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VNIR spectral measurements on rock slabs with ExoMars-Ma_Miss instrument

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Introduction

Ma_Miss (Mars Multispectral Imager for Subsurface Studies) experiment onboard of ExoMars 2018 mission to Mars will study the Martian subsurface down to a depth of 2 meters [1]. Ma_Miss is a miniaturized spectrometer, integrated within the drilling system of the ExoMars rover; it will perform visible and near infrared spectroscopy in the 0.4 – 2.2 μm range, acquiring signal from the excavated borehole wall. The spectroscopic characterization of the subsurface rocks will give us important information about mineralogy, petrology and geological processes; moreover it will give insights about materials that have not been altered by surface processes such as erosion, weathering or oxidation. Spectroscopic measurements have been performed on Terrestrial Mars Analogues with the Ma_Miss laboratory model (*breadboard*).

1. The Ma_Miss instrument

The miniaturized spectrometer will be integrated within the rover drill [2]. A 5W lamp and an optical fiber bundle provide the illumination of the target; the Optical Head focuses the light on the target (1 mm spot) and collects the scattered light from the target (about 100 μm spot, spatial resolution). An optical fiber carries the light to the spectrometer. The optical fibers system is hosted within the driller; a depth of 2 meters can be reached using four 50-cm extension rods. A sapphire window is the interface between the Optical Head and the target. This window is characterized by a high transparency and hardness. The focal distance, between the window and the subsurface wall, is less than 1 mm. The breadboard (BB) consists of the optical main subsystems (Optical Head, Sapphire Window) and the illumination system (illumination bundle and signal fiber). In the laboratory it must be coupled with another spectrometer: here we used the FieldSpec Pro spectrophotometer [3]. Details on the laboratory BB setup are in [4]. All samples have also been characterized with a second laboratory setup, the spectro-goniometer setup (SPG) [3,4]. Spectral measurements with both setups have been then compared.

2. Spectral characterization of Mars Analogues

In this study a set of five rock slabs, three volcanic rocks and two carbonates, has been analyzed by VNIR spectroscopy with the Ma_Miss BB laboratory setup. Volcanic samples are a basalt from Stromboli (Aeolian Islands, STR72) and two altered basalt samples from Montiferru (Sardinia, FOR5 and MFEB1). Carbonate samples are two limestones (Umbria, CAL1 and Latium Apennines, GPR18). Here we focus on the volcanic sample MFEB1. In figure 1 there is an image of the slab.

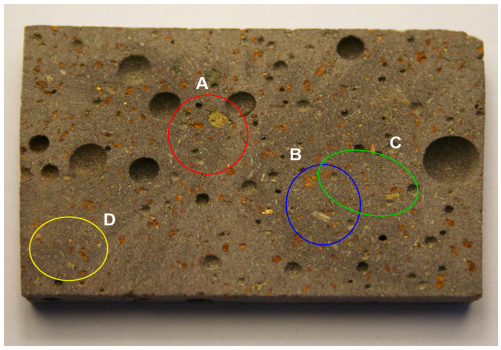

Figure 1: volcanic sample MFEB1. Each ellipse is a zone analyzed with SPG, corresponding to one spectrum (6 mm spatial resolution). In each zone 10 spectra have been acquired with Ma_Miss BB (100 μm resolution).

Spectro-goniometer analyses.

Four zones have been selected on the rock surface (fig.1): the sample has been first analyzed with SPG. Each of the selected zones is approximately 8 mm in diameter and equals the area illuminated by the SPG radiation source. The spatial resolution of SPG setup is about 6 mm in diameter so one single spectrum is acquired from each zone. Spectra acquired with SPG setup in the four zones are in figure 2, in which they have been shifted in reflectance for clarity. The peak in the visible is in the range 17-20% of reflectance, and they show a similar spectral shape. The continuum is characterized by blue slope, onto which few absorption bands are superimposed. Spectra A,B show absorption at 1 μm that can be due to Fe^{2+}; the feature near 0.5 μm is probably due to Fe^{3+}; all spectra show OH and H_2O absorption at 1.4 and 1.9 μm respectively. A weak feature near 2.2 μm is also present in all spectra, while the spectrum B shows a broad absorption near 1.6 μm.

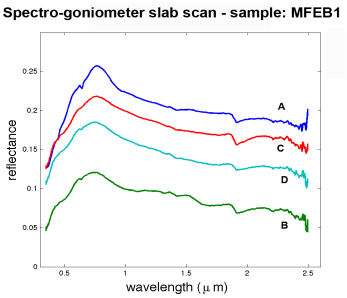

Figure 2: VNIR reflectance spectra acquired with SPG setup on MFEB1 slab sample, in 4 different zones.

Ma_Miss Breadboard analyses.

Spectra have been acquired with the Ma_Miss breadboard on the same 4 zones. Within each zone 10 spectra have been acquired with a spatial resolution of about 100 μm. Some spectra for each zone are showed in figure 3. Ma_Miss spectra allow to recognize a wide spectral variability along the rock surface, and thus to discriminate between different mineralogical phases. The main mineralogical phases appear to be: 1) spectra with a broad Fe^{2+} band at 1 μm and H_2O absorption (spectrum A-10), possibly an altered olivine; 2) spectra with strong OH and H_2O bands (A-2); 3) a spectrum with a broad Fe^{2+} absorption near 1.2 μm (B-7), consistent with plagioclase; 4) dark minerals without evident features (C-5).

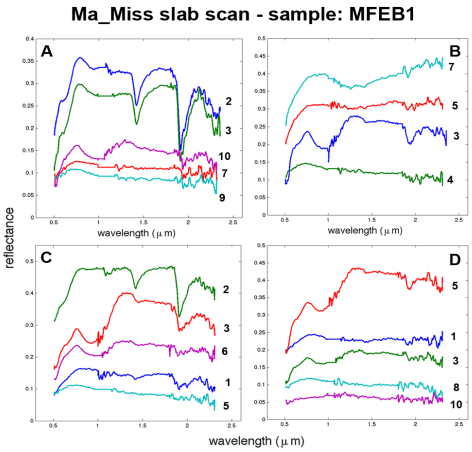

Figure 3: spectra acquired with Ma_Miss BB on MFEB1 sample, in 4 different zones. Ten spectra have been acquired with Ma_Miss in each zone.

3. Summary and Conclusions

The ExoMars/Ma_Miss miniaturized spectrometer will be integrated within the Rover Drill, and will perform VNIR spectroscopy of the subsurface rocks. Five rock slabs (volcanic and carbonate rocks) have been preliminary analyzed with the breadboard and with another setup SPG both at INAF-IAPS laboratory. The high spatial resolution of Ma_Miss (from 6 to 0.1 mm) allows a great detail in the mineralogical characterization of a rock sample.

Acknowledgements

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