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Surface micromorphology of regolith particles from Asteroid Itokawa: Implication for space weathering of regolith

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Spectral features of airless bodies are known to be modified by processes called space weathering. From Analysis of lunar samples, the space weathering is considered to be caused by mainly nano phase iron (npFe^0) formed by mainly vapor deposition produced by micrometeorite bombardments and solar wind irradiation [1].Space weathering of asteroid is also considered to progress by mainly solar wind irradiation and micrometeorite bombardments [1]. Detailed Space weathering processes on asteroids are expected to be revealed by analysis of asteroidal regolith samples. Hayabusa spacecraft recovered regolith particles from S-type asteroid 25143 Itokawa. In previous study, implantation of solar wind to Itokawa regolith particles was detected by noble gas isotope analysis [2]. The space weathering rims including npFe^0 were observed on regolith particles using transmission electron microscopes [3][4]. Surface micromorphology of regolith particles are expected to have information to reveal space weathering processes related to surface activity on Itokawa and applied to. So far, general surface features of regolith particles have not yet been clearly understood. Therefore, this study investigates Itokawa regolith particles focusing on their surface micromorphology.

Three-dimensional (3D) external shapes of the regolith particles were analyzed by microtomography. Surface morphologies of the regolith particles were observed by field-emission scanning electron microscopy (FE-SEM). It is revealed that the regolith surfaces can be classified into fractured surfaces formed by impact and surfaces formed by condensation from vapor in microdruses of original chondritic materials. Regardless of these surface types, there are matured surfaces, which have rounded edges. The matured surfaces are considered to be formed by abrasion processes on Itokawa [5]. Internal structures of space weathering rim of regolith particles was observed by transmission electron microscopy (TEM/STEM) and this was compared with the surface morphologies of the same surface observed by FE-SEM. Observed space weathering rim have vesicles and form blister structures. The blisters can be identified by FE-SEM, indicating that space weathering rims with blisters can be observed by FE-SEM without any destructive methods. Space weathering processes related to the surface activities on Itokawa is considered from observation of blister distribution on the regolith particles. It is revealed that there is no correlation between blister distribution and the roundness of the surface morphologies, indicating that dominant mechanism of the abrasion process is not solar wind sputtering but mechanical abrasion. The abrasion processes can peel off the space weathering rims. In addition, there are heterogeneous distribution of blisters suggesting migration and fragmentation of regolith particles. Two distinct time-scales for the spectral reddening of S-type asteroids due to space weathering were proposed [7]: solar wind irradiation for about 10^6 years and micrometeorite bombardment for about 10^9 years. This study proposes that spectral change of Asteroid Itokawa by space weathering would have gradually occurred for 10^6 years at the latest by regolith activities on Asteroid Itokawa such as mechanical abrasion, migration and fragmentation of regolith particles, while space weathering rims are developed on local surface of individual regolith particles for 10^3-10^4 years[4].

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