

Distribution of fractures on boulders on (101955) Bennu: OSIRIS-REx searching for evidence of thermal cracking

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Introduction

Preliminary observations of the near-Earth asteroid (101955) Bennu by NASA’s Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) space mission [1][2] reveal a body covered with boulders ranging in size from some tens of meters down to the several centimeters that are the spatial resolution of images acquired so far [3]. Some of the boulders are fractured, and some present arrangements consistent with them having broken down in place [3][4][5].

Morphology of boulder fractures, broken boulder arrangements, and the locations and spatial density of fractured boulders may clarify processes at play on the surface. Moreover, when a weathering process creates fractures, spatial density and the distribution of the fractured to non-fractured boulder ratio may shed light on relative surface unit ages (Fig. 1).

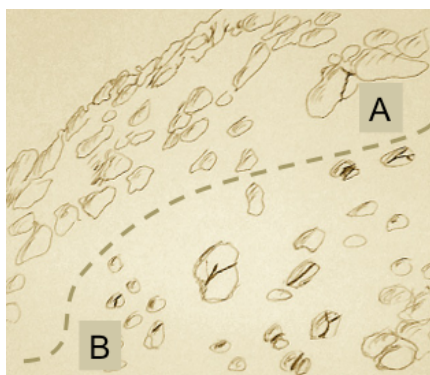


Figure 1: Schematics of terrains with different amounts of fractured boulders. (A) Unit with few fractured boulders. (B) Unit with a large number of fractured boulders. One can estimate that (A) is younger than (B). In (B), fractures are preferentially aligned.

In addition, different types of rocks or geological units can react differently to the process generating the fractures (e.g. impacts, thermal cracking/fatigue). The distribution of the orientation of fractures may indicate the dominant process at play [6]. For instance, in the case of impact-generated fractures on a randomly oriented boulder population, fractures are expected to have propagated along all possible azimuthal directions. On the other hand, rocks in Earth’s mid-latitude deserts and on Mars present fractures that are oriented in statistically preferred directions [6]. Models show that this preferred direction can be due to fractures propagating along a direction forced by the cyclic Sun-induced thermal stresses [6].

Observations and Methods

We used a series of images obtained by the OSIRIS-REx Camera Suite (OCAMS), with a scale of 5–6 cm/pixel, during the first and third “baseball diamond” flybys of the Detailed Survey mission phase, which occurred on 7 and 21 March 2019, respectively. Other, lower-resolution images were composited into two global mosaics whose x and y coordinates correspond to the longitude and latitude on the asteroid. We used different visualization tools, such as SAOimageDS9 (ds9.si.edu) and JASteroid (jmars.mars.asu.edu/j-asteroid-and-3d-shapes), to visually identify and map fractures on boulders. We drew line segments along each fracture. When we identified on a single boulder multiple fractures, we mapped each one of these fracture with a different broken line (Fig. 2). This fracture mapping effort was carried out by different co-authors on similar asteroid regions to minimize the biasing effects of having only one person in charge of fracture identification.

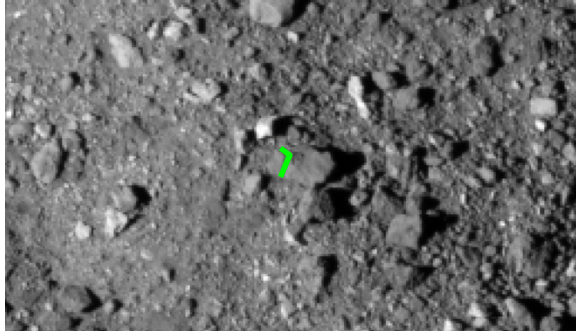


Figure 2: Example of fracture mapping on boulders at the centre of two different images. (Top) A broken line made of two segments (green) was used. Image is 20181201T064101S472_pol from the Preliminary Survey phase of the mission [3][4][5][7]. This image has a spatial resolution of 0.323 m/pixel and a phase angle of about 49.9°. (Bottom) Example fracture mapping using a broken line made of several segments (green) from image 20190321T203550S089_pol that has a spatial resolution of 4.67 cm/pixel and was obtained at a phase angle of 30.25 deg. Results presented in this paper will be based on the Detailed Survey images, which have a spatial resolution of 5–6 cm/pixel.

Preliminary Results

We will present the global mapping of fractures on the boulders on Bennu. Preliminary results from our boulder mapping indicate that the fractured boulders are a few percent of the total boulder population. It also appears that there is a preferential direction of the fractures. Fracture mapping is still ongoing, at the time of writing of this abstract, and will be completed at the time of the meeting. We will present updated results and discuss the possible preferred direction of the fractures, which likely indicates a preferential fracture propagation mechanism.

Acknowledgements

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