Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PPS23-P10 Room:Convention Hall Time:May 25 18:15-19:30

Features of 3D shapes of lunar regolith particles: comparison with Itokawa particles and experimental impact fragments

SAKURAMA, Takashi[1*] ; TSUCHIYAMA, Akira[1] ; NAKANO, Tsukasa[2] ; UESUGI, Kentaro[3]

[1]Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, [2]Geological Survey of Japan, AIST, [3]SPring-8/JASRI

To understand formation and evolution of regolith on airless bodies such as the moon and asteroids, 3D shape distributions of regolith particles have been measured and compared with those of experimental high-speed impact fragments. The 3D shapes of asteroid Itokawa particles recovered by the Hayabusa spacecraft were measured using X-ray microtomography [1], and it was proposed that the 3D shape distributions of Itokawa particles are undistinguishable from those of experimental impact fragments [2], but lunar particles from Descartes Highlands (Apollo 16 sample; 60501) [3] are more spherical than Itokawa particles. Lunar particles from Mare Tranquillitatis (Apollo 11 sample; 10084) are also more spherical than Itokawa particles [4]. However, as these returned samples were imaged grain by grain, the data collection was time-consuming, and thus the numbers of particles measured were limited up to about sixty. In addition, it is necessary to obtain more data efficiently for lunar samples, which may have variety. In this study, more lunar regolith samples were efficiently examined by tomography to understand 3D shape features of lunar regolith particles and compare those with Itokawa particles and experimental impact fragments.

In the present study, in addition to the Apollo samples (10084 and 60501), we used Luna samples; L1613-3 (Luna 16: Mare Fecunditatis), L2001-4 (Luna 20: Apollonius Highlands) and L24130.3-2,3,4 (Luna 24: Mare Crisium). The sample particles were attached on a toothpick with double-sided tape to take CT images at once by X-ray microtomography. Imaging experiments were made at BL20B2 of SPring-8 with the X-ray energies of 17.9, 18.1 or 20 keV and voxel size of 1.73 um. Particles were extracted by binarization. The isolated particles having more than 10,000 voxels, which are possible for significant 3D shape measurement [5], were analyzed. So far, we have examined 156 and 90 particles of 10084 and L2001-4, respectively.

The axial lengths of particles were measured by ovoid approximation (OA) and bounding box (BB) method [4]. In BB method, the axial lengths differ if the order of determination of the shortest, intermediate and longest lengths (S, I and L, respectively) is different. We adopted two methods, where S was determined first followed by I and L corresponding to the impact fragments of [6] and L was determined first followed by I and S corresponding to [2]. The axial ratios, I/L and S/I, were plotted as Zingg diagrams. These 3D shape distributions were compared with the previous data of lunar regolith particles [3,4], Itokawa particles [7] and experimental impact fragments [2,5,6] using Kolmogolov-Smilnov (K-S) test.

There is no significant difference between the particle shape distributions of the same sample with different imaging methods (grain by grain or many particles at once) at least for 10084. As far as the samples analyzed and the previous samples concerned, there are basically no significant differences of the shape distributions among lunar samples irrespective of mare and highland samples. In contrast, the lunar particles are more spherical than the Itokawa particles and the experimental impact fragments. Because residence time scale of particles in lunar regolith is long (the order of one billion years) [8], it is possible for lunar regolith particles to become spherical by abrasion due to gardening. We are planning to report the results of more samples in the presentation.

[1] Tsuchiyama et al. (2011) Science 333: 1125. [2] Capaccioni et al. (1984) Nature 308: 832. [3] Katagiri et al. (2014) J. Aerosp. Eng.. 10: 1061. [4] Tsuchiyama et al., (2013) Goldschmidt Conf. Abstract 2361. [5] Shimada (2014) Masters thesis (Graduate School of Science, Osaka University). [6] Fujiwara et al. (1978) Nature, 272: 602. [7] Tsuchiyama et al (2014) MAPS, 49: 172. [8] Wieler (2002) Rev. Mineral. Geochem., 47: 21.

Keywords: Apollo mission, Luna mission, Hayabusa mission, X-ray tomography, SPring-8