PHOTOMETRIC AND OPTICAL MATURITY INVESTIGATIONS AT LUNAR LOBATE SCARPS.

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Introduction: Lunar lobate scarps, or thrust faults, are widespread across the lunar surface. They are among the youngest landforms on the Moon with some likely still active today [1-4]. Absolute model ages estimated using the size-frequency of impact craters show that most studied scarps were active in the late Copernican (<50-100 Ma), and that fault activity causes surface renewal and disturbance up to kilometers away from the scarp trace itself [5,6]. This finding has important implications for future human and robotic exploration as potential locations of resources exposed near the surface, and for potential landing-site hazards.

We investigate the photometric and Kaguya MI-derived optical maturity (OMAT) of surfaces around lobate scarps. Here we present preliminary results for the Lee-Lincoln (~20.30°N, 30.59°E), Henderson-2 (~7.77°N, 152.07°E), and Feoktistov (~32.02°N, 140.49°E) scarps. The objectives of this study focus on assessing whether photometric and OMAT investigations reveal distinctive results for surfaces disturbed by ground motion from seismic slip events, and whether these surfaces contain materials beneficial to future exploration.

Methods: *Optical Maturity Index* – Lunar soils change (mature) over time because of micrometeorite impacts, solar wind implanted gasses, and other space weathering effects. The most immature or fresh soils/regolith on the Moon appear optically bright in images created to lessen compositional effects and isolate optical maturity [7-10]. For example, craters with bright ejecta blankets in OMAT (i.e., high OMAT values) are younger than craters with darker ejecta blankets; rough or sloped surfaces tend to be brighter/less mature in OMAT (regolith is continuously being "refreshed"). The OMAT value provides information directly relevant to landing site considerations including roughness, hazards, and soil composition; large- and small-scale roughness may be an important factor in sequestration of volatiles on the lunar surface [11].

Photometry – Photometry is a valuable tool for assessing the potential variation of physical and compositional properties of the regolith around scarps. We used Hapke formulations [12] and nonlinear optimization techniques in MATLAB to produce photometric parameter maps (5 mpp) of the scarps from Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) images and NAC-derived Digital Terrain Models (DTMs). Details of the methods can be found in [13,14]. The *b*-parameter of the single particle phase function within the Hapke model is of particular interest owing to its observed correlation with physical variations (e.g., grain size/shape, glass content) in surface properties.

Preliminary Results: None of the scarps we analyzed, nor their surroundings, show a distinctive signature in OMAT images. Lack of immaturity related to these 'young' features may be a consequence of (1) the slopes being too shallow to allow constant refreshing of material on the scarp ridge, or (2) an aspect of the ongoing scarp-forming processes that erases a distinct OMAT signature. The parameter maps do not reveal variations in *b* as a function of distance from each scarp. However, *b*-values are slightly higher on the tops of the scarps, most notably at Henderson-2 and Lee-Lincoln, which may indicate differences in backscattering characteristics, (e.g., grain size/shape), between the scarp and its surroundings.

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References: [1] Watters T. R. and Johnson C. L. (2010) in *Planetary Tectonics*, Cambridge Univ. Press, 121–182. [2] Binder A. B. and Gunga H.-C. (1985) *Icarus, 63*, 421-441. [3] Watters, T.R. et al., (2010) *Science*, *329*, 936-940. [4] Watters et al. (2012) *Nature Geoscience*, DOI: 10.1038/NGEO1387. [5] van der Bogert et al. (2018) *Icarus*, *306*, 225-242. [6] Clark et al. (2015) *LPSC XLVI*, #1730. [7] Lucey et al. (1995), *Bull. Am. Ast. Soc*., *27*, 54.. [8] Lucey et al. 2000, *JGR*, *105*, E8, 20377-20386. [9] Grier et al. 2001, *JGR*, *106*, E12, 32847-32862. [10] Lemelin et al. (2016) *Icarus*, *273*, 315-328. [11] Farrell et al, (2015), *Icarus*, *255*, 116-126. [12] Hapke B. (2012) Cambridge Univ. Press. [13] Clegg-Watkins R.N. et al. (2017) *Icarus*, *285*, 169-184. [14] Hahn T. et al. (2019), *LPSC L*, #1976.

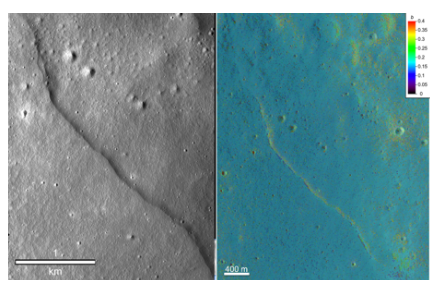

Figure 1. Henderson-2 scarp. (left) LROC NAC M115319317 [5]. (right) *b*-map, created using NAC M1159101897L.