EPSC Abstracts
Vol. 7 EPSC2012-881-1 2012
European Planetary Science Congress 2012

Analysis of the 3.9 μm carbonate band on Mars by means of Rosetta-VIRTIS-M data

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Abstract

ESA's Rosetta VIRTIS-M Infrared data acquired during the flyby of Mars have been analyzed looking for spectral features related to surface carbonates.
Differently from previous works an approach allowing the separation of thermal and emitted part of the spectra have been used, resulting band depth similar to already published ones.

1. Introduction

The Visual and Infrared Thermal Imaging Spectrometer (VIRTIS-M) is an imaging spectrometer onboard the ESA's Rosetta mission, with two different channels: the VIS covering the 0.25 – 1.1 μm spectral range at 1.88 nm of resolution and the IR for the 1 – 5.2 μm range at 9.43 nm sampling step [1]. Albeit designed to study the 67P/Churyumov-Gerasimenko comet, on February 2007 the Rosetta spacecraft performed a flyby of Mars [2]. Therefore, after the detection of a surface carbonatic features on the surface of Mars by [3] and [4], this flyby could be used to perform a global study of the same band, even though at much lower spatial resolution.

2. Data analysis

In this work we analyzed only one set of data (i.e. the I1_00130974741 one), acquired by the VIRTIS-M instrument on 24 February 2007. We focused our attention on wavelength comprised between 3.87 and 3.92 μm that, as can be seen in [4], can be considered free from atmospheric contribution.
After correcting for solar bands using the same procedure described in [4] also in this case the band seems to be of surface origin as, for different albedo and same temperature, brighter areas show deeper band; as expected for areas of similar albedo and different temperatures the warmer area has shallower band depth (Fig. 1).

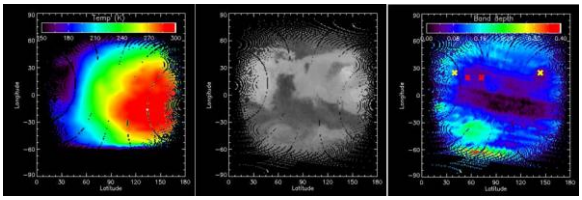

Fig. 1 Left: MCD (Mars Climate Database [5]) ground temperature. Center: Bolometric Thermal Emission Spectrometer (TES) albedo [6]. Right: VIRTIS-M 3.9 μm band-depth. Yellow markers indicate areas with similar albedo and different temperature. Red markers areas with different albedo and similar temperatures.

As already explained in several works (e.g., [7] and [4]) at this wavelength the mixed contribution of thermal and reflected radiation makes it difficult to correctly assess the band depth, since at the solar distance and typical ground temperature of Mars, roughly at 4 μm the two blackbodies assume similar values.
In this work, once the surface origin of the band has been assured a further analysis has been performed. By using ground temperatures from MCD and albedo data from TES, synthetic emitted (I_T) and reflected (I_S) radiances can be used to individuate the "real" band depth (BD) starting from the observed feature (BD_{obs}):

$$BD = [(BD_{obs} * I_S)-I_T]/(I_S-I_T)$$

In this case we used for Syrtis ground temperatures ranging from 230 to 250 K, solar temperature of 5777 K, solar radius 0.00466 AU and Mars-Sun distance 1.44 AU.
Using this approach it is evident that over Syrtis Major BD is deeper than BD_{obs}, with maximum values of the order of 0.07, rather than 0.06 (Fig. 2).

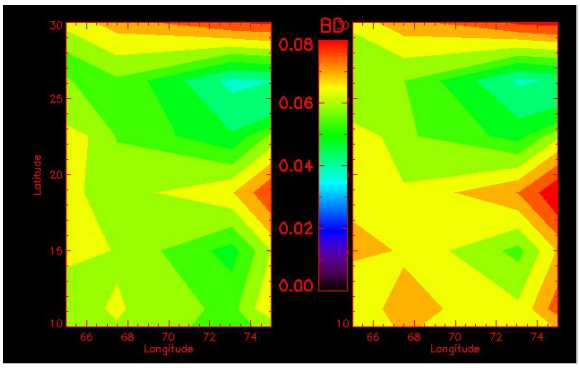

Fig. 2 BD_{obs} (left) and BD (right) over Syrtis Major. It is clear that on Syrtis Major the feature is larger in BD than in BDobs. The maps are at horizontal resolution of MCD.

3. Conclusions

By means of the analysis here shown it has been possible to individuate a surface carbonate IR feature, as already found out by previous studies performed with different instruments (e.g., [3] and [4]).
Thanks to the technique here used spectra coming from regions with higher temperatures than in [4] (i.e., 230-250 K rather than 220 K) gave similar results.
In particular [4] reported 3.9 μm band depths over Syrtis Major roughly ranging from 0.07 to 0.09, depending on the particular area (Figure 4 by [4]), whereas here we found a maximum value of 0.07.

Aknowledgments. The authors acknowledge ASI and all the European national agencies supporting the Rosetta mission. This research is funded by ASI grant ASI-INAF I/062/08/0.

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