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DawnKey: Automated Identification of Terrains on 4 Vesta using Dawn Framing Camera Bands

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Abstract

The Dawn mission will rendezvous with asteroid (4) Vesta in July 2011. We have developed criteria for classifying terrains on Vesta by using the Dawn Framing Camera (FC) spectral bands and laboratory spectra of meteorites that are related to Vesta. Howardite-Eucrite-Diogenite (HEDs) meteorites and, for example, pallasites, and mesosiderites are likely representative for the composition of these terrains. We implemented the classification of terrains in a program called DawnKey, which allows ingesting Dawn FC color cubes consisting of 7 filters. The software then returns the meteorite type that best fit the spectrum for each pixel.

1. Introduction

Vesta is the 3rd largest asteroid in the main belt [1] and the first target of NASA's Dawn mission which is expected to begin its mapping phase in Survey Orbit around Vesta in August 2011. The FC is one of three scientific instruments onboard the spacecraft [2], contains a set of 7 color filters ranging from 0.44 to 0.97 micrometers in addition to a clear filter (Table 1). The latter will be used mainly for mapping the morphology of Vesta's surface whereas the color filters will provide information about the basic surface composition by creating color composite images (color cubes) in order to identify spectrally distinct units, and by comparing the color spectra with laboratory spectra of well known HEDs and non-HEDs samples.

2. Characterizing terrains

Several spectral criteria such as reflectance ratios, spectral slopes and pseudo Band I minimum were plotted as a function of ratios of FC color filters to look for the best color parameters that can be used to extract compositional information [3]. In order to be able to distinguish the putative meteorite analogues on the surface of Vesta we selected the most relevant plots showing clusters of data points in distinctive areas or linear trends for each type. We also applied Principal Component Analysis (PCA) on this dataset. For each of them, 4 or 5 plots were attributed and will be used to identify surface composition in FC data (Fig. 1). We can distinguish between eucrites and diogenites by using specific FC filters. Other non HEDs types are recognizable as well. These plots, in combination with the linear trends are implemented in the DawnKey program.

Filter name	Wavelength center (µm)	Bandwidth (µm)
F8	0.438	0.040
F2	0.555	0.043
F7	0.653	0.042
F3	0.749	0.044
F6	0.829	0.036
F4	0.917	0.045
F5	0.965	0.086

Table 1: List of FC filters (except clear filter) with their respective band width and center wavelength.

Subsequently, the ultimate goal of our work is to derive the mineralogy of the terrains matching the eucrite or diogenite type with equations using characteristics of the pyroxene Band I and to create compositional maps.

3. DawnKey

DawnKey is an automated terrain classification pipeline being developed by the Dawn Framing Camera science team at the Max-Planck Institute for Solar System Research. The pipeline ingests PDS compliant calibrated images in seven filters of a given location (color cubes) and automatically computes color ratios for that location. Apart from color ratios the program is capable of extracting spectral slopes (F3 and F4 filters) and pseudo Band I minima. Calculation of the latter parameter is accomplished using only four of the seven bands as an array to apply low order polynomial fit in order to retrieve the Band I shape. The result of the fit is then used to find the reflectance minima and the corresponding wavelength. Our extensive testing with laboratory spectral data of HED and non-HED meteorites related to Vesta has shown that pseudo Band I minima and actual Band I minima of high resolution (6 nm) spectra correlate very well (R^2=0.94).

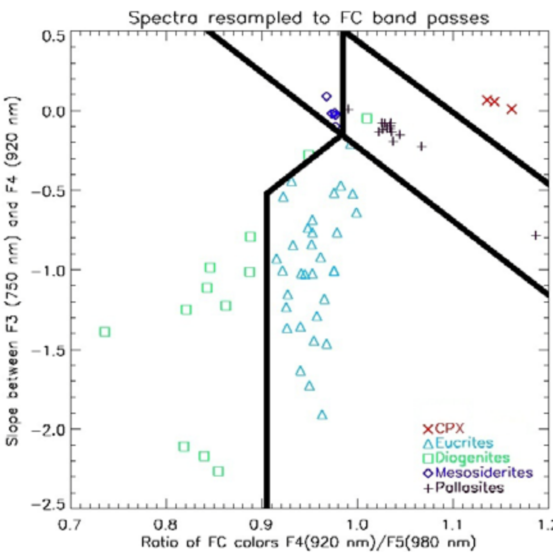

Figure 1: Example of a plot allowing identification of Eucrite and Diogenite-like terrains relative to non-HEDs mineralogy.

Terrain classification is accomplished based on the position of the color ratios for each pixel on scatter plots similar to Fig. 1. We have ~10 different scatter plots that the pipeline iterates between before classifying a pixel as a eucrite for example. Of course, all results are subject of inspection by scientists. The output from DawnKey is a detection layer for each of the specific meteorite types we have included in the database that can be imported into ArcGIS for terrain mapping and classification. Our DawnKey is expected to carry most of the load in our initial terrain identification.

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