



Phobos surface composition: clues from laboratory emissivity measurements and MGS-TES spectral data

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Abstract

The debate about the composition of the Martian moon Phobos is still open, even if it has been observed both from Earth and from spacecraft orbiting Mars.

In this work we used the linear deconvolution technique on thermal infrared spectra acquired by Mars Global Surveyor Thermal Emission Spectrometer (MGS-TES) [1] to investigate its surface composition.

The preliminary results here shown seem to be indicative of a large abundance of phyllosilicates (e.g. biotite), with small amounts of other materials, mainly olivines. In particular the grain sizes involved should be very fines, with particle diameter less than 25 μm .

However, since the linear deconvolution can be considered high efficient only for large particles, further investigations, involving laboratory spectra of mixtures of phyllosilicates and olivines, have to be performed.

1. Introduction

The origin and composition of Phobos is an open issue and different hypothesis have been made about them.

Albeit it has initially been compared to C-type porous objects for the very low density and visual albedo values [2], subsequent analysis of Vis/NIR spectra contrasted with this hypothesis, showing a nearly featureless spectrum, without traces of hydration, but with a very steep red slope [3].

More recent studies [4] suggest that Phobos may be composed by two different units, differing for their spectral slope. In this case the Blue unit should be similar to a T-type asteroid, whereas the Red unit resembles a D-type asteroid.

2. Data analysis

TES observed Phobos at the end of the 1998 summer. Due to the very irregular shape of Phobos the shadow and the full sunlight can characterize in a very dramatic way adjacent regions. In the thermal infrared region this would result in a superposition of emitted radiances originated at different temperatures. Therefore, in order to retrieve a meaningful spectral emissivity, it has been necessary for us to develop an algorithm to fit the TES observed radiance with the suitable number of Planck curves.

The same algorithm automatically computes the optimal number of Planck curves to be used, their temperatures and areal fraction in the field of view. Finally some constraints to avoid mathematically correct configuration physically not meaningful have been added.

Due to the low radiance coming from Phobos, in order to have a good SNR, the spectral region between 250 and 1300 cm^{-1} has been analyzed in this study and, to retrieve and characterize the number and spectral shapes of the different surface units present, an R-mode factor analysis technique [5][6], together with Principal Component Analysis (PCA) [7], has been applied.

The different spectral units have been finally differentiated by means of an unsupervised hierarchical cluster algorithm based on the pairwise distance between each couple of data.

3. Results

For the present work we found two different spectral units in the thermal infrared. However the clustering procedure is still under study and in the future other spectral units may be differentiated in the dataset.

The spectral contrast of the retrieved spectrum is very low, with the largest emissivity variation of only 3%. Nonetheless some spectral features may be discerned, such as the Christiansen Frequency (CF)

and the Transparency Feature (TF). These features are respectively located at 1148 and 1170 cm^{-1} (i.e. 8.71 and 8.55 μm) and 810 and 852 cm^{-1} (12.35 and 11.74 μm).

3.1 Laboratory spectral comparison

To retrieve compositional information from Phobos spectra we first compared them to laboratory data.

To this aim the spectra of the Berlin Emissivity Dataset (BED) [8] have been used. The use of real emissivities is certainly more suitable than the Kirchoff law applied to reflectances (i.e. $E = 1 - R$), as this can be correctly applied only in conditions of thermal equilibrium [9], not always present in the space.

In this case the comparison has been mainly focused on the CF position. By looking at Fig. 1 it is evident that in the Phobos spectra the CFs are located between those of phyllosilicates, olivines and pyroxenes.

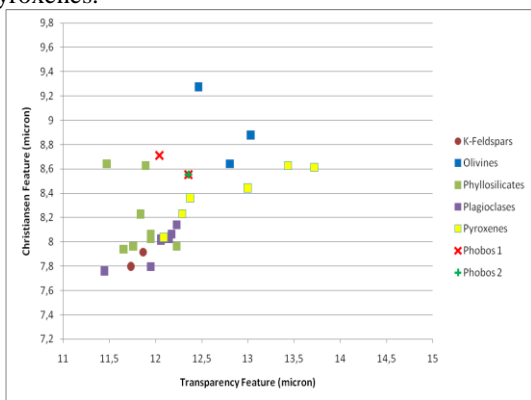


Figure 1: The CF positions of different minerals analysed and the 2 Phobos spectral units retrieved with the clustering algorithm.

3.2 Linear deconvolution

The spectral units retrieved have been analyzed by means of the linear deconvolution technique, using the BED spectra with grain size $< 25 \mu\text{m}$ as spectral library, in the spectral range between 300 and 1300 cm^{-1} .

The results indicate that the composition is mainly of phyllosilicates and olivines, with mass fraction of roughly 45% each (Fig. 2).

4. Conclusions and future works

The analysis of the Phobos spectral emissivities by means of two different techniques led to similar results.

In particular the comparison of the CF position between minerals and Phobos indicates a composition near those of phyllosilicates, olivines and pyroxenes.

On the other hand the linear deconvolution results show that a composition of phyllosilicates and olivines may correctly fit the retrieved Phobos spectral units.

However, since the linear deconvolution technique has been correctly validated only for coarse particles, more detailed analysis are needed.

In particular laboratory measurements of emissivities of different mixtures of phyllosilicates and olivines will be of crucial importance to decipher the TES observations of Phobos.

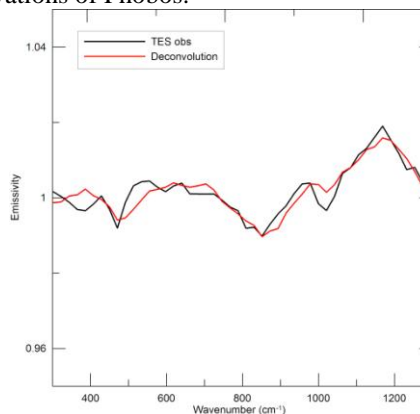


Figure 2: A Phobos spectrum compared with the spectrum derived from its deconvolution.

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