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Space weathering and the suface composition of Phobos

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Abstract

The most of the observed Phobos area is characterized by redder spectral unit (PRU), while bluer spectral unit (PBU) is being generally associated with the interior and the ejecta of Stickney crater. We present a model that is based on laboratory experiments and using which we try to explain the difference in spectral slopes of the two parts of Phobos surface.

1. Introduction

The question of the origin of the Martian moons Phobos and Deimos remains still open. Phobos and Deimos share similar visible-near infrared (0.4–2.5 μm) spectra suggesting that they have a similar surface composition. However, on the basis of different observational campaigns it was confirmed the large-scale (hemispheric) spectral heterogeneity on Phobos. The spectrum of Phobos consists of "redder" and "bluer" units [4, 6, 7]. The most of the observed Phobos area is characterized by the redder spectral unit (PRU), while the bluer spectral unit (PBU) is being generally associated with the interior and the ejecta of Stickney crater.

It is well known, that the color of the surface of Solar System bodies not protected by atmosphere or global magnetosphere may progressively change in time under the influence of micrometeorite (interplanetary dust) bombardment and ion irradiation. The set of such induced processes - observable mainly as reddening and darkening of solar reflectance spectra of the surface - is known as space weathering.

Several irradiation experiments aimed at simulating space weathering of organic and silicate materials have been performed in our laboratory in Catania. On the basis of these experiments we can say that the ion irradiation can produce the spectral redening of the material, which has initially high albedo and flat spectrum (e.g. C-rich ices and polymeres like polystyrene [1, 2]); but a flat and dark spectrum can be the result of irradiation of an originally red material (e.g. asphaltite and organic residues [3, 1]).

2. Model

We present a model based on laboratory experiments in which we assume that PRU is made of the same material as the interior and the ejecta of Stickney crater (associated with PBU) but it is covered by low volatility organic materials.

We computed the reflectance spectra R^* of material similar to PBU (which reflectance spectrum is $= R_{BU}$ constructed to match the bluer part of Phobos spectra) covered with a layer of irradiated organic material. According to the simple optical model proposed by Kaňuchová et al. [2], the expected reflectance spectrum can be expressed as:

$$R^* = R_{BU} T^2, \quad (1)$$

where $T = e^{-\alpha s}$ is transmittance of deposited organic material of thickness s, whose wavelength dependent absorption coefficient is α. We used the absorption coefficient of polystyrene at the fluence of 5.2x10^{15} argon ions cm^{-2}, at which the saturation of the spectral changes occured [2].

Computed reflectance spectra were normalized to 1 at λ = 550 nm and compared with those of the PBU and PRU. The fit of the red part of Phobos spectra was achieved (Fig. 1) under the assumption that the PBU-like matter is covered by irradiated organic matter having a thickness of 0.015 μm.

3. Summary

We suggest that the difference in the slope of two spectral units of Phobos is caused by the presence of the weathered organic material of low volatility. The part of Phobos observed as red could be composed of the same material as that observed as blue, but covered with some amount of weathered (irradiated) organic material of low volatility. The organic material can be

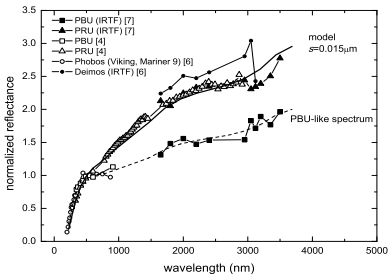

Figure 1: Spectra of Phobos and Deimos, synthetic spectrum of PBU-like matter. The PRU was fitted with a reflectance spectra of PBU-like matter covered with a 0.015 μm layer of irradiated polystyrene.

accreted Deimos material, as Rivkin et al. are concluding [7]. The organic material could have been evaporated (removed) by the Stickney impact, thus the crater Stickney and the excavations around it are formed by the deeper material.

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