µLIBS: DEVELOPING A LIGHTWEIGHT ELEMENTAL MICRO-MAPPER FOR *IN SITU* EXPLORATION. W. Rapin[1], S. Maurice[1], A. Ollila[2], R.C. Wiens[3], B. Dubois[1], T. Nelson[2], L. Bonhomme[1], Y. Parot[1], S. Clegg[2], R. Newell[2], L. Ott[2], B. Chide[2], V. Payre[4], C. Bedford[3], S. Connell[3], H. Manelski[3], S. Schröder[5], M. Buder[5], C. Yana[6], P. Bousquet[6], [1]IRAP, OMP, CNRS, Toulouse, France, [2]LANL, New Mexico, [3]Purdue University, [4]University of Iowa, [5]DLR-OS, [6]CNES, Toulouse, France, (william.rapin@irap.omp.eu).

Introduction: Recent instrument deployments have demonstrated the power of fine-scale composition analysis. It took the PIXL instrument a single elemental map to prove the cumulate nature and alteration history of rocks in the Jezero crater floor [1]. As of now, in planetary exploration, a diversity of terrains have been observed from orbit or even *in situ*, yet remain of uncertain origin [2]. Micro-mapping can associate chemical composition with submillimeter-scale crystals, assemblages, mesostasis, fracture and void fills, and alteration phases in igneous rocks; and likewise, mineral grains, concretions and cements in fine-grained sedimentary rocks. These are all crucial to reconstruct the processes that generated these features.

Laser Induced Breakdown Spectroscopy (LIBS) is a technique that uniquely provides elemental abundances at submillimeter scales on naturally exposed rocks while removing surface dust. It can quantify the abundance of major elements (Si, Fe, Mg, Al, Ca, K, Na, Ti) in addition to all light elements relevant to organics and volatiles (C, H, N, O, P, S) as well as other minor or trace elements (Li, Sr, Cr, Rb, Mn...).

Technology and heritage: LIBS is now widely used in the laboratory for micro-mapping, and on Mars we have a decade of experience with ChemCam [3] and now SuperCam [4] and MarsCode [5], which have proven the technique's reliability and capability to analyze rocks geological investigations. It has been also test in lunar conditions [6]. However, none of these instruments were capable of fine-scale mapping. Miniaturization of LIBS systems has recently matured and now a set of handheld commercial devices ≤ 2 kg are available for geochemical raster analyses [6]. Based on ChemCam/SuperCam heritage, we propose a new ≤ 1.5 kg instrument to perform LIBS micro-mapping.

Foreseen capabilities: µLIBS will operate at an adjustable distance of 20 to 50 cm. This shorter range, compared to ChemCam and SuperCam designs, enables significant mass reduction. Importantly, it will include a 2-axis actuated scanning mirror to enable both micro-mapping on areas < 1 cm² and analysis of multiple targets within an area below the platform (Fig. 1). It also includes a remote micro-imager to provide dust-free micro-textures with elemental grid overlaid. A µLIBS laser can operate at 10 Hz and lower energy, making a typical 30x30 grid under 1 hour. These nearly 1000 grid points will help detect minor phases down to 0.1% of the rock and map their distribution.

Conclusions: µLIBS can provide micro-scale elemental maps with a science return similar to contact instruments for lower cost, as it can operate remotely from a mobile platform undercarriage with no need of arm deployment nor platform turret. It is overall low risk (heritage-based), low mass, and low cost with significant improvements in terms of accuracy and rapidity.

References: [1] Liu Y. et al. (2022) *Science* **377**, 1513–1519. [2] DSPSA 2023-2032 doi:10.17226/26522. [3] Maurice S. et al. (2016) *JAAS* **31**, 863–889. [4] Wiens R. C. et al. (2022) *Sci. Adv.* **8**, eabo3399. [5] Xu W. et al. (2021) *Space Sci. Rev.* **217**, 64. [6] Lasue J. et al. (2012) *JGR Planets* **117**, E01002. [7] Senesi G. S. et al. (2021) *SAPB At. Spectrosc.* **175**, 106013.

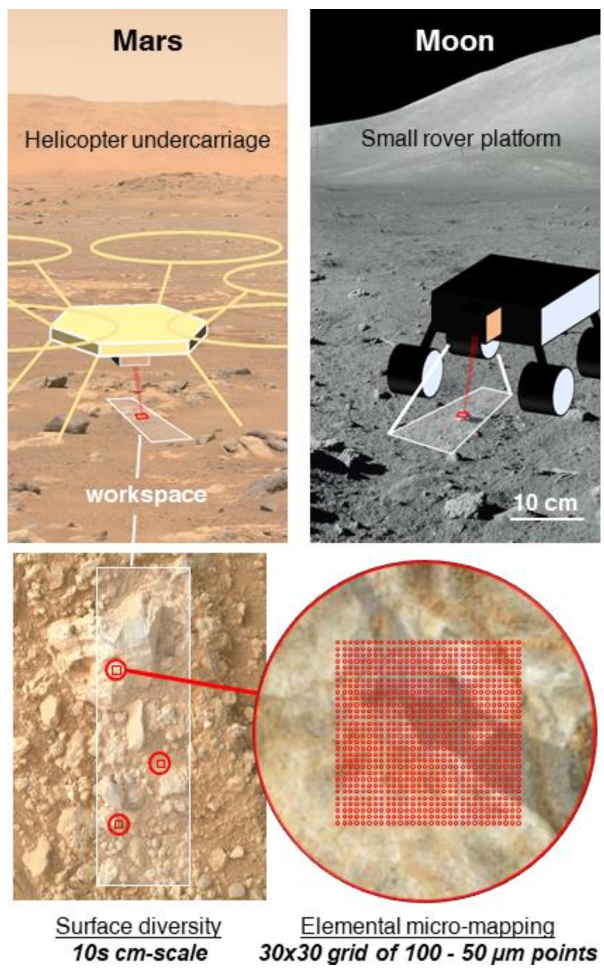

Figure 1: Examples of µLIBS onboard ~30 kg vehicles providing workspace targeting and micro-mapping. Background images: Curiosity rover and Apollo 17.