IODP Proposal Cover Sheet

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Title:	Tectonic and oceanographic controls on of fluid flow, and their impact on gas hydrate and biosphere processes on southern Hydrate Ridge.		
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Abstract: (*400 words or less)*

The proposed drilling experiment is designed to characterize the temporal and spatial variability of processes associated with the free gas and gas hydrate rich environment of Hydrate Ridge (HR) in the Cascadia margin. We believe that this area is ideally suited to test our hypothesis that *large-scale fluid flow, which feeds massive gas hydrate deposits on active continental margins, responds to perturbations that occur on time scales of hours to decades and that these transient events impact the deep biosphere, biogeochemical cycles, and the mechanisms that mediate the formation and destabilization of gas hydrates*.

The distribution and abundance of gas hydrate in HR are very well constrained. Recent modelling efforts have revealed that the very rapid gas hydrate formation at the ridge summit is supported by a high flux of free methane gas. Most of the gas flow into the GHSZ occurs along one stratigraphic horizon, which is well imaged in 3D seismic records providing a well-defined target to monitor. This Horizon A also hosts an unusually abundant microbial biomass. Moreover, the HR region is subject to a variety of transient forcing factors that vary in time scales that can be monitored with subseafloor instrumentation, such as parameters that control flow (e.g. pressure), are altered by variations in flow rate (e.g. temperature), change as gas hydrates form or decompose (e.g. conductivity), or may drive change (e.g. seismic events). We will also recover samples to evaluate the biosphere response to changes in rate and composition of the migrating fluids.

The backbone of this experiment uses a new type of sub-seafloor observing system –dubbed SimCORK for simplified CORK- which will be installed along a transect of sites that follow Horizon A as it shoals towards the ridge summit. The design of the SimCORKs takes advantage of off-the-shelf components and of the natural tendency of the borehole wall to collapse and seal the system. This approach is significantly less expensive or time consuming than a traditional CORK, and is not affected by formation of hydrate within the hole. The SimCORK installations will be complemented by one CORKed site for fluid and microbiological sampling and by casing of one hole for installation of seismic and electromagnetic sources.

We recognize that this program entails significant engineering developments, and anticipate obtaining funding for the design and implementation of these installations from sources external to the IODP structure. Some of the technological needs foreseen here are currently under development with funding from NASA and MBARI.

Scientific Objectives: (*250 words or less*)

Specific objectives: 1) Constrain the nature and episodicity of multiphase flow along a well defined high permeability horizon for which good regional coverage exists in the 3D seismic data; 2) Document and quantify the effect of seismic and oceanographic perturbations on the flow regime; 3) Monitor the response of the deep biosphere to changes in flow and chemical conditions, and 4) Unravel the mechanisms that mediate the formation and destabilization of gas hydrates, with special emphasis on the massive shallow near the seafloor.

Please describe below any non-standard measurements technology needed to achieve the proposed scientific objectives.

Logging while drilling, PCS, SimCORKs and CORK.

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SHR-1	44°3 4.6'N, 125° 9.0'W	845	300		300	Changes in hydrology, microbiology and chemistry in response to forcing along a high permeability horizon that supplies methane to the GHSZ.
SHR-2	44° 34.1'N, 125° 9.0'W	807	200		200	Changes in hydrology, microbiology and chemistry in settings where gas hydrate occurs as large deposits near the seafloor. Controls and mechanisms regulating methane flux below the GHSZ, within the GHSZ and at the seafloor. Nature of convective flow due to highly saline fluids near the seafloor, and effects on shallow hydrology and microbiology.
SHR-3	44° 34.2'N, 125° 8.8'W	788	90		90	
SHR-4	44° 35.1'N, 125° 9.3’W	913	165		165	Sampling of Horizon A within the GHSZ. Characterizing the nature of a double BSR.
SHR-5	44° 34.4'N, 125° 9.3’W	849	160		160	Sampling of Horizon A within the GHSZ. Characterizing the nature of a double BSR.
SHR-6	44° 35.2'N, 125° 5.3’W	1050	160		160	Determine gas hydrate distribution in a steeply fractured formation.

1. INTRODUCTION

This proposal describes IODP drilling of instrumented boreholes on Southern Hydrate Ridge (SHR, Cascadia margin) to provide time series observations of the dynamic processes associated with the gas and gas hydrate-rich subseafloor environment. Our proposed experiment goes beyond traditional leg-driven expeditionary science, which infers subseafloor processes based on a snapshot of recovered of samples. It represents a step towards a new style of science for the ocean drilling community, which strives to monitor and measure processes as they happen on and in the seafloor through use of observatories that collect time-series data to document the changes.

As the result of previous ODP legs to the area and numerous expeditions using submersibles, towed cameras, coring, 3D-seismics, and other tools, Hydrate Ridge (HR) is one of the best-characterized sites of marine gas hydrate occurrence (Fig. 1; Trehu et al., 2004a). Recent studies indicate a very dynamic system, with hydrate formation rates at the summit of SHR on the order of 100 mol/m^{2}yr (Torres et al., 2004). These deposits are fed by methane gas supplied from below the gas hydrate stability zone (GHSZ). Methane gas is channeled from deep accretionary margin sequences though a permeable layer that has been mapped seismically (Horizon A) (Figs. 1 and 2). This horizon, characterized by a coarse-grained, glass-rich turbidite (Trehu et al., 2003), captures and transports significant volumes of gas (Trehu et al., 2004b).

The complex nature and temporal variability in the hydrologic activity of this gas-hydrate-bearing subduction-setting is revealed by observations of punctuated gas discharge episodes (Torres et al., 1999; Heeschen et al., 2003; A. Schultz, 2004, Fig. 3A), measurements of highly variable fluxes through surface seeps (Tryon et al., 2002), and evidence for tectonically-driven non-uniform flow of warm pore fluid (Davis et al., 1995). Driving mechanisms for this flow may include tidal pressure changes, longer-term buildup of critical fluid pressures, and recent seismic activity. Fundamental questions remain as to the nature and driving mechanisms for flow and biological interactions in environments where gas hydrates are present and fluid (aqueous and gas) migration occurs. The proposed experiment will address the hypothesis that there is a dynamic flow field driven by a buoyant gas column trapped beneath the hydrate stability zone. Gas flow is focused along a permeable layer beneath the GHSZ and expelled upward from this zone. Within the GHSZ gas flux is rapid enough at the vent location to allow free gas to migrate through the GHSZ. Superimposed on this ***large-scale hydrologic flow field, there are***

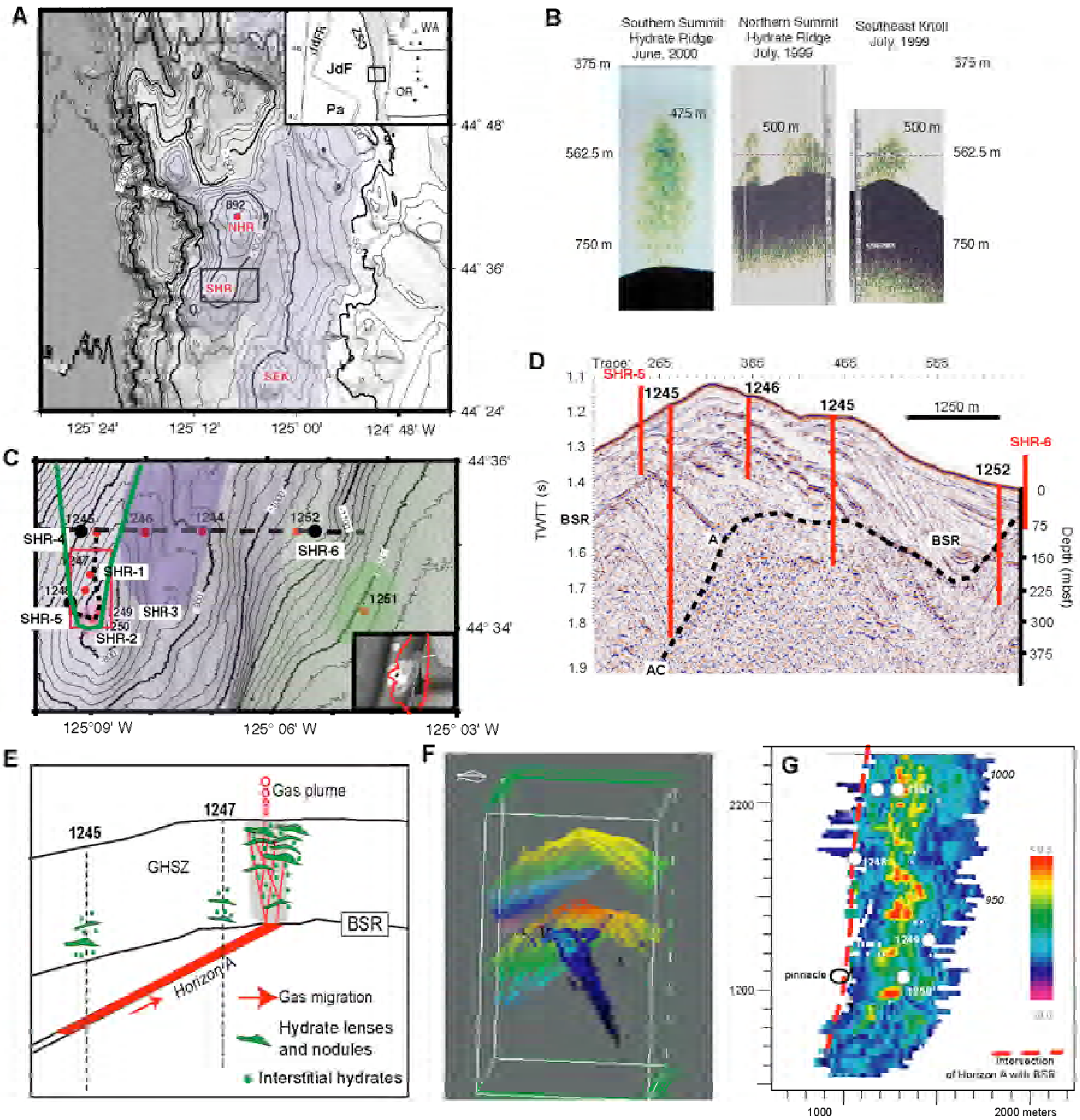


Figure 1. A. Bathymetric map of Hydrate Ridge. Insert shows tectonic setting. B. 12 kHz acoustic images of bubble plumes. C. Bathymetry of SHR and location of sites drilled during ODP Leg 204, and proposed sites SHR-4 to SHR-6. Box (red) demarks the area shown in Figure 3. Insert shows seafloor reflectivity at the summit. Green line outlines the extent of Horizon A. D. EW seismic section across SHR showing lithified, fractured sediments of the accretionary complex (confirmed by drilling at Sites 1244, 1251 and 1252) overlain by younger uplifted and folded sediments. Horizon A is labeled. E. Schematic diagram showing the fluid migration system on Southern Hydrate Ridge. Horizon A is a permeable layer that captures abundant free gas and transports it to the summit. As the gas column builds up, it fractures the overlying material, and is forced upward to ultimately be expelled at the ridge crest. Variable aqueous and gas flow along this horizon, and the effect of the varying flow on the geochemistry, microbiology and gas hydrate dynamics are the focus of the proposed experiment using instrumented boreholes. F. 3-D view of the geometry of Horizon A, BSR and seafloor reflectors in the area of study. G. Reflection amplitude of Horizon A and Leg 204 sites; changes in the amplitude of Horizon A are correlated to the depth of Horizon A beneath the sea surface (pressure), indicating that the onset of very strong reflectivity reflects the onset of gas exolution within Horizon A (Trehu et al., 2004b). A map view of the gas effective stress calculated using these data, and showing location of proposed and existing drilled sites, is shown in Figure 3.

perturbations that occur on time-scales of hours to decades. This hydrodynamic system controls gas hydrate dynamics and impacts biogeochemical cycles and the deep biosphere.

To test this hypothesis we propose to characterize hydrogeological and biogeochemical processes in both space and time. The backbone of our experimental design uses a new type of subseafloor observing system –SCIMPI, a Simple Cone Instrument for Measuring Parameters In-situ (section 3.3)- to obtain continuous data on key subseafloor parameters within an array of low cost installations. The SCIMPI design is based on the use of off-the-shelf components, and takes advantage of the natural tendency of the borehole wall to collapse and seal the instrumented observatory. The SCIMPIs will be outfitted with pore pressure transducers, temperature sensors, resistivity probes, and ground motion sensors. This approach is significantly less expensive and time consuming than deploying traditional CORKs, which require the installation of a cased hole, and it is not adversely affected by formation of hydrate within the hole. The SCIMPIs we pioneer here will be useful for addressing a wide range of problems in marine geohydrology.

The proposed SCIMPI array will be complemented by a cased-hole CORK site for fluid and microbiological sampling and for in situ and seafloor geochemical sensing. An additional non-CORKed cased legacy hole will be installed for deployment of seismic signal sources for cross-borehole time-dependent tomography. Fluid and microbiological sampling will be supported in scheduled and event-triggered modes. Techniques for dealing with multiphase flow and the possibility of gas hydrate formation during sampling are being considered. The borehole experiments will be coordinated with other seafloor observatory efforts that include tools to monitor oceanographic parameters and methane discharge at the summit.

The proposed drilling by IODP will allow us to install the instruments in boreholes drilled on SHR. We anticipate obtaining funding for the installations described here (which include SCIMPIS, CORKS, and seafloor instrumentation) from sources external to the IODP structure. A proposal (Moran, PI) was submitted to NSF to develop the SCIMPI tool with trial tests to be conducted in the upcoming drilling leg on Monterrey Bay (IODP full 621). Some of the seafloor components of the observatory are currently under advanced development and field testing through support by NASA. Development of inter-hole cabling necessary to connect to common data loggers is underway at MBARI. Additional proposals will be submitted to NSF and NASA for development and fabrication of the required borehole instrumentation. We recognize that consultation with the IODP engineers will be necessary during the instrument design process.

2. BACKGROUND

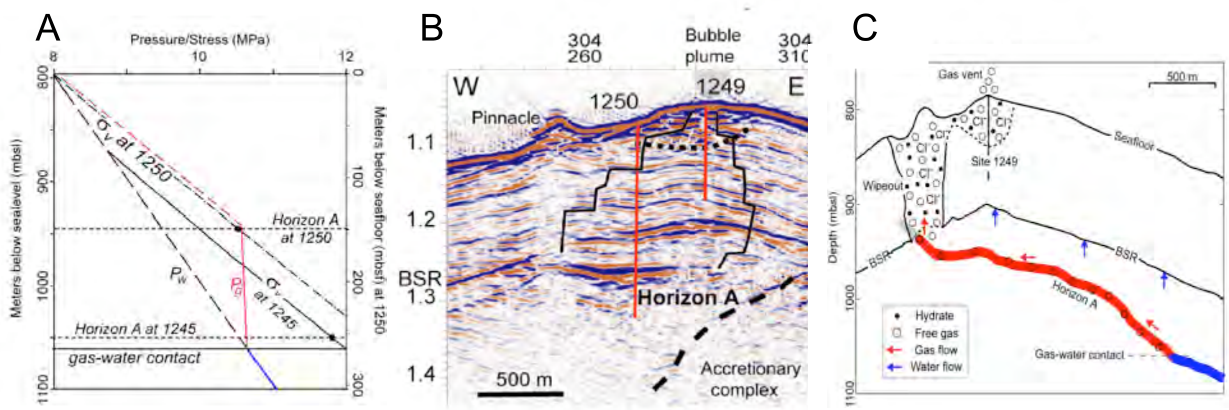
Reports generated during the last decade (e.g. COMPOST, 1993, COMPOST II, 1998; CONCORD, 1997) have identified the essential roles that scientific ocean drilling has played in advancing Earth Science and related fields, and have outlined critical scientific and technical goals for the new IODP program. The most recent report of the IPSC (IODP, 2002) identifies the deep biosphere and the sub-seafloor ocean as an over-arching goal for scientific ocean drilling beyond the year 2003. The study of gas hydrates -a frozen compound in which hydrocarbons are trapped in a water lattice- has been identified as an important research initiative within this goal.

Numerous laboratory and field studies at gas-hydrate-bearing sites, including several drilling expeditions in the past decade, have provided critical background data on the conditions of gas hydrate stability, and have given an overall view of the composition and distribution of gas hydrates in nature (e.g. Dickens, 2001, Kvenvolden and Lorenson, 2001; Milkov, 2003). These results sparked the development of models relating hydrate dynamics to tectonic and slope stability, and the possible impact of this system on global climate (e.g. Dickens, 2003; Davie and Buffett, 2001; Sloan, 1998; Clennell et al., 1999). Work carried out heretofore highlights the complexity of gas hydrate systems. The factors influencing gas hydrate stability and processes that occur as a consequence of gas hydrate formation and destabilization result in a highly <u>dynamic subseafloor environment.</u> These dynamics can only be understood through time-series monitoring of complementary parameters over space and time, and monitoring can be best accomplished though the installation of a borehole observatory. The development of borehole observatories is on the cutting edge of the seafloor science and has the potential to dramatically expand the types of science questions that IODP addresses.

2.1 WHY HYDRATE RIDGE:

Hydrate Ridge provides an unparalleled opportunity to site a borehole observatory in an exceptionally dynamic seabed. Rich hydrate deposits, gas discharge and a complex biosphere at the seafloor have been documented at the crests of HR. ODP Leg 204 showed that this complex environment extends well below the seafloor and has provided clues to the forces driving it. Log and core data document gas saturations as high as 90% in a coarse-grained turbidite sequence beneath the GHSZ at SHR. The geometry of this gas-saturated bed is defined by a strong, negative-polarity reflection in 3D seismic data, known as Horizon A (Fig. 1).

Analyses of seismic sections and core data from Leg 204 suggest that a column of free gas over-pressures the section until it fractures or percolates through the overlying material at the summit, where ultimately it is incorporated into gas hydrate, or expelled into the ocean (Fig 2A;



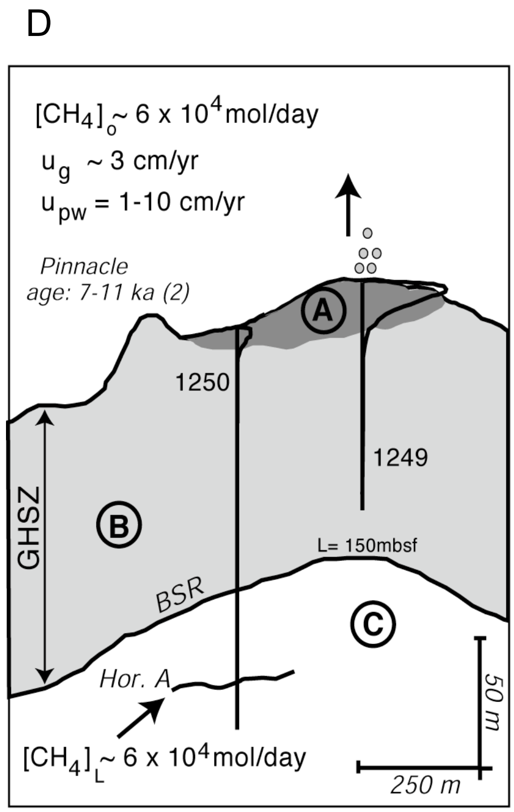


Figure 2. A. Hydrostatic pressure (P_w), lithostatic stress (σ_L) and gas pressure (P_g) beneath the summit. A 100 meter free gas column has a gas pressure immediately beneath the BSR that is interpreted to equal the overburden stress (Trehu et al., 2004b). B. High gas pressure drives gas migration by two possible migration pathways through the gas hydrate stability zone (black lines). C. Hydrate Ridge hydrodynamics. Beneath the BSR, gas is focused along the Horizon A. Lithostatic gas pressure opens fractures within the BSR and gas is forced upward. Gas migration through the GHSZ is possible either because of high salinity fluid beneath the pinnacle (e.g. Lui and Flemings, 2005), or supported by hydrate inhibition driven by high capillary entry pressure (Torres et al., 2004). D. Schematic representation of the gas hydrate forming system at SHR. Sites 1249 and 1250 are depicted by solid lines, on which we have superimposed dissolved chloride profiles. Dark area demarked as A also corresponds to the zone of high-amplitude, chaotic reflectivity in the 3D-seismic data. The lateral extent of this seismic pattern (~15 x 10^4 m^2) is coincident with moderate-to-high seafloor acoustic backscatter (Johnson et al., 2003). Methane discharge at the ridge summit has been estimated to be ~10^4 mol/day (Heeschen et al., in press.). Assuming steady state, this is the methane supplied to the base of the GHSZ. Upward fluid flow of 1 to 10 cm/yr have been estimated from temperature data. From Torres et al., 2004.

Trehu et al., 2004b). Based on the work of Clennell et al. (1999), Torres et al (2004a) hypothesized that the inhibition of hydrate formation within the GHSZ by capillary effects supports gas transport through the GHSZ. Alternatively, Milkov et al (2004) and Lui and Flemings (in review) suggest that hydrate formation on HR generates a high salinity front, which shifts the hydrate stability field enough to preclude gas hydrate formation and thus support methane transport as a

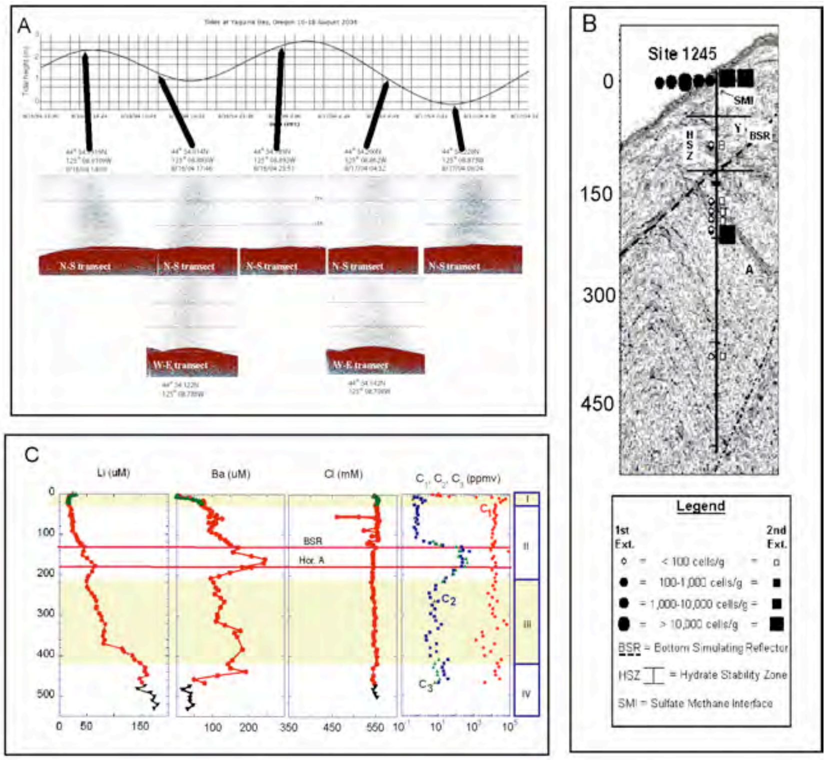


Figure 3. A.12 KHz acoustic images at depths of 500-900 mbsl, during a series of repeat transects across southern HR on August 16-17, 2004. Five repeat transects were taken while passing from the north to the south over the summit, and two were taken when passing from the west to the east, also over the summit. Tidal sealevel changes are indicated by the curve at the top of the figure, referenced to Yaquina Bay, OR. Previous tidal observations at HR indicate the phase lag between Yaquina Bay and HR is negligible, for our present purposes. The acoustic images indicate significant energy return from the plume of clathrate-coated methane bubbles that was reported reported previously by Heeschen et al. (2003). The width of the plume is consistently near 200 m, but the intensity does vary significantly over the observation period. B. Methanogen numbers present in samples acquired from ODP Leg 204 Site 1245 as determined by real time QPCR directed at the methyl CoM reductase gene in DNA extracted from the samples. Methanogen numbers are depicted by the size of the symbol and plotted by depth. The microbiological data is superimposed on a seismic cross-sections obtained for the sediments surrounding the borehole (Trehu and Bangs, 2001). C. Downcore distribution of dissolved Li, Ba, Cl at Site 1245 (solid symbols). Different colors reflect different holes drilled at this site. The right panels show the distribution of methane (red), ethane (blue),and propane (green) measured in headspace samples at Site 1245 as well as a lithostratigraphic column for this site (Trehu et al., 2003). The increase in lithium and barium reflect fluid migration from sediment sections that have experienced temperatures >70 C, which at this site occur at

gas phase to the sediment surface where it vents. The high-salinity hypothesis is linked to observations of seismic 'wipe-out zones' located beneath a carbonate structure ~250 meters away from the summit of HR, known as "the Pinnacle" (Torres et al., 1999; Figs. 1 and 2). To further constrain gas flow processes a proposal was submitted to NSF (Torres, PI) to install mini-borehole probes (Johnson et al., 2003) at the Pinnacle, to determine whether a brine exists that transports methane gas beneath this structure, and to constrain the gas migration.

Figure 3C illustrates some of the chemical discontinuities measured in samples recovered during Leg 204. These and other data have been used to document a deep source for water and gas migrating along Horizon A, and to establish that this is the pathway that supplies methane to the hydrate deposits at the summit (Figs. 1&3) (Trehu et al., 2003). Hydrate formation in the upper 20 mbsf at the summit leads to the formation of pore water brines, reaching Cl^- concentrations of up to 1370 mM. These high chloride values can only be sustained by formation of gas hydrate at very fast rates (Torres et al., 2004). Leg 204 provided a compelling, yet static view of this dynamic system. ***We now wish to quantify geochemical fluxes, the nature of their variability, and the factors that control their fluctuations***.

The HR area experiences significant change on timescales that can be measured within the life of a seafloor observatory. Because many of the processes occurring at HR are characteristic of active margins worldwide, lessons learned here will have broad application. HR is subject to transient forcing factors such as tidal modulations and significant bottom water temperature variations, including those linked to el Niño. Motion on the plate boundary between the Juan de Fuca and North American plates leads to both earthquakes and slower creep events, and strain waves from both types of events are likely to perturb fluid flow. The importance of seafloor observatories for understanding hydrologic responses to seismic activity was clearly demonstrated by the seafloor observatory installed on the Middle Valley rift of the Juan the Fuca Ridge for monitoring steady-state conditions. This observatory provided extremely valuable data for characterizing the hydrological response of the system during and after a seismic event on Sept. 7, 2001 (Davis et al., 2004). After the event, no hydrothermal activity was detected in the water column. Instead, it appears that the space created by extension in the crust was filled by water (drawn from the adjacent crust) rather than magma, resulting in a drop in fluid pressure at the CORK. These recent observations highlight the critical role of borehole observing systems in hydrologically and seismically active regions. ***We propose to establish whether seismic activity leads to measurable changes in the flow regime at HR.***

While large earthquakes historically are rare in this central part of the Cascadia subduction zone, the paleoseismic record indicates that large "fast" earthquakes occur at intervals of 200-1200 years and that there is a 20% probability of a large earthquake in the next 50 years. Two moderate-size earthquakes (mag 4.9 and 4.7) occurred recently (July 12 and Aug. 18, 2004) ~20 km from HR beneath the continental shelf. Ground motion from these events was probably significant in the soft sediments of HR. Moreover, small events that are not recorded by land-based seismic networks probably occur frequently.

A more frequent source of tectonically-driven perturbation of the fluid flow regime may result from creep events, as recently reported in GPS data from northern Cascadia. These events occur at intervals of 13-16 months; each event lasts 1-2 weeks and is accompanied by a seismic tremor (Rogers and Dragert, 2003). They have also been reported from southern Cascadia, Japan

(Obara, 2002) and Costa Rica (Protti et al., 2004) and represent a moment release comparable to a magnitude 6-7 earthquake (Melbourne et al., 2005). The tremor is thought to be related to fluid motions, although the detailed mechanisms remain enigmatic. Information on the updip extent of this behavior in Cascadia does not exist because of the absence of offshore seismic and geodetic data. However, results recently reported by K. Brown et al. (2005 EarthScope annual meeting; papers in review in EPSL and Science) indicate a clear correlation between pulses of fluid flow at the seafloor and increases in background seismic noise levels near the toe of the accretionary complex in Costa Rica. Simultaneous recording of fluid pressure and seismicity beneath HR will allow us to test whether these slow slip events extend updip, thus providing additional clues to their origin and insights into the factors that control slip on the megathrust. Continuous down-hole recording of seismic activity, dilatational strain, and pore pressure may enhance our understanding of seismic hazards (to identify precursors to great earthquakes) and will constrain the impact of seismic activity on the plumbing system feeding gas hydrate formation.

Large (mag. >7) earthquakes occur frequently on the Blanco and Mendocino transform faults and within the Gorda plate at distances of 200-500 km from HR. Earthquakes of this magnitude and in this distance range have been documented to affect strain and fluid pressure in boreholes at Long Valley CA (E. Roeloff, pers. comm., 2005) and should be detectable at HR. At Long Valley, Roeloff speculates that the data reflect breaching of diagenetic seals by seismic waves, leading to fluid mobilization. Similar processes may occur at HR within the GHSZ.

There is already intriguing evidence for the existence of transient variations which may be associated with tectonic stresses in this region. Although there are no long-term temperature records available on SHR, a thermal anomaly was observed (increase of 4° K in 5.5 months) after the installation of an instrumented borehole seal (CORK) on northern HR (NHR) in 1992. This temperature anomaly has been attributed to a change in fluid flow rate within the conduit that feeds the seafloor vents (Davis et al., 1995). Because steady flow at this rate would have a larger impact on the BSR depth than is observed, the authors conclude that the average fluid flux at the drilling site results from short-lived and localized transient flow events.

Data from Leg 204 have also revealed an unusually abundant microbial biomass at the depth of Horizon A, where gas is migrating through the sediments (Figure 3B). This deep horizon contains high abundance of methanogens (> 10,000 cells per gram), which is particularly striking when compared to levels that are below the detection limit for most of the sediment column sampled, with exception of the shallow sub-seafloor depths (Colwell et al., 2004). Presumably the methanogen communities are responding to enhanced flow through Horizon A. ***We do not know, however, how these communities respond to variations in rate and composition of the flow along this high permeability horizon, nor do we have detailed information about other communities that are likely to exist near Horizon A***.

To unravel the complex interactions among the forcing parameters and to quantify the response of the flow regime and its geochemical and microbiologic impact, subseafloor time-series data are essential. The examples cited above illustrate episodic perturbations that affect the flow regime on HR in time-scales that can be monitored with the borehole instrumentation proposed here. In addition, the hydrate deposits occur in relatively shallow water, and the thermal regime results in a thin gas stability zone. Consequently, IODP holes do not have to be deeper than 300 mbsf to span the range of targets needed to monitor methane transport into the GHSZ and gas hydrate formation. Moreover, HR is located only 50 miles west of Newport, OR, thus making it readily accessible.

3. DRILLING PROGRAM

3.1 Objectives

Our goal is to gain a thorough understanding of the hydrologic regime of a well-characterized, moderately high flux gas-hydrate-bearing system in an active margin, where methane transport to the GHSZ is focused along a well-defined high-permeability horizon but transport through the GHSZ is more complex. The HR system is arguably the best-suited locality to test our hypothesis that: there is a dynamic flow field driven by a buoyant gas column trapped beneath the hydrate stability zone. Gas flow is focused along a permeable layer beneath the GHSZ and expelled upwards from this zone. Within the GHSZ gas flux is rapid enough at the vent location to allow free gas to migrate. ***Superimposed on this large-scale hydrologic flow field, there are perturbations that occur on time-scales of hours to decades. This hydrodynamic system controls gas hydrate formation/dissociation and impacts biogeochemical cycles and the deep biosphere.***

The primary drilling objective of this proposal is to install borehole sensors to measure temporal changes in physical and chemical parameters in a series of shallow boreholes on SHR to document this hydrodynamic flow field. We also propose three targeted coring sites to better constrain the interpretation of the monitoring results. These targets are relatively shallow, and this additional coring can be accomplished with minimal impact on the rest of the program. Furthermore we will be able to compare hydrological properties (e.g. pressure, temperature), the pore water and gas chemistries and microbial characteristics of the cores to that of the samples collected by the borehole instruments.

3.2 TARGET AREAS

We propose to drill, core and log six sites on SHR (Table 1, Fig. 4). Three of the sites (***SHR-1 to SHR-3***) are in areas where high variation in the flow is expected, thus these sites will be instrumented for long-term monitoring of sub-seafloor processes. Proposed ***Site SHR-1 (ODP Site 1247)*** is located ~ 800 m northwest of the southern summit, and ***Sites SHR-2 (ODP Site 1250) and SHR-3 (ODP Site 1249)*** are located at the ridge summit, where massive hydrate deposits are forming at very fast rates near the seafloor and to a depth of 20 mbsf.

Samples and data from Leg 204 provided evidence for methane migration in the gas phase through the GHSZ, driven by critically pressured gas in Horizon A. Observatory data

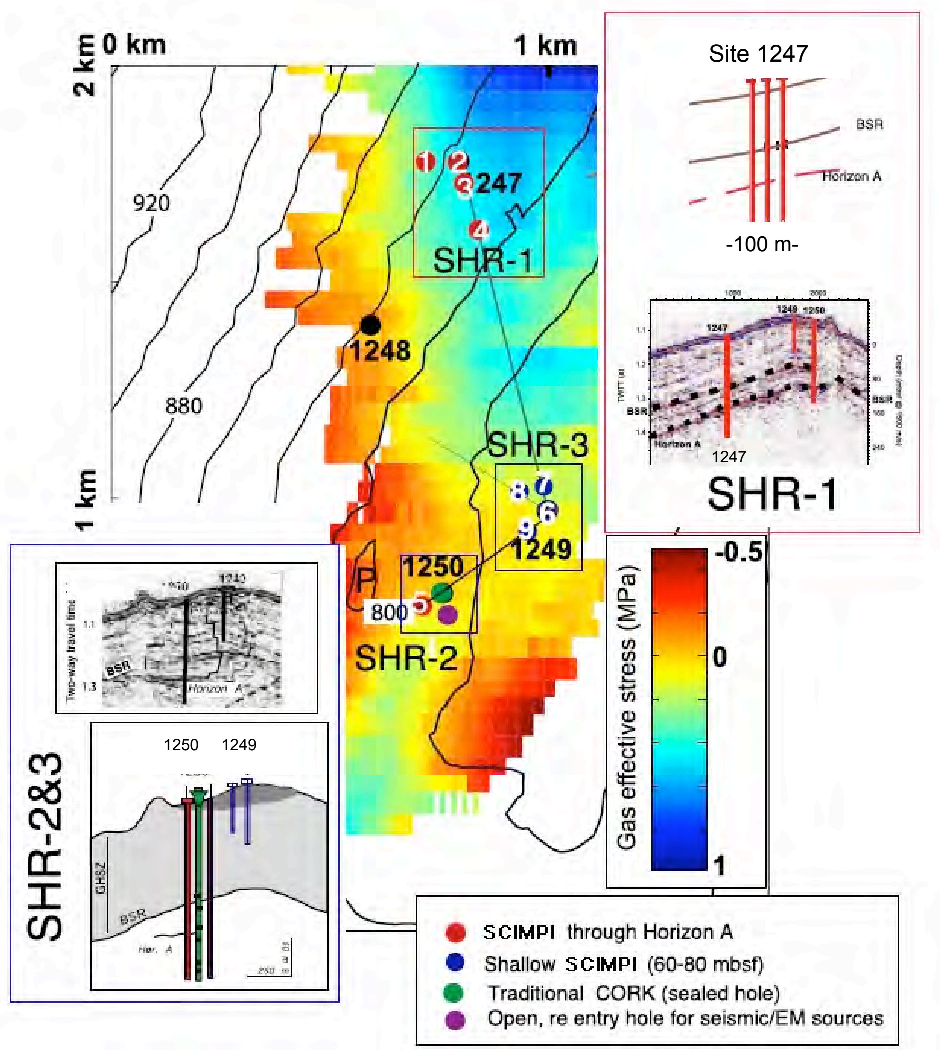


Figure 4. Experiment design, showing locations of the proposed instrumented holes on SHR, superimposed on a map of gas effective stress. Gas effective stress was calculated from the relative depths of Horizon A, BSR and seafloor (Figure 1F), and the depth at which gas saturation is high enough to allow for gas to be interconnected in the pore space (Trehu et al., 2004b). SHR- 2&3 insert is shown in more detail in Figure 2.

will indicate how the measurable parameters that control flow (e.g. pressure) are altered by variations in flow rate (e.g. temperature) or change as gas hydrates form and decompose (e.g. conductivity), and how the various forcing forces (e.g. seismic) control these variations. Site SRH-1 is also targeted for dense microbiological sampling of Horizon A beneath the GHSZ. Quantitative PCR analysis of the DNA extracted from sediment recovered from this interval during Leg 204 indicate anomalously high methanogen cell counts typical of shallow sediments at this depth, suggesting that enhanced microbial activity here is supported by large fluid fluxes along this horizon. Site SRH-2 has been selected as the best location to install a CORKed hole that will permit collection of fluid samples and microbial cultures in biotraps. Regular temporal sampling of fluids, and event-triggered fluid sampling may be accommodated at this site.

Table 1: Target areas, for map view see Fig 4.

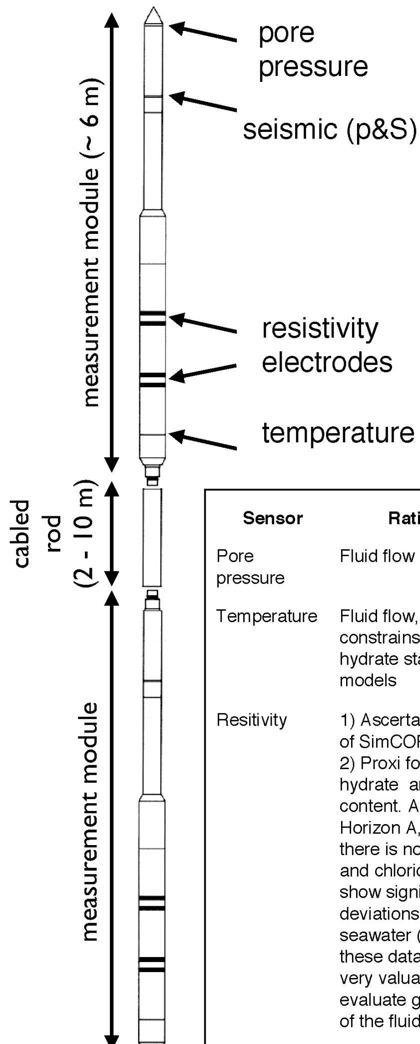
Site	Location	Water depth (m)	Penetration (mbsf)	BSR depth (mbsf)	Horizon A (mbsf)	Objectives	Priority	Expected lithologies
SHR-1 (Site 1247)	44°34.6'N 125°9.0'W	845	300	124	162	Coring. Logging and SCIMPI 1	3	Clay with sand/silt turbidites
At least 2 SCIMPIs are proposed with highest priority to test fluid flow through Horizon A. Three sites will enhance characterization and a 4th SCIMPI will allow for 3-D modeling needed for futures hole-to-hole active hydrology experiments						Coring. Logging and SCIMPI 2	1	
						Coring. Logging and SCIMPI 3	1	
						Coring. Logging and SCIMPI 4	2	
SHR-2 (Site 1250)	44°34.2'N 125°9.0'W	807	200	112	150	CORK	1	Clay with sand/silt turbidites. Massive hydrate near the seafloor
CORK and re-entry holes are critical for in-borehole experiments and sampling. SCIMPI at this site will be used to monitor in situ changes as well as record seismic data from active source experiments. All are priority 1 objectives.						Re-entry hole for seismic and electromagnetic sources	1	
						Coring. Logging and SCIMPI 5	1	
SHR-3 (Site1249)	44°40.0'N 125°8.0'W	788	90	115		Coring. Logging and SCIMPI 6	1	
At least 2 shallow (60-80 mbsf) SCIMPIs are proposed with highest priority to address tasks associated with formation of shallow hydrates at the ridge summit. Three sites will enhance characterization and a 4th SCIMPI will allow for 3-D modeling needed for futures hole-to-hole active hydrology experiments						Coring. Logging and SCIMPI 7	2	
						Coring. Logging and SCIMPI 8	3	
						Coring. Logging and SCIMPI 9	1	
SHR-4	44°35.1'N 125°9.31'W	913	165	126 (BSR2 -154)	96	Sampling Horizon A within the GHSZ. Double BSR	2	Clay with sand/silt turbidites.
SHR-5	44°34.44'N 125°9.26'W	849	160	122 (BSR2 -150)	102	Sampling Horizon A within the GHSZ. Double BSR	1	Clay with sand/silt turbidites.
SHR-6	44°35.2'N 125°5.29 'W	1050	160	171		Determine hydrate distribution in steeply-dipping fractures	1	Clay with sand/silt turbidites.

Proposed ***Sites SHR-4*** and ***SHR-5*** (Table 1**,** Fig. 1C**)** will sample Horizon A within the GHSZ to test the hypothesis that formation of gas hydrate within this zone plays a role in the development of venting by creating a low permeability layer that generates a dynamic rather than a structural seal along the western boundary of Horizon A. We have speculated that this dynamic seal is critical for allowing gas pressure to build up, thus focusing venting at the summit (Trehu et al., 2004b). At these sites, we will focus on recovering material at in situ pressure in order to accurately determine the amount of gas hydrate present in Horizon A. These sites are located a few 100's of meters west of Leg 204 Sites 1245 and 1248, which sampled Horizon A below the GHSZ. These two sites also provide an opportunity to recover pressure core samples from a 30-m-thick region beneath the BSR and a deeper, low amplitude BSR. The deeper BSR may be a relict of a thicker gas hydrate stability zone prior to a change in bottom water temperature; alternatively, it may represent a zone that contains more stable structure II gas hydrate (Bangs et al., in press). No pressure cores from this zone were obtained during Leg 204. Proposed ***Site SHR-6*** (Fig. 1D) is designed to sample sediment overlying a buried anticline on the eastern flank of HR. This site will test the hypothesis that small tensional cracks in the GHSZ overlying the crest of the anticline are filled with gas hydrate, and that second order seismic observations can be used to predict regional variations in gas hydrate abundance. We will not penetrate the BSR at this site because of safety concerns. No significant variations in fluxes are expected at these three sites, thus no provisions are made to install observatories at Sites SHR-4, SHR-5 and SHR-6.

The backbone of the proposed experiment lies on the installation of an array of closed hole (SCIMPI) observatories that will continuously monitor temperature, resistivity, pore pressure and ground motion along a NW transect that follows Horizon A as it shoals towards the summit (Fig. 1E, 1F). In addition we propose to case one re-entry hole for periodic deployments of seismic and electromagnetic sources; and to emplace one CORK at the ridge summit that will permit fluid sampling for chemistry and microbiology characterization.

3.3.1 SCIMPIs

To characterize the hydrogeological processes, both in space and time, we propose to use a new type of sub-seafloor observing system –SCIMPI, Simple Cone Instrument for Measuring Parameters In-situ. The design is based on two concepts: (1) SCIMPIs use of proven, off-the-shelf components; and (2) the natural tendency of the borehole wall to collapse is exploited to seal the SCIMPI. The SCIMPI consists of an instrumented probe that is inserted into the hole as the drill string is withdrawn. The length of the probe is adjusted so that its top section extends out of the seafloor as the hole closes in on it. Thus the sensors remain in the closed borehole, but there is no need to install casing and this does not depend on packers. Connections to the SCIMPI are made with an ROV or HOV.



Sensor	Rationale
Pore pressure	Fluid flow
Temperature	Fluid flow, and constrains on gas hydrate stability models
Resitivity	1) Ascertain sealing of SimCORK. 2) Proxi for salinity, hydrate and gas content. Along Horizon A, where there is no hydrate and chloride does not show significant deviations from seawater (Fig. 2), these data would be very valuable to evaluate gas content of the fluids.
P & S wave receivers	Natural seismicity and active source experiments

Figure 6. Schematic diagram of the proposed SCIMPI. It consists of a series of modules that would be spaced out with cabled rod of various lengths to allow for positioning of each module at the appropriate depth interval in the hole. Each module will be fitted with electrodes and insulators for resistivity, pore pressure, temperature and P&S wave receivers. Insert shows rationale for each sensor.

The off-the-shelf technology for this instrument is taken from cone penetration test equipment (CPT), which has been routinely used as a site investigation tool for almost 75 years in geotechnical practice. CPTs are used routinely to complement conventional geotechnical drilling and sampling programs both onshore and offshore (e.g. Moran et al., 1989), and have evolved to become a cost-effective means of collecting both geotechnical and environmental data. Our approach is to use CPT technology modified so that the sensor packages are distributed along the full length of each SCIMPI.

Each SCIMPI will consist of a series of modules spaced out with a cabled rod, such that the cabled rod will allow positioning of each module at the appropriate depth interval (Fig. 6). Availability of cabled rods of different lengths will permit assembling of the tool onboard to optimize sensor spacing as indicated by data collected by logging while drilling (LWD) and shipboard analyses of sediment and pore fluid data. The sensors we propose to install along the SCIMPI include: pore pressure transducers, temperature sensors, resistivity probes, and ground motion sensors (geophones or accelerometers). These will be incorporated in the sensor module, and each sensor will have its own microprocessor. Development of this instrumentation is proceeding in connection industrial partners that have a long history of innovative cone penetrometer development and construction of deep-water instrumentation. Additional development of ground motion sensors, which may require separate modules that are decoupled from the main rod to improve coupling with the sediment, is foreseen.

Installation procedures of the SCIMPI are well-suited to the non-riser vessel or any open hole drilling method used by a mission specific platform. A SCIMPI would be installed by: (1) washing to the target penetration depth using slightly weighted drill mud; (2) lowering the SCIMPI observatory to the bottom of the hole (each rod will be screwed together at the surface and hung from the drill floor until the full SCIMPI is assembled) with a latch on the wireline; (3) once at the bottom, the latch will be released during wireline retrieval; and (4) the drill string will be tripped to the surface.

This approach is significantly less expensive or time consuming than a conventional CORK. Moreover, we argue that this is actually a more suitable approach for instrumenting the GHSZ than a conventional CORK for parameters that do not require physical sample return, or exposure to open volumes of fluid, because it is not affected by formation of hydrate within the hole. Preliminary estimates indicate a cost of approximately $320K per SCIMPI, which is significantly less than that of a CORK (ca. $800k - $1M). Funding for the development and fabrication of these instruments is being sought from national funding sources (NSF, Moran-PI), but consultation with IODP engineers is considered critical to the success of the project.

3.3.2 CORK: To complement the SCIMPIs, we propose to install a more traditional cased hole (CORK) observatory in the southern summit region to target flow and biosphere changes associated with Horizon A. Monitoring pressure, temperature and resistivity at this site will be accomplished with sensors installed in the outer casing, thus providing a means of comparing the data collected with this more traditional sealed borehole approach with the those obtained with the proposed SCIMPI instrumentation. The CORK at SHR-2 will permit in situ borehole chemical analysis and microbial incubation, as well as chemical and biological analysis of fluid samples returned to the well-head. We are currently evaluating several approaches to sealed boreholes, including strategies that permit seal manipulation and instrument deployment and retrieval with an ROV. Among ideas to be developed are a threaded device that will cap the hole to prevent circulation with the overlying water, a cable to allow heating of the hole prior to sample recovery in order to remove any hydrate that could prevent opening and removal of the packer and a variety of devices for sample collection and microbial incubation can be installed in the hole. Details of the proposed CORK on HR, however, await efforts that are underway to evaluate various CORK design strategies. A workshop is being planned to discuss the unique challenges and opportunities presented by CORKs in gas hydrate zones, and we plan to participate in this workshop. Other engineering developments include those currently being planned or pursued by MBARI for their MARS-IODP bore hole test site development (IODP 621).

3.3.2.1 Fluid sampling: The existence of a borehole makes possible certain in situ physical meas-

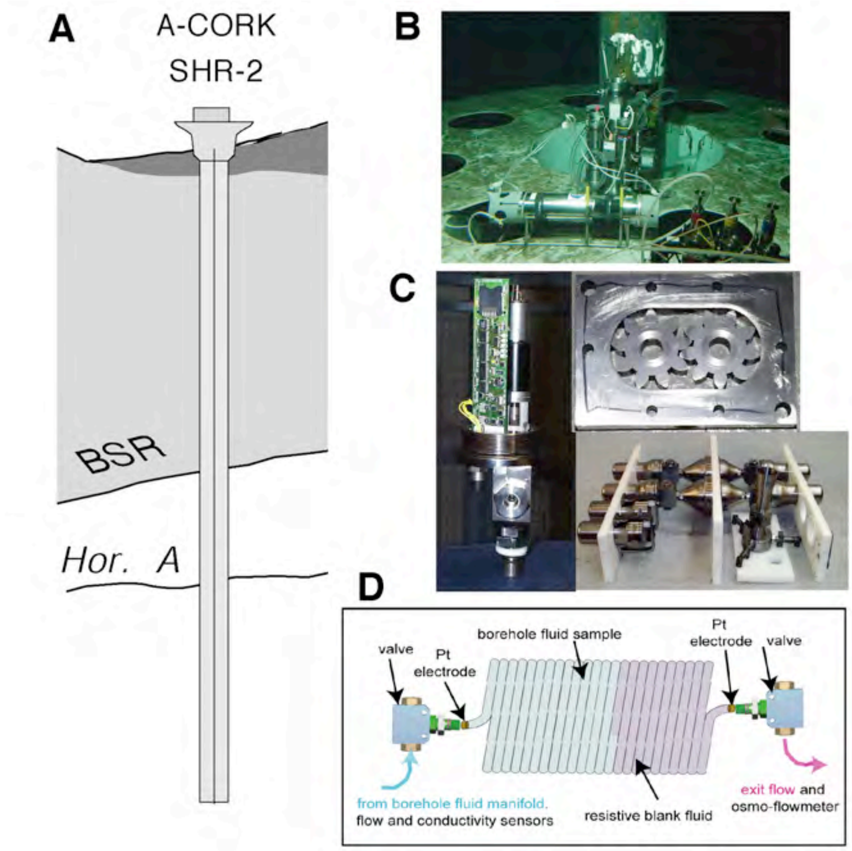


Figure 7. A. Schematic of the proposed CORK installation at Site SHR-2, showing horizons of interest: bottom of the gas hydrate stability zone (BSR), Horizon A and a sediment section deeper than Horizon A. The actual design in terms of number, types and position of packers awaits ongoing efforts aimed at evaluating CORK design strategies in gas hydrate systems. B. Medusa Deployed at ODP Site 1999 – extracting formation fluids from deep biosphere. C. Major systems of new Medusa/DALEX instrument showing (l) interior of each small Ti pressure case with microcontroller and power supply, valve motor/gearbox. (top r) interior of Ti gear pump used to draw fluids through sample manifold (bottom r) two sample bottles with 4 valve control assemblies, sensor head, sensor electronics housing and pump electronics housing assembled into two-bottle Medusa/DALEX configuration. D. Schematic of 400 m-long 1mm inner diameter PTFE spiral-wrapped tubing section of "*spiral sampler*". A similar length and diameter of copper tubing for retaining hydrocarbon gas samples is not shown. The two sampler spirals are connected in parallel to the fluid sample manifold. The inlet and outlet ends of the spiral sampler are fitted with high pressure titanium *isosampler* valves. Each valve is equipped with its own small Ti pressure case, internal controller/data logger board, motor, gearbox and C-cell battery pack. The controller boards have a 24-bit ADC and are designed to carry out accurate and stable "4-wire" resistance measurements. Just inside of each valve, at each end of the spiral sampler tube, a Pt electrode is used to determine the total resistance through the fluid within the full 400 m length of the tube. An electrically resistive "blank" fluid (lavender color – right hand side, in this illustration) is progressively displaced by fluid sample (light green – left hand side) entering the spiral sampler from the fluid sampling manifold. This decreases the resistivity between the electrodes in linear proportion to the amount of fluid displaced. The resistivity of the sample fluids is also measured in the sample manifold before the fluid enters the spiral sampler. The fluid flow rates are also measured by an osmo-flow meter connected to the outlet of the spiral sampler (right hand side, to the right of the valve – not shown here).

urements (e.g. phase characterization), chemical analyses (e.g. Seyfried, et al, 2000) and microbiological studies, and provides a working space in which fluids may be captured for subsequent recovery and analysis. Our own experience and that of others from existing ODP holes (e.g. Schultz, ODP Site 1025C) suggests that high flow rates can result when CORK valves are first opened, and that several days of equilibration may be required before slower flow rates are obtained. It is also possible that regional tectonic/seismic events may lead to abrupt changes in flow regime. A NSF proposal currently under review aims at building and testing a *broadband fluid sensor and sampling instrument* for deployment on HR (Torres, PI). By "broadband" we mean that the physical property sensors and the fluid samplers, will be capable of operating over a broad range of flow rates, from almost purely diffusive (<0.1 m/year) to vigorously advective (up to 1 m/second). This is required because: 1) we will be perturbing the system for a period of time by inserting boreholes; 2) the underlying dynamic range of the flow regime is not well established; 3) there is no firm understanding of the response of the system to regional forcing. No single existing sensor or sampler can accommodate such a broad range of fluid flux rates. We have therefore designed the broadband fluid sampling and flow sensor device, based on available technologies (e.g. osmosampler, Jannasch *et al*, 2004) and available OSU *isosampler* instrument components. Isosampler is a modular instrument developed over the past five years using European and NASA funds, each component of which is a self-contained, network-enabled unit that can be operated independent of any other component, or as part of a modular collection of sensors, high pressure sample bottles, dynamic pressure compensators, valves and pumps.

Although the isosampler system was designed for seafloor use, it can be adapted for downhole use with minor modification. Indeed, the isosampler predecesor (Medusa) was deployed at ODP Site 1025C on the Juan de Fuca flanks in 1999 (Fig. 5) to evaluate temporal variations in borehole effluent temperatures, flow rate, and chemical composition (Flynn 2000). The isosampler system is designed to operate either as part of a networked observatory system or as a standalone device. Ongoing developments of an improved Isosampler-DALEXs system (with funding from NASA) incorporate a flow through sampling chamber that permits coupling to additional instrumentation for in situ analyses. For example, it includes coupling with a ZMAS (ZAPS microanalyzer system) instrument to measure several of the critical parameters associated with fluid flow discharge (e.g. Cl, Ba, dissolved organic matter) using adsorption and fluorescence techniques. Extensive sample collection capabilities will be provided to facilitate calibration and validation of in situ measurements.

We recognize, however, that there are still some engineering issues that need to be addressed. For example, we need to move formation fluids up through the GHSZ to the seafloor, where the samples can be made available for those aspects of processing and analysis that cannot yet be performed down-hole. As fluids are brought up through the GHSZ, we can anticipate that the fluid sample manifolds would become clogged with gas hydrates. We are investigating strategies developed in the gas industry to capture finite fluid volumes through sample manifolds that extend up to the seafloor; by using, for example, heat-conductive tape to inhibit the formation of manifold-clogging hydrates as they pass upward through the GHSZ.

3.3.2.2 Microbial experiments: In many cases, boreholes are the only means by which in situ microbial experiments can be conducted and by which unique data can be collected on deep biosphere processes. To better characterize microbial communities in this deep-biosphere system, we plan to deploy biotraps in the borehole to enrich for organisms, an strategy analogous to that used during the recent drilling on the Juan de Fuca flanks (Leg 301). Biotraps are solid, porous spheres made of inert material that permit microbes to become attached and subsequently sampled for microbial characterization.

In addition to biotrap samplers, isosampler instrumentation allows for fluid collection in the borehole using multiple strategies. For example, fluids can be captured in duplicate spirals (Fig. 7D), one of which could be fixed for future microbial analyses while samples in a companion spiral can be left pristine (or acidified) for chemical measurements. The system capabilities also allow for microbial incubations of samples collected at the well-head during periodic scheduled visits to the site, as well as in response to system perturbations (e.g. earthquakes). Sampling following a perturbation may include several visits over 7 to 10 days. Fluids will be pumped to the seafloor and collected in individual chambers for either immediate retrieval for community characterization, or capture in dynamic pressure compensation chambers. These can be coupled with high-pressure bacterial cultivation and isolations system (e.g. HYACINTH) currently under development with funding from the UK NERC for activity measurements under in situ conditions (J. Parkes, pers. comm., 2005). Analyses of the fluids collected in these visits can thus be used to evaluate how microbial communities and fluid chemistry in hydraulically connected intervals (Horizon A) compare with communities and chemistries in other intervals that are less-well connected. The proposed use of heat-tape to permit transport of fluids through the GHSZ, will not involve increasing the in-situ temperature, rather the tape will maintain the temperature at that of the collection depth beneath the GHSZ. In addition to these strategies, a pending NASA proposal (Flynn PI) includes funds for integrating isosampler capabilities to a fluorescence microbial detection system (L. Powers, Utah State). There are a variety of compounds that are indicative of life and offer a fluorescent response appropriate for analytical determination. L. Powers (Powers, 1999, Shear, 1996) has developed and patented a technique to detect intrinsic metabolites present during cellular respiration; and research is underway for the in-situ detection of various intrinsic fluorophores. Although the prototype being considered by NASA is designed for seafloor use, the tool can be modified to allow for deployment in a borehole, such as the one proposed here, where the changes in temperature are not extreme. This development will permit continuous monitoring of fluids along the horizons of interest and any changes in response to system perturbations. We are aware that some of these technologies will not be ready for deployment in the early stages of this program; however, having access to a CORKed borehole facility will permit emplacement of new instrumentation as it becomes available.

3.3.3 Seismic observatory

SCIMPIS will include ground motion sensors in targeted regions of the subsurface, including Horizon A and the region of massive gas hydrate near the seafloor at SHR-2 and SHR-3. In addition to providing data to monitor regional and local earthquakes, other sources of naturally occurring ground motion could be recorded. These may include vibrations excited by fluid flow in conduits analogous to those observed in volcanic and hydrothermal regions (e.g. Molina et al., 2004; Kumagi and Chouet, 2000). We also allow for repeated active source experiments to monitor changes in the amount of gas and gas hydrate averaged over a larger volume around the borehole.

3.3.3.1 Passive seismic experiments: For the passive seismic experiment, geophones within SCIMPI will record data continuously at a sampling rate of 50-250 Hz in the seafloor data acquisition package (which may eventually be replaced by a real-time data link). Data will be recovered annually, and ground motion resulting from earthquakes and other sources will be identified. For larger events that are also recorded onshore (magnitude threshold ~2.5 for regional events from the Cascadia margin), data will be combined with those from onshore seismic arrays to improve hypocenter and source mechanism determinations, to enhance our capabilities of locating continental margin earthquakes (Braunmiller et al. (1997). These data will be used to evaluate the impact of seismic activity on the plumbing system feeding gas hydrate formation and on disruption and destabilization of hydrate near the seafloor. Subseafloor observatory data from future events in this region is also be critical for evaluating seismic hazards in this region.

Continuous seismic recording will also indicate whether smaller, local earthquakes and non-tectonic acoustic emissions are occurring. Both types of events may be related to fluid flow. The sub-seafloor array geometry in multiple boreholes will permit application of beam-forming techniques to increase location resolution. It should also result in better signal-to-noise ratio compared to seafloor seismometers (Collins et al., 1998; Duennebier et al., 2002). The SCIMPI approach should provide good borehole/geophone coupling, compared to open borehole installations where fluid flow within the borehole has been a problem. However, it may be necessary to develop separate ground motion sensor modules that are mechanically decoupled from the other elements of the SCIMPI.

3.3.3.2. Active source seismic experiments: Active source seismic experiments will be proposed to NSF-IODP, to be conducted every few years during annual service runs. These will include sources within the water column and within a cased borehole installed to allow subsurface seismic and electromagnetic sources and will require that the recording parameters of the ground motion sensors in the SCIMPIS be changed to allow a much higher sampling rate of 0.5-1 ms. This will require either resetting the program in the seafloor recording package prior to starting the experiment or redirecting the output of the SCIMPI geophones to a shipboard acquisition package for the experiment. The latter option is preferable because it will allow for real-time quality control of the data.

A variety of different experiment geometries can be obtained using shots in the water column and ground motion sensors in the SCIMPIs. Shots using a GI-gun source that is fired along walk-away lines and in a series of circles of different radius around the borehole will be used to detect temporal variations in the amplitude versus offset and attenuation of seismic energy in Horizon A and thus map temporal and spatial changes in gas distribution within this conduit. It is possible that seismic waves representing energy trapped within this low velocity layer will also be recorded. Similar shot patterns recorded on sensors within the massive hydrate zone at the summit will be used to detect changes in the thickness of this zone and in the position of migrating free gas using travel-time tomography to map patchy changes in velocity.

Borehole shots should produce higher frequency, higher resolution data along sections that are embedded within the lower resolution volumes imaged using sources in the water column. For example, sources and receivers within Horizon A can be used to record high frequency trapped waves within this low velocity zone. Repeated cross-borehole travel-time tomography coupled with reflection imaging between boreholes placed 10s to a few 100 m apart has been proved to be a successful tool for monitoring the temporal evolution of aquifers, hydrocarbon reservoirs, and CO_2 injections sites (e.g. Harris et al., 1995; Lazaratos et al., 1995; Mathisen et al., 1995; Liberty et al., 2000). Sparkers and piezoelectric sources that generate frequencies of 400 Hz or higher are available for use downhole (e.g. Rechtien et al., 1993; Harris et al., 1995).

The infrastructure required to permit downhole seismic sources may also be used, in the future, to support the development of seafloor cross-borehole electromagnetic tomography (Wilt, et al, 1995). This is a method developed for terrestrial use at Lawrence Livermore National Laboratory in the 1970s, and more recently by groups including Sandia National laboratory, in which multi-MHz EM signals ("radar" frequencies) are used to determine the electrical resistivity structure in a cross-borehole and borehole-to-surface configuration, using downhole sources and downhole or surface-based receivers (Borns et al, 1993; Lane et al, 2004). A lower frequency variant has been developed in the kHz frequency range, by researchers at UC, Berkeley and the Berkeley Laboratories (Wilt et al, 1995), for greater separation between borehole (up to 1 km). The method has been applied successfully in terrestrial settings to imaging the advection/diffusion of sub-surface plume from groundwater contaminates with spatial resolution better than 1 m, and to oil field reservoir characterization efforts including monitoring of salt water injection plumes. The cross-borehole EM tomographic method is sensitive to changes in porosity, fluid saturation, permeability, and pore fluid chemistry (e.g. salinity), and provides complementary data to that determined from seismic tomography.

The installation of the open legacy hole will provide access to a volume of borehole for future observatory instrumentation and expansion. We note this is consistent with the rationale behind legacy installation during ODP.

3.3.4 Power sources and requirements:

3.3.4.1 SCIMPIS: Signals from each of the sensors will be transmitted through the central cable running inside the rods and recorded by a computer acquisition and battery power pack rod located on the seafloor. The design of the power/data-rod will be modular with a wet connect at the power/signal cable termination so that the package can be removed and replaced by new power/data-package. For a year of operation, we anticipate a power requirement of ~130-200W per SCIMPI, which can be supplied with seafloor battery packages. We propose to have the drill ship install the SCIMPI and follow this with a visit by an ROV to deploy the data logger on the seafloor next to the well-head and connect it to the SCIMPI. One option would be to have an autonomous data logger/controller at the head of every borehole; however, this approach can present clock synchronization and drift problems that would limit the accuracy by which seismic events can be correlated among SCIMPIs. Another approach is to use an ROV to lay a network of seafloor cables to interconnect each well-head's data controller to a common data concentrator. This minimizes the synchronization problems and is a necessary step to connect the grid to a possible future seafloor cabled observatory. Funding for such networked infrastructure will be sought from sources external to IODP. The ROV cable laying equipment required to plug into the well-heads, and to run cables to a common hub already exists at MBARI. Our initial implementation plan calls for use of interconnected systems with internal power, with the capability of logging autonomously, and in the future connecting with an ORION science node. A proposal (Trehu, PI) will be submitted to the upcoming RFA to site an ORION node on HR.

3.3.4.2 Fluid sampling: We plan to use resistive heating tape around insulated fluid sample manifolds to avoid hydrate formation during episodes of fluid sampling. The heaters can operate continuously, if sufficient power is available, (as above, in cable observatory mode) or episodically (if powered by local batteries), to defrost the sample manifolds at those times fluid samples are drawn. We estimate the power needed to raise the temperature of fluid within an insulated 6mm diameter tube by 10 degrees to be on the order of 100 W, depending on depth to the CORK formation fluid sampling port. Fluids will be pumped from the sampling depths to the seafloor using a pump located at the seafloor. This is in contrast to low rate osmotic pumps, which continuously extract small volumes of fluid sample. Our requirements call for a controllable rate, on/off switchable pump capable of higher peak flow rates when needed. One candidate technology is a titanium gear pump design first developed for the Isosampler/DALEX instrument, but modified to provide a longer duty cycle between service calls. This type of design has advantages over other current active pump candidates because of its modest power requirements, making it suitable for operation by local battery supplies, although alternative pump designs will be considered as part of the final system design review. For the gear pump design, power consumption depends on pumping speed, and we estimate that 6W will yield 3 liters per minute through the sample manifold. For multiple pumps at various pumping rates we estimate needing 6-10 W for continuous operation.

To keep the samples from freezing within the insulated and pressurized titanium sample chambers developed for Isosampler/DALEX (volumes as large as 1 liter may be kept under pressure within any single sample chamber), we will need to expend in the region of 1-5 W continuously, for a total of approximately 7-15 W. The power requirement will be reduced significantly if the system is not run continuously, but instead an episodic sampling protocol is implemented. Several options to supply this power to the system are being evaluated. Options being considered are the use of a large seafloor battery pack, a surface buoy that can supply power (MBARI and other groups are currently developing these), and episodic sampling using power supplied by ROV landings on the well head until such times as a cable is run from a junction box to an ORION cable node.

3.3.5 Post-drill plans:

Immediately after the drill ship installs the subseafloor instruments, we plan a ROV visit to the site to connect instruments to the data loggers. Following this initial trip, we plan annual visits to the observatories to retrieve samples and data and to change batteries; however, two visits to the site may be needed during the first year of operation. A spring visit will make possible implementation during the late summer of engineering improvements and repairs found to be necessary during the spring visit. Following this initial period, annual visits would be scheduled during the duration of the experiment, which we envision to last for 5 to 10 years. Although a more frequent schedule might be attractive, there are financial and logistic reasons (including a short weather window), which make it difficult to currently plan for more than one visit per year. Fortunately, proximity of the site to shore (50 miles from Newport, OR) makes relatively rapid response and engineering interdiction feasible by coastal and open-ocean class vessels.

3.4 DRILLING STRATEGY

The proposed drilling strategy is detailed in Table 1, which summarizes the experiment design and planned instrumentation. Leg 204 proved the value of logging while drilling (LWD) data to provide a first look at the sub-seafloor structure. This early arrival of data was critical for planning the rest of the leg. Because of significant lateral heterogeneity (Trehu et al., 2003), we propose to repeat this approach, obtaining LWD data within 5-10 m of the proposed SCIMPI and

CORK sites to identify regions of rapid change in physical properties prior to coring (except as minimally required to ensure safety) and observatory installation. This approach will provide high-quality porosity and density (ADN) logs and various resistivity measurements, including gamma radiation at the bit (RAB), to pinpoint gas and gas hydrate bearing zones. Following the LWD operations, a second hole will be cored, sampled and logged to define fine scale variability of chemical and physical properties at the horizons of interest. Installation of the SCIMPIs will follow. The final step in our drilling plan is installation of the CORK and of a cased legacy hole for subsurface seismic and electromagnetic sources.

3.5 Drilling conditions, safety conditions and time estimates

The target depths are all within reach of APC/XCB drilling. Target lithologies are primarily clays with silty turbidites that posed no drilling problems during Leg 204. Massive hydrate occurs near the seafloor at proposed sites SHR-2 and SRH-3. Recovery (and preservation) of the hydrate is sometimes difficult; however, we foresee no problems with drilling and stabilizing SCIMPIS in these sediments. At the summit sites, there exists the possibility of hydrogen sulfide hazards; however this challenge was efficiently met during Leg 204 drilling by following IODP safety protocols during the periods of possible hydrogen sulfide discharge. A similar approach will be used in the proposed program. The proposed penetration at each site is similar to that drilled during Leg 204.

Preliminary time estimates are based on time requirements to complete coring, logging and CORK installation in previous drilling programs on HR, plus estimates of time required for SCIMPI installations. The SCIMPIS installations to 300 m are conservatively estimated to take 4 days each, and 3 days are estimated for SCIMPIS to 90 mbfs. These estimates assume continuous coring to TD, and a maximum of 24 hours for deployment of the SCIMPI. We have allocated 5 days for logging while drilling, 10 days for additional coring and wireline logging, 32 days for SCIMPI installation, 7 days for CORK installation on the ridge summit, and 5 days to drill and case a hole for seismic and electromagnetic sources. This schedule results in a total of 59 days on site. Transits to/from Victoria, BC add 1.5 days to the expedition.

4. SITE SURVEY DATA

The proposed drilling sites lie within the 3D survey conducted prior to Leg 204, which is currently in the ODP data-base. Temperature data were collected downhole during Leg 204. In addition, preliminary analysis of shallow temperature data acquired by MBARI in 2000 was conducted by Trehu, and a report will be submitted to the SSP. A preliminary active source EM survey (using 25 EM receivers and a deep-tow horizontal electric dipole signal source) along the E-W transect formed by sites 1245, 1246, 1244 and 1252 was conducted Constable & Key of Scripps Institution of Oceanography, with the participation of one of this project's proponents (A. Schultz) during August 2004. These data are currently being processed to incorporate navigation data. Proposals to acquire additional heat flow and electromagnetic data in this region have been submitted to NSF and NURP. In addition, we plan to compile all existing data on the ridge summit (submersible, camera tow, seafloor reflectivity) into an integrated GIS database that will allow us to best place SCIMPI sites at the ridge summit.

5. SUMMARY PLAN

A summary of the proposed experiments, including various engineering tasks that need to be completed before drilling, is given in Table 2

Table 2: Summary plan

Task	Component	Technology developing needs	Proposed funding sources
Coring and LWD at 6 sites		none	IODP
SCIMPIS	Sensor module & cabled rod	Adaptation of CPT technology to downhole use	Proposals will be submitted to NSF and NASA (K.Moran)
	Seafloor data loggers	Spider web network and single data logger	System engineering is being pursued by MBARI. Cable costs for this facility will be requested from NSF-IODP
CORK	Pre-perforated casing for a 200 m hole	none	IODP
	Sensors for outside casing	minimal	NSF-IODP
	Mechanical, ROV-removable seal	Seal design and ROV compatibility	Pending results of planned IODP workshop on this topic, funding would be requested from NSF-IODP
	Bio-traps	minimal	
	Broadband sampler/sensor	Proposal submitted	NSF (M. Torres)
	Seafloor instrumentation for in situ monitoring		NASA (M. Flynn)
	Capabilities for sample collection and redeployment by ROV		Major theme of IODP engineering bore hole test facility (proposal 621 Paull et al.)

6. VISON FOR FUTURE INSTALLATIONS ON HYDRATE RIDGE.

6.1 THE NEPHOS OBSERVATORY

The proposed drilling program has specific objectives and targets a well-characterized, highly dynamic environment on southern HR. The experimental design will allow us to monitor the long-term variations in the parameters that determine flow and the geochemical and microbiological response of the system. This information will be extremely valuable in moving forward with our understanding of hydrate-bearing provinces in active margins.

In addition, the proposed observatory has also been conceived within a larger, multidisciplinary and staged program to develop a North East Pacific Hydrate Observatory System (NEPHOS). The goal of this larger observatory concept is to acquire contemporaneous and correlative data critical to understanding the processes associated with gas hydrate dynamics. The NEPHOS ultimate (long-term) goal is the development of a comprehensive model of carbon cycling in gas hydrate bearing accretionary margins, which will be consistent with chemical, microbiological and physical data and that can be used to predict the response of these systems to oceanic and tectonic perturbations.

The NEPHOS observatory is based on a comprehensive strategy that includes continuous monitoring of water column and seafloor parameters in an area of known surface manifestations of fluid venting and hydrate deposits, linked to borehole monitoring of the methane reservoir, transfer zones and gas hydrate stability zone. The step-wise approach needed to implement NEPHOS will require several expeditions to the area, building incrementally on progress made. The results of the proposed experiment on SHR, will be extremely valuable to future IODP efforts in the area, which are part of the conceptual NEPHOS observatory. These include: 1) Boreholes on NHR; 2) Hydrologic experiments between two holes (most likely at SHR-1 after hydrological characterization is completed based on SCIMPI data); and 3) Gas hydrate perturbation experiments.

Development of some of the seafloor components of the observatory are underway through research funded by UK-NERC, industry and NASA (leveraging a total instrumentation development investment exceeding $ 1M thus far), and future studies are being proposed to NSF, NOAA-NURP and NASA (http://amesnews.arc.nasa.gov/releases/2004/medusa/medusa.html) in a coordinated effort between OSU, URI and MBARI (http://www.mbari.org/mars/Default.html). NASA interest in this program has been enhanced by the recent discovery of methane and water in MARS. In addition, plans are underway for cooperative efforts with Germany (IFM-Geomar, and the University of Bremen) and England (Cardiff University).

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IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New [ ] Revised [X]

Section A: Proposal Information

Title of Proposal:	Tectonic and oceanographic controls on of fluid flow, and their impact on gas hydrate and biosphere processes on southern Hydrate Ridge.
Date Form Submitted:	1 Oct. 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Changes in hydrology, microbiology and chemistry in response to forcing along Horizon A, a high permeability horizon that supplies methane gas to the GHSZ. This is a priority 1 site.
List Previous Drilling in Area:	ODP Leg 204

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SHR-1 (ODP Site 1247)	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Oregon margin
Latitude:	Deg: 44°	Min: 34.6'N	Jurisdiction:	US
Longitude:	Deg: 125°	Min: 9.0'N	Distance to Land:	50 miles
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: 1	Alt:	Water Depth:	845 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	300 What is the total sed. thickness? 2000 m	none
		Total Penetration: 300 m
General Lithologies:	clay with sand/silt turbidites	
Coring Plan: *(Specify or Circle)*	APC and XCB to 300 m. PCS as needed. Installation of 4 SimCORKS* (2 of the SimCORKs have priority 1) [x] 1-2-3-APC , [x] XCB, [x] PCS, ** Systems Currently Under Development*	

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity [x]	Borehole Televiewer	Formation Fluid Sampling [x]	Density-Neutron [x]
Litho-Density [x]	Nuclear Magnetic Resonance [x]	Borehole Temperature & Pressure [x]	Resistivity-Gamma Ray [x]
Gamma Ray [x]	Geochemical [x]	Borehole Seismic [x]	Acoustic [x]
Resistivity [x]	Side-Wall Core Sampling [x]		
Acoustic [x]			
Formation Image [x]		Others ( )	Others ( )

Max.Borehole Temp. :	*Expected value (For Riser Drilling)* 20 °C
Mud Logging: *(Riser Holes Only)*	Cuttings Sampling Intervals from m to m, m intervals from m to m, m intervals *Basic Sampling Intervals: 5m*
Estimated days:	Drilling/Coring/SimCORK installation: 15 | Logging: 2 | Total On-Site: 17
Future Plan:	**Longterm Borehole Observatory**

Hazards/ Weather:

Please check following List of Potential Hazards			*What is your Weather window? (Preferable period with the reasons)*
Shallow Gas [x]	Complicated Seabed Condition	Hydrothermal Activity	July-August best June-Sept. OK
Hydrocarbon [x]	Soft Seabed	Landslide and Turbidity Current	
Shallow Water Flow	Currents	Methane Hydrate [x]	
Abnormal Pressure	Fractured Zone	Diapir and Mud Volcano	
Man-made Objects	Fault	High Temperature	
H_2S [x]	High Dip Angle	Ice Conditions	
CO_2			

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-1	Date Form Submitted: Oct 13, 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time only) Hydrate Ridge 3D survey 2000, in ODP Leg 204 database Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) Regional deep reflection/refrraction-based model within 15 km (published in Trehu et al., 1994; Gerdom et al., 2000) Crossing Lines(s):
3	Seismic Velocity†		X	OBS survey done with 3D reflection survey in 2000. 3D tomographic model in ODP Leg 204 database
4	Seismic Grid		X	see 1
5a	Refraction (surface)		X	see 3
5b	Refraction (near bottom)			NA
6	3.5 kHz			Location of Site on line (Time) NA
7	Swath bathymetry		X	In Leg 204 database
8a	Side-looking sonar (surface)		X	In Leg 204 database (from MBARI 1998 cruise)
8b	Side-looking sonar (bottom)		X	In Leg 204 database (see also Johnson et al., 2003)
9	Photography or Video			NA
10	Heat Flow		X	ODP Leg 204, Site 1247
11a	Magnetics			regional available but not relevant (see Fleming and Trehu, 1999)
11b	Gravity			regional available but not relevant (see Fleming and Trehu, 1999)
12	Sediment cores		X	Leg 204, Site 1247
13	Rock sampling			NA
14a	Water current data		X	general current data available in NOAA buoy database
14b	Ice Conditions			NA
15	OBS microseismicity			NA
16	Navigation			? - navigation is available for all data cited above.
17	Other			NA

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-1	Date Form Submitted: Oct. 13, 2004
Water Depth (m): 845	Sed. Penetration (m): 300	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No X ☐
Are high temperatures expected at this site? Yes ☐ No X
Are there any other special requirements for logging at this site? Yes ☐ No X ☐
If "Yes" Please describe requirements:____

What do you estimate the total logging time for this site to be: 2 days __________________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	all logs will be used to determine gas hydrate distribution and concentrations	2
Litho-Density		2
Natural Gamma Ray		2
Resistivity-Induction		2
Acoustic		1
FMS		2
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		1
Resitivity-Gamma Ray (LWD)		1
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	SimCORKS: sensors for resistivity, temperature, pore pressure, P&S wave receivers for fluid flow monitoring fluid flow, salinity, gas content, natural seismicity and active source experiments	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New **X** ☐ *Revised* ☐

Proposal #: 635-full	Site #: SHR-1	Date Form Submitted: Oct. 13, 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	APC to refusal. XCB when needed
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	Expect to encounter gas hydrate lenses from 40 to 112 mbsf based on results from Leg 204 Sediments should be primarily clay with some silt and fine sand turbidite layers. 2-4 mt hick coarse-grained layer (Horizon A) at 162 mbsf Age < 1.6 Ma above 160 mbsf, 1.6-1.7 Ma below 160 mbsf Sedimentation rate 4-22 cm/ky above 160 mbsf, unconstrained below 160 mbsf
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no commercial drilling in the region.
4	Are there any indications of gas hydrates at this location?	yes
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	yes (gas hydrates). Higher accumulations within Horizon A as observed during leg 204
6	What "special" precautions will be taken during drilling?	We will follow procedures established during ODP Leg 204.
7	What abandonment procedures do you plan to follow:	We will follow procedures established during ODP Leg 204.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	None
9	Summary: What do you consider the major risks in drilling at this site?	No significant risks as long as we follow procedures established during ODP Leg 204.

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-1	Date Form Submitted: Oct. 13, 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (cm/kyr)*	*Comments*
124 mbsf 162 mbsf	BSR Horizon A	<1.6 Ma above 160 mbsf, 1.6-1.7 Ma below 160 mbsf	1.6	clay with minor silt and fine sand. 2-4 m coarse sand layer (Horizon A) at 162 mbsf	slope basin and trench	4-22 cm/ky above 160 mbsf, unconstrained below 160 mbsf	based on results from ODP Site 1247

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New [ ] Revised [X]

Section A: Proposal Information

Title of Proposal:	Tectonic and oceanographic controls on of fluid flow, and their impact on gas hydrate and biosphere processes on southern Hydrate Ridge.
Date Form Submitted:	1 Oct. 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Changes in hydrology, microbiology and chemistry in areas where gas hydrate occurs as large deposits near the seafloor. Controls and mechanisms regulating methane flux below the GHSZ, within the GHSZ and at the seafloor. Nature of convective flow due to highly saline fluids near the seafloor, and effects on shallow hydrology and microbiology.
List Previous Drilling in Area:	ODP Leg 204

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SHR-2 (ODP Site 1250)	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Oregon margin
Latitude:	Deg: 44°	Min: 34.1'N	Jurisdiction:	US
Longitude:	Deg: 125°	Min: 9.0'N	Distance to Land:	50 miles
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: 1	Alt:	Water Depth:	807 m

Section C: Operational Information

	Sediments		Basement
Proposed Penetration: (m)	200		none
	What is the total sed. thickness? 2000 m		
			Total Penetration: 200 m
General Lithologies:	clay with sand/silt turbidites		
Coring Plan: *(Specify or Circle)*	APC and XCB to 200 m. PCS as needed. Cased re-entry open hole for seismic and electromagnetic sources. Installation of 1 SimCORK* and 1 Conventional CORK. [x] 1-2-3-APC , [x] XCB, [x] PCS, ** Systems Currently Under Development*		

Wireline Logging Plan:	Standard Tools	Special Tools		LWD
	Neutron-Porosity [x]	Borehole Televiewer	Formation Fluid Sampling [x]	Density-Neutron [x]
	Litho-Density [x]	Nuclear Magnetic Resonance [x]	Borehole Temperature & Pressure [x]	Resistivity-Gamma Ray [x]
	Gamma Ray [x]	Geochemical [x]	Borehole Seismic [x]	Acoustic [x]
	Resistivity [x]	Side-Wall Core Sampling [x]		
	Acoustic [x]			
	Formation Image [x]		Others ( )	Others ( )

Max.Borehole Temp. :	*Expected value (For Riser Drilling)* 20 °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from	m	to	m,		m intervals
from	m	to	m,		m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring/SimCORK/ CORK and open cased hole: 15	Logging: 2	Total On-Site: 17

Future Plan: Longterm Borehole Observation. Fluid and microbiological sampling, cross-hole tomography

Hazards/ Weather:

Please check following List of Potential Hazards			*What is your Weather window? (Preferable period with the reasons)*
Shallow Gas [x]	Complicated Seabed Condition	Hydrothermal Activity	July-August best June-Sept. OK
Hydrocarbon [x]	Soft Seabed	Landslide and Turbidity Current	
Shallow Water Flow	Currents	Methane Hydrate [x]	
Abnormal Pressure	Fractured Zone	Diapir and Mud Volcano	
Man-made Objects	Fault	High Temperature	
H_2S [x]	High Dip Angle	Ice Conditions	
CO_2			

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-2	Date Form Submitted: Oct 13, 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time only) Hydrate Ridge 3D survey 2000, in ODP Leg 204 database Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) Regional deep reflection/refrraction-based model within 15 km (published in Trehu et al., 1994; Gerdom et al., 2000) Crossing Lines(s):
3	Seismic Velocity†		X	OBS survey done with 3D reflection survey in 2000. 3D tomographic model in ODP Leg 204 database
4	Seismic Grid		X	see 1
5a	Refraction (surface)		X	see 3
5b	Refraction (near bottom)			NA
6	3.5 kHz			Location of Site on line (Time) NA
7	Swath bathymetry		X	In Leg 204 database
8a	Side-looking sonar (surface)		X	In Leg 204 database (from MBARI 1998 cruise)
8b	Side-looking sonar (bottom)		X	In Leg 204 database (see also Johnson et al., 2003)
9	Photography or Video			NA
10	Heat Flow		X	ODP Leg 204, Site 1250
11a	Magnetics			regional available but not relevant (see Fleming and Trehu, 1999)
11b	Gravity			regional available but not relevant (see Fleming and Trehu, 1999)
12	Sediment cores		X	Leg 204, Site 1250
13	Rock sampling			NA
14a	Water current data		X	general current data available in NOAA buoy database
14b	Ice Conditions			NA
15	OBS microseismicity			NA
16	Navigation			? - navigation is available for all data cited above.
17	Other			NA

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-2	Date Form Submitted: Oct. 13, 2004
Water Depth (m): 807	Sed. Penetration (m): 200	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No X ☐
Are high temperatures expected at this site? Yes ☐ No X
Are there any other special requirements for logging at this site? Yes ☐ No X ☐
If “Yes” Please describe requirements:______________________________

____

What do you estimate the total logging time for this site to be: 1 days ______________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	all logs will be used to determine gas hydrate distribution and concentrations	2
Litho-Density		2
Natural Gamma Ray		2
Resistivity-Induction		2
Acoustic		1
FMS		2
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		1
Resitivity-Gamma Ray (LWD)		1
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	SimCORKS: sensors for resistivity, temperature, pore pressure, P&S wave receivers for fluid flow monitoring fluid flow, salinity, gas content, natural seismicity and active source experiments	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New **X** ☐ *Revised* ☐

Proposal #: 635-full	Site #: SHR-2	Date Form Submitted: Oct. 13, 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	APC to refusal. XCB when needed (for massive hydrate)
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	Expect to encounter massive hydrate in the upper 25 mbsf, and gas hydrate lenses from 25 to 112 mbsf based on results from Leg 204 Sediments should be primarily clay with some silt and fine sand turbidite layers. Age < 1.0 Ma above 80 mbsf, 1.0-1.6 Ma below 80 mbsf Sedimentation rate 3-15 cm/ky above 80 mbsf, >100 cm/ky below 80 mbsf
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no commercial drilling in the region.
4	Are there any indications of gas hydrates at this location?	yes
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	yes (gas hydrates). Higher accumulations within Horizon A as observed during leg 204
6	What "special" precautions will be taken during drilling?	We will follow procedures established during ODP Leg 204.
7	What abandonment procedures do you plan to follow:	We will follow procedures established during ODP Leg 204.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	None
9	Summary: What do you consider the major risks in drilling at this site?	No significant risks as long as we follow procedures established during ODP Leg 204.

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-2	Date Form Submitted: Oct. 13, 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (cm/kyr)*	*Comments*
112 mbsf 150 mbsf	BSR Horizon A	<1.6 Ma above 80 mbsf, 1.6-1.7 Ma below 80 mbsf	1.6	clay with minor silt and fine sand. 2-4 m coarse sand layer (Horizon A) at 150 mbsf	slope basin and trench	3-15 cm/ky above 80 mbsf, >100 cm/kyr below 80 mbsf	based on results from ODP Site 1250

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New [ ] **Revised** [X]

Section A: Proposal Information

Title of Proposal:	Tectonic and oceanographic controls on of fluid flow, and their impact on gas hydrate and biosphere processes on southern Hydrate Ridge.
Date Form Submitted:	1 Oct. 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Changes in hydrology, microbiology and chemistry in areas where gas hydrate occurs as large deposits near the seafloor, driven by migration of methane in the gas phase. Controls and mechanisms regulating methane flux below the GHSZ, within the GHSZ and at the seafloor. Nature of convective flow due to highly saline fluids near the seafloor, and effects on shallow hydrology and microbiology.
List Previous Drilling in Area:	ODP Leg 204

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SHR-3 (ODP Site 1249)	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Oregon margin
Latitude:	Deg: 44°	Min: 34.2'N	Jurisdiction:	US
Longitude:	Deg: 125°	Min: 8.8'N	Distance to Land:	50 miles
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: 1	Alt:	Water Depth:	788 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	90 What is the total sed. thickness? 2000 m	none
		Total Penetration: 90 m

General Lithologies:	clay with sand/silt turbidites	
Coring Plan: *(Specify or Circle)*	APC and XCB to 90 m. PCS as needed. Installation of 3 SimCORKs * [x] 1-2-3-APC , [x] XCB, [x] PCS, ** Systems Currently Under Development*	

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity [x]	Borehole Televiewer	Formation Fluid Sampling [x]	Density-Neutron [x]
Litho-Density [x]	Nuclear Magnetic Resonance [x]	Borehole Temperature & Pressure [x]	Resistivity-Gamma Ray [x]
Gamma Ray [x]	Geochemical [x]	Borehole Seismic [x]	Acoustic [x]
Resistivity [x]	Side-Wall Core Sampling [x]		
Acoustic [x]			
Formation Image [x]		Others ( )	Others ( )

Max.Borehole Temp. : *Expected value (For Riser Drilling)* 20 °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring/SimCORK installation: 8	Logging: 1	Total On-Site: 9

Future Plan: Longterm Borehole Observation

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas [x]	Complicated Seabed Condition	Hydrothermal Activity
Hydrocarbon [x]	Soft Seabed	Landslide and Turbidity Current
Shallow Water Flow	Currents	Methane Hydrate [x]
Abnormal Pressure	Fractured Zone	Diapir and Mud Volcano
Man-made Objects	Fault	High Temperature
H_2S [x]	High Dip Angle	Ice Conditions
CO_2		

What is your Weather window? (Preferable period with the reasons)

July-August best
June-Sept. OK

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-3	Date Form Submitted: Oct 13, 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time only) Hydrate Ridge 3D survey 2000, in ODP Leg 204 database Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) Regional deep reflection/refrraction-based model within 15 km (published in Trehu et al., 1994; Gerdom et al., 2000) Crossing Lines(s):
3	Seismic Velocity†		X	OBS survey done with 3D reflection survey in 2000. 3D tomographic model in ODP Leg 204 database
4	Seismic Grid		X	see 1
5a	Refraction (surface)		X	see 3
5b	Refraction (near bottom)			NA
6	3.5 kHz			Location of Site on line (Time) NA
7	Swath bathymetry		X	In Leg 204 database
8a	Side-looking sonar (surface)		X	In Leg 204 database (from MBARI 1998 cruise)
8b	Side-looking sonar (bottom)		X	In Leg 204 database (see also Johnson et al., 2003)
9	Photography or Video			NA
10	Heat Flow		X	ODP Leg 204, Site 1249
11a	Magnetics			regional available but not relevant (see Fleming and Trehu, 1999)
11b	Gravity			regional available but not relevant (see Fleming and Trehu, 1999)
12	Sediment cores		X	Leg 204, Site 1249
13	Rock sampling			NA
14a	Water current data		X	general current data available in NOAA buoy database
14b	Ice Conditions			NA
15	OBS microseismicity			NA
16	Navigation			? - navigation is available for all data cited above.
17	Other			NA

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-3	Date Form Submitted: Oct. 13, 2004
Water Depth (m): 788	Sed. Penetration (m): 90	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No X ☐

Are high temperatures expected at this site? Yes ☐ No X

Are there any other special requirements for logging at this site? Yes ☐ No X ☐

If "Yes" Please describe requirements:__________

What do you estimate the total logging time for this site to be: 1 days __________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	all logs will be used to determine gas hydrate distribution and concentrations	2
Litho-Density		2
Natural Gamma Ray		2
Resistivity-Induction		2
Acoustic		1
FMS		2
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		1
Resitivity-Gamma Ray (LWD)		1
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP	CORK-Packer: sample fluids for chemistry and microbiology SimCORKS: sensors for resistivity, temperature, pore pressure, P&S wave receivers for fluid flow monitoring fluid flow, salinity, gas content, natural seismicity and active source experiments	1

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-3	Date Form Submitted: Oct. 13, 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	APC to refusal. XCB when needed (for massive hydrate)
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	Expect to encounter massive hydrate in the upper 25 mbsf, and gas hydrate lenses from 25 to 90 mbsf based on results from Leg 204 Sediments should be primarily clay with some silt and fine sand turbidite layers. Age < 1.0 Ma above 80 mbsf, 1.0-1.6 Ma below 80 mbsf Sedimentation rate 3-15 cm/ky above 80 mbsf, >100 cm/ky below 80 mbsf
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no commercial drilling in the region.
4	Are there any indications of gas hydrates at this location?	yes
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	yes (gas hydrates)
6	What "special" precautions will be taken during drilling?	We will follow procedures established during ODP Leg 204.
7	What abandonment procedures do you plan to follow:	We will follow procedures established during ODP Leg 204.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	None
9	Summary: What do you consider the major risks in drilling at this site?	No significant risks as long as we follow procedures established during ODP Leg 204.

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-3	Date Form Submitted: Oct. 13, 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (cm/kyr)*	*Comments*
115 mbsf	BSR	<1.6 Ma above 80 mbsf, 1.6-1.7 Ma below 80 mbsf	1.6	clay with minor silt and fine sand.	slope basin and trench	3-15 cm/ky above 80 mbsf, >100 cm/kyr below 80 mbsf	based on results from ODP Site 1249

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New: X Revised:

Section A: Proposal Information

Title of Proposal:	Tectonic and oceanographic controls on of fluid flow, and their impact on gas hydrate and biosphere processes on southern Hydrate Ridge.
Date Form Submitted:	1 Oct. 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Sampling of Horizon A within the GHSZ to test that hypothesis that hydrate formation in this horizon acts as a dynamic seal for upward fluid migration, thus channeling the gas transport to the ridge summit. Characterizing the nature of a double BSR.
List Previous Drilling in Area:	ODP Leg 204

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SHR-4	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Oregon margin
Latitude:	Deg: 44°	Min: 35.1'N	Jurisdiction:	US
Longitude:	Deg: 125°	Min: 9.3'N	Distance to Land:	50 miles
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: 1	Alt:	Water Depth:	913 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	165 What is the total sed. thickness? 2000 m	none
		Total Penetration: 165 m
General Lithologies:	clay with sand/silt turbidites	
Coring Plan: *(Specify or Circle)*	APC and XCB to 165 m. PCS as needed. No permanent installations ☒ 1-2-3-APC , ☒ XCB, ☒ PCS, ** Systems Currently Under Development*	

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity ☒	Borehole Televiewer	Formation Fluid Sampling ☒	Density-Neutron ☒
Litho-Density ☒	Nuclear Magnetic Resonance ☒	Borehole Temperature & Pressure ☒	Resistivity-Gamma Ray ☒
Gamma Ray ☒	Geochemical ☒	Borehole Seismic ☒	Acoustic ☒
Resistivity ☒	Side-Wall Core Sampling ☒		
Acoustic ☒			
Formation Image ☒		Others ( )	Others ( )

Max.Borehole Temp. : *Expected value (For Riser Drilling)* 20 °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from	m	to	m,		m intervals
from	m	to	m,		m intervals

Basic Sampling Intervals: 5m

Estimated days:		
Drilling/Coring: 0.8	Logging: 0.6	Total On-Site: 1.6

Future Plan: No permanent installations

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas ☒	Complicated Seabed Condition	Hydrothermal Activity
Hydrocarbon ☒	Soft Seabed	Landslide and Turbidity Current
Shallow Water Flow	Currents	Methane Hydrate ☒
Abnormal Pressure	Fractured Zone	Diapir and Mud Volcano
Man-made Objects	Fault	High Temperature
H_2S ☒	High Dip Angle	Ice Conditions
CO_2		

What is your Weather window? (Preferable period with the reasons)

July-August best
June-Sept. OK

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-4	Date Form Submitted: Oct 13, 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time only) Hydrate Ridge 3D survey 2000, in ODP Leg 204 database Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) Regional deep reflection/refrraction-based model within 15 km (published in Trehu et al., 1994; Gerdom et al., 2000) Crossing Lines(s):
3	Seismic Velocity†		X	OBS survey done with 3D reflection survey in 2000. 3D tomographic model in ODP Leg 204 database
4	Seismic Grid		X	see 1
5a	Refraction (surface)		X	see 3
5b	Refraction (near bottom)			NA
6	3.5 kHz			Location of Site on line (Time) NA
7	Swath bathymetry		X	In Leg 204 database
8a	Side-looking sonar (surface)		X	In Leg 204 database (from MBARI 1998 cruise)
8b	Side-looking sonar (bottom)		X	In Leg 204 database (see also Johnson et al., 2003)
9	Photography or Video			NA
10	Heat Flow		X	within 500 m, ODP Leg 204, Site 1245
11a	Magnetics			regional available but not relevant (see Fleming and Trehu, 1999)
11b	Gravity			regional available but not relevant (see Fleming and Trehu, 1999)
12	Sediment cores		X	Leg 204, Site 1245
13	Rock sampling			NA
14a	Water current data		X	general current data available in NOAA buoy database
14b	Ice Conditions			NA
15	OBS microseismicity			NA
16	Navigation			? - navigation is available for all data cited above.
17	Other			NA

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-4	Date Form Submitted: Oct. 13, 2004
Water Depth (m): 913	Sed. Penetration (m): 165	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No X ☐
Are high temperatures expected at this site? Yes ☐ No X
Are there any other special requirements for logging at this site? Yes ☐ No X ☐
If "Yes" Please describe requirements:____________________

____

What do you estimate the total logging time for this site to be: 0.6 days __________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	all logs will be used to determine gas hydrate distribution and concentrations	2
Litho-Density		2
Natural Gamma Ray		2
Resistivity-Induction		2
Acoustic		1
FMS		2
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		1
Resitivity-Gamma Ray (LWD)		1
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		NA

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-4	Date Form Submitted: Oct. 13, 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	APC to refusal. XCB when needed (if there are massive hydrate or carbonate layers)
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	Expect to encounter gas hydrate lenses based on results from Leg 204 Sediments should be primarily clay with some silt and fine sand turbidite layers. 2-4 m tick coarse-grained layer (Horizon A) at 96mbsf Age < 1.0 Ma above 80 mbsf, 1.0-1.6 Ma below 80 mbsf Sedimentation rate 10-25 cm/ky above 155 mbsf, 62 cm/ky below 155 mbsf
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no commercial drilling in the region.
4	Are there any indications of gas hydrates at this location?	yes
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	yes (gas hydrates), higher accumulations expected at Horizon A, such as observed during Leg 204 drilling
6	What "special" precautions will be taken during drilling?	We will follow procedures established during ODP Leg 204.
7	What abandonment procedures do you plan to follow:	We will follow procedures established during ODP Leg 204.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	None
9	Summary: What do you consider the major risks in drilling at this site?	No significant risks as long as we follow procedures established during ODP Leg 204.

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-4	Date Form Submitted: Oct. 13, 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (cm/kyr)*	*Comments*
96 mbsf 126 mbsf 154 mbsf	Horizon A BSR BSR2	<1.0 Ma above 80 mbsf, 1.0-1.6 Ma below 80 mbsf	1.6	clay with minor silt and fine sand. 2-4 m thick coarse grained layer (Horizon A) at 96 mbsf	slope basin and trench	10-25 cm/ky above 155 mbsf, 62 cm/kyr below 155 mbsf	based on results from ODP Site 1245

IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New X **Revised**

Section A: Proposal Information

Title of Proposal:	Tectonic and oceanographic controls on of fluid flow, and their impact on gas hydrate and biosphere processes on southern Hydrate Ridge.
Date Form Submitted:	1 Oct. 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Sampling of Horizon A within the GHSZ to test that hypothesis that hydrate formation in this horizon acts as a dynamic seal for upward fluid migration, thus channeling the gas transport to the ridge summit. Characterizing the nature of a double BSR.
List Previous Drilling in Area:	ODP Leg 204

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SHR-5	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Oregon margin
Latitude:	Deg: 44°	Min: 34.4'N	Jurisdiction:	US
Longitude:	Deg: 125°	Min: 9.3'N	Distance to Land:	50 miles
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: 4	Alt: 1	Water Depth:	849 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	160	none
	What is the total sed. thickness? 2000 m	
		Total Penetration: 160 m
General Lithologies:	clay with sand/silt turbidites	
Coring Plan: *(Specify or Circle)*	APC and XCB to 160 m. PCS as needed. No permanent installations	
	[x] 1-2-3-APC , [x] XCB, [x] PCS,	** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity [x]	Borehole Televiewer	Formation Fluid Sampling [x]	Density-Neutron [x]
Litho-Density [x]	Nuclear Magnetic Resonance [x]	Borehole Temperature & Pressure [x]	Resistivity-Gamma Ray [x]
Gamma Ray [x]	Geochemical [x]	Borehole Seismic [x]	Acoustic [x]
Resistivity [x]	Side-Wall Core Sampling [x]		
Acoustic [x]			
Formation Image [x]		Others ( )	Others ( )

Max.Borehole Temp. : *Expected value (For Riser Drilling)* 20 °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from	m	to	m,		m intervals
from	m	to	m,		m intervals

Basic Sampling Intervals: 5m

Estimated days:

Drilling/Coring: 0.8	Logging: 0.6	Total On-Site: 1.6

Future Plan: No permanent installations

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas [x]	Complicated Seabed Condition	Hydrothermal Activity
Hydrocarbon [x]	Soft Seabed	Landslide and Turbidity Current
Shallow Water Flow	Currents	Methane Hydrate [x]
Abnormal Pressure	Fractured Zone	Diapir and Mud Volcano
Man-made Objects	Fault	High Temperature
H_2S [x]	High Dip Angle	Ice Conditions
CO_2		

What is your Weather window? (Preferable period with the reasons)

July-August best
June-Sept. OK

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-5	Date Form Submitted: Oct 13, 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time only) Hydrate Ridge 3D survey 2000, in ODP Leg 204 database Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) Regional deep reflection/refrraction-based model within 15 km (published in Trehu et al., 1994; Gerdom et al., 2000) Crossing Lines(s):
3	Seismic Velocity†		X	OBS survey done with 3D reflection survey in 2000. 3D tomographic model in ODP Leg 204 database
4	Seismic Grid		X	see 1
5a	Refraction (surface)		X	see 3
5b	Refraction (near bottom)			NA
6	3.5 kHz			Location of Site on line (Time) NA
7	Swath bathymetry		X	In Leg 204 database
8a	Side-looking sonar (surface)		X	In Leg 204 database (from MBARI 1998 cruise)
8b	Side-looking sonar (bottom)		X	In Leg 204 database (see also Johnson et al., 2003)
9	Photography or Video			NA
10	Heat Flow		X	within 500 m, ODP Leg 204, Site 1248
11a	Magnetics			regional available but not relevant (see Fleming and Trehu, 1999)
11b	Gravity			regional available but not relevant (see Fleming and Trehu, 1999)
12	Sediment cores		X	Leg 204, Site 1248
13	Rock sampling			NA
14a	Water current data		X	general current data available in NOAA buoy database
14b	Ice Conditions			NA
15	OBS microseismicity			NA
16	Navigation			? - navigation is available for all data cited above.
17	Other			NA

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-5	Date Form Submitted: Oct. 13, 2004
Water Depth (m): 849	Sed. Penetration (m): 160	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No X ☐
Are high temperatures expected at this site? Yes ☐ No X
Are there any other special requirements for logging at this site? Yes ☐ No X ☐
If "Yes" Please describe requirements:______________________________

____

What do you estimate the total logging time for this site to be: 0.8 days ________________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	all logs will be used to determine gas hydrate distribution and concentrations	2
Litho-Density		2
Natural Gamma Ray		2
Resistivity-Induction		2
Acoustic		1
FMS		2
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		1
Resitivity-Gamma Ray (LWD)		1
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		NA

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-5	Date Form Submitted: Oct. 13, 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	APC to refusal. XCB when needed (if there are massive hydrate or carbonate layers)
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	expect to encounter gas hydrate lenses based on results from Leg 204 sediments should be primarily clay with some silt and fine sand turbidite layers. 2-4 m tick coarse-grained layer (Horizon A) at 102 mbsf. age < 1.5 Ma above 115 mbsf, 0.4Ma at the seafloor; sedimentation rate 7-21 cm/ky above 115 mbsf, unconstrained below 115 mbsf
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no commercial drilling in the region.
4	Are there any indications of gas hydrates at this location?	yes
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	yes (gas hydrates), higher accumulations expected at Horizon A, such as observed during Leg 204 drilling
6	What "special" precautions will be taken during drilling?	We will follow procedures established during ODP Leg 204.
7	What abandonment procedures do you plan to follow:	We will follow procedures established during ODP Leg 204.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	None
9	Summary: What do you consider the major risks in drilling at this site?	No significant risks as long as we follow procedures established during ODP Leg 204.

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-5	Date Form Submitted: Oct. 13, 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
102 mbsf 122 mbsf 150 mbsf	Horizon A BSR BSR2	~1.5 Ma	1.6	clay with minor silt and fine sand. 2-4 m thick coarse grained layer (Horizon A) at 102 mbsf	slope basin and trench	7-21 cm/ky above 115 mbsf, unconstrained below 115 mbsf	based on results from ODP Site 1248

IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New X **Revised**

Section A: Proposal Information

Title of Proposal:	Tectonic and oceanographic controls on of fluid flow, and their impact on gas hydrate and biosphere processes on southern Hydrate Ridge.
Date Form Submitted:	1 Oct. 2004
Site Specific Objectives with Priority (Must include general objectives in proposal)	Determine the gas hydrate distribution in a steeply fractured formation, to test the hypothesis that tensional cracks host hydrate formation, and that second order seismic observations can be used to predict regional variations in gas hydrate abundance.
List Previous Drilling in Area:	ODP Leg 204

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	SHR-6	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Oregon margin
Latitude:	Deg: 44°	Min: 35.2'N	Jurisdiction:	US
Longitude:	Deg: 125°	Min: 5.3'N	Distance to Land:	50 miles
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: 1	Alt:	Water Depth:	1050 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	160	none
	What is the total sed. thickness? 2000 m	
		Total Penetration: 160 m

General Lithologies:	clay with sand/silt turbidites	
Coring Plan: *(Specify or Circle)*	APC and XCB to 160 m. PCS as needed. No permanent installations	
	[x] 1-2-3-APC , [x] XCB, [x] PCS,	** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity [x]	Borehole Televiewer	Formation Fluid Sampling [x]	Density-Neutron [x]
Litho-Density [x]	Nuclear Magnetic Resonance [x]	Borehole Temperature & Pressure [x]	Resistivity-Gamma Ray [x]
Gamma Ray [x]	Geochemical [x]	Borehole Seismic [x]	Acoustic [x]
Resistivity [x]	Side-Wall Core Sampling [x]		
Acoustic [x]			
Formation Image [x]		Others ( )	Others ( )

Max.Borehole Temp. :	*Expected value (For Riser Drilling)* 20 °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals					
from	m	to	m,		m intervals
from	m	to	m,		m intervals
					Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring: 1	Logging: 0.8	Total On-Site: 1.8
Future Plan:	No permanent installations		

Hazards/ Weather:

Please check following List of Potential Hazards			*What is your Weather window? (Preferable period with the reasons)*
Shallow Gas [x]	Complicated Seabed Condition	Hydrothermal Activity	
Hydrocarbon [x]	Soft Seabed	Landslide and Turbidity Current	July-August best June-Sept. OK
Shallow Water Flow	Currents	Methane Hydrate [x]	
Abnormal Pressure	Fractured Zone	Diapir and Mud Volcano	
Man-made Objects	Fault	High Temperature	
H_2S [x]	High Dip Angle	Ice Conditions	
CO_2			

Form 2 - Site Survey Detail

IODP Site Summary Forms:

Please fill out information in all gray boxes

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-6	Date Form Submitted: Oct 13, 2004

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection		X	Primary Line(s) :Location of Site on line (SP or Time only) Hydrate Ridge 3D survey 2000, in ODP Leg 204 database Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): Location of Site on line (SP or Time only) Regional deep reflection/refrraction-based model within 15 km (published in Trehu et al., 1994; Gerdom et al., 2000) Crossing Lines(s):
3	Seismic Velocity†		X	OBS survey done with 3D reflection survey in 2000. 3D tomographic model in ODP Leg 204 database
4	Seismic Grid		X	see 1
5a	Refraction (surface)		X	see 3
5b	Refraction (near bottom)			NA
6	3.5 kHz			Location of Site on line (Time) NA
7	Swath bathymetry		X	In Leg 204 database
8a	Side-looking sonar (surface)		X	In Leg 204 database (from MBARI 1998 cruise)
8b	Side-looking sonar (bottom)		X	In Leg 204 database (see also Johnson et al., 2003)
9	Photography or Video			NA
10	Heat Flow		X	within 300 m, ODP Leg 204, Site 1252
11a	Magnetics			regional available but not relevant (see Fleming and Trehu, 1999)
11b	Gravity			regional available but not relevant (see Fleming and Trehu, 1999)
12	Sediment cores		X	Leg 204, Site 1252
13	Rock sampling			NA
14a	Water current data		X	general current data available in NOAA buoy database
14b	Ice Conditions			NA
15	OBS microseismicity			NA
16	Navigation			? - navigation is available for all data cited above.
17	Other			NA

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-6	Date Form Submitted: Oct. 13, 2004
Water Depth (m): 1050	Sed. Penetration (m): 160	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? Yes ☐ No X ☐
Are high temperatures expected at this site? Yes ☐ No X
Are there any other special requirements for logging at this site? Yes ☐ No X ☐
If "Yes" Please describe requirements:____

____

What do you estimate the total logging time for this site to be: 0.8 days ________________

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	all logs will be used to determine gas hydrate distribution and concentrations	2
Litho-Density		2
Natural Gamma Ray		2
Resistivity-Induction		2
Acoustic		1
FMS		2
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		1
Resitivity-Gamma Ray (LWD)		1
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		NA

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New **X** ☐ *Revised* ☐

Proposal #: 635-full	Site #: SHR-6	Date Form Submitted: Oct. 13, 2004

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	APC to refusal. XCB when neeed (if there are massive hydrate or carbonate layers)
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	expect to encounter gas hydrate lenses based on results from Leg 204 sediments should be primarily clay with some silt and fine sand turbidite layers. age < 2 MA; sedimentation rate 10-100 cm/ky
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	no commercial drilling in the region.
4	Are there any indications of gas hydrates at this location?	yes
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	yes (gas hydrates)
6	What “special” precautions will be taken during drilling?	We will follow procedures established during ODP Leg 204.
7	What abandonment procedures do you plan to follow:	We will follow procedures established during ODP Leg 204.
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	None
9	Summary: What do you consider the major risks in drilling at this site?	No significant risks as long as we follow procedures established during ODP Leg 204.

Form 5 – Lithologic Summary

IODP Site Summary Forms:

New **X** *Revised*

Proposal #: 635-full	Site #: SHR-6	Date Form Submitted: Oct. 13, 2004

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
60 mbsf	unconformity between slope basin sediments above and accretionary complex sediments below	~1.4 Ma	1.6	clay with minor silt and fine sand	slope basin and trench	10-100 cm/ky	based on results from ODP Site 1252