High velocity impact experiments for frozen sands related to crater scaling laws in strength regime

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Solid bodies in the outer solar system are mostly covered with icy crust, and it is composed of ice-rock granular mixture. There are a lot of impact carter on these surfaces, and crater scaling laws are necessary to derive information of impacted bodies from the observed craters and to estimate the regolith thickness deposited on the surface from the ejected material. Especially, on middle and small icy bodies, the crater formation process could be controlled by the material strength of the icy crust, so that the crater scaling laws applicable to the strength regime is necessary to study the crater observed on these small and middle size icy bodies. However, the crater scaling law in the strength regime has not been confirmed by the experiments using the material continuously changing the strength; especially, the ejecta velocity distribution in the strength regime has no been studied yet so far. Therefore, we conducted the impact cratering experiments on the icy material with the various strength to elucidate the material strength dependence on the ejecta velocity distribution and the crater size.

We used frozen quartz sand targets with the water content from 2.5 to 20 wt.%, and they were made at -20 degrees using quartz grain with the size of 100mm. This frozen sample was tested to obtain the tensile strength (*Y*) changing with the water contents (*C*), and the empirical equation was derived as follows, *Y*(MPa)=0.145*C* (wt.%). The impact experiments were conducted at 2, 4 and 6km/s using an aluminum projectile with the diameter of 2mm, and the frozen target was impacted by the projectile on the surface normal to the impact direction.

As a results, the crater formed on the frozen sand with various strength was found to change with the mechanical strength and the crater size increased with the decrease of the strength. The pi-scaling theory for the crater size was applied to these results and the following equation was obtained: $\pi_R=1.0p_Y^{-0.3}$, where $\pi_R=R(\rho/m)^{1/3}$, $\pi_Y=Y/\rho v_i^2$, R: crater radius, ρ: target bulk density, m: projectile mass, and v_i: impact velocity. We also measured the ejecta velocity distribution, which was the relationship between the initial ejection position and the ejection angle or the ejection velocity. Then, the ejection angle was found to increase with the distance from the impact point and to become very steep until vertical near the crater rim, and this feature of the ejection angle changing with the distance could cause the unique ejecta curtain call a pillar, which was ejecta curtain extending normal to the target surface. The pillar-like ejecta curtain could be a unique one formed in the strength regime, and it might be originated from the restricted ejecta flow field inside the crater.

Keywords: solar system small bodies, high velocity impact , crater scaling law

