DETECTION OF A LARGE VARIATION IN THE DEGREE OF SPACE WEATHERING ON THE SURFACE OF ITOKAWA BY HAYABUSA/AMICA OBSERVATIONS. M. Ishiguro[1], T. Hiroi[2], D. J. Tholen[3], A. Yamamoto[4], S. Sasaki[5], F. Yoshida[6] , B. E. Clark[7], R. Nakamura[8] and J. Saito[9] , [1]School of Earth Environmental Sciences College of Natural Sciences, Seoul National University, Seoul 151-742, KOREA (ishiguro@planeta.sci.isas.jaxa.jp), [2]Department of Geological Science, Brown University, Providence, RI 02912, U.S.A., [3]Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, HI 96822, U.S.A., [4]Remote Sensing Technology Center of Japan (RESTEC), 1-9-9, Roppongi, Tokyo 106-0032, JAPAN, [5]Mizusawa Astrogeodynamics Observatory, National Astronomical Observatory of Japan, Mizusawa 023-0861, JAPAN, [6]National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588 JAPAN, [7]Physics Department, Ithaca College, Ithaca, NY 14850, U.S.A., [8]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba 305-8568, JAPAN, [9]Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA), Sagamihara, Kanagawa 229-8510, JAPAN

Introduction: A discrepancy of the reflectance spectra between ordinary chondrites and S-type asteroids would be explained by space weathering, which is caused by the impact of micrometrorite and/or solar wind irradiation [1-3]. In the previous mission targets, the space-weathering effect was observed on the surfaces of S-type asteroids 951 Gaspra, 243 Ida, and 433 Eros [4-5], whose diameters are larger than 10km. From spectral slopes of near-Earth asteroids obtained through groundbased telescopes, it was suggested that the transition from ordinary chondrite-like objects to S-type asteroids exists over the size range of 0.1 to 5km [6]. Thus, close-up color observations of sub-km to km asteroids could provide the new understandings of space-weathering process. A unique chance has opened up; Hayabusa spacecraft rendezvoused the sub-km S-type asteroid 25143 Itokawa and performed a color imaging using its onboard camera. In this report, we present maps of spectral slope and space-weathering index, which has been proposed by [7].

AMICA Observations of Itokawa: AMICA is the Asteroid Multiband Imaging CAmera onboard Hayabusa spacecraft, which rendezvoused with the near-Earth asteroid Itokawa on September 12, 2005. AMICA is equipped with seven narrowband filters for the scientific observations as well as a wide-band filter for the optical navigation [8]. The filter system of narrowband filters is nearly equivalent to that of Eight Color Asteroid Survey (ECAS) system [9-10], that is, the designed effective wavelengths using solar incident light are 0.38 μm (ul band), 0.43 μm (b band), 0.55 μm (v band), 0.70 μm (w band), 0.86 μm (x band), 0.96 μm (p band), and 1.01 μm (zs band). We have obtained the multi-color images of Itokawa at the solar phase angles between 0 and 35 degrees during nearly 2-month observation period.

Image Processing: To derive the space-weathering map of Itokawa, we focus on the analysis of AMICA data in the b, v, and w bands. First, smear flux is subtracted from original images. In some cases, the smear operations were done onboard, and otherwise we calculated it using the observed flux of Itokawa itself. The obtained data were divided by the preflight flat-field data in order to correct the uneven sensitivity of pixels and vignetting. Irreproducible stripe patterns, which are induced by the electrical interference with the other devices onboard, were subtracted by fitting them with sinusoidal curves. Flux calibration was performed using both ground-based observations of Itokawa by the ECAS filter system and AMICA data around the phase angle of 30 degrees. Here we assume that the filter system of AMICA in the b, v, and w bands are identical to the standard ECAS system.

Results: Fig. 1 shows a false-color map indicating the ratio of the w-band intensity to the b-band intensity. This map indicates that the surface of Itokawa is generally categorized into bright bluish terrain and dark reddish region, which has already been pointed out by [11]. It is important to note that the color variation and the reflectance are subject to the effects of variation in grain size and viewing geometry as well as the degree of space weathering.

In order to produce more accurate space-weathering maps which are mostly free from the above effects, we adopt the following space-weathering index, newly developed by [7]:

$$Cv = \frac{(1 - R_v / R_w)}{\lambda_w - \lambda_v} - \frac{(R_v / R_w - R_b / R_w)}{\lambda_v - \lambda_b},$$

where R_b, R_v, and R_w indicate the reduced intensities, and λ_b, λ_v, and λ_w indicate the effective wavelengths of the b, v, and w filters, respectively. The resultant images are shown in Fig. 2 (global map) and Fig. 3 (close-up image). In these maps, fresher areas should look bluer, and weathered areas redder. The Cv index is valid in estimating the degree of space weathering of similar materials if the solar incidence angle is not extremely large (~60 degrees) [7].

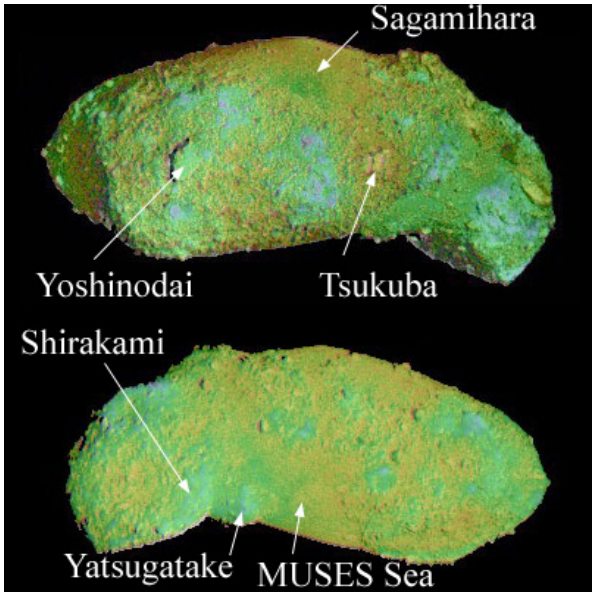

Fig. 1. False color images of both hemispheres. Intensity is modulated by an underlying w-band image, and R_w/R_b ratio is shown in false color as hue.

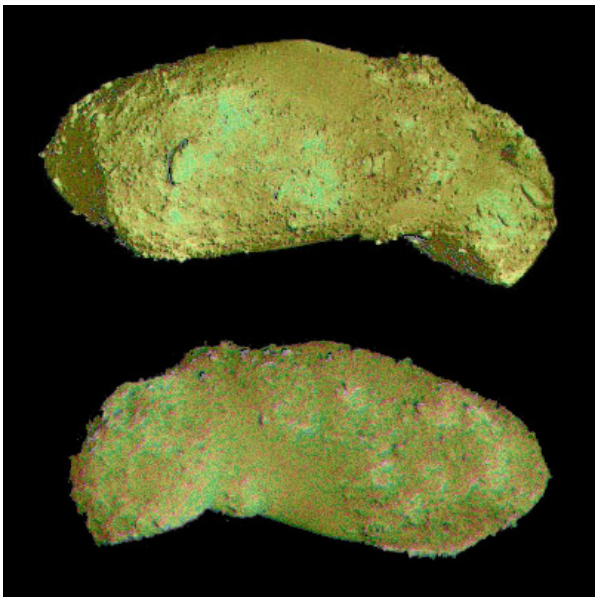

Fig. 2. Space-weathering index (Cv) map overlaying w-band image.

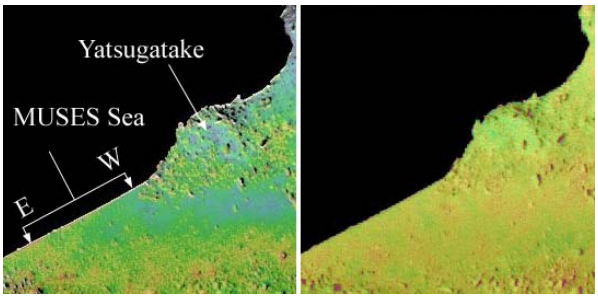

Fig. 3. Close-up view of R_w/R_b (left) and Cv (right) around MUSES Sea and Yatsugatake.

Discussion: It is clear in Fig. 2 that some pristine areas are found in regions with steeper slopes (*e.g.*, Shirakami) and local highs (*e.g.*, Yoshinodai). From this, it is inferred that they might be subterranean fresh materials exposed after thin weathered layer was removed by impact or gravitationally slipped off.

The circular area surrounding the Tsukuba boulders is uniformly very reddish in R_w/R_b (Fig. 1 top) and also very dark in the Cv index (Fig. 2 top). This area may have a mature regolith deposit. Detailed characterization such as this would have to wait for further analysis using higher-resolution maps.

While most brighter and bluer areas in the R_w/R_b map in Fig. 1 correspond to fresher areas in Fig. 2, some regions show unusual trends. In the top map of Fig. 1 there are deep-green areas such as Sagamihara and the area east of Tsukuba. These areas have intermediate spectral slope but do not show any clear color in the Cv index in Fig. 2, except looking a little brighter in the area east of Tsukuba. They may correspond to areas of intermediate freshness if not due to the influence of viewing geometry.

In Fig. 3, MUSES Sea appears to change in color from bluer in the western (Yatsugatake) side to redder in the eastern (boulder-rich) side in the R_w/R_b map. However, in the Cv map, MUSES Sea appears to be mostly space-weathered. The cause of this east-west variation in color and brightness of MUSES Sea may be either grain size or freshness change. In the latter case, the change may be too subtle to detect using the Cv index.

Conclusion: We have identified fresh and space-weathered areas on Itokawa. Estimating the degree of space weathering in some areas, especially MUSES Sea, requires further analysis.

Acknowledgment: We would like to thank all members of Hayabusa mission, especially Tatsuaki Hashimoto and Takashi Kubota, for their kind support of the development and the data acquisition of AMICA.

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