SHERLOC: ON THE ROAD TO MARS. L. W. Beegle[1], R. Bhartia[1], L. DeFlores[1], E. Miller[1], R. Pollack[1], W. Abbey[1], B. Carrier[1], S. Asher[2], A. Burton, M. Fries[3], P. Conrad[4], S. Clegg[5], K. S. Edgett[6], B. Ehlmann[7], W. Hug[8], R. Reid[8], L. Kah[9], K. Nealson[10], T. Nelson[5], M. Minitti[11], J. Popp[12], F. Langenhorst[12], P. Sobron[13], A. Steele[14], N. Tarcea[12], R. Wiens[5], K. Williford [1], R. A. Yingst[11]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena Ca, 91109 (Brandi.L.Carrier@jpl.nasa.gov, Rohit.Bhartia@jpl.nasa.gov, Luther.Beegle@jpl.nasa.gov),[2]University of Pittsburgh, [3]Johnson Space Center, [4]Goddard Space Flight Center, [5]Los Alamos National Laboratory, [6]Malin Space Sciences, [7]California Institute of Technology, [8]Photon Systems Inc., [9]University of Tennessee, [10]University of Southern California, [11]Planetary Science Institute, [12]University Of Jena, [13]SETI Institute, [14]Carnegie Institute Washington

Introduction: SHERLOC is a Deep UV (DUV) native fluorescence and resonance Raman spectrometer that was selected as part of the Mars 2020 payload. It is a robotic arm mounted instrument that utilizes a DUV laser to generate characteristic Raman and fluorescence photons from a targeted spot. The DUV laser is co-boresighted to a context imager and integrated into an autofocusing/scanning optical system that allows us to correlate spectral signatures to surface textures, morphology and visible features. Additionally, it has recently been augmented with an imaging system that is a built-to-print version of the MArs Hand Lens Imager (MAHLI) instrument on the Mars Science Laboratory (MSL).

The SHERLOC investigation combines two spectral phenomena, fluorescence and pre-resonance/resonance DUV Raman scattering. Raman scattering enables classification of bonds such as C-H, CN, C=O, C=C, NHx, NOx, SOx, POx, ClOx, and OH. These spectral features are resolvable when a high-radiance, narrow linewidth, laser source illuminates a sample. In fluorescence, the incident photons are absorbed and re-emitted at a longer wavelength. The difference between the excitation and emission wavelength is the difference between the excitation frequency and the lowest electronic state frequency that increases with increasing aromatic structure (i.e., number of aromatic rings). Typical fluorescence cross-sections are 10^4 greater than traditional Raman, enabling the detection of sub-picograms levels of aromatic organic compounds. Through the use of an internal scanning mirror, autofocusing lens, and a depth of focus of ±500 µm, the 100 µm laser spot can be systematically scanned over a 7x7 mm area with a fine-scale spatial resolution on natural or abraded surfaces and boreholes to a depth of at least 13 mm, without further arm movement. Through the use of the context imager, SHERLOC's data products can be combined with observations made by other instruments on the Mars 2020 payload. By bringing to bear multiple scientific instruments on a single sample, our ability to assess the habitability of ancient environments and search for potential biosignatures preserved within the geologic record will be greatly enhanced, making possible the selection of high-priority samples for caching.

Fluorescence emission of organics extends from ~270 nm into visible wavelengths. On the other hand, mineral fluorescence emission stemming from crystalline defects and impurities is weak in the deep UV, and typically begins longward of 360 nm continuing through the visible and into the NIR. Mineral fluorescence is very unlikely to be seen in samples found on Mars. The DUV fluorescence technique employed by SHERLOC is well-suited to the detection of organics on mineral surfaces.

The road from concept to eventual flight for SHERLOC first started in 1998. An internal program at JPL called the "Grand Challenge" awarded grants to multiple instrument teams to designed and develop instrumentation to detect evidence of extant and extinct life. In the time between that first endeavor and the submission of Mars 2020 proposal, multiple different funding from sources including DARPA, ASTID, NAI and PIDDP were obtained. After selection, the design of the instrument underwent several changes including the including of WATSON, the modification of the optical path and packing all the hardware on the resource constrained arm.

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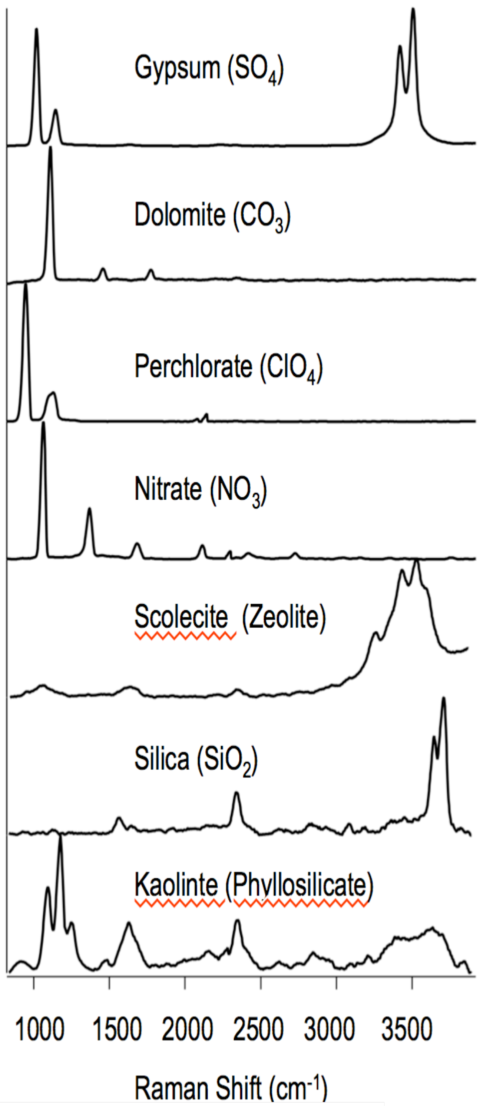

Figure 1 (above): Figure 1 (above) Raman Spectra of minerals of astrobiological importance and indicators of water activity that are targeted by the SHERLOC Raman Spectrometer.

Figure 2 (Right) Raman and fluorescence spectra demonstrating organic molecule detectability. These spectra including organics ranging from PAHs (polyaromatic hydrocarbons), condensed carbon, and proposed mars carboxylic acids. In the SHERLOC investigation, these Spectra are obtained on the same CCD at the same 100 micron condensed spot that is then related to images obtained by the SHERLOC imaging system.