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Experimental study on the collisional accretion process of icy planetesimals in thermal evolution

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It is widely accepted that icy planets were formed by collisional disruption and re-accumulation processes of icy planetesimals. It is expected that icy planetesimals have various porosities and tensile strength due to their thermal evolution, and this variation of the physical property should affect the formation process of icy bodies. The scaling law proposed by Mizutani et al. (1990) could be a useful theory for the impact disruption of icy planetesimals with various physical properties. Thus, the purpose of this study is to reveal whether the impact disruption of snowballs with various physical properties is scaled by a non-dimensional impact stress or not, where the snowball is an analogue of icy planetesimals. Bulk sound velocities (C0) of the snow with the porosity from 0 to 70 % was measured and the empirical relationship was obtained to be C0 = 2.9 - 0.03P, where P is the porosity. Tensile strength of the snow with the porosity of 30 to 70 % was measured to be found that it decreased with increasing porosity. We conducted impact experiments on the sintered snowball with the diameter of 60 mm and the porosity from 40 to 70 %. Impact fragment masses and the fragment velocity distributions are measured. We classified disruption modes into sticking, rebound, cratering, bow like envelope disruption, bullet like envelope disruption and penetration; sticking only occurs when the porosity is larger than 60 %. The slopes of cumulative mass distribution for impact fragments were found to be flat with increasing the porosity. The largest fragment mass normalized by original target mass (ml/Mt) was found to be well scaled by PI at the porosity smaller than 50 %. Moreover, the following empirical equation was obtained in this study: $ml/Mt = a*PI^{b}$, where a is 0.6 and b is 0.85.

Keywords: impact experiment, snow, porosity, planetesimal, thermal evolution