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MA_MISS: a miniaturized spectrometer on the ExoMars Drill System

M.C. De Sanctis (1), F. Altieri (1), E. Ammannito (2), S. De Angelis (1), M. Ferrari (1), D. Biondi (1) P. Tinivelli (1), R. Mugnuolo (2), S. Pirrotta (2) and the MA_MISS team.

(1) Istituto di Astrofisica e Planetologia Spaziali (INAF-IAPS) , Rome, Italy, mariacristina.desanctis@iaps.inaf.it, (2) Agenzia Spazile Italiana, ASI, Italy

Abstract

Ma_MISS (Mars Multispectral Imager for Subsurface Studies) is the Visible and Near Infrared (VNIR) miniaturized spectrometer hosted by the drill system of the ExoMars 2020 rover. It will perform spectral reflectance investigations in the 0.4–2.2 µm range to characterize the mineralogy of the excavated borehole wall at different depths (≤2 m). Ma_MISS has been completed and calibrated in early 2018 and is now on the way to be integrated on the rover.

Introduction

Search for life on Mars is primarily focused on the analysis on the subsurface layers. Due to the very tenuous Martian atmosphere, potential chemical bio-signatures at or in the vicinity of the Martian surface could have been degraded or destroyed by i) ultraviolet (UV) radiation ii) UV-induced photochemistry producing reactive oxidant species, and iii) ionizing radiation. The effects of the radiation decrease with depth: organic molecules and potential biomarkers could be better preserved in the subsurface. Thus, ExoMars rover is devoted to subsurface investigations for possible indicators of past life. Ma_MISS instrument [1] is a miniaturized imaging spectrometer designed to provide spectra in the VNIR (0.4–2.2 µm) wavelength region. The spectral sampling is 20 nm while the spatial resolution is 120 µm. By operating during pauses in drilling activity, it will produce spectra of the drill's borehole. Ma_MISS is the only instrument in the rover's Pasteur payload able to analyze subsurface material in its natural condition (in situ), prior to extracting samples for further analysis. Ma_MISS findings will help to refine criteria for deciding from where to collect samples.

1. MA_MISS scientific objectives

Ma_MISS will accomplish the following scientific objectives:

1) *determine the composition of subsurface materials*: MA_MISS spectral range and high spatial resolution will allow identifying differences in lithologies. Analysis of absorption bands can be used to identify different mineralogical phases, such as iron-bearing minerals, silicates, oxides, hydrated materials, etc. [2, 3].

2) *map the distribution of subsurface ices*: Currently ice deposits in the Martian shallow subsurface have been inferred from remote-sensing detection of hydrogen [4], from permafrost evidences[5] and the detections of low latitude H_2O frost on pole facing slopes [6]. Both H_2O and CO_2 ices show diagnostic features in the Ma_MISS spectral range.

3) characterize important optical and physical properties of materials: The study of spectral parameters, such as continuum reflectance level and slope can help to determine important physical parameters like the different grain sizes in materials that can help us to assess the type and state of sediments in the subsurface.

4) *produce a local stratigraphy of the subsurface:* Mars surface is rich in sedimentary outcrops that exhibit stratigraphic features at a range of spatial scales. Having access to the Martian subsurface will be fundamental to constrain the nature of processes at the ExoMars rover locations.

2. Instrument Description

The spectrometer is placed in a box on the side wall of the drill box (fig.1). The light from a 5W lamp is collected and carried, through an optical fiber bundle, to the miniaturized Optical Head (OH), hosted within the drill tip. A Sapphire Window (SW) with high hardness and transparency on the drill tip protects the Ma_MISS OH allowing to observe the borehole wall. Different depths can be reached by the use of 3 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.

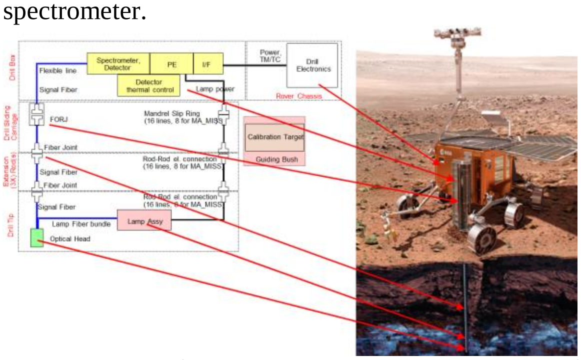

Figure 1: Scheme of Ma_MISS instrument and an artistic view of the EXOMars Rovere and Drill.

3. MA_MISS calibration

Ma_MISS instrument has been radiometrically and spectrally calibrated in April 2018, using the calibration facility available in Leonardo, Firenze (Italy). During this activity, some dedicated measurements have been carried out on calibration targets (WCS-E0–Erbium Oxide, WCS-MC–Reflectance standard) and rocks (Dunite, Gypsium, Basalt lava). Spectra of the two standards are shown in fig.2. In fig.2, we compare the spectra acquired with Ma_MISS and those acquired with the FieldSpec in the laboratory. The spectra are in very good agreement each other. Data analysis confirms that Ma_MISS spectral range, resolution, and spectral capabilities are suitable to characterize the subsurface environment and the samples that will be delivered to rover's analytical laboratory.

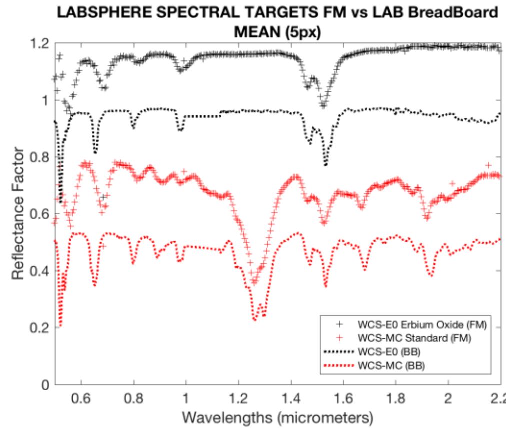

Figure 2: Spectral reference samples seen by Ma_MISS(crosses) in comparison with the spectra acquired by laboratory spectrometer (dots).

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