ORIGIN OF SURFACE ALBEDO/COLOR VARIATION ON RUBBLE-PILE ITOKAWA: S. Sasaki[1], M. Ishiguro[2], N. Hirata[3], T. Hiroi[4], M. Abe[5], S. Abe[6], H. Miyamoto[7], J. Saito[5], A. Yamamoto[8], H. Demura[3], K. Kitazato[5], R. Nakamura[9], [1]RISE Project Office, National Astronomical Observatory of Japan, Oshu, Iwate 023-0861, Japan (sho@miz.nao.ac.jp), [2]School of Earth Environ. Sci., Seoul National Univ., Seoul 151-742, Korea, [3]The Univ. Aizu, Fukushima 965-8580, Japan, [4]Dept. Geol. Sci., Brown Univ., Providence, RI 02912, U.S.A., [5]ISAS/JAXA, Kanagawa 229-8510, Japan, [6]Grad. School Sci. Tech., Kobe Univ., Nada, Kobe 657-8501, Japan, [7]University Museum, Univ. Tokyo, Tokyo 113-0033, Japan, [8]RESTEC, Tokyo 106-0032, Japan, [9]AIST, Ibaraki 305-8568, Japan.

Introduction: Between September and November 2005, Japanese asteroid explorer Hayabusa observed S-type asteroid (25413) Itokawa [1], a small S-type near Earth asteroid (550m x 300m x 240m). Hayabusa has Asteroid Multiband Imaging CAmera (AMICA) and Near Infrared Spectrometer (NIRS). AMICA has a wide bandpass filter and seven ECAS narrowband filters 380 (ul), 430 (b), 550 (v), 700 (w), 860 (x), 960 (p), and 1010 nm (zs) [2]. Spectral range of NIRS is from 760 to 2100nm. From 7km, AMICA observed the whole Itokawa with resolution 70 cm at solar phase angle within 10 degree. The best resolution during close approaches was less than 1cm [2].

Albedo/color variations on Itokawa: As shown in Fig. 1 (from b-v-w bands), Itokawa is heterogeneous in both albedo and color [2]. The albedo difference is approximately 10-20% from 7km distance and as high as 30% on close-up images. Brighter areas usually correspond to at locally elevated zones and at gravitationally steep zones like Shirakami on Itokawa's head [3]. As seen in Fig. 2 for example, brighter zones occupy rims of polygonal features on Itokawa, which are distinct around both ends of the long axis of Itokawa. Gravitationally steep zones are not always bright. Brighter areas are usually bluer and darker areas are redder in color [3, 4, 5]. No previously observed asteroids show such large variations in both albedo and color [5]. These variations can be explained b the space weathering process [5,6] on LL (probably LL6) chondrite composition [7]. X-ray spectrometer observation also supports ordinary chondrite composition of Itokawa [8].

Figure 3 is a close-up image at the northern rim of Little Woomera. As seen in the left-hand side of Fig. 2, Little Woomera is a depressed region at the end of Itokawa's body; it is probably a. remnant of impact feature. In Fig.3, we observe that a darker surface layer should overlap the brighter area with sharp boundaries. Thickness of dark layer is less than 1m and there are unremoved dark boulders on brigher regions. This feature strongly indicates that the brighter area is formed by the removal of the surface darker materials.

Weathered boulders and experimental confirmation: Figure 4 is a very high resolution (a few cm) image of bouldered surface on a darker rough terrain of Itokawa. There are various size of dark boulders but the surface of lack of fine regolith. On some large boulders, brigher scratches and dots are observed. This feature can be explained if rock surface is thinly weathered by bombardments of micrometerorites and/or solar wind irradiation. Previously the presence of regolith was considered to be essential for the space weathering [9,10]. To similate the space weathering of rocky surface, we irradiated nanosecond pulse laser [11] on meteorite samples of LL and L type chondrites. As shown in Fig. 5, the meteorite surface should be weathered. It is probably because of microscopic porosity of meteorite surface [12].

Space weathering and seismic shaking: From albeodo/color observation [4, 5], detailed surface morphology, and experimental data [11,12], we conclude that the darker materials experienced more space weathering than the brighter materials. After boulder emplacement, Itokawa's surface was weathered by impacts of micrometeorites (and high-energy particles). Then, dark weathered boulder-rich surfaces were removed, leading to the exposure of underlying relatively fresh bright area (Fig. 6). Itokawa shows albedo/color heterogeneity probably because it is too small to be totally covered with regolith-like materials. Smooth areas on Itokawa which are covered with cm-sized pebbles do not show distinct albedo/color variation.

Although there are apparent bright craters which would have been formed and become brighter by direct excavation [13], most of bright areas would not be related to local impact events but recent (probably less than 10Ma) global event(s) since clear brightness difference is spread on all over Itokawa. Seismic shaking or tidal distortion during planetary encounter would be responsible for surface movements of dark bouldered layer. The observed morphology that locally elevated regions like faceted rims are bright could be explained by the seismic shaking, since surface motion at elevated region would be stronger due to concentration of internally propagating waves. The fact that the brighter facets are observed at both ends of Itokawa may be also explained by the shaking process, since at the both ends concentration of propagating waves could be expected and surface escape velocity is lower.

Figure 1 Composite color images of Itokawa using b-, v-, and w-band data. Top: Eastern hemisphere with the Muses Sea. Bottom: Western hemisphere where the left hand side with Yoshinodai boulder is shown in Fig. 2. The contrast adjustment was done for enhancing the color variation [3].

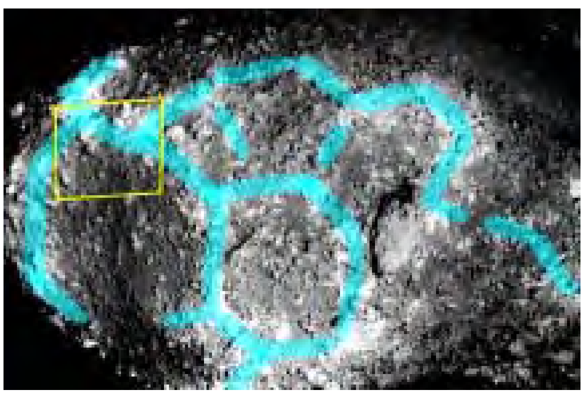

Figure 2 Little Woomera – Yoshinodai zone with faceted polygonal feature. Rims of facets (locally elevated zone denoted by light blue) are usually brighter. A rectangular box is the region of Fig. 3. The brightness contrast is enhanced in this image.

Figure 3 Close-up v-band image of the north region of the Little Woomera. Scale in the figure is 10 m.

Figure 4 High resolution image of surface boulders of Itokawa (image scale being 6m). Boulder surface looks dark with brighter scratches. The surface is lack of fine regolith.

Figure 5 Aritifically space-weathered sample of LL6 Bensour by nanosecond pulse laser irradiation. Darker area was irradiated by 20 mJ pulse laser scanning.

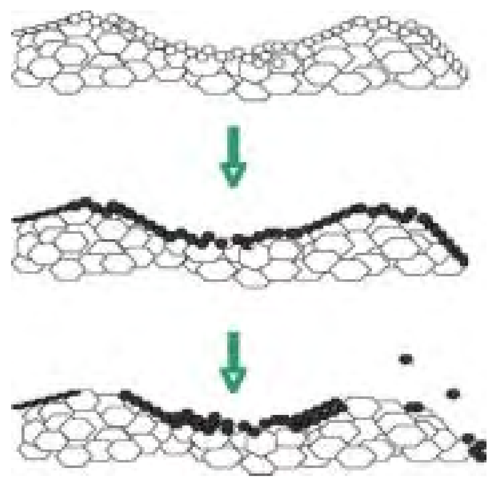

Figure 6 A plausible model of albedo/color heterogeneity on Itokawa. After the surface layer with boulders are weathered and matured, seismic shaking or planetary encounder would move or escape the surface dark materials. As a result, underlying fresh bright materials are excavated.

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