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Basaltic material in the main belt: a tale of two parent bodies?

S. Ieva (1), E. Dotto (1), D. Lazzaro (2), D. Fulvio (3), D. Perna (1,4), E. Mazzotta Epifani (1), H. Medeiros (2), M. Fulchignoni (4)
(1) INAF – Osservatorio Astronomico di Roma, Via Frascati 33, 00078 Monte Porzio Catone (Roma), Italy (simone.ieva@oa-roma.inaf.it)
(2) Observatório Nacional, R. Gal. José Cristino 77, 20921-400 Rio de Janeiro, Brazil
(3) Departamento de Física, Pontifícia Universidade Católica do Rio de Janeiro, Rua Marquês de São Vicente 225, 22451-900 Rio de Janeiro, RJ, Brazil
(4) LESIA, Observatoire de Paris, PSL Research University, CNRS, Univ. Paris Diderot, Sorbonne Paris Cité, UPMC Univ., Paris 06, Sorbonne Université, 5 Place J. Janssen, Meudon Cedex F-92195, France

Abstract

The majority of basaltic objects in the main belt are dynamically connected to Vesta, the largest differentiated asteroid known. Others, due to their current orbital parameters, cannot be easily linked to Vesta and could be fragments of another differentiated asteroid. We conducted an on-going spectroscopic survey to characterize basaltic candidates in the middle and outer main belt. Here we present the latest results.

1. Introduction

The study of basaltic asteroids in the main belt has been a powerful tool to constrain the presence and frequency of differentiated material in the early Solar System. These asteroids, classified as V-type in all the latest taxonomies [6], are thought to represent the crust of planetesimals that undergone a complete metal-silicate differentiation: iron core, olivine mantle and basaltic crust.

Vesta has been long considered the parent body for all the basaltic material in the solar system, due to several clues: i) the similarity of their spectrum characterized by two deep absorption bands at 0.9 and 1.9 μm [1,5]; ii) the presence of two large basins in the southern hemisphere of Vesta [12] identified as the origin for the dynamical family (the so-called *vestoids*).

The discovery of V-type asteroids with no dynamical link with Vesta, beyond the 3:1 mean motion resonance with Jupiter [2,7,9] raised doubts if all the basaltic asteroids in the Solar System come from Vesta. Dynamical simulations show that the probability for an asteroid of a D > 5 km to evolve from the Vesta family and cross over the 3:1 resonance, reaching a stable orbit in the middle belt, is almost 1% [11]. Moreover, laboratory studies on meteorites [3,13] and dynamical considerations [4] suggest that several large asteroids (D = 150-300 km) should have been differentiated in the early Solar System. The inconclusive search of these bodies lead to the idea that these basaltic progenitors were battered to bits; or that maybe our understanding of differentiation processes is not complete [10].

In order to characterize basaltic candidates in the middle/outer main belt (or MOVs) we are conducting an observational campaign via visible and near-infrared spectroscopy. The observed objects were identified among the SDSS - Moving Object Catalog (MOC), assuming that candidates with photometric colors and albedo indicative of a basaltic composition are indeed basaltic asteroids.

2. Results

Here we present the latest results of two observational campaigns we have conducted at Telescopio Nazionale Galileo (TNG) in 2015 and at ESO - New Technology Telescope (NTT) in 2016. We spectroscopically characterized 18 MOV candidates in the visible range. In order to compare the results with our previous statistical analysis on the largest collection of V-type spectra [8], we computed three spectral parameters: reflectivity gradients between 0.5-0.75 μm (slopeA) and 0.8-0.92 μm (slopeB) and the reflectance ratio 0.75/0.9 μm (depth). Our analysis has shown that the differences between MOVs and vestoids seem to be more evident comparing slopeB and depth, with the MOV population having the extreme spectral parameters of the sample. Moreover, the analysis of the spectral parameters in three different regions of the main belt with a high concentration of MOVs has shown that the depth is always higher than the Vesta family.

The presence of a cluster of basaltic objects with similar spectral parameters, but different from Vesta's, could be a strong indicator of the presence of another differentiated family. This could alter the current paradigma of differentiation processes, implying that the extension of the temperature gradient in the protosolar nebula at the epoch of planetary formation was different from always thought, in order to reach the right amount of heat able to sustain differentiation at solar distances a > 2.5 au.

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