**Introduction:** Raman spectroscopy is an important technique of the scientific payload onboard NASA Mars2020 and ESA ExoMars rovers with various instrumental designs and scientific strategies. Mars2020 Sherloc instrument is a deep UV Raman and fluorescence instrument optimized to detect organics in situ at the near contact with the rock target [1]. Mars2020 SuperCam instrument is a remote multi-tool instrumental suite including a time-resolved (TR) Raman and luminescence instrument [2] and ExoMars RLS is a continuous-wave (CW) Raman microscope working on powder after drilling and grinding [3]. On Mars, Raman is expected to detect and identify possible organics as well as to characterize mineral structure and provide chemical information whenever possible. In addition, TR luminescence may provide crucial detection for some trace elements like REE in minerals.

Here we combine and compare CW and TR Raman and luminescence spectroscopy to investigate diverse minerals in various sections of NWA7533 Martian regolith breccia [4-6] and on reference minerals and/or rocks relevant to Jezero crater, the landing site of the Mars2020 rover. In NWA 7533, we put particular emphasis on phosphates which are important markers of volatiles composition during magma evolution or alteration, and other accessory mineral phases present in the mineral matrix. For Jezero, we present Raman data for a large series of minerals detected from orbital IR spectroscopy [7]. In particular, we document the Raman signature of a large series of carbonates including polymorphs and variously hydrated Mg-carbonates as they may be present in the targeted olivine-carbonate unit of the landing site and could provide key environmental information on fluid-rock interactions.

**Methodology:** Polished uncoated sections of NWA7533 and a series of reference minerals and rocks (raw or saw) were selected. These minerals were first characterized by X-ray diffraction and their chemistry was analyzed when necessary: some of them are not completely pure and exhibit traces of other mineral phases and/or organic matter. Raman measurements were carried out at IMPMC (Paris, France) using a homemade time-resolved Raman/luminescence instrument with both microscopic and remote macroscopic analysis working at 532 nm. This instrument can be operated in a SuperCam-like configuration in terms of irradiance (in the range $10^{10}-10^{11}$ W.m$^{-2}$) and data collection (ICCD gating of 100 ns, spectral resolution of Ca. 10 cm$^{-1}$). All samples were also analyzed using a CW Raman microspectrometer (Renishaw In-Via, excitation 532 or 785 nm) in a configuration close to the ExoMars RLS instrument. When needed, Raman micro-mapping was performed to decipher microtextural information between mineral phases (not implemented on instruments going to Mars). To complete the dataset and make the link with orbital and future SuperCam IR data, diffuse reflectance IR spectra were obtained by using a Nicollet 6700 in the range 1.3-2.6 μm on some samples.

**Some insights from NWA 7533 Martian breccia:**

Figure 1 depicts a Raman image of a phosphate grain with a merrillite core and an apatite rim in NWA7533.

![Raman image of a phosphate grain in NWA7533 and corresponding Raman spectra. The core is composed by merrillite and the rim by apatite.](image)

Such microtexture has been observed in other sections of this meteorite and suggests that apatite is secondary after merrillite. Interestingly, except detection of this merrillite/apatite assemblage, all Raman data are remarkably homogeneous within the various NWA7533 sections, in agreement with existing literature: pure apatite is detected (constant position at 960 cm$^{-1}$).
cm-1 of the νPO4 mode) with low or no water detected (chlorapatite as confirmed by EMP analysis). Only TR luminescence data suggest diverse REE patterns among the phosphate grains that will be discussed combined with microtextural observation. Major (olivine, pyroxenes, plagioclases...) and minor mineral (zircon, Fe-oxides...) and organic phases are documented by Raman and discussed in light of existing literature.

Raman spectroscopy for Jezero mineralogy: Mars2020 rover will land at Jezero crater and will likely further explore the region around the crater towards the Midway ellipse. During its trip, the rover will traverse a wide diversity of lithologies and mineralogy [8] including mafic rocks, detrital rocks in the delta originating from geologically diverse sources, mafic/igneous rocks with various degrees of hydrothermal alteration (in particular the olivine-carbonate unit). Not only the Raman instruments onboard the rover are expected to identify minerals complementing chemical information from LIBS and PIXL, but Raman is powerful to investigate structure, possible hydration and even chemistry for these minerals. However, analysis on Mars will be challenged by many parameters like dust, raw and rough surfaces, grain size compared to spot size, complex mineralogical assemblages likely including luminescent phases... that can be tested in the laboratory. Such tests were performed and main conclusions and recommendations will be presented.

To go further in terms of Science, we present Raman data for carbonates which are expected at various places at Jezero. Carbonates are actually key players in the Martian carbon cycle and they may constitute a rocky shallow carbon reservoir which has likely interacted with the Martian atmosphere through time [9]. Carbonates are also tracers of shallow or deeper fluid-rock interactions (hydrothermalism) identified on Mars [10], in particular around Jezero. Last but not least, one of the main objectives of the Mars 2020 mission is the identification of past or present life on Mars. Carbonates being frequently formed by biological processes on Earth in lacustrine environments possibly similar to Jezero, they are also excellent candidates to trace Life on Mars surface. A series of reference carbonate minerals were analyzed including Ca-, Fe-, Mn-and (hydro)Mg-carbonates and some compositions in between. Figure 2 depicts Raman spectra for a series of hydrated Mg-carbonates obtained with (i) conventional CW configuration and (ii) our TR Raman instrument in SuperCam configuration. Monocrystals of pure endmembers (e.g. calcite, aragonite, magnesite, siderite, rhodocrosite) are rather easy to analyze and yield high-quality Raman spectra for both configurations. In contrast, all fine-grained carbonates and most (hydro-)Mg carbonates analyzed with the CW mode were characterized by an intense background often masking the Raman peaks. Alternatively, using the TR instrument and closing the ICCD gate around the laser pulse allows us to significantly decrease this background and in most cases to retrieve high quality Raman spectra even when these minerals are dispersed in rocks. We will briefly discuss some environmental implications of the presence of these phases in particular for fluid-rock interactions.

![Figure 2: Raman spectra for various (hydrated or not) Mg-carbonates acquired in CW (green) and TR (red) Raman at 532 nm. Note that the strong background present in the CW spectra and masking the Raman signal can be removed with time-resolution. Note that lattice vibrations (<400 cm⁻¹) and internal modes (e.g. νCO3 at ca. 1085-1090 cm⁻¹) are easily observed in TR spectra and that the presence of OH or H2O in the structure generates bands in the range 3000-4000 cm⁻¹.](Image)

Acknowledgements: Funding by Sorbonne Universités, CNRS INP, CNES and Labex Matisse is acknowledged.