Micro-nano impact features on the surface of an Itokawa particle, RA-QD02-0265.

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Introduction: We studied a particle Extra-0013, which was not picked up by a normal procedure from the Hayabusa sample catcher. The particle was found unexpectedly on an Au SEM holder. After detailed investigations, the particle was confirmed as one of Itokawa particles and named as RA-QD02-0265. Observation of the surface of RA-QD02-0265 by FE-SEM shows anomalous number of micro-impact features.

In this paper, we show the result of chemical composition analysis of RA-QD02-0265 by FE-EPMA, and also show the result of observation of the impact features on the surface of the particle by FE-SEM.

RA-QD02-0265: Samples unexpectedly found during the manipulations and do not have records of picking up from a Quartz Disk or a sample catcher were named EXTRA particles and excluded from the normal list of Hayabusa-returned samples. The particle, named Extra-0013, is around 20 μm along the long axis, and is mainly composed of high-Ca pyroxene, olivine and plagioclase. There are two distinct parts in the particle, a large high-Ca pyroxene crystal part and the aggregate part made of small particles of high-Ca pyroxenes, olivines and plagioclases. The particle was divided into two pieces by FIB in order to obtain the smooth surface, and analyzed by FE-EPMA at JEOL. The result showed that the distribution of chemical composition of high-Ca pyroxene crystals in the particle agrees well to the diopsides found in LL6 chondrites and in Itokawa particles analyzed by the preliminary examination [1]. This particle was named as RA-QD02-0265 after the analysis, and listed in the normal sample list of the Hayabusa-returned samples.

Surface observation: Before cutting by FIB, the surface of the particle was precisely observed by FE-SEM. The observation appears that anomalous number of the impact features, micro-nano impact craters and impact-melted iron-sulfide. Six micro-nano impact craters were reported in the preliminary examinations [2]. However, such craters have not been found in other Itokawa particles so far. On the surface of RA-QD02-0265, 15 craters were found on the surface of the largest pyroxene crystal. The diameter of these craters ranges from 250 nm to 500 nm, and most of them are surrounded by a droplet-array. The craters are heterogeneously distributed on the surface of the particle, and 12 craters were found within 5 μm^2 area of the surface of the pyroxene crystal. In addition to the craters, there are amount of iron-sulfides on the surface of the pyroxene crystal. The size of the iron-sulfides ranges from less than 100 nm to larger than 1 μm. Some iron-sulfides show melt-splashed shape, indicating high velocity impact after melting of the sulfide. It is interesting that the surface of the large pyroxene crystal which contains micro-nano craters and iron-sulfide droplets shows sharp steps. It indicates that the surface is relatively fresh, and the duration of exposure to the space would be short. The high number density of the impact-feature on such a fresh surface and small area suggest a bombardment of a cluster of tiny particles in a short period on the surface of the particle. It indicates highly heterogeneous spatial distribution of such small dust particles in the interplanetary space.

References: [1] Nakamura et al. 2011. *Science 333*:1113-1116. [2] Nakamura et al. 2012 PNAS, 109, E624。