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POSTER ABSTRACTS

ROV-Serviceable, Submarine Cable-Connected Wellheads for IODP Borehole Observatories

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ABSTRACT

A new wellhead design that is easily ROV/HOV serviceable has been developed for installation at IODP borehole observatories. The original impetus for this development was the need for an ROV-serviceable, submarine cable-connected wellhead design for the Monterey Bay Borehole Observatory IODP drilling expedition once scheduled for late 2005. This expedition was removed from the active schedule because of permitting issues, but the design has been completed.

The evolution of cased holes that could be re-entered started during the Deep Sea Drilling Project (DSDP) with the initial objective of replacing drill bits and reentering the existing hole to achieve greater total depth. This was achieved with the installation of seafloor reentry cones with casing extending down into the borehole. However, over the next decade the potential of using cased legacy holes for subsurface monitoring was realized and has been increasingly utilized by either CORK or seismometer installations. Modifications to the initial designs of the reentry structures were incremental, and ROV/HOV servicing of borehole monitoring experiments was achieved by placing a metal platform on top of the reentry cone to provide a place for the ROV/HOV to land. One result of this configuration is that the monitoring equipment rises several meters above the reentry cone into the water column. Because most previous Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP) observatory installations have been in remote deepwater locations, this exposure of the monitoring equipment and the upper part of the borehole CORK body or instrument hangers has not been a major design consideration. However, several developments are occurring that require a substantial redesign of the current seafloor expression of the reentry cone and completion equipment. First, drilling operations involving cased reentry structures are increasingly being proposed for shallower water depths (<2 km) on continental margins. Second, the increasingly sophisticated observatory deployments and experiments conducted during the IODP will increase the dependence on ROV/HOVs to service these facilities. Finally, there is the intention to be able to connect instruments on the seafloor to submarine cables. To ensure the long-term viability and science return of these observatories, newly designed wellheads will be deployed that are intended to protect the scientific instrument, facilitate servicing by ROV/HOV, and able to accommodate seafloor cable connections.

The surface expression of the new wellhead design is a radical departure from traditional re-entry cone designs used by the ODP and IODP. However, the design dimensions of the mud skirt have not changed, nor has the interface with the Drill Quip casing hanger

assemblies been modified. The mud skirt has been modified to accept modular assemblies, which includes a substantially smaller re-entry cone module, which are indexed and bolted onto the mud skirt.

Highlights of the design changes include:

- A shape that is trawl-resistant, limiting liability.
- A modular design that allows reconfiguration by an ROV or HOV.
- A re-entry cone that has been reduced from 8-ft vertical height to a 3-ft height and integrated into a removable central module.
- A re-entry cone module that can be removed and replaced by an ROV or HOV.
- Side modules adjacent to the central re-entry cone module that form a shock absorbing structure that is designed to withstand and deflect drillpipe hits.
- ROV-serviceable science and submarine-cable communications modules that replace the drilling modules after borehole completion.
- A wellhead designed to accept an ROV-serviceable mini-packer for sealing the well opening.
- ROV-serviceable fluid and electrical connections to a casing manifold.
- A non-corrosive ROV hot stab for making downhole fluid connections.

These designs are available for implementation on future IODP borehole observatories and will be posted on an IODP website in the near future.

Data Report: Long-term Temperature Measurements in Holes 1253A and 1255A off Costa Rica, ODP Leg 205

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ABSTRACT

Long-term temperature measurements using miniaturized temperature loggers (MTLs) were performed in Ocean Drilling Program Holes 1253A and 1255A across the Middle America Trench off the Nicoya Peninsula, Costa Rica. All three recovered loggers, which were retrieved fully functional, provided high-resolution temperature records. These records cover a time span of ~2 yr and were sampled at an interval of 17 min. There are a number of signals in the temperature data that are most likely caused by hydrologic events. These events are also present in the pressure data recorded by CORK-IIs that are installed in these boreholes. Moreover, the temperature data are important input parameters for calculating pumping rates of the OsmoSamplers, within which the MTLs were integrated. Therefore, the MTL temperature records combined with the CORK-II pressure measurements and the data from the OsmoSampler fluid samples allow the investigation of subduction zone hydrologic processes.

Measuring Temporal Variability in Pore-Fluid Chemistry Within Gulf of Mexico Hydrate-Bearing Sediments

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ABSTRACT

Hydrate formation and decomposition events may result in temporal changes of methane, chloride, and sulfate concentrations dissolved within pore-fluids. To follow such changes and collect pore-fluids over time, we designed a specialized Pore-Fluid Array (PFA) made up of an interchangeable instrument package that houses four individual OsmoSamplers (Jannasch et al., 2004), a connector that allows the instrument package to be changed out while minimizing sample disruption, and a 10-meter long probe tip along which 8-filtered ports are evenly spaced. At each port, pore-fluids are slowly pumped up the probe tip, across the connector, and into long length of small-diameter tubing coil using OsmoSampler technology to collect ~4 months data with week resolution. Two of the four samplers were plumbed into a high-pressure valve that, when closed on the seafloor, kept the sample from degassing upon ascent through the water column. In May 2005, the PFA was deployed at a cold seep site in Mississippi Canyon lease block 118 (MC 118), Gulf of Mexico, on the northern edge of a bright acoustic seafloor anomaly known to have outcropping hydrate. After 1.5 years, the PFA's instrument package was successfully recovered and the individual OsmoSamplers were found to be collecting from the overlying water, 1.2 m, 3.2 m, and 8.5 m below the seafloor. From the sampler coils, pore-fluids were extracted and measured for chloride, sulfate, and methane concentrations and methane isotope ratios. The overall results showed normal seawater conditions in the bottom waters, averaging 549 mM chloride and 30 mM sulfate. At deeper depths, there was evidence for brine fluids, averaging 4561 mM chloride and 0.7 mM sulfate. Since brine inhibits hydrate formation, the discovery of brine radically changes the hydrate stability zone. At deeper depths, high methane concentrations were also measured, averaging 4.2 mM with a maximum of 14 mM, whose $\delta^{13}C\text{-}CH_4$ averaged -32.35±3.4‰, suggesting a mixed biogenic and thermogenic source. Over the 4 month collection, temporal variations in methane concentrations and isotopic ratios suggest this mixed source methane is accompanied by spikes of purely thermogenic fluid. Although hydrate formation and decomposition events were not evident in this deployment due to the presence of the brine, the PFA is a valuable instrument needed to follow hydrate formation and decomposition over time.

Catastrophic Seepage and Hydrate Climate Impact

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ABSTRACT

The emission of methane that is trapped in deep-sea methane hydrates has been postulated to explain abrupt climate change; however, dissolution to the water column presents a sever obstacle to its effect on the atmosphere. We present quantitative observations of methane emissions from a blowout from a shallow (22 m) hydrocarbon seep. Emissions were determined from atmospheric plume measurements. Observations for the blowout and for non-blowout seepage were used to validate a bubble propagation model. Simulations suggest a 1.1% gas loss to dissolution compared to ~10% loss for a typical low-flux bubble plume for this shallow blowout. Transport to the atmosphere largely was enhanced by the rapid upwelling flows induced by the massive discharge. Model simulations for deeper blowouts suggest that similar size blow-outs within the hydrate stability zone could allow a significant fraction of the emitted methane to atmospheric methane budgets.

Passive and Active Vector Acoustic Observatories for Monitoring and Imaging of Hydrate Deposits

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ABSTRACT

Using newly developed vector acoustic sensors we can locate sound sources in three dimensions using a very small number of sensors. When we employ a pulsed sound generator, we can generate 3D images of multiple, discrete, scattering targets with a single, fixed vector acoustic sensor. We demonstrated this concept in a scaled water tank experiment. Vector acoustic observatories could be deployed next to a borehole in hydrate regions that have associated fluid flow. These passive observatories could monitor not just the level of activity but map the location in 3D of the sound-generating fluid flow. They would be anchored on the bottom and floating in the water column. The vector sensor in the water retains near ideal coupling with the particle motion in the water unlike bottom mounted geophones or even down-hole geophones. The high-fidelity coupling allows for more reliable and accurate directional sensing. The addition of active sound sources, surface towed, bottom or down-hole mounted, would enable one to image the hydrate deposits. A water-column towed source would enable one to survey the general region. A bottom mounted or borehole mounted seismic source would generate shear waves as well as compressional waves. Shear waves should scatter more strongly than comperssional waves off of hydrate deposits and may allow for differentiation of gas and solid hydrates. Near-borehole observatories would be a valuable addition to down-hole sensors for short term imaging of local geological structures as well as long term monitoring of fluid flow activity. This work was supported by the Office of Naval Research, program element 61153N.

Using Ambient Noise to Image the Interior of a Carbonate/Hydrate Mound

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ABSTRACT

A sea-floor observatory is being installed in Mississippi Canyon Lease Block 118 (MC118) by the Gulf of Mexico Hydrates Research Consortium. MC118 is located about 100km southwest of the mouth of the Mississippi River. The sea floor there is within the hydrate stability zone. The observatory will use ambient seismo-acoustic noise to monitor physical changes within a carbonate/hydrate mound over five-to-ten years.

The block has been surveyed by an AUV equipped with a swath fathometer. An oblique view of the resulting bathymetric image is shown. The sea floor is seen to be smooth except for a canyon that cuts across the northeast corner of the block and a region of irregular bathymetry in its south-central portion. The irregular bathymetry shows the kilometer-wide carbonate/hydrate mound to be monitored is at about 900m depth.

The observatory includes six line arrays of seismo-acoustic sensors: a vertical water-column array, four horizontal sea-floor arrays cross configuration and a vertical array in a borehole. At first these arrays will be used with artificial sources at known locations to generate a model of the mound’s interior. Later, they will operate in a passive listening mode to record ambient noise, i.e. passing ships, wind and waves at the water surface, microseisms, etc.

The impulse response of each propagation path between pairs of sensors can be determined by processing ambient signals from all possible sensor pairs. Doing this over a period of time long enough to include noise sources that are distributed more-or-less uniformly around the mound will allow a tomographic image of the interior of the mound to be generated. Doing this over a much longer period of time will generate a sequence of images that reveal any internal changes that may occur. Examples in recent literature demonstrate that this method, known as seismic interferometry, is extremely sensitive to small changes in the medium of propagation.

Why and How Hydrates Fill Fractures in Soft Sediments

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ABSTRACT

The Gulf of Mexico Hydrate Research Consortium has postulated that gas hydrate occurs in fine-grained sediments by filling fracture porosity. That was confirmed recently when fracture-filling hydrate was observed on x-ray images of fine-grained cores recovered under *in-situ* pressure. Laboratory experiments sponsored by the Consortium reveal why the fracture filling occurs. Those experiments show that biosurfactants produced by the microbe *Bacillus subtilis* catalyze hydrate formation, increasing its rate by orders of magnitude and decreasing the length of time prior to its onset. The experiments also show that biosurfactants promote hydrate nucleation on particles of smectite clay but not on kaolinite clay particles or quartz sand grains.

These findings have particular relevance in the northern Gulf of Mexico where smectite is a significant fraction of the fine-grained hemipelagic material that covers much of the sea floor. The material occurs in the water column as “marine snow” and is deposited on the sea floor as a gel. Soon after deposition, the gel develops a state of internal tension that produces a system of interconnected extensional fractures. Smectite is exposed along the walls of the fractures where it provides nucleation sites when conditions are favorable for hydrate formation.

Evidence is presented that it is possible, perhaps even probable, that a system of extensional faults exists within portions of MC798. If so, it could provide fracture porosity that would facilitate circulation of fluids past smectite particles lining the fracture walls. If the fluids contain water and hydrocarbon gas, hydrates would form within the fractures. Convincing evidence for this would be a horizontal slice through a 3-D volume that confirms that extensional faults intersect in a polygonal pattern. It has been demonstrated that such suitably high-resolution 3-D volume can be obtained using an AUV.

Borehole Monitoring of Gas Hydrates for Future Drilling Well

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ABSTRACT

One of the goals of setting gas-hydrate observatories should be served for drilling well of the future gas hydrate exploitation.

Gas Hydrate Drilling Problems

The environment of drilling is very poor because gas hydrate deposits exist mostly in the permafrost and deep ocean zones. Besides, the formations containing gas hydrates are weak and friable and the hydrates are very unstable. These factors cause the complicated drilling problems (Fig 1). Sampling difficulty, borehole instability such as collapse and enlarged hole, kick and even blowout are main challenges. To realize controlled and safe drilling, some measures should be taken to confront the challenges. Detecting gas hydrates prior to drilling is a good method so that hydrate-bearing sediments can be avoided or safely managed where avoidance is not feasible or necessary. In addition, proper drilling fluids which have the right density and low temperature and penetration rate are also available means to prevent gas hydrates from dissociating largely.(Ning Fulong,2005). However, if we want to carry out these measurements successfully, we must character the gas hydrates and its bearing formations in situ. Therefore, some properties and their changes need monitoring in the gas-hydrate observatories.

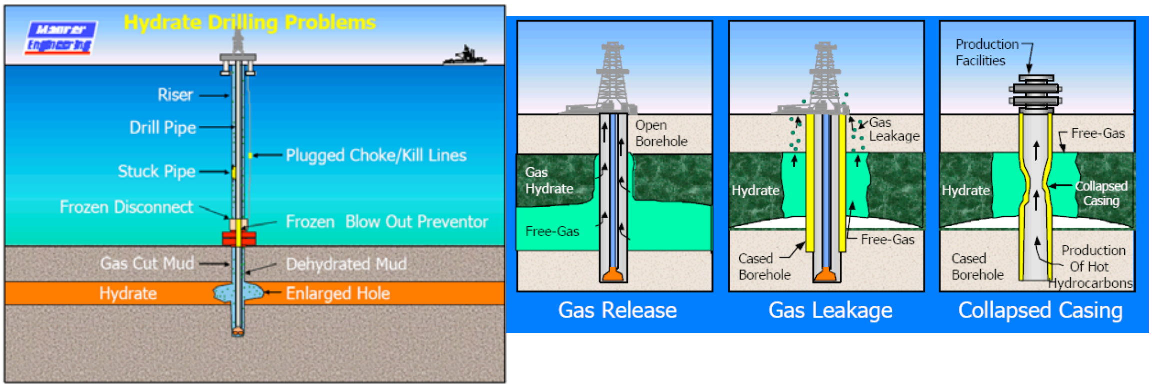

Fig.1 The problems of gas hydrate drilling

Main properties which should be monitored by gas-hydrate observatories from the viewpoint of drilling

Obviously temperature and pressure in situ should be monitored and recorded firstly, the same with other goals. In order to detect gas hydrates prior to drilling, acoustic, resistive or electromagnetic properties and distribution model of gas hydrates bearing formations need to be acquired, such parameters should be observed as density, acoustic velocity, resistivity and frequency etc. To study the borehole stability and safety, it also needs to obtain the physical and mechanics properties such as saturation of gas hydrate in sediments, porous water pressure, porosity, permeability etc. Besides, the gas component and pore water salinity are also needed and should be considered.

How to observe these parameters

The University of Mississippi carried out the Gulf of Mexico Gas Hydrates Seafloor Observatory Project with the support of DOE (Fig 2). Texas A&M University observed the hydrate mound of the GOM slope with the support of DOE-NETL, NSF, NOAA and etc. However, the two observations are both in the sea floor but not in the borehole. In ODP and IODP, CORK and ACORK are borehole observatories and can monitor the thermal and pressure characterization, allow studying the hydrological, chemical, microbiological, and thermal regimes, as well as hydrologic responses to seismic ground motion, tides, and barometric loading. Hence, while considering the geomechanical stability of hydrate-bearing sediments, referring to the experience of MWD and LWD in oil&gas drilling, it may be a feasible way to monitor those parameters through improving ACORK in the borehole. Our idea about gas-hydrate observatory is illustrated as Fig. 3.The key difficulties or problems we think are selection of parameters observed, sensors integration and data transmission.

Fig.2 Gulf of Mexico Gas Hydrates Seafloor Observatory

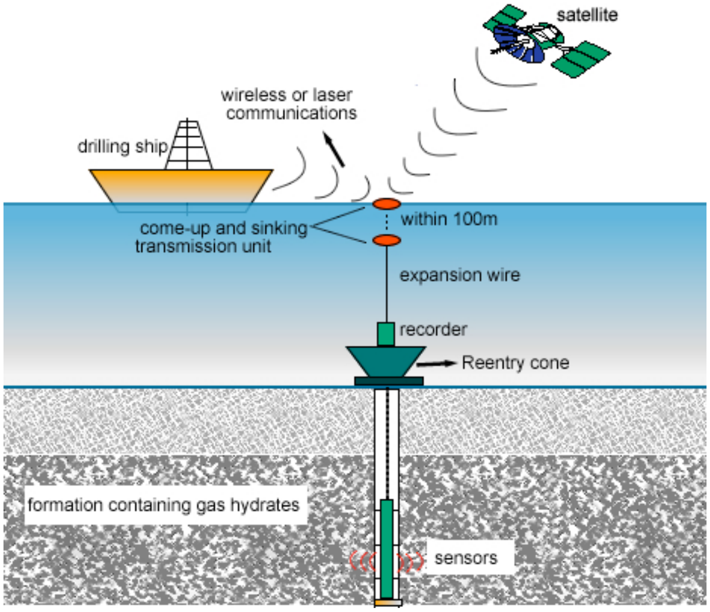

Fig.3 The schematic diagram of gas-hydrate Observatory

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http://www.oceandrilling.org

Making the Case for In Situ Characterization of Gas Hydrate-Bearing Sediments at Observatories: Laboratory and Catwalk Results Testing the Impact of Core Retrieval

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ABSTRACT

A major motivation for gas hydrate observatories is the need to characterize gas hydrate reservoirs under *in situ* conditions. Results obtained at Georgia Tech since 2002 provide two key classes of results (laboratory experiments on natural and synthetic cores and catwalk measurements on pressure cores) that underscore the need for in situ characterization of hydrate-bearing sediments, either in an observatory setting or during/just after drilling:

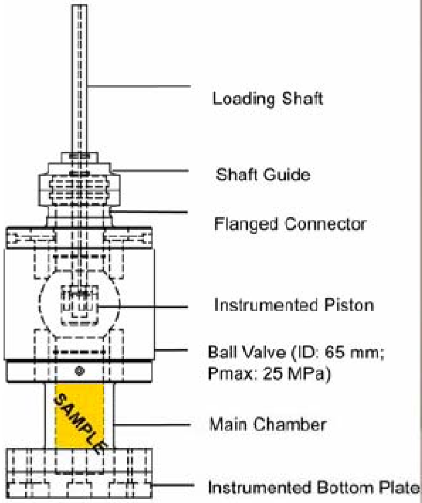
1. ***Laboratory experiments*** to measure the mechanical, seismic, and electrical properties of sand, silts (precipitated and crushed), and clay subjected to different confining pressures and containing well-controlled concentrations of THF hydrate (from 0% to 100% of pore space) formed from the dissolved phase demonstrate clear changes in the properties of hydrate-bearing sediments during unloading and during phase transformation (Yun et al., 2005, 2007; Lee, 2007). Similar experiments were conducted on natural Gulf of Mexico sediments in which we formed synthetic gas hydrate with THF (Lee et al., in review). Recently, we demonstrated that THF and methane interact with sediments and pore fluids in a similar way and that THF hydrate is an apt analog for methane hydrate for mechanical experiments (Lee et al., 2007).

Our results on synthetic and natural cores containing synthetic hydrates show that laboratory recovery of the in situ physical properties of hydrate-bearing sediments are best when the sediment fabric experiences the least disruption during coring and the subsequent retrieval/hydrate phase transformation process (Lee et al., in review). The best prospect for sampling hydrate-bearing sediments and measuring laboratory properties that are representative of the in situ characteristics is to obtain cores subject to low in situ vertical effective stress (so that expansion due to stress relaxation is low) and with high hydrate concentration (probably >50%) using thin-wall samplers that cause only minimal strains during sampling. Restoring vertical effective stress on the core as quickly as possible after retrieval is also critical (Lee, 2007). Because most natural gas hydrate deposits do not occur at shallow depths (low vertical effective stress) or have gas hydrate concentrations >50% of pore space, it is generally advisable to study hydrate-bearing samples either in situ or using pressure core samples for which effective stress can be rapidly restored.

2. ***Catwalk measurements***. In 2005 and 2006, a special pressure chamber (Instrumented Pressure Testing Chamber or IPTC) developed at Georgia Tech was used to measure the physical properties of IODP-style pressure cores obtained in the Gulf of Mexico (GoMex) as part of the DOE-Chevron Joint Industry Project and off India as part of the National Gas Hydrate Project. These "catwalk measurements" represented the first time that a suite of physical properties measurements was ever collected on pressure core material that had never been subjected to depressurization and that had been maintained at *in situ* hydrostatic pressure (Yun et al., 2006). The GoMex cores did not contain gas hydrate, while the Indian cores did. For the Indian project, the IPTC was also used to monitor changes in physical properties during depressurization of a hydrate-bearing core as part of a mini-production test.

A comparison of seismic velocities, undrained strength, and electrical properties measured on conventional cores, conventional cores that have been repressurized, and pressure cores that had never experienced depressurization demonstrates that the pressure cores yield seismic velocities closest to those determined in situ by downhole logging.

The first generation IPTC operated on full-length (~1 m) pressure cores at in situ hydrostatic pressures. The IPTC drilled through the core liner to access core material for various physical properties measurements (Yun et al., 2006). A second generation chamber has now been developed with JOI and JIP funding and is available for use in IODP programs. This chamber, shown below, accommodates a whole round section (up to 100-mm-long) that has been extracted from a pressure core by third party instrumentation. With the new chamber, we can restore vertical effective stress, while maintaining the hydrostatic pressure at in situ conditions at all times. The new chamber, which can accommodate pressure cores obtained with either the Fugro (FPC) or HYACINTH (HPC) pressure coring systems, is instrumented to measure P- and S-wave velocities, electrical conductivity, and undrained shear strength. This chamber is particularly convenient for small-scale production tests on the undisturbed specimens with simultaneous monitoring of critical mechanical (e.g., volume contraction, produced gas and liquid) and geophysical parameters (Vp, Vs, electrical conductivity and thermal characteristics). Future chambers can be modified for a range of physical and chemical property measurements, for chemical or biological sampling, or even for incubation experiments under in situ conditions, as discussed by Yun et al. (2006).



The new testing chamber developed at Georgia Tech with JOI and JIP support can measure the physical properties of a whole round (up to 100-mm-long) from an IODP (FPC or HPC) pressure core that has never been depressurized and can restore the in situ vertical effective stress, a critical factor in controlling the physical properties of hydrate-bearing sediments. Currently, third party instrumentation is used for subsampling of the pressure core to extract the whole round section and transfer of the core section through a series of ball valves into the Georgia Tech chamber.

Acknowledgments

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Methane Sensor Deployment for Deep-Sea Observations

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ABSTRACT

Two commercially available methane sensors (METS of Franatech GmbH and HydroC of Contros Systems GmbH, both companies located in Germany) have been deployed for recordings in different oceanic environments and deep-sea tectonic settings for over a decade without a real break through until recently.

Both instruments rely on a gas-selective permeable membrane to create a methane gas phase within a detection chamber. For the METS detection is through a semi-conductor with an active layer that absorbs methane. Absorption leads to an exchange reaction and thus a change in conductivity of the active layer generating an output signal. The reaction is temperature dependent. For the HydroC detection is by optical IR absorption that changes light intensity in generating an output signal. Both companies point to successful applications in off-shore pipeline inspections, exploration of oil and gas deposits, and water and waste water treatment. Detailed specification sheets for each of the sensors are available as well as pricing and other information. We report here on results obtained from two types of METS-sensor (K-series and METS-classic).

In the marine environment, applications have been plagued by great and variable water depth, low methane concentrations, slow response time, instrument drift and memory effects. We have experimented with the METS sensor for over a decade using different modes of deployment, e.g. sensors attached to CTD-casts, deep-tow instruments and most recently sensors attached to ocean bottom seismometers during seismic experiments. Although the output signal in all cases is significant and readily detectable, the conversion to methane concentration sometimes has not been easy using the manufacturer-supplied calibration equations.

Stationary deployment

Our best and most reliable results are derived from stationary deployment over several days at the seafloor with the sensors attached to OBS-units. Hereby ambient temperature and pressure are kept constant, greatly reducing most of the problems encountered with dynamic deployment. Positioning the sensor at water depths within the limits given by the manufacturers, generally not deeper than 2000 m, prevented any pressure related failures that have occurred in the case of deep-towed dynamic deployments exceeding 3000 m. Detectable concentration changes were generally <10 to >100 nM, in rare cases 2 nM of methane, as confirmed by discrete water sampling from CTD casts and subsequent gas stripping or head-space equilibration and gas chromatographic measurements.

The data from stationary deployment were obtained at active cold seeps (700-1200m) from the Hikurangi convergent margin off northern New Zealand during RV SONNE-cruises early in 2007. Results from three stations are discussed, 2 from active vent sites, about 9 km apart and recorded simultaneously for 3 days and 1 off-vent site station recorded for 2 days. Data show extreme dynamics in frequency and magnitude of methane emissions. Tidal control as well as spatial coherency, as previously detected by visual recordings between vent sites, is not immediately obvious, although final analysis has yet to be completed.

Dynamic deployment

Equally encouraging results were recorded during deep-towed search for hydrothermal venting along spreading segments of the Indian Ocean Ridge. Both types of METS-sensors were deployed with an array of turbidity-sensors attached to the conducting cable of a deep-towed vehicle. A self-contained package, consisting of a sensor and a CTD-unit for data storage and power supply, is positioned at pre-determined depth above the towed vehicle, usually between 250-350 m. As the vehicle follows the bottom morphology closely, the sensor depths vary and often exceed 3000 m when descending the ridge flanks causing instrument failure due to great hydrostatic pressure.

The strongest and most reliably calibrated methane signals were observed over the active hydrothermal vent fields EDMOND and KAIREI on the Central Indian Ridge during RV DAYANG YI HAO Cruises in late 2005 and early 2007, respectively. Over the EDMOND field a highly detailed plume structure and rapid sensor response was recorded while transiting the hydrothermal plume (DY-105-17A, Leg IR). However, since the temperature also changed during transit and up-cast of the instrument, the effect on the methane signal had to be corrected and hence calibration became uncertain (70±20 nM). Clearly though, the nature of the methane plume was ascertained and corroborated by simultaneously recorded turbidity anomalies. During a follow-up search for hydrothermal activity in early 2007 (DY-115-19, Leg 3) the same deep-towed set-up with a METS-classic sensor was deployed over the nearby KAIREI field. A clear methane plume was recorded here with maximum methane of 59.5 nM.

Previous successful dynamic deployment of METS was at an active vent site of the Hikurangi margin and recently published by Faure et al. 2006 (New Zealand J. Geol. and

Geophys. 49, 503-516). The data were obtained by sensors mounted to a CTD-optical backscatter device that was towed across an active cold seep mound. Methane background concentrations were between 2-4 nM and a plume maximum >8 nM was detected at the flank of the mound coinciding with the increased light scattering. The methane concentrations were verified by discrete CTD-sampling. A 20-minute delay between the METS-signal and CTD-derived methane content is attributed to the slow response time of the sensor. This observation appears to contradict the rapid sensor response observed with the recent models deployed at the Indian Ridge and mounted to the OBS-units, as described above.

The least convincing yet undisputable positive methane recordings were obtained from sensors attached to CTD-casts. Data of four casts obtained by RV SONNE in early 2007 are provided from another active vent site of the Hikurangi margin. Discrete water sampling and gas stripping for GC-detection shows a highly stratified methane plumes with 2 thin layers of maximum methane (>150 nM) around 800 and 1300 m of depth. The corresponding sensor records however show a single broad maximum over that depth whereby the minima are completely wiped out. Broadening of the maxima with little or now structure and suppressing of the minima appears clearly related to the temperature effect on the methane signal as the ambient water temperature changes from <4° to >7° C during up-cast over the methane-containing water strata.

Consideration for methane sensor deployment at ocean observatories

Maintaining an air space in the detector head requires that the membrane be supported to withstand high hydrostatic pressures. The METS K-series sensor provides such a pressure support for depth up to 3500 m, the HydoC-sensor for 4000 m. This feature is not required for their normal commercial use at ambient pressures or shallow ocean margins depths. Our results have shown that water depths of up to 2000m do not pose a problem; even at around 3000m recordings were still possible with METS K-series and classic models. Depending on the depth of planned gas hydrate observatory stations, there might be no limitation at all.

The calibrated and tested range of detection for commercial use (METS = 50 nM to 10 μM; HydroC = 100 nM to50 μM) is higher than what is expected for transient seafloor methane plumes (<10 nM). However, stationary plumes might easily reach high concentration near the seafloor and hence the calibrated versions might directly be deployable at gas hydrate observatory stations or other types of seafloor observatories.

An obstacle for the METS-sensor seems to be temperature variations encountered during dynamic deployment in ocean environments. These affect the conductivity of the active layer of the semi-conductor in the heated air-space and thus interfere with methane detection. The temperature of the heated space in the detector head must be accurately known in order to compensate the temperature effect during calibration. CONTROS claims no such limitation exist for the HydoC-sensor. To our knowledge this claim has not been tested. For METS the problem caused by temperature variations can be totally overcome by the stationary deployment as illustrated now for the first time by the OBS-mounted sensors. This deployment mode seems closest to that envisioned for gas hydrate observatories.

The successful deployments reported here from OBS-mounted METS-sensors were intended as tests for another important new application currently underway to complement passive seismic recordings for tsunami early warning systems. Fluctuations in methane emissions might be earthquake precursor signals and hence provide critical information of impending seismic events.