DETERMINATING THE Ma_MISS INSTRUMENT CAPABILITIES FOR ORGANICS DETECTION.

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Introduction: The key scientific objectives of the ESA mission ExoMars2022 are searching for signs of past and/or present life on Mars and characterizing the subsurface geochemical environment as a function of depth. The Rosalind Franklyn rover [1] payload consists of a suite of nine instruments that will provide information about the geological and geochemical environment of the surface and subsurface of the selected landing site (i.e., Oxia Planum) [2]. Remote sensing measurements performed by OMEGA and CRISM suggest that the exposed rocks on the surface of Oxia Planum experienced an intense aqueous alteration [3]. The widespread presence of Fe/Mg-Al-phyllosilicates and, more generally, of silicates containing OH group confirms an interaction between water and mother rocks happened in the past geological history of the planet, which is a prerequisite favorable to the development of life. In this framework, we performed several laboratory spectroscopic measurements of clay minerals mixed with different organic compounds for determining whether the Ma_MISS (Mars Multispectral Imager for Subsurface Studies) instrument will be able to provide clues on the presence of organics in the Martian subsurface.

The Ma_MISS instrument: Ma_MISS is the Visible and Near Infrared miniaturized spectrometer hosted in the drill system of the ExoMars2022 rover that will characterize the mineralogy and stratigraphy of the excavated borehole wall at different depths (<2 m) [4]. Ma_MISS has a spectral range of 0.5–2.3 µm, a spectral resolution of >20 nm in the IR, a SNR~100, and a spatial resolution of 120 µm. It will accomplish the following scientific objectives: (1) determine the composition of the subsurface materials; (2) map the distribution of the subsurface H_2O (if present) and hydrated phases; (3) characterize important optical and physical properties of the materials (e.g., grain size); (4) produce a stratigraphic column that will provide information on the subsurface geology. Ma_MISS will operate periodically during pauses in drilling activity and will produce hyperspectral images of the drill's borehole.

Laboratory setup: The characterization of the scientific performances of the Ma_MISS instrument was made using the laboratory model (breadboard, Fig. 1 [5], [6]) at the Institute for Space Astrophysics and Planetology – INAF. The Ma_MISS breadboard includes the 5 W light source, the optical fibers and the Optical Head with the dual task of focusing the light on the target and recollecting the scattered light. However, it does not include the flight spectrometer and is therefore coupled with a laboratory spectrometer (FieldSpec 4).

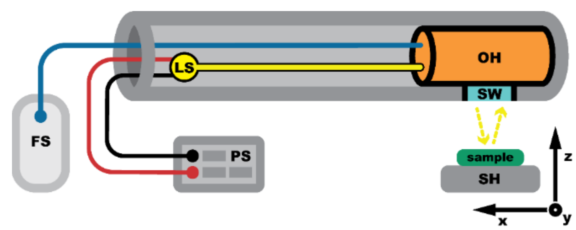

Figure 1. Schematic representation of the Ma_MISS breadboard setup where are reported the principal components: (LS) Light source; (OH) Optical Head; (SW) Sapphire Window (SH) Sample Holder.

Mineral/organic mixtures: For these tests we prepared numerous two-component mixtures, (phyllosilicate+organic), using as endmembers two clay minerals (nontronite and kaolinite) and four different organic compounds (asphaltite, glycine, benzoic acid, and polyoxymethylene). We used glycine and these other organic compounds as proxies of organic compounds that show absorption features in the VIS-NIR range, although we do not expect to find them in the Martian subsurface.

We tested different cases starting from the pure clay endmembers: 1) High Organic Concentration-we added separately asphaltite and glycine in different percentages (25, 50, and 75), producing six different samples; 2) Low Organic Concentration-we added separately benzoic acid and polyoxymethylene in percentages of 1, 5, and 10% preparing a set of six samples at a low concentration of organics. All mixtures with a grain size < 60 µm were measured using the Ma_MISS breadboard setup, collecting reflectance spectra in the range 0.5–2.3 µm.

Figure 2 shows an example of the data collected on the mixtures with high concentration of organics, between nontronite and asphaltite. Starting from the spectra of the pure clay (nontronite 100%, black spectrum in Fig. 2) and increasing the content of asphaltite by step of 25 wt.%, the band at 1.4 and 1.9 µm associated to the hydration of the nontronite decreases. At the same time, the bands near 0.7 and 1 µm linked to the iron content in nontronite become shallower. In the visible part of the spectrum, the addition of a very dark material to the mixture (asphaltite) causes the decreasing of the bands linked to the iron content (at 0.9 and 0.65 µm) in the nontronite unlike what was seen in the case of the addition of a bright compound like glycine.

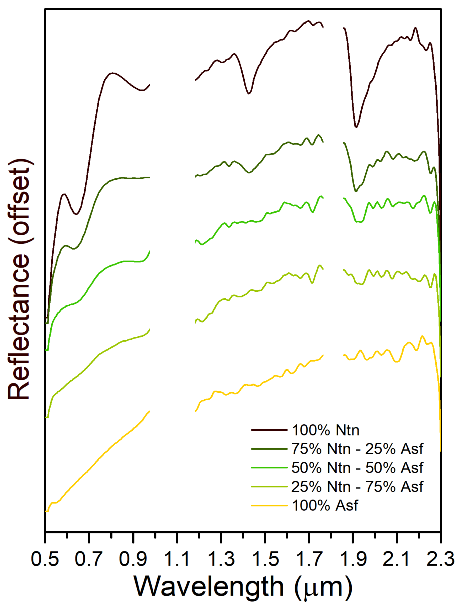

Figure 2. Example of measurement results of a high organic concentration mixtures (nontronite-asphaltite) in variable proportion, made by means of Ma_MISS emulating setup.

Figure 3 shows an example of the data collected on the mixtures with low concentration of organics, between nontronite and benzoic acid. In this case the C-H related band near 1.65 µm becomes evident in the mixture with the 1 wt.% of benzoic acid (dark green spectrum in Fig. 3). Increasing the benzoic acid percentage, the band near 2.1-2.2 µm becomes clear when the organic content is at least 5 wt.% in the mixture. In this case where the concentration of the organic compound is less than the 10 wt.% all the typical spectral features of the nontronite were maintained (e.g., the Fe^{3+} related band at 0.9 and 0.65 µm and the hydration bands at 1.4 and 1.9 µm).

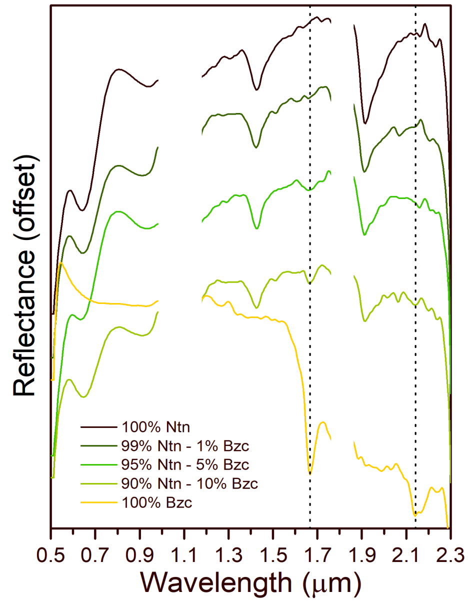

Figure 3. Example of measurement results on a low organic concentration mixtures (nontronite-benzoic acid) in variable proportion, made by means of Ma_MISS emulating setup.

Conclusions: Laboratory investigations have been performed using the Ma_MISS on mineral/organic mixtures in different proportions. Spectroscopic measurements collected on these mineral/organic mixtures are useful to characterize Ma_MISS instrument sensitivity in detecting traces of organic material intimately mixed with minerals that could be present in sedimentary sequences or in hydrothermal products in the Martian subsurface, which is one of the main scientific objectives of the ExoMars 2022 mission. The obtained results show that the Ma_MISS instrument can give hints of the presence of organics in the Martian subsoil, as well as characterizing the mineralogy of the drilling site. Moreover, the selected minerals and organic compounds allow us to test the instrument with both dark and bright samples. The spectra obtained during these tests will allow us to build a spectral database useful for the interpretation of the scientific data.

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