Project 600045
Laser Raman Spectrometer for Deep-Sea Studies

The project will hold a requirements review, PDR and CDR. At the PDR a preliminary test plan will be presented. At the CDR a detailed test plan will be presented.

The requirements review will be held during the first quarter, the PDR will be held during the second quarter, and the CDR will be held during the third quarter.

The project will ensure that the requirements of other potential users for the xyz positioning system are clearly identified and documented, prior to start of design work on the xyz positioning system. The requirements review will be the vehicle for insuring that this function is satisfied.

Project Manager: George Malby

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1) Abstract

This proposal is for the continuation of the efforts started on the year 2000 Laser Raman Spectrometer project under which the components of the spectrometer were defined and a purchase order placed with Kaiser Optical Systems for the acquisition of the basic spectrometer. Delivery from Kaiser of the basic spectrometer will occur the second week of August, 2000 and the spectrometer will then be packaged for deployment in the deep sea. A laboratory demonstration of a fully working spectrometer will be performed by the end of the year 2000. Year 2001 efforts will consist of the continuation of the engineering integration and test tasks for the spectrometer. Design and implementation of a "through the lens" visualization system and a design of an optical head precision positioning capability, both of which are need in order to make the instrument usable *in-situ,* will be completed. Integration with the Tiburon ROV and demonstration of in water operability of the spectrometer will be carried out. Scientific "methods development" for use of the instrument will take place and an initial set of protocols for validation of the *in-situ* scientific use of the spectrometer will be documented. The design of a sediment insertion probe for determining pore water geochemical signals will be initiated. Since this instrument will be used by the science community and deployed and operated by Marine Ops personnel, all aspects of the capabilities, design, configuration and operation of the spectrometer will be coordinated with those groups.

2) Proposal

a) The problem addressed

There is a very strong need within the scientific community to be able to determine the molecular composition of various samples *in-situ.* When samples are removed from their natural environment (especially the deep ocean) for analysis in the laboratory, they often undergo significant changes and no longer are - or possess the characteristics of the original material being sampled. Raman spectroscopy is capable of generating spectrograms for both organic and inorganic molecules (and in fact isomers of the same molecule) for solids, liquids and gasses . The Raman effect is based on observing the scattering caused by the interaction of incident light with the discrete interatomic vibrational states allowed by quantum physics. Spectrograms obtained are unique to and characteristic of the molecular species being illuminated thereby allowing the identification of the individual molecular species that are contained within a sample volume. The Raman technique does not normally require sample preparation and is nondestructive. It therefore also allows the

kinematics of a reaction to be observed undisturbed. Raman spectroscopy is however a relatively newly available analysis technique that is now advancing quickly because the technology to implement it is now becoming available (sharp cutoff optical filters, high resolution gratings, high sensitivity CCD cameras, stable narrow bandwidth lasers, etc.). This project will put MBARI in the forefront of the use and deployment of this measurement modality in addition to giving the MBARI's science community a very powerful analytical tool.

Within MBARI, three initial deep sea research goals have been set:

1. *In situ* analysis of CO2 and CH4 hydrates will be performed.
2. *In situ* analysis of microbial mats will be performed.
3. Detection of the SO4 gradient in pore waters will be performed.

b) Approach to the problems

As stated above, the elements of the spectrometer have been purchased from Kaiser Optical Systems. MBARI is in the process of designing and fabricating the pressure vessel(s) in which the spectrometer will be installed. The vessel in which the CCD camera will be installed will include a small liquid/liquid heat exchanger in order to cool the camera for maximum sensitivity.

The major year 2001 new/continuing efforts will consist of:

1. Integrating/installing the spectrometer into the pressure vessel(s)
2. Coding and debugging the new communications interface software for the ethernet spectrometer to Tiburon FO com link.
3. Augmenting the current NMR/Tiburon interface unit (IFU) to accommodate integration of the Raman spectrometer with the Tiburon - primarily by adding a FO to ethernet Rx/Tx unit in the IFU.
4. Integrating the packaged spectrometer with the Tiburon/Western Flyer including demonstrating operability with sea trials.
5. Design, fabrication, test and integration a "through the lens" white light video visualization system. This capability is necessary in order to confirm what sample surface/volume is being measured. White light illumination is necessary because the use of the already existing monochromatic laser illumination will create images consisting largely of

fringe patterns which are very hard to interpret when looking at a video monitor.

6. Design/acquire a precision remotely controllable xyz positioner for use with the spectrometer optical probe head. The spectrometer measurement field of view depends on the relay optics used and will ultimately be adjusted on a pre-use mission specific basis. It will generally be on the order of 1 mm or less and will therefore require an "off vehicle", but ROV deployable, independent free standing structure with a remotely controllable xyz positioning capability. It is intended that this positioner be "generic" in it's design so that it can for example support the needs of C. Sakamoto for micro profiling and K. Buck for microscope positioning. It is expected that this capability will largely be satisfiable with a purchased unit therefore requiring the expenditure of little personnel resources.

7. Since Raman spectroscopy is a relatively new measurement technique, large libraries of spectrograms current do not exist. The "methods development" tasks will therefore consist of acquiring and/or measuring the spectra for the molecular species of interest to the MBARI science community. In addition, MBARI analysis techniques for interpreting the spectra of multi molecular compounds will be developed (in conjunction with outside collaborators).

8. It is anticipated that the spectrometer will be ready by the fourth quarter of 2001 to support a demonstration of capability during the CO2 experiments to be carried out during the Hawaii cruise. The necessary protocols to support this activity will be developed and the necessary "on site" support provided.

9. The design of an optical probe head capable of being inserted into sediments for pore water geochemical analysis will be completed. It is anticipated that the actual acquisition of this probe head will occur in year 2002.

c) Specific deliverables

1. A completely packaged and functional Raman spectrometer will be delivered.
2. The spectrometer will be integrated with the Tiburon/Western Flyer and be verified to be operational in that environment.
3. The "white light" visualization capability will be implemented.
4. The precision xyz positioner will be designed and acquired.
5. The design and operation of the spectrometer will be documented.
6. The spectra of interest to the MBARI science community and spectra interpretation analysis techniques will be acquired.
7. All of the tasks necessary to support the use of the spectrometer for use during the Hawaii CO2 experiments will provided.

c) Project team

Science related tasks - Dr Peter Brewer, PI, Dr Ed Peltzer, Kurt Buck, and Dr Gregor Rehder

Engineering related tasks - George Malby, project lead, EE design, and system integration - Danelle Cline, SE design integration and test - Jon Erickson, mechanical design and packaging

Tiburon related tasks - Dale Graves and associates

Operations related tasks - Steve Etchemendy and associates

The inevitable overhead burden people

3) Budget

See attached detail budget sheets

4) Milestones

1. Stand alone integration of spectrometer - completed by 3/30/00
2. EE Bench testing of spectrometer - completed by 6/29/00

3. Spectra and analysis tools acquisition and familiarization - complete by 9/28/00
4. Hawaii ops - complete by 11/30/00
5. Visualization capability - complete by 12/14/00
6. Documentation - complete by 12/21/00

5) Curriculum Vitae

See attached CVs