THE ORIENTATIONS OF BOULDERS ON (101955) BENNU'S SURFACE.

S.R. Schwartz[1,2,*], R.-L. Ballouz[1], E. Asphaug[1], O.S. Barnouin[3], C. Bennett[1], K.N. Burke[1], H.C. Connolly, Jr.[4,1], C.Y. Drouet d'Aubigny[1], M. Delbó[2], D.N. DellaGiustina[1], E.R. Jawin[5], M. Jutzi[6], P. Michel[2], H. Miyamoto[7], J.L. Molaro[8], M. Pajola[9], A.C. Quillen[10], B. Rizk[1], D.J. Scheeres[11], S. Sandford[12], K.J. Walsh[13], D.L. Lauretta[1]. [1]Lunar and Planetary Laboratory, University of Arizona ([*]1629 University Blvd., Tucson, AZ 85721, srs@lpl.arizona.edu), [2]UCA-CNRS-Observatoire de la Côte d'Azur, [3]The Johns Hopkins University Applied Physics Laboratory, [4]Rowan University, [5]Smithsonian Institution, [6]University of Bern, [7]University of Tokyo, [8]Planetary Science Institute, [9]INAF-Astronomical Observatory of Padova, [10]University of Rochester, [11]University of Colorado, Boulder, [12]NASA Ames Research Center, [13]Southwest Research Institute.

Introduction: Small energy inputs to the surfaces of rubble-pile asteroids help to orient rocks and boulders in such a way as to minimize their potential energies, namely along lines of local slope. The largest of boulders require greater energy inputs to move toward their optimal energy-minimizing orientations. However, large-scale events may have the effect of pushing small rocks to a more randomized configuration, depending on their granular mechanical properties.

This points to a way, using the global-coverage, high-resolution images from the OSIRIS-REx spacecraft [1,2], to attempt to glean insight into the types and frequencies of processes experienced by (101955) Bennu. Here, we report on global distributions in the orientations of surface rocks, which may relate to the seismic efficiency of the subsurface and to the history of energetic events on Bennu.

Method: Using resolved image data from the Preliminary Survey mission phase [3], we have examined boulder orientation patterns as potential signatures of small-scale events [4,5]. For a region that spans 20° of longitude and about 100° of latitude (around 5% of the surface), we counted boulders by fitting ellipses [6,7] using the Small Body Mapping Tool [8]. This region was chosen to include some specific features of interest and may or may not be representative of the surface as a whole.

The preliminary dataset shown in this abstract suggests a trend for boulders to be oriented with their long ends along the north-south direction (Fig. 1, cyan), which corresponds to the global sloping direction that points towards the equator (a trend also supported by [9]). Further, this figure shows that if we weight the "value" of each boulder by its elongation, the case for this preferential boulder orientation becomes stronger (Fig. 1, purple). Going further still, and using the local dynamical slopes from the OSIRIS-REx Radio Science Working Group based upon shape models from the Altimetry Working Group [10,11], we showed how boulders align themselves in relation to the local dynamic slope.

We will present on results using this and other data, including counts that span most of the surface, and discuss implications.

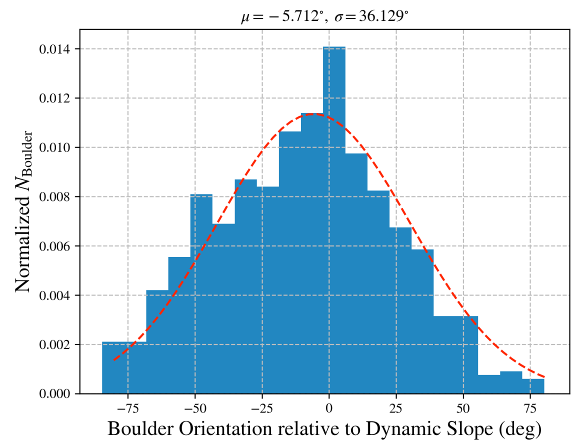

Figure 1: Boulder orientations relative to the local dynamic slope from several hundred counts within a certain 20º longitudinal slice on (101955) Bennu. Orientation angle is defined as the clockwise offset from perfect alignment with local slope (0°).

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References: [1] Lauretta, D.S. et al. (2017) *Space Sci. Rev. 212*, 925–984. [2] Rizk, B. et al. (2018) *Space Sci. Rev. 214*, 26. [3] DellaGiustina, D.N. et al. (2019) *Nat. Astron. 3*, 341–351. [4] Schwartz, S.R. et al. (2018) *AGU 2018*, Abstract #P21A-11. [5] Schwartz, S.R., et al. (2019) *LPSC 2019*, Abstract #2132, 2595. [6] Walsh, K.J. et al. (2019) *Nat. Geosci. 12*, 242–246. [7] Pajola, M. et al. (2018) *AGU 2018*, Abstract #P33C-3854. [8] Ernst, C.M. et al. (2018) *LPSC #49*, 2083. [9] Marshall, J. & Beddingfield, C. (2019) *Asteroid Science in the Age of Hayabusa2 and OSIRIS-REx*, Tucson, AZ (this workshop). [10] Scheeres, D.J. et al. (2019) *Nat. Astron. 3*, 352–361. [11] Barnouin, O.S. et al. (2019) *Nat. Geoscience 12*, 247–252.