PREPARING SUPERCAM FOR JEZERO CRATER, MARS: LIBS, RAMAN, VISIR, LUMINESCENCE, IMAGING, AND ACOUSTIC ANALYSES. A. M. Ollila (amo@lanl.gov)[1], R. C. Wiens[1], S. Maurice[2], A. Cousin[2], R. Anderson[3], O. Beyssac[4], L. Bonal[5], P. Beck[5], S. Clegg[1], B. Chide[2], L. DeFlores[6], G. Dromart[7], W. Fischer[8], O. Forni[2], T. Fouchet[7], O. Gasnault[2], J. Grotzinger[8], J. Johnson[9], J. Lasue[2], J. Laserna[10], J. M. Madariaga[11], M. Madsen[12], N. Mangold[13], T. Nelson[1], R. Newell[1], J. Martinez-Frias[14], S. McLennan[15], F. Montmessin[16], S. Robinson[1], S. Sharma[17], A. Misra[17], F. Rull[18], D. Venhaus[1], P. Bernardi[19], J.-M. Reess[19], A. Reyes-Newell[1], F. Poulet[20], N. Lanza[1], I. Torre[11], J. Aramendia[11], R. Perez[21], E. Cloutis[22], S. Angel[23], D. Mimoun[24], R. Lorenz[9], W. Rapin[8], P.-Y. Meslin[2], J. Frydenvang[12], T. McConnochie[25], S. Bernard[4], [1]LANL, [2]IRAP, [3]USGS, [4]Institut de Mineralogie, de Physique des Materiaux et de Cosmochimie, [5]Institut de Planetologie et d'Astrophysique de Grenoble, [6]NASA JPL, [7]Centre Nationale de la Recherche Scientifique, [8]Calif. Inst. of Tech., [9]JHU/APL [10]Univ. de Malaga, [11]Univ. of Basque Country, [12]Univ. of Copenhagen, [13]Univ. de Nantes, [14]CSIC-UCM, [15]Stony Brook Univ., [16]Laboratoire Atmospheres, Millieux, Observations Spatiales, [17]Univ. of Hawaii, [18]Univ. of Valladolid, [19]LESIA-Observatoire de Paris, [20]Institut d'Astrophysique Spatiale, [21]CNES, [22]Univ. of Winnipeg, [23]Univ. of South Carolina, [24]ISEA-SUPAERO, [25]Univ. of Maryland

Introduction: SuperCam is a multi-functional spectroscopy instrument on the Mars 2020 rover. It will remotely analyze the surface using Laser-Induced Breakdown Spectroscopy (LIBS), Raman spectroscopy, Visible-Infrared (VISIR) spectroscopy, and Time-Resolved Luminescence Spectroscopy (TRLS). A color micro-imager (RMI) will provide context images and textural detail (Fig. 1). It will also have a microphone to record the LIBS plasma shock waves and the sounds of Mars [1]. Mars 2020 is expected to launch in July 2020 and begin roving Jezero crater in February 2021.

SuperCam and the Mars 2020 Mission Goals: The primary goals of the Mars 2020 mission are to 1) search for habitable environments, 2) search for signs of past life, 3) cache samples, and 4) prepare for human exploration. SuperCam will address these goals by analyzing the chemistry of the rocks and soils using LIBS for major and trace elements and TRLS for trace elements, determining the mineralogy using VISIR and Raman spectroscopy, and potentially identifying organic materials using Raman, VISIR, and TRL spectroscopy. The microphone may also provide information on rock physical properties and on the martian winds.

Instrument Description: SuperCam consists of a Mast Unit (MU) and a Body Unit (BU). The MU houses the laser (Nd:YAG 1064 nm) for LIBS, the frequency doubling system for the Raman and TRLS laser (532 nm), the infrared spectrometer (spectral coverage from 1.3-2.6 µm), the RMI (70 µrad spatial resolution at the center of the field of view), the microphone, and the telescope and associated optics. The BU consists of a demultiplexer to split and direct the light into two reflection spectrometers (spectral ranges ~241-340 nm and 382-469 nm) and a transmission spectrometer (536-853 nm). A set of 31 calibration targets will be positioned at 1.6 m from the MU. The LIBS instrument operates to 7 m from the rover with an analysis spot size of 200-500 µm. Raman and TRLS will operate to 12 m with a spot size of 0.9 mrad. VISIR will operate to kilometers distances with a field of view of 1.15 mrad.

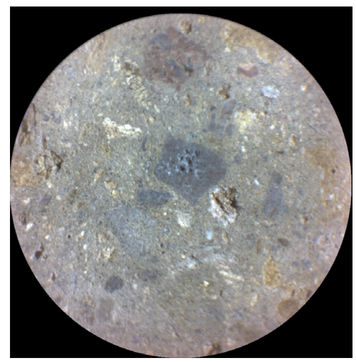

Fig. 1: Example SuperCam RMI of a rock with LIBS analysis pits (~350 µm diameter) on the central dark gray grain. The distance is 2 m and the image is corrected for flat field, contrast, balance, and color.

Development and Testing: SuperCam was developed in stages and the Engineering Qualification Model (EQM) version was tested in 2018. The BU Flight Model (FM) was completed and tested in April and is very similar to the EQM BU in spectral range and resolution. The FM MU is being finalized and therefore the data collected for the preliminary calibration of SuperCam used the FM BU with the EQM MU. There are some improvements of the FM MU compared to the EQM including 1) improved stability of the primary mirror over temperature for better quality LIBS and RMI data, 2) higher quality RMIs due to an improved objective and light path, and 3) a change in the mounting of the Schmidt plate for better alignment of the Raman/TRLS laser. SuperCam software, firmware, alignment, focusing, and other engineering capabilities have been tested and proven successful.

Calibration: In April 2019, SuperCam underwent a significant calibration effort to demonstrate the instrument's capabilities. Over 27,000 LIBS spectra were collected on ~300 geological materials (pressed pellets) and more than 100 Raman, 15 TRLS, and 50 VISIR spectra were collected on rocks and minerals.

Full calibration of the FM IR spectrometer will be completed within the next 2-3 months [2].

Synergy between Techniques: An example of how the SuperCam techniques may be integrated to identify a mineral is shown in Fig. 2. This data was collected in 2018 using the EQM BU and MU. The distance was 2 m and samples were under ambient conditions. Ambient conditions have a significant effect on LIBS spectra. Room lights were turned off and VISIR spectra were collected with a 75 W QTH lamp. TRLS spectra consist of 20 spectral co-additions with a 0.5 ms integration time at 3 time delays (730 ns, 53 µs, and 73 µs). Spectra were dark subtracted, wavelength calibrated, and instrument response corrected. The successful identification of rhodochrosite was made through the combination of all techniques: high Mn from LIBS, IR data consistent with Mn-rich calcite, Raman data consistent with rhodochrosite or calcite, and fast decaying Mn^{2+} and slower decaying Nd^{3+} indicative of rhodochrosite. XRD results confirm rhodonite, rhodochrosite, and quartz as the primary mineralogy in this rock. Due to the spot size, it is possible multiple phases were sampled but the rhodochrosite was more prominent in IR, Raman, and TRLS spectra.

References: [1] Wiens et al. (2017) Spectrosc. 32:5, 50-55 [2] Royer et al. (2019) 9th Int. Conf. Mars [3] Lafuente, B. (2015) In: Highlights in Mineralogical Crystallogr., Eds: Armbruster & Danisi.

Fig 2: Example SuperCam EQM data showing the synergy between the SuperCam techniques. Raman library data: RRUFF [3].