THE MICROMEGA INSTRUMENT ONBOARD EXOMARS AND FUTURE MISSIONS: AN IR HYPERSPECTRAL MICROSCOPE TO ANALYZE SAMPLES AT THE GRAIN SCALE AND CHARACTERIZE EARLY MARS PROCESSES. C. Pilorget[1], J.-P. Bibring[1] and the MicrOmega team[1], [1]Institut d'Astrophysique Spatiale, Orsay, FRANCE (cedric.pilorget@ias.u-psud.fr)

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 paylaod). 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 illustrate the instrument capabilities.

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 ~ 20 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.

Instrument capabilities: Its spectral range, 0.9 to 3.5 µm, and its spectral sampling of ~ 20 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, etc.).

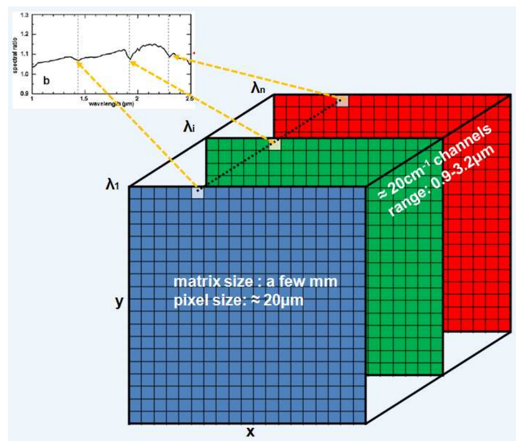

Fig 1. Principle of the measurement : an image is acquired at different wavelengths (about 500 channels), building the image cube.

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 (e.g. pH, pCO_2 vs pH_2O, etc.).

MicrOmega can perform these compositional identifications at a microscopic scale, close to that of the constituent grains. The prime goal is to observe the interrelation between the various phases and minerals, and to allow identifying molecules and minerals including those only present in small abundances (e.g. a few grains within the rock) or restricted to fractures or pores. Increasing the resolution directly leads to the possibility to enrich a given spot in species (such as organics and /or carbonates) which would not be detectable at a larger scale. The search for carbonates illustrates this potential. 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.

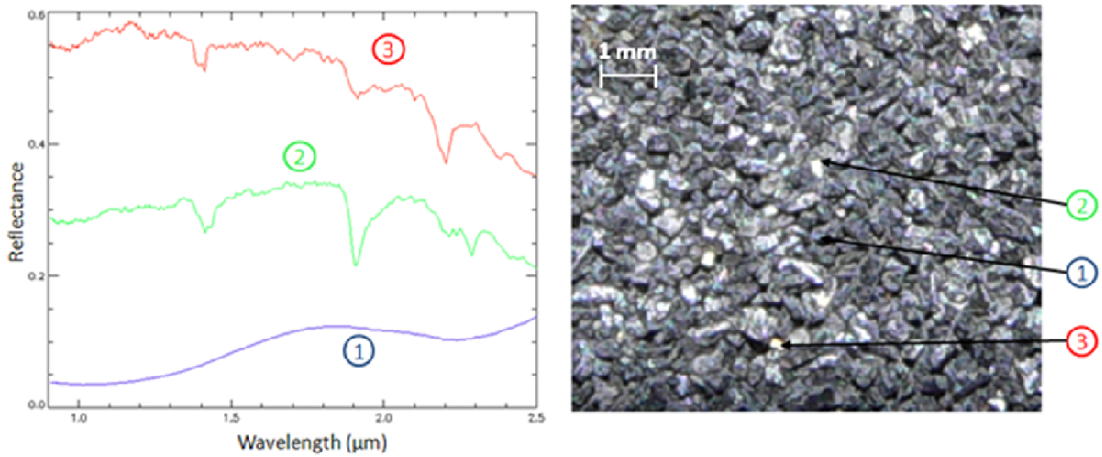

Fig. 2. A sample made of mafic minerals, kaolinite type clay and nontronite type clay, tested on a representative breadboard of the MicrOmega instrument. In blue: pyroxene spectrum ; in green: nontronite type clay spectrum ; in red: kaolinite type clay spectrum. Grains can be clearly identified and kaolinite and nontronite through their 1.4, 1.9 and 2.2-2.3 µm spectral features can be discriminated.

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, as planned for 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.