IS NORTH-SOUTH BOULDER ALIGNMENT ON BENNU A FUNCTION OF BOULDER SIZE? C. B. Beddingfield[1,2], J. Marshall[1], K. J. Walsh[3], D. S. Lauretta[4], [1]SETI Institute, Mountain View, CA, [2]NASA Ames Research Center, Moffett Field, CA (chloe.b.beddingfield@nasa.gov), [3]Southwest Research Institute, Boulder, CO, [4]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ.

Introduction: NASA's OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer) asteroid sample return mission confirmed that Bennu is a 492-m-diameter, spheroidal, spinning top–shaped asteroid [1]. Bennu is a near-Earth asteroid (NEA), and its density and porosity indicate that it is a rubble pile [2]. Images taken by the OSIRIS-REx Camera Suite (OCAMS) PolyCam instrument [3-5] revealed a surface covered in boulders of various sizes [e.g. 2].

Some of Bennu's boulders are preferentially aligned with N-S orientations [6-8] in the mid-latitude regions. This alignment has been hypothesized to result from surface creep of regolith and/or boulders on Bennu with orientations aligning parallel to the direction of transport [7]. Boulders are expected to align in a preferred orientation when relative motion of adjacent material reorients an elongate object into the position with the least resistance. Bennu's subtle N-S boulder alignment is consistent with equatorward motion of surface material [7-10].

Methodology: We are investigating whether Bennu's aligned boulders have a preferential size. If a preferential size exists, then boulders of this size may be preferentially in motion during surface creep on Bennu.

Boulder orientations were measured in midlatitude and equatorial regions across the surface of Bennu [6-8]. Study areas were chosen to avoid major features, such as craters, where localized boulder movements could overprint a global alignment trend [7]. In this work, we investigated three of these study areas in further detail (Fig. 1).

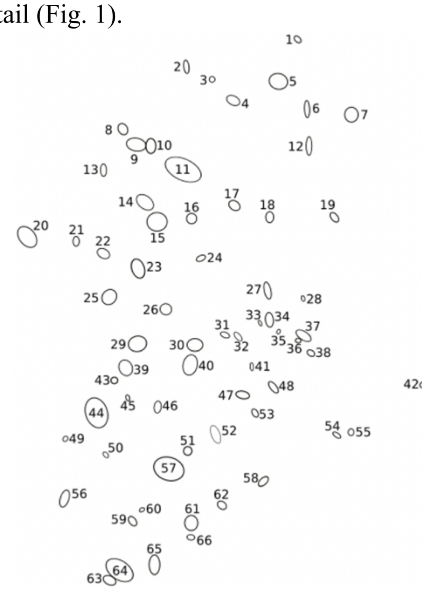

Figure 2: Example of ellipses that were fit to boulders in Study Area B. The orientations and diameters of the boulders were measured from the long axes of these ellipses. North is up in this figure.

These boulders were analyzed and measured by first manually fitting an ellipse to each boulder in an image in each study area (Fig. 2). All images used were PolyCam images without high incidence angles which

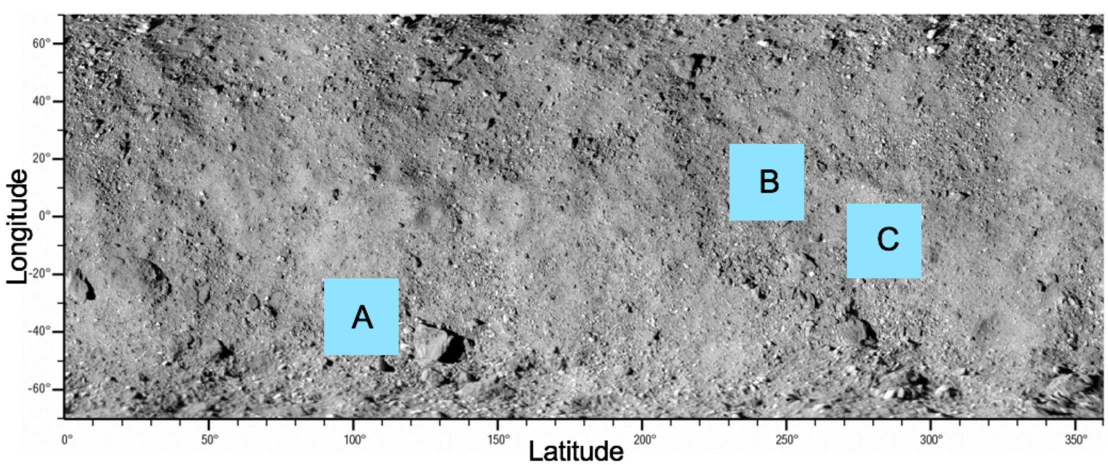

Figure 1: Mercator mosaic of Bennu showing Study Areas A (southern midlatitude PolyCam image 20190321t194439s822, 0.05 m/px, 41.6° minimum incidence angle), B (northern midlatitude, PolyCam image 20190225t023628s05, 0.02 m/px, 49.3° minimum incidence angle), and C (equatorial, PolyCam image 20190226t062628s068, 0.02 m/px, 51.0° minimum incidence angle). Blue boxes represent the locations of study areas but are not to scale.

exhibited small shadows. In locations where shadows are present in the images, we only analyzed boulders with clearly visible boundaries to reduce bias introduced from shadowing effects. The long-axes diameters and orientations of the boulders were measured.

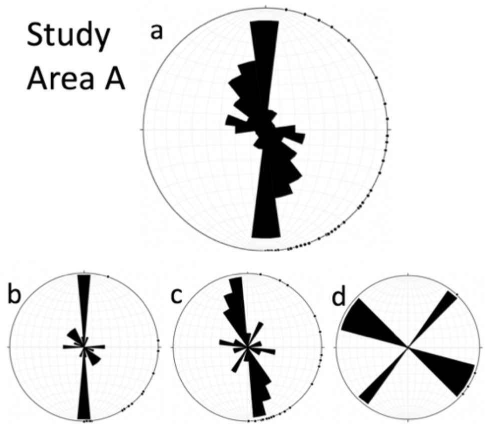

Figure 3: Rose diagrams for Study Area A that show orientations of: a) all boulders with a long axis up to 7 m (N=44), b) boulders <1 m (N=18), c) boulders of 1 to 3 m (N=22), and d) boulders ≥3 m (N=4).

Preliminary Results: We plotted the collected data on rose diagrams for Study Areas A (Fig. 3), B (Fig. 4), and C (Fig. 5). In Study Area A, a majority of the boulders analyzed, ranging from 0.4 m to 7 m in diameter (long-axes) exhibit N-S orientations (Fig. 3a). Of these boulders, those with diameters below 1 m show a stronger preferred orientation (Fig. 3b) than the cumulative boulder diameter diagram. Boulders with diameters of 1 to 3 m show a preferred N-S orientation (Fig 3c), but to a lesser extent than boulders less than 1 m. Boulders greater than or equal to 3 m did not show evidence of a N-S alignment (Fig 3d).

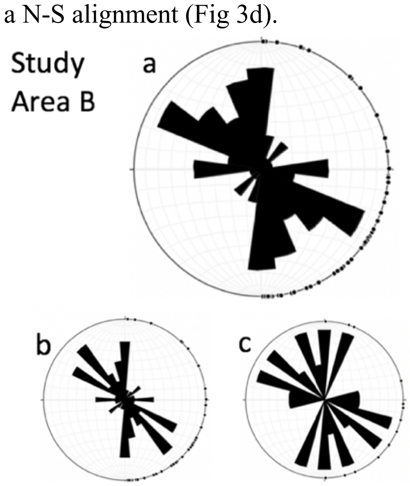

Figure 4: Rose diagrams for Study Area B that show orientations of: a) all boulders with a long axis up to 2.3 m (N=57), b) boulders <1 m (N=42), and c) boulders ≥1 m (N=15).

In Study Area B, some boulders exhibit N-S orientations while others exhibit NW-SE orientations (Fig. 2, 4a). Of these boulders, those with diameters below 1 m show a stronger preferred orientation of NW-SE (Fig. 4b) while those with diameters of 1 m or larger show a more scattered distribution of orientations (Fig 4c).

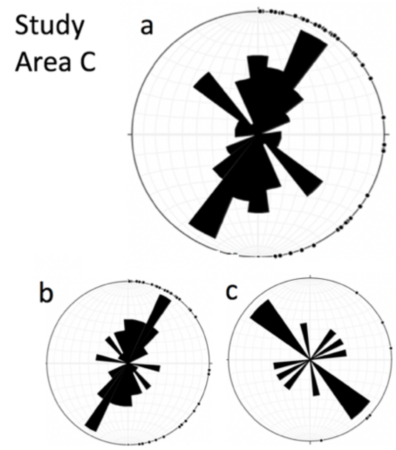

Figure 5: Rose diagrams for Study Area C that show: a) orientations of all with a long axis up to 3.5 m (N=50), b) boulders <1 m (N=42), and c) ≥1 m (N=8).

In Study Area C, most boulders analyzed exhibit NNE-SSW orientations (Fig. 5a). Of these boulders, those with diameters below 1 m show a stronger preferred orientation of NNE-SSW (Fig. 4b) while those with diameters greater than or equal to 1 m do not show this orientation (Fig 4c).

Future Work: The preliminary results of this work are consistent with an interpretation that smaller boulders are more commonly in motion during surface creep on Bennu than larger boulders. Smaller boulders may be easier to move from shear stresses resulting from centrifugal and gravitational forces. Further analyses are planned for additional study areas across Bennu's mid-latitude and equatorial regions.

Acknowledgments: This investigation was supported by NASA under Contract NNM10AA11C issued through the New Frontiers Program. We are grateful to the entire OSIRIS-REx Team.

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