Site U1301[1]

Expedition 327 Scientists[2]

Chapter contents

Background and objectives

Four long-term subseafloor borehole observatories ("CORKs"), two of which are located on 3.5–3.6 Ma seafloor in Holes 1026B and 1027C, were installed during Ocean Drilling Program (ODP) Leg 168 (Davis, Fisher, Firth, et al., 1997). Hole 1026B is located above a buried basement high, whereas Hole 1027C is located 2.2 km to the east, where basement is deeper and sediment is thicker. Integrated Ocean Drilling Program (IODP) Expedition 301 returned to this area in 2004, replaced the borehole observatory in Hole 1026B, drilled two additional boreholes, and installed observatories in Holes U1301A and U1301B (Fisher, Urabe, Klaus, and the Expedition 301 Scientists, 2005). These holes are located 1 km south of Hole 1026B above the same buried basement ridge, 2.4 km from Hole 1027C (Fig. **F1**). Hole U1301A was drilled through 262 m of sediment and 108 m into upper basement (Fig. **F2**). Hole U1301B was drilled 35 m from Hole U1301A through 265 m of sediment and 318 m into basement. Instruments were installed in the wellheads of both CORKs and deployed through the inner CORK casing on a Spectra cable. Instruments placed in Hole U1301A were deployed entirely within casing, whereas instruments placed in Hole U1301B were deployed through the CORK casing so that they were hanging in the open hole in basement (Fisher et al., 2005).

The annulus between the 0.41 m (16 inch) and 0.27 m (10¾ inch) casing strings at Site U1301 was supposed to contain a rubber mechanical casing seal near the seafloor. However, this component was not available for use during Expedition 301, and an attempt was made to seal the 0.27 m casing strings at depth with cement. Rubbly basement prevented the cement from sealing between the casing and the borehole wall. Both of these holes functioned as hydrothermal siphons for several years after Expedition 301, drawing cold water into basement at ~5 L/s (Fisher et al., 2008).

Both Site U1301 CORKs were serviced annually between 2004 and 2010. During servicing, pressure data were downloaded from wellhead loggers and seafloor OsmoSamplers were recovered and replaced. The instrument string originally deployed in the CORK in Hole U1301A was retrieved in summer 2008 using flotation and a winch operated from the deck of the R/V *Atlantis* and was replaced with a new instrument string deployed from the DSRV *Alvin*. The instrument string recovered from Hole U1301A provided valuable information and samples related to the thermal, chemi-

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[2]**Expedition 327 Scientists' addresses.**

cal, and microbiological state of the borehole and surrounding formation during the first 4 y after installation (Wheat et al., 2010; Orcutt et al., 2011). Thermal data from Hole U1301A showed that the flow of cold water down the hole varied for the first 3 y after the CORK was installed and then reversed in September 2007, with warm formation fluid discharging up the hole and out into the overlying ocean.

Researchers were unable to recover the instrument string deployed in Hole U1301B during a summer 2009 servicing expedition, despite pulling with the surface winch with >5000 lb. Apparently, the instrument package was being held in the open hole below the CORK, probably because the borehole collapsed after the instrument string was originally deployed.

Several attempts were made to seal the Site U1301 CORKs using cement delivered with the *Alvin* in 2006 and 2007, but these attempts were not successful. IODP Expedition 321T filled the reentry cones around both of the Site U1301 CORKs with cement during summer 2009. The cement appears to have stopped flow in Hole U1301B (as discussed later in this chapter), but shimmering water continued to flow from Hole U1301A at the start of Expedition 327.

The primary scientific objectives at Site U1301 were to recover the CORK instrument string deployed in Hole U1301B during Expedition 301 and to deploy a new instrument string that included some combination of thermal sensors, fluid samplers, and microbial growth substrate. The extent of instrumentation to be deployed in Hole U1301B was to depend on the components recovered with the R/V *JOIDES Resolution* and the amount of space available in the 4½ inch CORK casing. We were hopeful that some instruments would be recovered from Hole U1301B because the coring line on the *JOIDES Resolution* can be pulled with greater force than the Plasma line used on the *Atlantis* in 2009. We also planned to complete a depth check of open casing in Hole U1301B (unless we were fortunate enough to recover the entire instrument string) and collect thermal data inside the CORK to evaluate the thermal state of the borehole surrounding the CORK installation following Expedition 321T cementing operations.

Operations

Following the deployment of the Hole U1362A L-CORK (see **"Operations"** in the "Site U1362" chapter), the ship was offset in dynamic positioning (DP) mode to Hole U1301B (47°45.228′N, 127°45.827′W; 2671 m water depth), 800 m to the south-southwest. A bottom-hole assembly (BHA) that included a CORK recovery tool was made up and tripped to the seafloor by 1615 h on 17 August 2010. At 1730 h the recovery tool engaged the Hole U1301B CORK head, but before the J-slot tool could be engaged the recovery tool heaved off. This required a second engagement attempt, and by 1815 h the tool was back on the CORK head. Engagement of the J-slot tool was ineffectual, so 10,000 lb of weight was applied to the top of the CORK, allowing us to proceed with instrument string recovery operations. The CORK running tool used for operations was later determined to be incompatible with the wellhead, which had J-slot lugs that were too large. Fortunately, this did not prevent completion of planned work.

The sinker bars were lowered, and after multiple attempts the GS overshot engaged the instrument string top plug. Tension was applied to the instrument string, which was found to be stuck in place, as it had been during the *Atlantis* recovery effort in summer 2009. After working the sandline with various amounts of overpull, the cable stretched or the instrument string started creeping slowly upward. At 0920 h on 17 August the Spectra cable parted. The CORK recovery tool was disengaged, and a portion of the instrument string was recovered back to the surface. Upon recovery it was found that a splice in the Spectra rope had failed directly above the middle plug of the installed instrument string. Five temperature data loggers and 377 m of Spectra rope were recovered. After laying out the recovered portion of the instrument string the CORK head was reengaged at 2225 h. A temperature logger was deployed on sandline to obtain a temperature profile of the upper part of the CORK casing and to determine the depth of casing available for subsequent instrument deployment. This allowed proper configuration of the replacement instrument string. The logging tool was stopped for 5 min at 5 m increments in the uppermost 50 m of the CORK and subsequently at 25 m intervals. The bottom of the open CORK casing was tagged at 3037 meters below rig floor (mbrf; 370 meters below seafloor [mbsf]). The recovery tool was disengaged once again at 0130 h on 18 August.

Make-up of the replacement instrument string, including rigging of the Schlumberger electric logging line, began at 0145 h. The prototype Electronic "RS" (ERS; "RS" is an oil field designation for a particular geometry of fishing tool) tool system, under development by Stress Engineering for use with the developmental SCIMPI CORK system, was used for this deployment because the Hole U1301B CORK system was not configured with an instrument string latch-down system. Historically, there have been significant problems jarring off the instrument string without dislodging the upper CORK plug, which has tended to get pulled out of the wellhead during deployment. The replacement instrument string, which included three thermistor probes and extended to ~54 mbsf (end of sinker bar), was ready for deployment at 0330 h, and the CORK running tool was engaged once again at 0435 h. The instrument string was successfully landed and released using the ERS tool without incident, and the Schlumberger logging line was recovered and rigged down. At 0530 h on 18 August the CORK recovery tool was disengaged, ending operations in Hole U1301B.

Downhole measurements

A temperature log was collected inside the 4½ inch CORK casing in Hole U1301B following the recovery of part of the instrument string deployed during Expedition 301 (see **"Borehole observatories"** for a discussion of the recovery of this string and the deployment of a new string). A new autonomous temperature logger prepared for deployment on a CORK string during Expedition 327 was used as a logging tool. The logger was programmed to record temperature every 5 s and was placed inside one of the perforated steel carriers used to run pressure gauges below a go-devil during packer testing. The carrier was fitted to the front end of a sinker bar, and the complete assembly was run into the pipe on coring line to determine the temperature inside the CORK casing and the depth of open hole available for new instrumentation.

The temperature tool was run to within 5 m of the seafloor and was then stopped for 5 min to determine the temperature of bottom water. The bottom water temperature was found to be 1.79°C, consistent with earlier regional surveys and measurements made with the Hole U1301B CORK pressure logger. The temperature tool was lowered and held stationary for 5 min at 5 m increments from the seafloor to 50 mbsf. We continued lowering the tool and taking 5 min readings at 25 m increments until an obstruction was encountered in the CORK casing, with the final temperature measurement being made at 364 mbsf.

The primary data recovered from the tool comprise a record of temperature versus time (Fig. **F3**). Data were converted to pairs of temperature/depth values by averaging the most stable 3–4 min of temperatures measured when the tool was held stationary inside the CORK and merging these values with depth records from the wireline (Fig. **F4**). Temperatures at ~100 m into basement approach 63.5°C, somewhat higher than the value estimated for uppermost basement from extrapolation of the sediment thermal gradient in Hole U1301C (Expedition 301 Scientists, 2005), but conditions are considerably cooler within the uppermost 25–50 m of basement (Fig. **F4**). The thermal gradient indicated by temperatures measured in the CORK casing through the sediment section is also somewhat lower than that determined from in situ measurements in sediments during Expedition 301.

These data suggest that Hole U1301B was sealed successfully by cementing in summer 2009 during Expedition 321T and that thermal conditions within the borehole have rebounded considerably within the last year after the flow of cold bottom water down the annular gap between the 10¾ and 16 inch casings ended. The data are also consistent with the top of the primary crustal aquifer being located below uppermost basement.

Borehole observatories

The operational objectives for Expedition 327 included replacing the CORK sensor string that was originally installed in Hole U1301B during Expedition 301 (Expedition 301 Scientists, 2005). The sensor string could not be replaced as planned during 2009 operations using the *Atlantis* and the *Alvin*, despite pulling more than 5000 lb. We expected that the *JOIDES Resolution* would be more effective at pulling the sensor string, albeit with some risk of damaging the instrumentation originally installed during Expedition 301. Indeed, as described in **"Operations"** >10,000 lb of overpull was required before a portion of the Expedition 301 string broke free. The sensor string parted at the splice between the Spectra strength member and the middle plug at ~377 mbsf, and only the top plug and upper Spectra segment were recovered.

The recovered Spectra segment included five temperature loggers from the upper basement section, but nine other temperature loggers and all of the Expedition 301 OsmoSamplers were left in the hole. Of the five temperature loggers recovered (Table **T1**), only one had sufficient battery power to transfer the 6 y temperature record, which is not surprising given that the batteries were designed for 3–4 y deployments. Past experience suggests that the manufacturers should be able to recover the data files from nonvolatile memory in most of the nonresponsive units when they are returned for servicing. Given that most of the lower section of the casing and open hole was obstructed, the replacement sensor string was scaled back to ~54 m total length and included three Antares temperature loggers (temperature range = 0°–80°C) set for 2 h sampling intervals (Table **T2**) and a 200 lb (in water) sinker bar. These were positioned primarily to assess whether the hole was successfully sealed during Expedition 321T cementing operations by monitoring for the convex-upward gradient that would be diagnostic of upward flow in an unsealed, overpressured hole producing formation fluids.

Figure F5 shows the last year recorded by the Antares unit deployed at ~267 mbsf (~2 meters subbasement [msb]). The 2004 Antares electronics were designed to optimize resolution at expected basement temperatures of >60°C using a lower limit of ~40.5°C for the recording range; the first 5 y of the record was below this lower limit. The record shows a long-term recovery toward formation temperatures beginning shortly after the Expedition 321T cementing operations in June 2009, indicating that those operations reduced or ended cold-water flow down the hole. The most recent data are consistent with the temperatures recorded at the same depth during the temperature log conducted as part of the depth check before installing the replacement sensor string (see **"Downhole measurements"**). Thermal recovery of the borehole is incomplete, but this is not surprising given that the downhole flow lasted nearly 5 y, whereas the recovery period has lasted little more than a year thus far.

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Figure F1. Site maps showing location of Hole U1301B. **A.** Regional bathymetry (Davis, Fisher, Firth, et al., 1997) showing locations of ODP and IODP drill sites. Contour interval is 10 m. Solid circle is Hole U1301B; open circles are other holes drilled during earlier expeditions (blue) or Expedition 327 (black). Gold contours show locations of basement exposure on Baby Bare, Mama Bare, and Papa Bare outcrops. Area of dashed box is shown in B. **B.** Track chart of seismic lines around Site U1301 collected during the 2000 ImageFlux expedition (Zühlsdorff et al., 2005; Hutnak et al., 2006). Part of Line GeoB00-466 (thick dashed line) is shown in Figure F2.

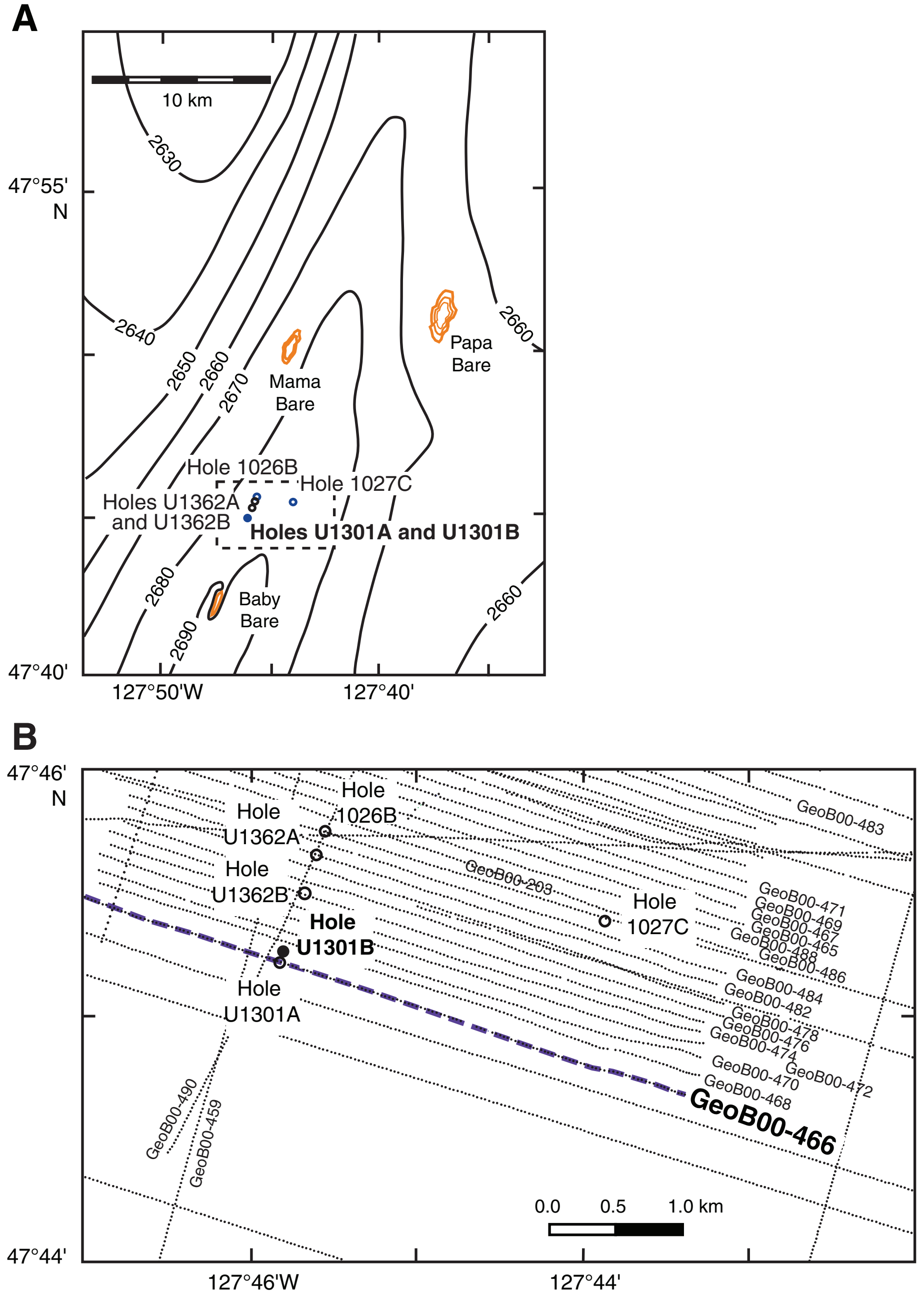

Figure F2. Reflection seismic Line GeoB00-466 near IODP Holes U1301A and U1301B (separated by 36 m). Sediment structures and the sediment/basalt interface are clearly visible, as are steeply dipping normal faults to the west of the holes (indicated with vertical lines that show total depth penetration). Both holes are located over the peak of a buried basement high, near the western edge of a major distributary channel for turbidites that flowed off the North American continental shelf (Davis et al., 1992; Zühlsdorff et al., 2005; Underwood et al., 2005; Hutnak et al., 2006).

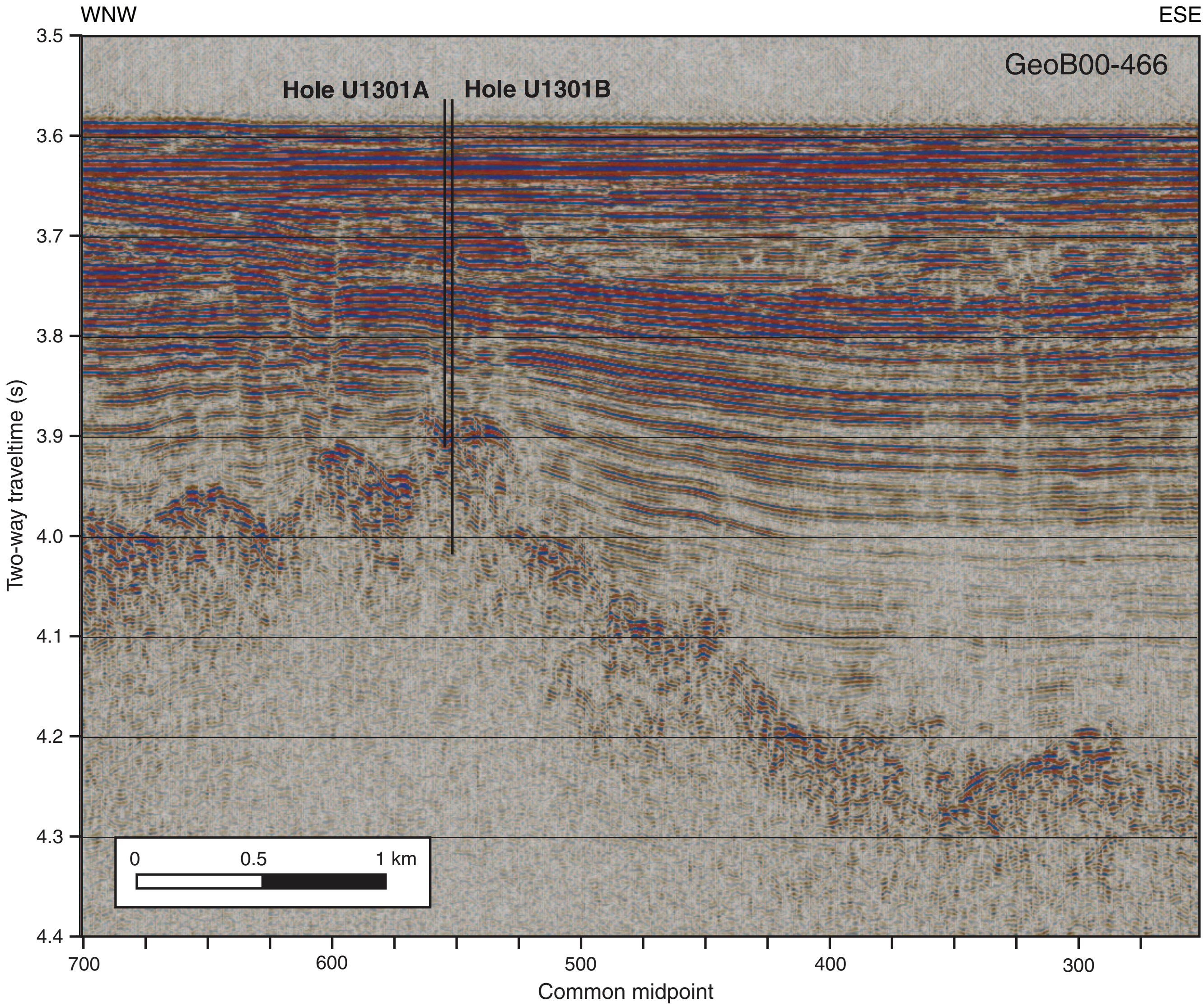

Figure F3. Plot of temperature vs. time, Hole U1301B. Temperature was determined with an autonomous thermal probe deployed below a sinker bar during a depth check on 18 August 2010.

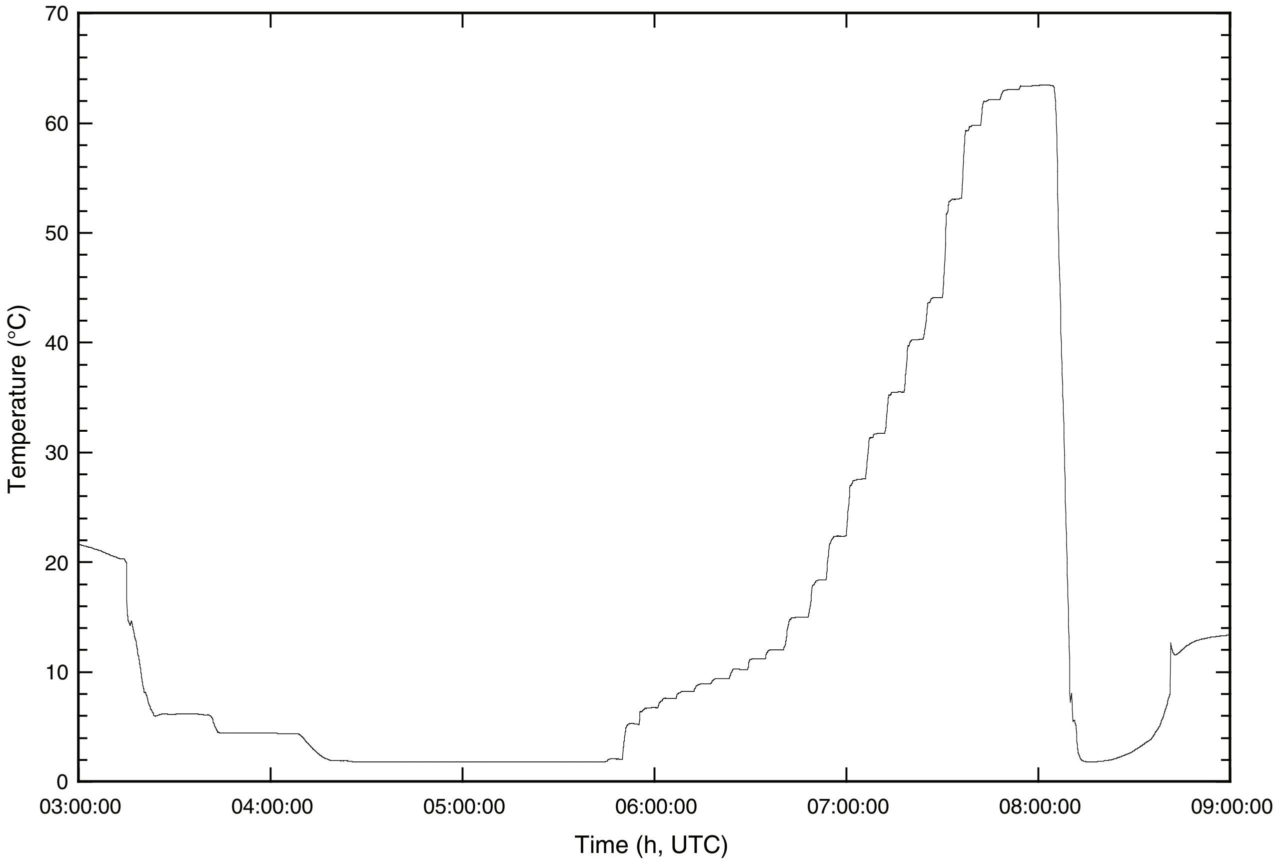

Figure F4. Plot of temperature vs. depth in the Hole U1301B CORK. Values shown comprise the means of 2–4 min of stable readings made at depths spaced 5 m apart from the seafloor to 50 mbsf and 25 m apart below that depth. Error bars (vertical lines inside of each square) indicate 2× the standard deviation of the values determined during the most stable period at each measurement depth.

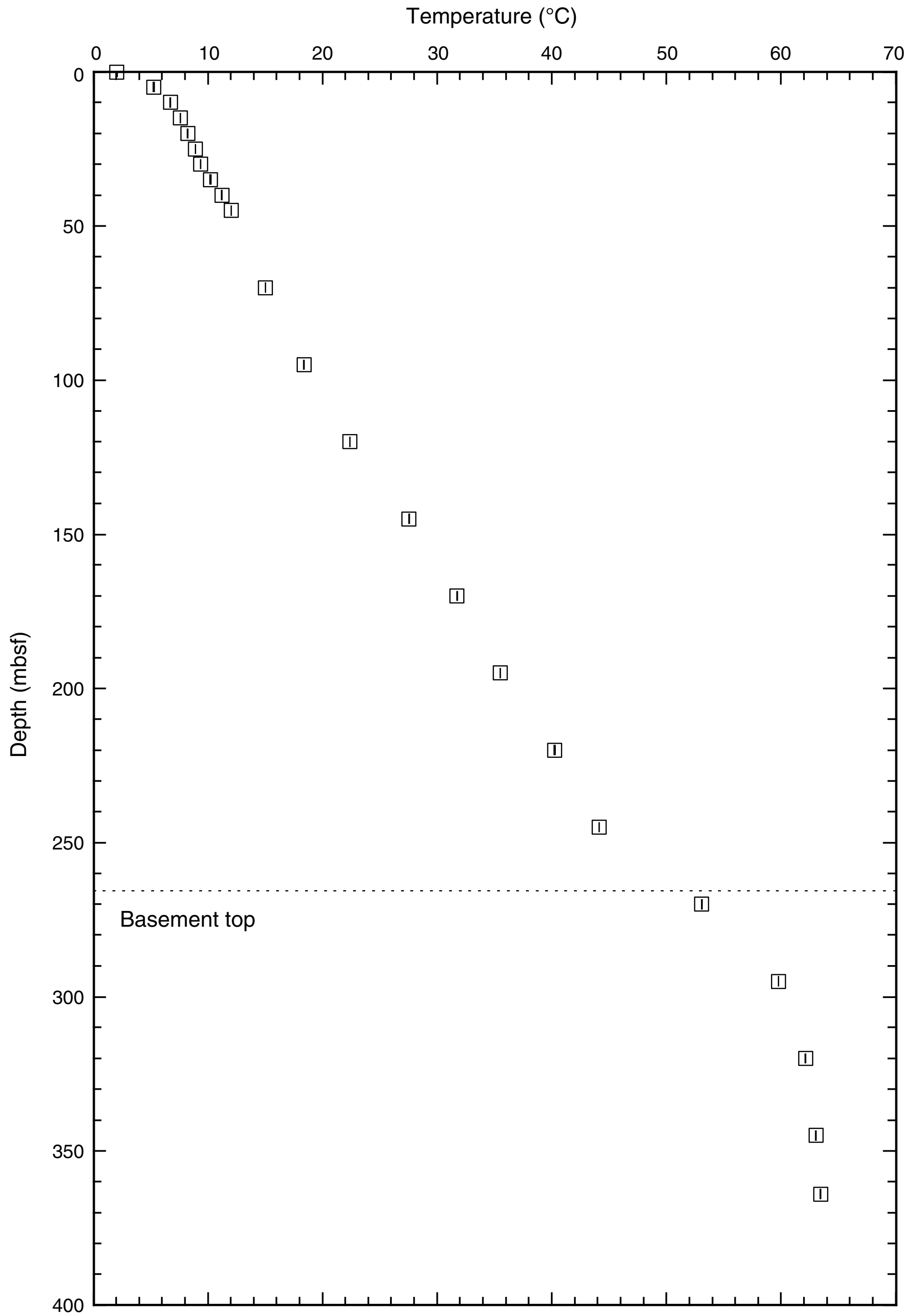

Figure F5. Plot of temperatures recorded by the Antares miniaturized temperature logger 1857-010 at 267.2 mbsf in Hole U1301B since Expedition 321T cementing operations.

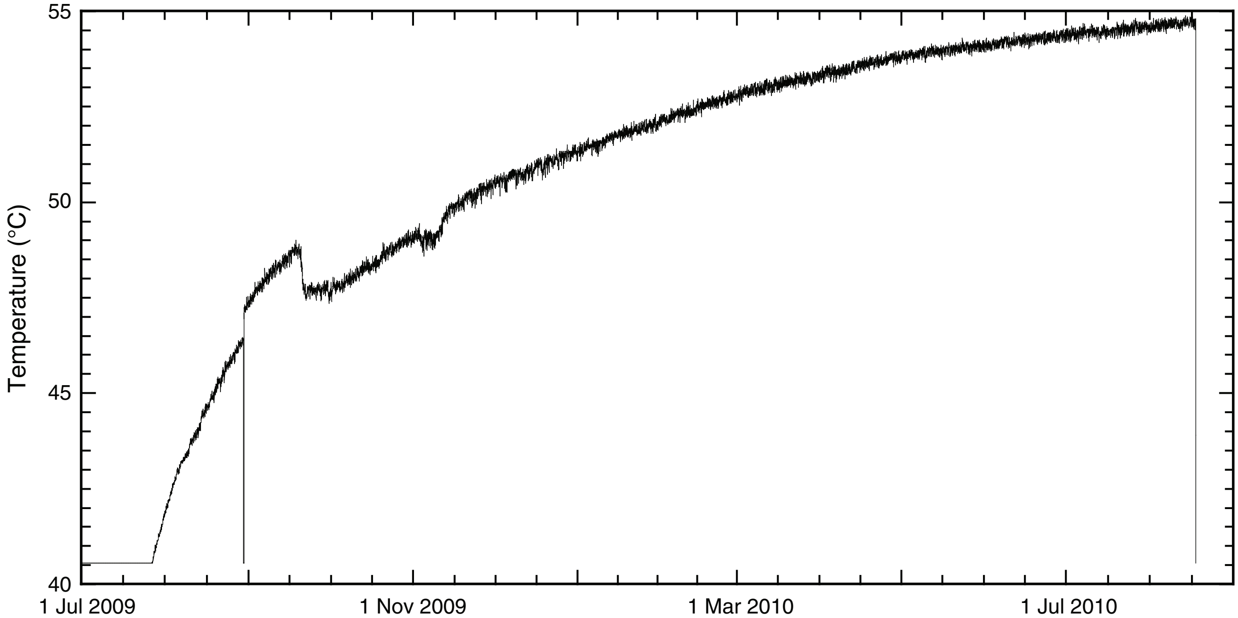

Table T1. Temperature loggers from the partially recovered sensor string originally installed in Hole U1301B during Expedition 301.

Manufacturer (serial number)	Depth (mbsf)	Logger/data status
Antares (1857010)	267.2	6 y record (Fig. F5)
Onset (768599)	291.7	No response
Onset (768600)	316.1	Insufficient battery to transfer data
Onset (768601)	340.6	Insufficient battery to transfer data
Antares (1857011)	364.0	No response

Table T2. Configuration of short replacement sensor string installed in Hole U1301B, Expedition 327. (**See table notes.**)

Manufacturer (serial number)	Position on Spectra cable (m)	Depth (mbsf)
Antares (1857029)	10	2.6
Antares (1857032)	20	12.8
Antares (1857033)	30	23.0

Notes: Lifting eyes are spliced in at 15 and 32 m from the top of the Spectra cable. A sinker bar (200 lb in water) is attached at the bottom of the Spectra cable (total string length = ~54 m).