ANALOGUE ROCK SAMPLES OBSERVATIONS WITH MICROMEGA, WITHIN THE H2020/PTAL PROJECT. D. Loizeau[1], F. Poulet[1], G. Lequertier[1], C. Pilorget[1], V. Hamm[1], C. Lantz[1], L. Meslier-Lourit[1], J.-P. Bibring[1], H. Dypvik[2], S. C. Werner[2], F. Rull[3], [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 and exploit an Earth analogues database [2], the Planetary Terrestrial Analogues Library, to help characterizing the mineralogical evolution of terrestrial bodies, with a special focus on the Martian analogue altered products. 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-Sud 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 microscope IR spectral imager [Bibring et al.]. Models of the MicrOmega instrument have already been flown on the Mascot module of the Hayabusa-2 mission to the asteroid Ruygu [3], and been selected to the internal laboratory of the ExoMars rover to be launched in 2020 to the surface of Mars [4]. Additional NIR spectroscopy analyses has also been made using a commercial FTIR point spectrometer mainly dedicated to the rock powders [5].

We here describe the implementation of a specific bench dedicated to measurements of the PTAL rocks using MicrOmega, the rock observation campaign and analysis that have been conducted. Final products of the analyses will feed the online PTAL spectral database.

MicrOmega: The MicrOmega instrument used within the PTAL project is the spare model of the ExoMars rover laboratory. It has a total field of view of 5 mm x 5 mm, with resolution of 20 µm/pixel in the focal plane. Its capabilities enables the identification of different crystals or grains of different mineralogy in the samples [6]. Identifying grains of different mineralogy 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.

Development of a MicrOmega/PTAL laboratory setup: To work in optimal conditions for the observations, to ensure the protection of the MicrOmega flight spare, and to reproduce conditions closer to the Mars surface, a specific set-up has been developed (Fig. 1).

The MicrOmega instrument was placed in a dedicated controlled chamber, saturated with dry air (pure nitrogen) to limit dust contamination and avoid frost on the instrument and samples. An actively cooled support (~ -30°C) for MicrOmega helps the instrument to regulate its temperature. Several mechanical and software interfaces were also implemented to be compliant with requirements linked to the use of the space instrument.

A moving stage inside the chamber brings the samples around to the MicrOmega field of view. The platform at the top of the stage, where the samples are set, can be cooled down (~ -20°C) to lower the temperature of the samples themselves and this way reduce undesired thermal emission. Samples are introduced through an airlock in the main chamber/glovebox to avoid bringing humidity inside the chamber, and are manipulated through gloves from the outside.

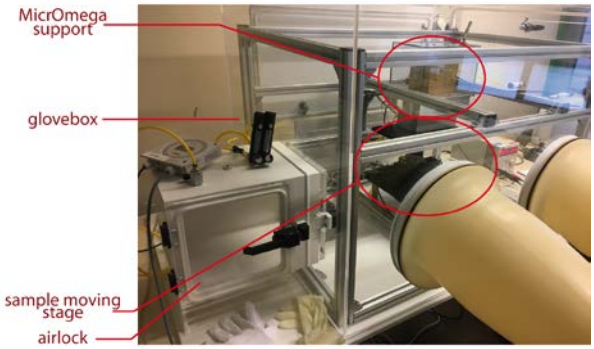

Figure 1. A view of the PTAL/MicrOmega bench.

Sample preparation: The PTAL rock collection includes a large set of samples (94 samples) of igneous, metamorphic, sedimentary or impact origin. The samples suffered alteration/weathering in near surface and deeper positions, resembling minerals reported elsewhere in the solar system and on Mars. Those rock samples were sub-sampled to be observed as "bulk" samples, to use the imaging capabilities of MicrOmega. Slices of rock were produced whenever possible, and fragile rocks were observed as patches of sand or crushed powder.

Rock slices were prepared to present the top surface in different states: most were recently broken with no sign of weathering, some were saw-cut, and some were weathered rock surfaces.

PTAL/MicrOmega observation campaign: We performed the full PTAL rock library observations in

May-July 2019. Fig. 2 shows an example of an altered impact breccia where millimeters and sub-millimeters grains of different mineralogy where identified after observation in the PTAL/MicrOmega set-up. Displayed spectra show identification of pyroxene (blue), strongly hydrated carbonates (red) and phyllosilicates (green). Those minerals could not be all identified from the spectrum of the rock powder made from the same sample (black).

From the 94 samples, 85 were analyzed as bulk rock (as in Fig. 2), one was a loose sand sample, and eight were analyzed only as crushed powder (rock 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. After data calibration, a quick-look data analysis based on a set of ~30 spectral indices similar to those used in OMEGA and CRISM orbital data analysis [e.g. 7] was performed to produce spectral indices maps and average spectra, then guiding the manual analysis in a second step, to verify for instance the actual presence of minerals.

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 phyllosilicates identification and qualitative estimation of major and minor mineral species thanks to its spectral-imaging capabilities.

PTAL/MicrOmega in the context of surface missions on Mars: The PTAL spectral database will assist in particular in interpreting *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] Veneranda et al. (2018) *2nd Int. Mars Sample Return, No. 2071*, 6069. [3] Bibring et al. (2017) *Space Science Reviews 208*, 401-412. [4] Bibring et al. (2017) *Astrobiology 17*, 621-626. [5] Lantz et al. (2019) *LPSC V, abstract #2132.* [6] Pilorget and Bibring (2014) *PSS 99*, 7-18. [7] Viviano-Beck C. et al. (2014) *JGR 119, 1403-1431*.

Acknowledgements: We are grateful for the whole team that developed the MicrOmega instrument. This project is financed through the European Research Council in the H2020-COMPET-2015 program (grant 687302).

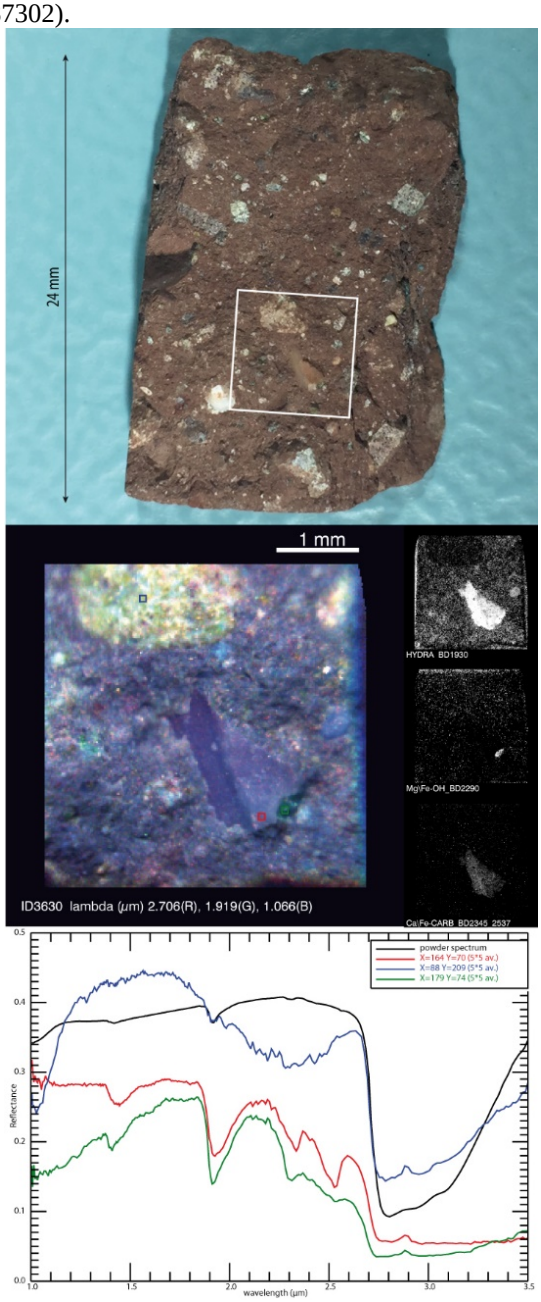

Figure 2. Example of a polymict breccia sample from Brazil, and characterization using MicrOmega/PTAL facilities. Top: picture of the rock surface; middle: IR composite image from MicrOmega and maps of different hydrated mineral spectral features; bottom: spectra taken from the colored squares above, and spectrum of the rock powder from the same sample.