Morphology of microcraters over a range of impact velocities

*Iwasa Kaishi[1], Akiko Nakamura[1]

1. Kobe University

Introduction :

Microcraters (micrometer-sized craters) were formed by impact of interplanetary dust on lunar rocks (Horz et al., 1974) and fine particles of asteroid Itokawa (Nakamura et al., 2012). Analysis of rock samples of the moon revealed that the microcrater having the ratio of pit depth to diameter of about 0.6 is the most frequent. Based on the relationship between impact velocity and the depth-to-diameter ratio of the microcrater formed on glass targets using iron, aluminum, and polystyrene projectiles, dust near the Earth orbit was estimated to have a density of 2 ~ 4 g/cm^3 with the assumption that the average collision velocity of dust was 20 km/s (Horz et al., 1975). However, based on recent observation of reflectance spectra of zodiacal light, it was estimated that > 90% of the dust near the Earth orbit is comet origin with density < 1 g/cm^3 (Yang and Ishiguro, 2015). Although the laboratory experiments of microcraters on glass targets showed that the ratio of depth-to-diameter increased with impact velocity (Vedder and Mandeville,1974), for the craters formed on rocks by millimeter-size projectiles accelerated by two-stage light-gas gun, the dependence of depth-to-diameter ratio of craters on impact velocity is not clear (Nakamura, 2017).

Method :

Using the shock physics code iSALE, the projectile was set to spherical aluminum and the target was granite, we simulated the formation of craters at different impact velocities. The impact velocity was changed in increments of 1 km/s in the range of 2 to 7 km/s, and we analyzed simulation images using Image J to obtain the diameter and depth of each crater. The size effect and the strain rate effect are thought to increase the strength of the target when the microcrater is formed, but in this study we focused on the influence of the size effect. The cohesion of the target was set to 10 MPa - 100 MPa based on the relationship of tensile strength *Y* to the sample volume *V*, Y∝V^(-0.0834) (Housen and Holsapple, 1999). All the other physical properties were fixed. The estimated strength of the target volume for the crater of about several tens of um in diameter was 50 MPa, and the strength for a microcrater of several μm was 80 MPa. ANEOS (Thompson and Lauson, 1972, Melosh, 2007) was used in the equation of state for granite.

Result :

When the cohesion was 50 MPa, the depth-to-diameter ratio increased with impact velocity. The depth-to-diameter ratio increased with impact velocity with the cohesion of 80 MPa, but the rate of increase was smaller than in the case of 50 MPa. The numerical simulation suggested that, the depth-to-diameter ratio of crater becomes dependent on the impact velocity when cohesion is large, i.e., the scale of the cratering process is small even for rock target. However, rate of increase and absolute value of depth-to-diameter ratio in this study are different from the result of Vedder and Mandeville (1974). This result seems to be due to the difference of target material and the model used. We will carry out the simulation of glass target.

©2018. Japan Geoscience Union. All Right Reserved.

Acknowledgments :

We would like to thank the developers of the iSALE impact simulation code: G. Collins, K. Wunnemann, J.Melosh, B. Ivanov, D. Elbeshausen. We are grateful to K. Kurosawa, R. Suetsugu, S. Wakita, and A. Suzuki for their introduction and support for usage of the iSALE code.

Keywords: crater, iSALE, impact, sample return

©2018. Japan Geoscience Union. All Right Reserved.