REGOLITH GENERATION DUE TO MULTIPLE IMPACT CRATERING ON THE MOON. Masatoshi Hirabayashi, Auburn University (thirabayashi@auburn.edu).

Introduction: The surface on the Moon has been influenced by a numerous number of impact craters at a wide range of sizes [e.g., 1]. Such impact cratering processes fragment the surface structure and generate regolith layers on bombarded surfaces. The recent numerical simulation study showed a regolith layer in a crustal layer due to shear and tensile-driven fragmentation [2]. A key issue is how such fragmentation processes have contributed to the evolution of regolith layers on the lunar surfaces. The thickness of the regolith layer on the lunar surface has been studied based on remote-sensing observations [e.g., 3], empirical analyses [e.g., 4, 5], and numerical modeling studies [e.g., 6]. However, the observed regolith thickness has not been well connected with our understanding of the mechanism of regolith generation [7]. A better understanding of this gap can provide detailed information about surface conditions that would be primarily important for the scientific purposes and connect with the landing and sampling selection processes that become a crucial element of future lunar exploration missions.

Statistical Model for Regolith Generation: The mathematical model used in this paper was developed by extending Gault et al. [8], who used Poisson's statistics to analyze a regolith mixing process due to multiple impact cratering processes. Using the size frequency distribution of visible craters, this model probabilistically described the three-dimensional distribution of the regolith layer by taking into account two critical elements of regolith regions in a crater: the ejecta blanket and the fragmented area generated by regolith infilling, or a so-called breccia lens. Importantly, this model can take into account the overlapping of regolith layers that reduces the amount of newly generated regolith.

This model was compared with the Monte-Carlo model by Oberbeck et al. [6], who focused on ejecta blanketing as the only source of regolith generation. Hirabayashi et al. [7], hereafter known as Hi2018, found that Oberbeck et al. [6] overestimated the contribution of ejecta blanketing to regolith generation, and the formation of breccia lenses might play more critical roles in regolith generation [Hi2018]. This model gave a regolith thickness consistent with the empirically derived regolith thickness at the Apollo 15 landing site.

Distribution and Time Evolution of the Regolith Thickness: Using the Apollo 15 landing condition, we show how the regolith distribution changes at depth and how the regolith thickness can grow over time (Figs. 1-2). The results were also given in Hi2018. These figures provide two key findings. First, the regolith thickness is not uniform in a given region (Fig. 1). Second, the regolith thickness initially rapidly grows over time but eventually saturates, depending on the size frequency function of produced craters (Fig. 2). Importantly, Hi2018 found that at the Apollo 15 landing site, the regolith thickness is still constantly growing at present [Hi2018].

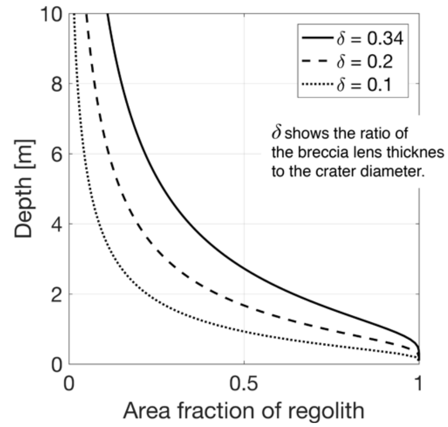

Figure 1. Distribution of the regolith region at different depth given different sizes of the breccia lens [Hi2018].

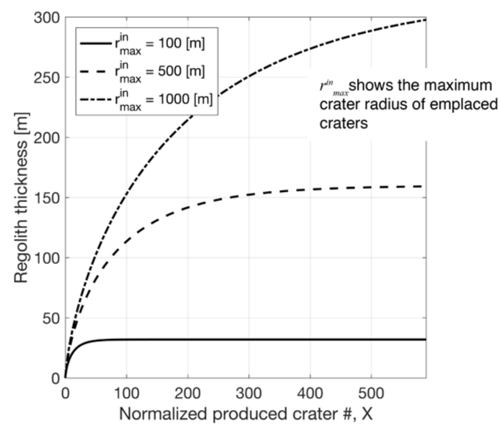

Figure 2. Time evolution of the regolith thickness given different crater population conditions [Hi2018].

Further Analysis: The recent numerical work proposed that the fragmented region could be much wider than the breccia lens [2]. By taking into account the fragmented region suggested by Wiggins et al. [2], this paper will discuss how the regolith thickness evolves. The present model will reduce the gap between the regolith evolution mechanism and the currently observed regolith thickness on the Moon.

Reference: [1] Baldwin (1963), Univ. of Chicago, [2] Wiggins et al. (2019), JGR-Planets 124, [3] Fa et al. (2012), Icarus 218, [4] Quaide and Oberbeck (1968), JGR 73, [5] Bart et al. (2011), Icarus 215, [6] Oberbeck et al. (1973), Icarus 19, [7] Hirabayashi et al. (2018), JGR-Planets 123, [8] Gault et al. (1974), Proceeding of LPSC 3.