CHARACTERISATION OF MARTIAN ANALOGS SAMPLES WITH MICROMEGA HAYABUSA-2 FLIGHT SPARE MODEL. L. Riu[1], F. Poulet[1], C. Pilorget[1], J-P. Bibring[1], V. Hamm[1], C. Saetre[2], S. C. Werner[2], [1]Institut d'Astrophysique Spatiale,Université Paris-Sud, 91405 Orsay cedex, France, [2]Center for Earth Evolution and Dynamics, University of Oslo, 0315 Oslo, Norway. Contact: lucie.riu@ias.u-psud.fr

Introduction: The imaging spectrometer MicrOmega (MMEGA) [1] is designed to perform *in situ* analysis of planeraty surfaces at a microscopic scale. such as Mars with the ExoMars rover of the ESA ExoMars18 mission and solar system bodies such as the C-type asteroid 162173 Ryugu [2] with the MASCOT lander (Mobile Asteroid Surface sCOuT) on board JAXA Hayabusa-2 mission. In the later case, it will also play a part in optimizing the selection of samples to be returned to Earth.

MMEGA operates between 1 µm to 3.55 µm with a spectral resolution of ~ 20 cm^{-1} providing a spectral sampling of 5 to 15 nm at 1 to 3.55 µm respectively. The wavelength selection uses an AOTF (Acousto-Optic Tunable Filter). For each wavelength, the sample is illuminated with a monochromatic light, and the image is acquired on a 2D detector providing a FOV of 3.2×3.2 mm² with a spatial sampling of 25 µm [3].

A campaign of various mineral samples measurements was carried out with the MMEGA-MASCOT spare at the DLR (Deutsches Zentrum für Luft und Raumfahrt) in Bremen. The measurements were made at ambient conditions with p=1bar and T=30°C. We present here the results for one selected sample (laboratory controlled-altered basalt type sample) to highlight the capacities of the instrument regarding the detection of different mineralogic phases at the grain scale within the same sample. These microscopic scale observations are possible thanks to the coupling of imaging and spectroscopy given by MMEGA. In ongoing and future missions, this precision will help identify and locate mineralogic phases that can only be detected at the grain-scale and will thus give better insight on the history of the studied surface.

Data and methods: The sample presented below is an altered basaltic glass of tholeiitic composition primarily made of forsterite and pyroxene mixed with glass. It was crushed to separate grains of typical size of about a few hundred of µm, and then was sealed into a reactor containing water for 3 weeks at a constant temperature of 150°C. The alteration processes and the resulting weathered phases revealed by XRD measurements are presented and described detail in [4].

The sample was analyzed with the MMEGA-MASCOT flight spare. The data were then calibrated as descrided in [3] in order to obtain a 3-D reflectance image cube (x,y,λ) of a selected part of the sample. Spectra can be then extracted and minerals phases identified. Maps of pyroxene and hydrated mineral based on the 2 µm and 1.91 µm bands respectively are also derived using the spectral parameters previously developed for the imaging spectrometer OMEGA on board Mars Express [5]. For comparison, the sample was measured with a FTIR PerkinElmer point spectrometer capable to provide a spectrum with a target-size of ~ 500 µm on the sample.

Sample characterisation: The basalt sample is composed of a few tens of grain of ~ 100 to 500 µm size presenting various albedos. The large variations in albedo observed in the scene may be due to photometric effects when it is observed inside the same grain. Nevertheless differences in composition between grains can also explain the differences in albedo (Figure 1).

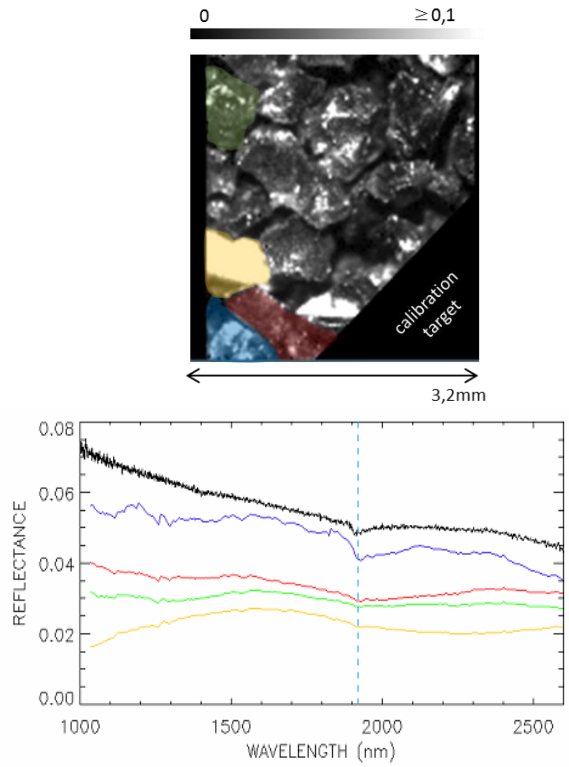

Figure 1. *Top: 2-D image of the altered basalt sample at 1.7µm. Bottom: Altered basalt reflectance spectrum measured with a PerkinElmer (black) compared with MMEGA spectra averaged for different grains with corresponding color overlapped on the top image – offset for clarity.*

A 1.91µm absorption band is observed in the PerkinElmer spectrum and in some of the spectra measured for different grains with MMEGA (blue and red spectra). It is indicative of the alteration of the basaltic sample, MMEGA enables to distinguish between different grains the presence or not of the 1.91 µm band, thus providing information about the alteration status of each grain.

One of the reflectance spectra (yellow spectrum) also presents a strong absorption band near 2.2 µm characteristic of high-calcium pyroxene consistent with the nature of the unaltered sample. Note that this pyroxene signature is observed in MMEGA but not in the PerkinElmer spectrum. Its spatial distribution is investigated and compared to the 1.91 µm signature that provides insight on the alteration of each grain (Figure 2). The hydratation map reveals that 1.91 µm depth is not homogenous, which illustrates a difference in the alteration status between each grain and even more precisely between different parts of the same grain.

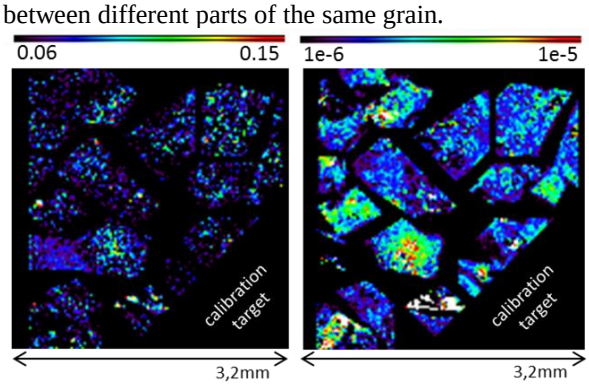

Figure 2. *Left: Pyroxene spectral index – threshold at 6% to account for photometric and noise effects. Right: 1.91µm band depth – threshold at 7%.*

Microscopic-scale spectral variations: The difference in the alteration was investigated in one of the grains (yellow in Figure 1).

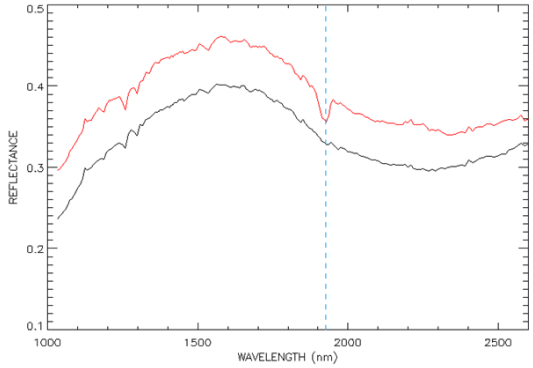

Figure 3. *Altered basalt reflectance spectrum averaged on 40 pixels (red) presenting the same absorption feature at 1.91µm in one selected grain compared to reflectance spectrum averaged on the 200 remaining pixels (black) of the same grain that do not have the 1.91µm absorption band.*

Figure 3 illustrates that we can identify pixels within the same grain where the 1.91 µm band is detected, and pixels where this feature is lacking. MMEGA enables the distinction in the grain (about a few hundreds of µm in this sample) between altered and non-altered spots, revealing non-homogeneous alteration below the grain-scale.

The MMEGA spatial resolution also gives access to microscopic effects. An example of this phenomenon is shown in Figure 4. It appears that the morphology of the grain can sometimes create interferences in spectra at the pixel-scale (Figure 4).

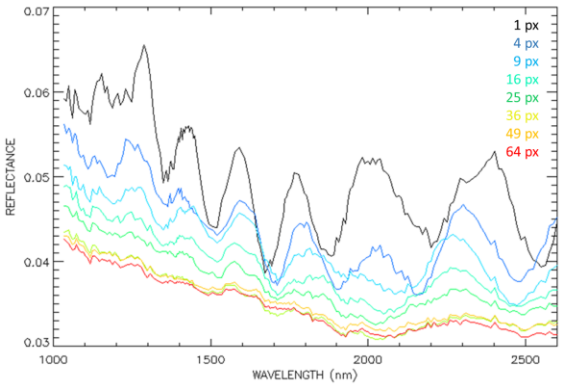

Figure 4. *Reflectance spectra of the altered basalt sample of 1 to 3,9,16,25,36,49 and 64 neighbours pixels - from dark blue to red.*

These unusual observations will have to be closely studied in the near future as to be able to characterize and fully understand them. Although, the averaging process with close neighbours cancels this phenomenon.

References: [1] C. Pilorget and J.-P. Bibring, (2013), Planetary and Space Science, volume 76, 42-52. [2] Tsuda Y., et al. (2013), Acta Astronautica, volume 91, 356-362. [3] Riu et al., (2016), this issue. [4] C. Sætre et al., (2016), this issue. [5] Poulet et al., 2007, *JGR*, 112, E08S02.