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Surface compositional heterogeneity of (4) Vesta from Dawn FC using a 3 dimensional spectral approach

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Abstract

The historic journey of the Dawn spacecraft in 2011-2012 was a turning point in understanding asteroid (4) Vesta. The surface composition and lithology were analysed and mapped in earlier studies using Dawn imageries [1], [2]. We introduce here a 3 dimensional spectral approach to analyze and map the surface composition using Dawn Framing Camera (FC) color data. Various laboratory spectra of available HEDs and their mixtures, including new spectra measured in this work, were used. Band parameters were reviewed and modified wherever necessary to make the best use of the data. We particularly focused on carbonaceous-chondrite-bearing and olivine-bearing lithologies. An attempt has been made to distinguish glass/impact-melt lithologies.

1. Introduction

Asteroid (4) Vesta is one of the most massive objects in the main belt which is presumed to be intact since the early solar system formation. It was the first target of the Dawn mission with an objective to study and reveal planetary evolution in the early solar system. The surface composition and mineralogy of Vesta is very important in order to understand its evolution. Such analyses and mapping were presented in earlier studies [1], [2]. Besides the overall HED lithology, other components are contributing to Vesta's heterogeneity, i.e., dark materials [3], [4], bright materials [5], [6], orange/glass/shock/impact-melt materials [7], [8], olivine-rich materials [8], [9], [10], [11]. Motivated by the current understanding of such heterogeneity, we introduce here a 3 dimensional spectral analysis approach and its applications.

2. Laboratory spectra

Various spectra of HED meteorites, CM2 chondrites, olivine, and olivine-orthopyroxene mixtures were collected from RELAB, USGS and HOSERLab [1], [10]. In addition we used spectra of eucrite-rich howardite NWA1949, diogenite-rich howardite DA779, Jbilet Winselwan (CM2 chondrite), olivine, and their mixtures in varying proportions. These samples/mixtures were prepared in a grain size range (less than 65 microns). The spectra were measured at HOSERLab (University of Winnipeg) using an ASD Fieldspec Pro HR spectrometer, relative to Spectralon® standard. The spectra were taken in the wavelength range from 0.35 to 2.5 microns, at i=30° and e=0°. All spectra were resampled to FC bandpasses [12]. Figure 1 shows resampled spectra which are normalized to 0.75 microns.

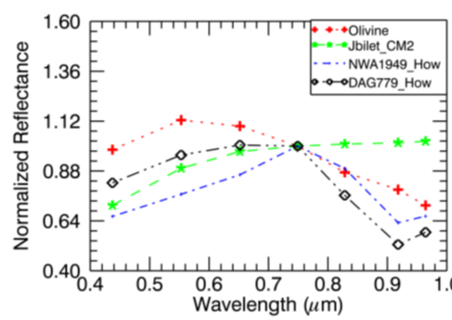

Figure 1. Normalized reflectance spectra of samples measured in this work (NWA1949, DAG779, Jbilet Winselwan, and olivine).

3. Analysis and preliminary results

We reviewed the existing FC band parameters and modified these, wherever necessary, to make the best use of the data. The parameters used here are:

1. VS: visible slope or gradient in % per 100 nm in the visible region, using the peak reflectance as upper wavelength limit [13], [14]
2. Ref: peak reflectance value in the visible region
3. BS: 1-µm band strength (i.e., the ratio between maximum and minimum reflectance values in the visible region and the near-infrared region, respectively)
4. MR: Mid Ratio, (0.75µm/0.83µm)/(0.83µm /0.92µm) [10]
5. BT: Band Tilt, (0.92µm/0.96µm) [1], [10], [15].

Significant changes were observed when applying our revised band parameters. For example, Figure 2 shows RGB composite images of Arruntia crater. The image on the left uses standard Clementine color ratios, while the right one uses our parameters. Red and blue represent spectral slope in the visible region, and green approximates 1-micron band depth.

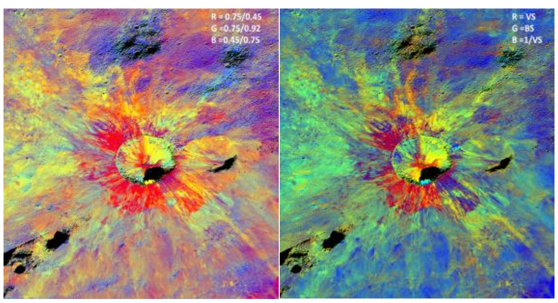

Figure 2. Clementine ratio RGB composite image (left), and revised composite image (right) of Arruntia crater (diameter ~ 12 km). R, G and B in the labels are ratios or parameters. Red and blue represent spectral slope in the visible region, while green indicates 1-micron band depth.

Three band parameter values were used to plot and discriminate lithologies in a three-dimensional space. Polyhedrons were created for each lithology, i.e., howardites, eucrites, diogenites, olivines, CM2's, olivine-HED mixtures, olivine-orthopyroxene mixtures and CM2-HED mixtures (Figure 3). A Macibini eucrite glass spectrum was also included in this plot as a single scattered point. The plots were analyzed for separability of the polyhedrons (lithologies). These polyhedrons were applied to map Vestan lithologies using FC data (~60 m/pixel). The analysis and mapping were done in MATLAB and IDL/ENVI software.

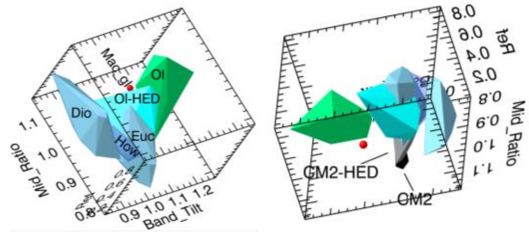

Figure 3. Two different views of a 3-dimenional band parameters space BT-MR-Ref. Each polyhedron represents a lithology (Euc - eucrite, Dio - diogenite, How- howardite, Ol - olivine, Ol-HED - olivine and HED mixtures/samples, CM2 - CM2 chondrite, CM2-HED - CM2 chondrite and HED mixtures/samples, Mac_gl - Macibini eucrite glass)

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References

[1] Thangjam, G. et al.: Meteorit. Planet. Sci., 48, 2199-2210, 2013.
[2] Ammannito, E. et al.: Meteorit. Planet. Sci., 48, 2185-2198, 2013.
[3] Reddy, V. et al.: Icarus 221, 544-559, 2012.
[4] Nathues, A. et al.: Icarus 239, 222-237, 2014.
[5] Longobardo, A. et al.: Icarus 240, 20–35, 2014.
[6] Zambon, F. et al.: Icarus 240, 73-85, 2014.
[7] Le Corre, L. et al.:, Icarus 239, 222-237, 2013.
[8] Ruesch, O. et al.: JGR, 119, 2078–2108, 2014.
[9] Ammannito, E. et al.: Nature, 504, 122-125, 2013.
[10] Thangjam, G. et al.: Meteorit. Planet. Sci. 49, 1831-1850, 2014.
[11] Nathues, A. et al.: Icarus, in press, (doi:10.1016/j.icarus.2014.09.045).
[12] Sierks, H. et al.: Space Sci. Rev., 163, 263-327, 2011.
[13] Luu, J. and Jewitt, D.: Astron. J. 99, 1985-2011, 1990.
[14] Doressoundiram, A. et al.: in The Solar System Beyond Neptune, 91-104, 2008.
[15] Isaacson, P.J. and Pieters, C.M.: JGR, 106, 28001-28022, 2009.