GLOBAL AND SELECT REGIONAL SIZE-FREQUENCY DISTRIBUTION OF BOULDERS ON ASTEROID (101955) BENNU. Maurizio Pajola[1], Keara Burke[2], Daniella DellaGiustina[2], Dante S. Lauretta[2], Bashar Rizk[2], Carina Bennett[2], Kevin Walsh[3], Erica Jawin[4], Marco Delbo[5], Jamie L. Molaro[6], Stephen R. Schwartz[2,5], Ron Ballouz[2], John Robert Brucato[7], Elisabetta Dotto[8], Edward B. Bierhaus[9], Humberto Campins[10], Michael Daly[11], Catherine Elder[12], Patrick Michel[5], Olivier Barnouin[13], Michael C. Nolan[2], and the OSIRIS-REx Team. [1]INAF-Astronomical Observatory of Padova, Vic. Osservatorio 5, 35122 Padova, Italy (maurizio.pajola@inaf.it); [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA; [3]Southwest Research Institute, Boulder, CO, USA; [4]Smithsonian Institution, National Museum of Natural History, Washington D.C., USA; [5]Observatoire de la Côte d'Azur, Nice, France; [6]Planetary Science Institute, Tucson, AZ, USA; [7]INAF-Arcetri Astrophysical Observatory, Italy; [8]INAF-Astronomical Observatory of Rome, Italy; [9]Lockheed Martin Space Systems Company, CO, USA; [10]University of Central Florida, Orlando, FL, USA; [11]York University, Toronto, Canada, [12]NASA Jet Propulsion Laboratory, Pasadena, CA, USA; [13]Johns Hopkins Applied Physics Laboratory, Laurel, MD, USA;

Introduction: The OSIRIS-REx mission [1] reached the Apollo-type near-Earth asteroid (101955) Bennu (Fig. 1) on December 3, 2018. Since then, it performed a preliminary survey of the target with five different trajectories crossing over the north and south poles as well as its equatorial areas, at distances between 7.3 and 18.6 km. During this survey the OSIRIS-REx Camera Suite (OCAMS) Polycam instrument [2] returned a wide dataset of high-resolution images with spatial resolution ranging from 0.10 to 0.25 m. This dataset was mainly exploited to provide the 75-cm global shape model of Bennu and to properly define its rotation state [1]. Moreover, it permitted to identify possible latitudinal and longitudinal variegation on its surface, as well as it was used to identify all boulders and hazards located on multiple areas of interest.

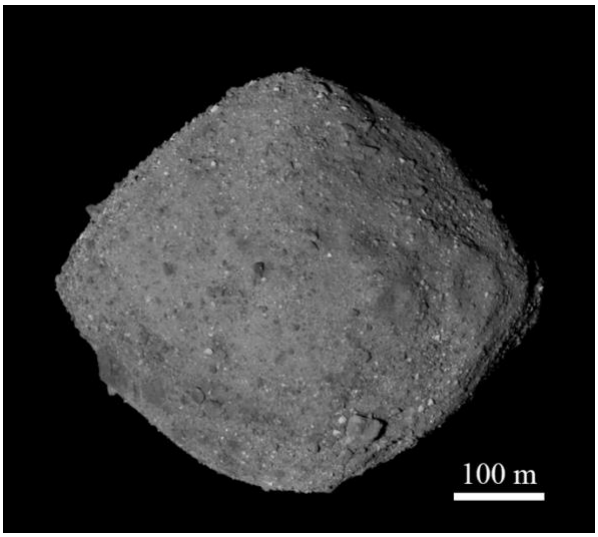

Figure 1: An OCAMS Polycam image of Bennu taken on November 27, 2018, from a distance of 62.6 km and at 08:23:16 UT.

The boulder identification: In order to identify a first list of possible OSIRIS-REx sampling sites on Bennu, we made use of the above mentioned OCAMS Polycam dataset and focused on the identification of all boulders ≥ 1m. We performed this identification through two different methodologies: the first one makes use of the Small Body Mapping Tool (SBMT) developed at the Johns Hopkins University Applied Physics Laboratory [3]. This tool provides the possibility to directly project the high-resolution OCAMS images onto the Bennu shape model [4] and to identify and count surface boulders as ellipses. The resulting tagged boulder area is then used as a proxy for its surface. The size of this area is then automatically extracted from the images and the boulders linear metric size is defined as the diameter of an equal-area circle. The second methodology makes use of ESRI's Geographic Information System software, ArcMap, and enables the identification of the longest axis of boulders on unprojected OCAMS images. Boulder coordinates and lengths are determined by extracting the body-fixed XYZ coordinates from ISIS3 cube backplanes of the images used for identification and calculating the latitude and longitude coordinates.

The boulder size-frequency distribution (SFD): To compare the density of boulders per square kilometer of the different areas, we first measured the studied surfaces from the 3D shape model of Bennu. In a log-log plot we then plotted the cumulative number of boulders per squre kilometer versus boulder sizes in meters for all studied areas. Afterwards, we fitted a regression line to the data and derived the power-law indices of the different distributions as done on multiple other minor bodies of the Solar System [e.g. 5,6]. The power-law indices we obtained, coupled with the densities of boulders per square kilometer provided us the opportunity to quantitatively compare the studied sites from a safety-of-sampling perspective. Moreover, the scientific interpretation of the different power-law indices obtained and their comparison with the Bennu global SFD distribution (Fig. 2) gives us clues about both the formation and degradation processes that occurred and are still occurring on multiple locations of Bennu. Indeed, by studying the obtained power-law

indices, it is possible to suggest if a boulder population is purely impact-related or it may have been heavily degradated through thermal stresses or covered, e.g, by dusty deposits.

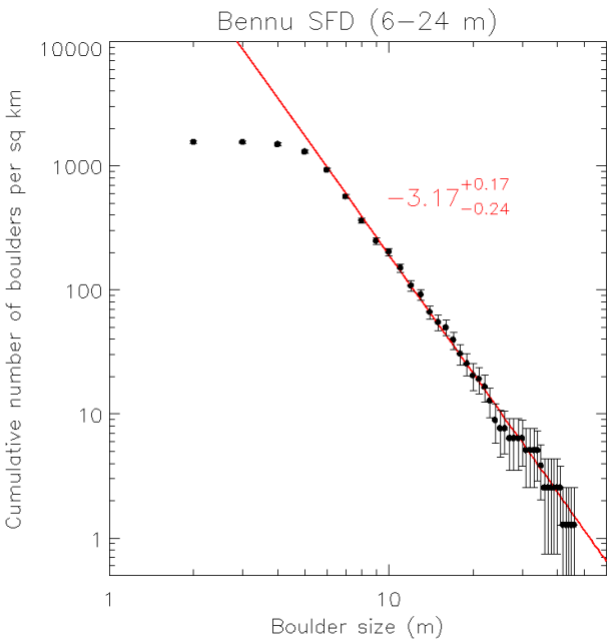

Figure 2: The global cumulative SFD of boulders ≥ 6 m per km^2 of Bennu (6-24 m in size). Vertical error bars indicate the root of the cumulative number of counting boulders divided by the area [6]. The continuous line is a fitted regression line to the data, and the power-law index of the size distribution is -3.17 +0.17/-0.24. The bin size is 1 m.

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References: [1] Lauretta, D.S. et al. (2017), OSIRIS-REx: Sample Return from Asteroid (101955) Bennu. *Space Sci. Rev.* 212: 925-984. [2] Rizk, B. et al. (2018), OCAMS: The OSIRIS-REx Camera Suite. *Space Sci. Rev.* 214:26. [3] Ernst, C.M. et al. (2018), The Small Body Mapping Tool (SBMT) for accessing, visualizing, and analyzing spacecraft data in three dimensions. LPSC #49, 2083. [4] Barnouin et al., LPSC #50, this meeting. [5] Thomas, P. C. et al. (2001). Shoemaker crater as the source of most ejecta blocks on the asteroid 433 Eros. *Nature*, 413, 6853, 393-396. [6] Pajola, M. et al. (2015). Size-frequency distribution of boulders ≥ 7 m on comet 67P/Churyumov-Gerasimenko. *A&A*, 583, A37.