Sintering of snow and the effect to the formation of impact craters

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Introduction:

Comet nucleus and Kuiper-belt object are candidates of the relic of icy planetesimals supposed in the solar nebula. Stardust mission observed the surface of comet Wild2 and found two kinds of crater morphology that have not been observed in other small bodies. These are called as pit-halo and flat-floor and they are evidence that the comet surface has mechanical strength enough strong to keep the morphology against the gravitational force. The mechanical strength should be caused by sintering among water ice and other volatiles. Therefore, the degree of sintering is important parameter to control the crater morphology on the comet surface. We studied the effect of the degree of sintering on the crater scaling law in the laboratory experiments.

Experimental method:

Impact cratering experiments were conducted by using snow particles (smaller than 500micron), which is contained in the stainless container with the diameter of 13.5cm and the height of 10 cm. The room temperature was set at -5, -10, -18deg.C. The snow porosity was from 35 to 45% and the standard sintering time was 15min. The snow target prepared at -10deg.C was sintered at variable duration from 3min. to 60hrs to change the degree of sintering. The impact experiments were made by a gas gun set in a cold room. Snow projectiles with the porosity of 30-45% or ice projectiles were launched at the velocities from 3 to 150 m/s. Crater morphologies were measured after the shot.

Results:

We have found that the crater size clearly increased with increasing the impact velocities at -10degC. The snow projectile was recovered intact at low velocity impacts, but it was broken completely at high velocities and the relic of impact point was observed as ring-like structure. At lower temperatures, the crater size became larger at the same impact velocity. In contrast, the crater size became smaller at higher temperatures. The relationship between the crater volume (Vc) and the projectile kinetic energy (Ek) was fit by power law equations for each temperature and projectile. The power law index derived from the fitting for each data was about 0.5 irrespective of the temperatures. The Vc of the lower temperatures becomes larger at the same Ek because of the effect of sintering. The Vc at -18degC is noted to be three times larger than that at -5degC. We also found that the crater size simply decreased with time from 3min. to 6hrs. at -10degC.