DEVELOPMENT OF PHOBOS SPECTRAL ANALOGS AND EVALUATION OF ORGANICS DETECTABILITY. A. Wargnier[1], T. Gautier[2,1], A. Doressoundiram[1], P. Beck[3], O. Poch[3], E. Quirico[3], G. Poggiali[1], A. Buch[4], T. Drant[2], Z. Perrin[2], and M. A. Barucci[1]. [1]LESIA-Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Université de Paris-Cité, 5 Place Jules Janssen, 92195 Meudon (France) antonin.wargnier@obspm.fr, [2]LATMOS, CNRS, Université Versailles St-Quentin, Université Paris-Saclay, Sorbonne Université, 11 bvd d'Alembert 78280 Guyancourt (France), [3]Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble (France), [4]Laboratoire Génie des Procédés et Matériaux, CentraleSupélec, Université Paris-Saclay, Gif-sur-Yvette (France).

Introduction: Origins of Phobos and Deimos – the two martian moons – are still unclear. Two main hypotheses are currently proposed to explain their formation. Phobos and Deimos could have been formed by a giant impact between Mars and a protoplanet [1]. The other hypothesis proposes that Phobos and Deimos may be captured asteroids [2]. JAXA Martian Moon eXploration (MMX) mission [3] – will be crucial in this context to unveil Phobos and Deimos origins. MMX will be the first sample return mission dedicated to the biggest martian moon, Phobos. The composition of Phobos will also be studied, by the infrared spectrometer MIRS [4]. In particular, MIRS will be able to observe Phobos at 3.4 µm (0.9-3.6 µm), where we can expect the detection of organic materials – in the case of captured asteroid hypothesis – due to the stretching vibration mode of CH_2, CH_3, CH, etc. In support of the MMX mission, we searched to develop a Phobos visible and near-infrared spectroscopic laboratory analog. We also studied the detection of organic compounds in a Phobos simulant [5] to support interpretation of future MIRS observations.

Methods: We performed reflectance spectroscopy measurements using a spectrogonio-radiometer at IPAG [6] Grenoble (France) laboratory at visible and near-infrared wavelengths (0.4 – 4.2 µm). Samples were prepared by mixing silicates (i.e. olivine and/or augite), opaque materials (i.e. anthracite or iron sulfide), and organic compounds. We first used tholins as a source of organic material and monitored the 3 µm band due to N-H stretching modes to assess the detectability of organics in a Phobos spectral analog. Some new measurements were also made with CH-rich organics (DECS-19 from the Penn State Coal Sample Bank).

Results: We first developed a Phobos simulant composed of olivine (77 vol.%, ~100 µm), anthracite (20 vol.%, <1 µm), and tholins (3 vol.%, ~200 nm) to reproduce Phobos reflectance and spectral slope in the near-infrared. Using this simulant, we added different proportions of organic compounds and evaluated band depth associated with the organic material. An increase in band depth is observed for higher quantities of organic matter (Figure 1 and 2). We noticed also a clear detection (Figure 2) of tholins for 5 vol.% in the mixture (SNR > LOD = 3). Knowing band strength, quantification appears possible for 15 vol.% of tholins. Investigation about geometry effects shows that band depth is generally constant except at high phase angles

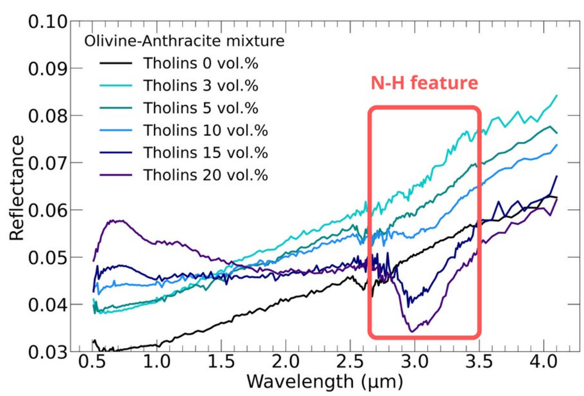

Figure 1: Spectra of the Phobos simulant with various quantities of tholins from 3 vol.% to 20 vol.%. (Adapted from Wargnier et al. 2023.)

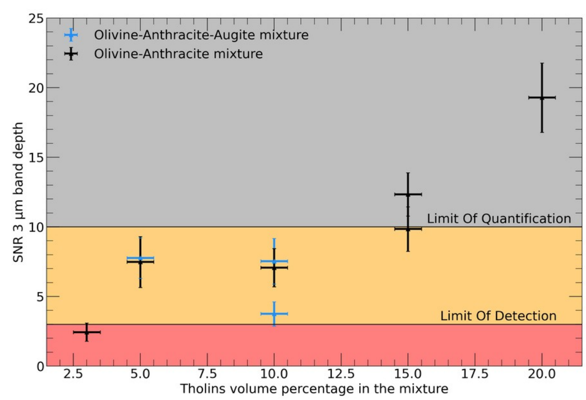

Figure 2: Signal-to-noise ratio of the 3 µm band depth attributed to the N-H feature in tholins. Limit of detection (LOD) is defined by a SNR of 3 and the limit of quantification by a SNR of 10. (Figure adapted from Wargnier et al. 2023.)

(> 80°) where organic band depth seems to decrease. Observations at low-phase angles should be prioritized to increase organic detectability with MIRS.

To be more representative of the expected composition of Phobos, we performed additional study on the evolution of the C-H bands at 3.28 µm and 3.42 µm due to the addition of DECS-19 in the mixture. Preliminary results (Figure 3) show that we also have an increase of the band depth with the increase of the volume fraction of DECS-19 in the simulant. We note also that the 3.28 and 3.42 µm band depth is around 1% for 20 vol.% of DECS-19. The final results will include the computation of the SNR of the bands at 3.28 and 3.42 µm.

We developed also a new spectroscopic analog that matches well the Phobos spectrum in the visible, composed of 60 vol.% of olivine, 20 vol.% of anthracite, and 20 vol.% of DECS-19 (Figure 4). This new Phobos analog match better with the Phobos spectrum in the VIS/NIR than previously proposed analogs such as heated Murchison meteorites [7] or the Univ. Tokyo Phobos Simulant (UTPS) [8]. Our analog will be useful for further studies in support to the MIRS team.

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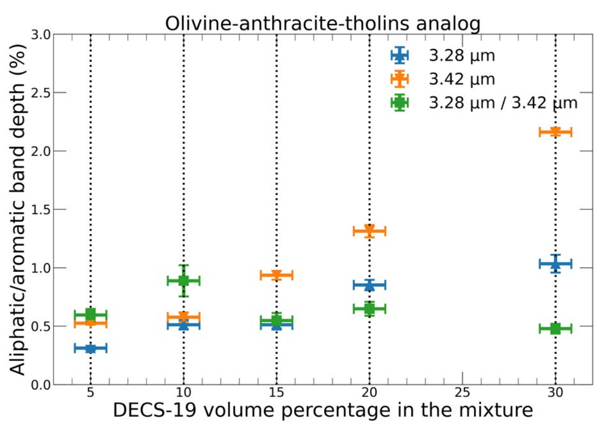

Figure 3: 3.28 µm and 3.42 µm band depth as a function of DECS-19 quantities in the Phobos simulant composed of olivine (77 vol.%), anthracite (20 vol.%), tholins (3 vol.%).

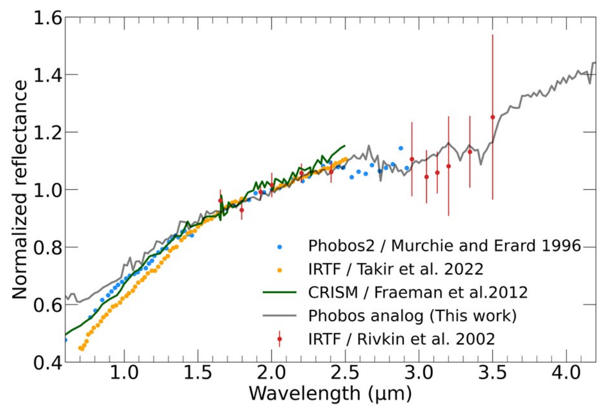

Figure 4: Comparison between the Phobos analog developed in this work and past observations of Phobos (red unit). The analog is a mixture composed of 60 vol.% of olivine, 20 vol.% of anthracite, and 20 vol.% of DECS-19. Our analog is in good agreement with the spectral slope in both visible and near-infrared.