COMBINING DIGITAL MICROSCOPY AND MICRO RAMAN SPECTROSCOPY: NEW WAYS FOR NON DESTRUCTIVE ANALYSES OF (EXTRA-)TERRESTRIAL MATERIALS

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Introduction
Raman Spectroscopy is a well established technique for investigations of space materials (meteorites, returned materials e.g. Hayabusa [1,2]). More sophisticated/miniaturized Raman systems have been developed as a payload on landers/rovers for running/ future planetary missions (e.g. Mars2020, Exomars [3,4]). Being non-destructive, allowing high-resolution mapping on natural surfaces without any preparation in 2D/3D are some of the major advantages of this technique.

Micro Raman Spectroscopy
We use a Horiba Jobin Yvon Micro Raman Spectrometer (XploRa One) at the Mineralogical State Collection Munich (MSM) for our experiments which is best suited for investigating non-prepared surfaces - to avoid any influence on preparation-sensitive extraterrestrial phases or tiny rare materials. Raman spectroscopy is a mostly non-destructive technique for systematic phase analyses specifically on very small, < 50-100 µm sized particles or even subsurface inclusions.
Performing successful Micro Raman experiments on highly fragile space materials such as carbonaceous chondrites, requires the design of a highly sophisticated experimental setup to avoid or at least minimize alteration effects already during the measurements on the one hand and to guarantee a reasonable signal/noise relation on the other.

Due to the significant brecciation and very fine grained matrix / phases, experiments on primitive carbonaceous chondrites are quite complex. Many phases in these primitive space materials are extremely sensitive against (even minor, or local) heating effects, and therefore any kind of preparation (cutting/grinding etc.), specifically in terrestrial atmospheric conditions should be minimized.
In order to avoid any such effects we prefer to investigate - whenever possible - naturally broken unprepared sample materials. The representativity of the data obtained on the often small amounts of available sample material was also topic of our studies: large sets of high resolution mappings in 2D/3D can help to overcome the problem of tiny samples / fragments. Our experiences from the earlier investigations on Hayabusa 1 materials (asteroid Itokawa) were highly profitable in this context [2].

Digital Optical Microscopy
Up to now, the surface morphology and mineralogy of the samples was pre-investigated routinely by SEM whereby in most cases carbon coatings are basic requirement. Raman experiments on such samples were then impossible because coatings on rough/raw samples cannot be removed and even more serious, investigating carbon phases was also blocked. High resolution digital microscopy (Keyence VHX950F system) can completely overcome all these severe disadvantages. The technique provides full control of sample materials by preselection of particles/areas in 2D/3D for the Raman experiments planed exactly on the same samples as a follow-up step. The capabilities of our approach will be demonstrated on a selected set of meteorite samples and terrestrial equivalents. The methodology is very well suited for a fast characterization and classification of tiny samples / fragile materials such as carbonaceous chondrites or returned samples.

Figures 1-3 represent a set of samples of the optical microscopy pre-investigations followed by detailed high resolution Micro Raman Spectroscopy / phases analyses.

Further details will be provided by our eposter contribution.

References
[1]https://www.isas.jaxa.jp/en/missions/spacecraft/past/ hayabusa.html
[2] Mikouchi T. and Hayabusa Consortium, 2014. Earth, Planets and Space, 66/82, 9pp.
[3] https://mars.nasa.gov/mars2020/
[4] https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars
[5] Meteoritical Bulletin Database, 12/2022.

Examples: Selected meteorites presently under investigation with our new approach:

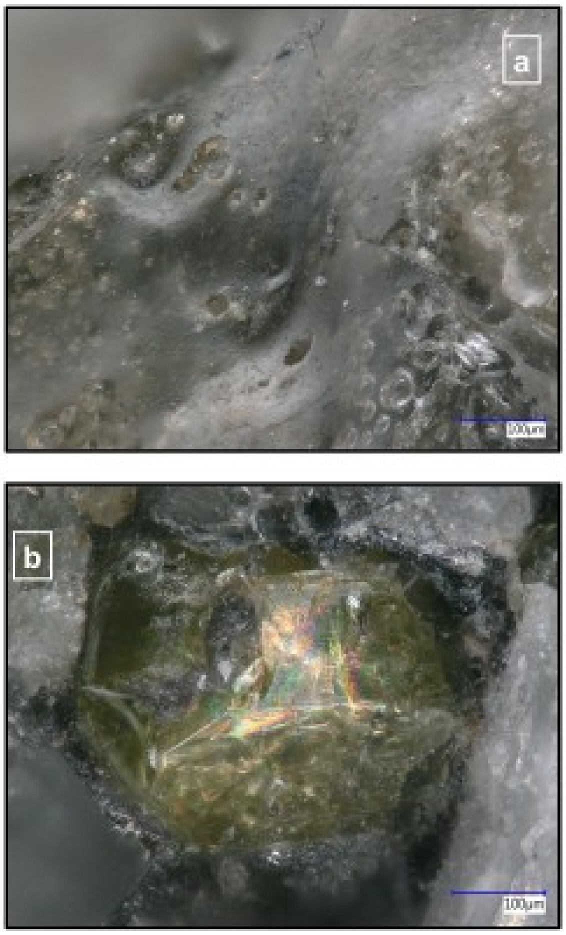
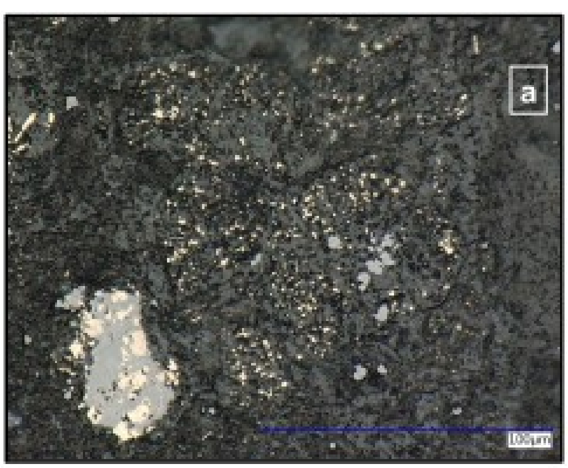


Figure 1: Almahata Sitta MS-MU 011 trachy-andesite [5]: (a) Detail of the unique, transparent fusion crust, (b) gemmy olivine; both images in 3D mode.



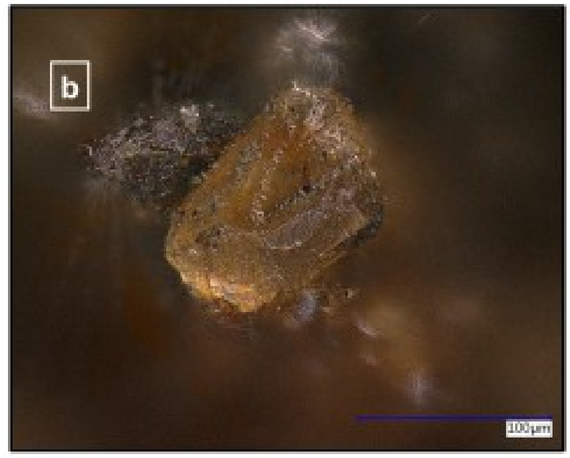


Figure 2 (a): Tochilinite chronstedtite intergrowth in Flensburg C1 ungr. [5]. (b) Aguas Zarcas CM 2 olivine [5] .

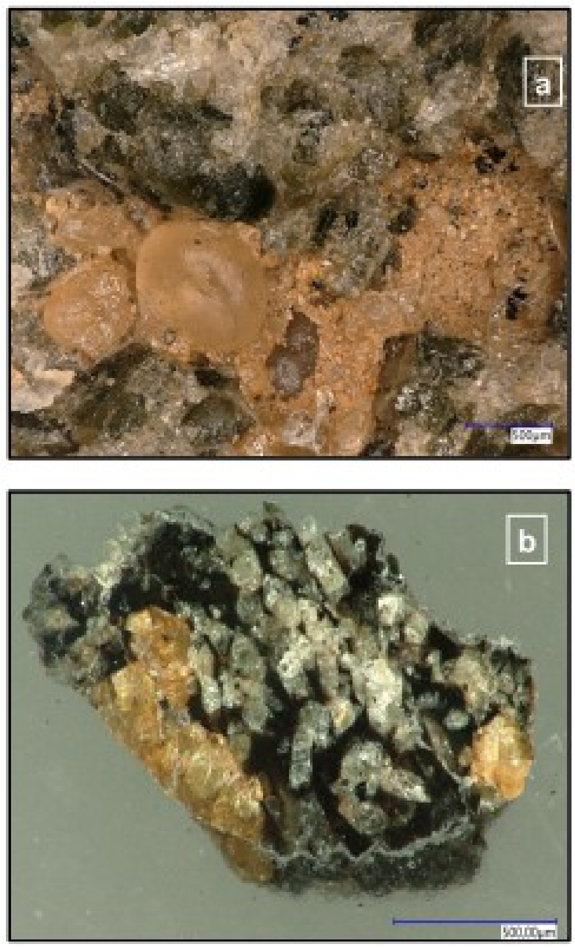


Figure 3(a): Erg Chech 002 [5], ungrouped achondrite: terrestrial quartz particles in small pockets. (b) Yamato 980459 olivine phyric shergottite [5]: lower shock of 20-25 GPa, orange olivines.