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Measurement of 3D shape distribution of fragments ejected by impact experiments

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It has been accepted that impact phenomena play a major role throughout the history of the solar system, such as formation and evolution of asteroids and satellites. Regolith on asteroid's surface is also formed by impact of small celestial bodies and cosmic dust onto the surface. Regolith particles on the asteroid Itokawa, which were recovered by the Hayabusa spacecraft, have been examined. In the preliminary examination, surface structures and size and 3D shape distributions of Itokawa particles were elucidated using x-ray microtomography [1], and micro-surface structures of the particles were observed using high-resolution scanning microscopy [2]. Processes on the asteroid surface will be understood comprehensively together with space weathering [3] and implantation of solar wind noble gases [4].

In this study, we performed impact experiments of cratering and recovered impact fragments to compare the results with regolith particles on Itokawa. The experiments were made using a two-stage light gas gun at Kobe University with the impact velocity of 4 km/s. A projectile was a nylon projectile (2.2 mm in diameter and 2.5 mm in length), and two kinds of a target (10 x 10 x 3 cm), marble (compressive strength of 96.9 MPa) and limestone (compressive strength of 53.9 MPa) were used. If we consider regolith formation process, it is reasonable to expect that ejecta with high velocities was easily lost into space while those with low velocities remained on the asteroid's surface as regolith. Therefore, to compare experimental fragments with regolith particles, it is important to recover fragments by considering their ejection velocities. In previous experiments, however, impact fragments were usually collected without separating their velocities except for a few experiments [5,6]. In the present study, we have developed a collection method, where the target was surrounded by Styrofoam boards. In this method, high velocity ejecta were captured into a Styrofoam, while low velocity ejecta fell down on the bottom of a Styrofoam board.

Recovered impact fragments were analyzed by high-resolution x-ray micro- tomography at Osaka University. In previous studies, analysis of fragments has been made using caliper, micrometer, and/or microscope. Therefore, only a limited data have been obtained on the 3D shape distributions. In the present study, 3D shapes of individual fragments were obtained by the x-ray microtomography, and the 3D shape information was successfully obtained from best-fit ellipsoids and compared with Itokawa particle data, which were obtained by similar method.

From the 3D shape information, we calculated size and shape distributions of fragments with the different impact velocities into the two different targets. There is a tendency that high velocity fragments are more spherical than low velocity ones irrespective of the targets. Moreover, low velocity fragments have similar 3D shape distribution to Itokawa particles. This is consistent with the expectation that Itokawa particles should be low velocity fragments ejected by cratering.

[1] Tsuchiyama A. et al. (2011) *Science, 333*, 1125-1128. [2] Matsumoto T. et al., (2012) JGUM abstract, this volume. [3] Noguchi T. et al. (2011) *Science, 333*, 1121-1125. [4] Nagao K. et al. (2011) *Science, 333*, 1128-1131. [5] Asada, N. (1985) *J. Geophys. Res. 90*, 12445-12453. [6] Yamamoto S. and Nakamura A. M. (1997) *Advances Space Res., 20*, 1581-1584.

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