SHERLOC: AN INVESTIGATION FOR MARS 2020.

L. W. Beegle[1], R. Bhartia[1], L. DeFlores[1], W. Abbey[1], B. Carrier[1], S. Asher[2], A. Burton[3], P. Conrad[4], S. Clegg[5], K. S. Edgett[6], B. Ehlmann[7], M. Fries[3], W. Hug[8], R. Reid[8], L. Kah[9], K. Nealson[10], M. Minitti[11], J. Popp[12], F. Langenhorst[12], V. Orphan[7], P. Sobron[13], A. Steele[14], N. Tarcea[12], G. Wanger[10], R. Wiens[5], K. Williford [1], R. A. Yingst[11]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena Ca, 91109 (Luther.Beegle@jpl.nasa.gov, Rohit.Bhartia@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: The next rover to explore Mars has been proposed to launch in 2020. The primary goal of the mission is to better understanding the geologic and climate history of Mars including the identification of potential signs of past life on Mars. Once identified, these samples will be collected and stored by the rover for return to the earth so they can be analyzed by state-of-the art instruments in terrestrial laboratories.

As part of the payload, NASA selected the Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals (SHERLOC) investigation. SHERLOC consists of a Deep UV (DUV) native fluorescence and resonance Raman spectrometer that includes a built-to-print version of the Mars Hand Lens Imager (MAHLI) instrument on the Mars Science Laboratory (MSL). 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. An internal scanning mirror enables the generation of maps that allow for the identification of spatially resolved organic structure.

The SHERLOC investigation combines two spectral phenomena, fluorescence and pre-resonance/resonance DUV Raman scattering. These spectral features are resolvable when a high-radiance, narrow line-width, laser source illuminates a sample. In fluorescence, the incident photons are absorbed and re-emitted at a longer wavelength. Typical fluorescence cross-sections are 10^4 greater than traditional Raman, enabling the detection of sub-picograms levels of aromatic organic compounds. Fluorescence emission of organics extends from ~270 nm into visible wavelengths.

The deep UV resonance Raman enables classification of bonds such as C-H, CN, C=O, C=C, NHx, NOx, SOx, POx, ClOx, and OH. It should be noted that Raman shifts (cm-1) (i.e., peak position as energy loss from the excitation energy) are invariant to excitation wavelength. Thus peak positions in Raman databases (at 229, 248, 488, 532 and 785 nm) can be compared (c.f. http://rruff.info/).

SHERLOC's science goals include the detection and classification organics and astrobiologically relevant minerals on the surface and near subsurface of Mars. It is capable of organic sensitivity of 10^{-5} to 10^{-6} w/w over the entire observation region of 7 mm x 7 mm. It is capable of organic sensitivity of 10^{-2} to 10^{-4} w/w spatially resolved at 100µm and can detect astrobiologically relevant aqueously formed mineral grains with sizes <100µm.

The figure below demonstrates the power that mapping of organic molecules over a surface and the ability of SHERLOC to identify potential biosignatures. The image on the left is of a carbonate collected on the sea floor (courtesy of V. Orphan Caltech). The mineral matrix is primarily dolomite $CaMg(CO_3)_2$. A map of the fluorescence features identifies organic structure that was not visible in the color image (purple image on right). Raman spectra (see insert) obtained in these fluorescence regions shows spectral features of aromatics, aliphatics, hydroxyls, nitrogen & sulfur bearing organics. These features would possibly a result of ancient microbial processes This sample would be a high priority sample to be collected and returned in a future mission.

Acknowledgement: This work was carried out at the Jet Propulsion Laboratory, The California Institute of Technology under a contract from NASA