SUBMICRON CRATER POPULATIONS ON REGOLITH PARTICLES OF ASTEROID ITOKAWA.

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Introduction: Understanding the surface modification processes on airless bodies provides an insight into the evolutional history of airless bodies in the solar system. The Hayabusa spacecraft touched down to an S-type near-Earth asteroid, 25143 Itokawa, and recovered surface regolith particles, which are consistent with minerals contained in LL5-6 chondrite [e.g., 1]. Micrometeoroid impacts are considered to be among the important agents for surface modification processes on Itokawa. These micrometeoroid impacts might have promoted dynamic regolith mixing/convection [e.g., 2] and caused space weathering via vaporization and recondensation processes [3].

In previous studies, submicron sized craters have been reported on Itokawa particles [2, 4, 5]. These small craters can give us information about the origin of micrometeoroid and the role of micrometeoroid impacts for surface modification on Itokawa. The craters are expected to have been formed through the impacts of secondary ejecta created by primary impacts on Itokawa [2, 5]. Since only 24 craters have been reported on Itokawa particles so far [2, 4, 5], statistical analysis of the craters is limited. In addition, it is not clear whether the few observed craters represent the whole submicron cratering processes on Itokawa.

In this study, we performed extensive investigations of submicron craters on Itokawa particles. The purpose of this work is the detailed characterization of abundance, areal and size distributions, and morphologies of submicron craters. In order to verify the secondary impact origin of these craters, we compared crater populations on Itokawa particles with the flux of primary impacts caused by interplanetary dust.

Experiment: We investigated 34 Itokawa regolith particles from approximately 10 μm up to 200 μm in size, which consist of 26 particles and 8 particles picked up from room-A and room-B of the Hayabusa sample catcher, respectively. Initial descriptions of picked Itokawa particles have been made using a scanning electron microscope (SEM; Hitachi SU6600) at the curation facility of Japan Aerospace Exploration Agency [6]. We observed the surface morphology of the Itokawa particles using the SEM after the initial description. The Itokawa particles were set on a gold disk of a sample holder for the SEM. Neither were these particles coated with any conductive materials nor have they ever been exposed to the atmospheric environment. We conducted secondary electron (SE) imaging at an accelerating voltage of 2 kV in high vacuum. To examine the concavity or convexity of the surfaces, the particles were imaged from two angles with a difference in tilt of 5 degrees to create stereograms.

Results: We found 8 Itokawa particles over 80 μm in size, with surfaces with numerous submicron craters (Fig. 1). Such crater-rich particles account for approximately 40 % of Itokawa particles over 80 μm in size observed in this study. We identified more than 30 craters on each Itokawa particle (Fig. 2). On five out of eight Itokawa particles, craters are widely dispersed as

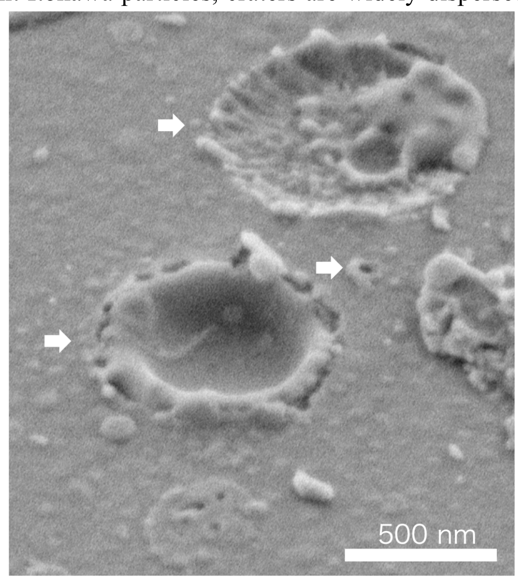

Figure 1. An SE image of typical submicron craters on the olivine surface of an Itokawa particle. This surface was imaged from an oblique angle. White arrows indicate craters.

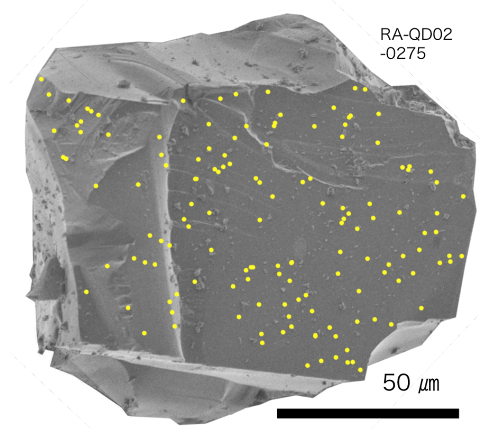

Figure 2. An SE image of an Itokawa olivine particle (RA-QD02-0275). Yellow dots correspond to the positions of craters from 40 to 680 nm in size.

shown in Fig. 2. On others, craters are partly concentrated in local areas. Craters several tens of nm in diameter are characterized as having a central pit and surrounding rim (Fig. 1). Craters over one hundred nm in diameter commonly have melted objects at the bottom of the craters (Fig. 1). The morphologies of the craters are similar to those of microcraters on lunar regolith [7]. Blisters are commonly developed on cratered surfaces (Fig. 1), which might have been formed due to the implantation of solar wind hydrogen and helium over a period of time [3, 8]. The threshold exposure time for blister formation is a few hundred to a few thousand years [3]. Most craters do not have blisters on their surface, indicating that majority of craters might have accumulated in a period shorter than that required for blister formation. We measured the cumulative number of craters as a function of crater diameter on 3 Itokawa particles (Fig. 3). In this study, we identified craters ranging from approximately 10 nm to 700 nm in diameter. Craters larger than 100 nm have slopes of -1.6 to -2.6. The steepest slope of craters on Itokawa particles has a similar value to that of lunar microcraters; Lunar microcraters show a size distribution with a slope of -2.5 to -2.6 for craters larger than 100 nm [7].

Discussion: From the size distribution and areal density of more than 400 craters on 3 Itokawa particles, we estimated the mass distribution of impactors that formed submicron craters (Fig. 4). We used the impact experimental data by [9] for the estimation of the mass of impactors from observed crater diameters, where the ratio of crater diameter to impactor diameter is approximately 2 to 3 in the range of 10 nm to 1000 nm. We assumed that the craters accumulated during direct exposure to space for 10^3 years from the common appearance of blisters on the surface. We compared impactor flux on Itokawa regolith with impactor flux on the lunar surface [7, 10] and interplanetary dust flux models [10, 11].

Figure 4 shows that the flux on Itokawa particles is up to two orders of magnitude higher than the interplanetary dust flux and is also comparable to the case of the Moon. Higher lunar surface flux over interplanetary flux was explained by high-speed secondary ejecta impacts and not by primary meteoroid impacts [10]. Similarly, secondary ejecta impacts are probably dominant cratering processes in the submicron sized range on Itokawa regolith particles, as well as lunar surfaces. Secondary impacts will have significant effects for submicron-scale cratering on airless bodies of various sizes in the solar system.

Acknowledgement: Authors acknowledge the JAXA curation team for providing them an opportunity to study Itokawa particles and supporting SEM observations.

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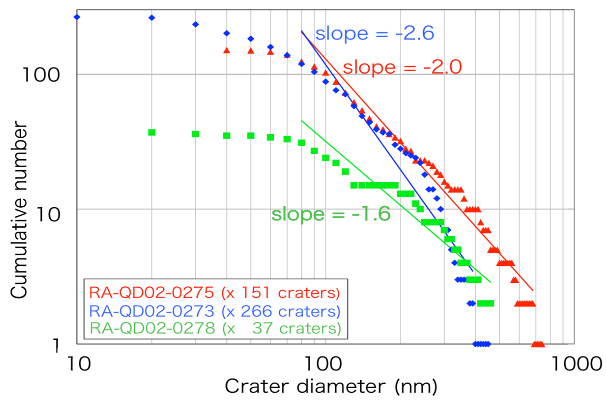

Figure 3. Cumulative number of craters as a function of crater diameter for 3 Itokawa particles.

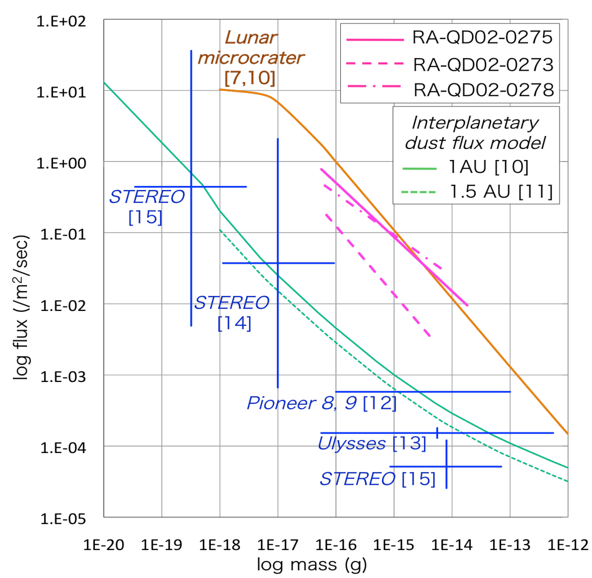

Figure 4. Cumulative fluxes of impactors on 3 Itokawa particles estimated using fit slopes in Fig. 3. Magenta lines: fluxes at the Itokawa particles. Orange line: flux at the lunar surface [7, 10]. Green lines: interplanetary dust flux models at 1AU [10] and 1.5AU [11]. Blue crosses: results from dust detection by spacecrafts at 1 AU [12 - 15].