Submicron crater populations on Itokawa regolith grains.

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Intoduction: The impacts of small bodies to S-type asteroid Itokawa is closely related to the surface evolution of Itokawa, such as cratering, dynamic regolith activity, and space weathering [1,2]. In previous studies, submicron sized craters have been reported on Itokawa regolith grains recovered by the Hayabusa spacecraft [3-5]. Occurrence of the craters on a limited numbers of Itokawa grains indicates that the craters have formed through the impacts of secondary ejecta created in primary impacts on Itokawa [4,5]. The secondary cratering could have been potential contributor to space weathering [5]. So far, only 24 craters have been found on Itokawa grains. Compared to extensive study of microcraters on lunar samples (e.g., [6]), we have much less information about impact cratering on Itokawa grains. For better understanding of entire impact phenomena on Itokawa regolith, information of craters on Itokawa grains sufficient for statistical study is necessary. Previous surface observation has been performed for Itokawa grains below 50 µm in size [4]. In this study, we examine surfaces of Itokawa grains up to 200 µm in size for the first time, in order to search for craters over a wide area.

Experiment: We investigated 34 Itokawa regolith grains from 10 µm up to 200 µm in size, which consist of 26 grains and 8 grains picked up from room-A and room-B of the Hayabusa sample catcher, respectively. We observed surface morphology of the Itokawa grains using a scanning electron microscope (Hitachi SU6600). The present study was performed during initial description for Hayabusa samples at the curation facility of JAXA.

Results and Discussion: We found 8 Itokawa grains over 80 µm in size which have surfaces with numerous submicron craters. They account for approximately 40 % of Itokawa grains over 80 µm in size observed in this study. We identified more than 30 craters on each grains. Common features of these craters are droplet-decorated rim often accompanying melting objects on the crater floor (Fig. 1). Blisters are commonly developed on cratered surfaces (Fig. 1), suggesting that the surfaces were exposed to the sun over a period of time [7].

We calculated crater size-frequency distribution from more than 400 craters on 3 Itokawa grains. Using an impact experimental data by [8], we derived the mass distribution of particles that impact on the Itokawa grains from the crater distribution. We obtained the particle flux on the Itokawa grains (Fig. 2), assuming that direct exposure to space environment for the Itokawa grains is 10^3 years, which is consistent with estimated surface exposure ages of less than a few 10^3 years suggested by previous noble-gas analysis and TEM study [9, 10]. We compared the particle flux on the Itokawa grains (the Itokawa flux) with particle flux at the lunar surface (the lunar flux) [6, 11] and interplanetary dust flux models [11,12]. Figure 2 shows that the Itokawa flux is up to two orders of magnitude higher than the interplanetary dust flux. In addition, the Itokawa flux curves do not match the interplanetary dust flux. We conclude that secondary ejecta impacts are dominant processes in the submicron sized crater range on Itokawa grains, as well as lunar samples [11]. The Itokawa flux has shallower slope and is lower than the lunar flux. The difference could be partly due to the difference between the escape velocity of the moon and that of Itokawa. On the lunar surface, most of secondary ejecta returns to the lunar surface, which have velocities below the escape velocity of the moon (2.4 km/s) [13]. On the other hand, majority of secondary ejecta on Itokawa could not return because of the low escape velocity of Itokawa (0.2 m/s), which cause the low rate of secondary ejecta impacts on Itokawa.

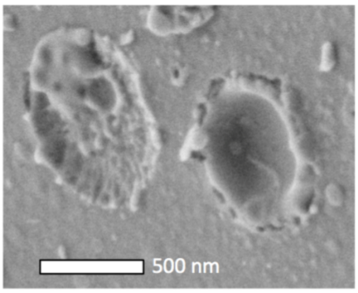

Fig.1. A secondary electron image of typical submicron craters on an Itokawa regolith grain.

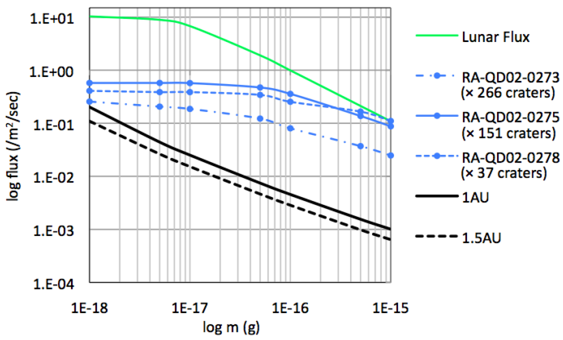

Fig.2. Cumulative particle flux on Itokawa regolith grains as function of the particle mass (blue lines). A green line is particle flux at the lunar surface. Interplanetary dust flux model at 1 AU (black solid line) and the flux at 1.5 AU (black dotted line) are also displayed.

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