Integrated Ocean Drilling Program
Expedition 301 Scientific Prospectus

Juan de Fuca Hydrogeology

The hydrogeologic architecture of basaltic oceanic crust: compartmentalization, anisotropy, microbiology, and crustal-scale properties on the eastern flank of Juan de Fuca Ridge, eastern Pacific Ocean

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DISCLAIMER

This IODP Scientific Prospectus is based on precruise Science Advisory Structure panel discussions and scientific input from the designated Co-Chief Scientists on behalf of the drilling proponents. During the course of the cruise, actual site operations may indicate to the Co-Chief Scientists and the Operations Superintendent that it would be scientifically or operationally advantageous to amend the plan detailed in this prospectus. It should be understood that any proposed changes to the science deliverables outlined in the plan presented here are contingent upon the approval of the IODP-USIO Science Services, TAMU, Deputy Director of Science Services in consultation with IODP-MI.

ABSTRACT

Integrated Ocean Drilling Program (IODP) Expedition 301 is part of a multidisciplinary experiment to evaluate formation-scale hydrogeologic properties (transmission and storage) within oceanic crust; determine how fluid pathways are distributed within an active hydrothermal system; establish linkages between fluid circulation, alteration, and geomicrobial processes; and determine relations between seismic and hydrologic anisotropy. During IODP Expedition 301, we will replace two existing subseafloor observatories and install two new observatories, creating a three-dimensional monitoring network. We will also core and sample basaltic upper crust and overlying sediments to assess physical, geochemical, and microbiological conditions and complete a series of downhole experiments (e.g., packer and downhole logging) in basement to assess hydrogeologic properties near the new boreholes. An additional basement hole will be drilled during a later expedition, allowing completion of controlled, long-term, cross-hole testing. Collectively, these operations and experiments will allow us to evaluate the extent to which oceanic crust is connected vertically and horizontally; the influence of these connections on fluid, solute, heat, and microbiological processes; and the importance of scaling on hydrologic properties.

SCHEDULE FOR EXPEDITION 301

Expedition 301 is based on Integrated Ocean Drilling Program (IODP drilling proposal number 535-Full3 (available at **www.isas-office.jp/scheduled.html**). Following ranking by the IODP Scientific Advisory Structure, the expedition was scheduled by the IODP Operations Committee for the research vessel *JOIDES Resolution,* operating under contract with the U.S. Implementing Organization (USIO). The expedition is currently scheduled to depart Astoria, Oregon (USA), on 28 June 2004 and to end in Astoria, Oregon (USA), on 21 August 2004 (for the current detailed schedule, see **www.iodp.tamu.edu/scienceops/**). A total of 52 days will be available for the drilling, coring, and downhole measurements and installation of subseafloor observatories described in this report. Further details on the *JOIDES Resolution* can be found at **iodp.tamu.edu/publicinfo/drillship.html**.

INTRODUCTION

Thermally driven fluid circulation through oceanic lithosphere profoundly influences the physical, chemical, and biological evolution of the crust and ocean. Although much work over the last 30 years has focused on hot springs along mid-ocean ridges, global advective heat loss from ridge flanks (crust older than 1 Ma) is more than three times that at the axis (Parsons and Sclater, 1977; Stein and Stein, 1992) and the ridge-flank mass flux is at least ten times as large (Elderfield and Schultz, 1996; Mottl and Wheat, 1994). Ridge-flank circulation generates enormous solute fluxes, profoundly alters basement rocks, supports a vast subseafloor biosphere, and continues right to the trench, influencing the thermal, mechanical, and chemical state of subducting plates (e.g., Alt, 1995; Ranero et al., 2003). These processes crosscut all three primary themes motivating the Initial Science Plan for the IODP.

Despite the importance of fluid-rock interaction in the crust, little is known about the distribution of hydrologic properties; the extent to which crustal compartments are well connected or isolated (laterally and with depth); linkages between ridge-flank circulation, alteration, and geomicrobial processes; or quantitative relations between seismic and hydrologic properties. IODP Expedition 301 comprises the first part of a two-expedition experiment to explore these processes and relations and to address topics of fundamental interest to a broad community of hydrogeologists working in heterogeneous water-rock systems: the nature and significance of scaling phenomena and the applicability of equivalent porous-medium representations of discrete fracture-flow processes. Expedition 301 benefits from operational and scientific achievements from Ocean Drilling Program (ODP) Leg 168 (Davis, Fisher, Firth, et al., 1997), which focused on hydrothermal processes within uppermost basement rocks and sediments along an age transect across a young ridge flank. The primary goals of Expedition 301 include replacement of long-term observatories established in two reentry holes during Leg 168 and establishment of two new observatories, creating a three-dimensional observational network in upper oceanic basement. These observatories will be used to passively monitor thermal and pressure conditions in basement and to collect long-term chemical and microbiological samples. During a later expedition, researchers will use these observatories for a series of multidisciplinary crustal-scale experiments. Other primary goals of Expedition 301 include coring, sampling, and short-term downhole measurements. Secondary objectives include drilling, coring, and sampling one or more holes in a region of known hydrothermal seepage, where sediment thins above a buried basement ridge, and drilling, coring, and sampling a much thicker sediment section to the east, where basement temperatures and alteration should be more extreme.

BACKGROUND

Geological Setting

The Endeavour segment of the Juan de Fuca Ridge (JFR) generates lithosphere west of North America (Fig. F1). Topographic relief produces barriers to turbidites from the continental margin, resulting in the accumulation of sediment and burial of the eastern flank of the JFR within Cascadia Basin. Oceanic basement is exposed to the west, where the crust is young, and the sedimented seafloor is relatively flat to the east, except over seamounts. Basement relief is dominated by linear ridges and troughs oriented subparallel to the spreading center and produced mainly by faulting, variations in magmatic supply at the ridge, and off-axis volcanism. Basement relief is relatively low near the ridge (±100–200 m) and higher (±300–700 m) to the east. Low-permeability sediment limits advective heat loss across most of the ridge flank, leading to strong thermal, chemical, and alteration gradients in basement.

The study area contains structural features common to most ridge flanks: extrusive igneous basement overlain by sediments, abyssal hill topography, high-angle faulting, and basement outcrops. Whereas the work sites may not be typical of all ridge-flank settings (higher than average sedimentation rate, younger buried basement, and stronger lateral gradients in temperature), the field area is ideal, in part because of these extreme conditions. High gradients result in strong signals that rise above natural and experimental noise. The high sedimentation rate allows us to work on crust that is much younger than we could study otherwise, providing indications of ridge-crest as well as ridge-flank properties and allowing study of sites in different hydrologic settings that are close together. Because many experiments have been completed in this area (seismic, thermal, geochemical, and surface/borehole), we can "calibrate" and compare interpretations based on different methods.

Previous Drilling

During ODP Leg 168, an 80 km transect comprising 10 sites was drilled on the eastern flank of the Juan de Fuca Ridge (Davis, Fisher, Firth, et al., 1997). Borehole (Cork) observatories were installed at Sites 1024 and 1025, near the western end of the drilling transect, and Sites 1026 and 1027 (Figs. F2, F3, F4, F5, F6, F7, F8), at the eastern end of the transect (Davis and Becker, 2002; Davis et al., 2000). Hydrogeologic results from Leg 168 include documentation of large lateral gradients in fluid temperatures, compositions, and ages in upper basement with distance from the ridge axis; local, thermal, and chemical homogeneity between adjacent sites; and rapid fluid flow rates and very small driving forces. Extensive, *across-strike* advection in the upper crust may be inferred from these overall trends (e.g., Davis et al., 1997, 1999; Elderfield et al., 1999; Spinelli and Fisher, 2004; Stein and Fisher, 2003), which requires very high formation permeability. This interpretation is consistent with Cork observations indicating extreme transport properties and high rates of fluid flow (Davis and Becker, 2002, in press). Packer and open hole experiments also indicate high permeabilities in uppermost crust and a systematic evolution in crustal permeability with age (Becker and Davis, 2003; Becker and Fisher, 2000). However, there are large differences in permeability estimated with different methods, likely resulting from either differences in interpretive assumptions or a scale effect (Becker and Davis, 2003; Becker and Fisher, 2000; Fisher and Becker, 2000; Fisher, 1998; Fisher et al., 1997).

There is also geochemical and thermal evidence for *along-strike* fluid flow, perhaps related to abyssal hill topography and associated faulting. Site 1026 is located along a buried basement ridge (Second Ridge; SR) and ~8 km from Baby Bare and Mama Bare outcrops, the tops of which are exposed to the south and north, respectively (Figs. **F2, F3**). Fluids collected from shallow sediments, Baby Bare springs, and Hole 1026B are similar in bulk composition (Mottl et al., 1998; Wheat and Mottl, 2000), but subtle differences in fluid chemistry indicate increased water-rock interaction from south to north. The young ^{14}C age of Hole 1026B water (4–5 ka) suggests that it is chemically distinct from older fluid to the west (Elderfield et al., 1999). Geochemical and thermal data suggest that Baby Bare springs recharge through basement more than 50 km south at Grizzly Bare outcrop (Fisher et al., 2003a). Although basement fluids from Sites 1030 and 1031 (First Ridge; FR) are also young (Fig. **F2**), they interacted chemically with basement as extensively as much warmer fluids to the east and are chemically distinct from crustal fluids to the west (Davis, Fisher, Firth, et al., 1997; Elderfield et al., 1999; Wheat et al., 2000). There are also important differences in composition between fluids from Baby Bare and Site 1027 (Wheat et al., submitted [**N1**]). Thus, there is geochemical evidence for the presence of distinct hydrologic systems within shallow basement in this area.

ODP Hole 1026B yielded some of the first direct microbiological observations of ridge-flank fluids. Rock and fluid samples collected during Leg 168 indicated the possible presence of microbes (Bach and Edwards, in press; Fisk et al., 2000), and a "biocolumn" experiment assessed microbial biomass and diversity in fluids venting from a subseafloor observatory. Cells collected from the biocolumn included bacteria and archaea, comprising nitrate reducers, thermophilic sulfate reducers, and thermophilic fermentative heterotrophs (Cowen et al., 2003).

The First Ridge area on 1.4 m.y. old crust (Fig. **F7, F8**) is known to experience upward fluid seepage through shallow sediments at a few millimeters per year (Spinelli et al., 2004; Wheat and Mottl, 1994). Sites 1030 and 1031 were positioned above a high-angle normal fault on a buried basement high. Heat flow above this ridge is elevated locally over that through surrounding crust of the same age (Davis et al., 1999; Davis, Fisher, Firth, et al., 1997), indicating that basement hosts vigorous convection. Measurements and sampling during Leg 168 revealed altered basal sediments and upper basement temperatures on the order of 40°C, but basement fluid composition is consistent with water-rock interaction at ~65°–70°C (Davis, Fisher, Firth, et al., 1997; Elderfield et al., 1999). In fact, basement fluid chemistry in this area is very similar to that at Baby Bare springs and Site 1026, 60 km to the east (Elderfield et al., 1999; Mottl et al., 1998; Wheat et al., 2000). Surprisingly, the ^{14}C age of Site 1030/1031 fluids is considerably younger than fluids at Site 1025 to the west.

Several studies have noted seismic anomalies (places where lateral continuity of seismic layers is disrupted) (Zühlsdorff and Spiess, 2001; Zühlsdorff et al., 1999). Seismic anomalies are commonly associated with areas of seafloor seepage. Sediments from Sites 1030 and 1031 have porosities and permeabilities significantly greater than those of the surrounding sediments, but these properties are consistent with deposition of normal hemipelagic material over local basement highs (Giambalvo et al., 2000). The distribution of seafloor seepage may be explained largely by a combination of basement relief, differential sediment thickness, heating from below, and variations in sediment properties (Spinelli et al., 2004).

Site 1030/1031 pore fluid may be upwelling through shallow sediments from a hydrothermal system deeper than that inferred at nearby drilling sites. Greater fluid alteration probably indicates a higher maximum temperature, followed by conductive cooling during fluid ascent. Observed ^{14}C dates preclude an alternative interpretation that Site 1030/1031 basement fluids are simply older. These fluids could not have recharged from areas of exposed basement 20 km to the west, since their age and composition is inconsistent with flow along this path. An alternative hypothesis is that these fluids recharged through seamounts (e.g., Fisher et al., 2003a, 2003b) north or south of the Leg 168 transect, perhaps flowing in basement through permeability enhanced by an along-strike crustal fabric.

Site Survey

Marine geophysical surveys in this region began in the 1950s and 1960s, but the first detailed studies of this ridge flank intended to resolve the existence and influence of hydrothermal circulation were completed in the mid- to late-1980s (Davis et al., 1989; Rohr, 1994). These studies included single-channel and multichannel seismic (MCS), gravity, magnetics, and heat flow, along with coring (with associated sediment and pore fluid analyses). Becker et al. (2000) show results from a 1992 *John P. Tully* survey that collected seismic data in the Second Ridge area, with an emphasis on nearby basement outcrops. Seismic results from two later surveys are summarized by Rosenberger et al. (2000).

Two additional site surveys were completed in 2000. The ImageFlux survey was completed with the *Sonne* (SO149; Chief Scientist: V. Spiess; seismic acquisition and processing: L. Zühlsdorff, both from University of Bremen, Germany), including collection of nearly 500 lines of seismic data and extensive hydrosweep coverage. The 2000 RetroFlux expedition was completed with the *Thomas G. Thompson* (Co-Chief Scientists: A. Fisher, University of California, Santa Cruz, USA; E. Davis, Pacific Geoscience Center, Geological Survey of Canada; M. Mottl, University of Hawaii, USA; and C.G. Wheat, University of Alaska, USA), with a focus on coring and heat flow (and limited acquisition of hydrosweep data). Finally, a 2002 expedition of the *Maurice Ewing* (Chief Scientist: S. Carbotte) collected MCS data mainly across the Juan de Fuca Ridge, but one line crossed the Expedition 301 area. Collectively, these data provide clear drilling targets at depth.

Conversions from two-way traveltime (TWT) between the seafloor and top of basement to sediment thickness were developed by Davis et al. (1999) using drilling results from Leg 168 (Davis, Fisher, Firth, et al., 1997). Shipboard velocity measurements made on recovered sediments were combined to generate an equation for time-to-depth conversion. This conversion was shifted linearly to force a fit through basement depths determined during drilling, with a resulting sediment velocity range of 1500–1700 m/s. For Expedition 301, the greatest uncertainty in estimated depths to drilling targets results from picking targets on a narrow basement peak where the upper basement surface is somewhat irregular, but confidence in these picks is relatively high where previous drilling helped confirm the nature of prominent subseafloor reflectors (SR and FR areas).

SCIENTIFIC OBJECTIVES

Our highest-priority objectives during Expedition 301 are those on Second Ridge, where drilling of new holes into basement, offset 1.0–2.4 km from existing Cork observatories, will allow evaluation of basement alteration, microbiology, solid and fluid chemistry, and crustal hydrogeologic properties (Figs. **F3, F4, F5, F6**). We are also prepared to drill into an upflow region on the first buried basement ridge (First Ridge), where the extent and significance of alteration and the likely importance of along-strike hydrothermal flow can be evaluated (Figs. **F7, F8**). Finally, we are prepared to drill into deeply buried basement 125–145 km from the spreading center, where basement temperatures approach and exceed 100°C, to evaluate the continuing influences of hydrothermal circulation on microbiology, fluid chemistry, and crustal evolution (Deep Ridge; DR) (Fig. **F9**). Site locations are summarized in Table **T1.** All sites present exciting opportunities, but only SR drilling will eventually allow completion of crustal-scale, cross-hole, multidisciplinary experiments. The other sites provide outstanding second-priority opportunities of various duration (1–24 days).

The operational plan for Expedition 301 is complex but contains considerable flexibility that will allow shipboard personnel to respond to conditions encountered during the expedition (Table **T2**). In particular, we will have at least two opportunities to drill into the upper oceanic crust and establish new basement observatories. We will also have the opportunity to collect sediment samples at one or more sites, using a combination of advanced piston corer/extended core barrel (APC/XCB) and rotary core barrel (RCB) coring, and to core a long interval into basement. Please see **"Drilling Strategy"** for more detailed discussion of priorities, options, and contingencies.

Second Ridge

Our highest priorities during Expedition 301 are to replace existing Cork systems at Sites 1026 and 1027, drill two new basement holes along the second buried basement ridge, and install new Cork observatories. Primary scientific objectives at the SR sites also include characterization of upper basement rocks (through coring, sampling, and downhole logging) and conduction of short-term packer experiments to determine near-borehole permeability. We will have an opportunity to collect sediment cores on the Second Ridge, although it may be preferable to devote coring time to the

First Ridge, where fluids are known to seep upward from basement and basement conditions are similar but the sediment section is thinner. Second Ridge Cork observatories will be used to monitor borehole thermal conditions immediately after installation, sample borehole fluids and inject tracers, and host incubation substrate for microbiological colonization experiments. Seafloor pressure gages, data loggers, and fluid samplers will be attached to the observatories by remotely operated vehicle (ROV) after completion of drilling operations.

The original proposal (545-Full3) planned for all operations at proposed Site SR-1 to occur in a single hole located 1 km south of Hole 1026B, including RCB coring of sediment and basement, reaming, casing, logging, and observatory installation. As a result of precruise discussions with IODP engineering and operations personnel, we have decided to separate shallower and deeper basement operations within two boreholes and install two observatories at Site SR-1. This should provide a better chance for success in achieving drilling, coring, downhole logging, and observatory installation objectives, allowing for both monitoring and penetration through an anticipated unstable ("rubble") zone in upper basement, commonly encountered when drilling young oceanic crust.

The deeper hole will be cased through the uppermost basaltic crust to avoid problems with hole stability and lost circulation and then will be cored to total depth, ideally 500 m or more into basement. The hole will be logged using conventional wireline tools and a borehole televiewer to delineate fine-scale lithostratigraphy, alteration patterns, and fracture distributions. If the hole produces fluids during drilling operations, samples can be collected in the open hole. A conventional vertical seismic profile (VSP) will be run to assess the depth extent of the uppermost extrusive crustal layer. Packer experiments will be run in straddle mode to evaluate near-hole permeability distribution within distinct crustal intervals, and a multilevel Cork-II, housing independent samplers and sampling lines, will be installed to isolate three crustal intervals. We originally hoped for 600 m of basement penetration, but there will be insufficient time to achieve this goal during Expedition 301. Instead, we will have to balance the extent of basement penetration at SR sites against time required to complete downhole measurements, install four Cork observatories, and collect sediment samples. Actual basement penetration at the deeper SR hole will depend on the conditions encountered during the expedition and discussions with shipboard personnel.

The shallower SR basement hole will be drilled a few tens of meters into uppermost basement. Based on consideration of conditions encountered during drilling of the deeper hole and during drilling of nearby Holes 1026B, we may attempt to core uppermost basement in the shallower Site SR-1 hole. However, given expected low recovery in rubbly upper basement rocks, the potential for losing the hole if difficult conditions are encountered, and the drilling depth achieved and conditions encountered in the deeper Site SR-1 hole, we may elect to not attempt basement coring in the shallower Site SR-1 hole. In any case, the open hole interval will be too short and unstable for logging. Once drilling is completed in the shallower Site SR-1 hole, casing will be installed to help hold the hole open, packer tests will be run, and a single-level Cork-II observatory will be installed.

Sediment coring at Site SR-1 is tentatively scheduled to occur after the first half of the expedition, so we can be sure to achieve the primary basement and observatory objectives. However, many basement and observatory operations require a calm sea state, whereas sediment coring can be done when conditions are rougher, so sediment coring may be completed earlier in the expedition depending on weather. It may also be desirable to break up complex Cork-handling activities with sediment coring. The Shipboard Scientific Party may elect to focus sediment coring at First Ridge, rather than at Second Ridge because there is (1) known fluid seepage from basement at First Ridge and (2) thinner sediment cover that would allow a short transect of holes to be completed in the time required to core a single SR hole. However, completing all sediment coring at Site FR-1 would not provide sediment temperature data at Site SR-1, so additional time would be required for this.

First Ridge

We may drill one or more sediment and shallow basement holes along the first buried basement ridge east of the spreading center to evaluate sediment properties, document fluid chemistry and evidence for along-strike fluid flow, and determine the nature of hydrothermal alteration and microbiology in uppermost basement. Sediment thickness is 40–60 m where basement comes closest to the seafloor. This work will require 1.0–5.1 days, depending on the extent of drilling and sampling. This small amount of time may become available if operations in the SR region are completed quickly or if some operations in the SR region are prevented because of weather conditions, drilling problems, or other difficulties. Alternatively, the Shipboard Scientific Party may, based on scientific objectives, elect to focus sediment coring at First Ridge instead of at Second Ridge.

Drilling a short series of shallow holes into First Ridge would allow us to address several questions:

- What is the importance of *along-strike* vs. *across-strike* fluid flow in basement?
- What is the origin and significance of shallow seismic anomalies associated with areas of seafloor seepage?
- What is the extent and nature of subseafloor microbiological activity within shallow basement, and how does it relate to the upward seepage of basement fluids?

Drilling will provide important information on the end-member composition of reacted fluid, alteration within overlying sediments, the geochemical and physical state of the altered basalt within an upflow zone, and the nature of the biological interactions with fluids, sediments, and basalt.

We may complete APC/XCB and/or RCB coring at two main locations at Site FR-1. APC/XCB Hole FR-1A is located to pass through the center of a narrow acoustic washout in an area where surface cores have detected chemical evidence for slow seepage of hydrothermal fluids (Spinelli et al., 2004; Zühlsdorff and Spiess, 2001). APC/XCB Hole FR-1B is located just west and outside of the acoustic washout. APC/XCB coring will provide excellent recovery above basement and limited basement recovery with a hard-formation XCB shoe. RCB Hole FR-1C would be drilled adjacent to Hole FR-1A, allowing penetration into uppermost basement (two to three cores). Within these holes, sediments will be heavily sampled for fluid chemistry and microbiology. Basement in this upflow area should be highly altered, and since this basement ridge is overpressured (Giambalvo et al., 2000; Spinelli et al., 2004; Stein and Fisher, 2003) and permeable (based on nearby measurements made during Leg 168), a crustal hole may produce fluid once basement is penetrated, potentially allowing fluid and biological sampling in the open hole. Should time allow, additional APC/XCB coring can be done along or across strike of the trend of the First Ridge.

Deep Ridge

Drilling through deeper sediments and into basement east of the Leg 168 transect would allow an assessment of crustal evolution at greater temperatures, basement ages, and depths of basement burial. Here we can assess the thermal state of young lithosphere and geochemical conditions that control microbial activity far from the spreading axis, where thick sediments and a lack of *along-strike* outcrops greatly restrict or eliminate continued thermal, fluid, and solute exchange with the overlying ocean. Two sites are located at the tops of buried basement ridges ~125 and ~145 km from the ridge axis: Sites DR-1 and DR-2, respectively (Figs. **F1, F2, F9**).

Based on experience elsewhere, these buried basement ridges are probably overpressured and should eventually produce samples of altered hydrothermal water and associated microbiological material. Production of uncontaminated crustal fluids could require thermal equilibration of the boreholes below Corks. DR sites are second priority sites and would require considerably more time for successful completion than would FR sites. Work at the DR sites will be considered only if operations at the SR sites cannot be completed and a significant amount of time remains available during the expedition.

Site DR-1 is located where the estimated basement temperature is ~90°–100°C, beneath 650 ms TWT (610 m) of sediment. A single RCB hole drilled in this location could permit core collection, allow measurement of sediment temperatures, and provide access to uppermost basement for coring. Should time allow, a free-fall funnel or a complete reentry cone and casing could permit deeper basement penetration and fluid and microbiological sampling.

Site DR-2 is located where the estimated basement temperature is ~140°C, below 900 ms TWT (890 m) of sediment. As at Site DR-1, a single RCB hole would permit collection of cores and water samples and measurement of sediment temperatures. Use of a free-fall funnel or a complete reentry system are also possible. The best options for recovering pore fluids indicative of uppermost basement at the DR sites are likely to be sampling of the deepest sediments immediately above basement and/or installation of complete reentry and Cork systems, followed by borehole reequilibration and long-term sampling.

DRILLING STRATEGY

Planned operations during Expedition 301 are summarized in Table **T2.** The expedition will begin with a jet-in test at Site SR-1, followed by emplacement of a reentry cone and 20 inch conductor casing. This cone and casing system will be used to establish the deep basement hole, Hole SR-1A. A more traditional strategy would begin with sediment coring, but this approach is not planned for Expedition 301 for several reasons. First, we already have a good understanding of the sediment thickness and properties on the basis of extensive site survey data and prior work at nearby Site 1026 during ODP Leg 168, which was cored continuously. In addition, sediment cores recovered during Expedition 301 will be subjected to extensive microbiological sampling and analyses, but we will begin at-sea operations less than 24 h after leaving port and it will be difficult to establish protocols and procedures for sediment sampling, handling, and analysis so quickly after the start of the expedition (particularly since this is the first expedition of IODP). Third, we want to save sediment coring options for times later in the expedition, when packer testing or observatory installation operations cannot be completed because of weather or sea state. We also would like to wait to dedicate time to sediment coring until we have greater confidence of achieving high-priority basement and observatory operations. Finally, geochemists and microbiologists may find it more scientifically desirable to complete coring work at First Ridge, rather than at Second Ridge. The sediment layer above shallow basement at First Ridge is much thinner, fluid is known to be seeping upward from basement, piston coring to basement will be easier and recovery more complete, and we would have time to core several FR holes in the time required to drill a single SR hole. Therefore, determining where coring will take place will require discussions with the shipboard geochemists and microbiologists to ensure the science return is maximized.

After installation of the cone and casing in Hole SR-1A, we will drill through ~260 m of sediments and into uppermost basement, and then set and cement 16 inch casing. Drilling will continue with a 14$^3/_4$ inch tricone bit to penetrate quickly through the most unstable zone in upper basement, estimated to be ~50–100 m thick. When drilling conditions indicate that basement rocks are more stable, 10$^3/_4$ inch casing will be run and cemented into place. Coring will commence using a standard 9$^7/_8$ inch bit and RCB system. Based on precruise time estimates, we anticipate 470 m of basement penetration (Table **T2**), but we may core somewhat more or less basement in Hole SR-1A during this first stage of operations, depending on rates of penetration, drilling conditions, and the nature of the rocks recovered. Hole SR-1A may be deepened later in the expedition, depending on the timing of observatory installation at this and other sites.

Once total depth is achieved in Hole SR-1A, the hole will be logged with conventional tools (triple combination [triple combo] and Formation MicroScanner/Dipole Sonic Imager [FMS/DSI] tool strings), a borehole televiewer (Ultrasonic Borehole Imager [UBI]), and a VSP (three-component Well Seismic Tool [WST-3]) using a single generator injector (GI) gun source. Packer experiments will be conducted in straddle-packer mode in the open hole. It is likely that we will move to other holes for drilling or Cork observatory operations prior to installation of the Cork observatory in Hole SR-1A because this is to be the most complex observatory installation. Depending on drilling conditions and timing, we may also wait to complete logging and other downhole work until after we return to this hole later in the expedition. Downhole logging is important for geophysical and hydrogeologic characterization and evaluation of alteration and fracturing and will guide positioning of packers for both short-term and longer-term experiments.

The ship will be offset ~20 m north-northeast from Hole SR-1A, and Hole SR-1B will be established in the same way, with a cone and 20 inch conductor casing. Once again, we will drill into uppermost basement and install and cement 16 inch casing. At this point, we have two options: (1) drill into upper basement using a $14^3/_4$ inch tricone bit or (2) attempt to core uppermost basement using a standard $9^7/_8$ inch RCB system. We consider the first option to be safer, since our primary objective is to emplace a Cork observatory to monitor conditions in uppermost basement. Also, we know from experience in Hole 1026B that drilling conditions in upper basement may be difficult and core recovery is likely to be low. It is unlikely that we would be able to core deeper than 20–40 m into basement in any case. If we do core this section, we will have to ream out the hole to make it large enough to receive $10^3/_4$ inch casing, which is needed to keep the hole open for the long-term observatory. Holes in unstable formations are more likely to remain open if they are drilled quickly and not reamed. We will be in a better position to evaluate the desirability of coring uppermost basement in Hole SR-1B when we see how well we achieve our drilling, casing, coring, and depth objectives in Hole SR-1A. As a practical matter, any time spent coring shallow basement in Hole SR-1B would have to come out of that for depth penetration in Hole SR-1A and/or sediment coring.

Once casing is in place in Hole SR-1B, we will conduct packer tests by setting the packer in casing and testing the open interval below. This open interval will be too short and unstable for wireline logging. We will then deploy the first Cork-II observatory of the expedition, which will be configured to isolate a single interval of upper basement (Fig. **F10**). Operations will include deployment of downhole temperature sensors, fluid samplers, and microbiological incubation substrate. Pressure sensors, data loggers, and an additional fluid sampler will be deployed and attached to the Cork-head plumbing during a later expedition by ROV.

We will move to Site 1026, recover the Cork system currently in the reentry cone in Hole 1026B, and deploy a new Cork-II system that will isolate a single interval of uppermost basement (Fig. **F11**). Cork operations will include deployment of downhole temperature sensors, fluid samplers, and microbiological incubation substrate. Pressure sensors, data loggers, and an additional fluid sampler will be deployed and attached to the Cork-head plumbing during a later expedition by ROV.

We have reserved sufficient time during the expedition to APC core the sedimentary section at Site SR-1. This would likely result in partial penetration of APC core barrels, since the sedimentary section is dominated by sandy turbidites, followed by "overdrilling" to successive coring depths. There is some risk in this approach, involving APC coring in unstable sands (as we encountered during ODP Leg 168), and the available time might be better used to piston core at the First Ridge or to wash partway to basement prior to the start of coring. A final decision will be reached regarding the location and extent of Expedition 301 sediment coring operations on the basis of experience gained during the first part of the expedition and discussion with shipboard scientists regarding the scientific merits of each area. Sediment coring will be accompanied by measurements of sediment temperatures using the Davis-Villinger Temperature Probe (DVTP) and/or the APC Temperature (APCT) tool. If sediment coring is completed near the middle of the expedition, we will still need to save 36 h of contingency time for the end of the program, in case difficulties are encountered when deploying the final Cork-II system.

The ship will return to Hole SR-1A and either continue coring (if this is desired, time allows, and depth goals are not achieved), complete downhole measurements (if these were not already completed), and/or deploy the Cork-II system. The Cork-II in Hole SR-1A will isolate three distinct basement intervals (Fig. **F12**). Downhole temperature sensors, fluid samplers, and microbiological incubation substrate will be placed in the lowermost isolated interval, and additional temperature sensors may be deployed on the line above the bottom plug of in the inner (4½ inch) Cork casing. Pressure sensors, data loggers, and additional fluid samplers will be deployed and attached to the Cork-head plumbing during a later expedition by ROV. However, there will be one seafloor fluid sampler attached to the Cork-II head and left running when the Cork-II is deployed by the drillship. Having a fluid sampler attached and running immediately after Cork installation will allow us to observe the early stages of borehole recovery.

The ship will move to Site 1027, recover the Cork system currently in the reentry cone in Hole 1027C, and deploy a new Cork-II system. We will check the total depth of Hole 1027C prior to Cork-II deployment using a cleanout bit on the drill string. The new Cork-II system will isolate two intervals in upper basement (Fig. **F13**). Downhole temperature sensors, fluid samplers, and microbiological incubation substrate will be placed in the lowermost isolated interval. Pressure sensors, data loggers, and additional fluid samplers will be deployed during a later expedition by ROV. If contingency time is left at the end of the expedition (allocated in case of difficulties with the final Cork-II deployment), it will be available for coring, temperature measurements in sediments, or other operations.

LOGGING/DOWNHOLE MEASUREMENTS

The main objectives of the downhole measurements program are to document crustal physical and hydrogeologic properties and to evaluate the nature of hydrothermal alteration. In addition to defining structural and lithologic boundaries as a function of depth, wireline logging data can be compared to results of laboratory analyses of discrete samples and should help delineate fracture densities and orientations. These measurements will complement core measurements by determining the thickness of lithologic units in intervals where core recovery is poor. Downhole measurements will also help determine the thermal state of sediments and upper basement rocks.

Wireline Logging

A series of four tool string deployments are planned for the basement section of Hole SR-1A. These tool strings include the triple combo, FMS/DSI, UBI, and WST-3. The time estimate for all four deployments is 39.4 h. Detailed descriptions of all wireline tools and applications are provided at **iodp.ldeo.columbia.edu/TOOLS_LABS/index.html.**

The triple combo, with caliper measurements and cable head temperature sensors, will be used to assess initial postdrilling borehole conditions such as hole size and fluid temperatures. This tool string will measure K, U, and Th concentrations; formation density; photoelectric effect; electrical resistivity; and porosity as a function of depth. These measurements will be used for characterization of stratigraphic sequences and to assess variations in alteration. Mapping the potassium distribution could help delineate acid-sulfate (K depletion) and higher-temperature phyllic (K addition) styles of alteration, particularly if core recovery is poor. The FMS will provide high-resolution borehole images of lithostratigraphic sequences and boundaries, oriented fracture patterns, and information regarding hole stability. The DSI will produce a full set of compressional and shear waveforms, cross-dipole shear wave velocities and amplitudes measured at different azimuths, and Stoneley waveforms. These types of measurements can be used to determine preferred mineral and/or fracture orientations and fracture densities and paleostress directions. The UBI will provide full coverage of the borehole walls while depicting structural and lithostratigraphic features related to paleo- and current stress environments. A VSP will be obtained using the WST-3. This tool will provide the shallow basement velocity gradient information that will be helpful for core-log-seismic correlations and for assessment of crustal layering.

The Ultra High Temperature MultiSensor Memory (UHT-MSM) tool could be used for obtaining a downhole temperature profile several days postdrilling and prior to the Cork-II installation in the SR-1A deep hole. The UHT-MSM is deployed on the coring line, rather than the logging line, and was successfully deployed during ODP Legs 169 and 193. The estimated time required for the deployment of this tool is 7–8 h.

Non-Wireline Downhole Tools

The DVTP and the APCT tool will be used to determine sediment temperatures and heat flow at one or more locations. This work is most likely to occur where sediment cores are collected. One or both tools could also be deployed in open hole to determine whether the formation is producing fluid. Similarly, the Water Sampling Temperature Probe (WSTP) may be deployed in an open hole to collect fluid samples if the formation produces crustal fluids.

The drill string packer is used to isolate part of an open or cased hole so that hydrogeologic properties near the borehole can be assessed (Becker, 1986). Packer experiments are planned for Holes SR-1A and SR-1B. In Hole SR-1A the packer may be run in straddle mode, with inflatable elements set at the top and bottom of the interval of interest, but it will be used to isolate the entire open borehole interval in Hole SR-1B.

SAMPLING STRATEGY

At the time of the publication of this Scientific Prospectus, a new IODP sample policy has not been finalized and the ODP Sample Distribution, Data Distribution, and Publications Policy (**www-odp.tamu.edu/publications/policy.html**) applies. Access to data and core sampling during Expedition 301, or within the 1 y moratorium following the expedition, must be approved by the Sample Allocation Committee (SAC).

The SAC (composed of Co-Chief scientists, Staff Scientist/Expedition Project Manager, and IODP Curator on shore and curatorial representative on board ship) will work with the Shipboard Scientific Party to formulate a formal expedition-specific sampling plan for shipboard and postcruise sampling.

Shipboard scientists are expected to submit sample requests 2–3 months before the beginning of the expedition. Sample requests may be submitted at **iodp.tamu.edu/curation/samples.html.** Based on sample requests (shore based and shipboard), the SAC and Shipboard Scientific Party will prepare a working cruise sampling plan. This plan will be subject to modification depending upon the actual material recovered and collaborations that may evolve between scientists during the expedition. Modifications to the sampling plan during the expedition require the approval of the Co-Chief Scientists, Staff Scientist/Expedition Project Manager, and curatorial representative.

The minimum permanent archive will be the standard archive half of each core; whole-round samples are exempt from this rule. On this expedition, we anticipate substantial whole-round core sampling for hydrologic, geochemical, and microbiologic investigations. Sampling may be particularly intense near the sediment/basement interface at one or more sites.

All sample frequencies and sizes must be justified on a scientific basis and will depend on core recovery, the full spectrum of other requests, and the cruise objectives. Some redundancy of measurement may be unavoidable, but minimizing the duplication of measurements among the Shipboard Scientific Party and identified shore-based collaborators will be a factor in evaluating sample requests.

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NOTE

N1. Wheat, C.G., Mottl, M.J., Fisher, A.T., Kadko, D., Davis, E.E., and Baker, E., submitted. Heat and fluid flow through a basaltic outcrop on a ridge flank.

Table T1. Site and hole locations for IODP Expedition 301, Juan de Fuca Flank.

Site/Hole	Latitude	Longitude	Seismic line	CDP/TR
SR-1A	47°45.209′N	127°45.832′W	GeoB 00-466	CDP 557
SR-2A*	47°45.662′N	127°45.674′W	GeoB 00-482	CDP 439
FR-1A, FR-1C†	47°54.105′N	128°33.468′W	InLine 44 (GeoB 00-365)	TR 426
FR-1B†	47°54.132′N	128°33.591′W	InLine 44 (GeoB 00-365)	TR 410
DR-1A†	47°38.673′N	127°26.311′W	EW0207 Line 1	CDP 3070
DR-2A†	47°37.297′N	127°19.329′W	EW0207 Line 1	CDP 1720
Hole 1026B‡	47°45.759′N	127°45.552′W	950813e	CDP 340
Hole 1027C‡	47°45.387′N	127°43.867′W	950813e	CDP 430

Notes: CDP = common depth point. TR = trace within 3-D seismic grid. * = work in Hole SR-2A is planned for another drilling expedition, to be scheduled. † = second-priority sites for Expedition 301. ‡ = Cork observatories in these holes are to be replaced; no additional drilling operations are planned.

Table T2. Final operations plan and time estimate, Expedition 1.

Proposed site	Location (lat/long)	Water depth (mbrf)	Operations description/depth (mbsf)	Task (h)	Transit (days)	Drilling (days)	Logging (days)	Total on hole (days)
Astoria	**46.12°N, 123.50°W**		**Transit 200 nmi - Astoria to Site SR-1 @ 10.5 kt**	**19.10**	**0.8**			
SR-1A	47°45.209'N	2611	**Jet-Test:**					
	127°45.832'W		1 - Conduct jet-in test	28.80		1.2	0.0	1.2
			[offset ship 10 m north x 10 m west in DP mode]					
			Deep Hole:					
			1 - Set reentry cone/jet-in 20" casing to 75 mbsf	39.60				
			2 - Drill with 21-1/2" bicenter and 9-7/8" pilot wobble bit	51.00				
			(15 m into basalt rubble to ~290 mbsf)	----				
			3 - Deploy 16" casing - cement casing shoe @ 280 mbsf	41.50				
			4 - Drill out 16" shoe/drill w/14-3/4" tricone to 390 mbsf	98.50				
			5 - Deploy 10-3/4" casing - cement shoe @ 380 mbsf	42.20				
			6 - RCB core massive basement 390 to ~730 mbsf	268.50				
			(CC-4/CC-7 core bits - includes logging hole prep time)	----				
			7 - Wireline log: ~730–390 mbsf (34 h) + POOH	39.40				
			(triple combo, FMS/DSI, UBI, WST-3*) *permit dep.					
			8 - Conduct straddle packer flow/injectivity tests (18 h)	42.00		25.7	1.5	27.2
			Total On-Site Days:	**27.1**				
			[offset ship 20 m south x 20 m east in DP mode]					
			Rubble Hole:					
			1 - Set reentry cone/jet-in 20" casing to 75 mbsf	39.60				
			2 - Drill with 21-1/2" bicenter and 9-7/8" pilot wobble bit	51.00				
			(15 m into basalt rubble to ~290 mbsf)	----				
			3 - Deploy 16" casing - cement casing shoe @ 280 mbsf	41.50				
			4 - Drill out 16" shoe/drill w/14-3/4" tricone to ~335 mbsf	53.10				
			6 - Deploy 10-3/4" csg w/2 ea 10 m screen jts to ~325 mt	40.40				
			7 - Conduct single packer flow/injectivity test (12 h)	31.90				
			8 - Deploy Cork-II/ROV platform w/4-1/2" tubing and 1 pkr	35.00		12.2	0.0	12.2
			Move 0.01 nmi - Site SR-1A to Hole 1026B at 0.5 kt in DP mode		**0.1**			
1026B	47°45.759'N	2669	**Hole 1026B:**					
(Cork-II)	127°45.552'W		1 - Recover Cork/stinger (TD = 295.2 mbsf)	20.75				
			2 - Deploy Cork-II with 4-1/2" tubing and single packer	22.25				
			3 - Deploy ROV/sub platform	11.50		2.3	0.0	2.3
			Move 0.01 nmi - Hole 1026B to SR-1A at 0.5 kt in DP mode		**0.1**			
SR-1A	47°45.209'N	2611	**Sediment Coring:**					
	127°45.832'W		APC to ~275 mbsf/APCT/DVTP/plug hole	41.20		1.7	0.0	1.7
SR-1A	47°45.209'N	2611	**Deep Hole- Install Cork-II:**					
(Cork-II)	127°45.832'W		1 - Cleanout hole to TD (~700 mbsf)	25.50				
			2 - Deploy Cork-II with 4-1/2" tubing and 3 packers	32.25				
			3 - Deploy ROV/sub platform	11.50		2.9	0.0	2.9
			Move 1.2 nmi - SR-1A to Hole 1027C at 0.5 kt in DP mode		**0.1**			
1027C	47°45.387'N	2667	**Hole 1027C:**					
(Cork-II)	127°43.867'W		1 - Recover Cork/stinger (TD = 632.4 mbsf)	20.75				
			2 - Run 9-7/8" tricone bit/cleanout hole to 632 mbsf	19.50				
			3 - Deploy Cork-II with 4-1/2" tubing and 2 packers	29.25				
			4 - Deploy ROV/sub platform	11.50		3.4	0.0	3.4
			Cork installation contingency time	36		1.5		1.5
Astoria	**46.12°N, 123.50°W**		**Transit 200 NMI to Astoria @ 10.5 kt**	**19.10**	**0.8**			
			SUBTOTAL:		**1.9**	**50.9**	**1.5**	**52.4**
			TOTAL DAYS AT SEA (OPERATING):		**54.3**			
			TOTAL EXPEDITION (including 6.0 day port call):		**60.3**			

Figure F1. Site map of the northeast Pacific showing regional features and location of the ODP Leg 168 transect (dashed red line). Proposed drilling sites (stars) are located along, east, and south of this transect. SR = Second Ridge, FR = First Ridge, DR = Deep Ridge. Primary objectives will be achieved at the SR site, whereas work at the FR and DR sites comprise secondary objectives.

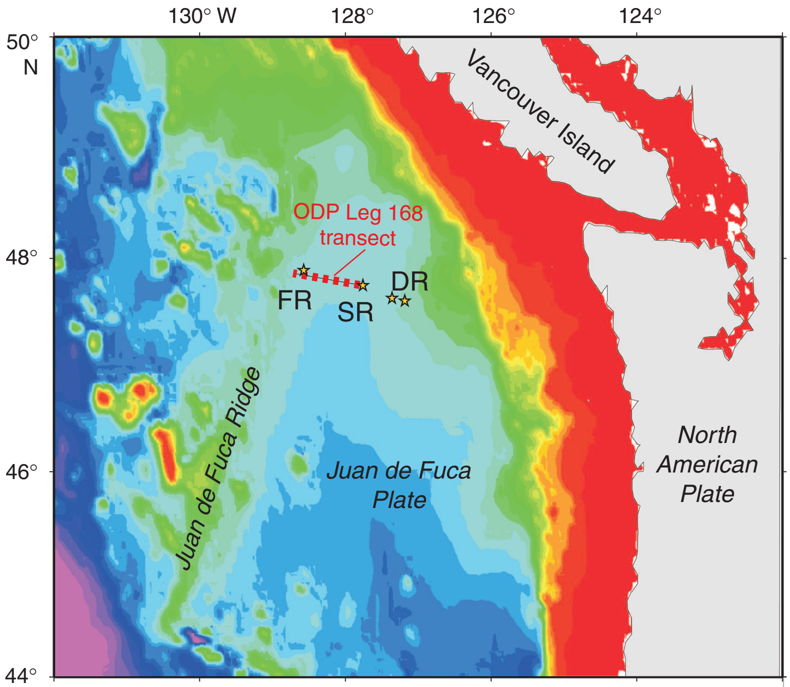


Figure F2. Leg 168 transect and locations of Second Ridge (SR), First Ridge (FR), and Deep Ridge (DR) drilling sites. Top: Interpretation of seismic data along Leg 168 drilling transect, showing sediment thickness, basement relief, and depths of existing (thin, solid lines) and proposed (thick, dashed lines) holes. Middle: Measured (solid) and anticipated (open) upper basement temperatures, based on results from Leg 168 and regional surveys. Bottom: Mg concentrations from uppermost basement pore fluids and apparent ^{14}C ages of these fluids. Note the relative youth of SR fluids, thought to recharge through a large basaltic outcrop, 52 km to the south. See text and drilling proposal for discussion and references.

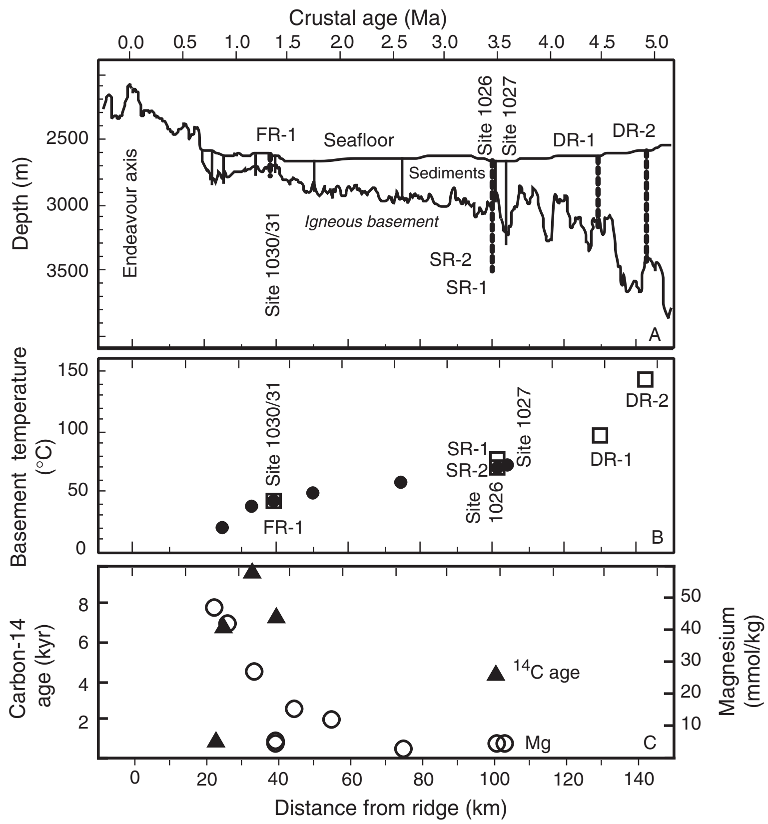


Figure F3. A. Second Ridge (SR) site map showing track lines from SO149 (solid lines) and older seismic data and locations of ODP Leg 168 drill holes. Seismic line spacing is 100 m within 1 km to the north-northwest and south-southeast of ODP Hole 1026B, with most lines oriented perpendicular to the structural strike of basement. Corks will also be replaced at Sites 1026 and 1027 during Expedition 301, but there will be no additional drilling at these sites. Detail of track lines, showing line numbers and common depth points (CDPs), is included in Figure **F4.** **B.** Topography of top of basement around Second Ridge based on multichannel seismic data collected during SO149, showing tops of outcrops (in white), Leg 168 Holes 1026B and 1027C, and proposed Sites SR-1 and SR-2 (stars) (figure courtesy of L. Zühlsdorff and V. Spiess, University of Bremen, Germany). **C.** Map view indicating spatial relations between Corked Holes 1026B and 1027C, Sites SR-1 and SR-2, and nearby basement outcrops. Inset shows relative locations of pumping (P) and observation (O) wells for cross-hole experiments, to be completed during a later expedition. Depth contours in meters. **D.** SO149 seismic Line GeoB 00-203, passing through Sites 1026 and 1027, which penetrate only into uppermost basement rocks. Seismic data passing through Site SR-1 are shown in Figure **F5.** This site is located 1000 m south of Site 1026, near the peak of the same buried basement ridge. (**Figure shown on next page.**)

Figure F3 (continued). Caption shown on previous page.

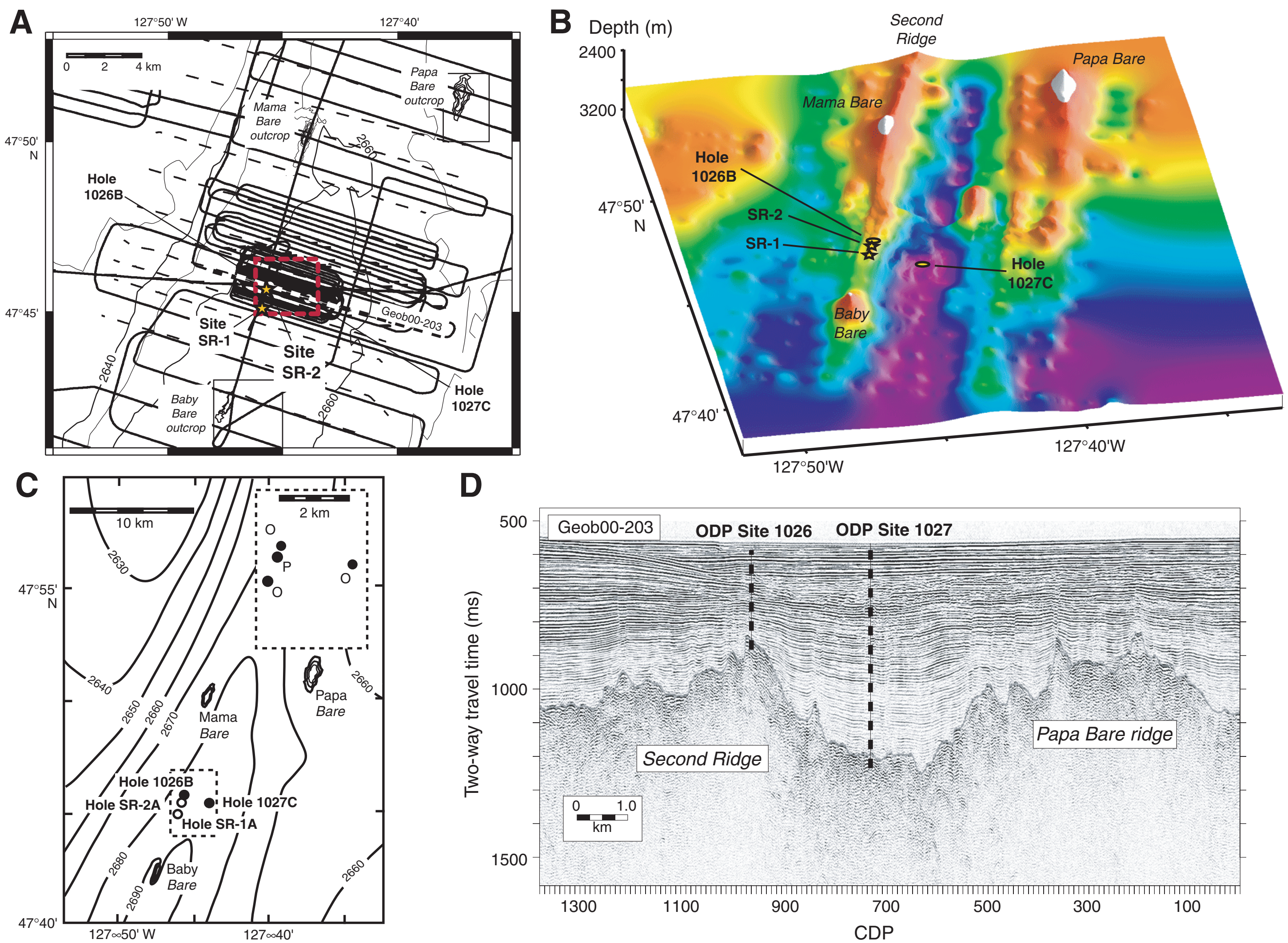


Figure F4. Detailed track chart showing area around ODP Sites 1026 and 1027 and IODP SR sites, including multichannel SO149 seismic data acquired in 2000. Spacing of seismic lines over the buried basement ridge comprising the primary target for drilling is 100 m within 1 km north and south of Hole 1026B. Expedition 301 will replace Cork observatories in Holes 1026B and 1027C and drill and emplace new observatories at Site SR-1. Work will be done at Site SR-2 during a subsequent expedition. Thick dashed lines show locations of seismic Lines GeoB 00-203 (Sites 1026 and 1027; Fig. **F3D**), GeoB 00-466 (Site SR-1; Fig. **F5**), and GeoB 00-482 (Site SR-2; Fig. **F6**). Two additional line locations are shown: crossing Line GeoB 00-490 and Line GeoB 00-483, which defines the northernmost extent of the area of dense seismic coverage. (**Figure shown on next page.**)

Figure F4 (continued). Caption shown on previous page.

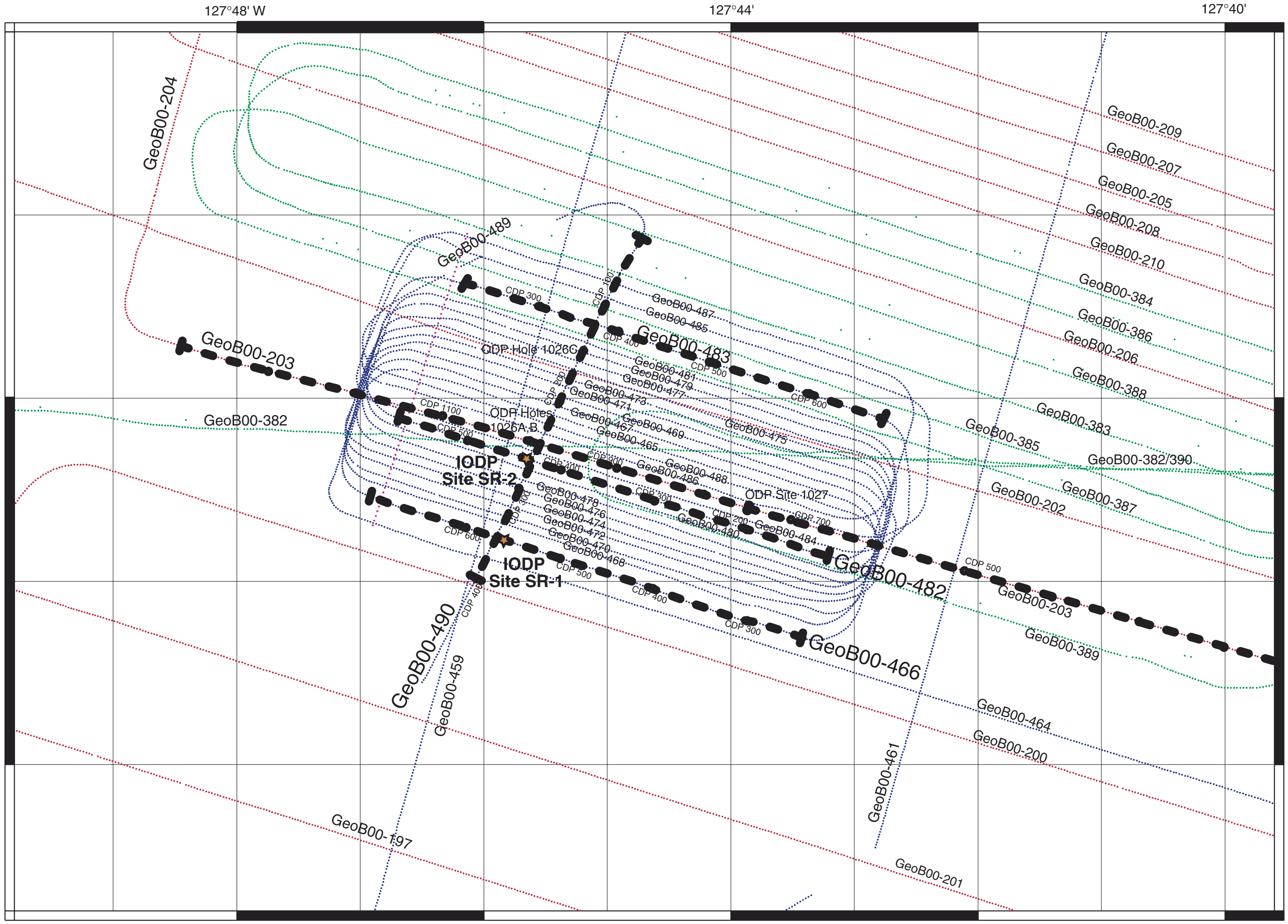
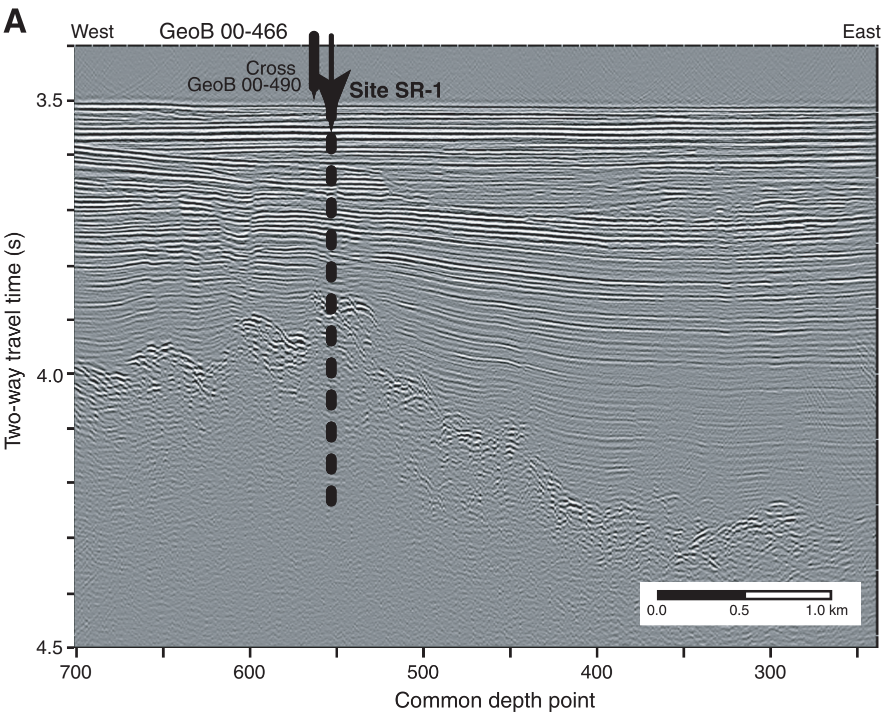


Figure F5. Multichannel seismic lines across the South Ridge area. Line locations are shown in Figure **F4.** **A.** GeoB 00-466, crossing Site SR-1. **B.** GeoB 00-490, a "crossing line" that runs roughly perpendicular to GeoB 00-466, subparallel to the buried basement ridge. The basement reflector is not particularly distinct on this image because it does not follow the peak of the buried ridge.



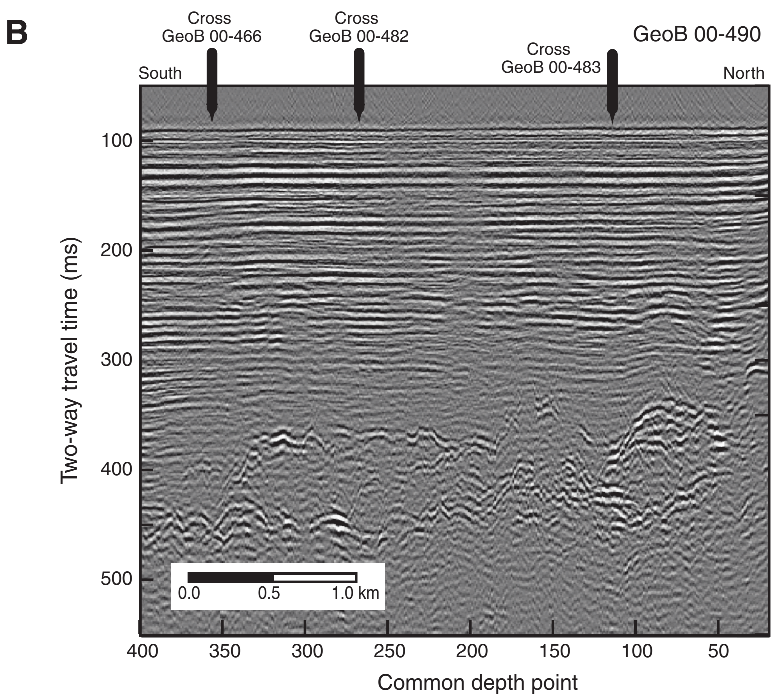


Figure F6. Multichannel seismic lines across proposed Site SR-2. This site is planned for a subsequent return expedition to conduct cross-borehole hydrologic experiments to the monitoring borehole installations deployed during this first Juan de Fuca expedition (Hole SR-1A, Site 1026, and Site 1027). Line locations are shown in Figure **F4.**

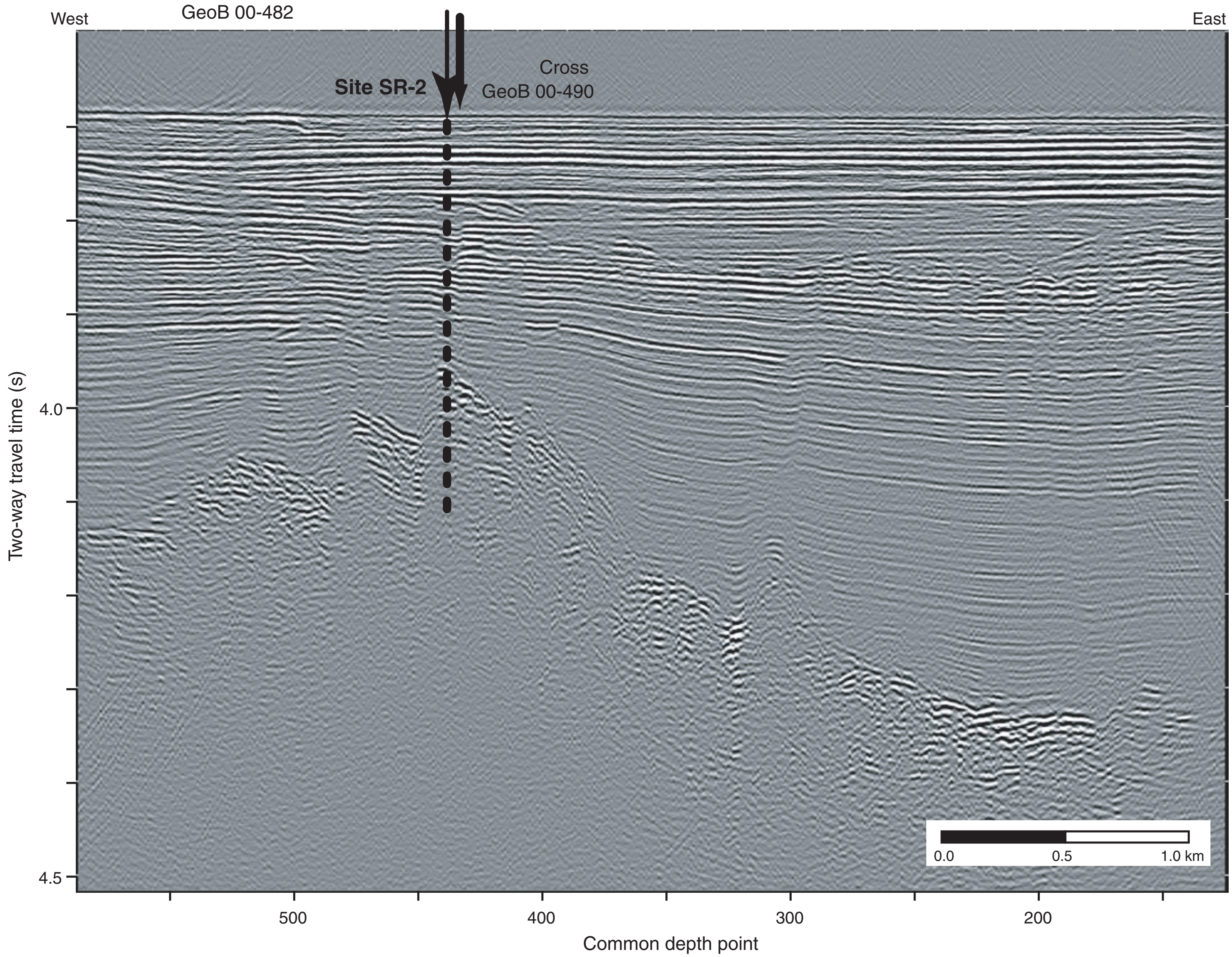


Figure F7. Track chart showing SO149 coverage around First Ridge (FR), including locations of ODP Sites 1030 and 1031 and IODP Site FR-1. Thick dashed lines shows location of InLine 44 (offset by ~20 m from Line GeoB 00-365) from the 3-D data set. Additional lines are shown for reference. FR holes are targeted inside and outside of a region of acoustic blanking above the buried basement high. CDP = common depth point.

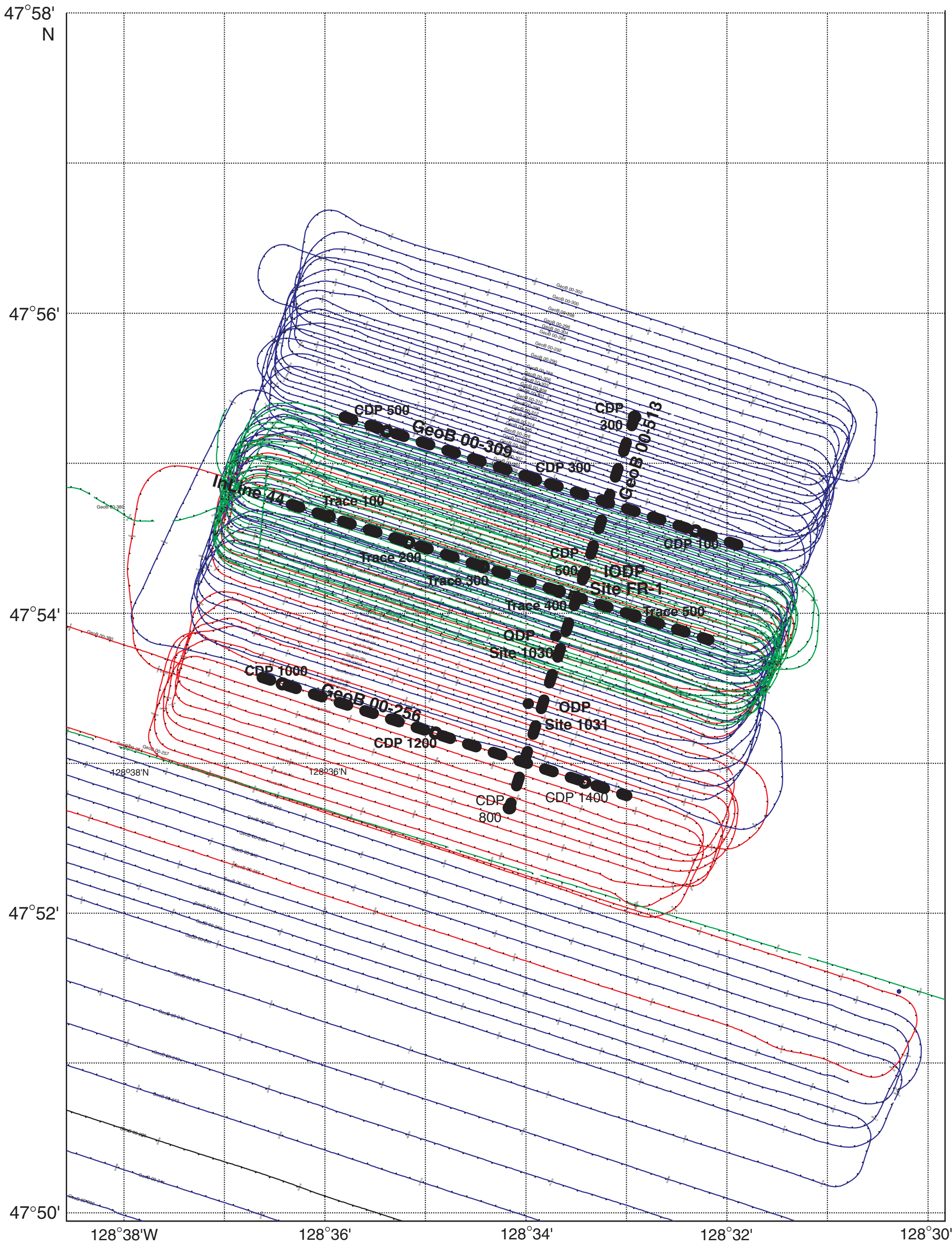


Figure F8. A, B. Parasound data and multichannel seismic data from 3-D seismic grid, InLine 44, oriented perpendicular to basement structure and running through proposed Site FR-1. **C.** Crossing seismic Line GeoB 00-513, oriented subparallel to basement structure.

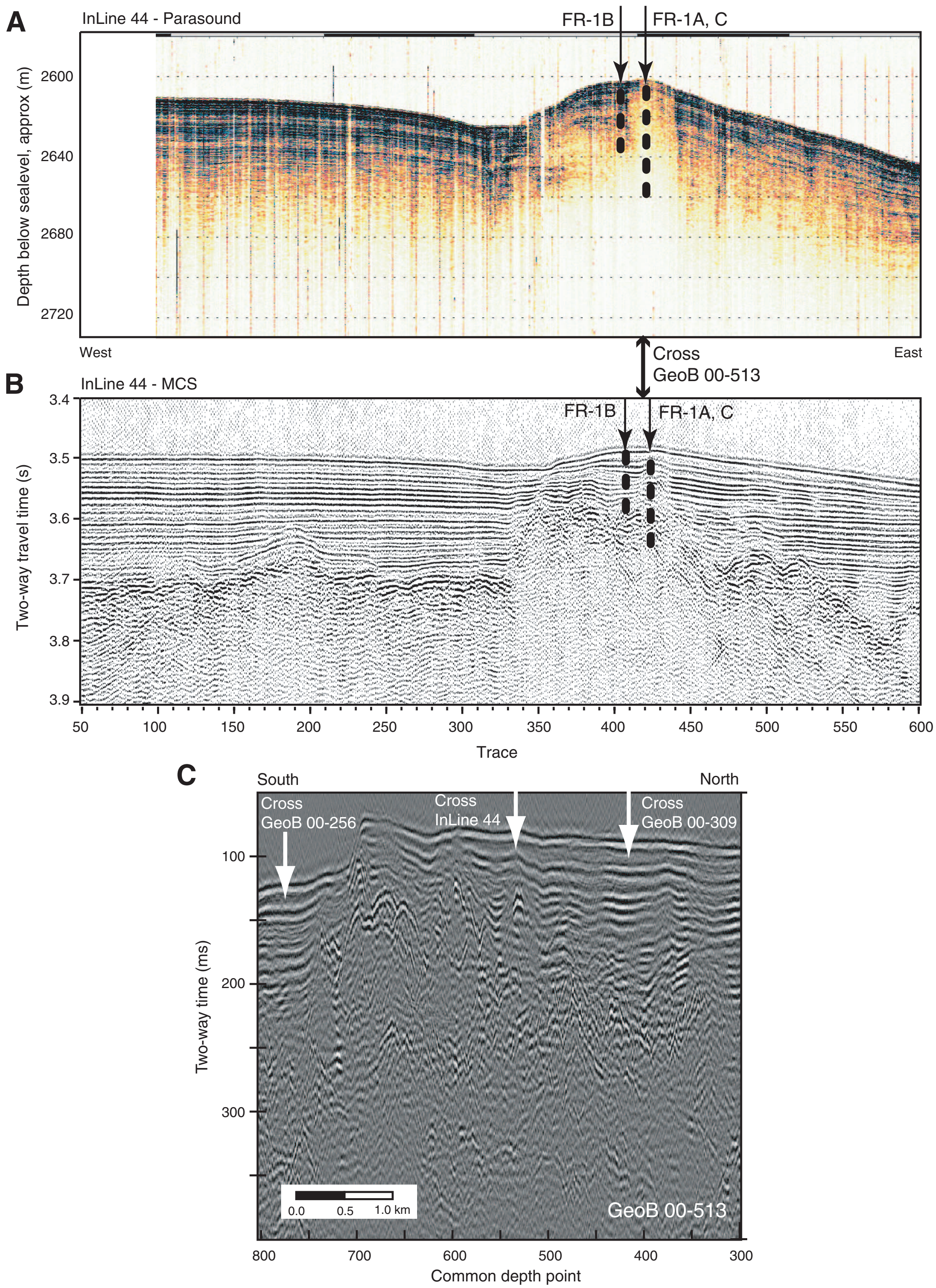


Figure F9. Deep Ridge (DR) site map and seismic data. **A.** DR site map. Planned DR sites are shown as stars. ODP Sites 1026 and 1027 are shown for reference, as are proposed Sites SR-1 and SR-2. **B.** Multichannel seismic EW0702 Line 1, showing proposed Sites DR-1 and DR-2. Both sites are positioned over buried basement highs (data courtesy of S. Carbotte and M. Nedimovic, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York, USA, and the shipboard scientific party of EW0207). CDP = common depth point.

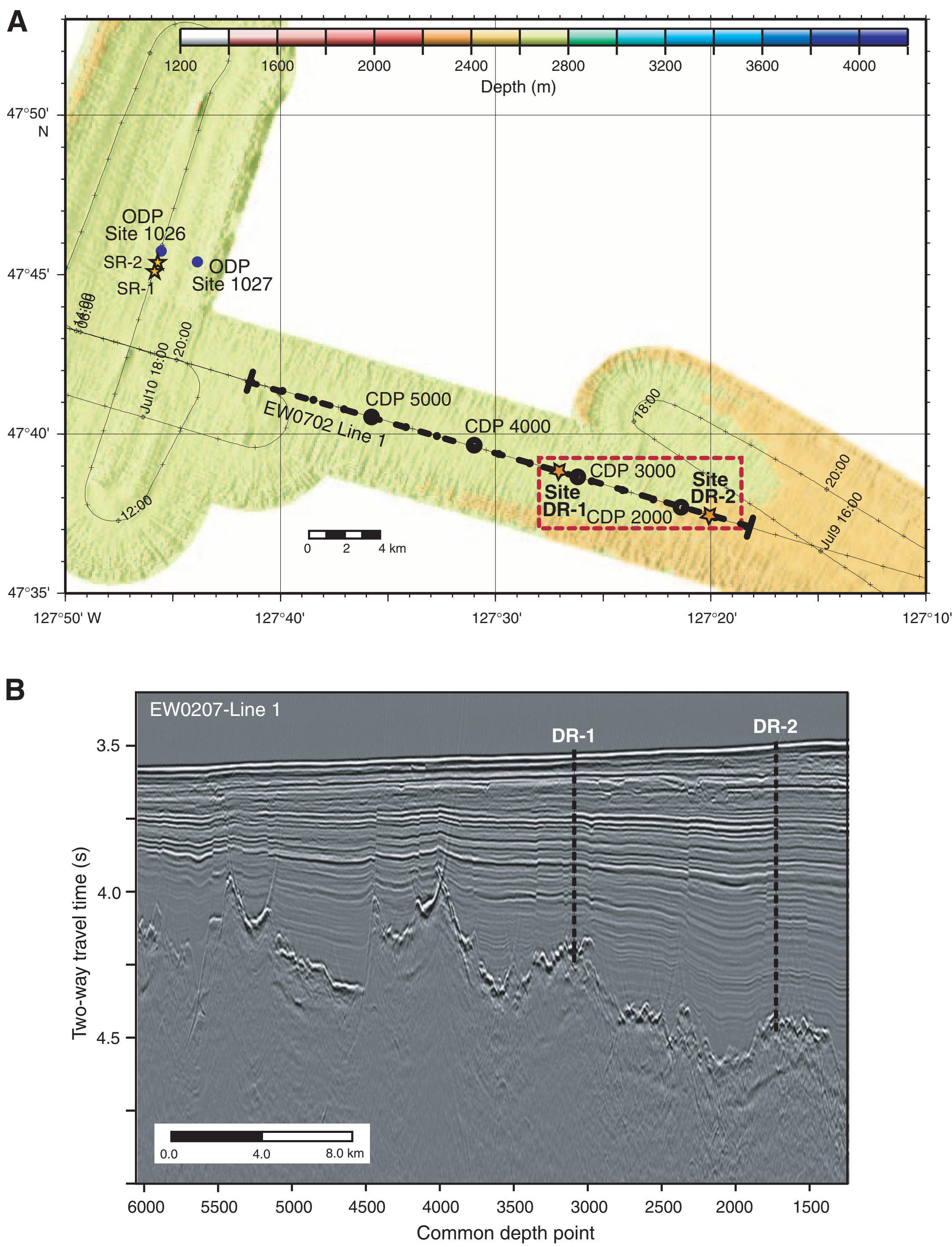


Figure F10. Planned configuration of Cork observatory in shallow-basement rubble zone, Hole SR-1B.

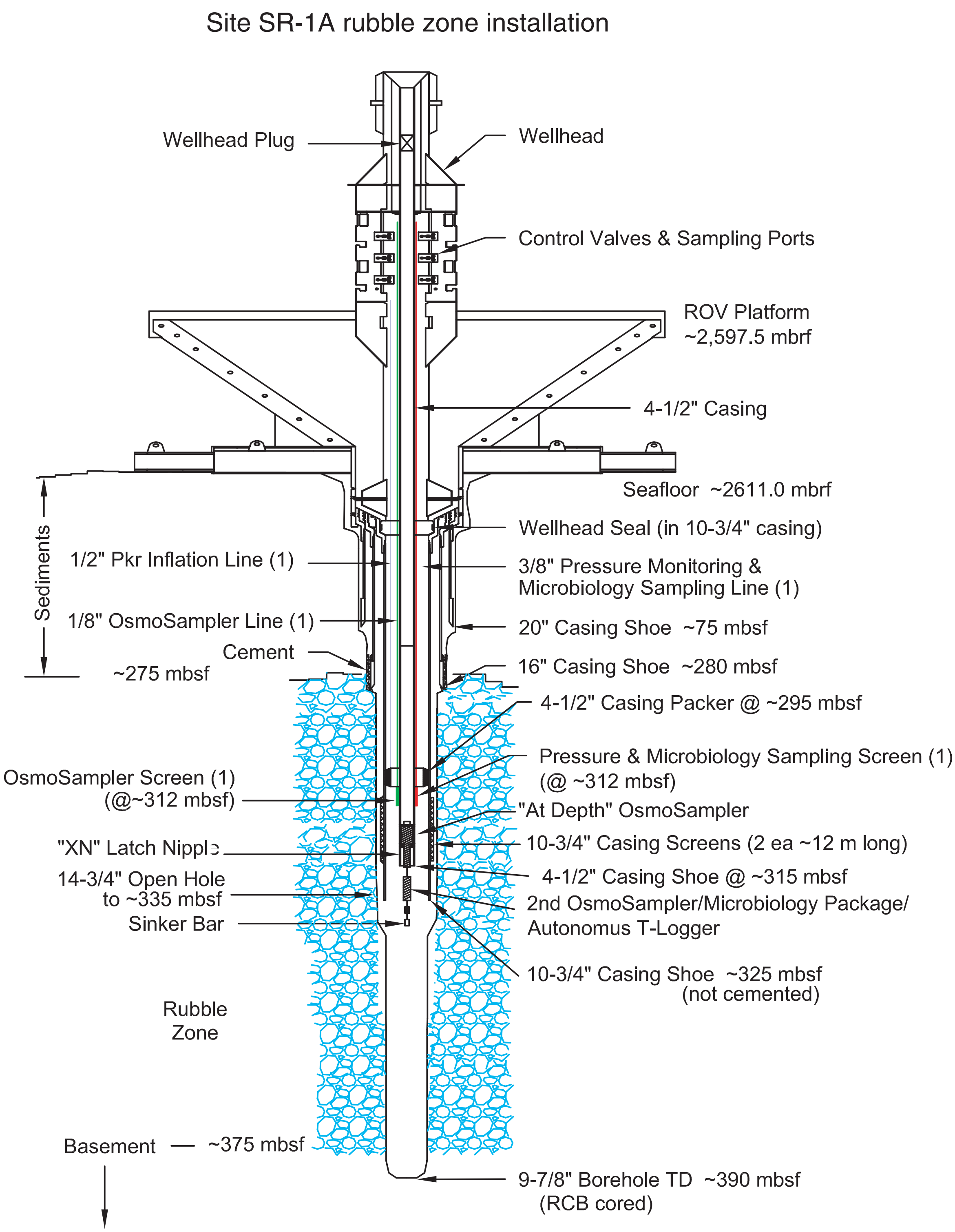


Figure F11. Planned configuration of Cork observatory in Hole 1026B.

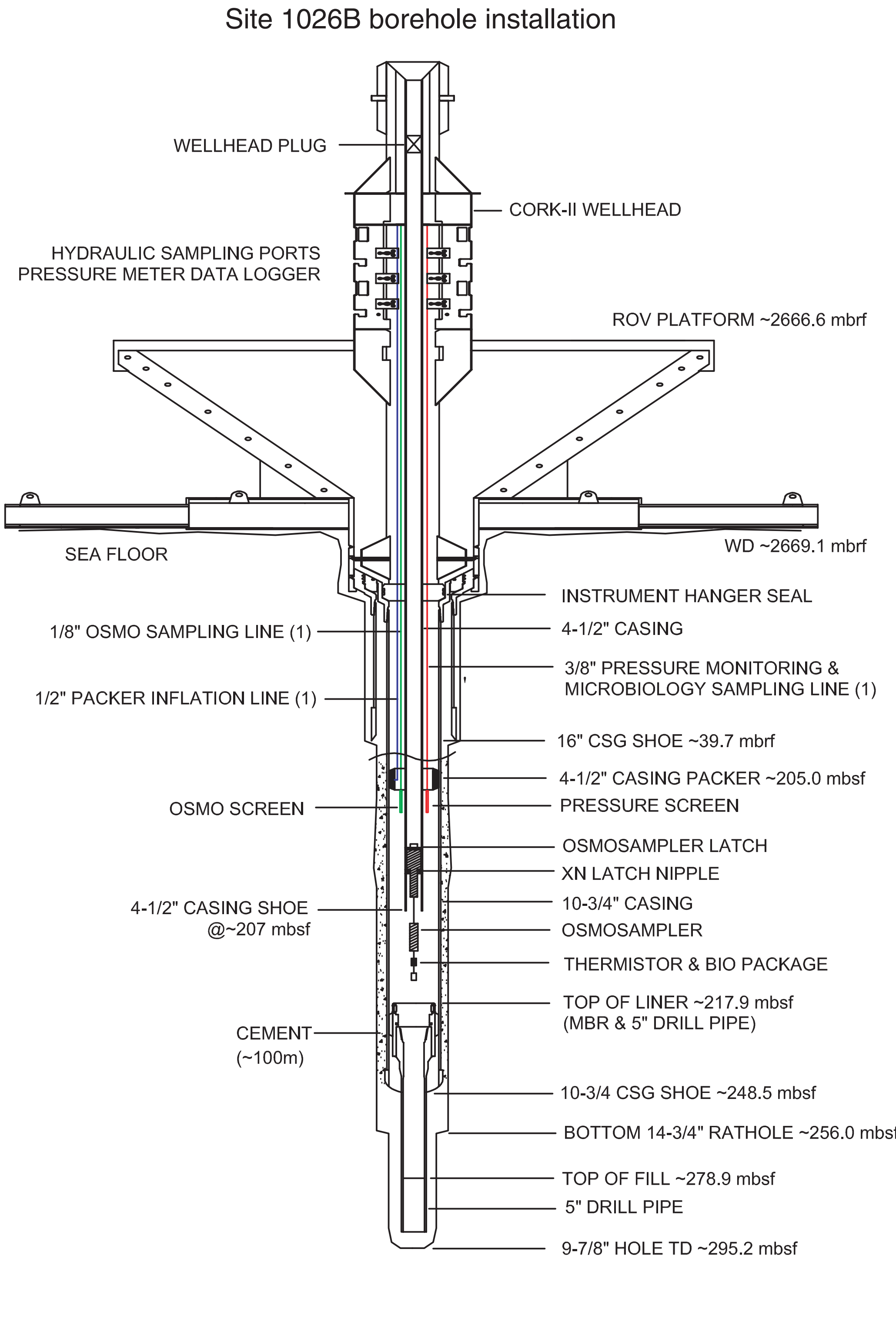


Figure F12. Planned configuration of Cork observatory in deep-basement Hole SR-1A.

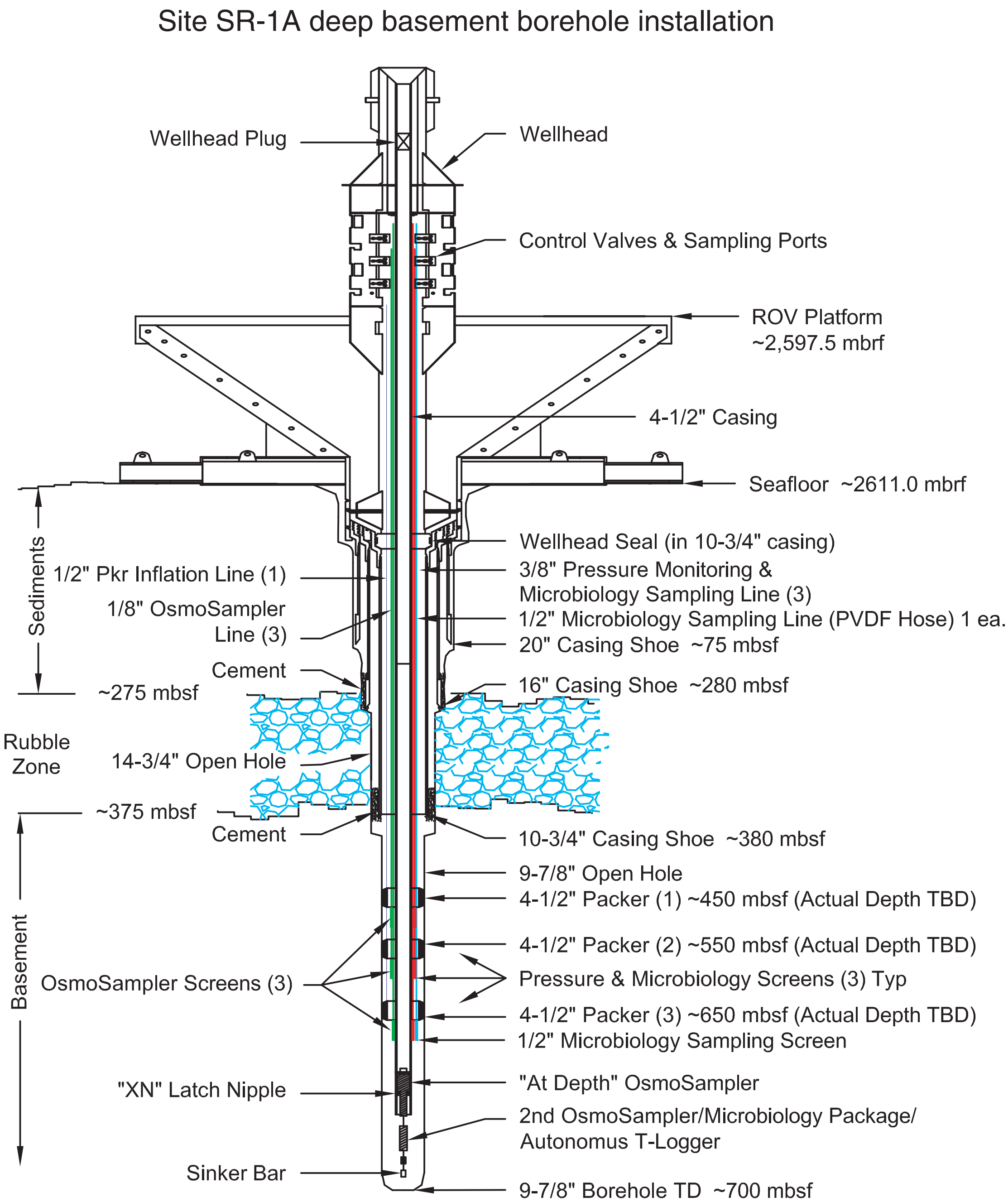
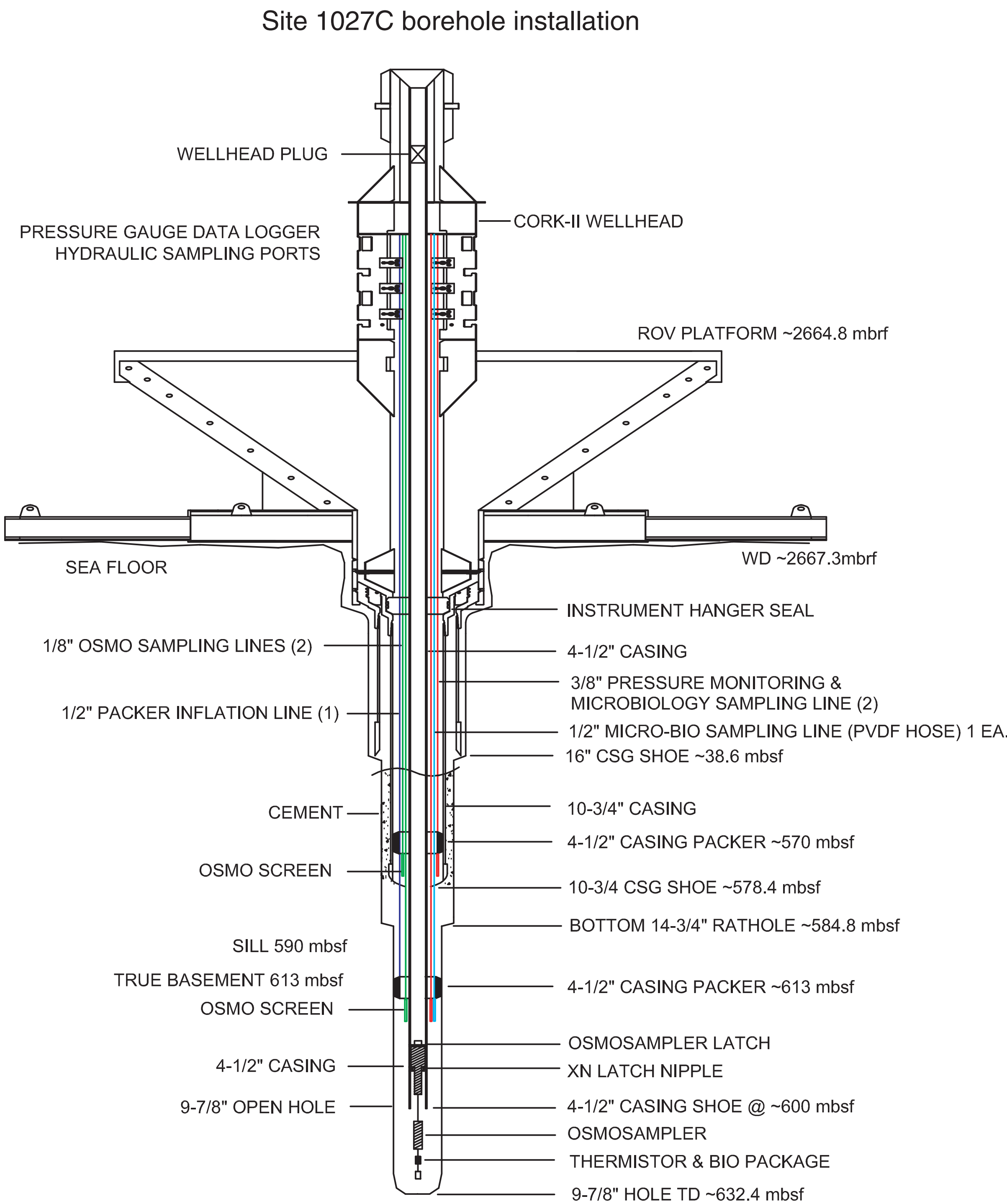


Figure F13. Planned configuration of Cork observatory in Hole 1027C.



SITE SUMMARIES

Site: SR-1

Priority:	Primary
Position:	47°45.209′N, 127°45.832′W; approved for 500 m radius surrounding position
Water depth (m):	2611
Target drilling depth (mbsf):	730
Approved maximum penetration (mbsf):	860
Survey coverage:	GeoB 00-466: CDP 557 (track map–Fig. F4; seismic profile–Fig. F5)
Objective:	• Characterize upper basaltic crust • Install long-term borehole observatory (pressure, geochemistry, microbiology) • Core and sample sediments • Measure downhole formation temperatures
Drilling/logging program:	Deep Hole: • Install reentry cone, 20 inch casing to ~75 mbsf; • Install 16 inch casing into top of basaltic basement (~280 mbsf) • Install 10 3/4 inch casing through rubble zone to ~380 mbsf • RCB core basaltic crust 390 to ~730 mbsf • Wireline log with triple combo and FMS-sonic tool strings and UBI and WST-3 • Packer experiments • Install long-term borehole observatory Rubble Hole: • Install reentry cone, 20 inch casing to ~75 mbsf • Install 16 inch casing into top of basaltic basement (~280 mbsf) • Install 10 3/4 inch casing into rubble zone (~325 mbsf) • Packer experiments • Install long-term borehole observatory Sediments: • Core sediment section for geochemical and microbiological experiments • Temperature measurements (APCT, DVTP) • Potential water sampling (WSTP) and core orientation • See "Drilling Strategy;" Table T2
Nature of rock anticipated:	Turbidites (sand, silt, clay) and hemipelagic mud, overlying basalt

SITE SUMMARIES (CONTINUED)

Site: SR-2

Priority:	Secondary (planned for subsequent return expedition)
Position:	47°45.662′N, 127°45.674′W; approved for 500 m radius surrounding position
Water depth (m):	2600
Target drilling depth (mbsf):	475
Approved maximum penetration (mbsf):	475
Survey coverage:	GeoB 00-482: CDP 439 (track map–Fig. **F4;** seismic profile–Fig. **F6**)
Objective:	• Characterize upper basaltic crust and hydrologic properties • Conduct cross-borehole hydrologic and geochemical experiments • Install long-term borehole observatory (pressure, geochemistry, microbiology)
Drilling and logging program:	• Core into upper basement • Conduct wireline logging, vertical/offset seismic profile, and packer experiments • Install borehole observatory (Cork)
Nature of rock anticipated:	Turbidites (sand, silt, clay) and hemipelagic mud, overlying basalt

SITE SUMMARIES (CONTINUED)

Site: ODP Hole 1026B

Priority:	Primary
Position:	47°45.759′N, 127°45.552′W
Water depth (m):	2669
Target drilling depth (mbsf):	Not applicable; reoccupy existing borehole; no new penetration
Approved maximum penetration (mbsf):	Not applicable; reoccupy existing borehole; no new penetration
Survey coverage:	950813e: CDP 340 (track map–Fig. F4; seismic profile–Fig. F3)
Objective:	Install long-term borehole observatory (pressure, geochemistry, microbiology)
Drilling and logging program:	• Remove existing borehole observatory (Cork) and install new long-term borehole observatory • See "Drilling Strategy;" Table T2
Nature of rock anticipated:	Not applicable; reoccupy existing borehole; no new penetration

SITE SUMMARIES (CONTINUED)

Site: ODP Hole 1027C

Priority:	Primary
Position:	47°45.387′N, 127°43.867′W
Water depth (m):	2669
Target drilling depth (mbsf):	Not applicable; reoccupy existing borehole; no new penetration
Approved maximum penetration (mbsf):	Not applicable; reoccupy existing borehole; no new penetration
Survey coverage:	950813e: CDP 430 (track map–Fig. **F4**; seismic profile–Fig. **F3**)
Objective:	Install long-term borehole observatory (pressure, geochemistry, microbiology)
Drilling and logging program:	• Remove existing borehole observatory (Cork) and install new long-term borehole observatory • See **"Drilling Strategy;"** Table **T2**
Nature of rock anticipated:	Not applicable; reoccupy existing borehole; no new penetration

SITE SUMMARIES (CONTINUED)

Site: DR-1

Priority:	Secondary
Position:	47°38.810′N, 127°26.999′W; approved for 500 m radius surrounding position
Water depth (m):	2600
Target drilling depth (mbsf):	660
Approved maximum penetration (mbsf):	660
Survey coverage:	EW0207 Line 1, CDP 3070 (track map and seismic profile–Fig. **F8**)
Objective:	Drill into deeply buried basement ridge 125 km from the spreading center, where basement temperatures may approach 100°C, to evaluate the influences of hydrothermal circulation on crustal evolution and microbiology. Sediment thickness = 610 m Basement penetration = 20–50 m
Drilling and logging program:	• RCB through 610 m of sediment and into uppermost basement • If time allows, install cone and casing through sediment • Temperature measurements (DVTP)
Nature of rock anticipated:	Turbidites (sand, silt, clay) and hemipelagic mud, overlying basalt

SITE SUMMARIES (CONTINUED)

Site: DR-2

Priority:	Secondary
Position:	47°37.449′N, 127°20.049′W; approved for 500 m radius surrounding position
Water depth (m):	2600
Target drilling depth (mbsf):	940
Approved maximum penetration (mbsf):	940
Survey coverage:	EW0207 Line 1, CDP 1720 (track map and seismic profile–Fig. F8)
Objective:	Drill into deeply buried basement ridge 145 km from the spreading center, where basement temperatures may approach 140°C, to evaluate the influences of hydrothermal circulation on crustal evolution and microbiology. Sediment thickness = 890 m Basement penetration = 20–50 m
Drilling and logging program:	• RCB through 910 m of sediment and into uppermost basement • If time allows, install cone and casing through sediment • Temperature measurements (DVTP)
Nature of rock anticipated:	Turbidites (sand, silt, clay) and hemipelagic mud, overlying basalt

SITE SUMMARIES (CONTINUED)

Site: FR-1A

Priority:	Secondary
Position:	47°54.105′N, 128°33.468′W; approved for 500 m radius surrounding position
Water depth (m):	2600
Target drilling depth (mbsf):	110
Approved maximum penetration (mbsf):	110
Survey coverage:	• InLine 44 • TR426 • GeoB 00-365 (track map–Fig **F6;** seismic profile–Fig. **F7**)
Objective:	Drill a short series of sediment and shallow basement holes along the first buried basement ridge east of the spreading center to • Evaluate sediment properties • Document fluid chemistry and evidence for along-strike fluid flow • Determine the nature of hydrothermal alteration and microbiology in uppermost basement Sediment thickness = 40–60 m where basement comes closest to the seafloor
Drilling and logging program:	• APC/XCB and RCB core through sediments and into uppermost basement • Core into upper basement • Temperature measurements (APCT, DVTP) • Potential water sampling (WSTP)
Nature of rock anticipated:	Turbidites (sand, silt, clay) and hemipelagic mud, overlying basal

SITE SUMMARIES (CONTINUED)

Site: FR-1B

Priority:	Secondary
Position:	47°54.132′N, 128°33.591′W; approved for 500 m radius surrounding position
Water depth (m):	2600
Target drilling depth (mbsf):	110
Approved maximum penetration (mbsf):	110
Survey coverage:	• InLine 44 • TR410 • GeoB 00-365 (track map–Fig F6; seismic profile–Fig. F7)
Objective:	Drill a short series of sediment and shallow basement holes along the first buried basement ridge east of the spreading center to • Evaluate sediment properties • Document fluid chemistry and evidence for along-strike fluid flow • Determine the nature of hydrothermal alteration and microbiology in uppermost basement Sediment thickness = 40–60 m where basement comes closest to the seafloor
Drilling and logging program:	• APC/XCB and RCB core through sediments and into uppermost basement • Core into upper basement • Temperature measurements (APCT, DVTP) • Potential water sampling (WSTP)
Nature of rock anticipated:	Turbidites (sand, silt, clay) and hemipelagic mud, overlying basalt

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