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Fragmentation degree of impactor in collision with asteroid regolith

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Introduction: Many of meteorites are fragments of disrupted asteroids, therefore we can get the information of early stages of the Solar System, because it is considered that thermal activity was stopped in the early stage in the parent bodies of chondrites. However, there are meteorites in which the components from various parent body origins are mixed. These meteorites contain the fragments of the different bodies' material and are brecciated. For example, it was reported that the fragments of carbonaceous chondrite are contained in Tsukuba meteorite and Almahata Sitta meteorite (Nakashima et al. 2003, Jenniskens et al. 2009). HED meteorites are known to be originated from asteroids (4) Vesta. HEDs generally contain the carbonaceous chondrite to 5vol. % (Zolensky et al. 1996), and on the Vesta surface there is a crater that was probably formed by the carbonaceous chondrite impact (Reddy et al. 2012). Thus, brecciated meteorites containing the fragments of other bodies' material were probably formed by impacts of smaller bodies into boulders or regolith of another bodies to have been captured in the regolith. The regolith containing the fragments was lithified by further impacts (e.g. Rubin et al. 1983). In addition, a 6 m-sized black boulder on the surface of Itokawa (Hirata and Ishiguro 2011) may also be carbonaceous chondrite of other body origin. Therefore, taking the material of other bodies has likely been a universal process on asteroid surface. In this study, we investigated the fragmentation degree of projectile by laboratory impact experiments in order to clarify the fragmentation degree of a meteorite in collision with asteroid regolith.

Experiment: Basalt projectiles simulating meteorites were impacted on regolith like silica-sand-target. We previously conducted the experiment at velocities of 167 to 960 m/s (Nagaoka et al., the Japanese society for planetary science, fall meeting, 2012). In this study, we conducted the experiment at velocities of 2 to 5 km/s that simulated the mean impact velocity in the asteroid belt, which is ˜4.4 km/s (Bottke et al. 1994). The experiments were performed by a two-stage light-gas-gun facility at the ISAS/JAXA. Recovered fragments were sorted out by 0.5 mm size meshes.

Result: We studied the relation of the largest fragment mass fraction to the non-dimension impact pressure (in this study, it was defined as the initial peak pressure divided by the tensile strength of projectile). It was found that projectile began to break at pressure of ten times greater than the tensile strength of projectile that corresponded to about 200 MPa. Moreover, the largest fragment mass fraction was larger than that expected from the impact experiments at velocities of a few 100 m/s. This may be explained by the increase of the dynamic strength of projectile according to a strength-strain rate relation (Grady and Kipp 1980).

Keywords: asteroid, meteorite, impact