THE RATE OF CRATER DEGRADATION AND TOPOGRAPHIC EVOLUTION ON THE MOON: RESULTS FROM THE MARIA AND INITIAL COMPARISONS WITH THE HIGHLANDS. C. I. Fassett[1] & J. R. Combellick[1]. [1]Mount Holyoke College, 50 College St., South Hadley, MA 01075 (cfassett@mtholyoke.edu).

Introduction: Impact cratering dominates the landscape evolution of the Moon in recent epochs. As a result, the degradation of craters has long been thought to be diffusional and controlled primarily by the accumulation of smaller later impacts [1-4].

New topographic measurements of the Moon in the last decade using laser altimetry [5] and stereo photogrammetry [6-7] provide an excellent dataset for improved characterization of craters and other landforms. Because craters have a regular and characteristic initial morphometry and form randomly in space and time, their degradation state is particularly useful for quantitatively assessing how quickly the lunar surface changes and the processes controlling topographic evolution as a function of time.

Since the work presented at last LPSC [8], we have made progress in characterizing moderate-sized craters on the maria (D=800 m to 5 km), increasing the number of craters with measured topography by a factor of ~25× to >13500. Kaguya Terrain Camera (TC) DTMs [6] are the main source for these new measurements, rather than LOLA profiles, although where both instruments have coverage the results are essentially equivalent. Here, we update the status of these observations, which remain broadly consistent with results presented last year, and then describe our initial assessment of how crater degradation compares between the highlands and the maria.

Methods: *Mapping:* Craters with diameters between 800 m and 5 km were mapped with LROC WAC data on approximately half of the area of the lunar maria (totaling ~2.2×10^6 km^2). Each crater's position was then automatically refined to coregister it to the TC topography, maximizing the radial symmetry of the crater profile inside the crater's rim. This step is required because the coregistration of the LROC WAC mosaics and TC data is imperfect; our process suggests an average offset of ~500 m (~5 WAC pixels).

Model Fitting: A forward model of topographic diffusion was applied to initial topography based on direct observations of the freshest rayed craters in our initial study. Results of the diffusion model were then used to establish a lookup database of crater profiles at a range of initial crater sizes (D=600 m to 5 km) and diffusion times (κT=0 to 100000 m^2). The resulting crater profiles evolve with the curvature and position of the rim and overall crater depth changing as κT increases. Using this database, best-fit degradation states were determined by minimizing the difference between the lookup profiles and observations of every crater.

Results. Example of four craters with different derived degradation states is shown in Fig. 1, and our current estimate for how degradation states correspond to time is shown in Fig. 2. This curve, from the mare data alone, is nearly linear for the period between ~500 Ma to 3 Ga. Its slope implies "steady" degradation diffusivity κ=0.005–0.007 m^2/Kyr, or ~160× less than what is typically measured in the western United States (κ~1 m^2/Kyr) [9]. This implies an average erosion rate across the lunar surface of ~0.3–0.5 mm/Myr, slightly larger than the characteristic lunar erosion rate reported by [4] (0.2 mm/Myr). Note that this average masks substantial variation, with faster erosion expected to occur on steeper slopes (e.g., new craters; rilles), and virtually no erosion is expected where topography is lacking, such as on smooth regions between impact craters on the maria.

Fig. 2 also implies that the youngest craters degrade more quickly than steady linear diffusion would predict (for the first ~500 My of their evolution, κT<~7000). This is likely a result of enhanced mass wasting on their initially steep slopes. Based on the slope of the curve in Fig. 2, degradation rates in the period prior to ~3 Ga (κT>~16000 to ~18000) were also higher, consistent with the enhanced crater flux in that era [11].

Maria/Highlands Comparison: An obvious question is whether the degradation behavior of craters is the same in the maria and highlands. We have begun to explore this question by characterizing craters in several small test areas. Craters were measured in a similar way as in the maria, although because the highlands generally have steeper regional slopes, we first excluded all areas with regional (1-km-baseline) >5°.

The median crater degradation state in our highlands sample was κT=24750, a factor of two higher than the median in the maria, κT=12000 (Fig. 3). This is consistent with the relative age of these units. The magnitude of this difference is substantial, however, and is again a likely consequence of the enhanced crater degradation rate early in lunar history (>3.5 Ga). The degradation state of less degraded craters is also consistent with a modestly faster degradation rate in the highlands than the maria in recent times, although more data is necessary to fully test this hypothesis.

References: [1] Ross, H.P. (1968) *JGR, 73*, 1343–1354. [2] Soderblom, L.A. (1970) *JGR*, *75*, 2655-2661. [3] Soderblom, L.A. & Lebofsky, L.A. (1972) *JGR*, *77*, 279-296. [4] Craddock, R.A. & Howard, A.D. (2000) *JGR*, *105*, 20387-20401. [5] Smith et al. (2010), *Space Sci. Rev.*, *150*, 209-241. [6] Haruyama, J. et al. (2008) *Earth Pl. Sp.*, *60*, 243-255. [7] Robinson, M.S. et al. (2010), *Space Sci. Rev.*, *150*, 81-124. [8] Fassett, C.I. (2013), *LPSC*, *44*, 2026. [9] Pelletier, J.D (2008). *Quantitative Modeling of Earth Surface Processes*. [10] Kreslavsky, M.A. (2011), *EPSC-DPS 2011*, 1494. [11] Neukum, G. et al. (2001). Space Science Rev., 96, 55-86.

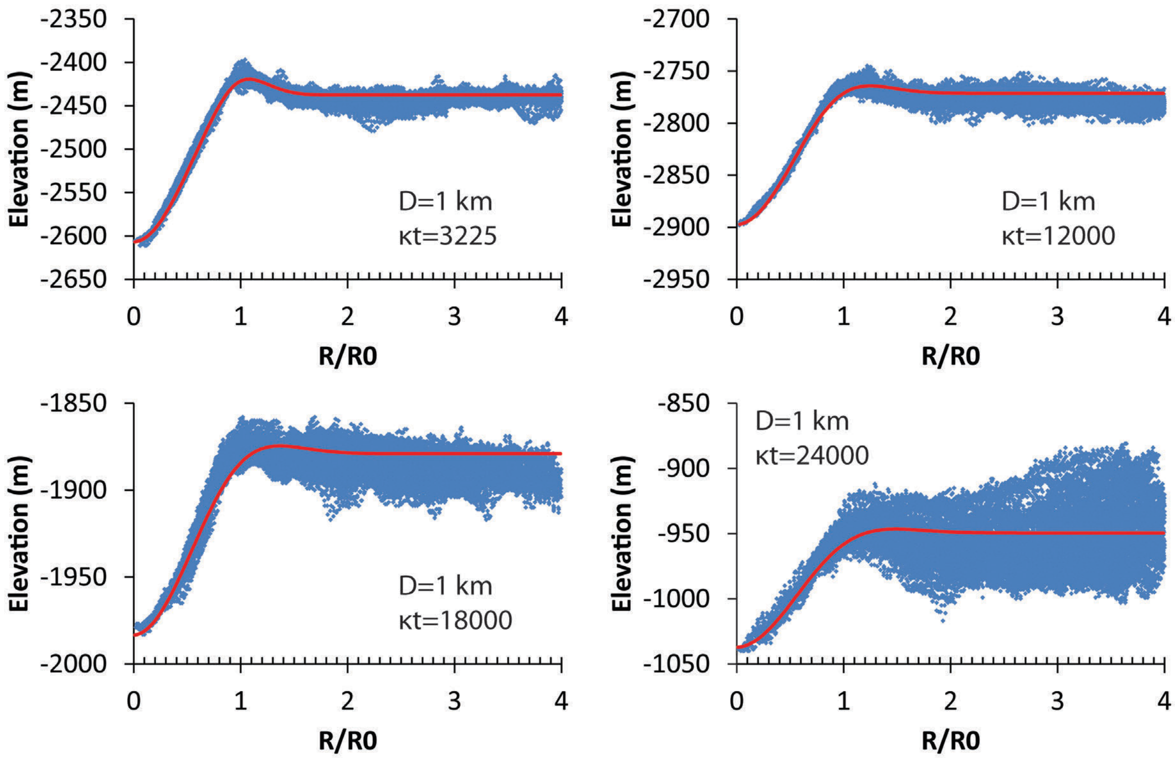

Figure 1. Example of profiles for four craters with initial diameter of 1 km and different degradation states.

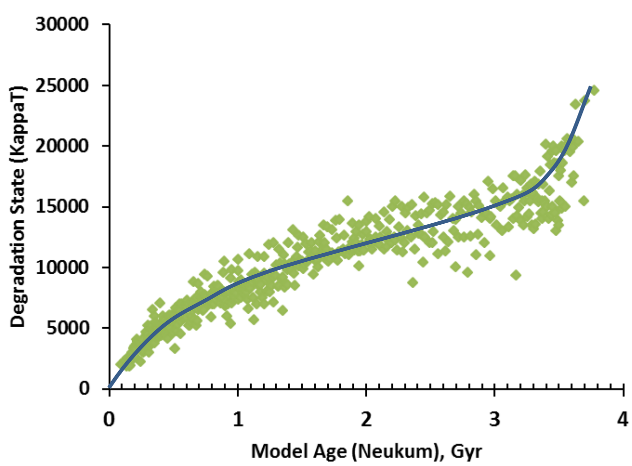

Figure 2. Evolution of crater degradation state as a function of time from measurements on the lunar maria. The age of these data are from [11] and are thus modestly model depedent. However, the general trend (gray line) is robust: it implies faster degradation of younger craters (likely as a result of their steep initial slopes), followed by a longer-term steady period of degradation, and faster degradation early in lunar history when the impact flux was enhanced.

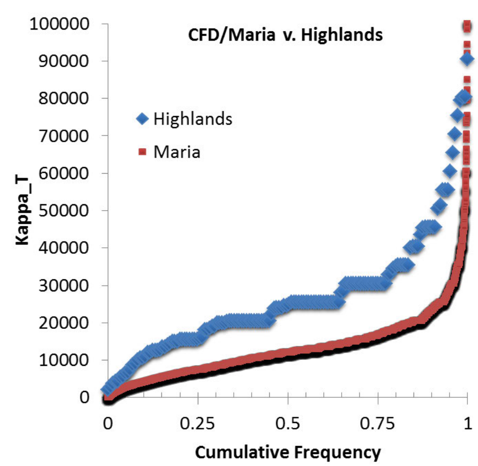

Figure 3. CFD comparison for craters in a test area of the lunar highlands compared to the maria. Highland craters are, on average, more degraded than craters in the maria, as expected. The steep upturn for the most degraded craters is potentially due to a combination of higher degradation rates early in lunar history, and contamination by secondaries, which have lower initial depth.