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Influence of Observation Geometry and Composition on Vis-NIR Spectra of HED Meteorites

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Abstract

Interpretation of Dawn data from asteroid (4) Vesta need a good understanding of analog materials: i.e. HED meteorites. Here we analyze the Vis-NIR spectra (0.3-2.5 microns) of 11 HED meteorites, most of them previously unmeasured, including an olivine diogenite. We focus on spectral variations induced by observation geometry and composition.

1. Introduction

Dawn mission has obtained high-resolution spectral data of Vesta using the Visible and Near-Infrared Mapping Spectrometer (VIR) [1,2]. Telescopic observations have shown that spectral properties of HED meteorites are similar to Vesta, confirming its composition as a basaltic object [3]. In the last decades spectral analyses of dozens of HED meteorites have been carried out [e.g. 4,5]. One of the outcomes of these analyses has been the ability to recognize different subgroups of the HED meteorites at different locations on the asteroid surface [6,7,8]. However, to fully understand the surface spectral observations, laboratory spectra of all recovered HED meteorites are needed and attention should be given to critical factors affecting spectra [e.g. 9,10,11]. Here we present spectra of 11 HED: 8 previously unmeasured meteorites and 3 falls and we focus the analyses on spectral variability as a function of observation geometry and of composition.

2. HED meteorites and methods of analyses

The following HED meteorites were analyzed: four with provisorial names, one of which is an olivine rich diogenite, NWA 2968 a dunitic diogenite, NWA1836, Talampaya, Millbillillie, NWA1942, NWA1943 and Tatahouine, for a total of 4 eucrites, 4 howardites and 3 diogenites. The spectra were measured at the University of Winnipeg HOSERLab with a spectral sampling of 1 nm between 0.35 µm and 2.50 µm. Powders of <45 [µm] were measured under the following illumination conditions: i=0, 15, 18, 30, 45, 60° and e=0, 15, 18, 30, 45, 60°. Since the spectra are dominated by pyroxenes bands at 1 µm (BI) and 2 µm (BII), the depth and center of BI and BII are systematically measured. BI and BII center are calculated from a polynomial fit around the minimum after linear continuum removal [e.g. 13]. Overall reflectance and spectral slope are measured using the maxima of reflectance: i.e. at ~0.7 and ~1.4 µm. A slope in the visible domain is calculated with reflectance at 0.42 and 0.75 µm. Chemical analyses of the powders and mineral abundances are carried out at the Westfälische Wilhelms-Univerität Münster with the SEM Jeol840.

3. Preliminary Results on Observation Geometry

A diversity of spectral parameters variations as a function of increasing phase angle is observed for the 11 samples (Figure 1). Some common trends in the parameter variation are however identified. These general trends are presented here.

Effect on band depths. The BI depth decrease start at 30° and become pronounced >60°. In addition, for half of the samples, a slight increase at small phase angle is observed. The BII is approximately constant until 45°-60°, then decrease. At 90° the BI and BII depth are reduced by half the depth at 18°. Furthermore BI depth values have a scattered distribution compared to the BII depth values.

Effect on band centers. The BI center values show a scattered distribution, with a variation up to 5 nm. No systematic trend is observed. The BII center trends toward shorter wavelengths with increasing phase angle. At 75° the variation may be up to 13 nm.

Effect on the slope. The spectral slope values tend to increase for small phase angles (30°) and to decrease with higher phase angle, with variations up to 10%. However the distribution of spectral slopes values versus phase angle show a large scattering.

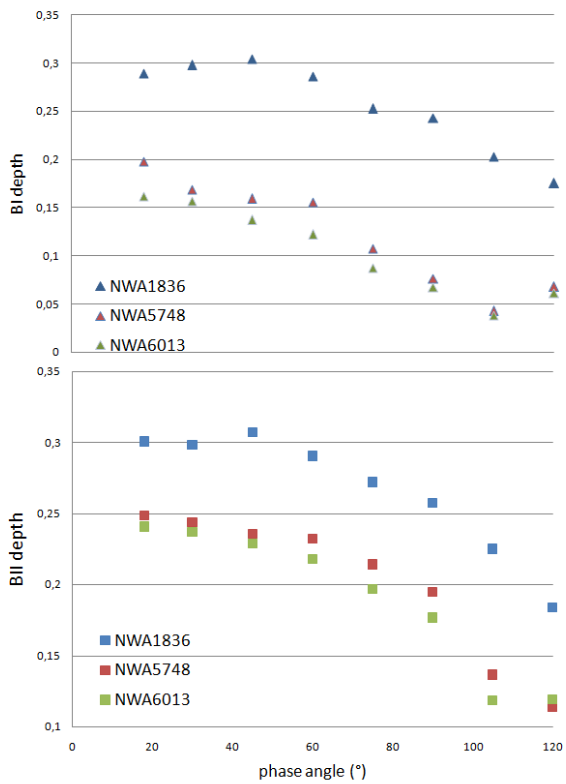

Figure 1. Diversity of bands depths variations versus phase angle of three HED meteorites.

4. Discussion and Conclusion

Currently, our preliminary results only allow for some general remarks on the spectral characteristics of the investigated HED meteorites. (i) Variations in viewing geometry may lead to misinterpretation of surface composition [e.g., 14, 15]. Despite photometric corrections, observation geometry variations may persist as part of the surface roughness [16]. BI and BII center are critical indicators of pyroxenes composition, e.g. Fs and Wo abundance [e.g., 10, 13]. The observed band centers variations are however limited for low phase angle (<60°). Band depth and spectral slope variations are also limited for low phase angle. Overall the observed trends in spectral parameter variability agree with previous analyses of a HED sample [14], asteroids [15] and other materials [17]. However the suite of HEDs presents some variations from the systematic trends both at low and high phase angle. (ii) Compositional influence on spectra will be discussed with particular regard to the pyroxene composition, the presence of one or two pyroxene phases, plagioclase and opaque minerals abundances. Because of its relevance in magmatic history of Vesta, [12], we will also focus on the influence of olivine abundance.

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