EPSC Abstracts
Vol. 5, EPSC2010-78, 2010
European Planetary Science Congress 2010


# Ground-based observations of V-type asteroids, in support to the DAWN mission

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## Abstract

We present new reflectance spectra of 12 V-type asteroids, selected from different dynamical populations in order to understand if they belong to the Vesta family. Asteroids were observed at the 3.6 m Telescopio Nazionale Galileo, during a 2-nights program on December 2007, in the 0.8-2.5 μm spectral range. In this range, the characteristics pyroxene features at 1 and 2 μm allow a precise mineralogical characterization of the asteroids. A new method of analysis is investigated and successfully applied to the observed data and the ones previously published in [1]. Only the IR spectral range is used to infer mineralogical information of the observed asteroids, to avoid additional errors introduced when visible and IR spectra are joined.
The V-type asteroids, analyzed in this work, show a mainly orthopyroxene mineralogy. Moreover, most of them show a low level of Ca content which implies a diogenitic component in addition to the eucritic one. The investigation of these asteroids related to Vesta is done in support of NASA's Dawn mission that enters into orbit around Vesta in the summer of 2011.

## 1. Introduction

(4) Vesta is the only known large asteroid with a basaltic crust which was first inferred by [2] just from visible spectra. Subsequent works [3, 4, 5, 6] proved that this was indeed the case. An extensive differentiation and resurfacing is the only plausible cause to explain Vesta composition. For its peculiarity, it is the target of the NASA DAWN mission that will arrive at (4) Vesta in 2011 remaining in orbit around it for several months [7, 8]. It is quite debated why just (4) Vesta would have been able to undertake a complete differentiation and resurfacing. Recent discoveries indicate the possible presence in the early Solar System of several differentiated bodies, which partly answer to the above question. However, the origin of the observed basaltic asteroids as well as that of the parent body/bodies of many HED meteorites is still not clear. In particular, do the many V-type asteroids located in the region near Vesta, but far away from the limits of the dynamical family [1, 9, 10, 11], still belong to the Vesta family or rather come from another differentiated parent body? Numerical simulations and analytical studies 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 [12,13]. However, these results indicate that this is not the case for the low inclination objects for which a different origin must be assumed.
The mineralogical analysis of two groups of basaltic asteroids belonging to Vesta's family and in the neighbourhood of Vesta also showed the possible presence of distinct mineralogies [1]. However, their results are not conclusive. The recent work by [14], on the other hand, found that amongst the inner Main Belt asteroids there is no evidence for non-Vestoid mineralogies. Instead, according to their analysis, these asteroids seem to represent a continuum of compositions, consistent with an origin from a single differentiated parent body.
The NASA DAWN mission, launched on 27$^{th}$ Sept 2007 is designed to investigate the origin of the Solar System, by studying the two major main belt asteroids, (1) Ceres and (4) Vesta. The space craft will arrive at Vesta on july 2011, and it will orbit the asteroid for several months, in order to understand the planetary evolution and the role of water on this. We started ground-based observations of V-type asteroids, in order to better characterize the so-called Vesta family, and clarify the relationship between V-type asteroids and Vesta itself.

## 2. Method

Twelve asteroids were selected from a dataset of already known V-type asteroids, 7 of them being members of the Vesta-family, according to [15].
The observed asteroids are listed in table 1.

| Asteroid | a (AU) | e | i (°) | Vesta Family |
|---|---|---|---|---|
| **1929 Kollaa** | 2.363 | 0.114 | 7.065 | Yes |
| **1933 Tinchen** | 2.353 | 0.094 | 9.468 | Yes |
| **2011 Veteraniya** | 2.387 | 0.111 | 6.367 | Yes |
| **2912 Lapalma** | 2.289 | 0.117 | 6.742 | No |
| **3944 Halliday** | 2.368 | 0.109 | 6.754 | Yes |
| **3968 Koptelov** | 2.321 | 0.091 | 6.679 | Yes |
| **4147 Lennon** | 2.362 | 0.102 | 6.482 | Yes |
| **4993 Cossard** | 2.369 | 0.091 | 6.373 | Yes |
| **6406 1992 MJ** | 2.275 | 0.127 | 7.712 | No |
| **7148 Reinholdbien** | 2.286 | 0.099 | 5.641 | No |
| **8693 Matsuki** | 2.406 | 0.122 | 6.269 | No |
| **21238 1995 WV7** | 2.541 | 0.137 | 10.754 | No |

They have been observed in a 2-night program at TNG telescope, in December 2007. 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 2$^{nd}$ 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 [16]. The resulting parameters for the observed asteroids were then compared with the Vesta values for band centres and minima, in order to point out possible relationship between such asteroids and Vesta. A reassessment of data previously published (Duffard et al. 2004) has also been performed using only the infrared part of the spectrum (from 0.7 to 2.5 micron) so that it can be directly compared to the new data here presented.

## 3. Results

The band centers obtained are plotted in fig. 1. As it is shown in fig. 1, it seems that while (4) Vesta lies in the a region between Diogenites and Eucrite (mainly Howardite region) most of the objects observed in the present work have a tendency to occupy the region with smaller values of band I centre.
Several asteroids are set, however, in a region quite distinct from the HED´s. Most of the observed Vestoids show a low level of Ca content (<10% Wo). This result implies that none of the Vestoids studied consists of just eucritic material but must contain a diogenite component. The diogenites are orthopyroxenites, and therefore contain Ca-poor (low Wo) pyroxenes.

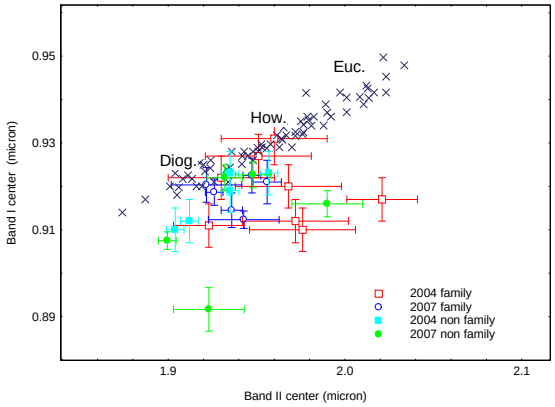


Figure 1. Values of *band I centre* versus *band II centre* for our sample of asteroids superimposed on an adaptation from [17] and [14] for HED values. Open and filled symbols represent asteroids that are members and non-members of the Vesta dynamical family, respectively.

## 4. Summary and Conclusions

We have observed 12 V-type asteroids and extended the proposed analysis to a wider dataset of V-type asteroids, which include 26 objects in total. Comparison of their band parameters to those of HED meteorites from the RELAB database reveals a correlation between band centres of the two samples. Using the new methodology in the band analysis, we do not find the wide range of band centres that was reported by [1] and the band separation plot constrains very well the revised results. Most of the analyzed asteroids show low levels of Ca content (<10% Wo). Moreover, comparing them with HEDs, we found that the analyzed Vestoids must have a diogenite component.

## References

[1] Duffard, et al., 2004; [2] McCord et al., 1970; [3] McFadden et al., 1977; [4] Larson and Fink, 1975; [5] Gaffey, 1997; [6] Binzel et al., 1997; [7] Russell et al., 2007; [8] Russell et al., 2004; [9] Xu et al., 1995; [10] Burbine et al., 2001; [11] Alvarez-Candal et al., 2006; [12] Carruba et al., 2005; [13] Nesvorný et al., 2008; [14] Mosckovitz et al. (2010); [15] Mothé-Diniz et al. (2005); [16] Cloutis and Gaffey (1991); [17] Duffard et al. (2005).