by presently available FC LAMO data (framed in solid black lines) from cycle 0 and 1 covering the interior and proximal ejecta of Occator Crater. Superposed craters > 398 m (red) and > 77 m (orange) identified within the count areas (blue lines). The black dashed circle represents the idealized crater ellipse prior to Occator's rim collapse.

Provided that the area is only marginally contaminated by secondary craters and that local variation of surface material properties are negligible, differences in crater frequency can be considered temporally distinct. This would indicate some form of resurfacing possibly long after the crater has formed (though the term "long" still needs to be quantified by further investigations). An alternative mechanism which might explain crater density variation between a crater's interior and its ejecta blanket, in the absence of obvious resurfacing, was recently investigated for young lunar craters [4-7]. The idea is that on planetary bodies with moderate to high gravity, secondary projectiles ejected at very steep angles will re-impact close to their ejection point forming so-called self-secondary craters. The problem hereby is that the projectiles ejected at high angles are at the same time the ones ejected close to the primary crater center at the highest velocities [8-9]. These projectiles therefore probably escape Ceres with its low gravity of about 0.28 ms^{-2}. A certain fraction of slower eastbound ejected fragments, however, has the potential to re-impact close to the ejection point due to Ceres' quick rotation. On the other hand, these fragments would probably hit Occator's interior and proximal ejecta to the same degree. Nevertheless, there is a considerable spatial variability in crater frequency on Occator's ejecta which will definitely challenge prospects of model age estimates.

In order to put these and other fresh, conspicuous geomorphologic units into a time-stratigraphic framework we depend on the analyses of size-frequency distributions of craters below a few km in diameter as it is only these that occur in statistically significant numbers. The benefit of increasing "statistical" robustness due to large numbers of small craters, however, can be misleading because small craters are also the first ones to be affected by subsequent modification [10-12]. This includes (among other processes) an admixture of sec-

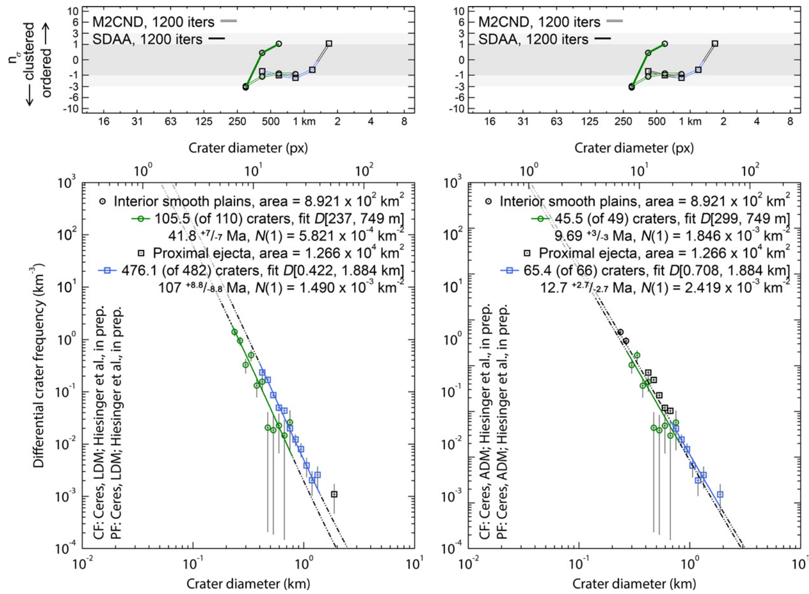

Figure 2: Differential crater size-frequency distributions measured on Occator's interior smooth plains and its proximal ejecta.

ondary craters which, due to the specific shape of the SFD of secondary projectiles ejected during larger impacts and the inverse relation between the spall size and ejection velocity [13-18], can considerably increase the numbers of small craters.

Methodology: For the investigation of local surface units and identification of impact craters we used individual FC LAMO images (no mosaics) with a native resolution of ~35 mpx^{-1}. Crater counts were performed within ESRI's ArcGIS by using the *CraterTools* [19] extension which allows comfortable and most accurate measuring of areas and crater diameters by automatically solving the problem of map-projection related distortions. Though the 940 km in diameter reference sphere used for the map projection is already very close to Ceres' actual shape, we have nevertheless corrected topography-related area and crater distortions [20]. In order to investigate the spatial variability of craters within the mapped units we perform two individual randomness tests, *Standard Deviation of Adjacent Area* (SDAA) and *Mean 2nd-Closest Neighbor Distance* (M2CND) both implemented in the widely used *Craterstats* software [21-22]. Results are plotted in Fig. 2

Prelimenary results: In Fig. 2 we plotted the CSFDs measured on parts of Occator's interior smooth plains and its proximal ejecta. Additionally, we compared the distributions with the two chronology models prepared for Ceres, namely the Lunar Derived Model scaled to Ceres (LDM) as well as the Asteroid Derived Model (ADM) [23]. Randomness analyses basically plot within one standard deviation above or below the Monte Carlo-derived mean. Thus, craters are, at least in the measured size interval, interpreted to be randomly distributed. Of course, we can never be sure that counts are not contaminated by randomly distributed background secondaries which is still an open issue.

Future work: As becomes obvious in Fig. 1, coverage of high-resolution LAMO data which is a basic requirement for our study is still low. With subsequent data acquisition we will continue to investigate the SFD of small craters on very fresh and therefore probably less altered surfaces which we assume to deliver a closer image of the corresponding asteroid SFD.

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