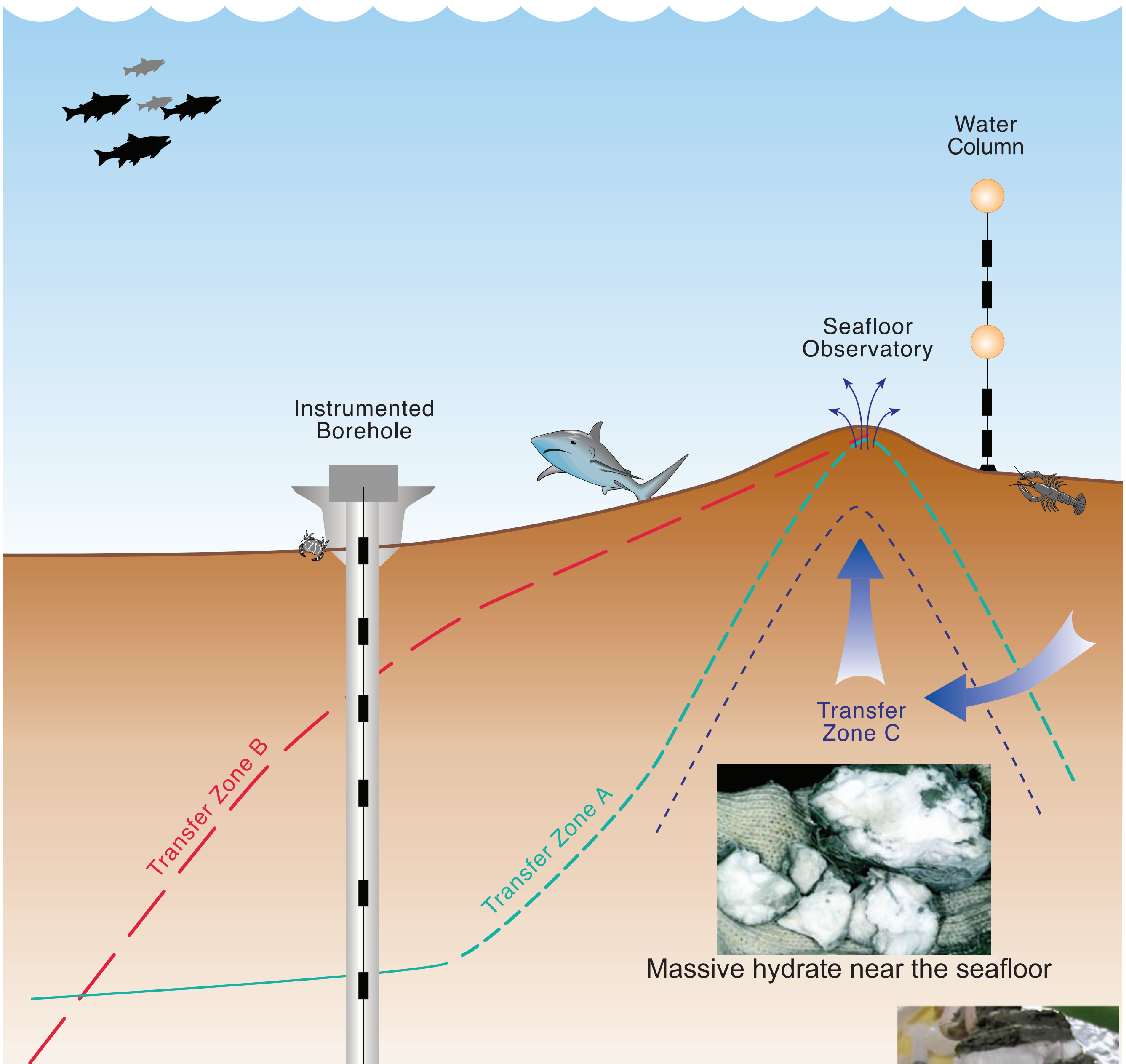
Gas-Hydrate Observatories Workshop
(GHOBS)
July 18-20, 2007
Portland, Oregon



Massive hydrate near the seafloor

Schematic representation of a coupled "bottom-to-top" gas hydrate observatory. Modified from **Workshop on Linkages between the Ocean Observatory Initiative (2003).**

Hydrate veins at depth

Sponsored by JOI and DOE

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GAS HYDRATE OBSERVATORIES: SCIENCE QUESTIONS AND EXPERIMENTAL STRATEGIES

INTRODUCTION

Climate, oceanographic and tectonic processes can affect gas hydrate stability conditions, resulting in highly dynamic seafloor and subseafloor environments. These dynamics can only be understood through time-series monitoring of complementary parameters over space and time, and monitoring can be best accomplished through the installation of a coupled seafloor/borehole observatory system.

This JOI/DoE-funded workshop on gas hydrate observatories reflects a critical need in the immediate future to develop specific plans and strategies for the successful deployment of borehole and seafloor instrumentation to characterize the dynamics of gas-hydrate-bearing environments.

The outcome of this workshop ought not be yet another list of potentially useful strategies and tools, but rather a focused plan for implementing the technologies needed for a successful gas hydrate monitoring program.

SCIENCE QUESTIONS

The overall goal of this research is the development of a comprehensive model of carbon cycling in gas hydrate-bearing continental margin sediments that is consistent with chemical, microbiological and physical data and can be used to predict the response of these systems to oceanic and tectonic perturbations.

To move forward we need to clearly define the specific science goals and the means to accomplish these goals.

We urge all workshop participants to look at the list of workshop deliverables prior to the workshop (see below), and come prepared to provide feedback on what you think are the key questions and approaches.

Workshop deliverables:

1) Documentation of key scientific questions that need to be addressed with instrumented boreholes and seafloor observatories. These include high priority interdisciplinary science questions; potential forcing functions to be observed and what measurements are needed to study them; science questions that must be addressed on a regional scale (e.g. across a cabled grid); and science questions that can be addressed by observations at a specific site.

2) Documentation of questions that can be addressed with current capabilities should major new funding not be forthcoming.

3) Definition of the "must have" new technologies to obtain critically needed data, including detailed lists of required engineering advances and outstanding challenges related to various instruments, tools and sensors.

4) Updated tables that follow the ORION sensor template, including a list of current sensors and instruments, instruments under development, and critical new technology needed to answer high priority questions.

5) Definition of synergies that link this activity with cabled observatory science and testing strategies (NEPTUNE-Canada, Mars, ORION); and

6) An outline of outreach opportunities related to this effort.

ONGOING EFFORTS AND PROPOSED STRATEGIES

There is currently a confluence of efforts aimed at designing experiments to monitor gas hydrate dynamics. Documents discussing these efforts, based on material currently available to the steering committee, will be available during the workshop on a CD. During the workshop we will review these and other ongoing projects or ideas contributed by the participants. It will be important to evaluate these strategies, and comment on the scientific value, technical readiness and potential outcomes from these approaches, so that a focused community effort can be made to design the optimal implementation plan for gas hydrate monitoring.

Please keep in mind that a ***phased approach*** will be required because of budgetary constraints, and that the various components that will make up the proposed integrated observatory should be designed as ***stand-alone systems*** to ensure timely development, testing, and acquisition of data. In addition, a ***comprehensive approach*** will likely be required that includes continuous monitoring of the water column and seafloor in an area of known surface manifestations of fluid venting and hydrate deposits; seafloor monitoring will be linked to borehole monitoring of the methane source reservoir, the gas hydrate stability zone, and the transfer zones. While some experiments may be feasible using buoyed observatories, others may require ***cabled ocean observatory technology*** to satisfy high power and/or bandwidth requirements (e.g. fluid pumping, heating of the system to avoid hydrate formation during fluid sampling or to perturb the hydrates, operation of seismic source; high data rates and interaction needed to support a wide range of measurements; multi-year deployments needed to capture the various time scales operating in this system; and the need for real-time intervention to capture infrequent events).

Engineering advances and outstanding challenges

Some of the documents related to technologies (available and in development), which have been suggested for use in a gas hydrate observatory, are included on the CD, and a preliminary listing is given in Table 1. The contents of the table should be considered as an informal list intended to initiate discussion with the goal of assembling a complete and up to date compilation of the "ready or soon to be ready" instrumentation and the "must have but needs development" technologies needed to attain key science objectives.

We need to identify special challenges that arise from the likely spatial and temporal heterogeneity of these gas hydrate bearing systems; the need to monitor a potentially broad range of fluid flow rates; and the likelihood of instrumentation failure due to induced gas hydrate formation in seafloor and borehole packages installed in the gas hydrate stability zone. We also need to identify which of these systems is critically dependent on cable or mooring technologies, and the challenges involved in the installation, operation and maintenance of such systems.

During the workshop we will evaluate the readiness of existing and pending technologies for borehole, seafloor and water column instrumentation for multiphase fluid sampling and remote sensing, including *in situ* mass spectroscopy, photospectroscopy, Raman spectroscopy, fluorescence spectroscopy, fiber-optic temperature sensors, optrodes and electrodes, and other methods.

EDUCATION AND OUTREACH

The JOI-learning office has already developed educational materials associated with gas hydrates (www.joilearning.org and documents on CD).

Workshop deliverable: an integrated approach by which the proposed gas hydrate observatories could best provide formal and informal education opportunities. Some ideas to consider: integration with COSEE Centers, K-12 outreach, informal education, adult basic education outreach.

Table 1: This table lists instruments, tools and sensors proposed for various gas hydrate observatories. Its presented here only as a starting point for discussion and to illustrate OOI formatting requirements (NA – not currently available)

Instrument/ outstanding challenges	**Components**	**Development status**	**sampling rate**	**power**	**estimated cost**
SCIMPI/ Deployment protocols. Reliable borehole closure and sensor-formation coupling. Optimum spatial density of measurements Expansion from low data-rate (e.g. temperature, pressure) to high data-rate (e.g. seismic) measurements.	Phase I: temperature, pressure, resistivity to log fundamental physical properties controlling fluid flow in the subsurface	Proposal submitted to NSF to adapt CPT technology to downhole use and set up Spider web network and data logger (K. Moran)	1 Hz for each data stream; ~15 data streams/ SCIMPI	NA	$320K/ SCIMPI 9 SCIMPIs = $2,880K
	Phase II: geophones and/or hydrophones to detect seismic events and use for active source imaging experiments	Proposal being discussed (A. Trehu and R. Stephen)	50 Hz/ channel 6-12 chan./ SCIMPI	NA	NA
	Phase III: additional modules	No proposal yet	NA	NA	NA
CORK/ Seal manipulation and instrument access via ROV Move formation fluids up through the GHSZ to the seafloor, we can anticipate that the	Pre-perforated casing for a 200 m hole; sensors for outside the casing; mechanical ROV-removable seal; bio-traps; Isosampler/D	Some development needed to adapt isosampler and seals for this application. Development needed for bio-traps.			

fluid sample manifolds will become clogged by gas hydrate	ALE				
mini-CORK Installation of sensors, fluid sampling strategies, ROV access	Sampling and temperature measurements in shallow boreholes	Proposal submitted by Torres, Schultz and Johnson			
Bottom pressure recorders	Sensor records ambient absolute pressure	Autonomous instruments exist; cable-friendly version planned. Included in several other community experiments	<10 bits/s; sample interval = 15 sec.	150 W max (probably <50W). 48VDC	$50K each 3 units proposed = $150K
Seafloor flow monitors/ Need to span a large range of potential flow rates Event response	Measure fluid flow rate in and out of the seafloor	Design completed, including acoustic telemetry. Minimal design needed to mate to a cable			
Temperature probes (Distributed Temperature Sensor, fiber optic)	Measure temperature in seafloor and shallow sediments. Proxy for fine-scale spatial variation in fluid flow.	Design is straightforward. Proposed but not initially funded. DTS SGER grant recently awarded to Trehu et al.	1 s/mn/RTD ~10 MB/yr for each probe.	NA	$3K each 30 units proposed = $30K
Bottom Cameras	Panoramic views of the seafloor. Use to monitor observatory condition as well as	Design completed and ready for fabrication.	1 MB/image 8.7 GB/yr if an image is recorded each hour.	<1W plus intermittent draw of 100W for strobe lights	50K for 2 cameras and command/ power node (does not include engineering)

	hydrate evolution and associated fauna.				
5-150kHz seafloor up-looking ACDP	Better understand the high-freq. currents coupled to estimates of the seafloor fluxes and mooring data.	Standard technology – integrate with bubble monitor or water column mooring.			$75K one unit at SHR3
Multifrequency acoustic bubble monitor	Quantify methane flux in bubbles by measuring bubble size distribution and rise speed.	Proposal under discussion (Trehu, Di Orio, Rona). Represents extension from single frequency instrument developed for hydrothermal vents	NA	NA	See Di Iorio, Rona et al. proposal for ballpark estimate. Detailed estimate awaits funding and completion of pilot study.
Water column mooring with methane and other sensors		Same technology proposed for NEPCM RFA. Two additional units needed for SHR.			$390K each/ 2 units proposed. $780K
Seismic monitoring	3-component broadband seismometer with differential pressure gauge and hydrophone	Existing	40 Hz	1.25W	$80K per unit

	3-component short period seismometer with hydrophone	Existing	100Hz	0.2W	p$20K per unit

APPENDIX 1- List of documents available through JOI prior to the workshop and included on the CD to be distributed at the workshop (in no particular order)

1) Results from previous relevant workshops.

2) Addendum to IODP proposal 553-Full2.

3) IODP proposal 635-Full2.

4) ORION Conceptual Science Proposal (Request For Assistance) for a North-East Pacific Hydrate Observatory System (NEPHOS).

5) NSF-funded DTS SGER proposal.

6) SeisSCIMPI report.

7) IODP pre-proposal 663- for a gas hydrate borehole perturbation experiment.

8) Abstracts submitted for the workshop.