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Measurements of impact strength of simulated regolith materials

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Asteroid and lunar surfaces are covered with regolith, which was impact fragments accumulated on their surfaces. The regolith layer consists of fragments with a wide range of size distribution from sub-microns to meters. They are compacted by stress or pressure induced by impact and self-gravity, then they would have mechanical strength according to the degree of compaction. The strengthen layer could be excavated and fragmented, and they are mixed with surface non-cohesive fine fragments, so that the solid rock fragments were consolidated by the fine fragments among them to form monomict or polymict breccias. A part of ancient regolith layer of extra-terrestrial planets is now obtained to be lunar rock and meteorite such as achondrites, e.g. HED. In order to study the origin of these breccias on the planetary surfaces, we should consider the impact strength of regolith layer, which would have a wide variety of strength depending on the internal structure and composition. In this study, we assume that the regolith might be composed of solid rock fragments consolidated by fine fragments with relatively weak strength, so the effect of this structure on the impact strength was investigated hereafter.

Impact experiments were conducted by using a two-stage light gas gun set in ISAS, and a nylon spherical projectile with the size of 200 mg was launched at from 2 to 6 km/s on a simulated regolith sample. The sample was prepared by using pebbles with the saize of 5 to 10 mm and gypsum: they are mixed each other with the mass ratio of gypsum to pebbles about 1/6. The sample had a cylindrical shape with the diameter and he height of 15cm and the mass of about 2.8kg. Most of the disrupted samples were recovered to measure the mass of the largest fragments and their size distributions depending on the energy density.

Impact strength of this regolith sample was determined from the relationship between the largest fragment mass and the energy density in this study. The impact strength is obtained to be 300 J/kg and this strength is rather smaller than that of basalt, 1000 J/kg, and gypsum, 2500 J/kg. The typical disruption mode of core type disruption in the high velocity impact higher than 1 km/s was never observed in this sample. The sample was disrupted and simply removed from the impact surface without any special failure events like spallation and radial split. The removed depth was observed to increase with the impact velocity monotonically. The weak impact strength of the regolith sample could be strongly related to the failure mechanism of this sample: the failure could be dominated by peeling pebbles from gypsum matrix. This strength required for peeling off pebbles from gypsum might be rather smaller than that of pebble and gypsum themselves.

Keywords: regolith, impact strength, compaction, crater, breccia, lunar meteorite