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Cratering on Snow by Low Velocity Impacts: Effect of Sintering on the Crater Formation

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Recent planetary explorations for small bodies revealed that they have a large porosity. These small bodies could be a mixture of silicates, ices, and organics and the large porosity means that they are not compressed by the stress causing the large plastic deformation. The important mechanism to give the strength in porous small bodies could be sintering of the dusts. Therefore, we studied the contribution of sintering in controlling the mechanical strength of icy bodies and the effect of sintering on the formation of impact craters made on snow. Impact experiments on snow were conducted to make clear the formation mechanism of crater on sintered porous materials. The target was made of ice particles with the size of about 500microns. The ice particles were put in a cylindrical container with the diameter of 13.5cm and the height of 10cm. The target porosity was in between 35 % to 45 % and the target was set in a cold room for sintering from 3 minutes to 16 hours. We used the projectile made of ice and snow with the porosity of about 30%. The projectile is a cylinder with the diameter of 7mm. The projectile was launched by a He-gas gun at the impact velocity from 3 to 150m/s. Every impact experiment was conducted in a large cold room at the temperature of -5 to -18deg. The crater volume was calculated by excavated mass and the mean target density. The projectile and the ejecta from the crater were observed by a high-speed video camera to determine the velocities. In our temperature range, ice particles sinter very quickly. Even if the duration of the sintering is less than 3 minuets, the target can keep its surface morphology against the gravity force. It is very clear that the crater size changes with the degree of sintering. In 16 hours-sintering target, the crater is small and shallow. The crater size increases with decreasing of sintering duration, so we see quite large crater with spall like outer boundary in 3 minuets target. The relationship between the projectile kinetic energy (Ek) and the crater volume (Vcr) shows that the Vcr is proportional to Ekˆ0.5 irrespective of the degree of sintering and the projectile strength. The crater volume at the same Ek depends on the degree of sintering. In the same projectile group, the crater volume becomes large with decreasing the temperature. We also notice that the crater made by the ice projectile is systematically larger than that made by the snow projectile. The crater volume for the targets sintered at different duration was examined. The target was sintered at -10 deg, and the crater was formed at the impact velocity of 100m/s. The crater volume decreases with increasing sintering duration (ts). The empirical relationship between Vcr and ts is as follows, Vcr[cmˆ3]=236x(ts[sec])ˆ-0.37. Because the target strength should increase with increasing the duration by sintering, we can expect that the above power law relationship can be explained by the strength variation with time.