ANALOGUE ROCK CHARACTERIZATION WITH MICROMEGA, WITHIN THE H2020/PTAL PROJECT. D. Loizeau[1], C. Pilorget[1], F. Poulet[1], C. Lantz[1], J.-P. Bibring[1], V. Hamm[1], H. Dypvik[2], A. M. Krzesińska[2], F. Rull[3], S. C. Werner[2], [1]Université Paris-Saclay, CNRS, Institut d'astrophysique spatiale, France. (Bât. 121, 91405 Orsay Cedex, damien.loizeau@ias.u-psud.fr), [2]Department of Geosciences, Univ. of Oslo, Norway, [3]Universidad de Valladolid, Spain.

Introduction: The PTAL project [1] aims to build an Earth analogues database, the Planetary Terrestrial Analogues Library, to help characterizing the mineralogical evolution of terrestrial bodies, with a special focus on Martian analogues (www.PTAL.eu). Within this project, a set of natural Earth rock samples have been collected, compelling a variety of igneous and sedimentary rocks with variable compositions and levels of alteration. Those samples are characterized with thin section observations and XRD analysis (Oslo University, Norway), NIR spectroscopy (Paris-Saclay University, France), Raman spectroscopy (Valladolid University, Spain) and LIBS (Paul Sabatier University, France).

The sample analysis has been performed with commercial and spare/qualification models of space instruments. This abstract focuses on the NIR (Near Infrared) spectroscopy analysis performed using a spare model of the MicrOmega space instrument, a NIR hyperspectral microscope. Models of the MicrOmega instrument have already been flown on the Mascot module of the Hayabusa-2 mission to the asteroid Ruygu [2], and been selected to the internal laboratory of the ExoMars rover to be launched in 2020 to the surface of Mars [3]. Additional NIR spectroscopy analyses has also been made using a commercial FTIR point spectrometer mainly dedicated to the rock powders [4].

We here describe the analysis of the sample observations made with MicrOmega, showing one example that illustrates what has been achieved. Final products of the analyses will feed the online PTAL spectral database, and a paper describing these analyses has recently been submitted to Astrobiology.

MicrOmega: The MicrOmega instrument used within the PTAL project is the spare model of the ExoMars rover laboratory, protected in a dedicated laboratory set-up [5]. It has a total field of view of 5 mm x 5 mm, with resolution of 20 µm/pixel in the focal plane. It covers the spectral domain from 0.98 µm to ~3.6 µm. Its capabilities enable the identification of grains of different mineralogy in the samples [6]. This mineralogical mapping can constrain the alteration history of the sample, but also participate to the selection of the Raman targets within this sample, onboard the ExoMars rover.

PTAL rock samples: The PTAL rock collection includes a large set of samples (102 samples) of igneous, metamorphic, sedimentary or impact origin. The samples have recorded alteration/weathering in near surface and in mantle-related conditions, and consist of minerals reported elsewhere in the Solar System and on Mars. Few-mm thick slices of rocks were produced whenever possible from the collected samples, and fragile rocks were observed as patches of sand or crushed powder. From the 102 samples, 94 were analyzed as bulk rock (as in Fig. 1), one was a loose sand sample, and eight were analyzed only as crushed powder (rock too small or too fragile to cut a section). Ten samples were analyzed both as bulk rock and crushed powder for comparison purposes.

MicrOmega data analysis: Each MicrOmega observation produces >65,000 spectra, hence automatic analysis is needed as a first step. After data calibration, a quick-look data analysis based on a set of ~16 spectral parameters based on the detection of single or multiple absorption bands was performed to produce spectral indices maps and average spectra, then guiding the manual analysis in a second step, to verify for instance the spatial coherence of the detection, and the shape of the spectra. After spectral endmembers are identified, they are compared to reference spectral libraries to identify the presence of mineral species in the sample. Spectral parameter maps can then be used to map the extent of the identified mineral species on the surface of the sample (see Fig. 1 for example).

Minerals and mineral species detected with MicrOmega in the PTAL samples include: Olivine, High Calcium Pyroxene (as Diopside and Augite), Low Calcium Pyroxene (as Pigeonite, Enstatite or Hyperstene), Amphiboles (Actinolite, Hornblende), Epidotes (Epidote, Zoisite), Zeolites, Opals, Phyllosilicates (Serpentine, Chlorite, Kaolinite, Smectites, Illite, Mica and others), Oxides and Hydroxides (Hematite, Goethite and Lepidocrocite, Diaspore), Carbonates, and Sulfates (Gypsum, Jarosite, Copiapite, etc).

Data comparison between spectroscopic techniques: Preliminary comparisons with XRD and Raman analysis show general consistency in the identification of olivine, pyroxene and hydrated phases. As expected, quartz and plagioclase, for example, are challenging to identify in NIR, but MicrOmega shows well the capacity in phyllosilicate identification and qualitative estimation of major and minor mineral species thanks to its spectral-imaging capabilities.

From rock surface to crushed powders: Comparison of observations made for both, bulk rock surface and crushed powder from the same sample shows that mineral identification is easier with the presence of large grains (few 100 µm) like on the rock natural surface or with coarse-grain powders. For comparison, samples observed by MicrOmega onboard ExoMars are expected to contain 10% of grains > 400 µm with many types of rock [7].

PTAL/MicrOmega in the context of surface missions on Mars: The PTAL spectral database will in particular assist to interpret *in situ* data from the next Mars surface rover missions. The target-rocks in Oxia Planum and Jezero Crater, the landing sites of the next missions to the surface of Mars, have compositional similarities with some samples of the PTAL collection, in particular with the orbital identification of clay minerals and serpentine. The NIR spectrometers on board the rovers (ISEM and SuperCam on the masts of the ExoMars and Mars2020 rovers, Ma-MISS in the drill and MicrOmega in the internal laboratory of the ExoMars rover) will be involved at multiple stages of the surface operations and will be crucial to understand the geologic history of each landing site, and in particular the context of the water alteration of the rocks.

References: [1] Werner et al. (2018) *Second International Mars Sample Return, No. 2071,* 6060. [2] Bibring et al. (2017) *Space Science Reviews 208,* 401-412. [3] Bibring et al. (2017) *Astrobiology 17,* 621-626. [4] Lantz et al. (2020) *PSS 189, #104989.* [5] Loizeau et al. (2020) *PSS 193, #105087*. [6] Pilorget and Bibring (2014) *PSS 99*, 7-18. [7] Redlich et al. (2018) *Proc. of the i-SAIRAS, 4-6 June, Madrid, Spain.*

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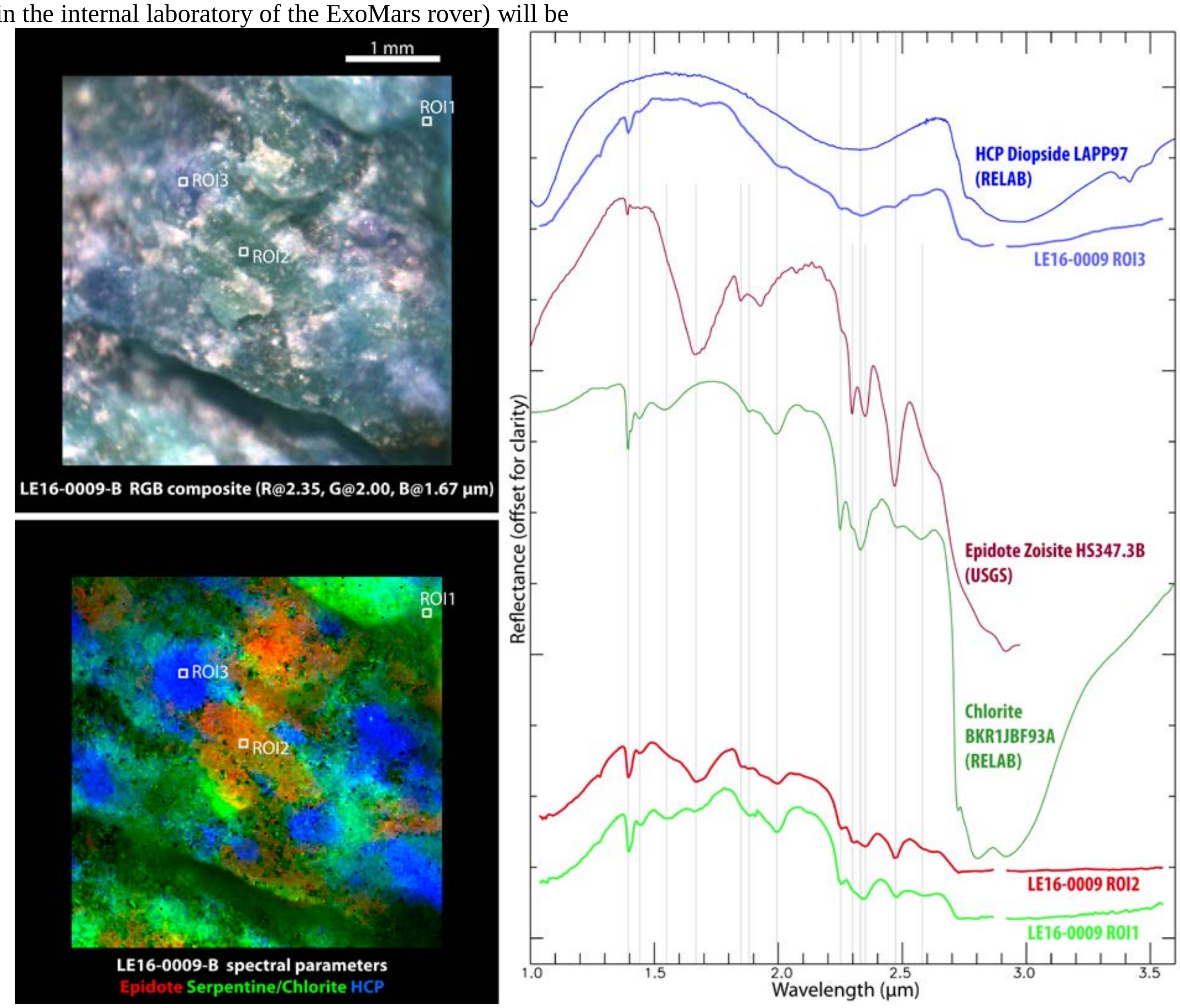

Figure 1. Example of a serpentinized rock from Leka, Norway, sample LE16-0009: from top to bottom and left to right, IR RGB composite image from MicrOmega, composite map of different mineral spectral features, spectra taken from the white boxes on the images compared to reference spectra.