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Investigation of the 3.4 µm absorption band in the spectra of low-albedo asteroids

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Organic materials are crucial for understanding the processes that took place at the early stages of Solar System formation and can bring some inputs on the origin of life on Earth. Organics is widely present in various groups of carbonaceous chondrite meteorites that are believed to be originated from dark primitive asteroids [1]. The absorption bands at 3.38, 3.42, and 3.47 µm are assigned to symmetric and asymmetric modes of CH_3 and CH_2 groups [2]. Thus, the identification of organic materials on the surface of low-albedo objects is rather difficult due to the fact that organic compounds have characteristic features outside the most accessible spectral region (0.4-2.5 µm). Furthermore, there is an overlap between organic and carbonate absorption bands [e.g., 3]. Up to now, the presence of organic band was detected only for a handful of objects, such as (1) Ceres [4], (24) Themis [5], (52) Europa [6], (65) Cybele [7], (121) Hermione [8], and (704) Interamnia [9]. The presence of organic features was also detected on the surface of the comet 67P/Churyumov-Gerasimenko [10].

In this work we studied the available spectra of low-albedo asteroids in order to find the signs of an absorption feature around 3.4 µm band and to examine the occurrence of organic matter on asteroid surfaces. We found 122 published spectra for 92 low-albedo asteroids which cover the range of 3-4 µm. Following spectra classification by [11], the majority of objects in the sample belong to the C-complex group. The rest of the objects belong to X-group, D-group, and T-group. We reduced our sample to 41 objects for which good-quality spectra were available. The presence of an absorption feature at 3.4 µm is detected for 20 asteroids (Fig. 1). As could be seen from the figure, the organic band is found for all asteroids in the sample that are larger than ~250 km, which is most probably related to a higher S/N ratio.

The band parameters such as central position and depth were calculated by fitting a 3.4 µm band with an Exponentially Modified Gaussian (EMG) following the method described in [12]. We found no correlation between the depth and position of the 3.4 µm band and the orbital elements of the asteroids.

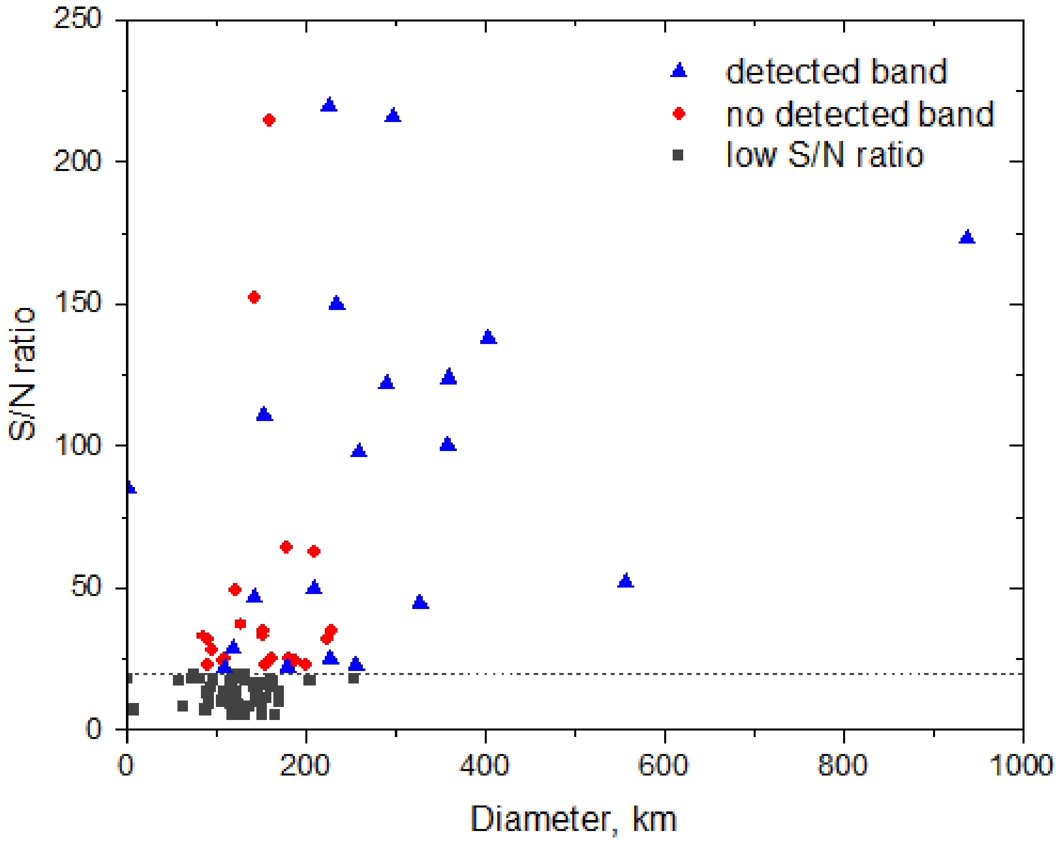

Fig. 1. Diameter vs. S/N ratio in the 3.3-3.5 μm wavelength range for dark asteroids in our ample.

Spectral types are not distributed evenly among objects with and without a band around 3.4 μm: all the spectra, except (121) Hermione, not showing the 3.4 μm band belong to the Ch or Chg classes, whereas asteroids with a detected band mostly belong to C, B, and P types. However, only two Ch/Chg asteroids in the sample, (51) Nemausa and (78) Diana, have high S/N spectra. Thus, the absence of the organic band for Ch and Cgh type asteroids can be related to the generally lower S/N ratio and/or a shallower organic band for these groups. Furthermore, there is a tendency for asteroids with the 3.4 μm band to have redder J-K colors and more neutral U-V colors (Fig. 2, left). Additionally, there is a trend for asteroids with a detected 3.4 μm band to have lower albedo (Fig. 2, right).

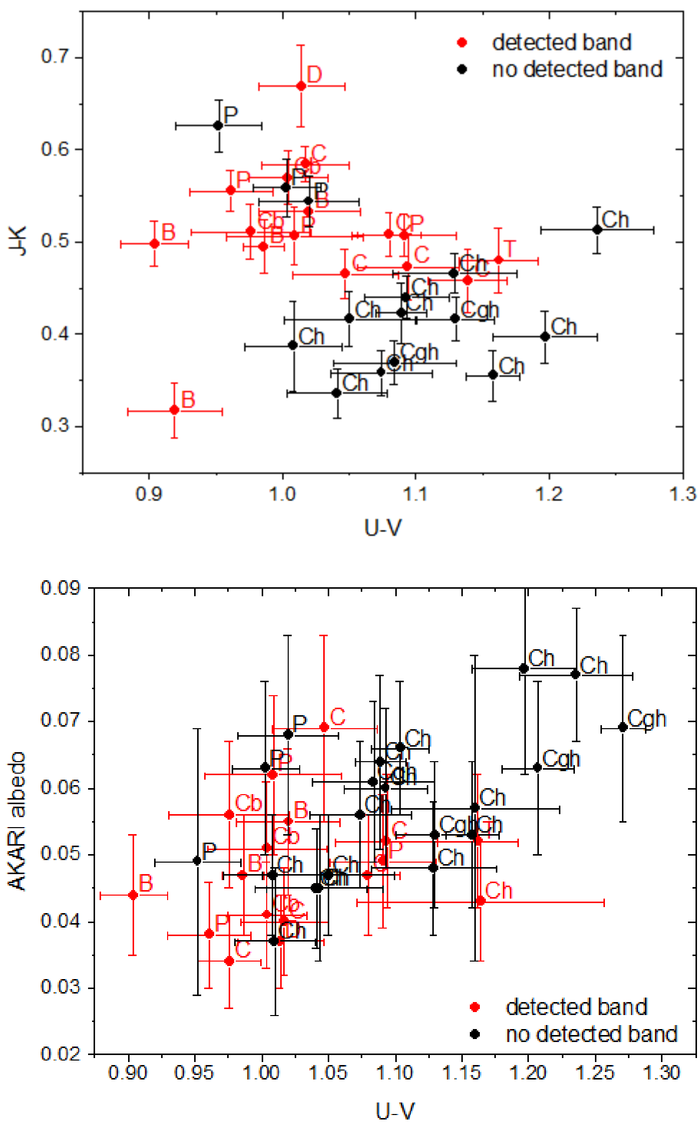

Fig. 2. U-V vs. J-K colors (left) and U-V vs. albedo value taken from the AKARI survey (right). The largest asteroids in the sample (1) Ceres and (2) Pallas are not shown in the plots.

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