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Ground-based observations of inner main belt V-type asteroids, in support to the DAWN mission

M.C. De Sanctis (1), A. Migliorini (1), F. Luzia Jasmim (2), D. Lazzaro (2), G. Filacchione (1), S. Marchi (3), E. Ammannito (1), M.T. Capria (1)

(1) INAF, Rome, Italy, (2) Observatório Nacional, Rio de Janeiro, Brazil, (3) Observatoire de la Core d'Azur, Nice, France, (mariacristina.desanctis@iasf-roma.inaf.it, Fax: +39/0645488188)

Abstract

New near-infrared reflectance spectra of 18 V-type candidate asteroids have been obtained at the 3.6 m Telescopio Nazionale Galileo covering the spectral range 0.7 to 2.5 μm. The observed objects were selected from diverse datasets of putative V-type asteroids in order to characterize them, and hence better understand their relationship with (4) Vesta. Most of the selected asteroids do not belong to the Vesta classical family, according to dynamical considerations. Spectral parameters from NIR spectra have been derived to infer mineralogical information of the observed asteroids. All the spectra of the asteroids here analyzed show two prominent absorption features at 1 and 2 μm that are typical of V-class objects, confirming their first classification as V-types, and indicating that the methods based on photometric surveys to infer the basaltic asteroids distribution seem to be quite robust.
The V-type asteroids here examined show a larger variability of band parameters with respect to HEDs values, as for (4) Vesta.

1. Introduction

(4) Vesta is likely the smallest differentiated object of the Solar System. Its composition was studied in the past decades [1, 2, 3], revealing the presence of a basaltic crust. Due to its peculiarity, (4) Vesta is the target of the DAWN mission [4], that will investigate its properties for about one year.
According to the classical scenario to explain the formation of (4) Vesta, after its differentiation, great impacts excavated its surface, producing a swarm of small fragments. Part of these fragments were injected into resonances and were thus ejected due to close encounters with terrestrial planets. Some remained in near-Earth orbits while further collisions ejected other fragments into Earth-colliding orbits, becoming the HED (Howardites, Eucrites and Diogenites) meteorites [5]. This scenario is strengthened by the evidence that (4) Vesta and HED meteorites have similar spectra. A large impact basin was then discovered by HST observations, supporting the idea that (4) Vesta is responsible for the creation of a class of Vesta-like asteroids (known as V-type asteroids) extending from the region surrounding (4) Vesta to the edge of the 3:1 resonance. Numerical simulations of the dynamical evolution of Vesta's fragments have shown that a relatively large fraction of the original Vesta family members may have evolved out of the family borders .It is noteworthy that the mineralogy of the above mentioned asteroids seem to show small differences with respect to that of other V-type asteroids in the inner belt [6,7]. However, their results are not conclusive. New spectra of 18 putative V-type asteroids, selected in the inner part of the Main Belt region, are here analyzed in order to shed light on their relationship with (4) Vesta.

2. Method

Eighteen possible V-type asteroids have been observed during a 6-night program at TNG telescope, in March 2010. Using the full NIR spectra we determined the two minima near 0.9 and 2.0 μm. These values have been calculated by fitting a 2nd order polynomial to the spectral curve in a small region of the minimum.
Band centres were evaluated by using the simple relations between band minima and band centre found by [8]. From these parameters, the [Wo], [Mg] and [Fs] contents were then estimated. The resulting parameters for the observed asteroids were finally compared with the Vesta values and HED values for band centres and minima, in order to point out possible relationship between such asteroids and Vesta.

3. Results

The V-type asteroids here analyzed show differences in their mineralogy with a prevalence of asteroids similar to Diogenites and Howardites, confirming the results found by [8]. Only few asteroids seem to have mineralogies consistent only with eucritic materials. Some of them occupy a region with relatively small values of BI and BII centers (figure 1), indicative of a low content of Ca (<10% Wo) and consistent with diogenitic material. It was noted on previous works that there appears to be a lack of diogenetic V-type asteroids in the inner Main Belt [9, 10].
The identification of diogenite-like asteroids has important implications on their formation. Diogenites material originated from a plutonic layer deep in Vesta's lower crust/upper mantle [11].

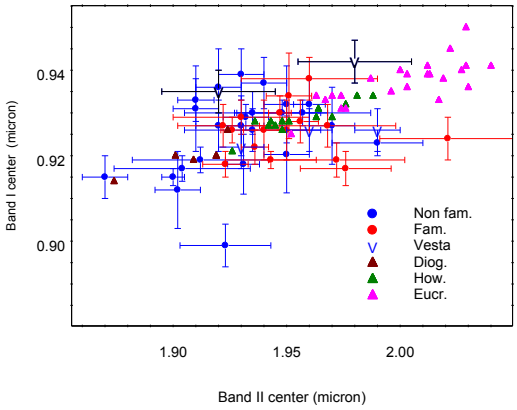

Figure 1. Values of *band I centre* versus *band II centre* for our sample of asteroids and HEDs. Data of previous observed asteroids [8, 9] are added, with a final dataset of 41 asteroids. The V symbols indicate (4) Vesta from [12] and [16]. Vesta family members are marked with red dots while non Vesta-family are marked with blue dots.

4. Summary and Conclusions

The whole dataset consists of 41 V-type asteroids. They were compared with the aim to find differences or trends among them.
From the band analysis we found that either the family and the non-family members have values consistent with the HED distribution. However, the distribution of band centers for the two subsets are slightly different: the non family objects show several, values corresponding to the diogenite region, while the family objects show a clear lack in that region.
The search for correlations between spectroscopic characteristics and dynamical properties did not reveal unambiguously significant results even if we noted that the smaller asteroids have composition more rich in [Fs] and [Wo] than the larger asteroids. However, due to the relatively small data set, it is difficult to state the statistical relevance of this trend.
Summarizing, the main results indicate that: (1) several asteroids present a Diogenite-like mineralogy; (2) almost none of the Diogenite-like asteroids are "classical Vesta family member.
The above findings could have important implications to understand the origin of basaltic material in the Main Belt, though more data could confirm or refute the significance of these results.
Moreover, they are of great importance for the future observations with instruments on board Dawn mission, which aim is to better investigate the properties of (4) Vesta and small bodies related to it.

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