EXPERIMENTAL STUDY ON IMPACT CRATERS FORMED ON MOUNTAIN-LIKE SURFACE TOPOGRAPHY OF ASTEROIDS

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Impact craters are one of the major geological features on solid bodies such as asteroids and satellites. A crater formed on a flat surface is observed to be a circle but a crater formed on a slope is ellipse. In particular, various topographic features such as slope, bulge, and canyon have been observed on asteroids and small satellites. Recently, Hayabusa2 and OSIRIS-REx revealed that Ryugu and Bennu have a large bulge on their equatorial regions. Furthermore, some craters with asymmetric profiles were found on the bulge of Ryugu. However, the conventional crater scaling laws based on the results of laboratory experiments conducted on the targets having the flat surface. In order to apply the scaling laws to the cratering process on the mountain-like surface topography of asteroids, it is necessary to improve the crater scaling laws including the effect of the surface topography. In this study, we conducted the impact cratering experiments on granular targets simulating the mountain-like surface topography of asteroids, and we investigated the effects of the surface topography on the crater size scaling law and the ejecta growth process.

We prepared two types of targets to simulate the surface topography of asteroids: they are granular targets having the shape of a mountain range and a cone. The inclination (θ) of the mountain range target was set to be 20° and 30°, and that of the cone target was ~30°. We also prepared the target having the flat surface (that is, $\theta = 0°$). We changed the impact point d for the mountain range target; the d was defined as the horizontal distance between the impact point and the summit. In the case of the cone target, we changed the foot width of the target w.

We conducted impact experiments by using a one-stage vertical gas gun at Kobe University and a two-stage vertical gas gun at ISAS. The impact velocities ranged from 69 to 202 m/s for the mountain range target, and from 41 m/s to 4.21 km/s for the cone target. In order to analyze the crater morphology, we constructed the 3D shape model by using the software of PhotoScan Pro.

For the mountain range target, we observed that the crater had an elliptical shape: the width of the crater on the ridge direction (major axis) was always larger than that on the slope direction (minor axis). Furthermore, the elevated crater rim was observed on the ridge direction but it was not observed on the slope direction. The asymmetry of the crater shape strongly depends on the d. Now, the crater asymmetry is shown by the aspect ratio defined as the ratio of major axis length to minor axis length. We found that the aspect ratio increases with the increase of the major axis length at the constant d value, and furthermore, it increases more rapidly with the decrease of d. These characteristics were also found on the target with the slope of $\theta = 20°$ but the aspect ratio for the target with the slope of $\theta = 30°$ was larger than that of $\theta = 20°$ at the same d and the major axis length. Also, we constructed the crater size scaling law described by π-scaling for the mountain range target. The normalized crater radius, π_R, clearly depends on the slope θ, that is, they are ~1.3 times larger than that of the flat surface, $\theta = 0°$.

For the cone target, we observed the ratio of the initial target height to the impacted target height. We investigated the relationship between the height ratio and the v^* at different impact velocities. The v^* is defined as the velocity derived from the projectile momentum divided by the cone mass. At $v^* < 0.5$ m/s, the height ratio decreases exponentially with the increase of the v^*, irrespective of the impact velocity. This means that the height ratio could be controlled by the projectile momentum. At $v^* > 0.5$ m/s, most of the cone was excavated so the height ratio was almost zero. We also measured the crater diameter formed

on the cone target and it was almost the same as that formed on the flat surface at the same projectile kinetic energy.

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