

Apparently Layered Boulders with Multiple Textures on Bennu's Surface

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Introduction: Asteroid Bennu is a carbonaceous near-Earth asteroid explored by the OSIRIS-REx mission, which discovered that Bennu's surface is covered with boulders as large as tens of meters in long axis [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]. Bennu is thought to be an accumulation of fragments of a ~100-km-diameter parent body that experienced aqueous alteration [4]. The OSIRIS-REx Camera Suite (OCAMS) [5] has provided high-resolution images (<2 cm/pix) of the surface of Bennu. We discovered some boulders that exhibit multiple, apparently layered textures that are divided by linear boundaries [6]. The layered structures might have formed by geologic activity within a parent body [1, 7]; hence, they reflect its geologic history. In this work, linearly layered boulders on the asteroid surface were identified and categorized by texture and average normal albedo.

Methods: We searched for layered boulders in a global mosaic of Bennu that was projected on a lidar-based global shape model (OLA v16; [10–12]) using the Small Body Mapping Tool [8]. Detailed observation and measurements of layered boulders were performed using OCAMS PolyCam [5] images with pixel scales of 2–5 cm/pix that had been converted into reflectance [9]. All the lidar scans available (typically 10 or more scans for each boulder) were registered using a Poisson reconstruction method to create a digital terrain model (DTM) covering the entire surface of the boulder. The PolyCam images were registered to the corresponding DTM using reconstructed SPICE kernels in USGS's ISIS3 software [10]. Normal albedo was calculated in the method described in [11, 12]. Three large boulders—Gargoyle, KLR1, and KLR2—were selected for detailed analysis.

Results: Normal albedo of units can be largely divided into two texture groups: one is rough and dark (4–5 % normal albedo), and the other is smooth and bright (5–7% normal albedo). The layers are ~1–10 m thick. Gargoyle's dark, rough unit includes more than 100 visible clasts with an average length of 23 cm in the longest dimension. Clast size will be looked into closely because the clasts could be the individual particle that was present in the hydrothermal convection.

Future work: [13] modeled 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. The thickness of the layers observed in the boulders suggests that the size sorting could have occurred at scales of 1 to 10 m. 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. Using the results of physical measurements, we will develop a model of sedimentation in hydrothermal convection to reproduce the layered boulders.

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