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Spatial variations in hydrated band depth on (101955) Bennu, using OVIRS reflectance spectra

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Abstract

The OSIRIS-REx Visible and InfraRed Spectrometer (OVIRS) is currently mapping the surface of asteroid (101955) Bennu at wavelengths between 0.4 and 4.3 µm. An absorption feature was detected in the 3-µm region across the entire surface of Bennu, indicating the presence of hydrated phyllosilicates. With the analysis of this hydration feature, our final goal is to estimate quantitatively the H/H_2O abundance on Bennu. The first step of this process, presented here, is to analyze the feature depth. We detected global spatial variations in the band depth, which seem to be connected to major morphological features.

1. Introduction

The Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS-REx) mission [1] is a NASA sample return mission to the asteroid (101955) Bennu. During the Approach, Preliminary Survey, and Detailed Survey phases of the mission, OVIRS [2] acquired reflectance spectra of Bennu's surface that show an absorption band in the 3-µm region, centered at 2.74 ± 0.01 µm, detected across the entire surface of Bennu. As this absorption band is due to hydrated phyllosilicates [3], our objective is to quantitatively estimate H/H_2O abundance on Bennu, as has been done for Mars and the Moon [4,5]. To achieve this goal, several methods will be used to analyze OVIRS reflectance spectra. For example, the conversion of reflectance spectra to single-scattering albedo [6] will allow the calculation of the effective single-particle absorption thickness (ESPAT), a spectral parameter less subject to the effect of surface albedo variations [7].

We started our preliminary analysis with the latest (at time of writing) OVIRS spectra acquired during the third "baseball diamond" flyby of the Detailed Survey phase, on March 2019, and we will continue with upcoming OVIRS data.

2. Data Analysis

OVIRS observation data first go through an automated data processing pipeline created by the OSIRIS-REx Team, which calibrates the data, resamples radiance spectra, and removes the thermal excess over several computational steps [2,3]. The OVIRS pipeline produces several outputs; two of them are of interest in this study. We use the value at 0.55 µm of the radiance factor corrected for i=30°, e=0°, and α=30° as surface albedo [8]. The 3-µm-region absorption band depths are calculated on photometrically corrected reflectance factor spectra (REFF(i=30°,e=0°,α=30°)). The spectral index (SPINDEX) calculation software, developed by the OSIRIS-REx Team [9], automatically calculates spectral indices, including absorption band depths and visible spectral slopes. Here, we used band index #7. The SPINDEX software band depth calculations use the absorption band depth definition of Clark and Roush (1984) [10]. We adapted the left, right, and center wavelengths defining the 3-µm-region band using values from the literature [11] and the average band minimum from OVIRS reflectance spectra. Hence, in this study, the left, center, and right wavelengths are 2.64, 2.74, and 3 µm.

3. Results

We created several maps using OVIRS spectra. As an example, preliminary maps from data obtained on 21 March 2019 are shown in Figures 1 and 2. These maps show variations of band depth that seem to be correlated with some morphological features. The equatorial area between –20° and 20° latitude is characterized by a shallower band depth, as are some boulders in the southern hemisphere. The albedo map is shown in Figure 2. Some regions characterized by lower band depth have a lower albedo.

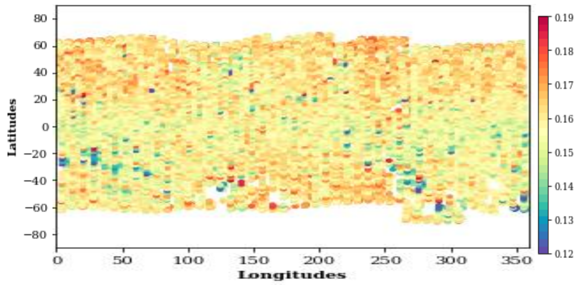

Figure 1: 2.74-μm band depth map using OVIRS data from 21 March 2019.

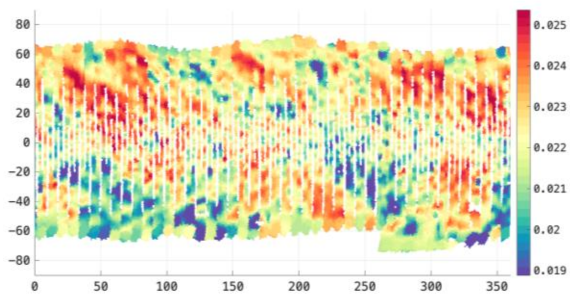

Figure 2: Albedo map from the same data as in Fig. 1, using the RADF(30,0,30) value at 0.55 μm.

4. Conclusions and Future Work

We will present maps of the 2.7-μm band depth, as well as maps of surface temperature, albedo, and other spectral parameters (i.e., visible slopes). Our preliminary results show variations of the 2.7-μm band depth with albedo and some morphological surface features. This could be explained by variation in particle size dimensions, surface temperature, different phyllosilicate content, and/or space weathering. As the thermal excess is not yet perfectly removed, its effect may still be present at wavelengths longer than 3 μm. We will continue to analyze the hydration absorption feature in upcoming OVIRS spectra. Future mission phases will provide us with higher-spatial-resolution OVIRS spectra. The first goal of our hydration feature analysis is to support and provide guidance in the selection of the two sampling sites. Then, we will focus on comparing several spectral parameters of the 2.74-μm absorption band to values from the literature, including those of CI and CM carbonaceous chondrites [12]. Our final objective is to estimate quantitatively and map the H/H_2O content at the surface of (101955) Bennu, which will give information about the aqueous alteration degree and chemistry of Bennu's surface.

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