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Boulders inside the craters of asteroid (101955) Bennu: Surface densities and size-frequency distributions

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Abstract

In this work we study the surface densities and size-frequency distributions (SFD) of boulders located inside different craters present on the surface of the near-Earth asteroid (101955) Bennu, i.e. homogeneous morphological units with distinct boundaries and origins. Through the quantification of such parameters we aim to understand whether there are any surface/texture differences among the craters and the possible reasons behind that, such as different emplacement processes or localized surface degradation phenomena.

Introduction

Since November 2018, NASA's Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx, [1]) mission has been acquiring resolved images of the surface of asteroid (101955) Bennu [2]. On December 1 and 2, 2018, the OSIRIS-REx Camera Suite (OCAMS, [3]) PolyCam instrument returned a set of 502 images of Bennu taken from distances between 31.9 and 23.5 km with a spatial scale ranging between 0.42 and 0.32 meters/pixel (Fig. 1). These images cover almost the entire surface of the asteroid with phase angles between 33.3° and 51.5°; hence, they are suitable to identify and study morphological features such as craters, boulders, and lineaments [4,5]. Initially, using these data, it was possible to derive the global cumulative size-frequency distribution (SFD) of boulders ≥ 8 m on Bennu [2] and to compare its power-law index (–2.9 ± 0.3) with those of other small bodies [2,6]. Nevertheless, given both the high resolution and wide spatial coverage of such images, we can exploit this dataset more deeply to quantify whether there are any boulder density and SFD variations among the asteroid's different morphological units and how they deviate from the global counts.

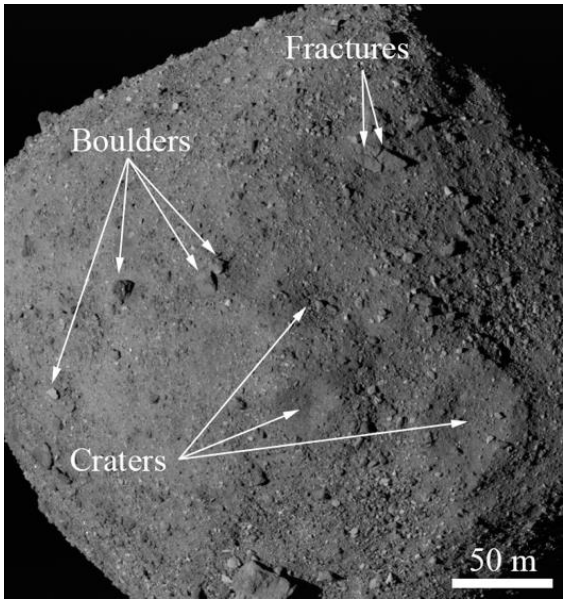

Figure 1: OCAMS PolyCam image taken on Dec 1, 2018, at 06:51:47 UT, and with a scale of 0.42 m per pixel.

Methods

In this work we focus on the boulders located inside different craters, i.e. morphological units that are visually identified as circular or ellipsoidal

morphological structures with raised rims [4]. By using the Small Body Mapping Tool (SBMT [7]) we directly project the OCAMS images onto the Bennu shape model [8] and then identify and manually count boulders as ellipses inside the craters. The value of an ellipse's major axis is then used as the maximum diameter of the boulder. By extracting the area of the studied craters, we compute the densities of the boulders per square meter at different sizes and the resulting SFD, comparing such values among all craters.

Preliminary Results

The preliminary results are shown in Fig. 2, where four different craters located in the equatorial region of Bennu are plotted (Fig. 2A) with the cumulative number of boulders per square meter (Fig. 2B). The power-law index of the curve fitting the four different boulder SFD ranges from –3.0 +0.2/–0.4 for crater 2 and –3.8 +0.4/–0.7 for crater 4, while the density of boulders ≥ 3.0 m (3.0 m is the completeness limit evaluated using both differential and relative plots) varies from 0.0110 (crater 4) to 0.0207 (crater 3) per square meter.

The obtained fits are comparable to the global SFD results, despite a wider fitting range. Future work will examine the boulder SFD inside a greater number of craters to seek differences, or confirm similarities, of the boulder SFD across Bennu.

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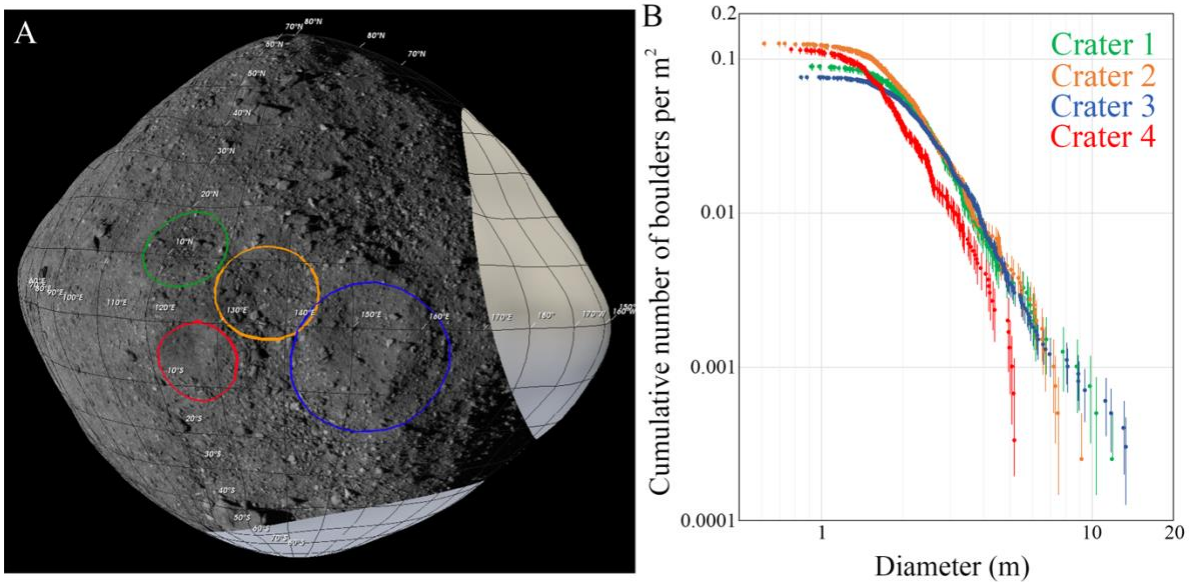

Figure 2: A) Four different craters located in the equatorial region of Bennu (20° N - 20° S). B) Cumulative number of boulders per m^2 of the four different craters identified in A. The OCAMS PolyCam image projected here through SMBT is the one shown in Fig. 1.