Lunar crater degradation processes inferred from boulder distributions and topographic features in inner crater walls

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Boulder falls and landslides, which have been found on lunar crater walls, are fast processes of mass wasting, degrading lunar craters. However, how boulders and regolith are provided and move on crater slopes remain unknown. Kumar et al. (JGR, 2016; GRL, 2019) found clusters of boulders near the crater rim, called boulder sources, and boulders fell down crater slopes from boulder sources. Bickel et al. (Nature Communications, 2020; JGR, 2021) showed that boulders distributed in and around craters globally. Ikeda et al. (submitted to JGR, 2021) suggest that small impacts produce boulders and trigger boulder falls, which cause crater slope degradation, although its universality is yet to be confirmed. In this study, in order to investigate the role of boulders and regolith in mass wasting processes on lunar craters, we clarified detailed surface features such as the distributions of boulder falls, slope angles, topographic profiles, and the optical maturity parameter (OMAT). We investigated eight craters: two craters studied by Ikeda et al. (2021), located in southern part of the Schrödinger basin and near the Lorentz basin, and the others (5°–17°S, 107°–116°E) where Bickel et al. (2021) found boulders. We used image and topography data obtained by Lunar Reconnaissance Orbiter and KAGUYA. We found boulder falls in most of our studied craters, where boulders were derived from upslope regions near the crater rims, although boulder sources were not uniformly distributed. We also found fresh landslide features in some craters, suggesting that regolith fell down the slopes. Our estimates of OMAT and slope angles in the eight craters indicate that the smallest OMAT value systematically increases with increasing slope angle and larger OMAT values show scatter but tend to increase with increasing slope angle. Our results suggest that these OMAT features, which have been already found by Ikeda et al. (2021), universally exist in lunar craters, indicating that fresh regolith fell down the slopes. Although topographic profiles of crater slopes without boulder sources were well described by smooth polynomial functions, those with boulder sources were clearly deviated from the functions in the upslope and middle portions, which correspond to boulder sources and slope bulges, respectively. Based on our finding of the close proximity of slope bulges to boulder sources, we interpreted the formation of slope bulges as follows. Regolith was efficiently provided from boulder sources to the slopes, and accumulated in the middle portion, forming slope bulges. When their angles become steeper than the angle of repose, the bulges collapse and supply regolith downward. Repetition of these processes result in degraded craters without boulder sources.

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