Optical Detection of Organic Chemical Biosignatures at Hydrothermal Vents P. G. Conrad[1], A. L. Lane[1], R. Bhartia[1] and W. H. Hug[2] [1]Jet Propulsion Laboratory, 4800 Oak Grove Drive, MS183-301, Pasadena, CA 91109 conrad@jpl.nasa.gov, [2]Photon Systems, 1512 Industrial Park St., Covina CA 91722

Introduction: We have developed a non-contact, optical life detection instrument that can detect organic chemical biosignatures in a number of different environments, including dry land, shallow aqueous, deep marine or in ice. Hence, the instrument is appropriate as a biosignature survey tool both for Mars exploration or in situ experiments in an ice-covered ocean such as one might wish to explore on Europa. Here, we report the results we obtained on an expedition aboard the Russian oceanographic vessel Akademik Mstislav Keldysh to hydrothermal vent sites in the Pacific Ocean using our life detection instrument MCDUVE, a **m**ulti**c**hannel, **d**eep **u**ltraviolet **e**xcitation fluorescence detector. MCDUVE detected organic material distribution on rocks near the vent, as well as direct detection of organisms, both microbial and microscopic. We also were able to detect organic material issuing directly from vent chimneys, measure the organic signature of the water column as we ascended, and passively observe the emission of light directly from some vents.

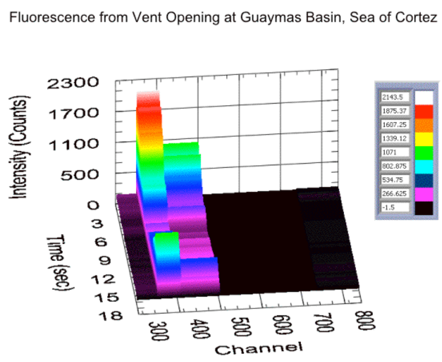
MCDUVE approximately 10 cm from the smoker

The Instrument: MCDUVE uses a deep ultraviolet hollow cathode laser (224.3 nm) to stimulate fluorescence in organic molecules (laser induced native fluorescence, or LINF). Actually, this particular instrument can be used to detect not only fluorescence, but luminescence or phosphorescence as well. Photomultiplier tubes detect wavelength bands determined by optical filters that are approximately 50 nm wide. We used optical bands ranging from the deep UV to the near infrared. Mineral fluorescence that would confound the organic fluorescence is typically not stimulated by the short excitation wavelength; in the rare cases where this might occur, mineral fluorescence photons are of a different wavelength than those associated with organic fluorescence. Thus, one can sweep over minerals, making multiple measurements, and organic molecules will stand out from the mineral matrix by virtue of their fluorescence behavior. A 100 microsecond laser pulse and collection exposure is adequate for detection of fluorescence from only 1000 molecules of tyrosine at a distance of 3 cm. Longer working distance can be accomplished by averaging tens to thousands of measurements.

The Deep Sea Deployment: MCDUVE was protected by a titanium pressure housing including separate front-end dome with UV transparent quartz windows and a rear end plate for electrical access by a Birns pressure-compensated cable. All components were certified to depths of around 9000 meters. The instrument was deployed on the front manipulator arm of the Russian submersible MIR1 and controlled via a laptop computer through the pressure-compensated cable and powered by the MIR's battery power.

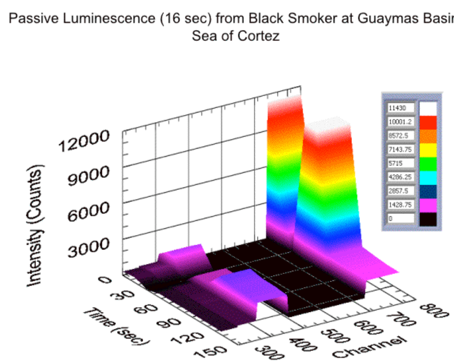
The instrument was held in a position with the manipulator folded in to the front end of the sub during descent, then extended toward the targets of interest. Measurements were typically made from 3 cm to 50 cm from targets. Longer working distances required several laser pulses per data set to achieve sensitivities comparable to the 3 cm working distance.

Results: MCDUVE was deployed at hydrothermal vent sites at the East Pacific Rise (21 degrees N) and in Guaymas Basin, Sea of Cortez. It was clearly able to distinguish organic molecules issuing directly from the vents as determined by fluorescence detection in wavelength bands centered at 293 nm and 337 nm. These bands correspond to fluorophores that have single and double ring structures such as tyrosine or phenylalanine (band 1) and tryptophan or elastin (band 2) [1]. When the instrument was pointed away from the vent opening, even by a few cm, the fluorescence was not observed:



Fluorescence detection of organics from a vent

MCDUVE was also able to detect the organic signature of microbial mats blanketing rocks nearby the vent chimneys, while showing a negative result when probing adjacent rocks without biofilms. Light emissions were detected by MCDUVE in passive luminescence mode from one chimney at 21N on the East Pacific Rise and at least one chimney at Guaymas Basin:



Luminescence from a Guaymas Chimney

We hypothesize this emanation to be caused by Cerenkov radiation, possibly from radon gas released from the vent.

Summary: The MCDUVE observations are astrobiologically important for three reasons. First, the detection of organic material emanating directly from a chimney could be an in situ confirmation of the laboratory synthesis experiments of Brandes et al [2] wherein organic molecules were synthesized in hydrothermal vent conditions with respect to P, T.

Secondly we have demonstrated that potential energy sources (photons) could be detected in situ in a deep marine environment by the passive luminescence experiment. This is an experiment one could propose for subaqueous deployment on Europa.

Finally, we have demonstrated the utility of a non-destructive life detection instrument in a challenging, marine high-pressure environment, corroborating the organic biosignature results we are obtaining with a terrestrial version of MCDUVE in desert environments. This optical instrument is non-invasive and sensitive, has low mass, power and volume requirements, makes rapid measurements, and is capable of non-contact organic detection in planetary samples *in situ* before they are touched or prepared for study by crushing or powdering.

References: Use the brief numbered style common in many abstracts, e.g., [1], [2], etc. References should then appear in numerical order in the reference list, and should use the following abbreviated style:

[1] Lakowicz, J. (1999) *Principles of Flourescence Spectroscopy* 2nd. Ed. Kulwer Academic/Plenum Publishers NY, NY.

[2] Brandes, J.A., G.D. Cody, R.M. Hazen and H.S. Yoder, Jr. (2001). *Astrobiology* 1(3):298.