Experimental Study on Collision Crater Formed on Bulge Geography

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An equatorial bulge was found on the surface of asteroid Ryugu and Bennu by recent spacecrafts of Hayabusa2 and OSIRIS-Rex, and ridge structures with various scales originated by geological activities have been recognized on icy satellites. Impact craters are dominant geological features on solid planets such as asteroids and satellites, and a crater rim are also recognized as a ridge or bulge with a circular shape. These bulges and ridges are shown to be erased with time because small scale impacts excavate and disrupt these topographies. It is well known that old craters gradually degraded by small impacts to get blurred and could be completely erased. We can expect the similar degradation process on large bulges and ridge structures, so that the life time of these structures by small impacts is a good indicator of the formation age of these structure by geologic activities. So far, the effect of small impacts on the degradation is estimated by using the results on the flat surface, but actually the surface of the bulge is curved and there is a summit on the bulge. Therefore, if we estimate the life time of the bulge structure, we should consider the effect of the topography such as a summit and curvature. Then, the impacts on the bulge structure was studied to clarify how the bulge structure affected the crater formation efficiency. In this study, we suppose the bulge made from regolith and boulders, such as an equatorial bulge of Ryugu and assume the crater formation process dominated by not the strength but the gravity.

We prepared a triangular prism target to simulate the bilge structure, and set it like that the base of this prism is rectangle, then it looks triangle when we look it at the horizontal direction, and we can look at the linear summit from the top view. Quartz sands with the size of 100μm was used to build the target and the angle of repose for this quartz sand is about 30 degree. The slope of the prism was measured from the base, and we set the angle from 20 to 30 degree. The quartz sands were filled into a transparent water tank with the depth of 20 cm to prepare the bulge structure. Impact experiments were conducted by using a vertical type gas gun, and the water tank was set in the chamber to evacuate below 1000 Pa. A alumina sphere projectile with the size of 3mm was launched at the velocity from 70 to 200 m/s, and it was impacted on the bulge in the vertical direction: the impact angle measured from the target surface was about 60 degree when the slope was 30 degree. The distance from the impact pint to the summit (deviation distance, d_d) was changed from 0 to 20mm.

We found that the crater shape strongly depended on the d_d, so the crater shape was an ellipsoid when the impact point was near the summit. Th major axis appeared along the linear summit and the minor axis appeared across the summit. The aspect ratio of the major axis to the minor axis gradually changed toward 1 with the increase of d_d. Moreover, the aspect ratio becomes large at the same d_d when the impact velocity increased. The major axis of the ellipsoid crater formed on the bulge was slightly larger than the crater diameter formed on the flat surface, and the slope angle might affect the size of the ellipsoid because we found that the crater formed on the slope of 30 degree was systematically larger than that formed on the slope of 20 degree. We also observed an asymmetric ejecta curtain from the impact point on the bulge, moreover the ejecta curtain was notice to be deformed so much at the impact point near the summit because of the effect of curvature of the bulge on the crater flow.

Angle of repose, Impact crater, Bulge and ridge structure, Ejecta curtain

