High-velocity impact cratering experiments on quartz target for constructing scaling laws of crater size and ejecta velocity distribution

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Regolith formation and surface geological evolution on asteroid are caused by impacts of small bodies. The ejecta velocity distribution is one of the most important physical properties; Tsujido et al. (2015) conducted impact experiments at 200m/s on the quartz sand target by using various projectiles and studied the effects of projectile density on ejecta velocity distributions. However, the mean impact velocity on the asteroid is about several km s^{-1}, then it is essential to study the effect of the impact velocity on the ejecta velocity distribution. So in this study, we performed impact cratering experiments on quartz sand to clarify the effect of impact velocity on the ejecta velocity distribution of the quartz sand target at the impact velocity of 1.5 to 6.9 km s^{-1}. We also investigated the scaling law of crater size, the ejection angle of ejecta grains, and the angle of the ejecta curtain. The ejecta velocity distribution obtained from each shot 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 k_2 and μ are constants (Housen and Holsapple, 2011), and then it was found that k_2 was almost constant of ~0.7 for all projectiles, while μ increased from 0.35 to 0.5 with the increase of the projectile density. On the other hand, μ was obtained to be 0.42 from the π-scaling theory for crater size, and it was close to the average of the μ obtained from ejecta velocity distributions. We determined the average of the ejection angle, θ_{ave}, far from x_0 = 0.4 R for each projectile. In this study, θ_{ave} is constant between 35° and 44° irrespective of the impact velocities and projectile densities. The relationship between the μ and the average of ejection angle, θ_{ave} was reasonably explained by the extended Z-model (Croft, 1980, Tsujido et al., 2015). Our result revealed that this model could apply for the results obtained for all conditions at the high-velocity impacts. On the basis of this result, we discuss how the scaling laws for impact cratering in the gravity regime depends on impact velocity and projectile density in detail.

Keywords: Impact crater, Scaling law, Regolith layer

