Experimental study on the relaxation of slope terrain due to small-scale impact

*Tomomi Omura[1], Shinta Takizawa[1], Hiroaki Katsuragi[1]

1. Department of Earth and Environmental Sciences, Nagoya University

Observation of planetary surfaces shows some evidence of the relaxation of sloped terrains such as impact craters. The mechanism of the relaxation might be the resurfacing due to impacts and/or the fluidization due to seismicity. Here we focus on relaxation due to small-scale impacts, which occurs on relatively large bodies, e.g., the Moon. Soderblom (1970) modeled the effect of a small-scale impact on the relaxation of the slope terrain by considering asymmetric ejecta deposit. However, the model did not consider the effect of the collapse of cavity and the impact angle. In this study, we study the effect of slope angle and impact conditions on the relaxation efficiency of slope terrain using the result of low-velocity impact experiments on the inclined granular surface obtained by Takizawa & Katsuragi (2020).

We used Toyoura sand in the diameter of 0.1-0.3 mm as a target material. The angle of repose of the sand was 34°. The spherical impactors in diameter of 6 mm and masses of 0.12, 0.25, and 0.4 g were used. The impact velocity was ranged from 7 to 97 m/s. Experiments were conducted under atmospheric pressure. We analyzed the data with the slope angle of the target θ of $0^\circ \leqq \theta \leqq 34^\circ$ and the impact angle measured from the upper surface ϕ of $50^\circ \leqq \phi \leqq 130^\circ$. The 3D profile before and after the crater formation was measured with a laser profiler.

We measured the displacement of the center of mass caused by the asymmetric ejecta deposit and the collapse of the crater cavity, as an index of relaxation efficiency. We conducted the analysis using the crater profile as follows. First, we made the reference shape using the crater profile obtained by experiment with $\theta=0^\circ$ and $\phi=90^\circ$. The profile was scaled based on the scaling law of the crater minor axis D_{cy} (Takizawa & Katsuragi, 2020) to equalize the D_{cy} of the reference shape and the analyzed profile, and the cavity part was extracted as the reference shape. Next, we subtracted the reference shape from the crater profile. We assumed the part higher/lower than the reference shape has plus/minus mass and calculated the center of mass of the differential part. Finally, we calculated the distance Δx from the impact point to the center of mass of the differential part with defining downward as a positive sense.

When $\theta=0^\circ$, the normalized migration distance of the center of mass $\Delta x/D_{cy}$ was almost 0 owing to the symmetric ejecta deposit around the impact point. However, $\Delta x/D_{cy}$ increased with an increase of slope angle θ because of the collapse of the crater cavity and the asymmetric deposition of the ejecta.

We approximated the dependence of $\Delta x/D_{cy}$ on $\tan\theta$ for data with similar ϕ based on the theoretical model of sediment flux of hillslope (Roering et al., 1999) as follows:

$\Delta x/D_{cy}=a[\tan\theta/\{1-(\tan\theta/b)^2\}]+c$ (1),

where a, b, and c are constants. We will discuss the physical interpretation of each constant on the presentation.

Keywords: Regolith, Planetary terrain, Modification process of craters

