THE SHAPE DISTRIBUTION OF SMALL BOULDERS ON ASTEROID RYUGU. T. Michikami[1] (michikami@hiro.kindai.ac.jp), A. Hagermann[2], T. Morota[3], H. Okamura[1], K. Nomura[4], H. Miyamoto[3], M. Hirabayashi[5], Eri Tatsumi[3], N. Hirata[6], T. Noguchi[7], Y. Cho[3], S. Kameda[8], T. Kouyama[9], Y. Yokota[10], R. Noguchi[10], M. Hayakawa[10], N. Hirata[4], R. Honda[11], M. Matsuoka[10], N. Sakatani[10], H. Suzuki[12],M. Yamada[13],K. Yoshioka[3], H. Sawada[10], R. Hemmi[3], H. Kikuchi[3], S. Sugita[3]. [1]Kindai University, [2]University of Stirling, [3]The University of Tokyo, [4]Kobe University, [5]Auburn University, [6]University of Aizu, [7]Kyushu University, [8]Rikkyo University, [9]National Institute of Advanced Industrial Science and Technology, [10]ISAS/JAXA, [11]Kochi University, [12]Meiji University, [13]Chiba Institute of Technology.

Introduction: In laboratory impact experiments, the shapes of fragments from catastrophic collisions defined by axes *a*, *b* and *c*, these being the maximum dimensions of the fragment in three mutually orthogonal planes ($a \geq b \geq c$), have been found to behave in a very regular way. In catastrophic disruption, the axial ratios of fragments are distributed around mean values of the axial ratios b/a ~0.7 and c/a ~0.5, i.e. corresponding to $a : b : c$ in the simple proportion 2: √2: 1 [1][2][3][4][5][6].

Michikami et al. (2010)[7], who investigated the shape distributions of boulders on Itokawa and Eros, propose that the actual shape distribution of the boulders on any asteroid is similar to laboratory impact fragments. Their hypothesis is shown by the following three observational results [8].

(i) In laboratory impact experiments, fragment shapes from catastrophic disruptions have been found to behave similarly, independent of various experimental conditions and target materials. A recent study shows that this result has been found to be valid for fragments ranging from several tens of microns to several cm [5][6].

(ii) Although only limited data on boulders whose three-axial lengths have been measured are available, the mean b/a and c/a ratios of boulders on Itokawa [5] and Ryugu [8] are similar to laboratory impact fragments. The sizes of these boulders, which are considered to be impact fragments from their parent body, range from several meters to several tens of meters.

(iii) The mean b/a ratios of small- and fast-rotating asteroids, i.e. those with a diameter < 200 m and a rotation period < 1 h, which are considered to be monolith bodies, are similar to laboratory impact fragments [7].

These three observational results strongly suggest that fragment shapes from catastrophic disruptions are independent of their sizes. However, no three-axial lengths of boulders less than several meters have been measured. In this study, we report the shape distribution of boulders with 0.2-2.1m on the surface of Ryugu based on the close-up image near the TD2 site.

Methodology: In this paper, we define a boulder as an isolated positive relief feature. In order to obtain the shape distribution of small boulders on the surface of Ryugu, we analyze ONC close-up images taken by the spacecraft at an altitude of 277 m (resolutions ~2.8 cm/pixel) on 30th May 2019 (near the TD2 site, Fig. 1).

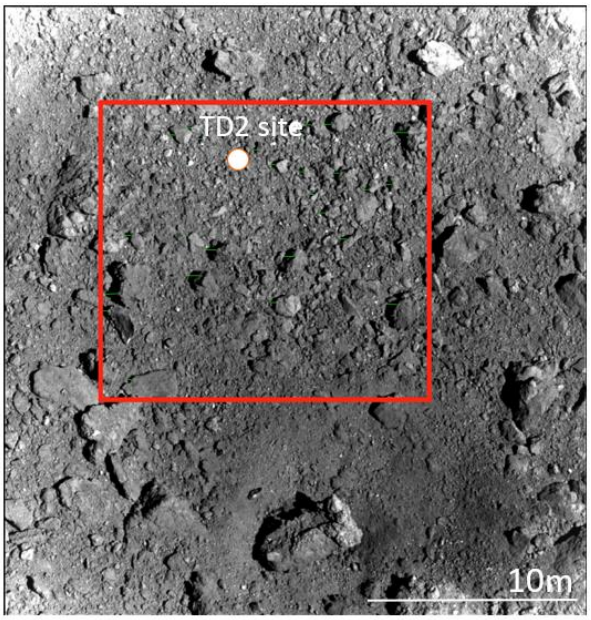

Fig. 1. The close-up image near the TD2 site acquired on 30th May 2019. Boulders on the squared marked area are measured. Image ID: hyb2_onc_20190530_023724_tvf_l2b.fit.

Small boulders with sizes of 0.2 to 2.1 m are mapped out on close-up images on the SAOimage DS9, where we measured the ellipses marked for these (*a* and *b*). Then, we choose some boulders to measure their apparent *c* by assuming that boulders' apparent height above the surface represent their *c* axes. The dimensions of the *c* axes are derived from shadow lengths of the boulders.

Observational results: A diagram of b/a and c/a of 145 boulders is shown in Fig. 2. The shape distribution of the boulders is similar to laboratory impact

fragments in heavier disruptions. The mean apparent axial *b*/*a* and *c*/*a* ratios are ~0.7 and ~0.5, respectively. According to [5]'s impact experiments, mean *c*/*a* ratio around 0.5 is indicative of fragments resulting from catastrophic disruption. This implies that the parent body of Ryugu is likely to have experienced a catastrophic rather than a weak disruption.

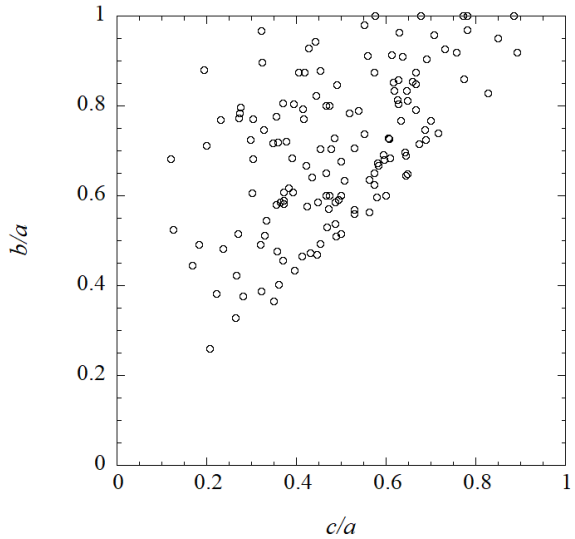

Fig. 2. Shape distribution of 145 boulders with sizes of 0.2 to 2.1m near the TD2 site. The mean *b*/*a* and *c*/*a* ratios are ~0.7 and ~0.5, respectively.

References: [1] Fujiwara et al. (1978) *Nature*, 272, 602-603. [2] Capaccioni et al. (1984) *Nature*, 308, 832-834. [3] Capaccioni et al., (1986) *Icarus*, 66, 487-514. [4] Durda et al., (2015) *Planet. Space Sci*, 107, 77-83. [5] Michikami et al. (2016) *Icarus*, 264, 316-330. [6] Michikami et al. (2018) *Icarus*, 302, 109-125. [7] Michikami et al. (2010) *Icarus*, 207, 277-284. [8] Michikami et al. (2019) *Icarus*, 331, 179-191.