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SEM AND STEM OBSERVATION OF THE SURFACES OF THE FINE-GRAINED PARTICLES RETRIEVED FROM THE ASTEROID ITOKAWA

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Surface materials on airless solar system bodies exposed to interplanetary space are gradually changed their visible to near-infrared reflectance spectra by the process called space weathering, which makes the spectra darker and redder. Hapke et al. proposed a model of space weathering: vapor deposition of nanophase reduced iron ($npFe^0$) on the surfaces of the grains within the very surface of lunar regolith. This model has been proved by detailed observation of the surfaces of the lunar soil grains by transmission electron microscope (TEM). The $npFe^0$ was formed by a combination of vapor deposition and irradiation effects. In other words, both micrometeorite impacts and irradiation by solar wind and galactic cosmic ray play roles on the space weathering on the Moon.

Because there is a continuum of reflectance spectra from those of Q-type asteroids (almost the same as those of ordinary chondrites) to those of S-type asteroids, it is strongly suggested that reflectance spectra of asteroids composed of ordinary chondrite-like materials were modified over time to those of S-type asteroids due to space weathering. It is predicted that a small amount of $npFe^0$ on the surface of grains in the asteroidal regolith composed of ordinary chondrite-like materials is the main agent of asteroidal space weathering. Detailed global measurements of reflectance spectra of Itokawa were performed by Hayabusa revealed that a sub-kilometer-sized small asteroid Itokawa experienced space weathering. Hiroi et al. (2006) discovered that the dark areas are more space-weathering than the bright areas. They estimated the former contains 0.069 vol.% $npFe^0$ and the latter 0.031 vol.% $npFe^0$ if the surface of Itokawa is composed of LL5-6-like materials. The main purpose of this study is to identify the direct evidence of space weathering on the surface of the fine-grained particles retrieved from the MUSES-C regio on 19 and 25 November 2005 UTC.

Among the particles in the room A of the sample catcher of the Hayabusa sample container, we used several particles for this study. Ultrathin sections of a few particles are prepared by an ultramicrotome set in a N_2-purged grove box and transferred into a scanning TEM (STEM) at the Hitachi High-Technologies Corporation to prevent to contact them with the earth's atmosphere. The others are prepared by an ultramicrotome set in the earth's atmosphere. We also made ultrathin sections of a fine-grained lunar soil grain collected by Apollo 15 to compare the surface texture of the fine-grained Itokawa particles. We also observed the surfaces of about 20 lunar soil grains to compare their surface morphology with those of the Itokawa particles.

Back-scattered images of typical fine-grained particles from the asteroid Itokawa and the Moon show that both particles are angular and fragmental. However, the Itokawa particle does not show any evidence of remarkable melting. Some fine-grained particles of Itokawa have multiple steps (each step has about 1 micrometer in width and height), which are very similar to fresh fracture surfaces of olivine and pyroxene when we lightly crush them. Therefore, fine-grained particles retrieved from the MUSES-C regio seem to have experienced the least surface modification after their formation. On the other hand, lunar soil grains show vesicles or walls of vesicles and reduced iron globules in glass. The lunar soil grains investigated in this study are composed of a mixture of vesiculated glass and embedded mineral fragments. By our rehearsal STEM observation, we easily identified $npFe^0$ on the surface of the lunar soil grain. Initial STEM observation of the fine-grained particles retrieved from Itokawa is now on progress. We will show the comparison of the surface microstructure between the Itokawa grains and the lunar soil grains.

Keywords: Itokawa, SEM, STEM, Space weathering