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イトカワ試料の形態的特徴と希ガス同位体組成との関係
Relationships between morphological features and isotopic signatures of noble gases of four Itokawa particles

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Introduction: Fine-grained particles of the asteroid Itokawa preserve the effects related to the processes on and near the surface of an asteroid. Various types of surface modification were found on the very surface (<100 nm) [1-6]. The modification textures suggest that irradiation by solar wind (SW) plays an important role for their formation. Number density of solar flare tracks in them ranges from a few $\times 10^9$ to a few $\times 10^{10}$ tracks/cm^2 [2, 5], which are considerably lower than expected. These data suggest the mechanisms and periods of the surface modification of Itokawa grains are still unresolved. In addition to the SW irradiation, there seems to have been another mechanism that modified the morphology and surface features of the grains. Matsumoto et al. [3] found some Itokawa grains were aggregates composed of subgrains with stepped surfaces, which suggests evaporation and/or condensation. Noble gas mass spectrometry is another tool to infer the individual history of each Itokawa grain. Nagao et al. [7] argued that a grain experienced multiple processes: exposure to SW, burial in the regolith layer, and removal of its external surface. We intend to investigate the relationships among morphology, surface modifications, and noble gas isotopic signatures to discuss the history of each Itokawa particle from various perspectives.

Samples and methods:. We fixed four Itokawa particles on tantalum plates by acetone-soluble glue. We observed the surface of the particles and prepared thin foils by FIB-SEM at Ibaraki University. After preparation of FIB foils, all the Ta plates with samples rinsed by acetone in a N_2 filled glove box. They were transferred to Kyushu University and noble gas mass spectrometry was performed for all the noble gas elements using a modified VG-5400. Noble gas extraction from each sample was conducted stepwise at 50, 100, 200, 300, 600 and 1400 ℃.

Results and discussion:. SEM observation of the four Itokawa grains investigated shows various morphology and surface features. Edges observed on the surfaces of three grains vary from sharp to dull. Additionally, one grain is composed of two subgrains with stepped surfaces. Morphology and surface features are related to the He release patterns. The three particles have similar ^{4}He release patterns; they release most ^{4}He below 200 ℃ fractions and a small amount of ^{4}He above 600 ℃. Although the gas-release profiles are similar to each other, there is a difference in the bulk concentrations of ^{4}He; one of the three grain having dull edges contain more abundant ^{4}He than the others having sharp edges. Because bulk ^{3}He/^{4}He ratios in the three grains are 2.5 to 6.5×10^{-4}, which is comparable with that in the solar wind of 4.57×10^{-4} [8], it is likely that the implanted He in the grains increased as the surfaces were degraded by solar wind sputtering. On the other hand, the grain composed of subgrains with stepped surfaces shows a different ^{4}He release pattern; ^{4}He was released only below 200 ℃. This fact suggests that deeply implanted He, which is probably related to He released above 600 ℃, was completely reset by severe heating. The steps on the surfaces of this grain may have been formed by evaporation and/or evaporation and subsequent recondensation by a heating event, which released He from the interior of the grain. These results strongly suggest that micrometer-size surface features are related to the amounts and the release patterns of the implanted He.

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