Optical detection of organic molecules in extreme environments

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In situ detection and identification of organic molecules in extreme environments on Earth can be almost as challenging as it is on another planet, depending upon the nature of the "extreme" classification. For example, deep sea deployments are particularly challenging because of high pressures, cold, and the physical properties of water (eg., absorption of infrared light, etc.). We have successfully used an optical instrument that measures laser-induced native fluorescence (LINF) and resonance-enhanced Raman scattering in several extreme environments, including deep sea hydrothermal vents, arctic and antarctic deserts, and hot deserts. The context of these measurements has been to provide targeting of rock samples for more rigorous analysis of chemical biosignature content. Our overall goal is development of a rapid survey instrument for deployment *in situ* on another planet, for detection and characterization of organic molecules.

Here we summarize the results of the LINF and Raman scattering measurements in the polar deserts (Svalbard and Antarctic Dry Valleys), Death Valley, CA (USA) and underwater at Pacific Hydrothermal Vent sites, presenting our state of the art with respect to molecular specificity and limits of detection. We also present the effects of environmental factors such as temperature, pressure, humidity, ambient light and lithology on the detection of organic molecules in these extreme environments.

Interaction of amino acids and peptides with minerals to produce biosignatures observable by laser desorption fourier transform mass spectrometry

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Unequivocal identification of life within the fossil record and understanding present day biogeochemical processes depends on our ability to accurately characterize mineralogical or chemical signatures that have arisen from the interaction of microorganisms with geological matrices. Laser desorption mass spectrometry (LDMS) has been proposed as a method to search for biosignatures on mineral surfaces for identifying signs of past or present terrestrial or extraterrestial life. Matrix-assisted laser desorption/ionization (MALDI), coupled with mass spectrometry, has been highly successful for analyses of biomolecules. MALDI uses a matrix, usually an aromatic carboxylic acid, to interact with the laser light to desorb from the surface and carry the biomolecule analyte into the gas phase. In addition, the matrix assists in ionizing the analyte directly or indirectly. The analysis of mineral surfaces by MALDI requires overspraying the surface with a matrix. In some cases it may not always be practical or prudent (e.g, space exploration) to utilize a matrix and solvent technique (i.e., MALDI) to search for signs of life. Without the use of a matrix, it will be necessary to rely on the mineralogy associated with the biomolecule for desorption and ionization processes.

To achieve our long term goals of examining microbial biosignatures that are present in heterogenous minerals, we are examining the efficacy of LDMS. The interactions of a range of biomaterials and minerals are being examined in our laboratory in order to assess and optimize the conditions for LDMS observation of biosignatures. We have observed that different minerals have varying desorption efficiencies depending on laser wavelength. Furthermore, the types of cations formed during the desorption event vary depending on the mineral type, which is important because ionization of the bioanalytes occurs through cation attachment. In this study we compare the production of biosignatures from sodium and potassium rich surfaces with minerals dominated by iron.