RELATIVE TO THEIR SIZE, SMALL CRATERS ARE MORE DESTRUCTIVE TO THE LUNAR TOPOGRAPHY THAN LARGE CRATERS. C. Riedel[1,2], D. A. Minton[3], G. Michael[2], C. Orgel[4], C. H. van der Bogert[5], and H. Hiesinger[5], [1]University of Potsdam, Department of Computer Science, An der Bahn 2, 14476 Potsdam, Germany (christian.riedel@uni-potsdam.de), [2]Freie Universität Berlin, Inst. of Geological Sciences, Malteserstr. 74-100, 12249 Berlin, Germany, [3]Purdue University, Department of Earth, Atmospheric, and Planetary Sciences, West Lafayette, IN, USA, [4]European Space Agency, Directorate of Human and Robotic Exploration, Noordwijk, The Netherlands, [5]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany.

Crater Equilibrium and Non-sparseness: The cratering-induced degradation of pre-existing lunar craters leads to two distinct states in which the observed crater population does not correspond to the primary impactor population: crater equilibrium [1,2] and non-sparseness [3,4]. Crater equilibrium describes a state, where on average, each new crater erases a pre-existing crater of the same size. Crater equilibrium is a well-observed phenomenon that affects small, simple post-mare craters (D < 1 km) on lunar surface units and causes the measured crater size-frequency distribution (CSFD) of a crater population to follow a constant power-law slope instead of a polynomial crater production function (PF). Such craters appear in a sparse configuration that corresponds to 1-5 % geometric saturation [5]. It is currently impossible to restore information about the primary impactor population from a crater population in equilibrium. Non-sparseness, on the other hand, describes a state in which the cumulative effects of geometric crater obliteration cause a repeated resurfacing of the cratered surface. It has been observed for large craters (D > 20 km) on ancient lunar surface units and causes an offset between the measured CSFD and the PF. Such craters appear in a dense configuration that can exceed geometric saturation rates of 10 % [6]. It is possible to restore information about the primary impactor population by applying the non-sparseness correction (NSC) CSFD measurement techniques [7].

Modeling a Pre-Nectarian Surface Unit: The previous observations suggest that crater equilibrium and non-sparseness describe two distinct types of crater saturation on the Moon. While they both have been investigated for small post-mare and large craters on pre-Nectarian surfaces, respectively, it is unknown how they scale with crater size and surface age. For this reason, we use the Cratered Terrain Evolution Model (CTEM) [8-10] to simulate the cratered surface evolution of an ancient, pre-Nectarian surface unit. We use an impactor population that resembles the PF by [11] and incorporate three major cratering-induced processes that lead to the degradation of pre-existing craters: (1) Geometric crater obliteration, where a fresh impact erases all smaller craters located within its rim, (2) Proximal ejecta blanketing, where low-energy excavated material buries pre-existing craters in the proximity of fresh craters, and (3) Downslope diffusion, where high-velocity primary and secondary projectiles induce a slope-dependent mass transport of surface material from a pre-existing crater's walls to its center.

A core component in the used CTEM version is the application of a topographic diffusion model that simulates the cratering-induced diffusive degradation of the surrounding topography by high-velocity secondary projectiles [10]. The total amount that a fresh impact crater contributes to the diffusion of its surrounding topography is controlled by a degradation function $K_d(\check{r}) = K_{d,1}\check{r}^{\psi}$, where ř marks the radius of a fresh crater, the coefficient $K_{d,1}$ regulates the strength of diffusive degradation, and the slope ψ controls how the per-crater contribution to topographic diffusion scales with crater size. In this work, we set ψ=2 for all simulations. Because K_d has units of m², ψ=2 represents a case where $K_{d,1}$ contains no information about scale. This implies that a simple scale-dependence controls the per-crater contribution to topographic diffusion. In other words, the relative contribution to topographic diffusion of small craters equals that of large craters. The area that experiences diffusive degradation by a fresh impact is circular and measures 10ř.

We simulate the cratered evolution of a pre-Nectarian surface unit and compare the modeled surface to previous investigations of ancient lunar terrains. To that end, we evaluate the presence of the non-sparseness effect and whether craters are in a configuration of > 10 % geometric saturation. We run three simulations, where we modify the strength of $K_{d,1}$. Simulation 1 ($K_{d,1}$=0.003) represents a case where [10] reproduced the small, simple crater equilibrium of the Apollo 15 landing site. Thus, we investigate how well the parameterization of the diffusion model scales with crater size. In simulation 2 ($K_{d,1}$=0.0001), we reduce the strength of the degradation function by a factor of 30, and in simulation 3 ($K_{d,1}$=0), we investigate the evolution of a pre-Nectarian surface unit when only proximal ejecta blanketing and geometric crater obliteration contribute to the erasure of pre-existing craters [12].

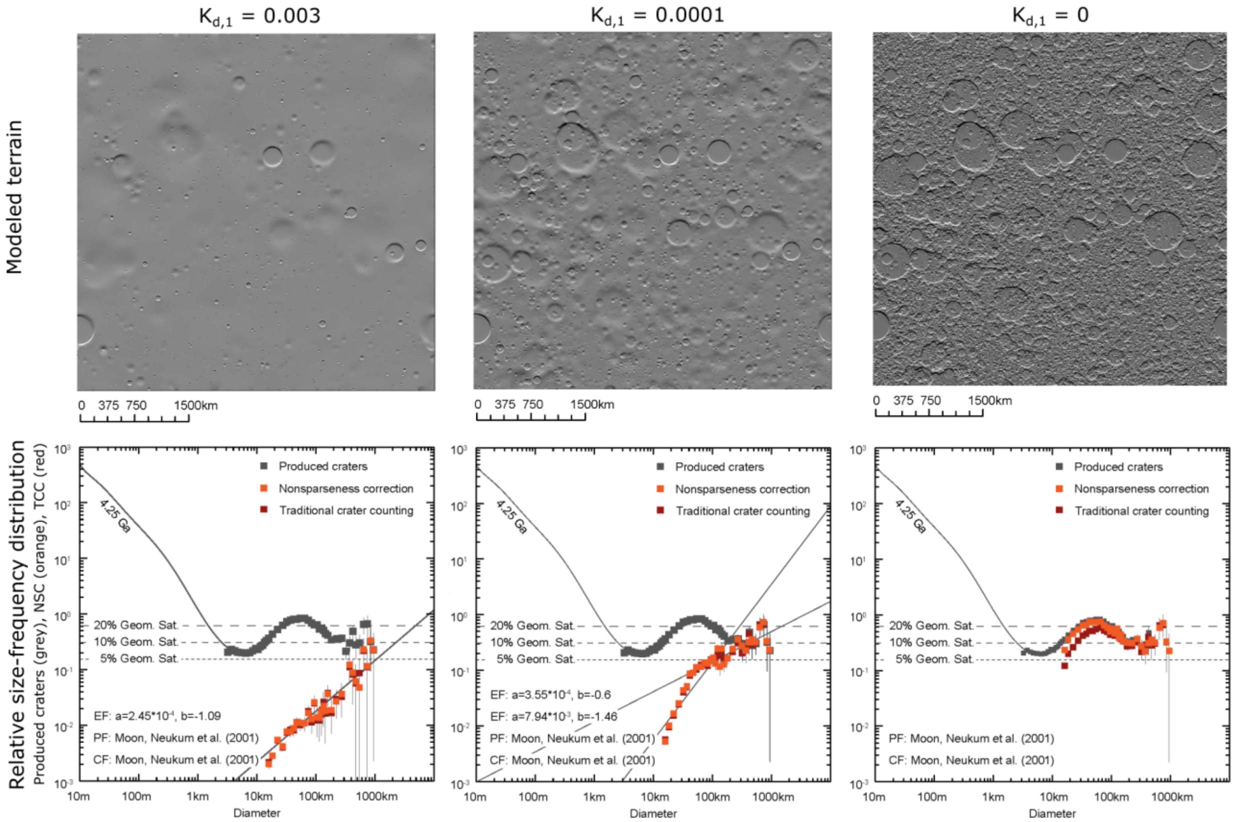

***Figure 1:** Modeled surface units and relative CSFD plots showing produced craters (grey) and obtained CSFDs from traditional crater counting (TCC) (red) and NSC (orange).*

Results: The summarized results in Figure 1 show that when we apply $K_{d,1}$=0.003 in Simulation 1, the obtained crater densities do not show a dense crater configuration or non-sparseness effect. Instead, measured CSFDs follow a constant power-law equilibrium. This implies that the model used by [10] to reproduce the small, simple crater equilibrium of the Apollo 15 landing site does not scale for large lunar craters. To reproduce a pre-Nectarian surface unit, where craters with D > 20 km are in a dense configuration of > 10% geometric saturation and measured CSFDs show a non-sparseness effect, $K_{d,1}$ has to be very low (0 in our case). This observation implies that topographic diffusion by high-velocity secondary projectiles does not significantly influence the cratering-induced crater obliteration for large lunar craters. However, this process dominates cratering-induced crater degradation for small post-mare craters. Since the intensity of geometric crater obliteration and proximal ejecta blanketing is the same in both simulations, we conclude that relative to their size, small, simple craters are more destructive to the surrounding lunar terrain than large complex craters due to the higher relative contribution to topographic diffusion from high-velocity distal ejecta. This suggests that the predominant process of cratering-induced crater obliteration also determines the crater saturation state. A strong influence of geometric crater obliteration leads to non-sparseness, and a strong influence of downslope diffusion by high-velocity distal ejecta leads to crater equilibrium. The results also show that the NSC techniques are appropriate to restore information about the crater production population on surfaces with strong geometric crater obliteration effects.

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