COMPUTER SIMULATION OF PHOBOS SPECTRUM: IMPLICATION TO SURFACE COMPOSITION; L. V Starukhina and Yu. G. Shkuratov, Kharkov Astronomical observatory, Sumska 35 Kharkov 310022 Ukraine, shkuratov@mak.kharkov.ua

Composite Phobos spectrum proposed by the authors is simulated. Calculation show that (1) modification of the carbonaceous chondrite spectra by formation of fine grains of reduced iron in the upper surface layers of particles (similar to those in lunar regolith) do not match the Phobos spectral curve; (2) a good fit for it is obtained for submicron mixtures of clay minerals and dark red organic compounds, so Phobos spectral curve can be explained by higher H content in the organic components of Phobos surface material as compared to carbonaceous chondrites.

Introduction. Up to recent years Phobos spectrum has been considered analogous to spectra of C-type asteroids, i.e. dark flat at wavelengths longer than 0.4 \( \mu \text{m} \) and with fall-off shortwave of 0.4 \( \mu \text{m} \) [1]. This type of spectra combined with low density of Phobos suggested an idea that Phobos surface material should be similar to that of carbonaceous chondrites (CC) supposed to originate from C asteroids. New data on martian satellite spectra [2-4] show that they are far from being "flat", so another asteroid type as analog to Phobos, namely, D type has been proposed [3]. However, surface exposure to cosmogenic factors could change the shape of spectral curves of CC as it occurs for the lunar soils. To choose between "C" and "D" hypotheses we recalculated spectra of CC taking formation of fine grains of reduced iron in the upper particle layer similar to those in lunar regolith into account.

Phobos composite spectrum. For simulation we have used Phobos composite spectrum obtained in [5]. To cover the widest spectral range possible the data of Mariner 9 UV spectrometer [1] combined with Hubble Space Telescope data [3] and IR spectrum [4] were taken. Intercalibration of the data has been performed as follows. First the normalized spectrum [3] in the range 0.35-0.8 \( \mu \text{m} \) and the IR spectrum [4] have been scaled using the two albedo values from [6] corresponding to the wavelengths 0.5 and 0.9 \( \mu \text{m} \), respectively. Then we rescaled the 0.35-0.8 \( \mu \text{m} \) spectrum [3] so as to match the point 0.8 \( \mu \text{m} \) of the obtained IR spectrum and the average of the two scalings has been taken. Finally we rescaled the IR spectrum [4] so as to fit the value for 0.8 \( \mu \text{m} \) of the obtained average spectrum. From the short waves so obtained composite spectrum turned out to be in good agreement with Mariner 9 UV data. The model wide range spectrum of Phobos is denoted as (1) in Figs. 1,2.

Theoretical model. For calculations we used our model for spectral albedo of multicomponent particulate surfaces [7]. The model enables one to calculate reflectance of a surface from the spectra of optical constants of constituents and vice versa, to determine effective optical constants (imaginary part of refractive index) for a surface particles from its reflectance.

Modification of carbonaceous chondrite spectra. In Fig.1 Phobos spectrum (1) is compared with spectra of carbonaceous chondrite Orgueil measured in laboratory (line 2, [8]) and after computer simulation (3) of spectral changes due to particle size decrease and formation of reduced iron grains (up to volume concentration of 4%) in the 1000 A upper surface layer of the particles. Such simulation is described in [9] where it has been carried out for lunar soils. So modified CC spectrum becomes much closer to that of Phobos but the steep fall-off in Phobos spectrum begins at much shorter wavelengths than for CC (about 0.4 and 0.6 \( \mu \text{m} \), respectively). Longwave of 1.5 \( \mu \text{m} \) the difference between curves 1 and 3 in fig.1 cannot be eliminated either. The results for carbonaceous chondrites of the other types are similar.

Simulation of D asteroid spectra. As proposed in [10] D asteroid surface is composed of mixtures of clay minerals with dark red organic compounds. We have made an attempt to construct the Phobos spectrum directly from possible constituents, supposing that Phobos surface composition differs from CC only in type of the organic component, namely, that Phobos organic has higher H content and, consequently, red-sloped IR spectrum instead of flat one. For calculations we used the spectra of bitumen
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series organics from [11] and hydrosilicate spectra from [12]. Rather good fit for the shape of the Phobos spectrum was obtained only for the darkest members of the series with the lowest red spectral slope - anthraxolite and shungite. Line 2 in Fig.2 represents the calculated spectrum for volume concentration of shungite 5%. The feature 2.7 \mu m due to hydrosilicates which appears in the calculated spectra is not pronounced in Phobos spectrum, probably, because of heating of the surface in meteorite bombardment.

Conclusions. Thus our calculations show that Phobos surface material resembles rather that of D asteroids than carbonaceous chondrites with reduced iron in particle surface layers. However, it does not mean the same origin for Phobos and D asteroids. Higher H content in Phobos organic substance may be due both to hydrogen in upper martian atmosphere and to ice in inner parts of Phobos. The hydrogen penetrating into particles can react with carbonaceous substance [13] heated by enhanced meteoritic bombardment in the vicinity of Mars.

References