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Spectral characterization of the Ma_MISS instrument on board the ExoMars 2020 rover

M. Ferrari (1), S. De Angelis (1), M.C. De Sanctis (1), F. Altieri (1), E. Ammannito (2), P. Tinivelli (1), D. Biondi (1), R. Mugnuolo (2), S. Pirrotta (2) and the Ma_MISS team.
(1) Institute for Space Astrophysics and Planetology, IAPS-INAF, Rome, Italy (marco.ferrari@iaps.inaf.it)
(2) Italian Space Agency, ASI, Italy

Abstract

During the calibration campaign, laboratory measurements were performed on different minerals and rocks that can be considered as Mars analogs with the aim of characterizing the scientific performance of the Ma_MISS (Mars Multispectral Imager for Subsurface Studies) flight spectrometer.

1. Introduction

Ma_MISS is a visible and near infrared (VNIR, 0.4-2.2 μm) miniaturized spectrometer hosted by the drill system of the ExoMars 2020 rover [1]. Ma_MISS will characterize the mineralogy and stratigraphy of the shallow subsurface down to two meters [2]. ExoMars will focus on the search for signs of life from both a morphological and a chemical point of view. Ma_MISS will be implemented to accomplish the following scientific objectives: (1) determine the composition of the subsurface materials; (2) map the distribution of the subsurface H_2O and volatiles; (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. The detector operating temperature is -50°C. The thermal excursions at the equatorial and mid latitudes that the ExoMars mission can target for landing oscillate between a few degrees above 0 and -120°C. Ma_MISS will operate periodically during pauses in drilling activity and will produce hyperspectral images of the drill's borehole.

2. The Ma_MISS instrument

The Ma_MISS instrument main requirement is its miniaturization because it is embedded within the drill (Fig. 1). The spectrometer is placed in a box on the side wall of the drill box. The spectral range is 0.4–2.2 μm, with a spectral sampling of 20 nm a SNR~100 and a spatial resolution of 120 μm. The light from a 5W lamp is collected and carried, through an optical fiber bundle, to the miniaturized Optical Head, hosted within the drill tip. A Sapphire Window with high hardness and transparency on the drill tip protects the Ma_MISS optical head allowing to observe the borehole wall. Different depths can be reached by the use of three extension rods, 50 cm long, each containing optical fibers and a collimator. The first extension rod is connected to the non-rotating part of the Drill, hosted on the rover, through a Fiber Optical Rotating Joint (FORJ), that allows the continuity of the signal link between the rotating part of the drill and the spectrometer.

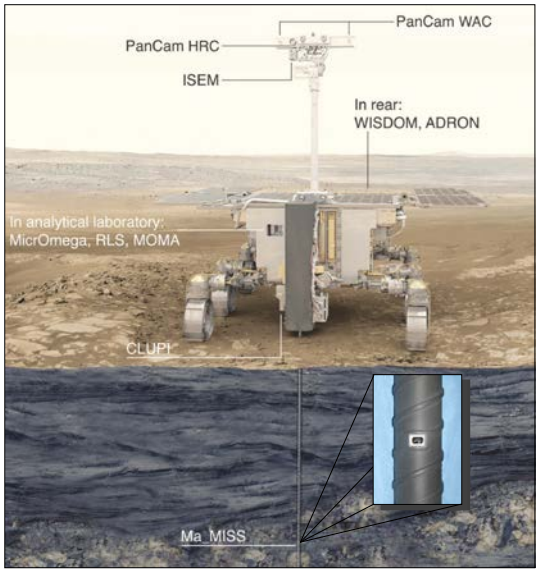

Fig. 1: Artistic view of the ExoMars-Pasteur Rover with instruments allocations. Ma_MISS is integrated within the drill.

3. Experimental setup

The characterization of the scientific performances of the Ma_MISS instrument was made in April 2018, at the Leonardo calibration facility in Florence (Italy). During this activity, the Ma_MISS spectrometer was inside a thermo-vacuum chamber (TVC) to maintain the detector unit at the operating temperature. The setup also included the GSE Tip Drill Tool

comprising the optical head with the illuminating system, the optical fibers with the FORJ, and the mini-AVIM connection adapters to pass the signal inside the TVC. During the characterization phase we selected three samples: a slab of Dunite rock, a slab of Montiferru lava and a slab of gypsum, a mineral that shows several spectral features in the range of Ma_MISS. All the samples were mounted on an ad-hoc sample holder (Fig. 2) screwed on a guide to permit micrometric movement, which was necessary to reach the focus position or to illuminate specific features of interest on the selected sample.

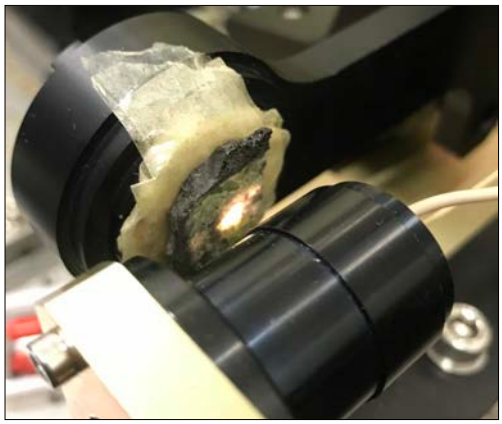

Fig. 2: The GSE Tip Drill Tool illuminating a dunite sample during the measurement session.

4. Discussion

Several measurements have been performed on samples of different nature to test the spectral performance of the Ma_MISS instrument. Data are reported here as function of spectral channels on X-axis. The spectra collected on the three points on the slab of Montiferru lava (purple, blue and black spectra in fig. 3) are quite similar to each other. The weak absorption features indicated with the gray dashed line (at ~ 340 px) represents the absorption at 1.9 μm due to the presence of hydrated phases in the sample.

The spectra obtained on the gypsum slab (cyan spectra in fig. 3) show all its typical absorption features reported in literature [3].

The green spectrum acquired on the dunite sample shows the wide absorption band (from 125 to 275 px) near 1μm typical of olivine. All the samples were measured a second time using a FieldSpecPro spectrometer in the INAF-IAPS laboratories to cross-check the obtained results, which are consistent with each other. However, the different spatial resolution between the two instruments (Ma_MISS 120 μm and FieldSpecPro 6 mm) can lead to collect quite different spectra when analyzing heterogeneous samples.

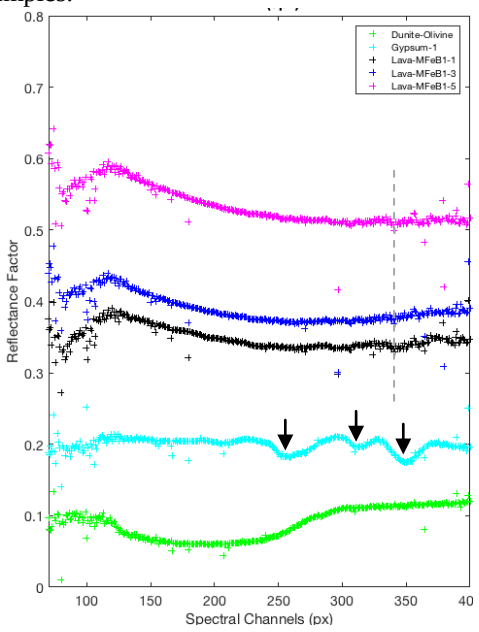

Fig. 3: Spectra obtained on Montiferru Lava, gypsum and dunite. The value on the x axis is referred to the number of pixels on the detector and not to the wavelength.

5. Summary and Conclusions

The Ma_MISS instrument has been developed to provide hyperspectral images of boreholes excavated by the ExoMars rover drill. The obtained results on the mineral/rock samples confirm that the Ma_MISS spectrometer have a spectral range, resolution and imaging capabilities suitable for the Mars subsurface characterization. An unambiguous understanding of the landing site subsurface composition will be crucial to reconstruct the geological evolution of Mars and determine whether life might have occurred on the planet.

Acknowledgements

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References

[1]Vago J.L. et al. (2017): Astrobiology, 17, 6, 7.

[2]De Sanctis et al. (2017): Astrobiology, 17, 6, 7.

[3]Clark R.N. et al. (1990) JGR, 95, N.B8, P. 12,653- 12,680.