OCEAN DRILLING PROGRAM

LEG 196 SCIENTIFIC PROSPECTUS

LOGGING WHILE DRILLING AND ADVANCED CORKS IN THE NANKAI TROUGH

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This Scientific Prospectus is based on precruise JOIDES panel discussions and scientific input from the designated Co-chief Scientists on behalf of the drilling proponents. The operational plans within reflect JOIDES Planning Committee and thematic panel priorities. During the course of the cruise, actual site operations may indicate to the Co-chief Scientists and the Operations Manager 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 plan presented here are contingent upon approval of the Director of the Ocean Drilling Program in consultation with the Science and Operations Committees (successors to the Planning Committee) and the Pollution Prevention and Safety Panel.

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ABSTRACT

Leg 196 is the second of a two-leg program of drilling, logging, and installing long-term observatories in the Nankai Trough, the type example of a convergent margin accreting a thick section of clastic sediments. The two-leg program was designed to define the interrelationship of the dynamics of deformation and fluid-flow processes in an accretionary prism characterized by thick terrigenous sediments. In 2000, Leg 190 investigation focused on coring at sites in undeformed to highly deformed zones along two transects across the Nankai Trough to investigate variability in deformational and hydrologic character. In 2001, Leg 196 research will first conduct logging-while-drilling (LWD) activities through the sediment section at three sites previously cored on the Muroto Transect during Legs 131 and 190: Sites 808 and 1174 near the deformation front at the toe of the prism and Site 1173, a reference site about 12 km seaward. During Leg 196, two holes at Sites 808 and 1173 will be sealed with multipacker advanced circulation obviation retrofit kits (ACORKs) for long-term monitoring of fluid-flow and tectonic processes. Contingent upon funding and JOIDES advisory structure approval, the ACORK at Site 1173 will incorporate a broadband seismometer cemented into the basement section, ~50 m of which will be cored. In concert with measurements made during Leg 190, the Leg 196 LWD data will document how physical properties change during accretion and provide critical information on stress, pore pressures, and permeability. Instrumenting the two holes with ACORKs will begin a long-term program of observation of seismicity, fluid-flow parameters, and fluid geochemistry at the Nankai Trough, a program that will involve future revisits by manned and unmanned submersibles.

INTRODUCTION

Prominent among the important scientific problems given high priority in the current Ocean Drilling Program (ODP) JOIDES Long-Range Plan (LRP) (1996) is understanding deformational and fluid-flow processes at convergent plate margins. Objectives include addressing "key questions, such as the distribution of deformation throughout an accretionary prism, the controls on what material is accreted and what is subducted, and the role of fluids and fluid flow in deformation of the prism" and understanding "the fluid-linked diagenetic and tectonic processes in the rapidly deforming geochemical factory of the accretionary wedge." These objectives are not only important scientifically but also have great societal relevance. For example, the deformation associated with plate convergence can be associated with catastrophic earthquakes and the fluid and chemical fluxes may impact global geochemical budgets, including carbon fluxes relevant to climate issues. The process-oriented, interlinked nature of these objectives requires not only detailed spatial and subsurface sampling but also a long-term time-series observational approach in the subseafloor. Thus, these objectives are highly appropriate for the ODP initiative for in situ monitoring of geological processes—the approach to be embodied in Leg 196.

The Nankai Trough accretionary prism represents an "end-member" prism accreting a thick terrigenous sediment section in a setting with structural simplicity and unparalleled resolution by seismic and other geophysical techniques, including a three-dimensional multichannel seismic (MCS) survey conducted in the summer of 1999 (Figs. 1, 2). It thus represents an excellent setting to address LRP objectives for accretionary prism coring, in situ monitoring, and refinement of mechanical and hydrological models. These are precisely the objectives of the two-leg (Legs 190 and 196) integrated program begun in 2000 to "define the interrelationship of the dynamics of deformation and fluid-flow processes in an accretionary prism characterized by thick terrigenous sediments." Coring operations during Leg 190 included coring a transect of sites off the Muroto Peninsula (Fig. 2). Leg 196 will complete the program with logging while drilling (LWD) at three sites along the Muroto Transect plus installation of two advanced circulation obviation retrofit kits (ACORKs) hydrogeological observatories.

Despite the various drilling successes mentioned above, direct measurements of fluid circulation indicators (e.g., pore pressures, flow velocities, in situ geochemical flow proxies) have been difficult to accomplish in an accretionary complex. Nevertheless, the combination of approaches planned for Leg 196—LWD plus long-term in situ monitoring—shows great promise in addressing these issues. For example, recent LWD data from the Barbados accretionary prism indicated that décollement sediments have near-surface porosity maintained by high pore-fluid pressures (Moore et al., 1995, 1998). CORK pressure data directly documented these high fluid pressures (Becker et al., 1997). In contrast, Leg 190 data shows the décollement at Nankai is marked by low porosity (Fig. 3); what is the role of fluid pressures there?

BACKGROUND AND STRUCTURAL SETTING

Recent studies of the processes occurring at convergent plate boundaries have established beyond doubt that fluids play a major role in how accretionary prisms and mountain belts evolve (e.g., Carson et al., 1990; Henry et al., 1989). Tectonic stresses at convergent margins lead to the expulsion of intergranular fluids through compaction of unlithified sediments (e.g., tectonic dewatering [Moore et al., 1986] or shear dewatering [Bray and Karig, 1988], whereas thermal alteration of primary minerals produces excess fluids by dehydration (Moore and Vrolijk, 1992). It is inferred that these fluids play an important role in the initiation and development of the basal décollement—the plate boundary fault— beneath an accretionary prism, commonly deep within subducting sediments. The décollement apparently can act as both a barrier to and a conduit for fluid flow, as it tends to have a strongly anisotropic permeability, being much more permeable along than across the plane of the fault zone. Even deeper than décollement, the possible role of fluid flow in subducted oceanic basement remains to be assessed; where young crust is subducted (as at Nankai Trough), basement should be expected to be quite permeable (e.g., Fisher, 1998) and may support an important component of the overall fluid-flow system. Finally, these fluids are also inferred to be intimately related to earthquake cycles and tectonic stress relief in subduction systems, but in a poorly understood manner.

Scientific ocean drilling into accretionary prisms has provided important insights into the mechanisms by which accretionary prisms dewater. Pore-water chemistry, temperature anomalies, and structural observations, particularly at the more mud-dominated Barbados prism, suggest that fluids move mainly through zones with high fracture permeability, specifically faults. In other prisms like Nankai, fluids also move by intergranular flow, probably along stratigraphic horizons (e.g., Hyndman et al., 1993). At the presently nonaccretionary Costa Rica Trench, similar data clearly demonstrate the importance of fluid circulation in the relatively young subducted oceanic basement (Silver et al., 1997). Results of Barbados drilling indicate that the décollement is an active fluid conduit; the fluid geochemistry indicates that the fluid source is deep seated. Rates and directions of fluid flow are generally inferred indirectly from heat-flow measurements and the thermal, geochemical, and isotopic composition of pore fluids (e.g., Fisher and Hounslow, 1990; Gieskes et al., 1990; Vrolijk et al, 1991; Langseth et al., 1990; Le Pichon et al., 1990). Pore-water chemistries from Nankai and several other complexes, which are otherwise quite different, show a strikingly similar pattern of anomalously low chloride concentrations (Taira et al., 1992; Moore et al., 1991; Kastner et al., 1990, 1991; Shipboard Scientific Party, 2000). These low-chloride zones occur as local minima along what appear to be zones of preferential fluid flow, either faults or sedimentary unconformities. At Nankai, they appear as broad minima within the lower Shikoku formation, centered roughly on the décollement (Fig. 4). The source of this fresher water and the mechanism for its transport over long distances in discrete zones is a topic of active debate and modeling efforts (e.g., Bekins et al., 1995; Saffer and Bekins, 1998).

SCIENTIFIC OBJECTIVES

Structural and Hydrologic Evolution of the Décollement Zone

The nature of the décollement zone along the transect remains a big puzzle. Seismic profiles across the transect represent the décollement as a reversed polarity reflection that extends well in front of the deformation front; this has been interpreted to indicate (1) the presence of fluids along a high-porosity fault zone and (2) the possible presence of high pore pressures (Moore and Shipley, 1993). The décollement zone was penetrated at Site 808 and revealed itself to be a 20-m-thick zone of intensely fractured sediment, with evidence for shear-induced brecciation, pore collapse, and local phyllosilicate reorientation (Byrne et al., 1993). Sediments from within the décollement have much lower porosities than samples from above and below. A subtle mottled texture in some samples led Maltman et al. (1993) to infer localized zones of elevated fluid pressure within the zone. At Site 1174, the décollement is a 32-m-thick zone characterized by a finer brecciation, despite this site's more seaward location, and by distinct physical properties (Shipboard Scientific Party, 2000). We need to sample the décollement zone at critical points beneath the Nankai prism and protothrust zone (PTZ) to document the spatial variations in structure and fluid pressure to test these hypotheses of décollement formation and evolution.

Fluid Flow Paths and Chemical Gradients

The origin of the Cl concentration depth profile is of great importance to the understanding of the hydrogeochemistry of the Nankai Trough Muroto region. Site 808 is characterized by a broad region of Cl concentrations that are lower than seawater (~20% less than seawater) within the Shikoku Basin hemipelagic section (~560-1240 mbsf), with a minimum concentration in the underthrust section at ~1100 mbsf (Kastner et al., 1993). Some of the shipboard scientists believe the preliminary one-dimensional modeling of this profile excludes the possibility of in situ production of water, hence requiring its introduction from elsewhere. In addition, two-dimensional models of smectite dehydration and fluid flow show that neither in situ dehydration nor steady-state fluid flow can produce the observed freshening (Saffer and Bekins, 1998). It is important to note that these calculations are strongly dependent on porosity and mineralogical data from Site 808 and may change significantly with revised porosity values or additional information about smectite content. The chemical and isotopic signatures of the pore fluids suggest a deep-seated, elevated temperature (>150°C) source. It seems that a combination of active or episodic lateral fluid flow along one or more sediment horizons and fluid advection may be responsible for this striking Cl zone. The sites along the Muroto Transect are aimed at understanding the lateral variability of fluid flow.

Spatial Distribution and Temporal Progression of Deformation

Although core recovery at Site 808 was exceptional and physical properties and structural observations complete, the results yield only a one-dimensional view of the interior of the Nankai prism. We have almost no constraint on how various fabrics, structures, physical properties, or geochemistry vary along and across strike or how these variations translate over time. This lack of spatial and temporal control makes it nearly impossible to determine the relationships between deformation, diagenesis, and fluid flow. However, first-order predictions for the distribution of physical properties and structures in two dimensions and the role of fluid pressures in their evolution have been made based on high-quality seismic images, velocities, and dispersed core data. The results provide models to test and guide the selection of future drill sites at the Nankai Trough, as well as the associated sampling and analysis. To test this distribution of structures and the role of diagenesis and fluid pressure in its development and to obtain better constraints on physical properties from which these models are derived, across-strike drill holes are desperately needed.

A high-resolution MCS survey conducted in 1999 enabled interpretation of several structural zones within the Nankai Trough accretionary prism, as shown in Figure 5. These are described more fully in the Leg 190 Prospectus (http://www-odp.tamu.edu/publications/prosp/ 190_prs/190toc.html) and Preliminary Report (http://www-odp.tamu.edu/publications/prelim/190_prel/190toc.html). The most important structural zones for Leg 196 operations include the following:

Nankai Trough Axis Zone. Prior drilling results indicate that the stratigraphy of the trench floor is composed of the following lithologic units in descending order: trench turbidites (Holocene to

Pleistocene), turbidite-hemipelagite transition (Pleistocene), hemipelagite with tephra layers (early Pleistocene to late Pliocene), massive hemipelagite (mid-Pliocene to mid-Miocene), acidic volcaniclastics (15 Ma), and pillow basalts (16 Ma).

Protothrust Zone (PTZ). This area represents a zone of incipient deformation and initial development of the décollement within the massive hemipelagic unit. Above the décollement, the sediment thickness increases landward, probably because of tectonic deformation with the development of small faults and ductile strain (Morgan and Karig, 1995a, 1995b).

Imbricate Thrust Zone (ITZ). Landward of the PTZ, a zone of well-developed seaward-vergent imbricate thrusts can be recognized. The thrusts are sigmoidal in cross section with a mean angle of about 30° and typical thrust spacing of 0.5 km. The seaward edge of the ITZ marks the deformation front. Two sites cored the frontal part of the imbricated thrust zone: Deep Sea Drilling Project (DSDP) Site 583 west of the Muroto Transect and ODP Site 808, which was incorporated into the Leg 190 Muroto Transect.

DRILLING STRATEGY

Among the sites on the Muroto Transect (Fig. 5), Sites 808, 1173, and 1174 were those originally proposed for LWD and ACORKs in a study of deformation and fluid flow processes near the toe of the accretionary prism. Site 808 is located in the frontal part of the ITZ, Site 1174 intersects the PTZ, and Site 1173 is a seaward reference site in the oceanic crust and sediments prior to subduction. Had Leg 190 data at other sites (particularly Site 1176) provided strong evidence for fluid flow and appropriate hole conditions, these would have been considered as possible primary LWD/ACORK sites for Leg 196. However, both operational considerations and scientific results from Leg 190 strongly confirm the original plan for Leg 196 of emphasizing LWD at Sites 808, 1173, and 1174, with ACORK installation at two of these sites. Based on fiscal and operational factors, as well as scientific reasons described more fully below, the two sites selected for ACORKs are Sites 808 and 1173.

Prior CORKs in Accretionary Settings and the Advanced CORK Concept

The multizone ACORK represents a significant improvement and completely new engineering approach compared to the original single-seal CORK (Fig. 6). Four of the original 13 CORKs were deployed in accretionary settings, two were deployed on the Cascadia margin, and two were deployed at the Barbados prism. Results from two of these CORKs, at Hole 892B on the north end of the "Hydrate Ridge" on the Oregon margin and Hole 949C through the Barbados décollement, particularly exemplify the potential of the planned Nankai Trough ACORKs. Close to the toe of the Barbados prism, the CORK at Hole 949C monitored in situ conditions and processes via a screened section that spans most (but not all) of the décollement zone, where it produces a moderate-amplitude negative-polarity seismic reflection (Shipley et al., 1994) interpreted to result from modest fluid overpressure (Moore et al., 1995, 1998). Located in a setting higher up the Oregon margin, the CORK at Hole 892B monitored conditions and processes via a perforated section spanning a thrust fault that intersects a bottom seismic reflector (BSR) updip— a BSR that is isolated behind solid casing at the CORK itself. Results from the two sites (Table 1) illustrate well the suite of investigations that are possible with CORKs (Fig. 6), including documenting in situ baseline conditions, capturing signals of fluid flow transients, sampling in situ fluids, directly testing the hydrogeological properties of the formation, and determining key elastic and fluid transport properties of the formation with the tidal-loading method of Wang and Davis (1996) and Davis et al. (2000). The last is a powerful method that strongly complements logging and traditional pressure-testing measurements for determination of formation properties at a range of spatial scales. It requires the sustained long time-series observations of subsurface pressures possible with a CORK in order to allow proper spectral analysis to determine formation response to the various components of the tidal signal.

Despite such successes, the original CORK design has one key scientific limitation: with a single seal near the top of casing, the CORK essentially integrated signals of hydrogeological processes from the entire open-hole section or screened interval. At the original CORK sites, this corresponded to a first-order natural hydrogeological stratification (i.e., relatively impermeable sediments overlying more permeable upper basement or fault zone). However, growing evidence indicates that more detailed subsurface sampling is needed for comprehensive understanding of in situ hydrogeological systems, which commonly have complex structures and more than one active zone in nature; this is certainly the case at Nankai. The planned Nankai Trough ACORKs are the first scheduled deployment of a new multizone CORK. This concept was developed in a scientific workshop and engineering meeting in 1997 and 1998 (Becker and Davis, 1998 [www.JOI-ODP.org/USSSP/Workshops/Advanced CORKS/Advanced_CORK_report.html]). The ACORKS thus represent an important engineering and scientific investment for future ODP and Integrated Ocean Drilling Program (IODP) in situ hydrogeological observations.

Figure 7 illustrates a composite concept for a multilevel isolation system in an accretionary prism in which one generic hole represents the range of possible hydrogeologically active formations that might require a sustained time-series observational approach for comprehensive understanding of the whole hydrological system. This figure illustrates four principal zones requiring separate isolation in this generic section: a gas hydrate horizon shallow in the section, a thrust fault within the accretionary prism, the décollement zone, and the subducting oceanic basement. The planned Nankai Trough ACORK program includes the two deepest zones illustrated in Figure 7, so it is appropriate to review the generic objectives of the packer configurations shown, realizing this is highly schematic. Short intervals are shown bracketing a thrust fault within the accretionary prism, as well as a primary detachment fault, to monitor activity in the parts of the system that are probably hydrologically most active. Multiple short intervals above and below a hydrate/gas phase boundary and the primary detachment boundary allow hydromechanical properties and vertical pore pressure gradients to be determined. Broader intervals within the prism, the underthrust sediments, and igneous basement allow definition of the overall thermal, fluid pressure, and compositional regimes. Finally, paired instrumented holes will allow lateral gradients and transient events to be characterized.

ACORK Configuration for Leg 196

The concept shown in Figure 7 has been brought to engineering fruition at ODP, and a schematic of the system under development for the two Nankai holes to be instrumented is shown in Figure 8. The design centers around a fully sealed liner built in modules, with external annular packers that hydrologically isolate a number of intervals. These intervals will be accessed for pressure monitoring and fluid sampling via gravel-packed screened ports and small-diameter lines connected to the seafloor landing module. The inside diameter of the liner is sufficient to allow use of a mud-motor and underreamer for deployment of the string and a coring bit for deepening below the ACORK liner/packer string after the string is reamed in (e.g., to create a hydrologic connection to upper basement).

Note that Figure 8 shows the configuration with the option for a seismometer and thermistor string deployed at the time of ACORK installation, as is planned for Site 1173. The seismometer and thermistor string installation are contingent upon funding and JOIDES Advisory Structure approval. As a final step in the operations, the liner needs to be sealed. If a seismometer/thermistor string is installed as shown in Figure 8, the liner would be sealed near the top with a plug that allows electronic feed-throughs. If no instrument is installed in the central bore, as planned at Site 808, the bottom of the liner would be sealed with a bridge plug. This would allow the full length of the liner to be accessed, from either the drillship or from a wireline reentry vehicle, for subsequent deployment of independent sensor strings that do not require hydraulic access to the formation, including thermistor cables, hydrophones, seismometers, and tilt or strain sensors.

Note also that Figure 8 shows only two packers and screens in the ACORK. For the Leg 196 ACORKs, five packers and six screens are planned for Site 808, with four packers spanning décollement and one packer just above basement. For Site 1173, two or three packers would span the "protodécollement" (as defined by changes shown in the Leg 190 physical properties and wireline logging data as well as Leg 196 LWD data) and one packer would be deployed just above basement. To connect the screened ports to the seafloor, well-protected, robust hydraulic lines will be strapped onto the outside of the liner as the string is made up at the rig floor and passed sequentially through each packer and screened port above. The lines will terminate at pressure gauges at the seafloor, with final spurs running via valves to hydraulic connectors, where fluids can be collected or pumping or flow tests can be performed. Long-term (5-10 yr) data loggers and pressure gauges will be installed at the rig floor. The loggers will be accessible with a manned or unmanned submersible via underwater mateable connectors for periodic data downloads and reprogramming.

Although it will be possible to drill in a multipacker string directly, the most efficient and scientifically most sensible approach for Nankai will be to ream the CORK strings into LWD holes drilled prior to CORK operations. Previous experience during Legs 131 and 190 shows that ~200 m of surface casing will be required to stabilize unconsolidated sandy sediments in the frontal thrust region. This will be jetted or drilled in with small reentry cones, allowing the LWD and CORKing operations to be completed sequentially in the same holes. With co-located holes, it will be possible to "fine-tune" the precise spacing of the screens and packers along the modular liner assemblies on the basis of the core and LWD results.

Seismometer and Thermistor String Installation

One possible interpretation of existing temperature data at the top of the oceanic plate (i.e., basement of the Shikoku basin) is that it is approximately isothermal with a maximum temperature of ~140°C. This implies that the basement plays an important role for fluid paths. Scientific monitoring using CORKs has revealed a strong relationship between formation fluid pressures, regional stress fields, and Earth tides (Davis et al., 2000; Davis and Becker, 1999) and allows monitoring of in situ dynamic fluid behavior. As recent studies show (e.g., Endo et al, 1997, Kiguchi et al, 1996), short period fluid pressure fluctuations can be used to estimate formation permeability for which it is difficult to directly obtain in situ values. Therefore, the installation of either a strainmeter or seismometer could provide additional information to estimate the permeability of oceanic crust through the monitoring of in situ dynamic fluid behavior in relation to mechanical properties of the rocks (Mikada, 1998).

Tidal influence on formation fluid behavior has been also observed using thermistor strings (Kinoshita et al., 1998). An additional objective for deploying an ACORK is to insert a thermistor string inside the casing to monitor formation fluid temperature over time. Thermistors arranged close to the seismometer are expected to not only measure the "static" in situ heat flow of the Shikoku Basin but also to reveal the "dynamic" behavior of such fluids because of the change in stress of the surrounding media from the propagation of earthquake signals.

LEG 196 OPERATIONAL PLAN SUMMARY

The basic Leg 196 operational plan calls for LWD operations to be completed at all sites before the two ACORK installations (Table 2). This is required for a number of reasons. The most important being (1) the scientific and operational need for LWD data at the ACORK sites to fine-tune placement of the packers and screened monitoring zones and (2) the fiscal need to limit the time LWD tools are on the drillship. Hence, a brief midleg port call is scheduled in Osaka to off-load the LWD tools and allow a personnel transfer. This scenario implies that the time available for LWD must be defined to allow sufficient time to deploy two ACORKs after the tool and personnel transfer. The operational estimates were constructed with modest contingency time for the ACORK installations after the midleg port call. This leaves sufficient estimated time for full LWD operations at the three primary Leg 196 sites, but not for additional LWD sites.

Continengencies

If the LWD operations at the primary sites are completed ahead of schedule, LWD may be conducted at additional sites as described below up to the time of the scheduled midleg port call. As the Leg 196 ACORKs will be the first installed by ODP, it is quite possible that the time estimates may differ from actual installation times. Furthermore, the Kuroshio Current could present additional risk to assembling and deploying the ACORKs. If time becomes available during the ACORK phase, for whatever reasons, contingencies include the following: (1) packer permeability measurements in the basement section at Site 1173 (prior to final completion of the ACORK there), (2) Davis-Villinger termperature probe (DVTP) and water-sampling temperature probe (WSTP) measurements in the sediments at previously cored or alternate sites, (3) coring at alternate sites already approved for Leg 190, or (4) coming to port a day or two early if that time can be utilized for Legs 197 or 198.

LOGGING PLAN

Difficulties in attempted wireline logging during previous legs at Nankai and other accretionary prisms clearly indicates that LWD will be required to acquire in situ physical properties in the Nankai accretionary prism. As noted above, Leg 196 LWD operations will be conducted at the beginning of the leg, prior to off-loading the tools at a midleg port call. We are planning to deploy the azimuthal density neutron (ADN) and resistivity-at-the-bit (RAB) tools (note that LWD sonic tools only operate in formations with Vp > 2 km/s and would likely not be useful in low-velocity formations [Vp <1.8 km/s]). As demonstrated by the results from Legs 156, 170, and 171A, the information acquired from these LWD logs will also allow in situ pore pressures within the accretionary prism to be inferred.

The RAB tool is a unique LWD device which acquires full-bore, quantitative, azimuthal resistivity images of the formation while drilling. The RAB images detect resistivity, heterogeneity, and borehole structures such as fractures and stratigraphic contacts. The RAB tool also provides azimuthal gamma-ray data per quadrants. The ADN tool will provide borehole-compensated formation density, neutron porosity, and photoelectric factor measurements in four quadrants around the borehole. The ADN will also measure standoff from the tool to the borehole wall per quadrants using an ultrasonic caliper. A rate of penetration of 25 m/hr is required for each site to ensure good gamma-ray data quality and RAB image resolution. Drill-in casing operations down to 200 mbsf will be required at all proposed sites, so the upper 200 m may be logged in a separate penetration.

Based on the results from Leg 190, LWD operations at Sites 1173, 1174, and 808 are the highest priority. If additional time becomes available before the scheduled midleg port call, alternate sites include ENT-10A and ENT-2A.

PLANNED SITES

Site 808

Site 808 was cored through the frontal thrust and décollement and into basement during Leg 131. Leg 196 will drill through the sediment section with the LWD tools and will install an ACORK with monitoring zones located above and below the décollement and at the top of basement.

Site 1173 (ENT-01A)

Site 1173 is a reference site cored to basement during Leg 190 seaward of the décollement tip to provide baseline physical properties and fluid flow measurements. Leg 196 plans call for drilling through the sediment section with the LWD tools, core ~50 m of basement with the rotary core barrel (RCB), and install an ACORK with a broadband seismometer cemented in the basement. The seismometer installation is contingent upon funding and JOIDES advisory panel approval.

Site 1174 (ENT-03A)

During Leg 190, Site 1174 was cored through the PTZ to sample a zone of incipient deformation and fluid flow. This site penetrated the subducting sediment section all the way to basement. During Leg 196, we will drill through the complete sediment section with the LWD tools.

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FIGURE CAPTIONS

Figure 1. Shaded relief map of the Nankai Trough produced from the Hydrographic Department of Japan's topographic data set (500-m grid interval). The inset shows a tectonic map of the Philippine Sea region that includes the Nankai Trough. The black box outlines the Leg 190 Nankai drilling area shown in Figure 2. The arrow shows the convergence direction of the Shikoku Basin beneath Japan.

Figure 2. ODP Leg 190 (solid circles) and previous ODP/DSDP drill sites (solid squares) in the Nankai Trough. The shaded outline shows the 3-D seismic survey of Bangs et al. (1999) and Moore et al. (1999). LWD will be conducted at Sites 808, 1173, and 1174 and ACORK long-term seafloor observatories will be emplaced at Sites 808 and 1173. Contour interval = 100 m.

Figure 3. Comparison of the structurally identified décollement interval and its physical properties and pore-water geochemistry across the Leg 131/190 transect. The décollement interval at Site 1174 has been projected to the reference Site 1173 based on correlation of patterns in magnetic susceptibility data (Shipboard Scientific Party, 2000).

Figure 4. Chloride concentrations in interstitial water samples from the Muroto Transect reference (Site 1173) and prism toe sites (Sites 1174 and 808) (Shipboard Scientific Party, 2000).

Figure 5. Schematic interpretation of seismic Line 141-2D in the Muroto Transect showing tectonic domains and location of Leg 190 drill sites (Shipboard Scientific Party, 2000).

Figure 6. Schematic diagram of a CORK hydrogeological observatory. Thirteen CORKS were deployed during 1991-1997 in accretionary prism settings and sedimented young oceanic crust. CORK = circulation obviation retrofit kit.

Figure 7. Generic ACORK envisioned for multilevel isolation within a composite section accretionary prism.

Figure 8. Schematic diagram of the ACORK for deployment on Leg 196. Note that the seismometer will only be deployed at Site 1173 (contingent upon funding and JOIDES advisory structure approval).

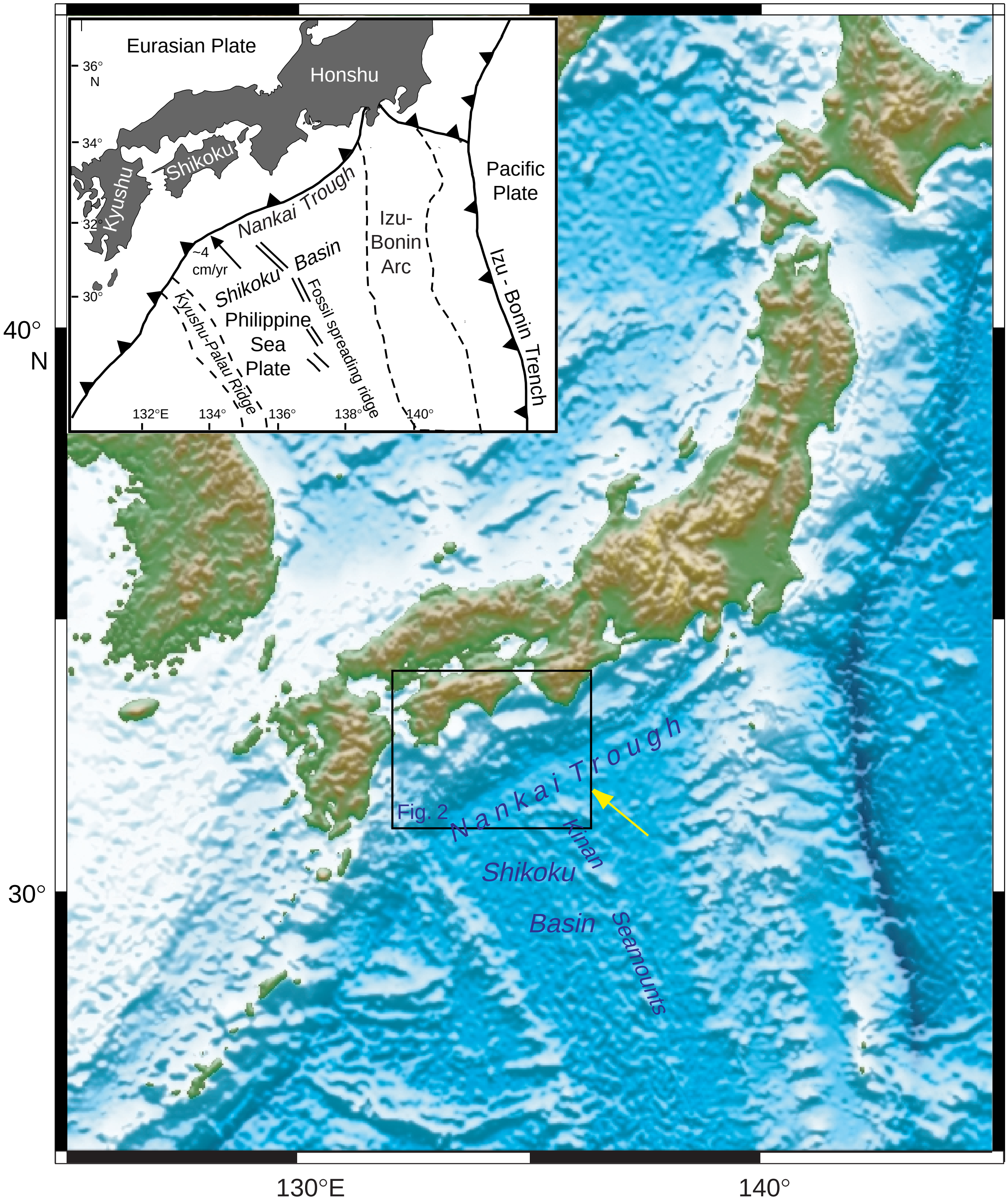
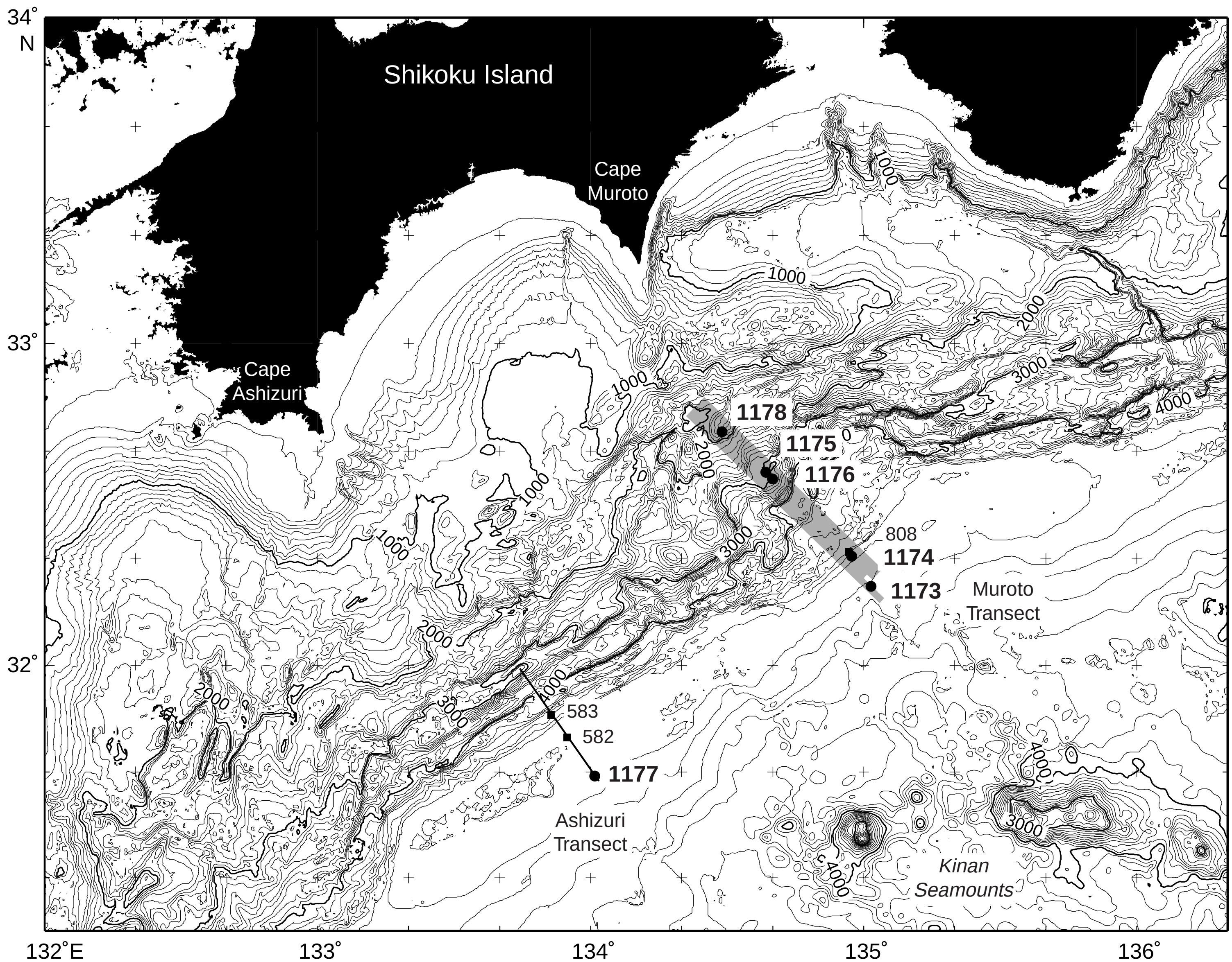

Eurasian Plate
Honshu
Shikoku
Kyushu
Pacific
Plate
Nankai Trough
Izu-
Bonin
Arc
~4
cm/yr
Shikoku Basin
Philippine
Sea
Plate
Kyushu-Palau Ridge
Fossil spreading ridge
Izu - Bonin Trench
36°
N
34°
32°
30°
132°E
134°
136°
138°
140°
40°
N
30°
130°E
140°
Fig. 2
Nankai Trough
Kinan
Shikoku
Basin
Seamounts

Figure 1



Shikoku Island
Cape Muroto
Cape Ashizuri
1178
1175
1176
808
1174
1173
Muroto Transect
583
582
1177
Ashizuri Transect
Kinan Seamounts
1000
2000
3000
4000
34° N
33°
32°
132°E
133°
134°
135°
136°

Figure 2

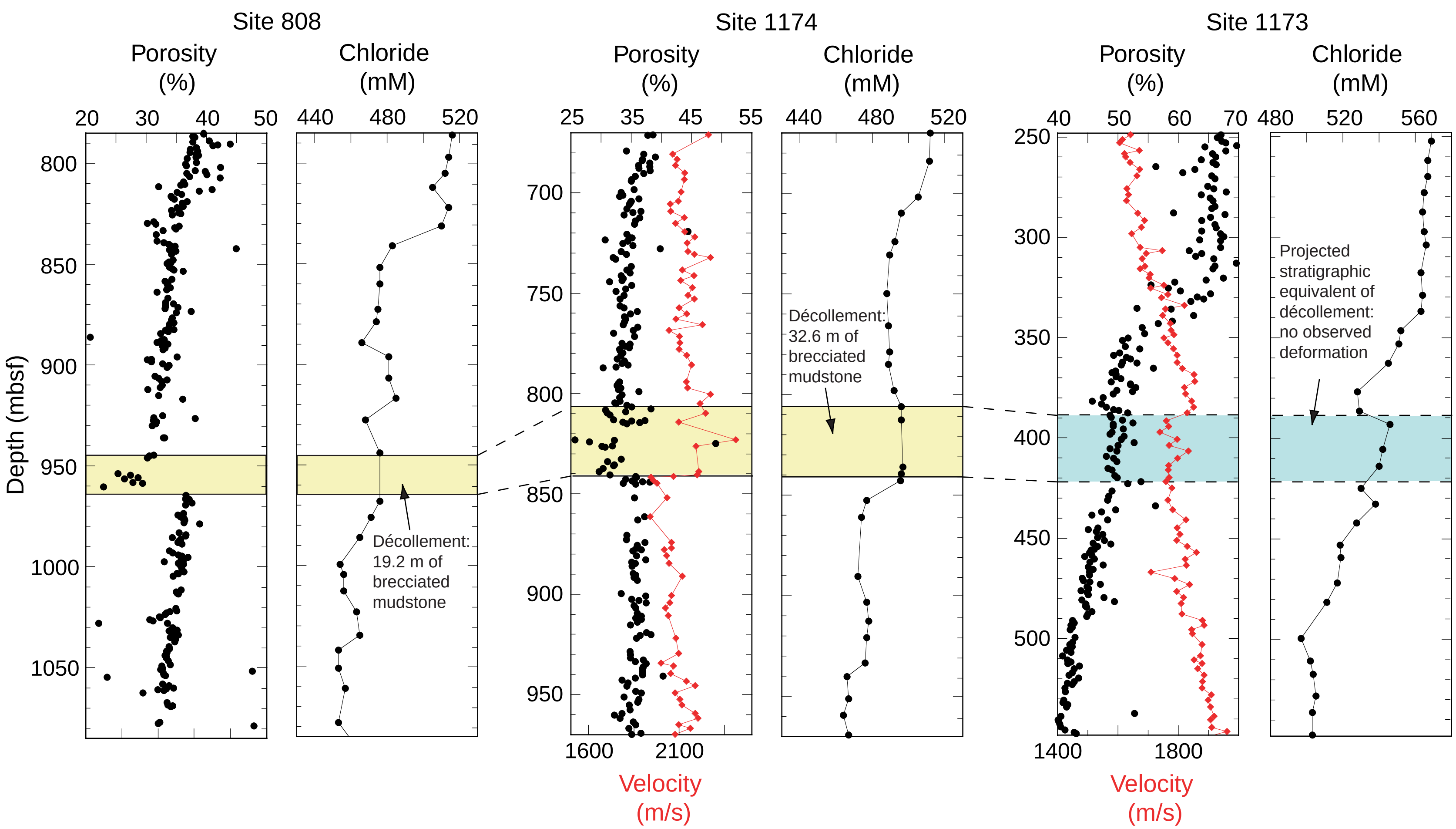

Site 808
Site 1174
Site 1173
Porosity (%)
Chloride (mM)
Depth (mbsf)
Velocity (m/s)
Décollement: 19.2 m of brecciated mudstone
Décollement: 32.6 m of brecciated mudstone
Projected stratigraphic equivalent of décollement: no observed deformation

Figure 3

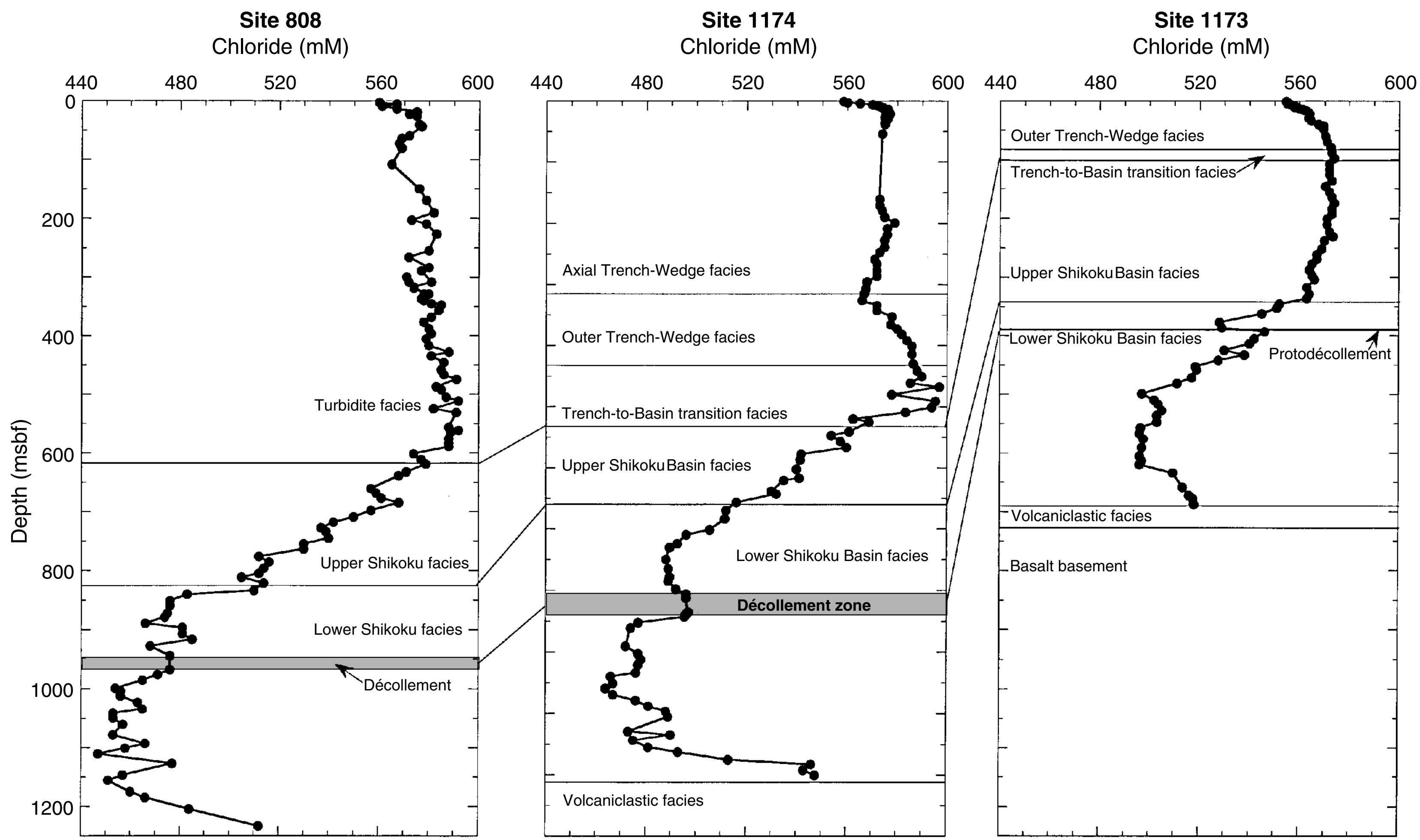

Site 808
Chloride (mM)
Site 1174
Chloride (mM)
Site 1173
Chloride (mM)
Depth (msbf)
Turbidite facies
Upper Shikoku facies
Lower Shikoku facies
Décollement
Axial Trench-Wedge facies
Outer Trench-Wedge facies
Trench-to-Basin transition facies
Upper Shikoku Basin facies
Lower Shikoku Basin facies
Décollement zone
Volcaniclastic facies
Outer Trench-Wedge facies
Trench-to-Basin transition facies
Upper Shikoku Basin facies
Lower Shikoku Basin facies
Protodécollement
Volcaniclastic facies
Basalt basement

Figure 4

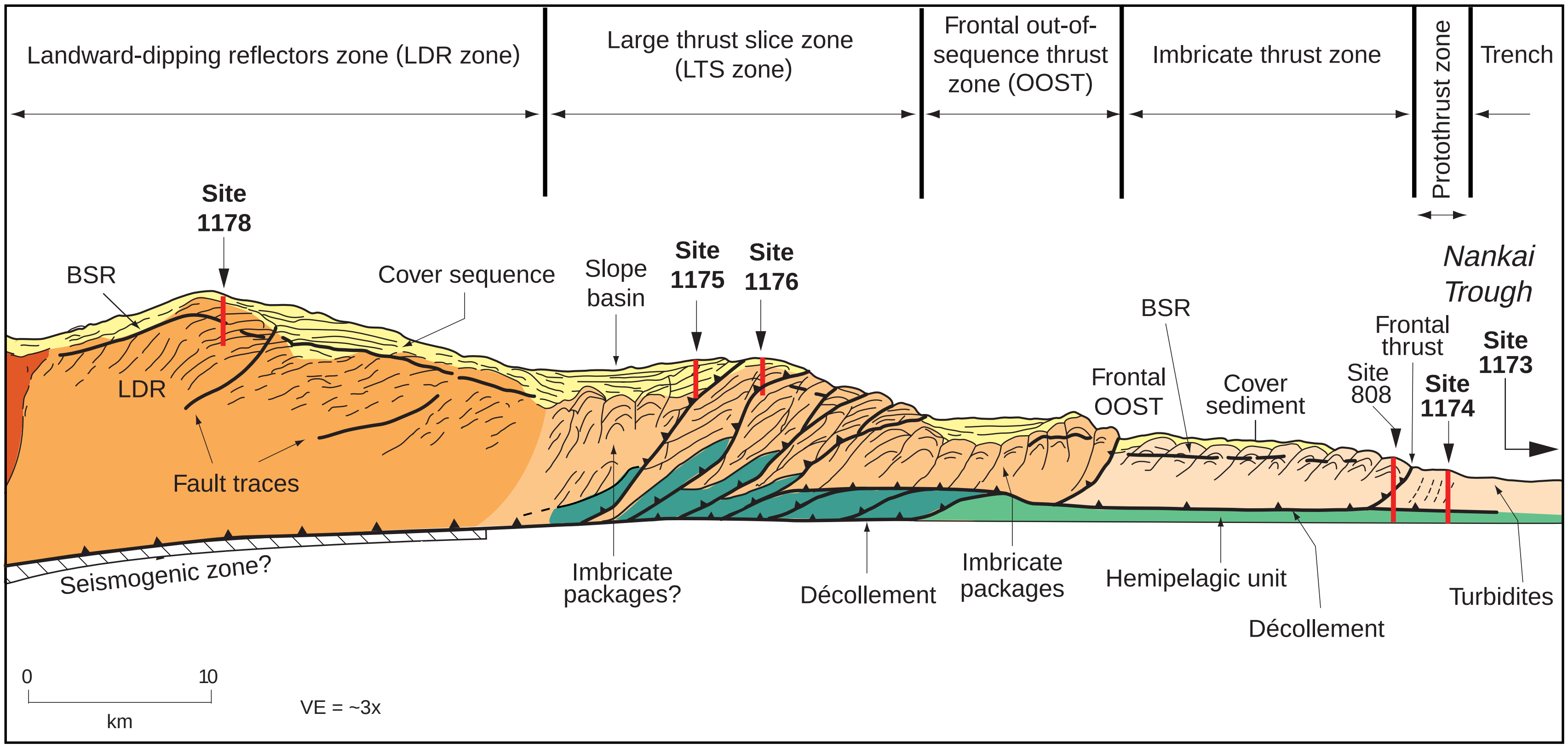

Landward-dipping reflectors zone (LDR zone)
Large thrust slice zone (LTS zone)
Frontal out-of-sequence thrust zone (OOST)
Imbricate thrust zone
Protothrust zone
Trench
Site 1178
BSR
Cover sequence
Slope basin
Site 1175
Site 1176
Nankai Trough
BSR
Frontal thrust
Site 1173
Frontal OOST
Cover sediment
Site 808
Site 1174
LDR
Fault traces
Seismogenic zone?
Imbricate packages?
Décollement
Imbricate packages
Hemipelagic unit
Décollement
Turbidites
0
10
km
VE = ~3x

Figure 5

Schematic CORK Hydrogeological Observatory

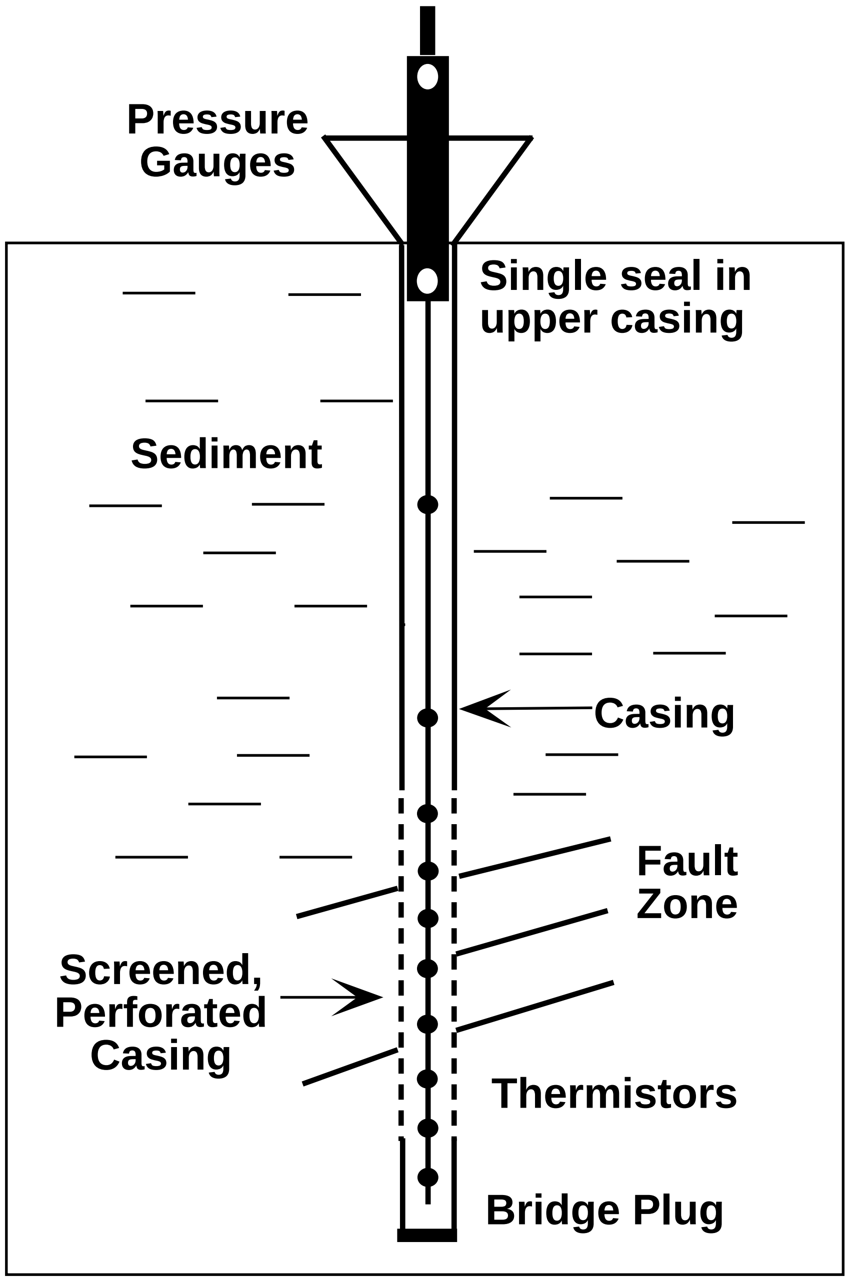


Figure 6

Accretionary Prism Generic Advanced CORK

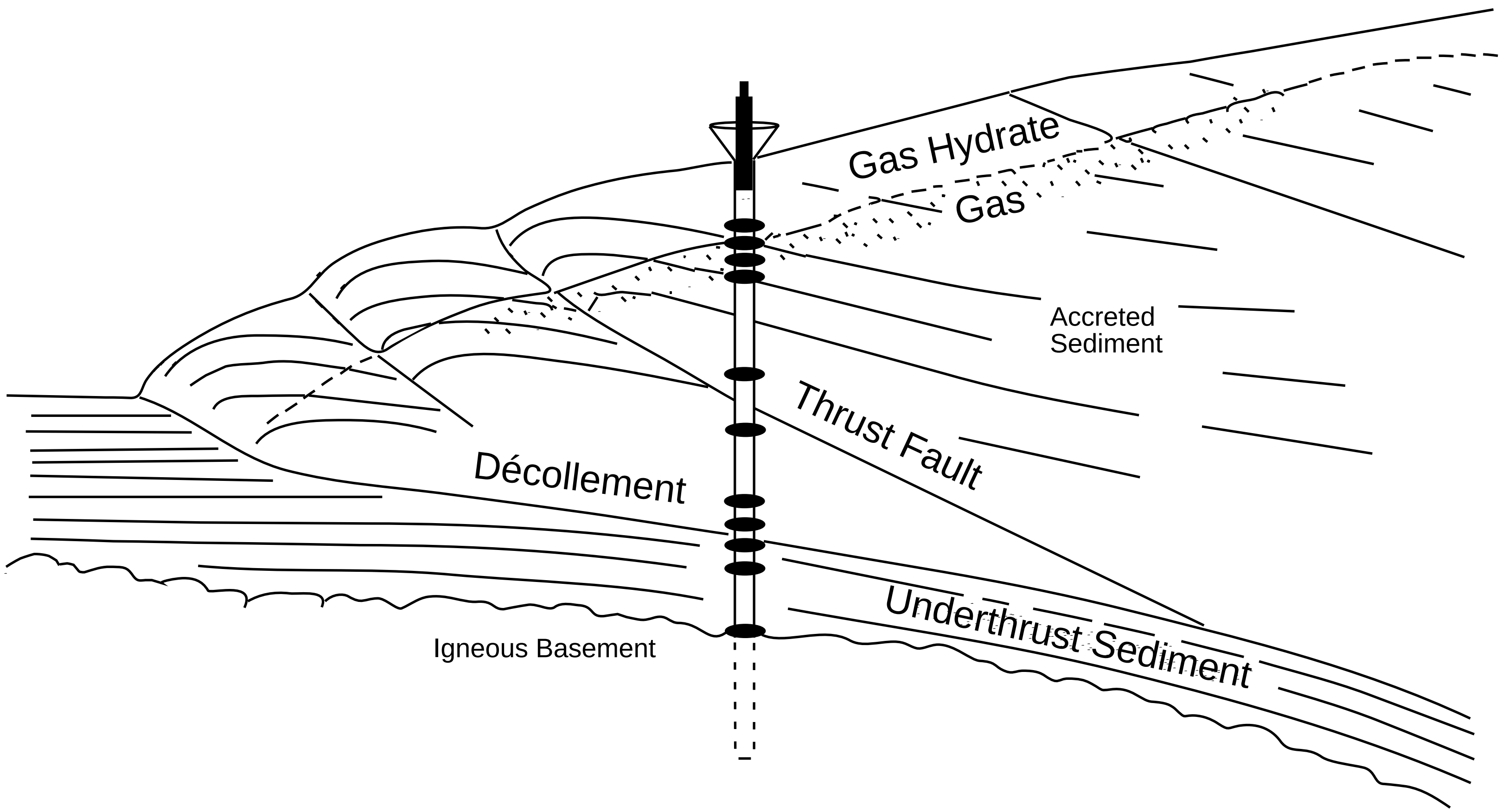


Figure 7

Leg 196 ACORK/SEISMOMETER INSTALLATION

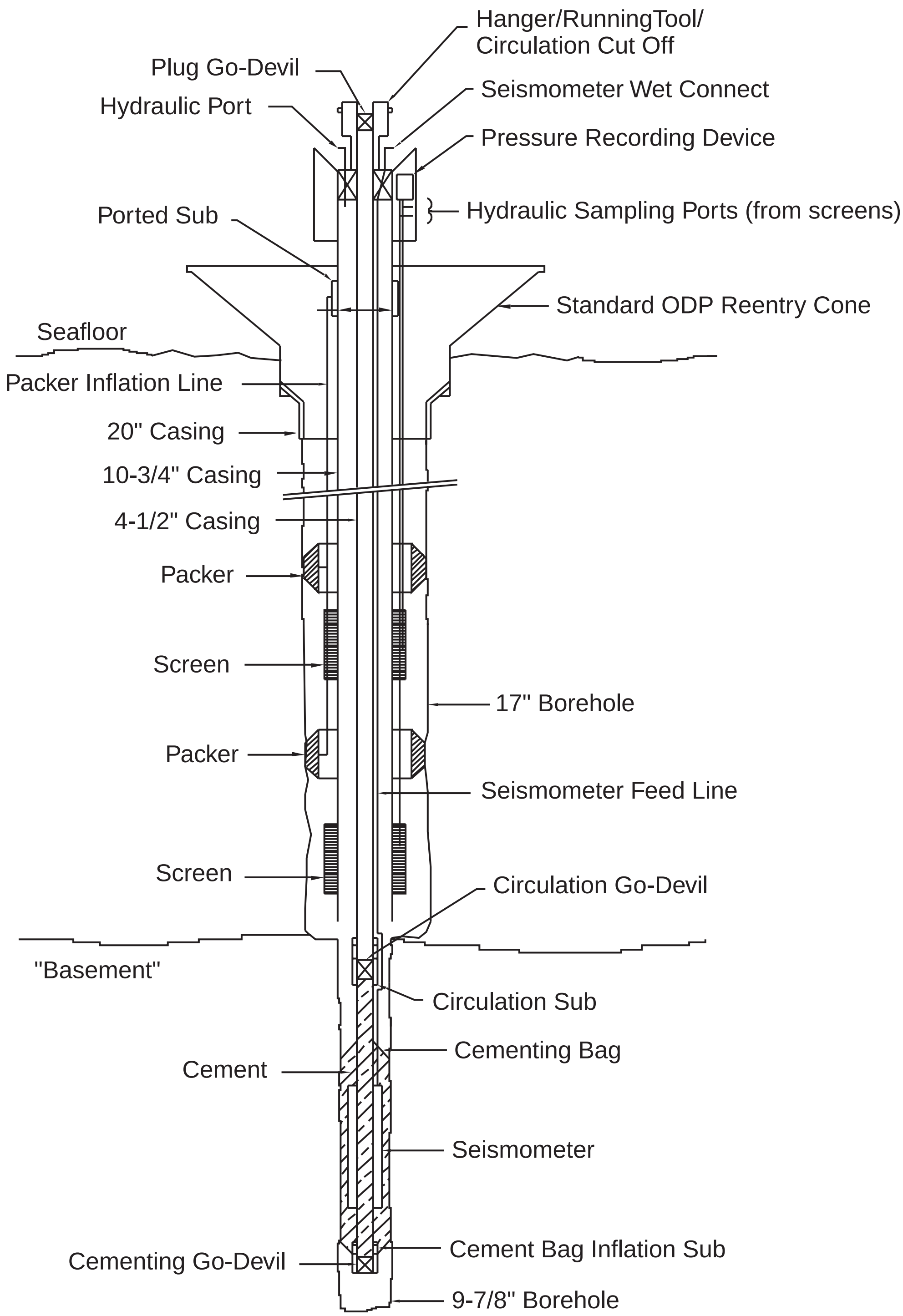


Figure 8

Table 1. Summary of results of prior CORKs in accretionary settings.

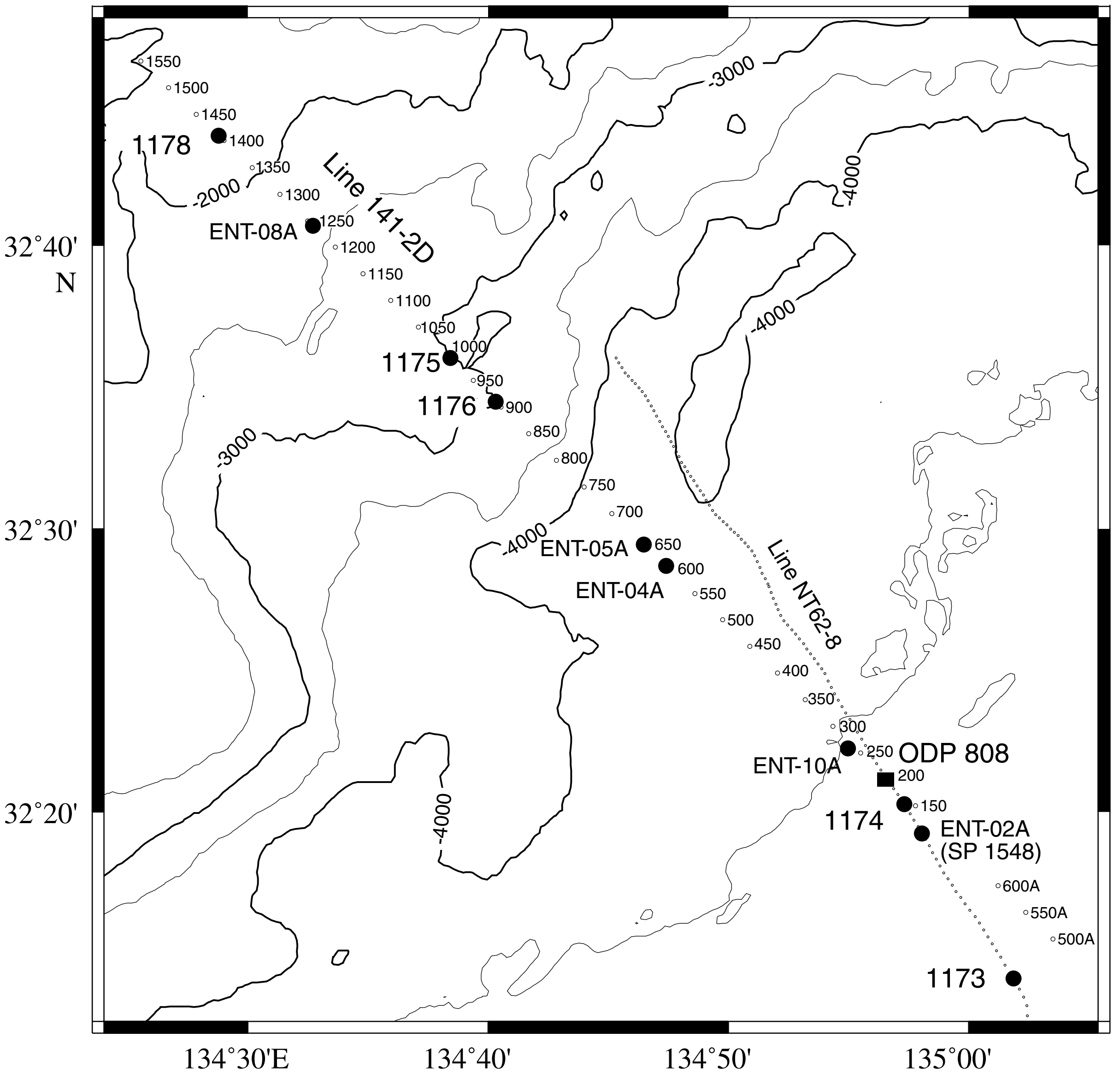
	Barbados Ridge (Hole 949C)	**Oregon Margin (Hole 892B)**
Zone monitored	Décollement at ~400 mbsf nearly spanned by screened section	Thrust fault that intersects BSR updip; at site, BSR behind casing ~40 m shallower than thrust fault
Period monitored	3.5 years: July 1994 - Jan. 1998	2 years: Nov. 1992 – Nov. 1994
In situ pressures	1.02 MPa stable overpressure (<~3MPa lithostatic)	Very low ΔP (13kPa) Higher ΔP drained at drilling?
In situ temperatures	Stable at geothermal gradient	Stable, but transient event in fault
Fluid flow transients?	No significant natural transients – pressure transients due to pump testing and LWD	Warming of thermistor in fault zone indicated transient upfault flow of warm fluids
Hydrological testing	Permeability varies several magnitudes with effective stress (Screaton et al., 1995, 1997; Fisher and Zwart, 1996)	
Fluid sampling	Despite high ΔP, low permeability prohibited fluid production at valve	No, low ΔP; later produced gas hydrates, after data logger removed
Tidal loading - attenuation	85% of seafloor amplitude, consistent with muddy sediments of 60% porosity above décollement	More attenuated, consistent with more cemented, lithified formation
Tidal loading - phase	Dispersive phase lag – requires weak formation outside screened interval, later verified with LWD	Slight phase lead confirmed presence of free gas
Main citation	Becker et al., 1997	Davis et al., 1995

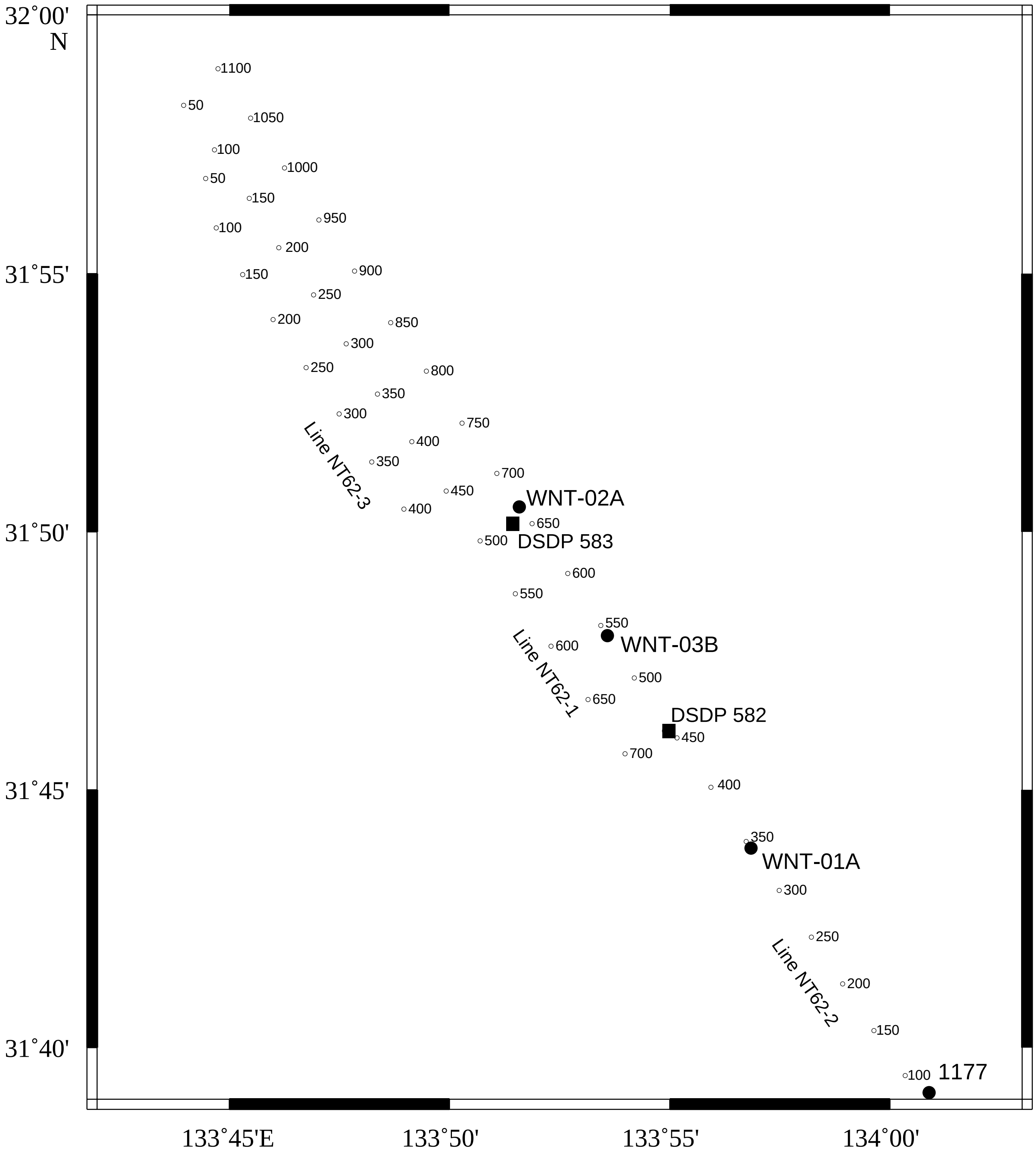
Table 2. Leg 196 Nankai Trough (Proposal No. 517)

Primary Operations Plan and Time Estimate

Site No.	Location Lat./Long.	Water Depth	Operations Description	Transit (days)	ACORK (days)	DIC (days)	LWD (days)	Total On Site
Keelung	25.1°N		Transit 833.2 nmi Keelung, Taiwan to Site ENT-01A	3.3				
	121.43°E							
1173	32°14.66'N	4790	Hole A: RC & LWD 200 - 725 mbsf		1.9		2.1	4.0
(ENT-01A)	135°01.51'E	mbsl	Hole B: LWD to 200 mbsf				0.8	0.8
			Note: PPSP-approved depth is 700 mbsf					
			Transit 7.4 nmi ENT-01A to 808	0.0				
808	32°21.10'N	4675	Hole A: RC & LWD 200 - 1290 mbsf		1.9		3.4	5.3
	134°56.60'E	mbsl	Hole B: LWD to 200 mbsf		0.0		0.8	0.8
			Note: PPSP-approved depth is 1160 mbsf					
			Transit 0.7 nmi 808 to ENT-03A	0.00				
1174	32°20.54'N	4751	Hole A: DIC -200 mbsf, LWD 200 - 1150 mbsf		0.0	2.0	2.8	4.8
(ENT-03A)	134°57.39'E	mbsl	Hole B: LWD to 200 mbsf		0.0		1.0	1.0
			Note: PPSP-approved depth is 1160 mbsf					
Osaka	34.4°N		Transit 124.7 nmi Site 1174 (ENT-03A) to Osaka	0.5				
	135.3°E		Mini - Leg Port Call to off load LWD Tools	1.0				
			Transit 130.1 nmi Osaka to Site 1173 (ENT-01A)	0.5				
1173	32°14.66'N	4790	Hole A: ACORK Installation to 700 m		10.9			10.9
(ENT-01A)	135°01.51'E	mbsl	Transit from Site 1173 to Site 808	0.0				
808	32°21.10'N	4675	Hole A: ACORK Installation to 1290 m		13.6			13.6
	134°56.60'E	mbsl	Hole A: Install bridge plug		1.2			1.2
			Transit 7.4 nmi 808 to ENT-01A	0.0				
1173	32°14.66'N	4790	Hole A: ACORK 50m Rat Hole		1.9			1.9
(ENT-01A)	135°01.51'E	mbsl	Hole A: Install integral thermistor/seismometer		4.1			4.1
Yokohama	35°28'N		Transit 300.1 nmi ENT-01A to Yokohama	1.2				
	139°38'E							
			Sub Total:		**35.5**	**2.0**	**10.9**	
			Sub Total:	**6.6**				**48.4**
			TOTAL DAYS:					**55.0**

Revision: 4 Date: 22 August 2000


1550
1500
1450
1400
1178
1350
Line 141-2D
-2000
1300
ENT-08A
1250
1200
1150
1100
1050
1000
1175
950
1176
900
850
-3000
800
750
700
ENT-05A
650
-4000
ENT-04A
600
550
500
450
400
350
300
250
ENT-10A
ODP 808
200
150
1174
ENT-02A
(SP 1548)
600A
550A
500A
1173
-4000
-3000
-4000
-4000
Line NT62-8
32°40'
N
32°30'
32°20'
134°30'E
134°40'
134°50'
135°00'


32˚00'
N
31˚55'
31˚50'
31˚45'
31˚40'
133˚45'E
133˚50'
133˚55'
134˚00'
Line NT62-3
Line NT62-1
Line NT62-2
WNT-02A
DSDP 583
WNT-03B
DSDP 582
WNT-01A
1177
1100
50
1050
100
1000
50
150
950
100
200
900
150
250
200
850
300
250
800
350
300
750
400
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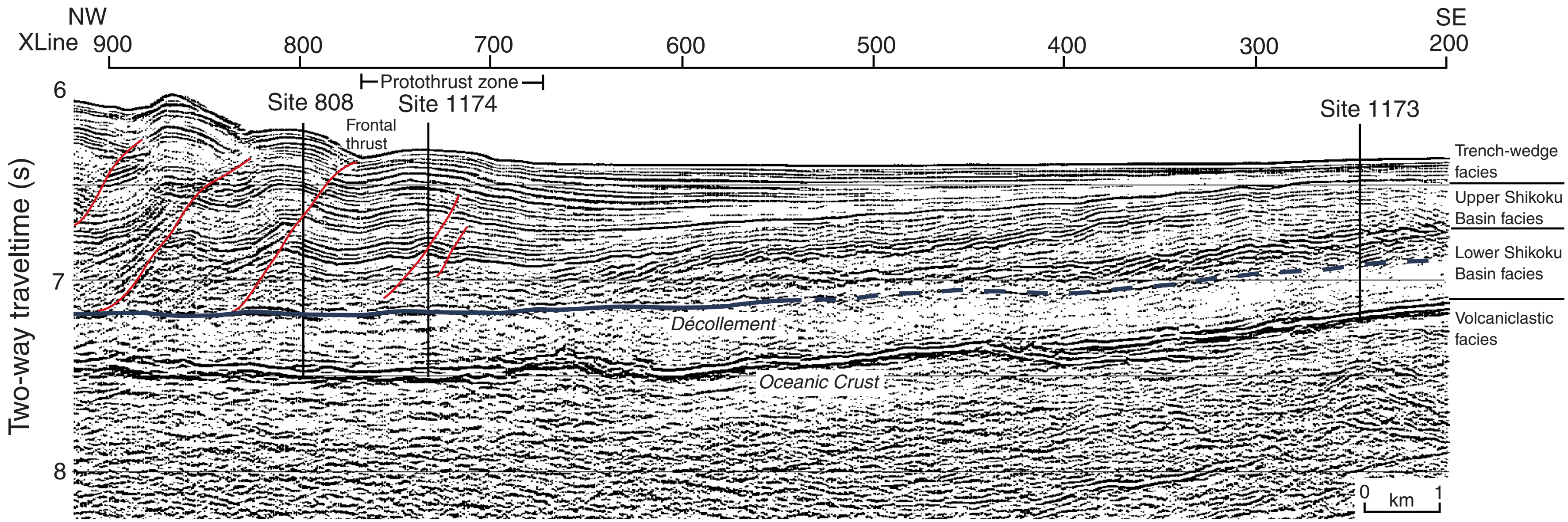
300
250
200
150
100


NW
SE
XLine
900
800
700
600
500
400
300
200
Protothrust zone
Site 808
Frontal thrust
Site 1174
Site 1173
Two-way traveltime (s)
6
7
8
Trench-wedge facies
Upper Shikoku Basin facies
Lower Shikoku Basin facies
Volcaniclastic facies
Décollement
Oceanic Crust
0
km
1

SITE SUMMARIES

Site: 808

Priority: 1
Position: 32°21.12'N, 134°56.67'E
Water Depth: 4676 m
Sediment Thickness: 1289 m
Target Drilling Depth: 1339 mbsf
Approved Maximum Penetration: 1339 mbsf
Seismic Coverage: *Fred Moore* Line NT62-8, shotpoint (SP) 1720, common midpoint (CMP) 950

Objectives: The objectives for Site 808 are to

1. Determine the spatial distribution and temporal progression of the deformation

2. Determine the structural and hydrologic evolution of the major thrust fault and décollement zone

3. Determine the fluid flow paths and chemical gradients

4. Deploy an ACORK instrument for long-term hydrologic monitoring

Drilling Program: LWD; RCB coring of basalt basement, if time permits

Logging and Downhole Tools: ADN and CDN

Nature of Section: Interbedded hemipelagic mud/silty-sandy turbidites, tuff

Site: 1173 (ENT-01A)

Priority: 1
Position: 32°14.66'N, 135°01.51'E
Water Depth: 4790 m
Sediment Thickness: 710 m
Target Drilling Depth: 760 mbsf
Approved Maximum Penetration: 760 mbsf
Seismic Coverage: *Fred Moore* Line NT62-8, SP 1116 (common depth point [CDP] 45); 1999 3-D sesimic survey, Line 215, cross Line 244

Objectives: The objectives for Site 1173 are to

1. Determine the spatial distribution and temporal progression of deformation
2. Determine the structural and hydrologic evolution of the décollement zone
3. Determine the fluid flow paths and chemical gradients
4. Deploy ACORK instrumentation for further long-term hydrologic monitoring
5. Deploy a seismometer in the basement for further long-term hydrological and seismic monitoring (contingent upon funding and JOIDES advisory structure approval)

Drilling Program: LWD; RCB in basaltic basement only

Logging and Downhole Tools: ADN and CDN, packer measurements in basement, if time permits

Nature of Section: Interbedded hemipelagic mud/silty-sandy turbidites, tuff, oceanic basalts

See seismic line for Site 808

Site: 1174 (ENT-03A)

Priority: 1
Position: 32°20.54’N, 134°57.39’E
Water Depth: 4751 m
Sediment Thickness: 1150 m
Target Drilling Depth: 1150 mbsf
Approved Maximum Penetration: 1160 mbsf
Seismic Coverage: *Fred Moore* Line NT62-8, SP 1641 (CDP 833); 1999 3-D seismic survey, Line 141, SP 165

Objectives: The objectives of Site 1174 are to

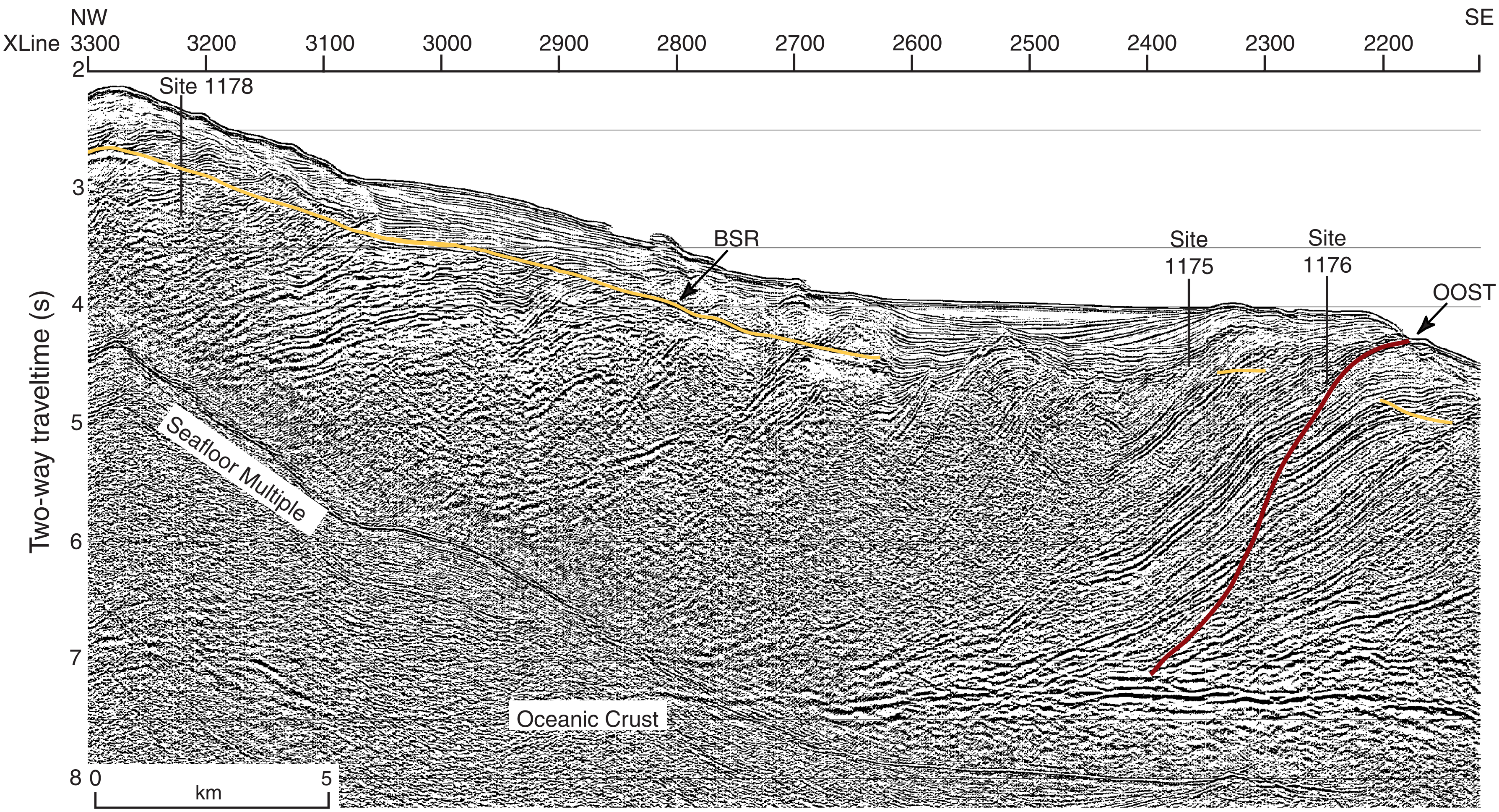
1. Determine the spatial distribution and temporal progression of the deformation
2. Determine the structural and hydrologic evolution of the minor thrust fault and décollement zone
3. Determine the fluid flow paths and chemical gradients

Drilling Program: LWD

Logging and Downhole Tools: ADN and CDN

Nature of Section: Interbedded hemipelagic mud/silty-sandy turbidites, tuff

See seismic line for Site 808


NW
SE
XLine
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2
3
4
5
6
7
8
Two-way traveltime (s)
Site 1178
BSR
Site
1175
Site
1176
OOST
Seafloor Multiple
Oceanic Crust
0
km
5

Site: 1175 (ENT-07A)

Priority: 2
Position: 32°35.88'N, 134°38.67'E
Water Depth: 2998 m
Sediment Thickness: 3000 m
Target Drilling Depth: 800 mbsf
Approved Maximum Penetration: 800 mbsf
Seismic Coverage: 3-D seismic survey in 1999

Objectives: The objectives of Site ENT-07A are to

1. Sample slope basin sediments to date prism deformation
2. Date the underlying accretionary prism
3. Determine the fluid flow paths and chemical gradients
4. Determine the spatial distribution and temporal progression of the deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites

Site: 1176 (ENT-06A)

Priority: 2
Position: 32°34.70'N, 134°39.94'E
Water Depth: 3020 m
Sediment Thickness: 3000 m
Target Drilling Depth: 800 mbsf
Approved Maximum Penetration: 800 mbsf
Seismic Coverage: 3-D seismic survey in 1999

Objectives: The objectives of Site ENT-06A are to penetrate a major OOST in the midslope region to

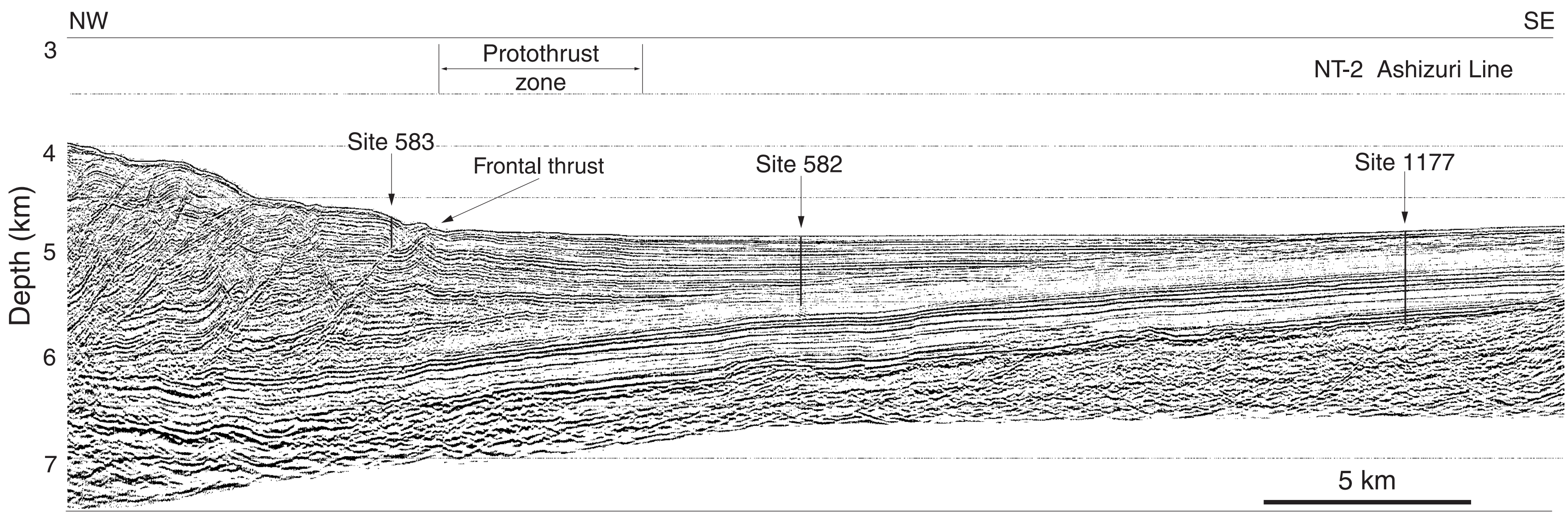
1. Sample the OOST for fluids
2. Date an older part of the prism
3. Determine the fluid flow paths and chemical gradients
4. Determine the spatial distribution and temporal progression of the accretionary prism deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites

See seismic line for Site 1175


NW
SE
3
4
5
6
7
Depth (km)
Protothrust
zone
NT-2 Ashizuri Line
Site 583
Frontal thrust
Site 582
Site 1177
5 km

Site: 1177 (WNT-01B)

Priority: 3
Position: 31°39.15'N, 134°0.71'E
Water Depth: 4844 m
Sediment Thickness: 831 m
Target Drilling Depth: 831 m
Approved Maximum Penetration: 1200 m
Seismic Coverage: *Fred Moore* Line NT62-2, SP 343 (CDP 1706)

Objectives: The objectives of Site 1177 are to

1. Contrast deformational and fluid flow behavior along the strike
2. Determine the structural and hydrologic evolution of the décollement zone
3. Determine the fluid flow paths and chemical gradients
4. Determine the spatial distribution and temporal progression of the deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites

Site: 1178 (ENT-09A)

Priority: 3
Position: 32°43.86'N, 134°28.77'E
Water Depth: 1778 m
Sediment Thickness: 3000 m
Target Drilling Depth: 800 mbsf
Approved Maximum Penetration: 800 mbsf
Seismic Coverage: 3-D seismic survey in 1999, Line 141-2D SP 1410, crossing line 1610

Objectives: The objectives of Site ENT-09A are to

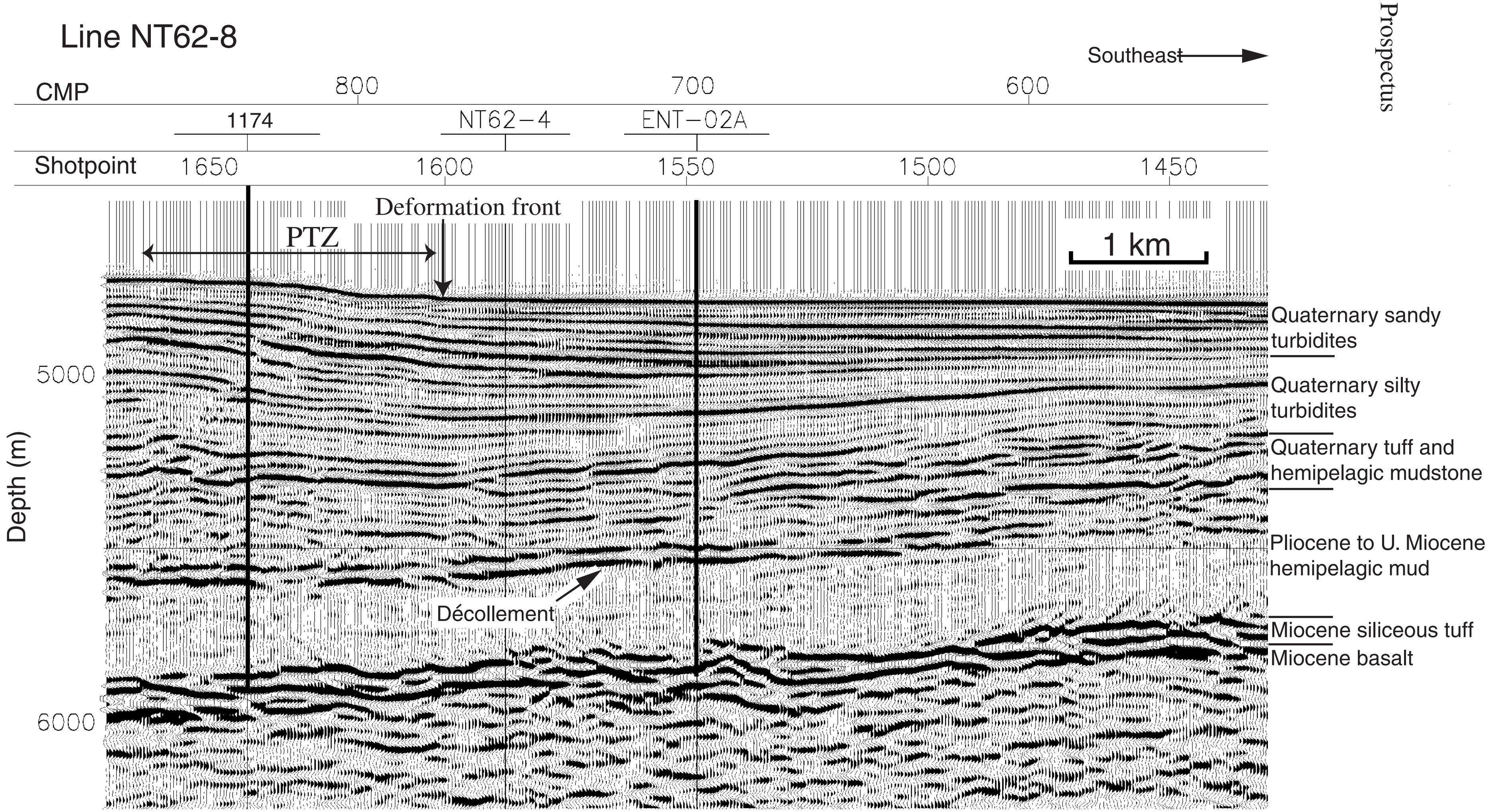
1. Sample slope sediments and older accreted strata
2. Determine the spatial distribution and temporal progression of the deformation
3. Determine the fluid flow paths and chemical gradients
4. Obtain samples of gas hydrate

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites

See seismic line for Site 1175


Line NT62-8
Southeast
CMP
800
700
600
1174
NT62-4
ENT-02A
Shotpoint
1650
1600
1550
1500
1450
Deformation front
PTZ
1 km
5000
6000
Depth (m)
Décollement
Quaternary sandy turbidites
Quaternary silty turbidites
Quaternary tuff and hemipelagic mudstone
Pliocene to U. Miocene hemipelagic mud
Miocene siliceous tuff
Miocene basalt

Site: ENT-02A

Priority: 3
Position: 32°19.26'N, 134°58.06'E
Water Depth: 4790 m
Sediment Thickness: 1040 m
Target Drilling Depth: 1040 mbsf
Approved Maximum Penetration: 1050 mbsf
Seismic Coverage: *Fred Moore* Line NT62-8, SP 1548 (CDP 699)

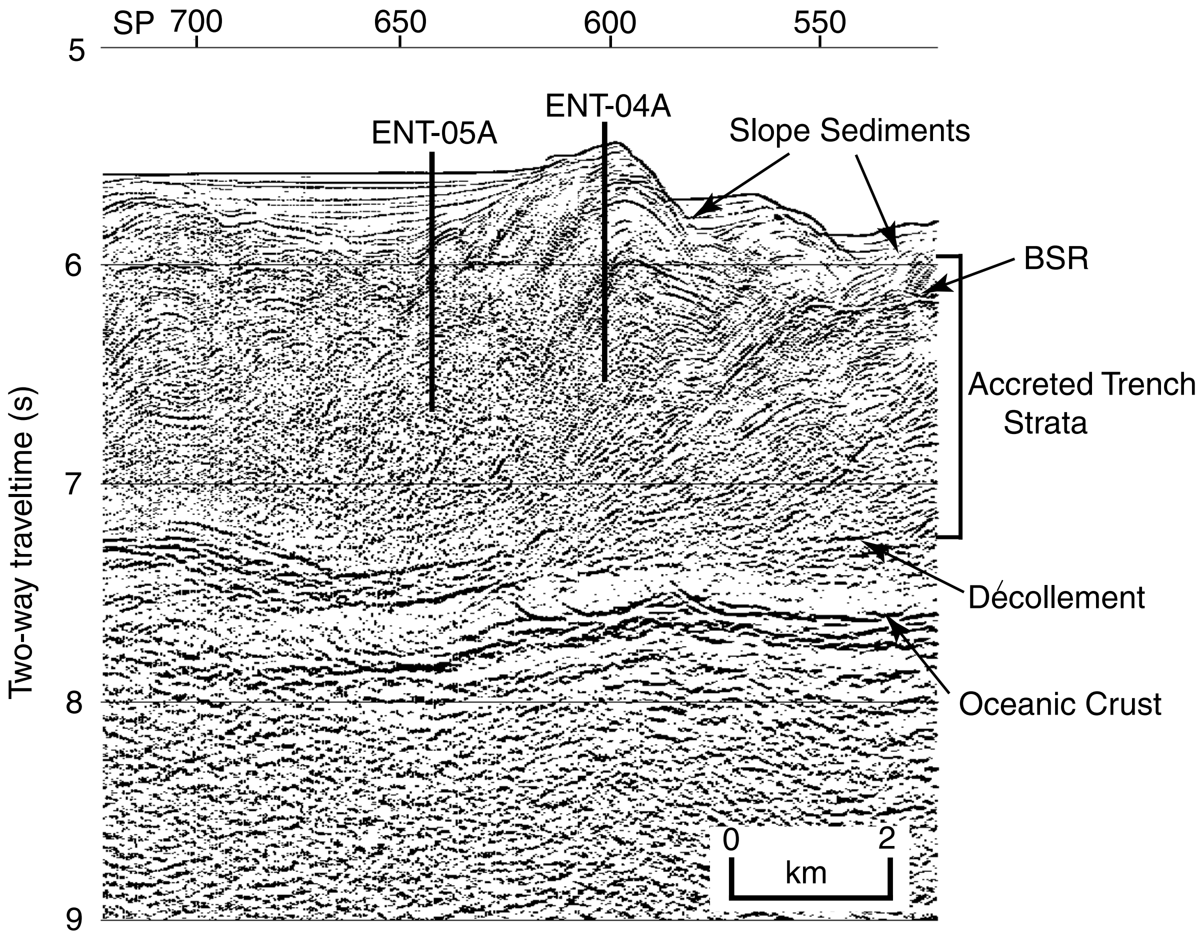
Objectives: The objectives of Site ENT-02A are to

1. Contrast deformational and fluid flow behavior along strike
2. Determine the structural and hydrologic evolution of the décollement zone
3. Determine the fluid flow paths and chemical gradients
4. Determine the spatial distribution and temporal progression of the deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites, tuff


SP 700
650
600
550
5
6
7
8
9
Two-way traveltime (s)
ENT-05A
ENT-04A
Slope Sediments
BSR
Accreted Trench
Strata
Décollement
Oceanic Crust
0
2
km

Site: ENT-04A

Priority: 2
Position: 32°28.71'N, 134°47.40'E
Water Depth: 4050 m
Sediment Thickness: 3000 m
Target Drilling Depth: 800 mbsf
Approved Maximum Penetration: 800 mbsf
Seismic Coverage: 3-D seismic survey in 1999, Line 141-2D SP 602, crossing line 802

Objectives: The objectives of Site ENT-04A are to drill through the seaward-most OOST to

1. Sample fluids along the OOST
2. Sample the older part of the accretionary prism
3. Determine the fluid flow paths and chemical gradients
4. Determine the spatial distribution and temporal progression of the deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites, tuff

Site: ENT-05A

Priority: 2
Position: 32°29.46'N, 134°46.48'E
Water Depth: 4125 m
Sediment Thickness: 3000 m
Target Drilling Depth: 800 mbsf
Approved Maximum Penetration: 800 mbsf
Seismic Coverage: 3-D seismic survey in 1999, Line 141-2D SP 642, crossing Line 842

Objectives: The objectives of Site ENT-05A are to

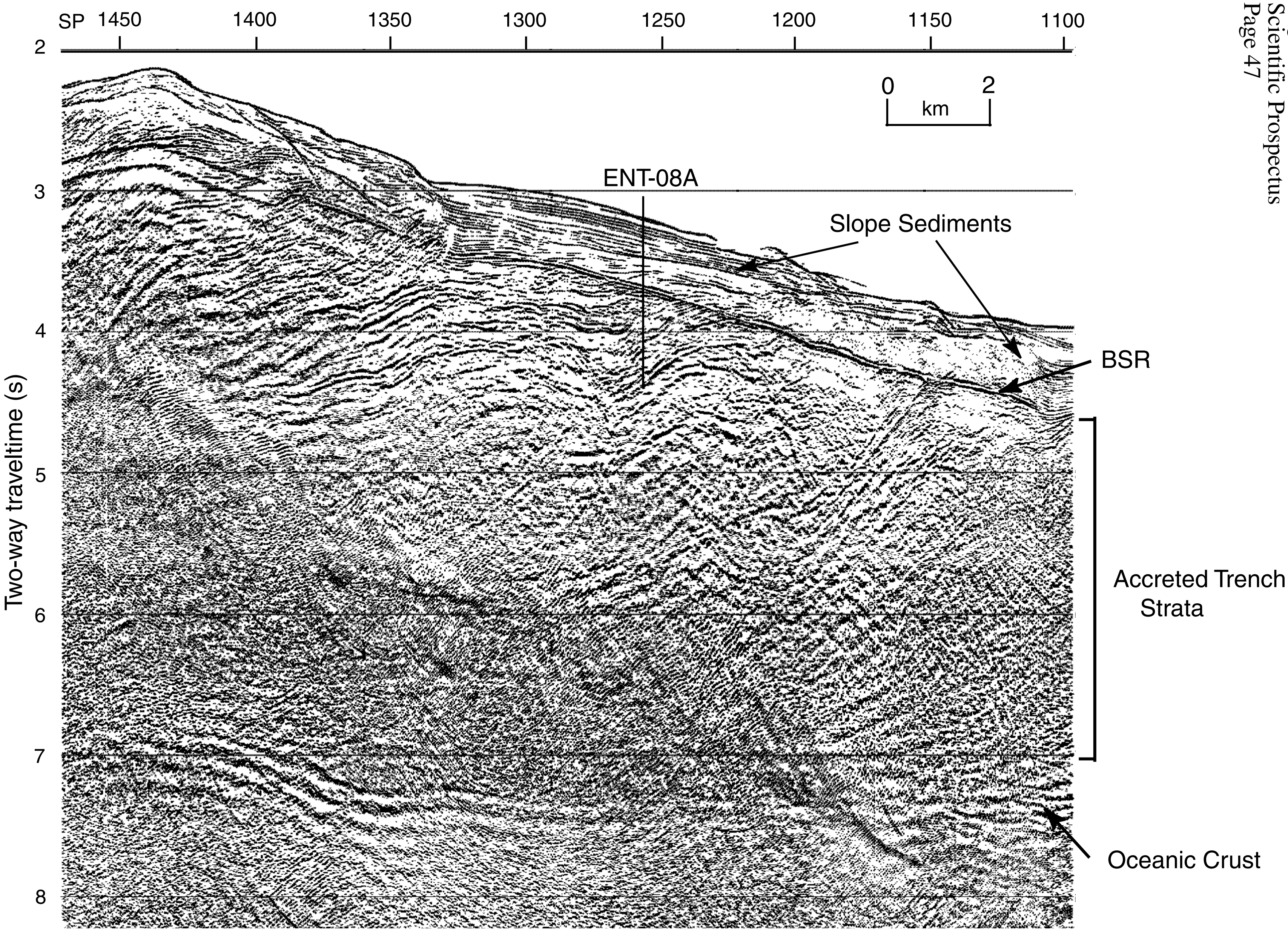
1. Sample slope basin strata to date prism deformation
2. Penetrate the seaward-most OOST for fluid sample
3. Date an older part of the prism
4. Determine the fluid flow paths and chemical gradients
5. Determine the spatial distribution and temporal progression of the deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites

See seismic line for ENT-04A


SP
1450
1400
1350
1300
1250
1200
1150
1100
2
3
4
5
6
7
8
Two-way traveltime (s)
0
2
km
ENT-08A
Slope Sediments
BSR
Accreted Trench Strata
Oceanic Crust

Site: ENT-08A

Priority: 3
Position: 32°40.68'N, 134°32.70'E
Water Depth: 2437 m
Sediment Thickness: 3000 m
Target Drilling Depth: 800 mbsf
Approved Maximum Penetration: 800 mbsf
Seismic Coverage: 3-D seismic survey in 1999, Line 141-2D SP 1257, crossing Line 1460

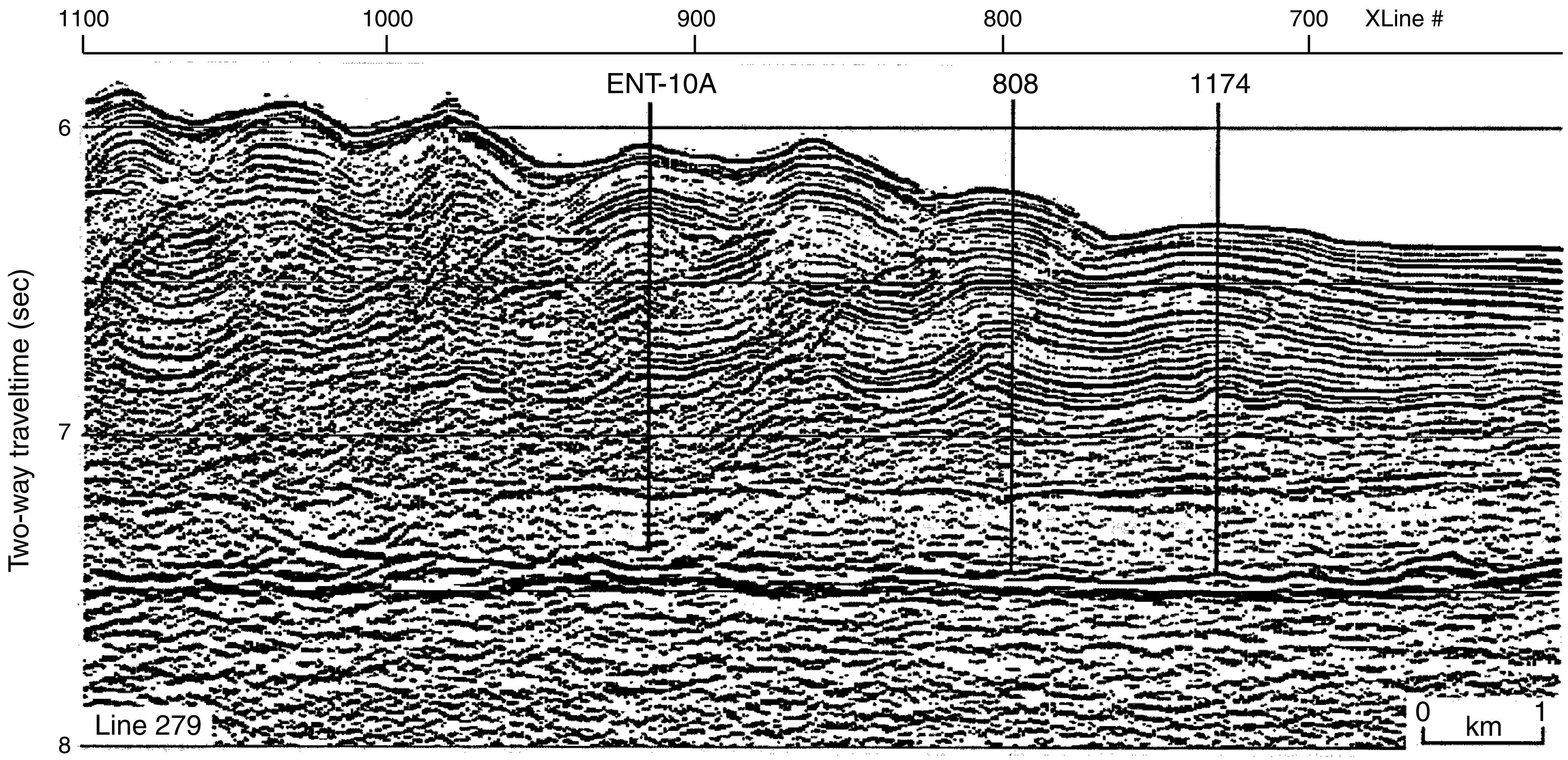
Objectives: The objectives of Site ENT-08A are to

1. Sample slope sediments and older accreted strata
2. Determine the spatial distribution and temporal progression of the deformation
3. Determine the fluid flow paths and chemical gradients
4. Obtain samples of gas hydrate

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites


1100
1000
900
800
700
XLine #
ENT-10A
808
1174
6
7
8
Two-way traveltime (sec)
Line 279
0
km
1

Site: ENT-10A

Priority: 2
Position: 32°22.2775’N, 134°55.1938’E
Water Depth: 4554 m
Sediment Thickness: m
Target Drilling Depth: 1340 mbsf
Approved Maximum Penetration: 1340 mbsf
Seismic Coverage: 1999 3-D seismic survey in 1999, Line 279, cross Line 922; about 1 km southwest of *Fred Moore* Line NT62-8, SP 1185 (CDP 1150)

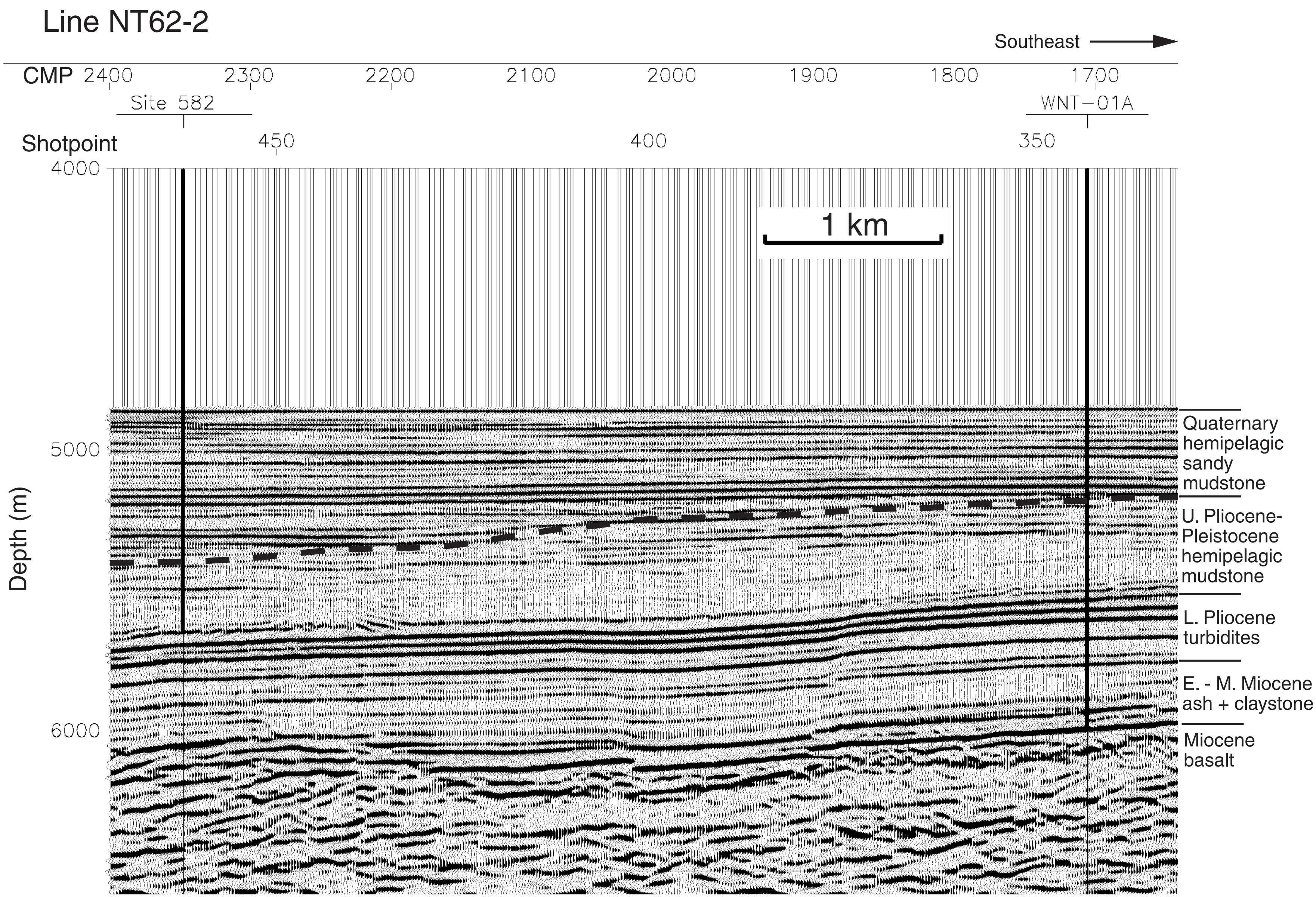
Objectives: The objectives of Site ENT-10A are to

1. Determine the spatial distribution and temporal progression of the deformation
2. Determine the structural and hydrological evolution of the major thrust fault and décollement zone
3. Determine the fluid flow paths and chemical gradients

Drilling Program: LWD, and APC/XCB coring,

Logging and Downhole Tools: ADN and CDN, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites, tuff


Line NT62-2
Southeast
CMP
2400
2300
2200
2100
2000
1900
1800
1700
Site 582
WNT-01A
Shotpoint
450
400
350
4000
5000
6000
Depth (m)
1 km
Quaternary hemipelagic sandy mudstone
U. Pliocene-Pleistocene hemipelagic mudstone
L. Pliocene turbidites
E. - M. Miocene ash + claystone
Miocene basalt

Site: WNT-01A

Priority: 3
Position: 31°43.87'N, 133°56.85'E
Water Depth: 4850 m
Sediment Thickness: 1150 m
Target Drilling Depth: 700 m
Approved Maximum Penetration: 1200 m
Seismic Coverage: *Fred Moore* Line NT62-2, SP 343 (CDP 1706)

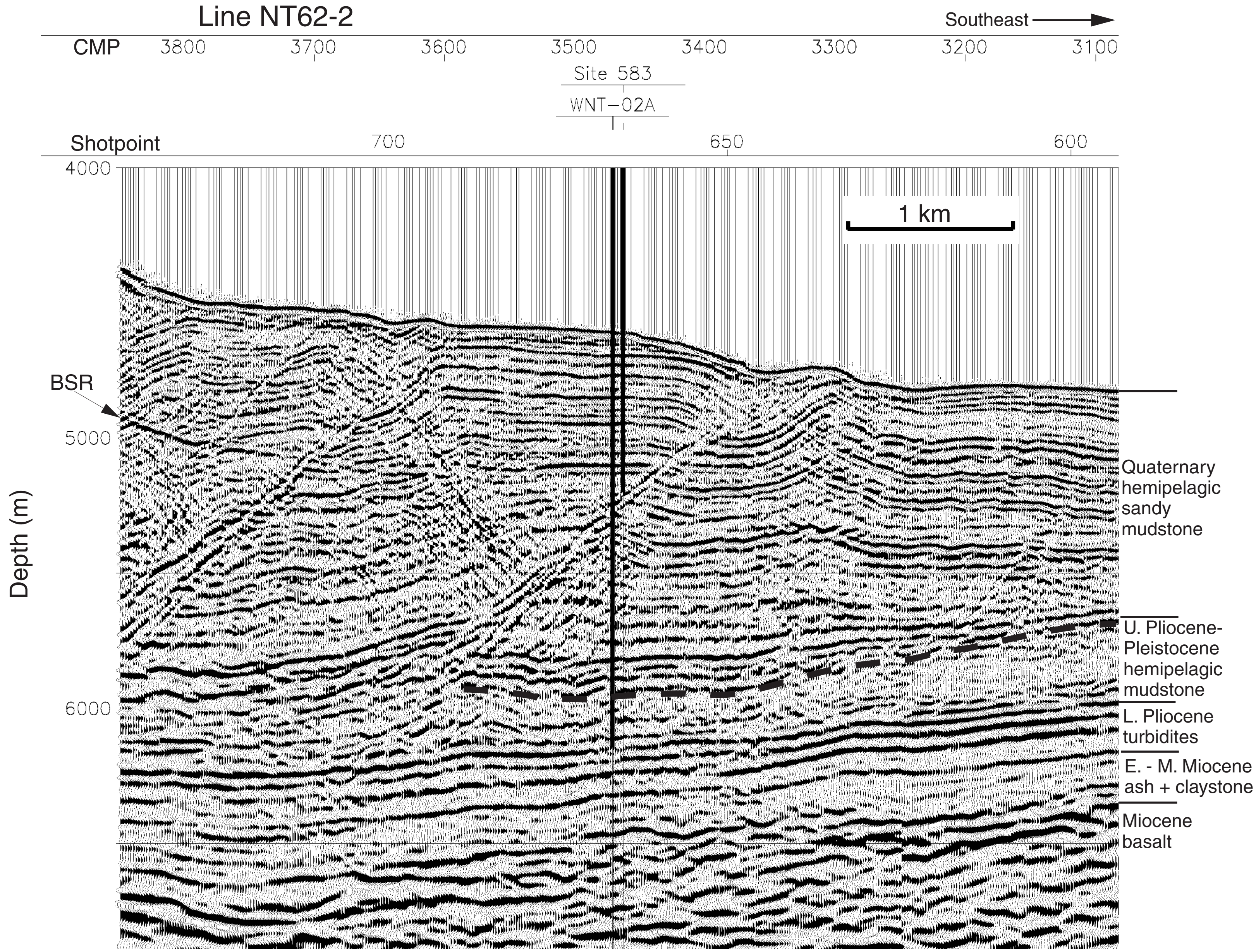
Objectives: The objectives of Site WNT-01A are to

1. Contrast deformational and fluid flow behavior along the strike
2. Determine the structural and hydrologic evolution of the décollement zone
3. Determine the fluid flow paths and chemical gradients
4. Determine the spatial distribution and temporal progression of the deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites


Line NT62-2
Southeast
CMP
3800
3700
3600
3500
3400
3300
3200
3100
Site 583
WNT-02A
Shotpoint
700
650
600
4000
5000
6000
Depth (m)
1 km
BSR
Quaternary hemipelagic sandy mudstone
U. Pliocene-Pleistocene hemipelagic mudstone
L. Pliocene turbidites
E. - M. Miocene ash + claystone
Miocene basalt

Site: WNT-02A

Priority: 3
Position: 31°50.48'N, 133°51.59'E
Water Depth: 4600 m
Sediment Thickness: 2000 m
Target Drilling Depth: 1700 m
Approved Maximum Penetration: 1700 m
Seismic Coverage: *Fred Moore* Line NT62-2, SP 667 (CDP 3471)

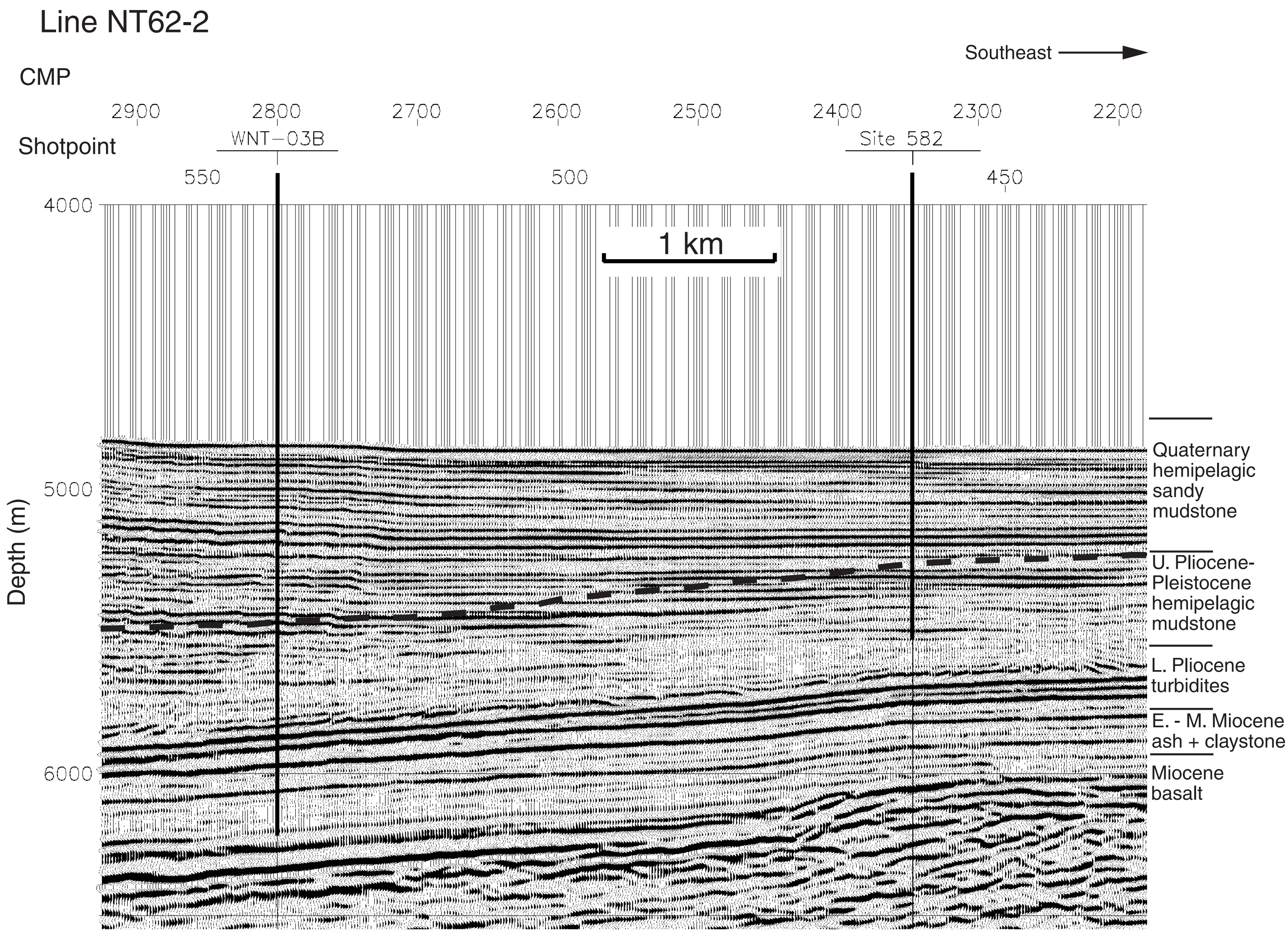
Objectives: The objectives of WNT-02A are to

1. Contrast deformational and fluid flow behavior along the strike
2. Determine the structural and hydrologic evolution of the décollement zone
3. Determine the fluid flow paths and chemical gradients
4. Determine the spatial distribution and temporal progression of the deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites



Line NT62-2
Southeast
CMP
2900
2800
2700
2600
2500
2400
2300
2200
Shotpoint
WNT−03B
Site 582
550
500
450
4000
5000
6000
Depth (m)
1 km
Quaternary hemipelagic sandy mudstone
U. Pliocene-Pleistocene hemipelagic mudstone
L. Pliocene turbidites
E. - M. Miocene ash + claystone
Miocene basalt

Site: WNT-03B

Priority: 3
Position: 31°47.99'N, 133°53.59'E
Water Depth: 4850 m
Sediment Thickness: 1510 m
Target Drilling Depth: 1510 m
Approved Maximum Penetration: 1510 m
Seismic Coverage: *Fred Moore* Line NT62-2, SP 540 (CDP 2800)

Objectives: The objectives of WNT-03B are to

1. Contrast deformational and fluid flow behavior along the strike
2. Determine the structural and hydrologic evolution of the décollement zone
3. Determine the fluid flow paths and chemical gradients
4. Determine the spatial distribution and temporal progression of the deformation

Drilling Program: APC/XCB and/or RCB coring

Logging and Downhole Tools: LWD, DVTP, and WSTP

Nature of Rock Anticipated: Interbedded hemipelagic mud/silty-sandy turbidites, basalt

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