

The MicrOmega experiment onboard ExoMars rover: an IR hyperspectral microscope to analyze samples at the grain scale

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1. Introduction

The coupling between imaging and spectrometry has proved to be one of the most promising way to study remotely planetary objects [1][2]. The next step is to use this concept for *in situ* analyses. MicrOmega IR has been developed within this scope in the framework of the Exomars mission (Pasteur payload). It is an ultra miniaturized near-infrared hyperspectral microscope dedicated to *in situ* analyses, with the goal to characterize the composition of Mars soil at almost its grain size scale, in a non destructive way. It will provide unique clues to trace back the history of Mars, and will contribute to assess Mars past and present astrobiological potential by detecting possible organic compounds within the samples.

Results obtained on ground both on a representative breadboard of the instrument and with a demonstrator developed in the scope of the Phobos Grunt mission will be presented during the conference to demonstrate the instrument capabilities.

2. Instrument concept

MicrOmega acquires reflectance spectra of 5 mm-sized samples with a spatial sampling of 20 μm . A monochromator, based on an AOTF (Acousto Optical Tuneable Filter), illuminates sequentially the sample in up to 500 contiguous wavelength channels (spectral sampling of $\sim 20 \text{ cm}^{-1}$) covering the spectral range of interest (0.9 - 3.5 μm). For each channel, an image is acquired on a 2D detector, building a tridimensional (x,y, λ) image cube.

One of the most critical devices in the instrument is the monochromator. We use an AOTF illuminated through a beam condenser by a white source from a tungsten filament lamp. The light is partly diffracted inside the AOTF and a monochromatic light exits the crystal in a given direction, distinct from that of the non diffracted (white) light. The

functioning of this component is based on the anisotropic Bragg diffraction [3] and requires no moving part.

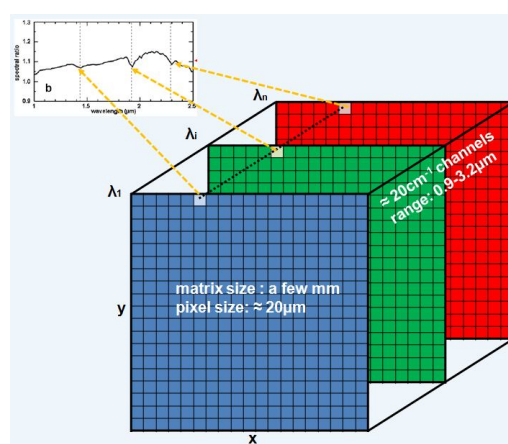


Fig 1. Principle of the measurement : an image is acquired at different wavelengths (about 500 channels), building the image cube.

3. Instrument capabilities

Its spectral range, 0.9 to 3.5 μm , and its spectral sampling of $\sim 20 \text{ cm}^{-1}$, have been chosen to enable the identification of most potential constituents: silicates, oxides, salts, hydrated minerals, ices and frosts, as well as organic compounds, discriminating between specific members in each family (e.g. low and high Ca pyroxenes, forsterite and fayalite, Mg and Al rich phyllosilicates, aliphatic and aromatic compounds).

In particular, in identifying and discriminating between the various phyllosilicates and sulfates, MicrOmega will provide key clues to decipher the early aqueous History of Mars, as each specific mineral preserve the record of the environment at the time it formed, in presence of water. Moreover, if the stability of surface liquid water was favored by CO_2 as the dominant greenhouse gas, small

inclusions of carbonates should be trapped within these soils, readily detectable with MicrOmega. Importantly, MicrOmega will be able, and for the first time, to identify carbon-rich phases at a microscopic scale, and to ascribe the mineralogical context in which they nucleated, through the unique capability of coupling spectroscopy to imaging.

Finally, MicrOmega will be able to locate, within the samples, with automated algorithm, specific “grains of interest” – containing for example hydrated or C-rich phases -, to enable their further

analysis by complementary investigations, within the ExoMars Analytical Laboratory.

References

- [1] Bibring J.-P., et al. (2006), *Science*, 312, 400 – 404.
- [2] Murchie S. and Erard S. (1996), *Icarus*, 123, 63-86.
- [3] Goutzoulis A.P. and Pape D.R. (1994), *Design and fabrication of acousto-optic devices*. Edited by Dekker Inc.

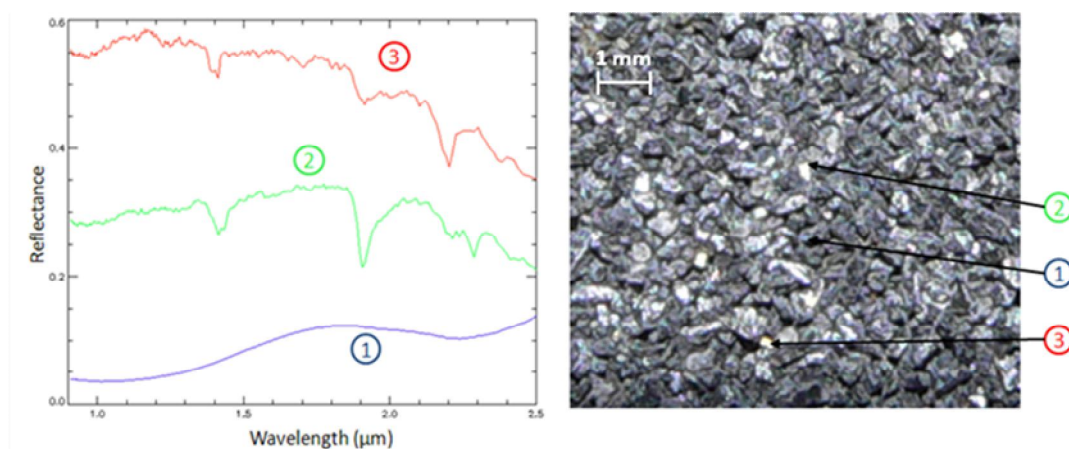


Fig. 2. A sample made of pyroxene, kaolinite type clay and nontronite type clay, tested on a representative breadboard of the MicrOmega instrument. In blue: pyroxene spectrum ; in green: nontronite type clay spectrum ; in red: kaolinite type clay spectrum