Integrated Ocean Drilling Program
Expedition 326 Preliminary Report

NanTroSEIZE Stage 3: Plate Boundary Deep Riser: Top Hole Engineering

19 July–20 August 2010

Expedition 326 Scientists

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Disclaimer

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Abstract

Integrated Ocean Drilling Program (IODP) Expedition 326 was the first preparatory stage of drilling and coring of the main IODP Hole C0002F to the boundary zone between the Philippine Sea and Eurasian plates in the Nankai accretionary margin, which is one of the main objectives of the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) complex drilling project. The objectives for this expedition were purely operational, with the goal being installation of the wellhead assembly and drilling and casing the uppermost 800 m of the planned 7 km deep hole. Accordingly, no science party was on board during the expedition and no scientific results are reported. Scientific objectives for the uppermost 1400 m at this site were previously fulfilled during NanTroSEIZE Stage 1 Expeditions 314 and 315.

This expedition was scheduled to run from 19 July to 8 August 2010. Delays due to various equipment failures and the loss of a casing string caused the expedition to be extended to 20 August. By that time, Hole C0002F had been drilled to 872.5 meters below seafloor and the hole was lined with successfully cemented 20 inch casing. A corrosion cap was set in preparation for a future return to continue drilling. We confirm that Hole C0002F is now ready for deep riser drilling, currently planned for 2011 to 2013.

Introduction

The Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) project is a multi-expedition, multistage Integrated Ocean Drilling Program (IODP) drilling program focused overall on understanding the mechanics of seismogenesis and rupture propagation along subduction plate boundary faults (Tobin and Kinoshita, 2006a). The drilling program includes a coordinated effort to characterize, sample, and instrument the plate boundary system at several locations offshore the Kii Peninsula (Fig. **F1**) culminating in drilling, sampling, and instrumenting the plate boundary fault system near the updip limit of inferred coseismic slip, at 5–7 km below seafloor (Tobin and Kinoshita, 2006b) (Fig. **F2**). The main objectives are to understand

- The mechanisms controlling the updip aseismic–seismic transition along the megathrust fault system;
- Processes of earthquake and tsunami generation and strain accumulation and release, including the role of recently discovered slow slip and very low frequency earthquakes (e.g., Ito and Obara, 2006);

- The absolute mechanical strength of the plate boundary fault and its degree of interseismic locking; and
- The potential role of a major upper plate fault system (termed the "megasplay" fault) in seismogenesis and tsunamigenesis.

The drilling program is evaluating a set of core hypotheses through a combination of riser and riserless drilling, long-term observatories, and associated geophysical, laboratory, and numerical modeling efforts. The following hypotheses are paraphrased from the original IODP proposals and outlined in Tobin and Kinoshita (2006a, 2006b):

1. Systematic, progressive material and state changes control the onset of seismogenic behavior on subduction thrust faults.
2. Subduction megathrusts are weak faults.
3. Plate motion is accommodated primarily by coseismic frictional slip in a concentrated zone (i.e., the fault is locked during the interseismic period).
4. Physical properties of the plate boundary system (including the fault system and its hanging wall and footwall) change with time during the earthquake cycle.
5. A significant, laterally extensive upper plate fault system (the megasplay fault; Park et al., 2002) slips in discrete events that may include tsunamigenic slip during great earthquakes. It remains locked during the interseismic period and accumulates strain.

At Nankai, high-resolution seismic reflection profiles across the outer rise clearly document a large out-of-sequence thrust fault system (the megasplay fault, after Park et al., 2002) that branches from the plate boundary décollement close to the updip limit of inferred coseismic rupture in the 1944 Tonankai M 8.2 earthquake (Fig. **F2**). Several lines of evidence indicate that the megasplay system is active and may accommodate a significant fraction of plate boundary motion (Moore et al., 2007, 2009). However, the partitioning of strain between the lower plate interface (the décollement zone) and the megasplay system and the nature and mechanisms of fault slip as a function of depth and time on the megasplay are not understood. One of the first-order goals in characterizing the seismogenic zone along the Nankai Trough—and which bears both on understanding subduction zone megathrust behavior globally and on defining tsunami hazards—is to document the role of the megasplay fault in accommodating plate motion (both seismically and interseismically) and to characterize its mechanical and hydrologic behavior.

IODP Site C0002 was selected as the primary site to target the megasplay and top of subducting basement reflectors in the seismic volume, in order to sample all the presumed fault zones that comprise the plate boundary, make downhole measurements of their physical properties, and place long-term monitoring instruments in and around the fault zone.

Site C0002 is the centerpiece of the NanTroSEIZE project, intended to access the plate interface fault system at a location where it is believed to be capable of seismogenic locking and slip and to have slipped coseismically in the 1944 Tonankai earthquake. The primary targets include both the basal décollement and the reflector known as the "megasplay fault" (Tobin and Kinoshita, 2006b). The megasplay fault zone and the accretionary prism domain are the location of a newly identified class of earthquakes known as very low frequency earthquakes (Ito and Obara, 2006) as well as the first observation of shallow tectonic tremor (Obana and Kodaira, 2009). The megasplay fault reflector lies at an estimated depth of 5000~5200 meters below seafloor (mbsf), and the top of the subducting basement is estimated to lie at 6800~7000 mbsf (Fig. **F3**).

During IODP Expedition 314, Site C0002 was drilled to 1401 mbsf with in situ measurement of physical properties and borehole imaging through logging while drilling (LWD) but no coring (Expedition 314 Scientists, 2009). Several months later, portions of Site C0002 were cored over the intervals 0–204 and 475–1057 mbsf during IODP Expedition 315 (Expedition 315 Scientists, 2009). Lithostratigraphy at Site C0002 is characterized by turbiditic sediments to ~830 mbsf, underlain by older rocks of the accretionary prism and/or early slope basin sediments deposited prior to the development of the megasplay fault.

Further background, objectives, and accomplishments to date for the NanTroSEIZE project are discussed in Tobin et al. (2009), Expedition 319 Scientists (2010), and Underwood et al. (2010).

Scientific objectives

The primary specific objective of IODP Expedition 326 was to establish the wellhead and 20 inch casing for later scientific riser drilling at this site. Preexpedition plans called for setting the 20 inch casing to ~800 mbsf or deeper. Because the main scientific objectives (see previous section) for Site C0002 all lie deeper than this and the uppermost 800 mbsf had already been comprehensively logged during Expedition

314 and mostly cored during Expedition 315, it was decided that no scientific measurements, coring, logging, or other data sets would be attempted during the limited time available for Expedition 326. Therefore, this expedition was purely operations focused, and all operations were carried out to support future deeper drilling, logging, and coring.

Operational strategy

Our drilling plan for Expedition 326 (Fig. **F4**) was to run a mudmat and a reentry assembly without the guide horn to the seafloor and jet in 36 inch conductor casing to 60 mbsf. After the casing angle had been confirmed by remotely operated vehicle (ROV) to be within 1.5° of vertical, the bottom-hole assembly (BHA) would be exchanged to a 26 inch drill-ahead assembly.

Using the 26 inch drill-ahead BHA, the hole was to be extended to at least 800 mbsf. Wiper trips were to be performed until no tight spots were observed, after which the ship would prepare for running 20 inch casing in the hole.

The 800 m 20 inch casing string was to be drifted to the site and have four ropes attached to it to reduce vortex-induced vibration (VIV) if current was strong. After cementing, the ROV was to dive with a corrosion cap to suspend the hole for future operations.

Site summary

Site C0002 ultra deep riser top hole

C0002F = 33°18.0507′N, 136°38. 2029′E (Fig. **F5**)
Water depth = 1968 m
Drilling depth = 872.5 mbsf

The D/V *Chikyu* left Shingu, Japan, at 0700 h on Monday, 19 July 2010 and started deploying transponders on the night of the same day until early morning on the next day. Meanwhile, the watch boat was surveying the Kuroshio Current speeds around the location. A seafloor survey was conducted early on 20 July and found no obstructions around the location. The 36 inch conductor pipe and jetting BHA were made up and run, and by 21 July the guide horn was installed and the vessel started drifting to site. However, ROV winch trouble on 22 July held up the operation until spare parts could be loaded. This happened on the night of 24 July, and repair of the ROV winch continued until 25 July. Hole C0002F was finally spudded at 38°18.0507′N, 136°38.2029′E on 25 July, jetting in the 36 inch conductor pipe to 54 mbsf. Releasing the drill-ahead tool went smoothly, followed by drilling with 26 inch bit to a target depth of 856.5 mbsf on 27 July.

The subsequent wiper trip encountered a few tight spots, including one too close to the target depth that could endanger the cement job for the casing operation. We decided to deepen the hole slightly to reach a more stable interval at 868.5 mbsf. Issues with mismatch in positioning software delayed the following reaming operations of the several tight spots, but by 30 July we were able to clear the hole and move upstream to prepare for casing operations.

Lowering of the 20 inch casing began on 31 July, and by 1 August the *Chikyu* could drift back toward Hole C0002F with 72 joints of 20 inch casing trailing underneath. However, during the afternoon of 1 August, probably due to a sudden intensifying of the current, the string sheared off just above the casing running tool and most of the casing was lost on the seafloor. The decision was made to return to Shingu, Japan, and load up new casing and try again.

The port call lasted less than a day, and by 3 August the *Chikyu* returned to sea to stand by while decisions were made on shore about how to proceed. It was decided to procure a sturdier but untested casing running tool, which was brought out by the *Heisei-maru* on 7 August. While decisions were still being made on shore, we surveyed current conditions with help from the *Heisei-maru*. Currents sometimes exceeded 4 kt, with an average around 3 kt.

Preparations for the second casing operation were completed by 12 August. We reamed down another 4 m (to 872.5 mbsf) and continued wiper trips until 14 August then returned upstream to a low current area to prepare for setting casing. On 15 August, the new casing was lowered with four ropes attached to the drill pipe to reduce VIV. Drifting downstream began in the early morning of 16 August. By midday on 17 August, the casing was stabbed into Hole C0002F under current speeds of >4 kt. On 18 August, the casing was successfully set and cemented, and the drill pipe could be tripped back up. The casing shoe is at 860.3 mbsf. By nighttime on 19 August, the ROV dove with the corrosion cap and set it before midnight. On 20 August, the ROV was retrieved back on the *Chikyu* and we headed toward Shimizu, Japan. In the evening of 20 August, the *Chikyu* arrived in Shimizu, Japan, and Expedition 326 came to an end at 0000 h.

Preliminary scientific assessment

The limited objectives of Expedition 326 were eventually completely met, albeit with setbacks and a necessary, though little-precedented, extension of the duration of the expedition. The wellhead, 36 inch conductor, and 20 inch casing were set and cemented to a depth somewhat in excess of the minimum requirement set out for this top hole portion of the planned riser borehole. The loss of a substantial length of 20 inch casing in the water column, presumably due to the strong current and VIV, was a costly problem. However, the lesson learned about how to deploy casing and other pipe through the Kuroshio Current using the vibration-damping rope coils proved to be key to the success of the second attempt. The outcome is that the stage is now set for riser drilling of Hole C0002F during future expeditions.

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Table T1. Expedition 326 operation summary.

Hole	Latitude	Longitude	Water depth (mbsl)	Drilled interval (m)	Total penetration (m)	Time on site (days)
C0002F	33°18.507′N	136°38.2029′E	1968	872.5	872.5	29

Figure F1. Map of Nankai accretionary complex off Kumano, showing NanTroSEIZE drill sites. Yellow arrows = computed far-field convergence vectors between the Philippine Sea plate and Japan (Seno et al., 1993; Heki, 2007), contours = estimated slip during the 1944 event (0.5 m interval), red box = region of recorded very low frequency events (Obara and Ito, 2005), red circles = NanTroSEIZE drill sites.

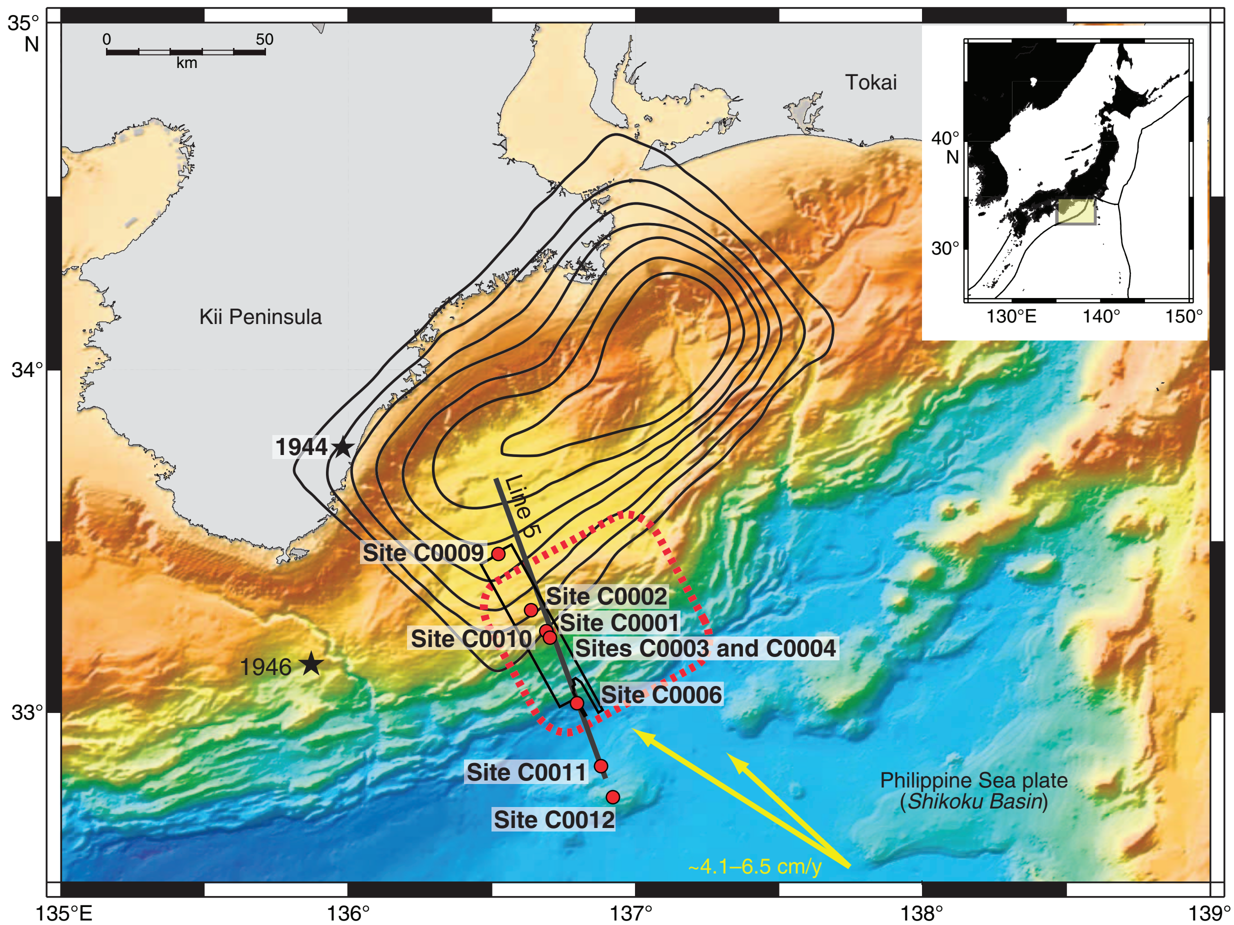

Figure F2. Spliced composite profile of a representative depth section from the NanTroSEIZE three-dimensional (3-D) seismic data volume (Moore et al., 2009) and Line 95 from Institute for Research on Earth Evolution mini-3-D seismic survey (Park et al., 2008). Projected positions of Stage 1 and 2 drilling sites, including Sites C0009, C0010, C0011, and C0012. Black lines = accretionary prism, green lines = major megasplay faults.

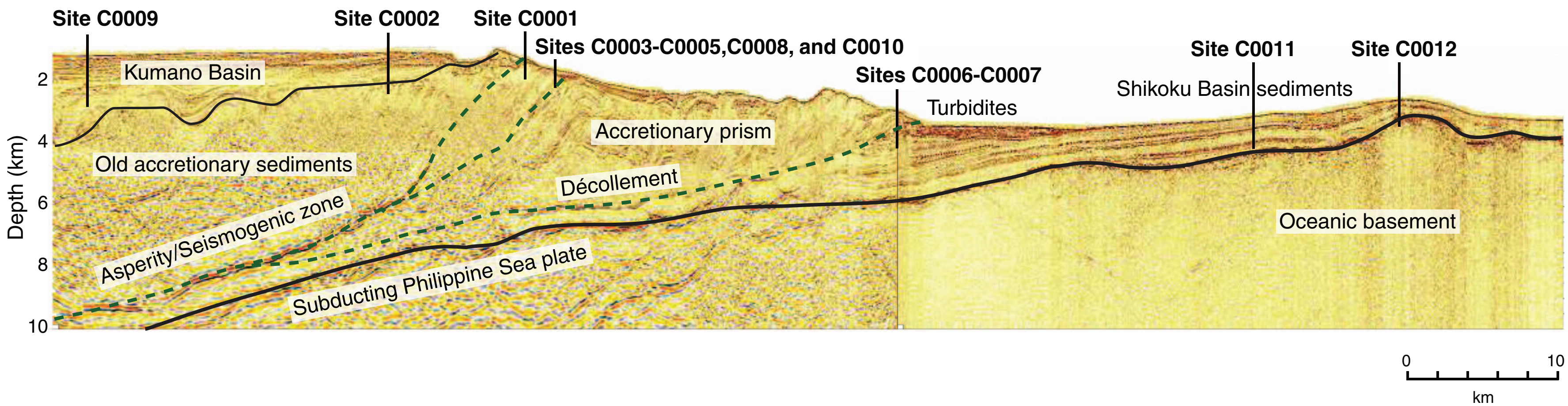

Figure F3. Interpreted three-dimensional seismic profile In-line 2645 across Kumano forearc basin, showing four major unconformities (black lines, S1, S2, S-A and S-B). The profile shows the correlation between Holes C0009A and C0002A, including stratigraphic columns. VE = vertical exaggeration.

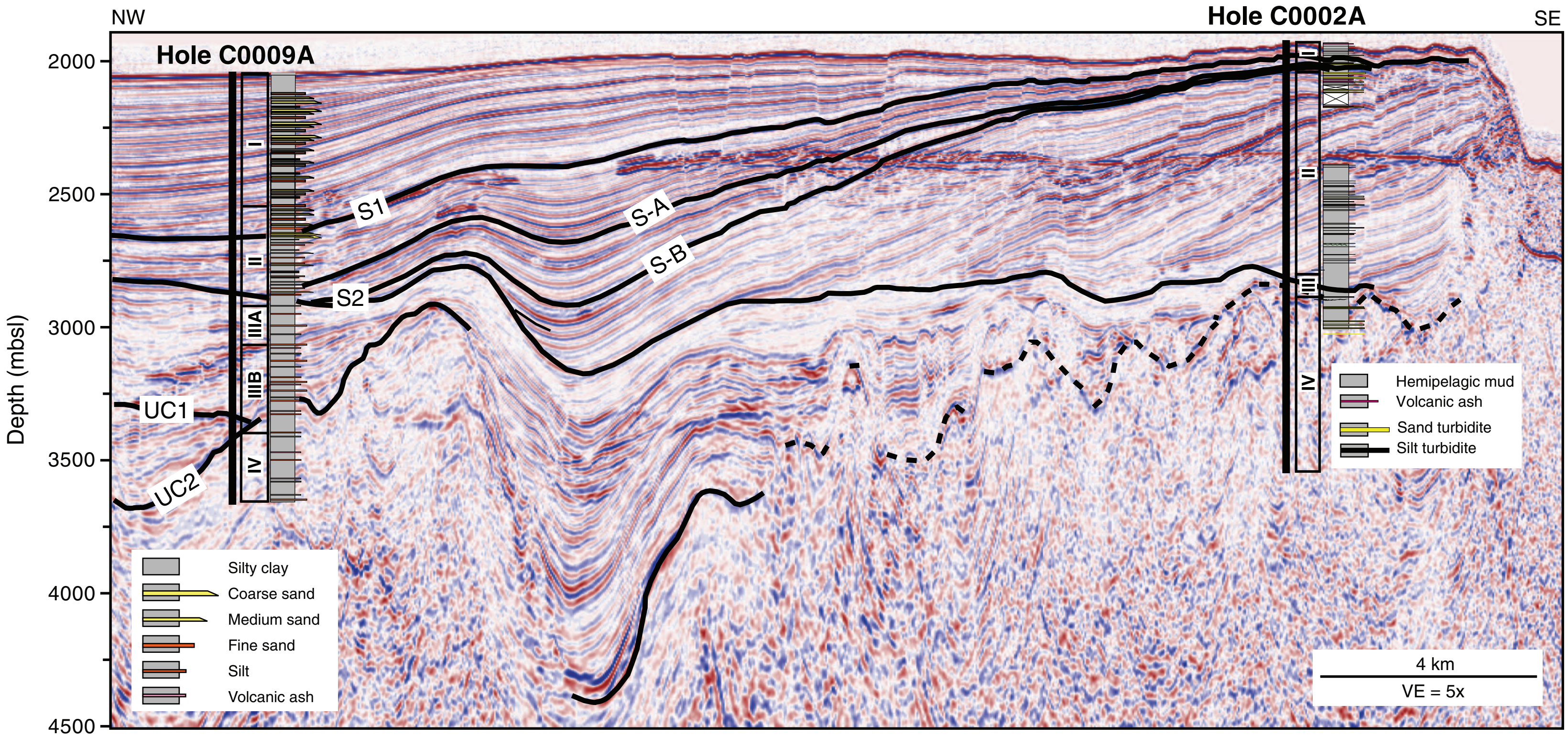

Figure F4. Casing plan for top hole portion of the riser hole, Hole C0002F. The 36 inch conductor casing was set at 54 mbsf and 20 inch casing was run to 856.6 mbsf.

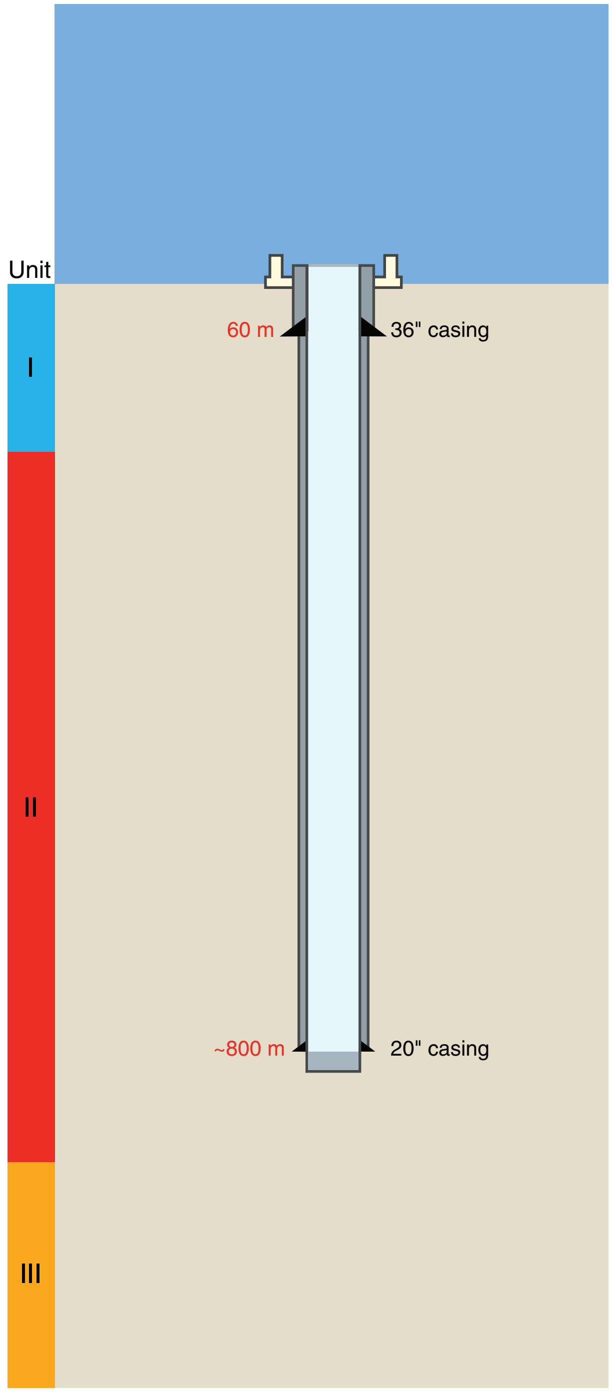

Figure F5. Bathymetric map, Site C0002. Black stars = holes drilled, green circle = proposed hole for Expedition 332 riserless observatory.

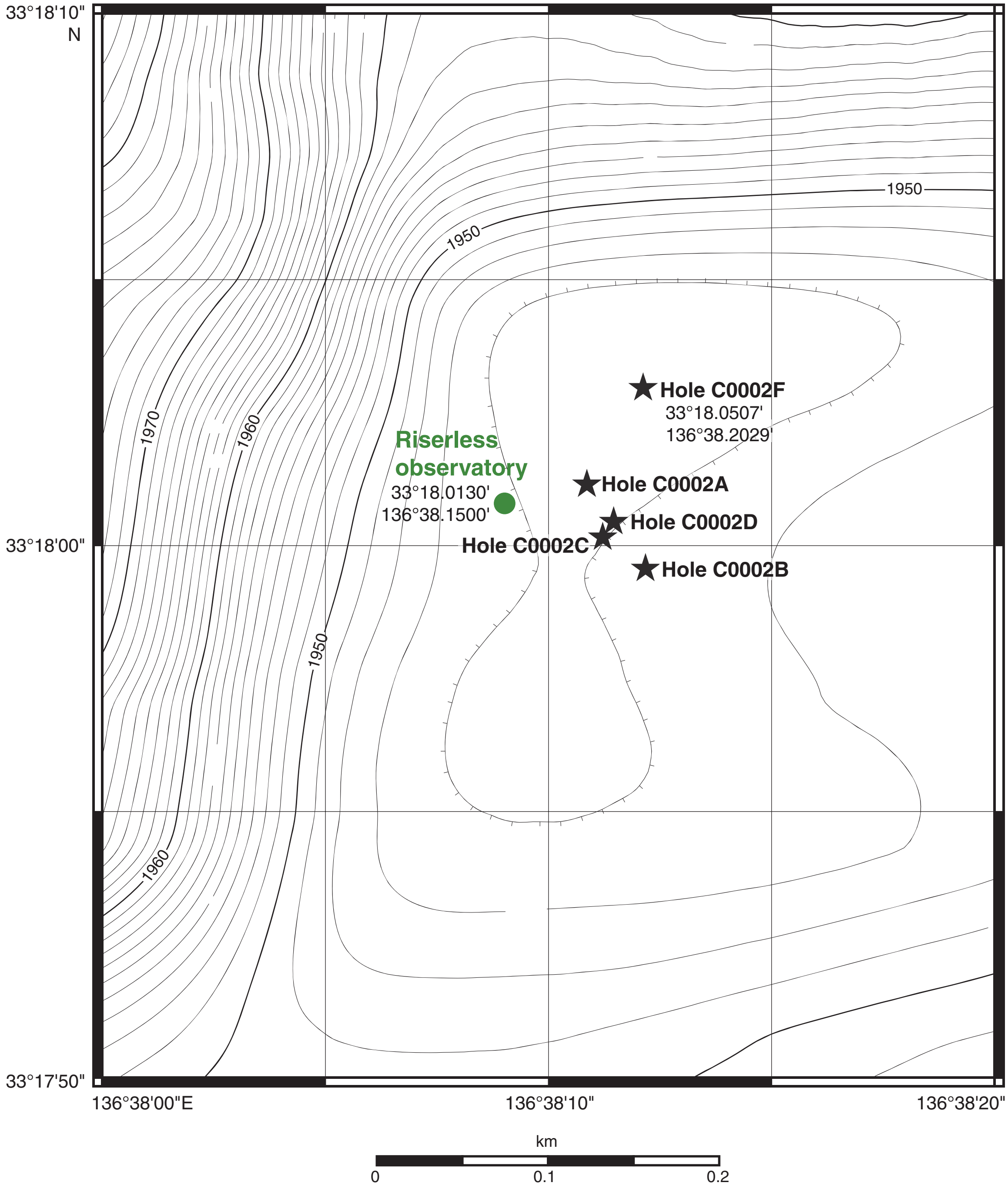

Figure F6. Seismic section of In-line (IL) 2529, showing current status and planned trace for deep riser Hole C0002F. Brown rectangle = progress made by Expedition 326. Note that the operational options shown here in green are only suggested by the Project Management Team. BSR = bottom-simulating reflector, LWD = logging while drilling, VE = vertical exaggeration.