Scaling of impact-generated cavity-size for highly porous targets and its application to cometary surfaces

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Recent spacecraft missions have brought us the information of highly porous small bodies. The detail images of these bodies show variety of the surface. One of the interesting findings is that the depressions on comets look shallower than the simple craters such as on the moon, that is the depth-to-diameter ratio of the depressions are smaller than ~0.2. Although the mechanisms for the formation of the depressions such as collapse after the sublimation of the sub-surface volatile (Vincent et al., 2015) and activities after impact such as sublimation and viscous relaxation (e.g. Cheng and Dombard 2006, Thomas et al., 2013) are controversial, the shape of the cavity formed on highly-porous surface by impact itself is not understood well.
We performed impact experiments of sintered glass-bead targets with porosity of ~94%, and 87%, as well as gypsum targets with porosities of ~50% and pumice targets with those of 74%. The cavity created by the impact has maximum diameter at some depth from the target surface. The shape of the cavity is called bulb-shape cavity (Okamoto et al., 2013).The maximum diameter, D_{max} and the bulb depth, d_b of the cavity were analyzed. In addition to the results of this study, we also compiled the results of previous impact experiments for crater sizes in which the targets with porosity larger than 30% were used. Then new empirical scaling relations for the wide range of target porosity were obtained.
We applied the relations to comets. The surface strength and the particle size of the comet Tempel 1 are estimated to be of the orders of 10^1–10^3 Pa, and larger than ~50 μm, respectively. The ratio of bulb depth to the maximum diameter is also calculated from the scaling relations. The results show that the ratio on the weak surface with the strength less than 100 Pa was smaller than the depth-to-diameter ratio of simple craters, ~0.2. It suggests that shallow depressions on comets could be formed only by impact without subsequent activities, such as sublimation and viscous relaxation.

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