Analysis of the OMEGA 0.4-2.5 µm Spectra of the Martian Satellite Phobos

J. Beccarelli[1,2], M. Pajola[2], G. Munaretto[2], A. Lucchetti[2], G. Poggiali[3,4], E. Simioni[2], F. Tusberti[2], C.M. Rossi[5], John Robert Brucato[4]

[1] CISAS/UNIPD, Padova, Italy; [2] INAF-OAPD, Padova, Italy; [3] LESIA, Meudon, France; [4] INAF-OA Arcetri, Firenze, Italy.

joel.beccarelli@phd.unipd.it
joelbeccarelli1997@gmail.com

AIM

Tha aim of this work is to properly analyze the MeX/OMEGA data, in order to retrieve useful information about the composition and mineralogy of the Martian satellite Phobos and gain more knowledge about its past history and formation scenario, the latter still being under discussion.

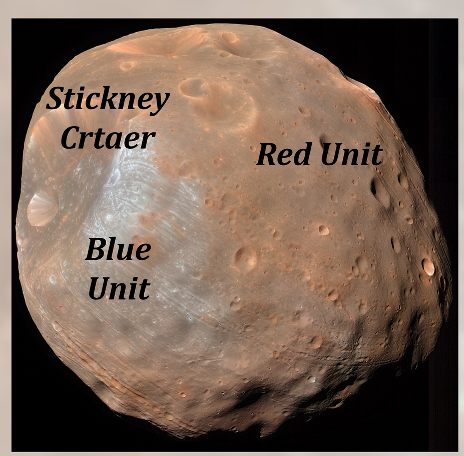
INTRODUCTION

Phobos is the largest satellite of the Martian system. The most important physical parameters for what concern this work are listed in the table below. The spectra of the surface have been deeply studied, and shows a red and very dark spectra. These, together with the low density and high porosity, seems to indicate a carbonaceous composition similar to the outer Solar System objects **[6-11]**, and points in the direction of a capture origin for *Phobos.* Other studies have instead pointed out that a collision between Mars and an unknown object **[7][12-16]** would be more feasible dynamically **[2] [16]** and coherent with both the MIR-TIR spectra **[17-18]** and the absence of volatiles (no band of such species have been detected). The surface of *Phobos* can be divided in two main unit: the **Blue Unit**, which has an higher reflectance in the VIS, and a **Red Unit**, which has an higher spectral slope as the wavelength increases toward the IR.

Up to now the origin of this satellite is still debated. Studying its mineralogy it is a way to understand its composition and retrieve useful information about the formation origin: finding a basaltic contamination would imply an impact origin, while finding phyllosilicates, volatiles and/or carbon compounds would instead imply a formation in the outer Solar System and then a capture origin.

PHOBOS PHYSICAL PROPERTIES

Dimensions (Km)	26.6x11.40x9,15 **[1]**
Semi-major Axis (km)	9375 **[2]**
Orbital Inclination (°)	1.067 **[2]**
Density (gr/cm³)	1.85-1.85 **[1] [3] [4]**
Geometric Albedo	0.06 - 0.07 **[5] [6]**
Porosity	25% - 30% **[3]**
Eccentricity	0.015 **[2]**

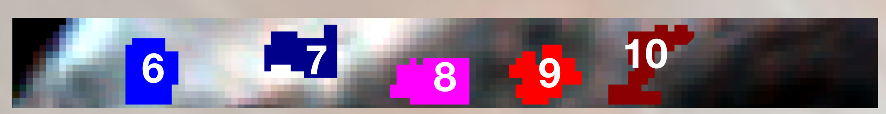


NASA/MRO-HiRISE image of Phobos (PSP_007769_9015)

DATASET

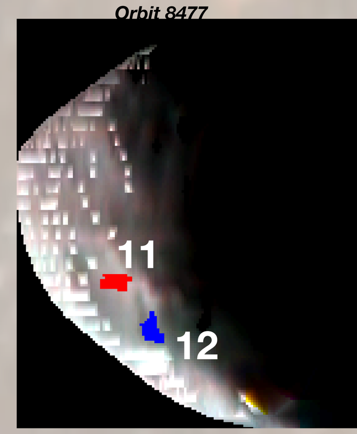
To study Phobos' spectrum we analyzed four dataset, taken by the spectrograph **MeX/OMEGA [19]** between 2004 and 2010. We have analyzed the spectra in the range **0.3 - 2.5 µm** since no thermal correction has been applied. In the Figures the spatial distribution of the of the *Region of Interests (ROIs)* on the surface of *Phobos* can be seen: orbit *0756* gave the best spectra in terms of quality and have been taken on the floor of Stickney, in blue unit and at increasing distance from the crater. The orbit *5851* is similar in these terms, although with higher resolutions. On the rest of the analyzed dataset (*7926* and *8477*) a lower numbers of *ROIs* have been considered due to geometric corrections and cube noise.

Orbit 0756



Orbit 5851

Orbit 8477



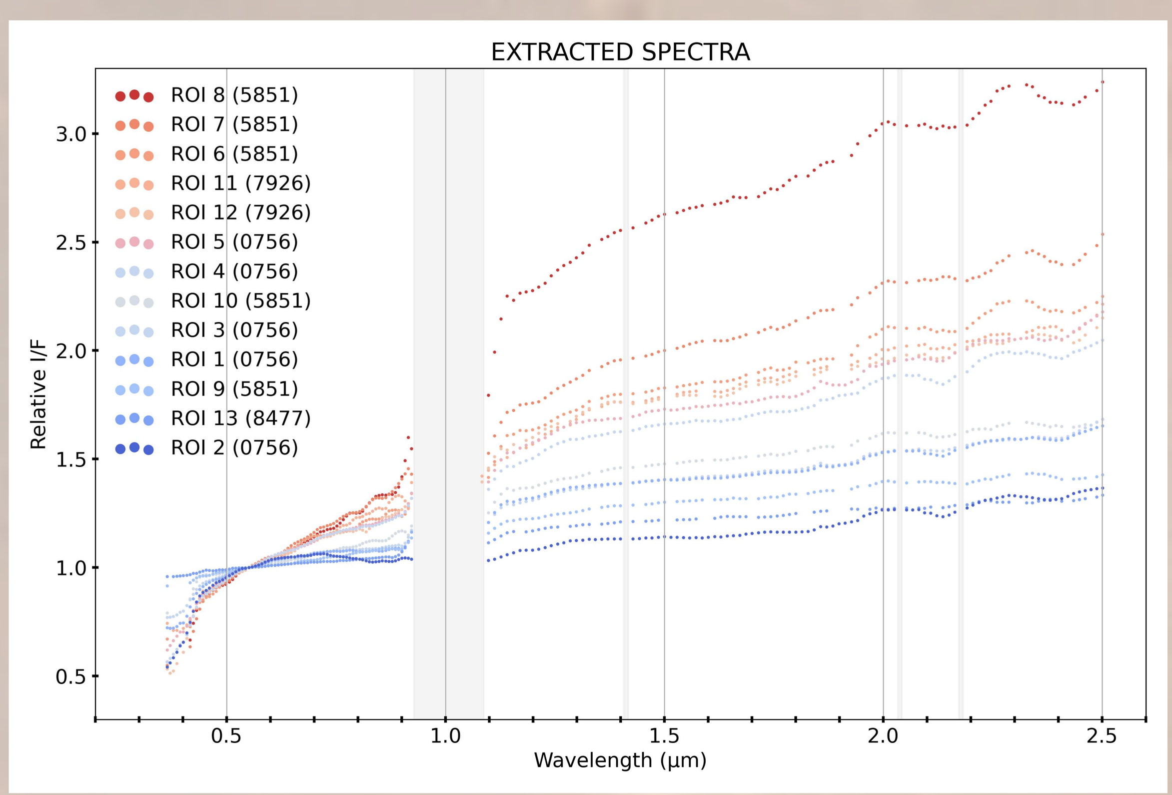
Orbit 7926

ANALYSIS PROCEDURE

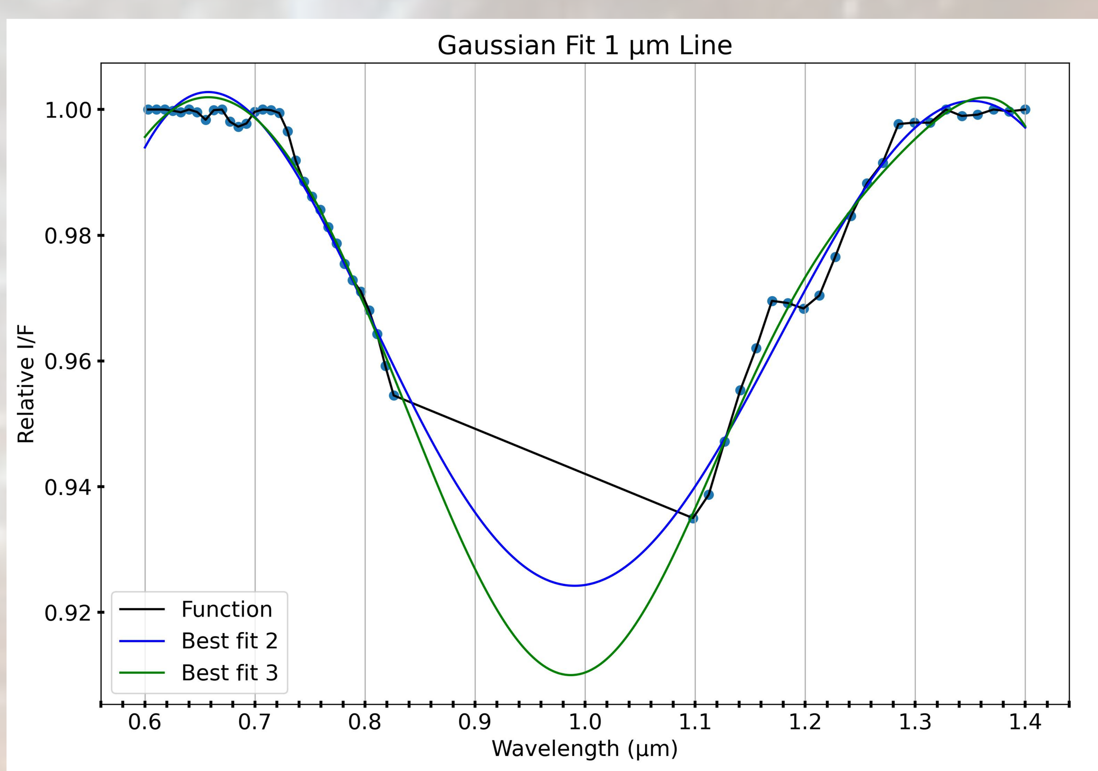
We have applied the following analysis procedure:

- Geometric and Photometric (*Lommel Seeliger* **[20]**) correction + removal of bad bands;
- Identification of the *ROIs;*
- Smoothing **[21]** and Normalization (0.55 µm) of spectra;
- Spectral analysis;
- Comparison with laboratory and other missions spectra;

SPECTRAL ANALYSIS

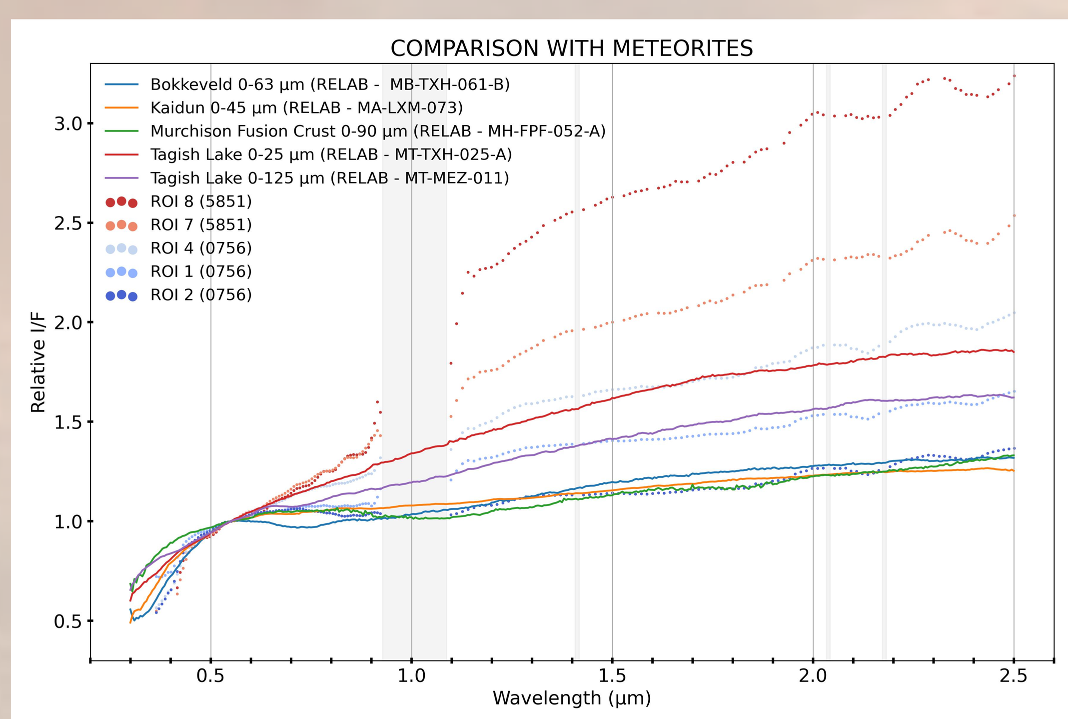


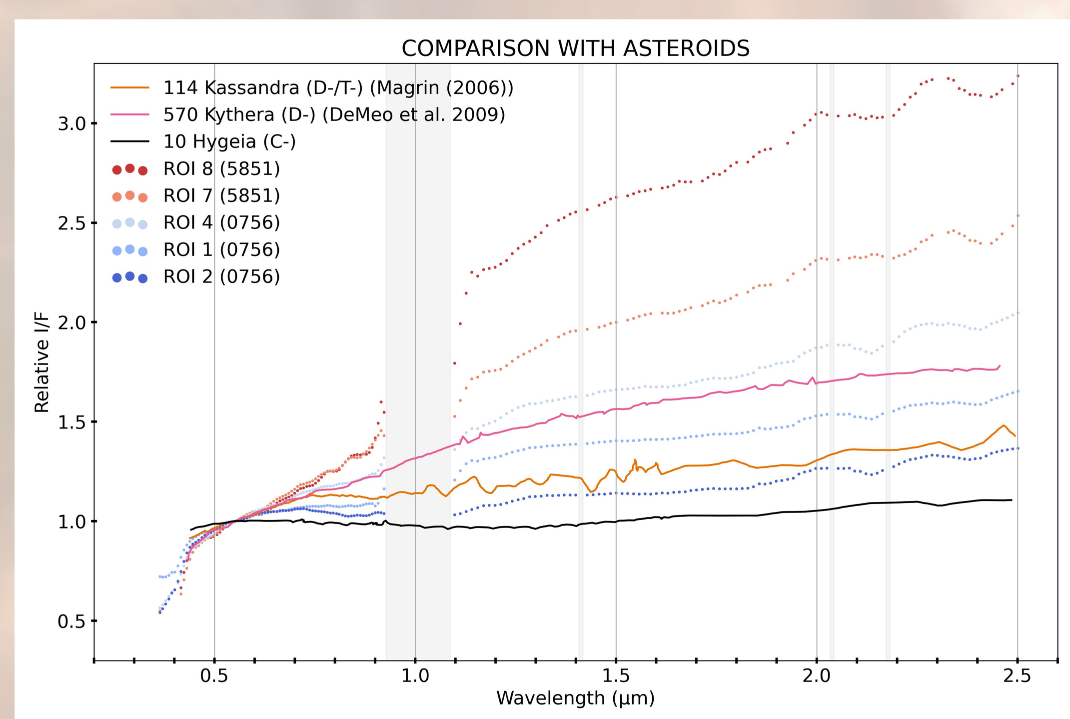
- A complete set of red and blue units has been extracted;
- **Gradual increasing of spectral slope** from blue to the red unit observed: *Space Weathering* is a possible explanation causing reddening over the red spectra;
- Consistent with hypothesis that the *Blue Unit* has been created in ejecta from Stickney;
- A possible ~ **1 µm line** detected in *ROI2* is consistent with **[22]**, but more study are needed due to:
  - No minimum detected due to lack of data;
  - Sensitivity decline of the detector could be responsible.



SPECTRAL COMPARISON

- D-type asteroid, and consistently **Tagish Lake** *(TL)* meteorite, were found to match the *Transitional/Red Unit;*
- Blue unit is well fitted by **CM-Carbonaceous Chondrites** and T-type asteroids;
- Such primitive match agrees with capture theory.





WORK PURPOSE

The main purpose of this work is to pave the future analysis of **MMX/MIRS** spectrometer, mission set to be launched in 2026.

FUTURE WORKS

- Thermal Correction of the data to access the range > 2.5 µm;
- Laboratory work to reproduce such spectral trend;

REFERENCES

[1] *Willner et al. (2010);* **[2]** *Jacobson and Lainey (2014);* **[3]** *Andert et al. (2010);* **[4]** *Rosenblatt et al. (2012);* **[5]** *Lynch et al. (2007);* **[6]** *Murchie and Erad (1996);* **[7]** *Rosenblatt et al. (2011);* **[8]** *Pajola et al. (2012);* **[9]** *Pajola et al. (2013);* **[10]** *Yamamoto et al. (2018);* **[11]** *Takir et al. (2022);* **[12]** *Craddock et al. (2011);* **[13]** *Rosenblatt and Charnoz (2012);* **[14]** *Rönnet et al. (2016);* **[15]** *Hyodo et al. (2017);* **[16]** *Bagheri et al. (2021);* **[17]** *Giuranna et al. (2011);* **[18]** *Glotch et al. (2018);* **[19]** *Bibring et al. (2004);* **[20]** *Hapke et al. (1981);* **[21]** *Gallagher et al. (2020);* **[22]** *Murchie et al. (1999).*