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# Spectral evolution of s-type asteroids suggested by principal component analysis of multi-band images of Itokawa

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**Objective**

Itokawa is covered with materials from the same initial material with different degree of space weathering[1,2]. However, it has not been verified sufficiently if there is other factors that change the spectra. Our analyses of principal component analysis (PCA) using multi-band images taken by Hayabsa's AMICA (Asteroid Multi-band Imaging CAmera) so far have provided the results that a component of spectral reddening, a typical trend of space weathering effect, is the first principal component (PC1) with comparison to laser-irradiated meteorites spectra. The comparison with main-belt asteroids suggests how the spectra of the asteroids develop in their PC space with weathering (by micrometeorites bombardment[3])[4]. However, further analysis had been impeded by electromagnetic noise. In this study, we remove the noise and examine spectral change trends caused by processes other than space weathering.

**Methods**

We used 2 sets of images of six visible bands (Central wavelengths of 381, 429, 553, 700, 861, 960 nm) taken by AMICA. Periodic electromagnetic noise is imposed on most of the images. We removed it by subtracting superposition of sine waves. The images were calibrated following [4] and coresistrated. Normalized ratio images were obtained by dividing the images by those of 553 nm.

We performed PCA on the normalized reflectance spectra. We used a set of images of a Itokawa semisphere and another set including a dark rock (Black Boulder). Shock darkening is indicated as a possible origin of it [5].

We also performed PCA on spectra of main-belt asteroids obtained in ECAS [6] and each Itokawa spectrum superimposed. Because AMICA and ECAS filter wavelengths are approximately same, we can compare the Itokawa surface in the PC space defined by ECAS data set.

**Results**

The PC1 of spectra of only Itokawa had a shape rising to the right with a steep rise in 430-700nm. The PC1 score spatial distribution was consistent with the distribution of space weathering degree obtained by [7]. PC2 had positive coefficients at the wavelengths except 553nm, and the spectrum shape was upward to both sides. The PC2 is different from sillicate spectra, therefore interpretation in a context of material science is difficult. We found a feature that PC1 score is low and PC2 score high in boulder-rich regions, but the muximum area of PC2 score lay around a boulder where PC1 score were minimum. Proportion of variance of PC1 and PC2 was 60-75% and 20-30%.

In the ECAS-defined PC space, the spectra of Black Boulder were distributed apart from the cluster of the other parts.

**Discussion**

The proportions of variance of PC1 and PC2 would suggest that the heterogeneity in Itokawa surface spectrum is dominated by two processes. The PC1 and PC2 score distribution might suggest that the process which changes PC2 score occurs where space weathering has moderately developed. We have observed only a part of the surface, and features observed in a global analysis will be reported in our presentation.

The fact Black Boulder spectral trend is different from that of the other parts suggests that another process than space weathering (shock darkening is a candidate) is the origin of its peculiar spectrum.

In this analysis, another trend than the general space weathering was captured. Consideration of an evolution caused by larger impacts together as well as the space weathering caused by micrometeorites bombardment may enable us to constrain the spectral evolution processes of asteroids and derive relationships among asteroids of different spectral classes.

**References**

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