RAMAN SPECTROSCOPY AND THE RLS INSTRUMENT FOR THE CHARACTERIZATION OF SOIL ON IN-SITU PLANETARY MISSIONS. G. Lopez-Reyes\textsuperscript{1}, F. Rull\textsuperscript{1}, M. Veneranda\textsuperscript{1}, J. A. Manrique\textsuperscript{1}, A. Sanz\textsuperscript{1}, E. Lalla\textsuperscript{2} and J. Medina\textsuperscript{1}, \textsuperscript{1}Unidad Asociada UVa-CSIC-Centro de Astrobiologia. C/ Francisco Valles 8, Valladolid (SPAIN) guillerermo.lopez@cab.inta-csic.es. \textsuperscript{2} Center for research in Earth and Space Science, York University, Canada.

\textit{In-situ exploration of Mars:} The in-situ exploration of Mars with rover-based missions will be continued with the launch next year of two new rover missions to the red planet: NASA Mars 2020 and ESA ExoMars rovers. These rovers will be the best equipped ever for the detection of biomarkers or organic molecules on Mars.

On one hand, Mars 2020 rover includes a very wide range of instruments, including two Raman spectrometers: SuperCam, a remote Raman-LIBS instrument also featuring microimaging \cite{1}, and Sherloc, an ultraviolet Raman spectrometer placed in the rover arm, especially suited for the analysis of organic materials. In addition, it features a carousel that will allow the instruments of the Analytical Laboratory Drawer (MicrOmega IR imager \cite{3}, the RLS Raman Spectrometer \cite{4} and the MOMA mass spectrometer \cite{5}) to analyze the same sample in the same spots.

\textbf{Raman spectroscopy and the Martian sample-return missions:} During the next years, following the needed technology development, the logical path is to evolve to Martian return missions. In a first step, before technology readiness for human exploration, the realistic approach consists on multi-phase sample return missions. Indeed, Mars 2020 features a series of containers to store samples that might be considered of high interest, for a potential future recollection mission.

Of course, the proper characterization and identification of the samples is of paramount importance to ensure that the right samples are selected for collection. In this sense, the Raman spectroscopy technique has proved to be considered as an essential tool for the chemical and structural characterization of samples in planetary in-situ missions given its non-destructive nature, as well as the possibility of being used in micro or macro analysis, while providing very useful and accurate identification of the analyzed materials in with a short operation time.

\textbf{The RLS instrument:} Developed by an international consortium led by the University of Valladolid (UVa) and the National Institute of Aerospace Technology (INTA), RLS will become the first Raman spectrometer ever used for space exploration. This instrument features a 532 nm continuous wavelength laser with a spot size on the sample of 50 microns and an irradiance level around 0.3 kW/cm\textsuperscript{2}, and a spectral resolution between 6 and 8 wavenumbers.

The flight model of the instrument has already been delivered for integration in the rover, but other replicates and models have been widely characterized and tested in multiple environments to demonstrate the capability of the technique -and the instrument- of fulfilling the ExoMars mission objectives, but also paving the way for the use of this technique in the upcoming missions to Mars or other planetary bodies such as Europa, or to comets.

Having a critical role in the development of the RLS, the Erica research group from UVa is involved in numerous research fronts converging towards two primary aims: 1) optimize the scientific outcome that could derive from the interpretation of RLS spectra, and 2) evaluate to which extend RLS data can contribute in the fulfillment of the general objectives of the ExoMars mission.

To achieve these aims, terrestrial analogues of Martian rocks and soils need to be studied through Raman systems that ensure a spectral response and an operational mode comparable to the RLS. For this, two RLS-representative analytical models have been developed by the Erica team to perform in-situ and laboratory studies of terrestrial analogues and further Martian-related samples.

On one hand, the RAD1 (RAman Demonstrator) is a field-portable prototype that has the same geometrical concept and spectral characteristics of the RLS instrument, mostly built with COTS elements (with the exception of the diffraction grating, which is identical to the RLS instrument one). RAD1 also make use of the same algorithms employed by RLS to automatically calculate the optimal analytical parameters to be set during analysis \cite{6}. In addition of being employed for the in-situ mineralogical screening of terrestrial analogue sites (important in the selection of the optimal samples to be collected for further laboratory studies), RAD1 has been successfully used to emulate RLS procedures during ExoMars mission simulations, as is the case of the ExoFiT field campaigns recently carried out in Almeria (Spain) and Atacama (Chile).

On the other hand, RLS ExoMars simulator is a laboratory prototype that, compared to RAD1, is coupled
to a vertical and horizontal positioner emulating the Sample Preparation and Distribution System (SPDS) of the ExoMars rover. The RLS ExoMars Simulator has been used to demonstrate that the analytical routine chosen for the RLS (between 20 and 39 spot of analysis per sample) allows to obtain a full picture of the mineralogical heterogeneities of powdered samples [7]. Furthermore, it also helped corroborating that, depending on the mineralogical complexity of the sample, a limited number of spectra can ensure a reliable semi-quantification of the detected mineral phases [7].

The intensive use of these models in the framework of the development of the RLS instrument for the ExoMars mission has provided a huge amount of data and results that have helped developing a series of analytical techniques including multivariate analysis [8] and/or data fusion techniques [9]. The study of analogues has resulted in the development of databases such as the Planetary Terrestrial Analogue Library (PTAL) [10], and also with interesting results on the potential identification of wet-target craters based on Raman spectroscopy data [11].

The use of these techniques will help improve the scientific return from the Raman spectroscopy data from in-situ instruments on Mars.

Conclusions: Raman Laser Spectroscopy is a key technique for the analysis of samples in planetary in-situ missions. The use of this technique has been amply demonstrated in field and laboratory tests around the world and will be corroborated during the upcoming ExoMars and Mars2020 missions due to its non-destructive analytical capabilities, combined with a powerful chemical and structural identification of the analyzed materials.

For all these reasons, this technique proves to be essential for any in-situ exploration mission, including the future Martian-sample return missions.

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References: