SURVEY OF CRATERS AND IMPACT STRUCTURES ON THE ASTEROID ITOKAWA. [1]N. Hirata, [2]C. Honda, [3]R. Nakamura, [4]H. Miyamoto, [5]S. Sasaki, [1]H. Demura, [6]A. M. Nakamura, [7]T. Michikami, [8]O. S. Barnouin-Jha, [9]R. W. Gaskell and [2]Jun Saito, [1]Department of Computer Software, The University of Aizu (Ikki-machi, Aizu-Wakamatsu, Fukushima, 965-8580, JAPAN, e-mail: naru@u-aizu.ac.jp), [2]Institute of Space and Astronautical Sciences, Japan Aerospace Exploration Agency, [3]National Institute of Advanced Science and Technology, [4]The University Museum, The University of Tokyo, [5]RISE project office, Mizusawa Astrogeodynamic Observatory, National Astronomical Observatory of Japan, [6]Graduate School of Science and Technology, Kobe University, [7]Fukushima National College of Technology, [8]Applied Physics Laboratory, The Johns Hopkins University, [9]Planetary Science Institute.

Introduction: The asteroid 25143 Itokawa is the smallest asteroid that has ever been observed by spacecraft. Even along the longest axis, the size is only about 500 m [1-2]. Observations of Itokawa by the HAYABUSA spacecraft reveal various features on the asteroid, such as a characteristic global shape resembling a sea otter [1], rough terrains consisting of numerous boulders, and smooth terrains covering by fine materials [3-4]. The estimated bulk density is very low (1.95 g/cm3), in comparison with other S-type asteroids [5]. From these pieces of evidence, Itokawa is considered to be a rubble-pile body [1, 6].

Because impact cratering is thought to have been the dominant process affecting asteroids, the survey of impact craters on Itokawa is one of the most important aims of the HAYABUSA mission. Morphology of craters gives information on the physical conditions of the surface materials, and the structure of the asteroid interior. Also geologic process on asteroid may modify crater morphology from the original state. The diameter-frequency statistics of craters is not only a basis of crater chronology, but also a clue to the size distribution of small bodies in the solar system. Here we report results on survey of craters and impact structures on Itokawa.

Criteria for Crater Survey: High-resolution images from HAYABUSA revealed that there are many unfamiliar features on Itokawa, relative to those found on previously explored asteroids [3]. There are no classical 'Bowl-shaped' craters. Considering impact history of Itokawa, however, it is natural that some of them were formed by hypervelocity impact. We examine high-resolution images from the Hayabusa mission to survey craters or impact structures on Itokawa. We also employed the shape model of Itokawa for the survey. A precise shape model of Itokawa was constructed by applying multi-image photoclinometry to over 600 Hayabusa AMICA images [7]. Synthetic images of Itokawa can be generated from the shape model at any preferred viewing angles and at any preferred illumination conditions.

We surveyed circular depressions on Itokawa as candidate for impact craters. The term "depression" includes not only a concave feature, but also a facet-like feature; at the edge of that feature, the surface curvature changes smaller (flatter) than that of surroundings, even though that feature actually is flat or convex. Circular features with a flat, convex or saddle-shaped floor are included into the list of crater candidates. Other than topographic features, circular features with smooth floors are also included in crater candidates. Early reports on Itokawa suggest that gravitational movement of finer materials leads to formation of deposits with smooth surface at local or global low regions [1, 3, 8]. Several circular features with smooth surface found on Itokawa are akin to ponded deposits on Eros [9], and they are possibly circular depressions filled with finer materials.

Morphologies of Crater Candidates: 37 crater candidates are identified through the survey. They show a wide variation of morphologies, including a saddle-shaped floor plan, lack of uplifting rim, both rough and smooth floor, exposure of un-weathered materials and lineaments. With careful assessments on possibilities of false recognitions and misinterpretation of non-impact origin features, we concluded that all of candidates are certainly formed by hypervelocity impacts.

Fig. 1 shows the relationship between the depth and the diameter, for crater candidates larger than diameter 10 m. Floor morphology and rim material type are also indicated in this plot. While fresh craters on the Moon have depth-diameter ratios of about 0.2 [10], crater candidates on Itokawa significantly shallow. Because crater candidates of which floor composed of smooth surfaces completely (categorized as type A in Fig. 1) or partially (type P) are extremely shallow, they can be explained as a result of degradation by the movement of finer material. However, considering that candidates with rough floors (type N) have an average depth-diameter ratio 0.09, only half for the lunar craters, additional cause(s) other than a simple degradation would be needed. Similar morphologies are also observed on other asteroids: the depth-diameter ratios of 0.14 for fresh craters on Gaspra [11], 0.15 for fresh craters on Ida [12], and 0.15 for typical craters on Eros [6].

Because almost all crater candidates on Itokawa lack for uplifting rims, that is the one of major causes of shallowness of crater candidates. Because of low gravity, ejecta from a crater on a small asteroid tend to distribute more widely, or escape from the asteroid. Thus, less ejecta would pile up on a rim, and an apparent depth of crater would reduce. While the average rim height-diameter ratio on the fresh lunar craters is 0.04 [10], the lack of uplifting rim would account for about 40 % of the crater shallowing on Itokawa. Consequently, remaining 60 % should be explained by other mechanisms.

Mechanical properties of the surface of Itokawa against impact cratering possibly affect to the initial shape of craters. The rough terrain of Itokawa is covered with numerous boulders. An average thickness of the boulder layer of Itokawa is probably several meters. There are similarities between the near-surface structures of the asteroids and that of the lunar maria where the regolith layer covers basaltic bedrock [12]. A transition of lunar crater morphology was associated with excavation depth and thickness of regolith [13]. When craters are large enough to penetrate both the regolith and the bedrock, their shapes are simple and bowl-shaped. With decrease of the diameter and the excavation depth, the floor shape of craters transform from the simple bowl type to the modified types, such as central-mounded, flat-bottomed, or benched floors. This transition occurs when the excavation depth reaches to the boundary between the weaker regolith layer and the harder bedrock. Consequently, the depth-diameter ratios also change at this transition. Smaller craters then become a simple bowl shape again, because they only excavate the regolith layer. Although we couldn't find any clear trends of morphologic changing on the crater candidates on Itokawa, shallow crater candidates is consistent with an existence of strength contrast between the weaker upper boulder layer and the harder underlying bedrock. Observations on Itokawa that crater candidates smaller than 50 m in diameter become shallower is possibly representative of the first transition from bowl-shaped floors to modified floors observed on the moon. The depth of crater candidates at this transition is about 5 m, which agrees with the thickness of boulder layer inferred from images.

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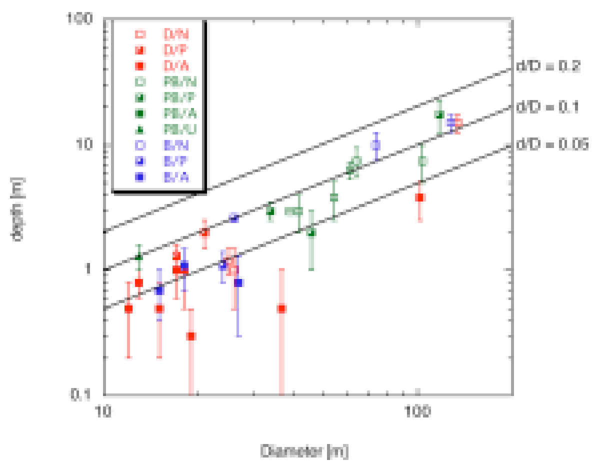

Fig. 1. Depth-diameter plot for crater candidates larger than 10 m on Itokawa. Colors of plots correspond to the types of the rim material (red (labeled as D): dark material, green (labeled as PB): partly bright material, and blue (labeled as B): bright material) and shape of plots indicate the types of the floor morphology (filled squares (labeled as A): almost covered with fine material, half filled squares (labeled as P): partly covered with fine material, and open squares (labeled as N): not covered with fine material). A triangle corresponds to a crater with an unknown floor morphology.