Astronomical Journal of Azerbaijan, 2022, Vol. 17, No. 1

ON THE POSSIBILITY OF ASTEROID MATTER COMPOSITION ESTIMATION NEAR PERIHELION

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Two programs in the MATLAB environment for studying chemical and mineralogical composition of asteroids from their visible-range reflectance spectra were previously developed by us. The first one is used for estimation of mineral composition of the asteroid surface matter on the basis of spectral characteristics of known meteorite and mineral analog samples. The second program allows estimation of a taxonomic class of an asteroid. As follows from our analysis of asteroid spectral characteristics, reflectance spectra of some of asteroids obtained near perihelion at good photometric conditions turned out to be very different in comparison with their spectra from SMASSII database and those of their probable meteorite analogs. We suggested that presence of a scattering media, like a dust exosphere arising due to sublimation of subsurface deposits of water ice on primitive-type asteroids near perihelion (at the highest subsolar temperatures), might have been an obstacle for a correct determination of their chemical and mineral matter composition by the spectral method. At the same time, such phenomenon (if present) could be used as an indication of a considerable H_2O content in interiors of asteroids considered.

Keywords: Asteroids, composition – Meteorites – Spectrophotometry

1. INTRODUCTION

Studying of asteroids is important because of several reasons. Along with the fundamental importance of the research of these most ancient small bodies, "near-Earth asteroids" (NEAs) could be potentially hazardous or may be sources of valuable mineral sources (including H_2O). Nowadays over 1 million asteroids

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is discovered and every year this number rises quickly. Thus, an amount of information to analyze is great, and it would be useful to accelerate and automatize studying the composition of asteroids. For this purpose two computer programs were written (see Section 2).
In December 2020, new spectral data for 10 main-belt asteroids (19, 52, 102, 177, 200, 203, 250, 266, 379, 383), when they were moving near their perihelia, were obtained. We applied our programs to analyse these data. Results of this study are presented in this paper.

2. PROGRAMS

The first program (that is called OSVAS, [1]) is used to find mineral and meteorite analogues for the surface matter of asteroids using their reflectance spectra. For the purpose of OSVAS performance, our own database of normalized reflectance spectra of minerals and meteorites was created. It was made using mainly the RELAB database [2] and that of the University of Winnipeg's Planetary Spectrophotometer Facility (PSF; aka HOSERLab) [3].

The algorithm of OSVAS is as follows. Some control points are chosen equidistantly on a normalized reflectance spectrum of an asteroid under study. Then the program selects spectra of minerals or meteorites from our database that differ minimally from the spectrum of the asteroid in the control points. After that, the program finds a linear combination of these spectra of minerals or meteorites that is fit to the spectrum of the asteroid by the total minimum of quadratic deviations. Thus, we can obtain a quantitative approximation of asteroid surface mineral composition by means of a "geographic" combination of those of mineral or meteorite analog samples. The second program is used to estimate a taxonomic class of an asteroid [4].

Consider a coordinate system "Normalized reflectance spectrum - wavelength". Let us call as "template" the boundaries in which normalized reflectance spectra of all known asteroids of each taxonomic class are put. These "templates" for all taxonomic classes were calculated according to SMASSII and Tholen classifications using SMASSII database [5]. Then reflectance spectrum of an asteroid in question is compared with "templates" of all spectral classes and its overlapping coefficients with the boundaries of each "template" are calculated. Also albedo of the asteroid (if known) is compared with albedo boundaries of taxonomical classes. Analyzing this information, one can estimate taxonomical class of asteroid observed.

3. RESULTS

Meteorite analogues for asteroids 102 Miriam (Frontier Mountain 99040 (CO3), Fig. 1) and 266 Aline (67% Nogoya (CM2) + 33% Murchison (CM2), Fig. 2) were found. These meteorite analogues agree well with known taxonomic types of these asteroids: SMASSII C class of 102 Miriam and Ch of 266 Aline. Also, estimated taxonomic types of these asteroids determined by our program coincided with the taxonomic classes.

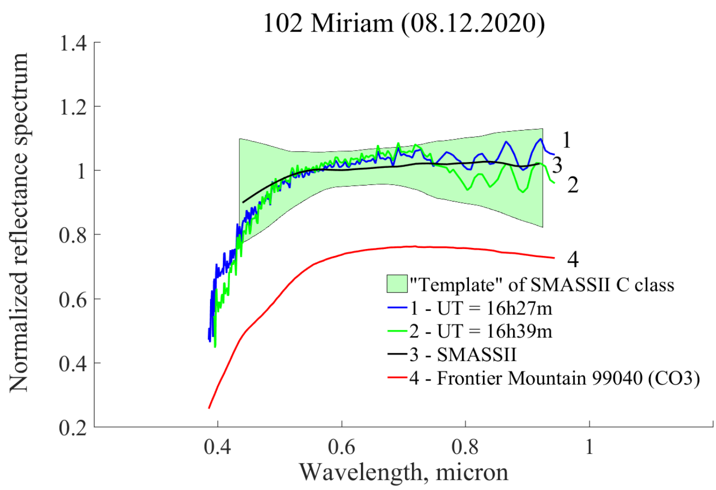

Fig. 1: Normalized to unity at 0.55μ reflectance spectra of 102 Miriam (1-2) placed on the "template" of SMASSII C class. Also a "reference" reflectance spectrum of the asteroid from the SMASSII database (3) and the spectrum of the meteorite analogue (4) are shown. Time (UT) for all observations is given on the figure.

Asteroid 203 Pompeja has not yet been assigned to a specific taxonomic class (e. g., [6]). Our program estimated its SMASSII taxonomic class as C using its three reflectance spectra in the wavelength range of 0.38-0.7 microns (Fig.3). However, the reflectance spectra of Pompeja in the range of 0.70-0.95 microns turned out to be outside the template of C-class because of probable influence of a dusty exosphere of the asteroid near perihelion [7]. The same reason did not allowed us to find a meteorite analogue for this asteroid.

Attempts to find meteorite analogues for other 7 asteroids (19, 52, 177, 200, 250, 379, 383) were also unsuccessful. Fig. 4 illustrates that reflectance spectra of the asteroids do not coincide with their “reference” reflectance spectra from the SMASSII database. For most of the asteroids of the program suggests three the

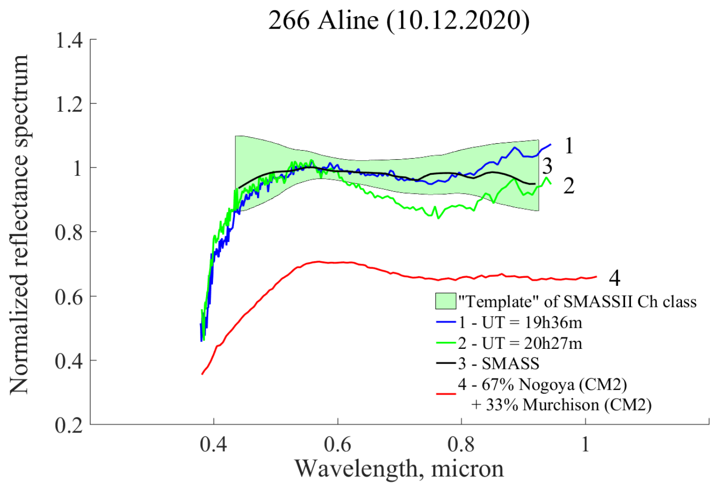

Fig. 2: Normalized to unity at 0.55μ reflectance spectra of 266 Aline (1-2) placed on the "template" of SMASSII Ch class. Also there is a "reference" reflectance spectrum of the asteroid from the SMASSII database (3) and the spectrum of the mix of the meteorite analogues (4). Time (UT) for all observations is given on the figure.

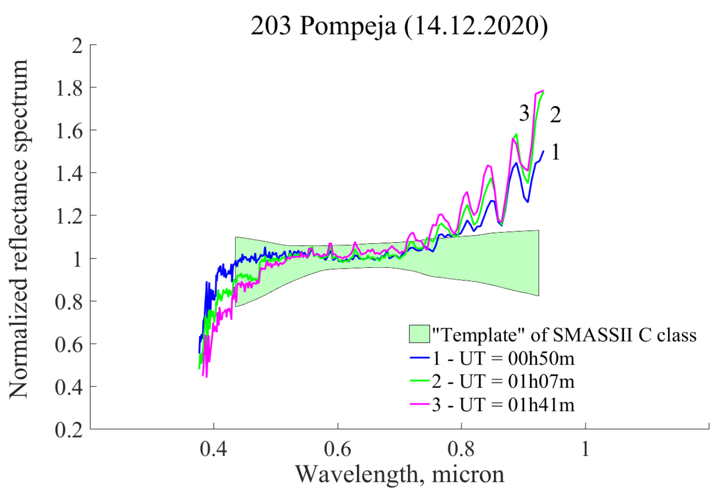

Fig. 3: Normalized to unity at 0.55μ reflectance spectra of 203 Pompeja (1-3) placed on the "template" of SMASSII C class. Time (UT) for all observations is given on the figure. Theere is no "reference" spectrum in the SMASSII database for the asteroid.

most possible classes, but in any case these asteroid spectra badly match with their "templates". It should be noted that most of the asteroids (with the exception of 200) were observed at good photometric conditions [7]. Then a reasonable explanation could be that the observed differences were caused by light scattering in a sublimation-driven dust exosphere of the primitive-type asteroids, which probably formed near perihelia of their orbits at the highest subsolar temperatures (e. g., [8]). As model calculations show (e. g., [9]), because of a high porosity of the surface matter of such main-belt asteroids (and, hence, its low thermal conductivity) water ice could survive in their interiors for billions of years.

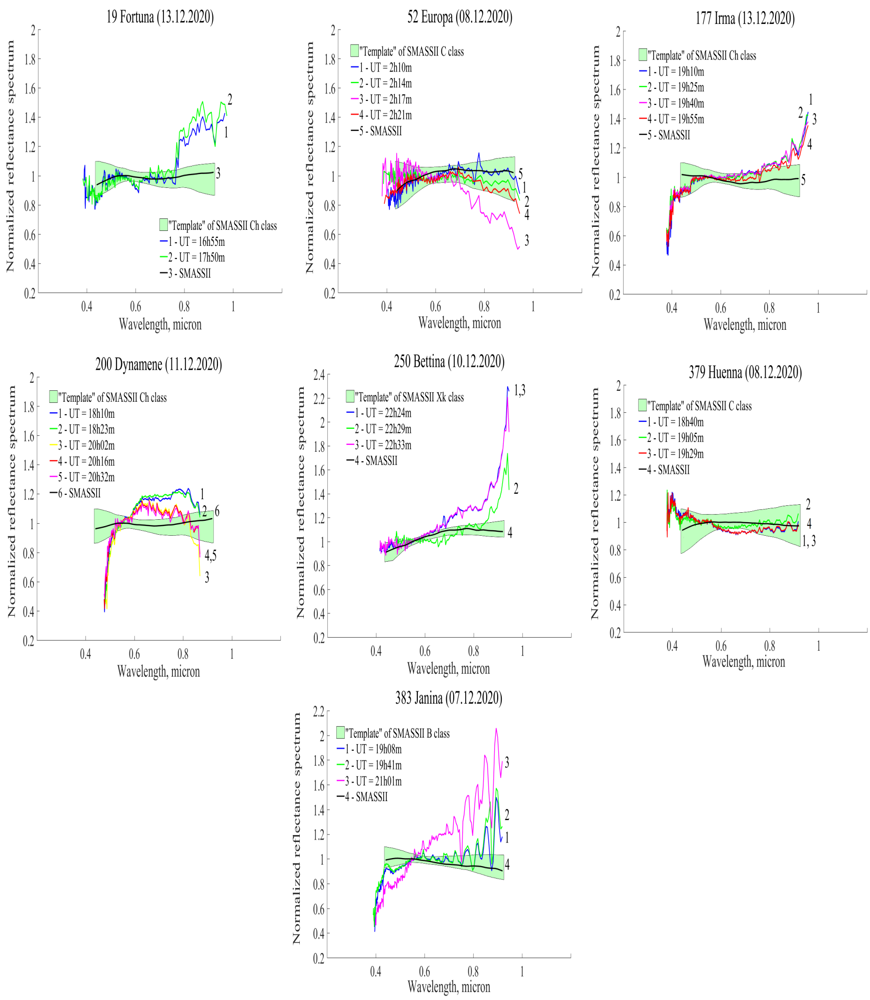

Fig. 4: Normalized reflectance spectra of other seven asteroids compared with "templates" of their known SMASSII classes.

4. CONCLUSION

Thus, it seems that at observation of primitive-type asteroids passing near perihelion, there is a high probability of distortion of their reflectance spectra due to influence of their sublimation-driven exosphere [8]. In this case determination of taxonomic class of an asteroid and estimation of its surface composition with its reflectance spectra could be incorrect. In our opinion, it should be borne in mind when choosing time for observation of asteroids. On the other hand, spectral signs of a dust exosphere around a primitive asteroid passing near perihelion (e. g., [8]) could be used as an indication of a considerable H_2O content in its interiors.

This work is supported by the Russian Science Foundation under grant 22-12-00115.

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