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Properties of basaltic asteroids in the middle and outer main belt

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Abstract

Basaltic asteroids, known as V-types, are distributed throughout the main belt region.

The greatest group of these objects is located in the inner main belt, constituting the Vesta family. However, in the last 20 years, many objects showing a basaltic composition have been identified also beyond 2.5 AU. These seem not to be related to (4) Vesta and require further investigation to better constrain their nature.

We present the spectroscopic and dynamical investigation of 23 asteroids, 15 of which located in the middle and outer main belt regions. Results show that asteroids in these regions, confirmed as basaltic based on their spectra in the visible and near infrared, are more likely related to other asteroidal families, possibly differentiated.

- Introduction

Basaltic material is reckoned as the result of an extensive geochemical differentiation, resulting in a body with a dense metallic core, a mantle of lighter olivine-rich material and an even lighter basaltic surface. This process should occur only on large-size objects, like (4) Vesta for instance, due to the heat needed to melt the chondritic material. The spectrum of (4) Vesta presents two deep absorption bands, at 0.92-0.94 μm and at 2.0μm, which are representative of pyroxenes. It also shows a very peculiar absorption band at 506 nm due to a forbidden transition of Fe^{2+}. Most of the basaltic asteroids, identified through photometric measurements and then spectroscopically confirmed, are located in the inner main belt region (2.15-2.5AU) and mostly constitute the so-called Vesta family. This family counts more than 4500 members, only a small percentage of which have been spectrally characterised so far. These asteroids are indeed dynamically linked to Vesta (Milani et al. 2014) and share similar spectroscopic properties (Duffard et al. 2006; Moskovitz et al. 2010; De Sanctis et al. 2011; Migliorini et al. 2017). However, recent measurements allowed the identification of basaltic asteroids located beyond 2.5 AU (Lazzaro et al. 2000; Hardersen et al.

2004, 2018; Roig et al. 2008; De Sanctis et al. 2011; Solontoi et al. 2012; Ieva et al. 2018, Leith et al. 2017; Medeiros et al. 2019; Migliorini et al. 2017, 2021), which are unlikely related to Vesta, based on dynamical considerations. In addition, their surface composition shows some differences with respect to the V-types in the Vesta family region (see Jasmim et al. 2013).

In the present work, we summarise the properties of basaltic asteroids, especially located beyond 2.5 AU, that were observed at Telescopio Nazionale Galileo (TNG) and ESO facilities during several observing runs. We also discuss their dynamical evolution, in relation to asteroid families that seem to be differentiated.

- Spectral analysis

We have obtained vis and nir spectra of 23 asteroids, 15 of which located in the middle and outer main belt, selected as putative V-types according to vis and nir photometric surveys (Roig and Gil-Hutton 2006; Carvano et al. 2010; Licandro et al. 2017). Eight more asteroids in the inner main belt, non-belonging to the Vesta family, were observed for comparison reasons. Figure 1 shows the distribution of the observed asteroids in the proper semimajor axis-proper inclination plane. Sixteen asteroids show the pyroxene bands at 1 and 2 μm, confirming their basaltic nature. In addition, these all show the faint band at 506 nm, strengthening the composition of the so-called V-type asteroids. Of the asteroids in the middle and outer belt, 9 are confirmed as basaltic asteroids, while 3 are more compatible with Q- or S- complex.

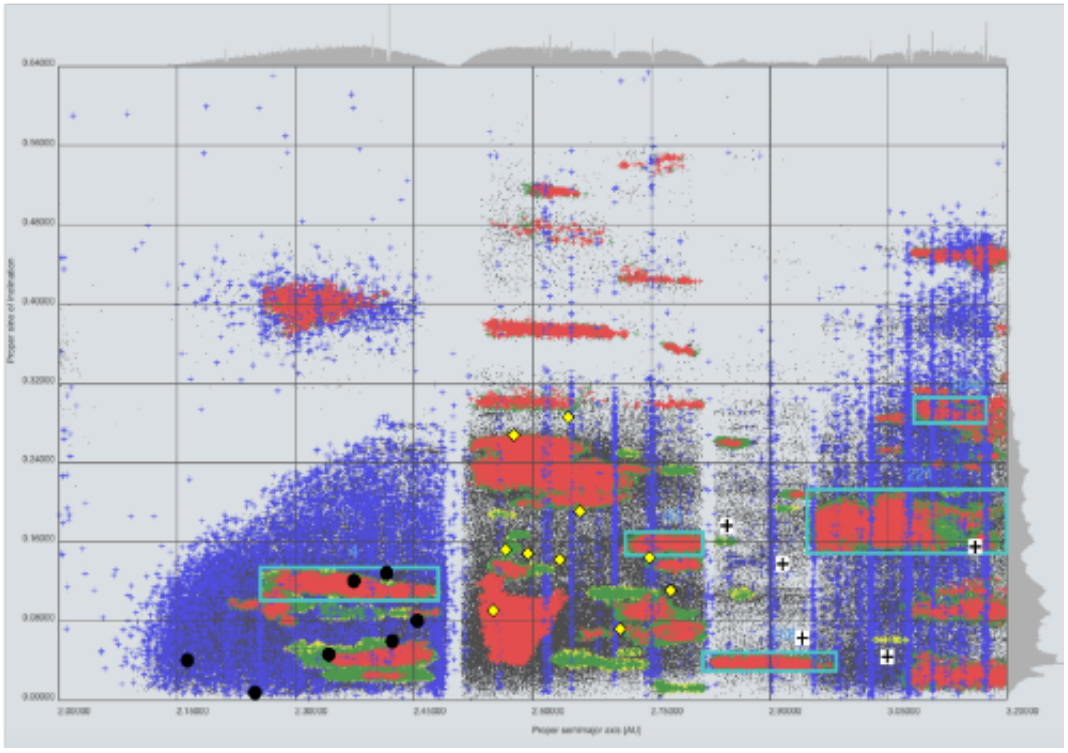

Fig. 1. Distribution of the observed asteroids in the inner, middle and outer main belt region. Observed asteroids are marked with black dots (in the inner main belt region), yellow diamonds (in the middle) and white squares (in the outer).

- Dynamical results

The presence of basaltic asteroids far from the Vesta family region raises the question whether the V-type asteroids, observed all around the main belt, are indeed basaltic, like Vesta, or from some

other bodies. In our work, the dynamics of a total of 14 asteroids in the middle main belt and 14 in the outer main belt (following Michtchenko et al. 2016), all confirmed as V-types was investigated. Among these objects, 7 were finally identified as either members or located nearby some families (Migliorini et al. 2021), whose parent body was probably differentiated or partially differentiated. This finding is in agreement with the hypothesis that V-types in the middle and outer regions have not been originated from (4) Vesta. In addition, this suggests that the number of differentiated objects in the middle and outer main belt must be much larger than previously assumed.

Our work has contributed to enlarge the number of asteroids in the middle and outer main belt region, confirmed as basaltic, and successfully identified asteroidal families, which might contain basaltic asteroids.

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