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Ejecta velocity distribution for impact crater formed on quartz sand: Effect of projectile density on crater scaling law

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In order to clarify the effects of projectile density on ejecta velocity distributions for a granular target, impact cratering experiments on a quartz sand target were conducted by using eight types of projectiles with different densities from 11 g cm^{-3} to 1.1 g cm^{-3}, and they were launched at about 200 m s^{-1} by a vertical gas gun at Kobe university. The scaling law of crater size, the ejection angle of ejecta grains, and the angle of the ejecta curtain were also investigated. The ejecta velocity distribution obtained from each projectile was well described by π-scaling theory of $v_0/\sqrt{\ } gR=k_2(x_0/R)$^(-1/$\mu$), where v_0, g, R and x_0 are ejection velocity, gravitational acceleration, crater radius and ejection position, respectively, and θk_2 and μ are constants mostly depending on target material properties (Housen and Holsapple, 2011), and then it was found that k_2 is almost constant of 0.7 for all projectiles except for a nylon projectile, while μ increases from 0.43 of a low-density projectile to 0.6 - 0.7 of a high-density projectile with the increase of the projectile density. On the other hand, μ was obtained to be 0.55 from the π-scaling theory for crater size, and it was close to the average of the μ obtained from ejecta velocity distributions. The ejection angle, θ, of each grain decreased slightly from higher than 45^o near the impact point to 30^o - 40^o at 0.6 R with the distance. The ejecta curtain angle is controlled by two elementary processes of ejecta velocity distribution and ejection angle; it gradually increased from 52^o to 63^o with the increase of the projectile density. The comparison of our experimental results with the theoretical model of the crater excavation flow called as Z-model revealed that the relationship between μ and θ obtained by our experiments couldn't be described by the Z-model (Maxwell, 1977). Therefore, we used the extended Z-model by Croft (1980) that could be applied to the crater excavation process when the point source was buried at the depth of d under the target surface, and then all the experimental results of μ and θ were reasonably explained by suitable Z and d of the extended Z-model.

Keywords: Impact processes, Regoliths, Cratering, Asteroid surfaces, Ejecta curtain, Scaling Law