EPSC Abstracts
Vol. 13, EPSC-DPS2019-346-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Investigation of aqueous alteration features on the surface of (101955) Bennu using OSIRIS-REx data

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1. Introduction

In early December 2018, NASA'S Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) [1] spacecraft arrived at the near-Earth asteroid (101955) Bennu. Bennu is spectrally classified as a B-type asteroid, associated with organic-rich hydrated carbonaceous chondrites, tracing back to the formation of the Solar System [2]. The main objective of the mission is to return samples from Bennu to Earth in 2023. OSIRIS-REx has been actively studying Bennu with the scientific instruments onboard to characterize the physical and chemical nature of Bennu.

The initial scientific results of the OSIRIS-REx mission [2,3,4] highlight the presence of magnetite (Fe_3O_4) on the surface of Bennu. This result is derived from two independent instruments: the OCAMS MapCam imager [5] and the thermal emission spectrometer OTES [6]. An absorption feature detected at 550 nm in MapCam spectrophotometric data and spectral features at 18 µm and 29 µm in OTES data are attributed to magnetite. The presence of magnetite suggests that this asteroid has experienced significant aqueous alteration in the past. It is also noteworthy that several B-type asteroids ((47) Aglaja, (142) Polana, (335) Roberta, and (1615) Bardwell) contain magnetite, according to Yang and Jewitt [7]. Moreover, in the context of Bennu, the early spectral results [4] from the visible and infrared spectrometer OVIRS [8], and from OTES, indicate the widespread presence of hydrated phyllosilicates on Bennu, indicating past aqueous alteration.

As such, the objective of this work is to analyze the MapCam and OVIRS data from the Preliminary Survey and Detailed Survey mission phases to characterize surface features that show evidence for the hydration absorptions. The two aqueous alteration bands associated with hydrated Fe-bearing minerals occur at 550 nm and 700 nm.

2. Data Analysis

The first part of our analysis corresponds to the Preliminary Survey mission phase. The analyzed MapCam and OVIRS data span from 11 December 2018 to 16 December 2018. The images were acquired in four filters and co-registered to reduce the effect of subtle changes in field of view in a pair of consecutive images. The resulting data cubes are used for the spectrophotometric work. We used 19 data cubes in this work, with phase angles ranging from 38° to 75°. The corresponding pixel sizes vary from 0.59 m/pixel to 1.22 m/pixel.

For a given data cube, we discarded all the pixels whose local illumination and emission angles were above 70° to avoid the artifacts associated with shadows. Then, we corrected the data photometrically, using the Lommel-Seeliger disk function and the Bennu phase function published by DellaGiustina et al. [3]. Next, we applied an additional filter of considering only albedo values greater than 0.025 to further ensure that shadowed pixels are excluded. In calculating the band depths, we applied a sampling of 3x3 pixels, and we verified that the sample does not contain any scrubbed pixels and only contains valid values. As a supplementary precaution, we additionally verified that this filtered sample with valid pixels is centered on an area of 5x5 pixels, which are themselves without any scrubbed pixels. This last step ensures that a valid sample is not immediately next to a shadow or any artificial artifact, which might have influenced the sampled area. Finally, we impose a threshold of 5% on band depth values. The same procedure was also applied

after discarding pixels with illumination and emission angles above 50°.

3. Results and Discussion

Results derived from MapCam Preliminary Survey data hint at the presence of features at 550 nm and 700 nm on several areas of the asteroid. One example of the feature at 700 nm is shown in Fig. 1. This has prompted us to search for these features in MapCam images with higher resolution and better signal-to-noise ratios from the second "baseball diamond" flyby of the Detailed Survey mission phase. We will present a complete mapping of the presence of these features using the aforementioned data sets, while comparing these results with the albedo variations on Bennu, which will be reported by DellaGiustina et al. [9]. We will also compare the maps with those obtained from the successive flyby data. Our results will be augmented by comparison with the OVIRS data.

4. Acknowledgements

This material is based on work supported by NASA under Contract NNM10AA11C issued through the New Frontiers Program. JDPD, MAB, AP, SF, PH, and FM acknowledge the funding support by CNES.

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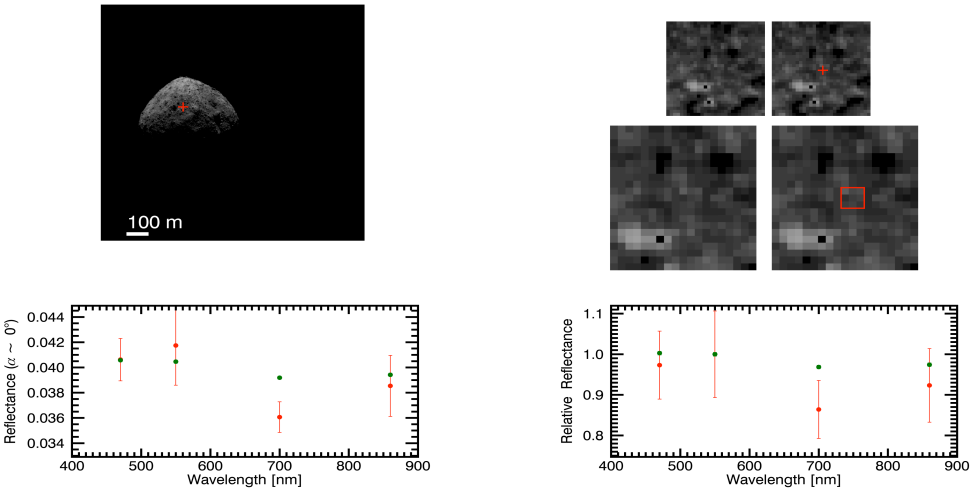

Figure 1: The top-left panel shows the MapCam full-frame view of Bennu on 11 December 2018 at 03:19:32 UTC. The top-right panel shows zoomed views of an example surface feature that we investigated. The bottom-left panel shows the photometrically corrected reflectance of the 3x3 pixels (in red) of the surface feature. The reduction at 700 nm is attributed to hydrated Fe-bearing phyllosilicates. The mean reflectance values are shown in green. In the bottom-right panel, the reflectance of each curve is normalised by its respective value at 550 nm.