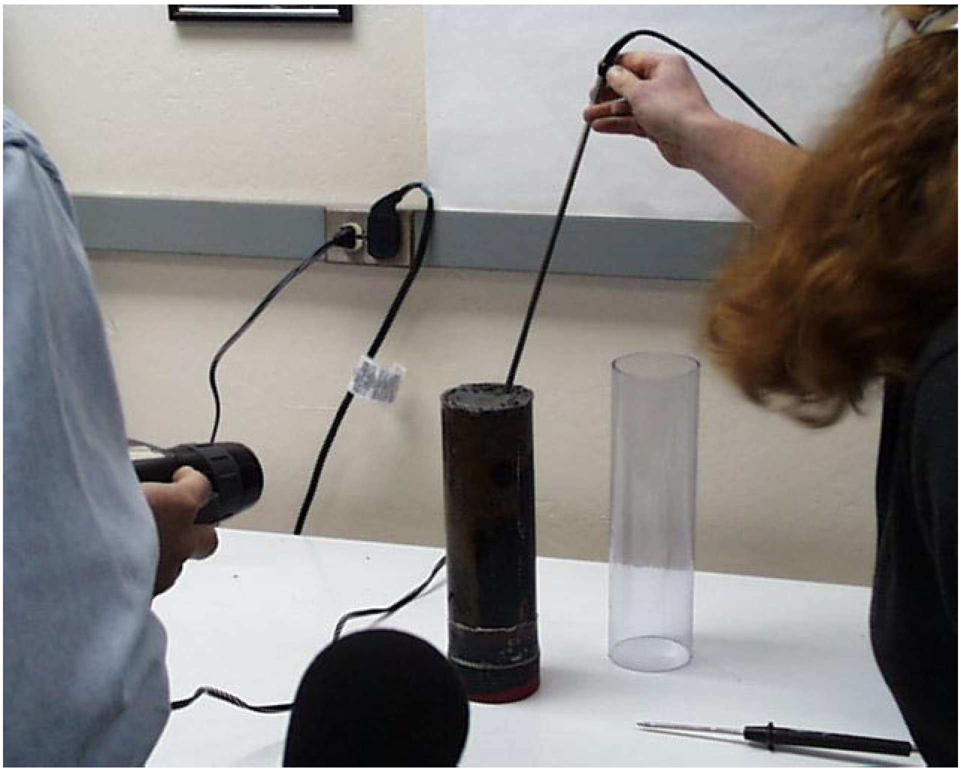
SCIMP APPENDIX 00-1-8

Gas Hydrate PPG (draft) Report:

“Distinct variations in temperature are commonly observed in freshly recovered core samples from gas rich sediments.”

“These variations are believed to be due to both endothermic gas hydrate decomposition and gas expansion, and thus represent fundamental information about the presence and distribution of gas and gas hydrate within cores.”

“Equipment to collect these data (such as an infrared thermoscanner) needs to be available on the drillship for both fortuitous encounters with gas hydrates and to use in a routine way on gas hydrate-dedicated legs.”



Using the draft recommendations expressed in the upcoming Gas Hydrate PPG Report as a guide, Frank Rack explored the readily-available options for IR camera systems using the following criteria:

- commercial, off-the-shelf (COTS) system
- demonstrated capability to make the required measurements
- evaluate the cost versus benefits based on science needs and goals relative to instrument configurations.

A web search was conducted, which resulted in the identification of several companies who market systems of this type. These were:

- FLIR Systems (Portland, OR); recently merged with both Inframetrics (Boston, MA); and Agema (Sweden) - sent brochures, arranged demo.

-Raytheon (Dallas, TX) - sent brochures, demo is possible.

Through discussions with Gas Hydrate PPG members and other interested scientists, primarily at the USGS (Woods Hole, Reston, and Menlo Park labs), Rack arranged a demonstration of two FLIR Systems IR cameras at the USGS lab of Laura Stern in Menlo Park during the Fall AGU meeting (December 17, 1999) with about 12 people attending. Future demonstrations are possible.

A representative of FLIR Systems demonstrated two Infrared Camera systems to a group of about 12 people at the USGS Menlo Park lab of Laura Stern.

1.) Inframetrics Short Wavelength IR camera (3-5 micron wavelength range), Thermal sensitivity = 0.07 deg C; temperature range = -20 to 350 deg C; uses a Sterling cycle cooler (He closed system); Platinum Silicide detector; Germanium lens; 30G shock rating; sealed housing.

2.) Agema Long Wavelength IR camera (7-13 micron wavelength range). Thermal sensitivity = 0.1 deg C; temperature range = -40 to 450 deg C; uncooled; microbolometer; Platinum Silicide detector; Germanium lens; 35G shock rating; sealed housing.

Both cameras have been operated at sea (US Navy).

The images can be acquired in Frame-by-Frame or Video mode of operation. The image formats include: .img (semi-proprietary bitmap format); TIFF (for frame-by-frame); and video (real time image analysis at 60 Hz).

In this image, the camera is looking at two sections of core liner - one is filled with sediment and is cold (blue) having just been removed from the refrigerator; while the other section of core liner is empty (filled with air) and therefore can not be readily seen on the monitor which is showing the IR camera output.

What was noted by the operator at the outset of the laboratory demonstration was that the plastic core liner was opaque to the IR camera system.

Therefore, these images are only “seeing” the surface of the core line “skin temperature” and are not penetrating through the plastic liner to the interior.

To test the conduction of heat to the surface of the core liner, Charlie Paull placed his fingers briefly on the interior surface of the empty core liner and we were able to watch the heat from his fingers be conducted to the outer core liner surface (red blotches in this image).

This image shows the two core liner sections (one filled with cold sediment, and one filled with warm air) placed on top of each other. The difference between the cold (lower) and warm (upper) core liners is clearly indicated.

An ice cube is sitting on top of the sediment, within the empty core liner in this picture. It appears that the IR camera may able to “see” the ice cube in this image, although the camera operator maintains that this is not the case. Further experiments are needed to determine whether a filter can be designed to render the liner transparent in the infrared range of the detector array of the camera.

Two cross-hairs can also be seen in the image. These marks can be used to acquire temperature readings at these two points in the image and to do a difference calculation using the imaging software.

The “Ice-Cube Test”

The most dramatic and effective test conducted during the demonstration was the “ice-cube test”, where an ice-cube was removed from the freezer and pushed into the interior of the (cold) sediment core within the core liner.

The following images show the evolution of a temperature anomaly on the surface of the core liner over time. Please note the time on the clock in the upper left hand corner of each of the following images. The core material is fine-grained mud contained within the plastic core liner.

The temperature anomaly at the surface is expressed within a few minutes. The ice cube is expressed as a darker blue (colder temperature) initially. As the cold anomaly associated with the ice cube expands, the rest of the core becomes more red in color as the image temperature map is re-calibrated by the camera system.

This is an image of the temperature anomaly caused by the ice cubs at about one minute after inserting the ice cube into the sediment.

This image shows the full expression of the temperature anomaly related to the ice cube contained in the sediment within the core liner.

Additional testing was conducted using methane hydrate samples that were manufactured in the lab and stored in liquid nitrogen.

The sample shown in this image has alternating layers of black sand and white methane hydrate. The difficulty with these tests was the fact that the hydrate samples were significantly colder than the range of the camera detector array. Even after waiting 15-20 minutes for the hydrate to warm up, the sample had not significantly warmed to the detection range of the camera.

Given enough time, the differences between the individual layers of hydrate and sediment began to appear in the camera images, but they are not reproduced very well in the two images that follow.

The inter-layered methane hydrate and sediment sample is contained in a teflon sheath that has been split longitudinally. Careful inspection of this image shows the blue (cold) sample and the edges of the teflon liner near the upper and lower surface of the blue interval. The inter-layering is not evident in this image due both to the uniform cold characteristics of this sample, which has just been removed from the liquid nitrogen bath, and the fact that these cold temperatures are beyond the range of the IR camera detector array limits.

The sample is beginning to warm up a bit and some subtle temperature anomalies between the inter-layers are beginning to appear. A blow-dryer was used to warm up the sample slightly, so the surrounding area is shown as being warm (red), while the hydrate sample is still dominantly cold (blue).

The path forward (proposed):

1.) Develop/refine test parameters to better understand the performance characteristics of this technology and to better understand the scientific return obtained from these measurements. Test - Evaluate - Test ….

2.) Determine the optimum way that this tool could be used on the drill ship without disrupting the core flow, as well as determining how the data would be used by scientists (e.g., quick look to guide sampling; stratigraphic mapping of temperature linked to a depth measurement along the core). It will also be important to specify how the camera would be used (e.g., capture individual frames; continuous video output; track mounted; cart mounted, etc.)

3.) Finally, if a field test is recommended, there should be a proponent identified to organize this process and report on the results of the testing.