PHOBOS AND DEIMOS SURFACE: ANALOG LABORATORY STUDIES AND COMPARISON WITH AVAILABLE DATA IN PREPARATION FOR MMX-MIRS OBSERVATIONS. G. Poggiali[1,2], A. Wargnier[1], L. Fossi[2] M. Matsuoka[3], M. A. Barucci[1], J. R. Brucato[2], P. Beck[4], T. Nakamura[5], S. Fornasier[1,6], A. Doressoundiram[1], F. Merlin[1], J. Beccarelli[7], M. Pajola[8], A. Alberini[2], [1]LESIA-Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Université de Paris, 5 place Jules Janssen, 92190 Meudon (France) giovanni.poggiali@obspm.fr, [2]INAF-Astrophysical Observatory of Arcetri, largo E. Fermi n.5, I-50125 Firenze, Italy, [3]The Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 1-1-1 Higashi, Tsukuba 305-8567, Japan), [4]Institut de Planétologie et d'Astrophysique de Grenoble, OSUG/CNRS, 122 rue de la piscine, F-38000 Grenoble, France, [5]Department of Geophysics, Tohoku University, Sendai Miyagi, 980-8578, Japan, [6]Institut Universitaire de France (IUF), 1 rue Descartes, F-75231 Paris Cedex 05, France, [7]Department of Physics and Astronomy, University of Padova, Via 8 Febbraio 2, 35122 Padova, Italy, [8]INAF-Astronomical Observatory of Padova, Vicolo Osservatorio 5, 35122 Padova, Italy

Introduction: JAXA Martian Moon eXploration (MMX) sample return mission [1], will study in detail Phobos and Deimos, the two moon of Mars, to investigate their origin and to collect a sample from the surface of Phobos, the biggest moon. MMX will be the first dedicated mission to the study of the Martian satellites since Phobos 2 mission, although in recent years multiple observations have been made by ground/space-telescopes and orbiters around Mars. Despite the data available so far, the composition of the two moons is still unclear with possible presence of hydrated minerals but also mafic minerals (i.e. olivine and pyroxene). MIRS spectrometer [2] on-board MMX mission will be pivotal to unveil the open question on the composition of Phobos and Deimos and to provide global maps of the satellites surfaces along with detailed observation of the possible landing site of the mission. As part of the global campaign in preparation of MMX mission, we started reviewing past spectroscopic observations of the Martian moons, both from ground observatories and spacecraft data set, aiming at better understanding the constraints in interpreting the Mars satellites composition and at identifying the best spectroscopic analogues. We also performed dedicated new laboratory measurements on analog mineral mixing and meteorites to match the satellites spectral behavior and understand the physical properties of the regolith on the surface [3].

Methods: Several sample were prepared mixing of analog of Mars soil and carbonaceous chondrites and dark component (i.e. synthetic amorphous carbon) with different hydrated and anhydrous mineral with different proportions and grain sizes. Some meteorites were also selected. New measurements were acquired at INAF-Astrophysical Observatory of Arcetri and IPAG Grenoble laboratories at room conditions exploring different geometries. The wavelength range was investigated from visible and near infrared (VIS-NIR) to medium infrared (MIR) and compared with the data collected from space mission and ground telescope in both the range.

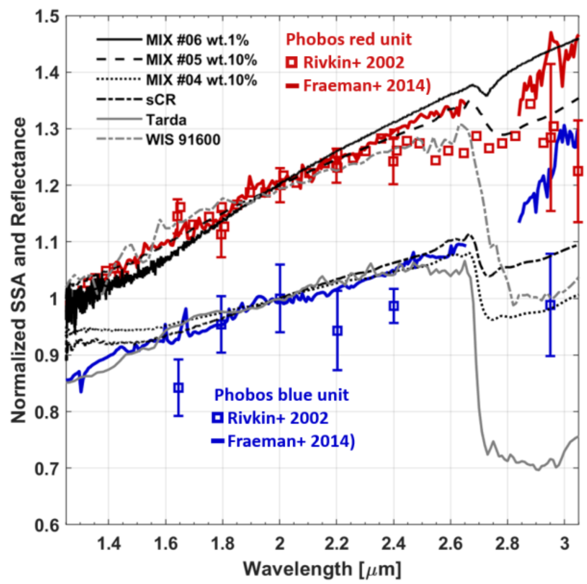

Figure 1. Comparison between Phobos and Deimos normalized spectra from Rivkin et al 2002 and single scattering albedo (SSA) from Fraeman et al 2014 with laboratory reflectance infrared spectra. In detail here are reported three mixtures: wt.99% amorphous carbon + wt.1% serpentine (MIX#06), wt.90% amorphous carbon + wt.10% basalt (MIX#05) and wt.90% CR meteorite simulant + wt.10% Mars simulant (MIX#04). In addition, we report the pure CR meteorite simulant (sCR) and two meteorites: Tarda and WIS91600. Meteorites show a very good agreement for the NIR slope but a bigger hydrated adsorption features at 2.7 micron on the other hand the mixtures are in good agreement with the hydrated features but in some case less comparable in terms of slope (figure adapted from Poggiali et al 2022).

Results: From our first laboratory experiments, the results suggest that the surface of Phobos and Deimos can be associated with samples characterized by a high presence of dark components (e.g. carbonaceous chondrite simulants and amorphous carbon) over a bright component (Mars simulant or hydrated/anhydrous minerals). Also product from space weathering (e.g. Fe0 and FeS-bearing materials) can be claimed as possible darkening agents. Some of the laboratory spectra obtained in our experiment are visible in Figure 1. In some sample prepared we stressed out the presence of amorphous carbon to very high concentration to study the extreme effects of C, we investigate mixture with amorphous carbon from low concentration to very high (spanning from 1% to 90%).

Our results show that presence of dark component could also be responsible for the reduced hydrated band observed on the moons without invoking dehydration or OH-implantation on anhydrous surface. The big hydrated features of some meteorites are not comparable with the very small features tentatively associated to Phobos and Deimos spectra although the NIR slope is in good agreement. Mixtures of analogs minerals are more in agreement with respect to the hydrate band at 2.7 micron but for some sample less comparable with the slope of the Martian moon spectra.

More critical is the MIR range where the presence of multiple bands makes it more complicated to find a mix that can match the spectra of Phobos. Some hints can be derived from our analogous samples: in particular, the presence of a double Christiansen Features (CF, linked with mineralogy of the sample) can be associate with a double composition of the surface. It can be related to two different components on the surface, one similar to carbonaceous chondrites and a second one similar to more evolved meteorites like HED and even Martian meteorites (Figure 2). Moreover, also ureilites meteorites seems to be in agreement regarding the position of CF pointing to more in depth study of this possible association.

In the presentation we will review the state of art of Phobos and Deimos observations and we will update on the ongoing campaign to find a spectroscopic analogs showing the latest laboratory measurements obtained by the MIRS science team.

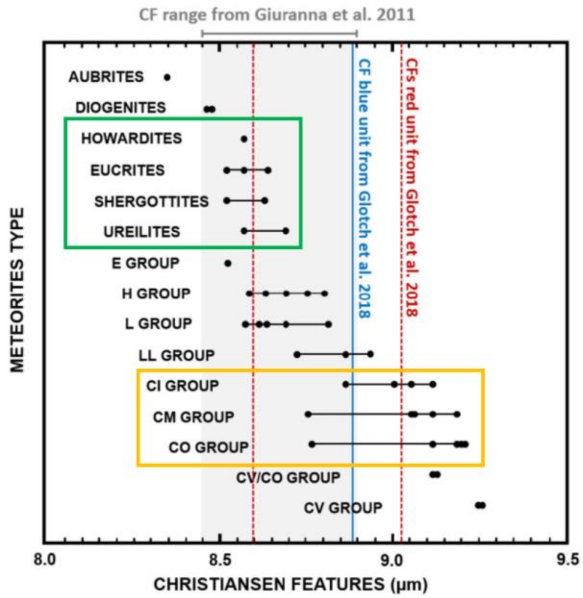

Figure 2. Comparison of the medium infrared Christiansen Features (CF) observed in Phobos spectra with the position of CF in different meteorites classes. The CF show in some case a double peak in particular for the red units that can be associated with two meteorites classes: carbonaceous chondrites (yellow box) and HED and martian meteorites (green box) (figure from Poggiali et al 2022, adapted from Salisbury et al. 1991)

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References: [1] Kuramoto K. et al. (2022) *Earth, Planets and Space*, 74, 12 [2] Barucci M. A. et al. (2021) *Earth Planets Space*, 73, 211. [3] Poggiali G. et al. (2022) *MNRAS*, 516, 1, 465–476.