Experimental study of low velocity impact onto granular media under reduced gravities:Effects of the regolith layer strength

*Masato Kiuchi[1], Akiko Nakamura[1], Koji Wada[2]

1. Graduate School of Science, Kobe University, 2. Planetary Exploration Research Center, Chiba Institute of Technology

Gravitational acceleration at an asteroid surface is very small. It is important to understand the gravitational dependence of the crater diameter in order to estimate evolutional processes and physical property of the asteroid surface. However, effects of gravitational acceleration on crater formation has not been understood in detail. Some hypervelocity impact experiments were conducted under increased gravities (Schmidt and Housen, 1987) and under low gravities (Gault and Wedekind, 1977; Takagi et al., 2007). It was shown that the crater diameter was proportional to -0.17 power of the gravitational acceleration by Schmidt and Housen (1987) and Gault and Wedekind (1977), on the other hand, Takagi et al. (2007) showed that the crater diameter formed under microgravity was not different from the one formed under 1 G. The difference in the results of previous studies is not understood because the number of available laboratory data is limited. In the microgravity environment, it is expected that there are conditions under which the cohesion force acting between regolith particles exceeds the gravity force. The boundary where the effect of the cohesion force on crater formation exceeds the effect of the gravity is determined by the strength of regolith layer, the gravitational acceleration, and the crater size, however it is not clearly known.

We developed a mechanism which can simulate gravities smaller than 1 G: a target container was suspended by springs of constant force. We conducted impact experiments under a gravity range of 0.01 -1 G. We used silica sand grain of average diameter 140 μm as the target material, and used stainless steel spheres and glass spheres as the projectiles. Stainless steel sphere is 7.9 g cm^{-3} in density and glass sphere is 2.5 g cm^{-3} in density and diameter of the projectiles was 8 mm. The impact velocity was between 1 and 5 ms^{-1}. As a result, the crater diameter formed under the gravity range between 0.01-1 G was proportional to about -0.2 power of the gravitational acceleration (Kiuchi and Nakamura, 2015 JPGU meeting). This gravitational dependence is roughly in agreement with the previous studies at hypervelocity (Schmidt and Housen,1987; Gault and Wedekind,1977).

Next, we used alumina particles of average diameter 60 μm as the target material with larger cohesion force than the silica sand grain. Alumina particles were filled in the target container and compressed to a porosity of 0.42 which was approximately equivalent to the porosity of the silica sand target. We measured the penetration resistance of target materials using a stainless steel cylinder of 10 mm in diameter and found that the strength of the alumina target is about five times larger than the silica sand target. We conducted impact experiments under similar conditions to the previous experiments of the silica sand target. As a result, the crater diameter formed under 0.1 G was not different from the one formed under 1 G. Since the gravitational dependence was not observed, the effect of the strength seems to exceed the effect of gravity. Furthermore, we will conduct additional impact experiments onto the target materials with intermediate strength between the silica sand target and the alumina target. Based on the results, we will discuss the boundary conditions between the gravity regime and the strength regime quantitatively.

Keywords: Crater formation expertiments, Microgravity, Regolith layer strength