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Impact experiments of sintered snow and the implication for re-accumulation condition of icy bodies

Yuri Shimaki[1]; Minami Yasui[2]; Masahiko Arakawa[2]

[1] Earth and Environmental Sciences, Nagoya Univ.; [2] Grad. School Env. Studies, Nagoya Univ.

Impact disruption processes were studied for sintered porous targets of pure ice in order to clarify the effects of sintering on impact strength and fragment velocities. There are a lot of small icy bodies in our solar system: they are a comet nucleus, a small icy satellite and a Trans Neptune Object. The porosity of these small bodies are estimated to be less than 1g/cm^3, that is, Cassini observed that Saturnian small icy bodies had the density between 0.5 and 0.7 g/cm^3. These densities mean a quite high porosity more than 40% even they are assumed to be made of pure water ice. The mechanical strength of these porous bodies are controlled by sintering among icy particles in the thermal evolution. Therefore it is very important for the collisional evolution of small icy bodies to study the relationship between the degree of sintering and the impact strength.

We used a vertical gas gun set in a large cold room to make impact experiments of snow. The sintered snowball with the porosity of 30 % or pure icy cylindrical projectile impacted on the sintered snow sphere with the size of 60mm and the porosity of 40 %. The impact velocity was from 30 to 450 m/s, and all of the experiments were conducted at -15 deg.C. in order to control the sintering process precisely. The high speed video camera was used to observe fragment velocities of snow target and they were recoded at 10^{4}FPS. The antipodal velocity, which is velocity at the antipodal point and the representative of the fragment velocity, was measured on the video image. The impact strength, the static strength and the fragment velocities were measured for the snow target sintered for 1 hour to 1 month. The static strength was measured by using a deformation machine, and the cylindrical sample was compressed to obtain the tensile strength according to the compress-tensile testing method.

As a result, we found that the antipodal velocity had no clear dependence on sintering duration. The empirical equation is written by as follows,

V_a(m/s)=0.074 Q(J/kg)$^{0.7}$,

where Q is an energy density defined as a projectile kinetic energy divided by a target mass. On the contrast, the impact strength ($Q*$) and the tensile strength (T) were found to be proportion to the power law of the sintering duration and they are written by the following equations,

$Q*$(J/kg)=5.7 t(s)$^{0.2}$ for impact strength,

T_{tens}(kPa)=7.2 t(s)$^{0.23}$ for tensile strength.

We notice that the power law index of time for both equations is almost the same, 0.2. Finally, we estimated the accumulation and disruption condition of icy planetesimals from our results. Then, we found that the collisional events were divided into four types: they are catastrophic disruption, rubble pile formation, cratering and regolith formation.