

3D shapes of Itokawa regolith particles: comparison with lunar regolith particles

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Regolith particles were returned from the surface of asteroid Itokawa by the Hayabusa spacecraft. The sample analysis elucidated a variety of surface processes on the asteroid (e.g., [1]): (1) Formation of regolith by impacts of small objects, with selective escape of the finest-scale particles. (2) Implantation of solar wind into the uppermost particle surfaces and formation of space-weathering rims. (3) Grain abrasion, probably due to seismic-induced particle motion. Processes (5) and (6) might have been repeated. (7) Final escape of particles from the asteroid by impact within the past 8 million years (1-3 million years [3]).

During the course of the analysis, 3D size and shape features of the Itokawa particles were obtained by SR-based x-ray microtomography to understand the origin and evolution of the regolith particles on Itokawa's surface [2,3]. In particular, the particle shape distribution with respect to their three-axial ratios was obtained and compared with that of fragments formed by high-speed impact in laboratory experiments [4,5] and of lunar regolith samples [6]. The 3D shapes of the lunar samples have been examined by tomography [6] but not grain-by-grain as performed for the Itokawa samples. In addition, the procedure for measuring the three axial lengths was different between the regolith particles and the impact fragments: the former was obtained from 3D external particle shapes by ovoid approximation [2,3,6], while the latter by bounding box method using a calliper [4,5]. In order to make strict comparison between them, lunar regolith particles were examined by the same method as the Itokawa particles, and the three axial lengths were measured from the tomography data by bounding box method that was newly developed in the present study.

The 3D shapes of 70 particles from 105-250 μm sieved fraction of Descartes highland (60501) and 74 particles from <1 mm sieved fraction of Mare Tranquillitatis (10084) were obtained by microtomography at BL47XU of SPring-8. Furthermore, the 3D shapes of new 24 Itokawa particles (3 of them are from Dr. M. Meier, personal communication) were also examined in addition to the previous 48 particles [3]. The three axial lengths were measured in the orders of short to long and long to short axes to compared with the data of [3] and [4], respectively. The shape distribution in a Zingg diagram was compared using the Kolmogorov-Smirnov test.

The shape distribution of the Itokawa particles cannot be distinguished from that of the impact fragments of [4] but can be distinguished from that of [3]. This may suggest that the Itokawa particles resulted from mechanical disaggregation, as a response to impacts with a specific condition. In contrast, the shape distribution of the lunar regolith particles can be distinguished from that of the Itokawa particles and the impact fragments although lunar regolith is the product of impact on the lunar surface. The lunar particle shapes are more equant than the others. The both lunar samples examined are matured (Is/FeO = 80 and 78 for 60501 and 10084, respectively [7]). These regolith particles should become equant from the shapes similar to the impact fragments by mechanical disaggregation or abrasion due to repeated impacts during a long residence time in the regolith layer although a specific process for the shape change is not known.

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