COMPARING CRATER MORPHOLOGIES ON RYUGU AND BENNU. C. M. Ernst[1], R. T. Daly[1], O. S. Barnouin[1], Y. Cho[2], T. Morota[3], Naoyuki Hirata[4], R. Noguchi[5], E. B. Bierhaus[6], M. G. Daly[7], Naru Hirata[8], S. Sugita[2,9], R. W. Gaskell[10], E. E. Palmer[10], J. R. Weirich[10], Y. Shimaki[5], S. Watanabe[3], J. Seabrook[7], M. Kanamaru[11], P. Michel[12], R. Honda[13], S. Kameda[14], E. Tatsumi[2,15], Y. Yokota[5], T. Kouyama[16], H. Suzuki[17], M. Yamada[9], N. Sakatani[5], C. Honda[8], M. Hayakawa[5], K. Yoshioka[2], M. Matsuoka[5], H. Sawada[5], K. Ogawa[5], D. S. Lauretta[18], [1]Johns Hopkins University Applied Physics Laboratory, [2]University of Tokyo, [3]Nagoya University, [4]Kobe University, [5]ISAS/JAXA, [6]Lockheed Martin Space, [7]York University, [8]University of Aizu, [9]Chiba Institute of Technology, [10]Planetary Science Institute, [11]Osaka University, [12]Observatoire de la Côte d'Azur, [13]Kochi University, [14]Rikkyo University, [15]University of La Laguna, [16]National Inst. of Advanced Industrial Science and Technology, [17]Meiji University, [18]Lunar and Planetary Laboratory, University of Arizona.

Introduction: Hayabusa2 arrived at the ~1-km-diameter asteroid Ryugu in late June 2018. OSIRIS-REx arrived at the ~500-m-diameter asteroid Bennu in December 2018. The concurrent exploration of these two small, top-shaped, carbonaceous asteroids has provided an extraordinary opportunity to enhance our insights by cross comparison. Optical Navigation Camera (ONC) and OSIRIS-REx Camera Suite (OCAMS) images revealed dozens of craters and crater candidates across the surfaces of Ryugu and Bennu, respectively [1–4]. We use ONC images and the Hayabusa2 stereophotoclinometry (SPC) shape model [5] to investigate the morphologies of 77 crater candidates ≥ 10 m in diameter [2] on Ryugu, and OCAMS images, OSIRIS-REx Laser Altimeter (OLA) data, and the OSIRIS-REx SPC shape model [6] to investigate the morphologies of 134 crater candidates ≥ 10 m [7] on Bennu.

Previous *d/D* measurements: Work has been done to measure the d/D ratios for craters on both Ryugu [8, 9] and Bennu [7,10]. Craters on Ryugu have *d/D* ranging from 0.03 to 0.21, and those on Bennu have *d/D* ranging from 0.04 to 0.16, with respect to elevation.

Methods: Here, we use the same method to measure crater dimensions and morphology on both asteroids. Eight profiles were taken across high-resolution digital terrain models of each crater candidate measured. Average values for depth, diameter, and rim height were recorded, using multiple methods: profile (combinations of individual profiles were used to measure these parameters) and plane (depth was measured with respect to a plane defined by the ellipse fit to the crater rim). Measurements were taken with respect both to geometric height (a geometric assessment of the shapes of craters without accounting for gravity) and to elevation (defined relative to a reference gravitational potential equivalent to a "geoid", with a correction applied to account for regional slopes). Between 2 and 8 of the profiles were used to measure each crater—some profiles were ruled out due to modification by subsequent craters, severe surface slopes, difficulty identifying a crater rim, or the presence of large blocks. Figure 1 shows an example of the measurements made for each crater.

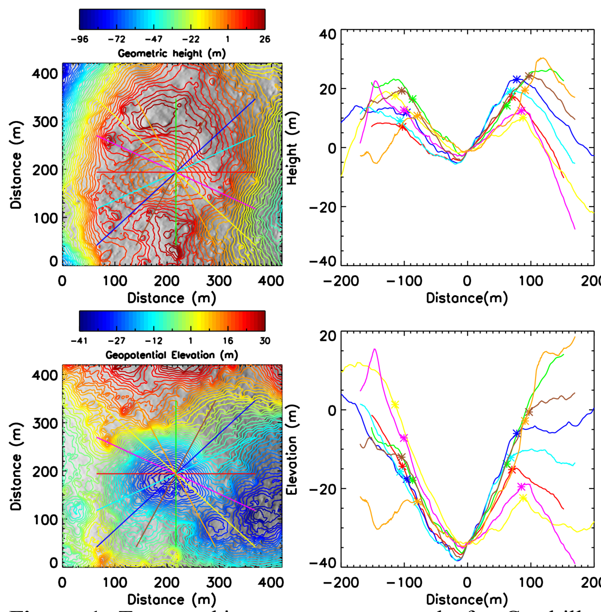

Figure 1. Topographic measurements made for Cendrillon crater (~185 m in diameter) on Ryugu. Left: The local digital terrain model with 8 profiles overlain, and the geometric height (top) or elevation (bottom) versus distance for those profiles. Right: Distance versus height (top) or elevation (bottom) for the eight profiles, showing the location of the rims (asterisks).

Preliminary Results: The craters of Ryugu and Bennu are more difficult to measure than those typically measured on larger asteroids and other planetary surfaces. The blocky surface, degraded nature of many of the craters, and significant slopes/curvature make measurements and even identification of craters difficult.

Despite these difficulties, we were able to measure useful diameter-depth relationships on both bodies. Figure 2 compares the depths and diameters of craters on Ryugu and Bennu. Generally speaking, the populations of Ryugu and Bennu sit atop one another when measured with respect to geometric height. Some differences can be seen at larger crater diameters (>120 m) when measured with respect to slope-corrected elevation: Bennu's appear shallower relative to Ryugu's. The low *d/D* values for Bennu's largest craters (Figure 2F) suggest that body curvature may in part be responsible, as

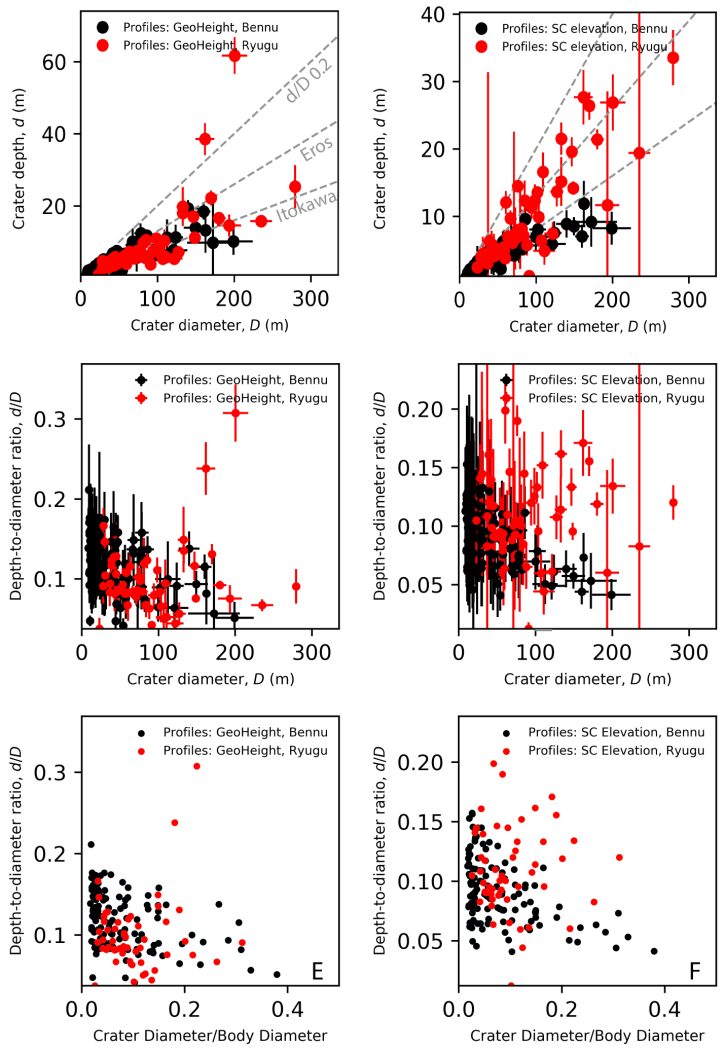

Figure 2. (A,B) The diameters and depths of analyzed craters larger than 10 m on Ryugu (black) and Bennu (red), with depth measured with respect to geometric height or slope-corrected elevation, respectively. Dashed lines in (A,B) indicate the *d/D* ratios for typical terrestrial planets (d=0.2D), the asteroid Eros (d=0.1D) [13], and rubble-pile asteroid Itokawa (d=0.08D) [14]. (C,D) *d/D* as a function of crater diameter, measured with respect to geometric height and slope-corrected elevation, respectively, which emphasizes the tendency for large craters to be shallower, on Bennu in particular. (E,F) *d/D* as a function of the ratio of crater diameter to body diameter.

the same low values are not for the largest Ryugu craters. Other contributors such as crater degradation and interior structure differences cannot yet be ruled out; evidence exits that Bennu possesses some interior stiffness [6] that could also influence crater shape. As the boulder populations of Ryugu and Bennu are similar [11, 12] and the differences are observed at the largest crater diameters, the coarseness of surface grains is likely not a factor. Further analysis will differentiate the crater populations by classification level.

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