BASALTIC INTERLOPERS IN THE C-COMPLEX ASTEROID FAMILIES: POSSIBLE SOURCES FOR EXOGENOUS MATERIAL ON (101955) BENNU AND (162173) RYUGU.

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Introduction: Asteroid (4) Vesta is the largest (~525 km in diameter) differentiated asteroid showing a basaltic crust. The collisional family of Vesta includes more than 15,000 known members [1]. The results found by the Dawn mission support the hypothesis that this family is a result of cratering events. They revealed two remnant craters, Rheasilvia (the young crater retention age of this basin indicates that it was formed \(\approx 1\) Gy) and Veneneia (the crater counts suggest an age of 2.1 ± 0.2 Gyr ago) with diameters of 500 ± 25 and 400 ± 25 km respectively [2].

The most likely origin of the two sample-return targets of OSIRIS-REx and Hayabusa2 space-missions, namely (101955) Bennu and (162173) Ryugu, are the C-complex families from the inner-main belt [3,4,5]. In this context, the aim of our work is to study the distribution of V-type asteroids (associated with basaltic compositions) across the inner main belt as a possible source for the basaltic material identified on Bennu [6].

Methods: Different all-sky spectrophotometric surveys have allowed the discovery of a large number of basaltic candidates over the entire inner-main belt [7,8,9]. Follow-up spectroscopic surveys confirmed their identification with a success rate of about 90% (e.g. \[10,11,12,13,14\] and references therein).

In order to test the hypothesis of exogenous origin of basaltic material reported on Bennu [6] we retrieved all spectrally confirmed V-types and the spectro-photometric basaltic candidates.

Results: Figure 1 shows the distribution of proper semi-major axis vs. eccentricity (top panel) and vs. sine of proper inclination (bottom panel) for the currently identified eight C-complex collisional families located in the inner belt [1]. The basaltic asteroids (V-types) are shown for comparison. Dynamically, some of the V-type candidates have orbital proper elements similar to those of the B/C-complex inner-main belt families. Part of these basaltic candidates are dynamically associated as members of these families [1]. There are 166 V-types spectrally confirmed (either in optical or near-infrared region or covering both spectral intervals).- A total number of 476 V-type candidates (with a probability higher than 50%) were reported by [7] based on the data obtained with u,g,r,i,z filters by the Sloan Digital Sky Survey. The near-infrared photometric measurements performed with Y, J, H, Ks by the VISTA-VHS survey allows the identification of 778 basaltic candidates [8,9].

These evidences are in favor of the presence of basaltic material at the surface of (101955) Bennu.

![Fig. 1 V-types and C-complex asteroid families distribution in the proper orbital elements space.](image_url)
The areal or linear mixture of basaltic and carbonaceous chondrites like compositions (dashed red line). The C taxonomic type spectrum (black line) is shown for comparison. The typical albedo of V-types and C-types are considered.

The spectrophotometric data of bright spots detected on Bennu show differences, in terms of albedo and 0.9 μm band depth, relative to the RELAB data of howardite, eucrite, diogenite meteorites. These differences are explainable by an approximation of an areal or linear mixture of basaltic and carbonaceous chondrite–like components. It involves a linear combination of the corresponding spectra. This "checkerboard" approach [15] assumes the constituent minerals are optically separated so that multiple scattering occurring between the constituents are negligible.

To exemplify this model, we considered the average spectrum of V-types asteroids (associated with basaltic howardite – eucrite – diogenite material) and the average spectrum of C-type bodies (associated with carbonaceous chondrite meteorites). To approximate the absolute reflectance, we considered a visual albedo of \( p_{\text{V}} = 0.36 \) for the V-type spectrum and \( p_{\text{C}} = 0.05 \) for the C-type one. These were combined linearly and the result is shown in Fig. 2. The result was obtained by calculating an areal ratio of 10% for the basaltic material and 90% for the carbonaceous material. This model is able to explain the spectrophotometric behavior of the brightest spots detected on Bennu [6].

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