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# Automated Spectral System for Terrain Classification, Mineralogy of Vesta from the Dawn Framing Cameras

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## Abstract

The Dawn mission will rendezvous with asteroid (4) Vesta in July 2011. We have developed a set of equations for extracting mean pyroxene chemistry (Ferrosilite and Wollastonite) for classifying terrains on Vesta by using the Dawn Framing Camera (FC) multi-color bands. The Automated Spectral System (ASS) utilizes pseudo-Band I minima to estimate the mean pyroxene chemistry of diogenites, and basaltic eucrites. The mean pyroxene chemistries of cumulate eucrites, and howardites overlap each other on the pyroxene quadrilateral and hence are harder to distinguish. We expect our ASS to carry a bulk of the terrain classification and mineralogy workload utilizing these equations and complement the work of DawnKey (Le Corre et al., 2011, DPS/EPSC 2011). The system will also provide surface mineral chemistry layers that can be used for mapping Vesta's surface.

## 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 FCs are a pair of cameras (one is redundant) that are one of three scientific instruments onboard the spacecraft [2], contains a set of 7 color filters ranging from 0.44 to 0.97 microns in addition to a clear filter (Table 1). The FC clear filter will be used primarily for mapping the surface of Vesta whereas the color filters will provide information about the basic surface composition.

## 2. Characterizing terrains

[3] have developed several spectral criteria such as reflectance ratios, spectral slopes and pseudo Band I minimum for terrain classification from Dawn FC color data. This tool, called DawnKey, can classify terrains on Vesta using these criteria. While color ratios are a first cut method for classifying terrains on any planetary body, surface mineralogy (inventory of minerals) and mineral chemistry (Fe, Mg, Ca content) are more robust and independent criteria for accomplishing the same. So ASS will be able to independently confirm the results of DawnKey [3] and complement its capabilities. Apart from terrain classification, ASS also outputs mean pyroxene chemistry of each pixel using pseudo Band I minima.

Application of mineralogy and mineral chemistry for identification of surface composition has successfully demonstrated with ground-based telescopic observations of Vesta. [4] and [5] have independently developed a set of equations that ingest spectral band parameters such as Band I and II centers, and Band Area Ratio of pyroxene absorption bands and output mean pyroxene chemistry (Fs, Wo and Mg#). These equations coupled with Gaussian analysis tools like MGM [6] can be used with Dawn VIR spectrometer data to constrain the mineralogy and chemistry of Vesta's surface. We have developed similar equations that ingest Dawn FC data (pseudo Band I minima) and output mean pyroxene chemistry.

| Filter name | Wavelength center (µm) | Bandwidth (µm) |
|---|---|---|
| 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 (used by ASS) with their respective band width and center wavelength.*

Our ultimate goal is to setup an automatic pipeline (DawnKey and ASS) that is capable of terrain classification and surface mineralogy to complement results from Dawn VIR and GRaND instruments.

## 3. ASS

ASS is an automated terrain classification and mineralogy 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 four filters (Table 1) of a given location and automatically computes pseudo Band I minima for each pixel of the image. Calculation of the pseudo Band I 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 (Figure 1). 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).

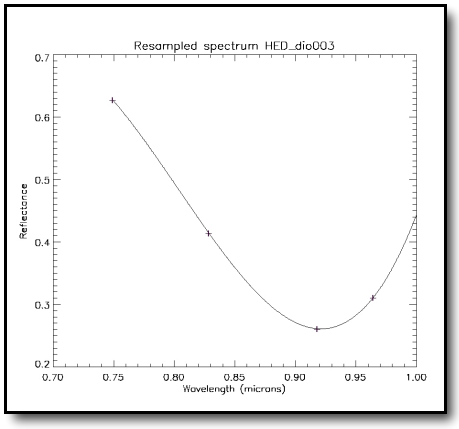


*Figure 1: Polynomial fit through a diogenite spectrum resampled to FC colors.*

The pseudo Band I minima is used to compute the Fs and Wo contents of a pixel and assign a tentative classification (HED) which is then cross checked with DawnKey for consistency. Similarly the mineral chemistry data can be cross-checked with Dawn VIR data before creation of layers. The output from ASS is a detection layer for each of the specific meteorite type, along with mineral chemistry layers for Fs, Wo, and En that we can include in a database that can be imported into ArcGIS for terrain mapping and classification.

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