LINEARLY LAYERED BOULDERS WITH MULTIPLE TEXTURES ON BENNU'S SURFACE. K. Ishimaru[1], R. L. Ballouz[1], D. R. Golish[1], D. N. DellaGiustina[1], B. Rizk[1], K. J. Walsh[2], and D. S. Lauretta[1]. [1]Lunar and Planetary Laboratory, University of Arizona, 1629 E University Blvd, Tucson, AZ, 85721, USA, [2]Southwest Research Institute, Boulder, CO, USA. (kana@orex.lpl.arizona.edu)

Introduction: The Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) mission has been exploring asteroid (101955) Bennu. Bennu is a carbonaceous near-Earth asteroid whose surface is covered with boulders of all sizes up to and larger than 50 m [1]. Bennu is a top-shaped, rubble-pile asteroid with diameter about 500 m [2]. Because of its small size, the collisional lifetime of Bennu is much shorter than the age of the solar system [3]. It is probably a fragment of a larger "parent-body" asteroid with diameter of approximately 100 km, and the materials were processed in the parent body [4].

The OSIRIS-REx Camera Suite (OCAMS) [5] has provided high-resolution images (<2 cm/pix) of the surface of Bennu. Among many boulders there are some that have multiple layered textures that are divided by linear boundaries [6] (Figure 1). The layered structure might have formed by parent-body processing [1, 7]; hence, they reflect its structure and geologic history. In this work, linearly layered boulders on the asteroid surface were identified and categorized by texture and average normal albedo. This work provides two hypotheses about how the layering could have originated in the parent body.

Data: The data utilized for this work were PolyCam images with a scale of ~10 cm/pix within the Small Body Mapping Tool [8]. The images typically had phase angles between 30 and 50°, and our search for was systematic up to 80° north or south latitudes. The total search explored roughly 80% of the entire surface of the asteroid under similar and controlled illumination and pixel scale.

Results: *Identifying layered boulders with multiple textures.* The Small Body Mapping Tool [8] was used to examine the surface by projecting images onto a shape model. Fourteen boulders were identified as layered boulders with multiple textures. We selected three boulders (Figure 1.) which are large and clearly show variations in texture out of the fourteen boulders for detailed photogeological analysis.

Categorizing the textures. Textural difference can be caused by variation in composition and the size of the constituent particles. Both these aspects can result in variation of the normal albedo. A global normal albedo map [9] was utilized with SAOImageDS9 [10] to calculate average albedo of each texture in the three layered boulders. In SAOImageDS9, a region was selected for each texture and the average within the region was calculated. Ranges are (from darkest to brightest) type 1: 3.0 to 3.4 %, type 2: 3.5 to 3.9 %, type 3: 4.0 to 4.2 %, type 4: 4.3 to 4.5 %, and type 5: 6.0 to 6.5 %.

Hypotheses of the formation of layered boulders with multiple textures. This work is designed to test two hypotheses of multi-texture layered boulder formation. One is brecciation in the parent body. Boulders could be fractured by thermal fatigue [6], impact, or internal pressure, and fragments with various textures could be melded together by melting or internal pressure. Second, Bland and Travis (2017) [11] modelled a mud convection in a 100-km asteroid parent body and showed that particle size sorting could occur. Catastrophic disruption of a parent body with a size-sorted interior could produce some rock fragments that include a boundary between two textures. It is possible for both situations to occur in one parent body. By mapping and characterizing the layering in some boulders on Bennu, we will be able to give some constraints on the interior environment of the parent body.

Conclusion: On the global map, fourteen layered boulders with varying textures were identified. Large three boulders were selected from the fourteen, and each texture in the three boulders were categorized into 5 albedo ranges. The presence of these multi-textured boulders might indicate that there were some activities in the parent body that mixed up rock materials with different textures. Normal albedo of each texture varies from about 3% to 6%, with most of the texture being under 4.3%. Textures with lower albedos tend to have a more rugged surface. Investigating the formation of layering will let us better understand the structures of asteroid parent bodies and their evolution, leading to the dynamic environment of the early solar system.

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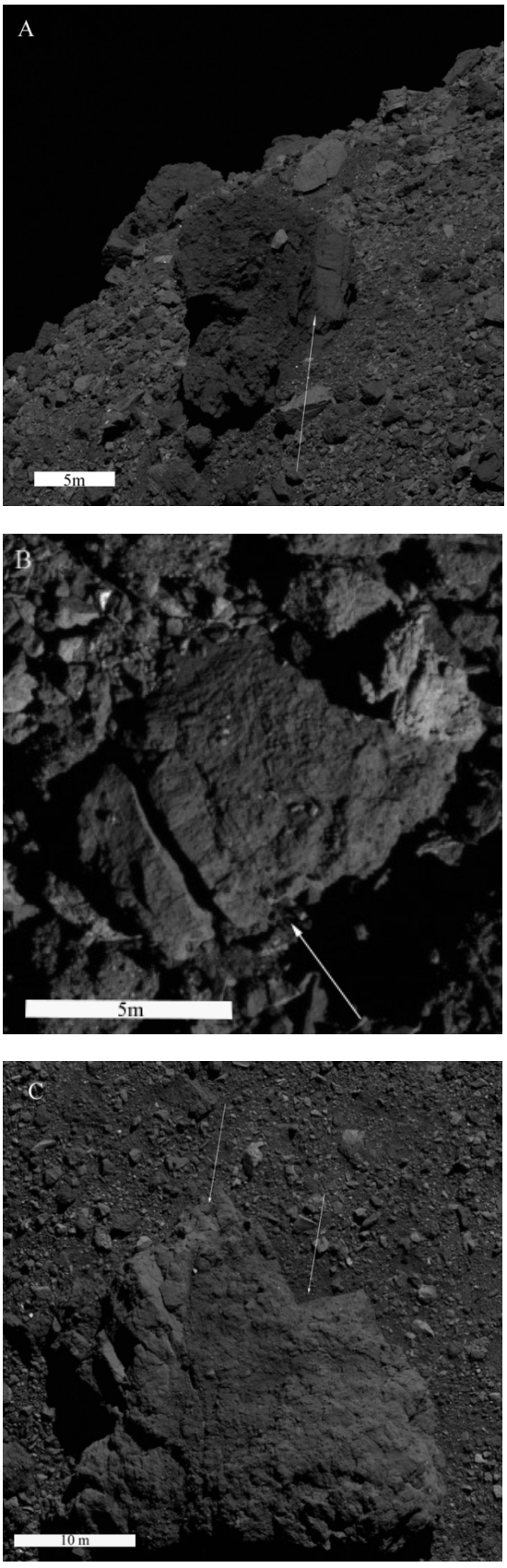

Figure 1. PolyCam images of multi-textured boulders which are selected for detailed photogeological analysis. They are all large (>10 m) and clearly show boundaries between different textures. (A) An image of a boulder (93° E, 5° N) acquired on April 5, 2019 at a scale of 3.8 – 4 cm/pix. It has both a dark and rugged texture and brighter and smoother texture. The arrow indicates a linear boundary which divides the two textures. (B) An image of a boulder (25.4° N, 190° E) acquired on March 29, 2019 at a scale of 4.8 cm/pix. It also has both a dark and rough texture and a brighter and smoother texture, divided by a linear boundary indicated by the arrow. (C) An image of a boulder (25° S, 3° E) acquired on March 21, 2019 at a scale of 4.7 cm/pix. This boulder contains three textures with two boundaries, which are indicated by the arrows. The texture on the right is the brightest, the one in the middle is the darkest, and the one on the left has medium brightness.

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