Hydration variations of Bennu's surface: comparison of different methods.

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1. Introduction

OVIRS [1, 2] acquired visible to near-infrared spectra of asteroid Bennu's surface showing an asymmetric absorption band centered at 2.74 ± 0.01 µm [3], attributed to the presence of hydrated phyllosilicates. This feature is widespread across Bennu's surface. Such an absorption band has been detected in some carbonaceous chondrite meteorites [4, 5].

In this study, we report the results from two distinct methods to estimate the hydration of Bennu's surface. We calculated the normalized optical path length (NOPL) as well as the effective single particle absorption thickness (ESPAT) [6, 7, 8] on Bennu's hydration band and on the selected meteorite spectra. For both methods, we compare meteorite results with their H_2O/OH^- H content, to estimate a H_2O/OH^- H content of Bennu's average surface. Carbonaceous chondrite meteorite H_2O/OH^- H contents are derived from laboratory studies [9, 10].

2. Data Analysis

Bennu spectra. Analysed spectra were acquired by OVIRS during Equatorial Station 3 (EQ3) of the Detailed Survey mission phase, on May 9, 2019, at 12:30 pm local solar time [11]. The reflectance spectra have been calibrated and photometrically corrected to an incidence angle of 0°, emission angle of 30°, and phase angle of 30°, using a McEwen photometrical model [12].

Meteorite spectra. We used three sets of meteorite absolute reflectance spectra, from [4,5], [8], and [13]. For each set, powdered meteorite sample spectra were measured under vacuum (asteroid-like conditions). We selected over 40 meteorites for which bulk H values have been independently measured [9, 10]. In the case of Orgueil, Bells, and Tagish Lake, several samples were analysed and several H contents were ultimately derived [9, 14], all of which were used.

3. Methods

Normalized Optical Path Length (NOPL). The NOPL parameter was calculated as described in [6, 7, 8] on each meteorite spectrum, each individual Bennu reflectance spectrum, and the global average spectrum of Bennu. A linear continuum was fitted from 2.67 to 3.3 µm. The wavelength, at which the NOPL parameter is calculated, is the mean band minimum position for the EQ3 data set at 2.73 µm. Methods used to locate the band minimum are described in [3].

Effective Single Particle Absorption Thickness (ESPAT). The ESPAT parameter was calculated following the method of [6, 7, 8]. Absolute reflectance spectra of meteorites and Bennu's surface were first converted into single-scattering albedo spectra [6, 7, 8]. A linear continuum was then fitted from 2.67 to 3.3 µm and the ESPAT parameter is calculated at 2.73 µm as well. Our analyses do not include the organic absorption bands, present longwards of ~3.3 µm [11, 15]. Thus, we compare NOPL and ESPAT results with the hydrogen content of H_2O/OH^- groups in hydrated phyllosilicates only, measured for the selected meteorites [9, 10].

4. Results

Figure 1 shows the NOPL parameter variations across Bennu's surface using EQ3 spectra.

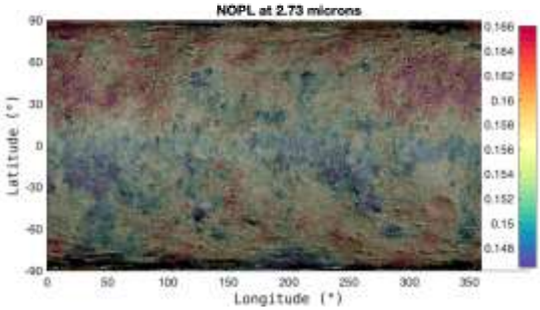

Figure 1: *Map of NOPL values computed at 2.73 µm for each EQ3 spectrum of Bennu.*

We find a linear correlation (Figure 2) between the NOPL parameter calculated at 2.73 µm on meteorite spectra and the meteorite H_2O/OH^- H content.
Using this linear correlation, for the NOPL calculated on Bennu's EQ3 average spectrum, we estimate a H_2O/OH^- H content for Bennu's average surface of 0.54 ± 0.11 wt.%.

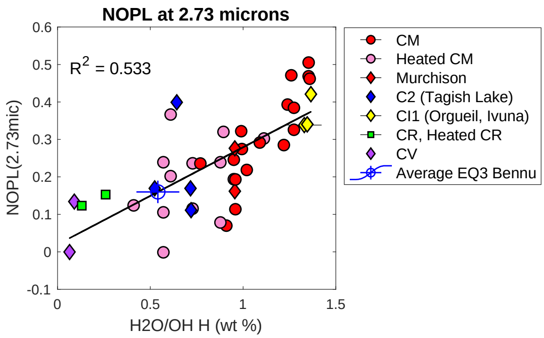

Figure 2*: Linear correlation between NOPL calculated at 2.73 µm and H_2O/OH^- H content of the seven selected meteorites (in colored points), and for average Bennu (blue circle).*

As with the NOPL parameter, we also find a linear correlation between the ESPAT parameter calculated at 2.73 µm on meteorite spectra and the meteorite H_2O/OH^- H content. We therefore estimate a H_2O/OH^- H content for Bennu's average surface of 0.49 ± 0.13 wt.%, using Bennu's EQ3 mean ESPAT value and the latter correlation.

Discussion and Conclusion

The H_2O/OH^- H content for Bennu's average surface obtained using NOPL parameters is consistent with the range obtained with the ESPAT parameter. Both methods are based on estimating global H content (in H_2O/OH^- groups of hydrated phyllosilicates) by analogy with meteorite data. The values of H_2O/OH^- H content of Bennu's average surface we obtained are 0.54 ± 0.11 and 0.49 ± 0.13 wt.% using the NOPL parameter and the ESPAT parameter, respectively. From our results (Figure 2), Bennu's average surface is most similar to heated CMs and Tagish Lake. Both estimated H_2O/OH^- H content ranges of Bennu's average surface are more consistent with those of CM meteorites (0.46–1.36 wt%), Tagish Lake (0.50–0.69 wt.%), CR meteorites (0.30–1.20 wt.%), and CO meteorites (0.49–0.52 wt.%) [3, 9]. The gaussian modeling of the hydration band will complete those results.

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