

<https://doi.org/10.14379/iodp.proc.380.103.2018>



Site C0006¹

M. Kinoshita, K. Becker, S. Toczko, J. Edgington, T. Kimura, Y. Machida, A. Roesner, B. Senyener, and T. Sun²

Keywords: International Ocean Discovery Program, IODP, *Chikyu*, Expedition 380, Site C0006, accretionary prism, frontal thrust, prism toe, Shikoku Basin, Nankai Trough, borehole observatory, long-term borehole observatory, LTBMS, Nankai Trough Seismogenic Zone Experiment, NanTroSEIZE, Dense Oceanfloor Network System for Earthquakes and Tsunamis, DONET, tsunami, tsunamigenic fault

Introduction

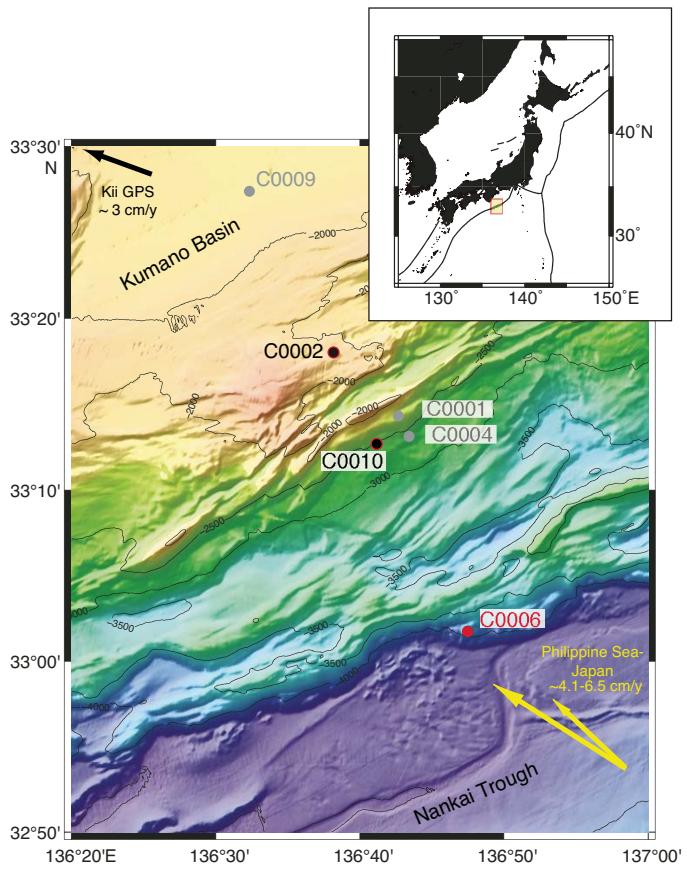
International Ocean Discovery Program (IODP) Expedition 380 returned to Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) Integrated Ocean Drilling Program Site C0006 in the toe of the Nankai accretionary prism ~2 km landward of the trench axis (Figures F1, F2, F3). The sole objective of Expedition 380 was the riserless installation of a long-term borehole monitoring system (LTBMS) in Hole C0006G to ~450 meters below seafloor (mbsf) in the hanging wall above the plate boundary fault. Site C0006 was logged and cored during two of the initial NanTroSEIZE expeditions, 314 (Expedition 314 Scientists, 2009) and 316 (Expedition 316 Scientists, 2009). The LTBMS was of the same general design as the borehole observatories previously installed in Integrated Ocean Drilling Program Hole C0010A farther up the accretionary prism (Kopf et al., 2017) and Integrated Ocean Drilling Program Hole C0002G at the southeastern edge of the Kumano Basin above the prism (Expedition 332 Scientists, 2011). The LTBMS observatories in Holes C0002G and C0010A are already connected to the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET) (<http://www.jamstec.go.jp/donet/e>), and the LTBMS in Hole C0006G was successfully connected in March 2018, shortly after Expedition 380. The transect of these three observatories should provide unprecedented resolution of the state of stress and strain in the leading edge of the overriding plate from the near-trench region to the seismogenic zone on a wide range of timescales, with near-real time data available to the scientific community.

The LTBMS in Hole C0006G shares the same general design as the two LTBMS systems previously installed in Holes C0002G and C0010A (see the [Expedition 380 methods](#) chapter [Kinoshita et al., 2018]). It includes an array of sensors designed to monitor slow crustal deformation (e.g., strain, tilt, and pore pressure as a proxy for strain), seismic events covering strong motion to very low frequency earthquakes, hydrologic transients associated with strain events, ambient pore pressure, and temperature. To ensure the long-term and continuous monitoring necessary to capture events

Contents

- 1** Introduction
- 4** Operations
- 10** LTBMS deployment
- 15** References

Figure F1. Site C0006 location. LTBMS Sites C0002 and C0010 are also shown. Inset shows region in relation to Japan. Black arrow = motion of Kii Peninsula determined from GPS measurements (Heki, 2007). Yellow arrows = computed far-field convergence vectors between the Philippine Sea plate and Japan (Seno et al., 1993; Miyazaki and Heki, 2001).



¹ Kinoshita, M., Becker, K., Toczko, S., Edgington, J., Kimura, T., Machida, Y., Roesner, A., Senyener, B., Sun, T., 2018. Site C0006. In Becker, K., Kinoshita, M., Toczko, S., and the Expedition 380 Scientists, *NanTroSEIZE Stage 3: Frontal Thrust Long-Term Borehole Monitoring System (LTBMS)*. *Proceedings of the International Ocean Discovery Program, 380*: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.380.103.2018>

² [Expedition 380 Scientists' affiliations](#).

Figure F2. Interpreted seismic cross section of Kumano transect offshore and southeast of Kii Peninsula (modified from Moore et al., 2009; after Strasser et al., 2014), with LTBMS Sites C0002, C0010, and C0006. NanTroSEIZE Sites C0013 and C0014 on the incoming Philippine Sea plate are not shown. VE = vertical exaggeration.

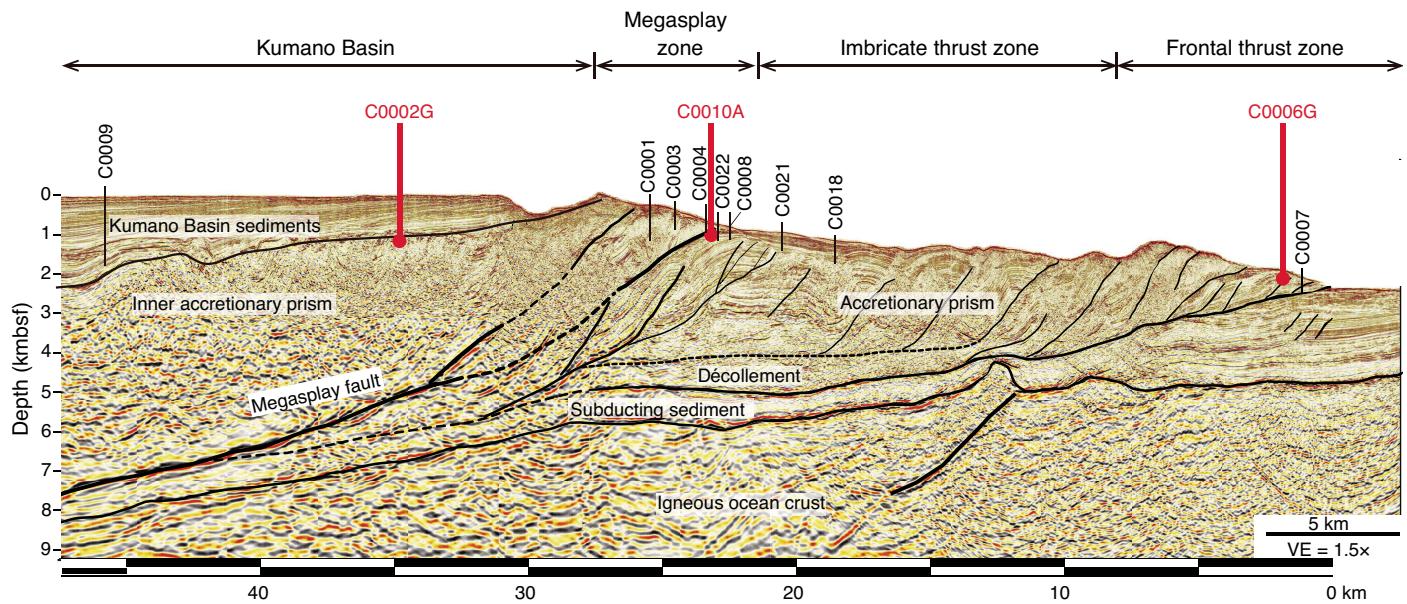
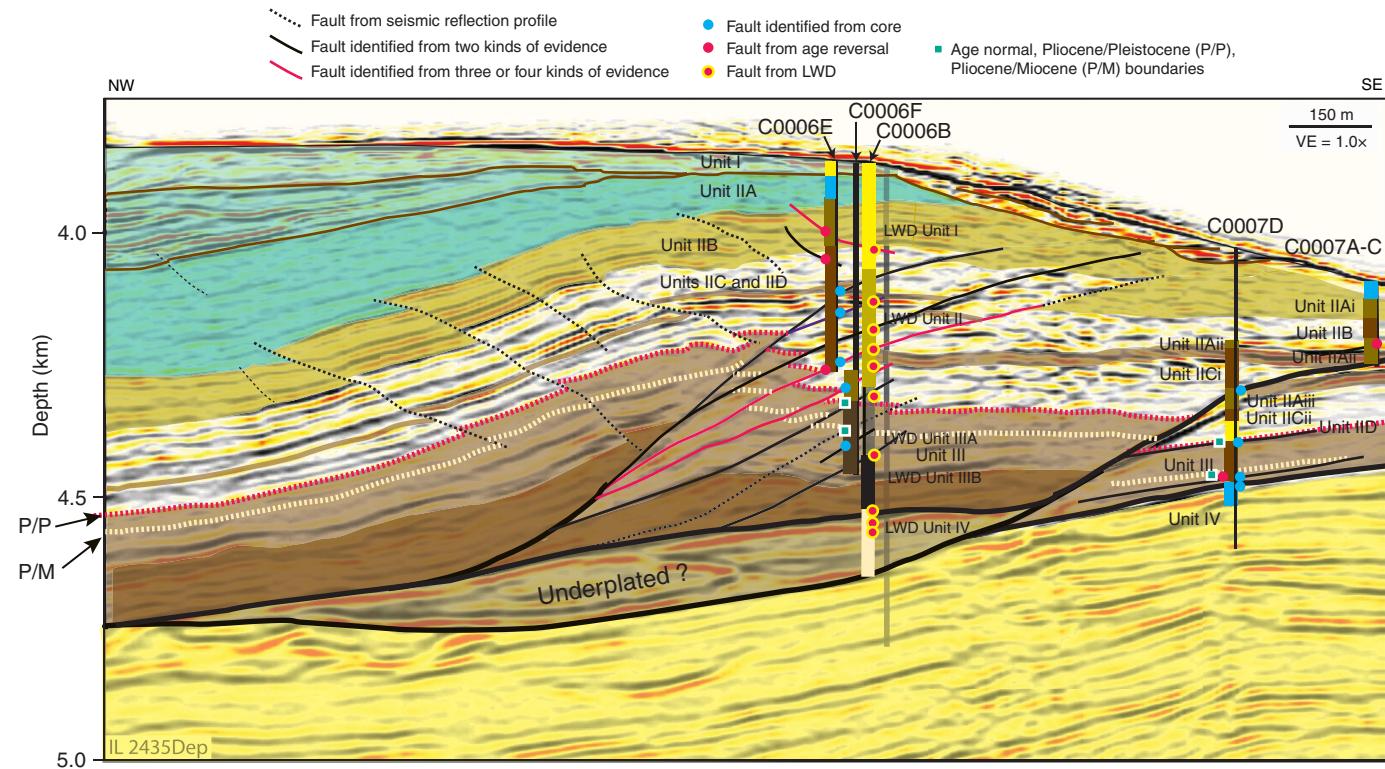


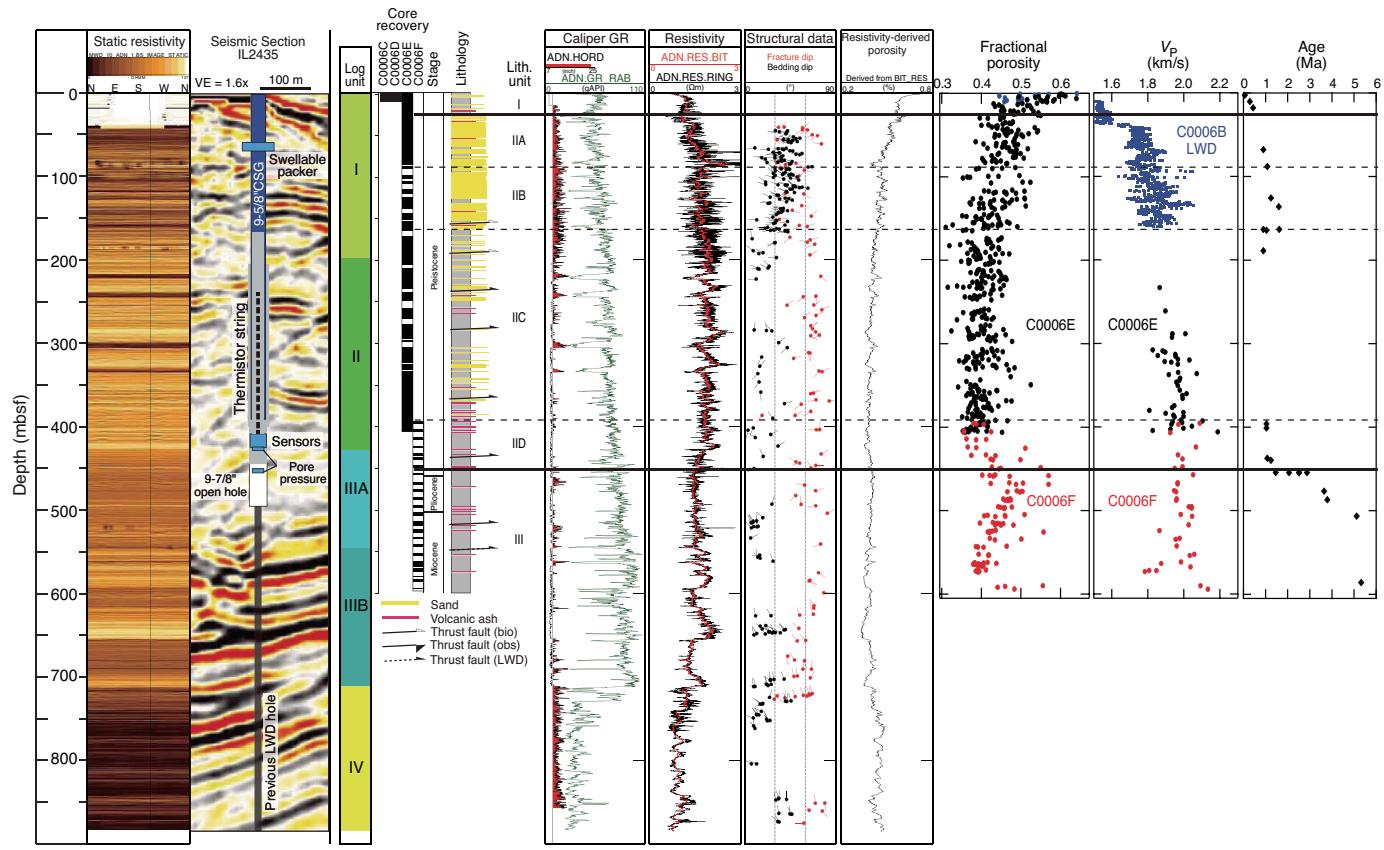
Figure F3. Interpreted seismic reflection depth section (Profile IL 2435Dep) around Sites C0006 and C0007 based on integrated interpretation of core and log data from the boreholes. Vertical gray line in the background indicates approved drilling location and penetration (1800 mbsf) approved by the IODP Environmental Protection and Safety Panel (EPSP) for Expedition 314 proposed Site NT1-03B (Site C0006).



that occur over a wide range of timescales, the borehole observatory was connected to DONET in March 2018 to provide power and allow for higher sampling rates than can be achieved in a standalone mode. The data from all three LTBMSs can be viewed and

downloaded at the J-SEIS open-access observatory data portal (<http://join-web.jamstec.go.jp/join-portal/en>). Data from the Site C0002 LTBMS can also be accessed at <http://offshore.geosc.psu.edu/about>.

Figure F4. Seismic section and logging and coring results used to determine configuration of the Expedition 380 LTBMS installation in Hole C0006G. GR = gamma ray, ADN = azimuthal density neutron tool, RAB = resistivity-at-the-bit tool.



Selection of LTBMS monitoring zones from previous results at Site C0006

Expedition 380 conducted no new coring or logging. Site C0006 was originally drilled during Expedition 314 with measurement while drilling (MWD) and then logging while drilling (LWD) to 885.5 mbsf in two holes ~30 m apart (Expedition 314 Scientists, 2009). Four holes were cored at this site during Expedition 316 to a maximum of 603 mbsf (Expedition 316 Scientists, 2009). The LTBMS design and operational plan for Expedition 380 were based on these previous results, especially the continuous logging profiles. Therefore, the new LTBMS Hole C0006G was positioned midway between the two Expedition 314 MWD/LWD Holes C0006A and C0006B.

From examination of the Site C0006 cores, Expedition 316 Scientists (2009) identified three primary lithologic units (Figure F4). Unit I extends from the seafloor to ~27 mbsf and comprises Pleistocene trench to slope transition facies. Unit II is composed of Pleistocene trench deposits divided into four subunits based mainly on variations in silt and sand content, with significant repetition of sequences caused by numerous thrust faults. It extends to ~407 mbsf in Hole C0006E and ~450 mbsf in Hole C0006F. Subunit IIA comprises mainly sand-dominated trench wedge deposits, Subunit IIB comprises mixed sand-mud trench wedge deposits, Subunit IIC comprises mud-dominated trench wedge deposits, and Subunit IID comprises deep-marine basin to mud-dominated trench transition

deposits. Unit III comprises late Miocene to Pleistocene deep-marine basin deposits.

Four primary logging units (Figure F4) were identified based on differing trends and LWD log responses (Expedition 314 Scientists, 2009). Logging Unit I (0–197.8 m LWD depth below seafloor [LSF]) was interpreted to be sandy and muddy deposits. Logging Unit II (197.8–428.3 m LSF) was interpreted to be mud with occasional thick sand layers. Logging Unit III (428.3–711.5 m LSF) was identified as alternating beds of mud and sand and is divided into two subunits. The boundary between Logging Units II and III might be a fault zone (Figure F4). Logging Unit IV (711.5 m LSF to total depth) was interpreted to be underthrust, coarse trench-fill sediments. The main frontal thrust was identified by a sudden decrease in gamma ray values (from ~90 to 20–50 gAPI) across the Logging Unit III/IV boundary.

Based on these results, the target zone for the main LTBMS instrument package (strainmeter/seismometer/tiltmeter/pressure sensor) was selected in the deepest part of Logging Unit II at ~410–425 mbsf (Figure F4). The formation in this interval was expected to be relatively competent mudstone suitable for monitoring formation pressure and deformation in the hanging wall at the frontal toe of the prism. With the main package at 410–425 mbsf, the LTBMS design also allowed for (1) a deeper pressure monitoring screen in the open hole near the boundary between Logging Units II and III and (2) placement of the thermistor cable from ~400 to 250 mbsf spanning much of Lithologic Subunit IIC.

Operations

Expedition 380 began in the port of Shimizu, Shizuoka Prefecture (Japan), on 12 January 2018. The first few days were spent quayside, loading cargo and supplies. The science party boarded the D/V *Chikyu* on 12 January and participated in the shipboard prespud meeting on 14 January. The *Chikyu* sailed from Shimizu at 0900 h (local time; UTC + 9 h) on 15 January and arrived on location at Site C0006 by 0300 h on 16 January.

Site C0006

Water depth: 3902 meters below rotary table (BRT); 3873.5 meters below mean sea level (MSL)

After arrival at Site C0006, four transponders were dropped (free fall) at the site. Making up and running the 20 inch casing began at 0845 h on 16 January 2018 (Table T1). The inner string bottom-hole assembly (BHA), composed of the jetting assembly and the drill-ahead tool (DAT) (Table T2), was made up and run into the casing at 2100 h. Make-up was paused for 1.5 h starting at 2300 h on 16 January to troubleshoot the closed-circuit TV (CCTV) camera system. Once resolved, the string and DAT were again lowered into the wellhead on the working cart in the moonpool from 0100 to 0230 h on 17 January. After picking up the casing with the internal BHA and confirming that the jetting BHA protruded 5 inches from the casing shoe, trouble with the CCTV halted all activities from 0400 to 0530 h. At 0530 h, the 20 inch casing was run to 3800 m BRT. Running stopped at 1815 h to install the underwater TV (UWTV) on the drill pipe. The UWTV was run down to 7 m above the 20 inch casing shoe by 2145 h. The vessel shifted to tag the seabed. At 2215 h, the Hole C0006G location and water depth (3900 m BRT; 3871.5 m MSL) were tagged and confirmed before jetting in.

Hole C0006G

Water depth: 3900 m BRT; 3871.5 m MSL

Jetting in for Hole C0006G commenced at 2215 h, reaching 3965 m BRT by 0345 h on 18 January. At this point, the UWTV was retrieved after confirming that the DAT was in good condition and before continuing to drill down. The UWTV reached the surface at 0700 h, and drilling down commenced. After performing a wiper trip from 399 to 457 mbsf, the hole was swept and spotted with saltwater gel. The drill string was picked up to 66 mbsf while the UWTV was run to 10 m above the wellhead. The DAT was recovered, and the UWTV was again recovered in the moonpool. The DAT BHA was pulled out of the hole to the surface and, once that was completed at 2300 h on 19 January, the 9% inch casing was made up and run. Once the casing reached 388 m BRT at 0745 h on 20 January, the casing hanger running tool (CHRT) was picked up and connected to the 9% inch casing hanger. The casing was run down and hung in the moonpool from the working cart while the CHRT was made up and attached to the top of the casing. Once the Activation Kit was charged, the casing, CHRT, and Activation Kit were all run down to 1410 m BRT by 1945 h. The UWTV was opened and set around the drill pipe and then run down to the Activation Kit so that the UWTV cameras could monitor the kit's pressure. The casing and CHRT were all run down to 3854 m BRT in preparation for reentering Hole C0006G. The wellhead was found, and the casing was run in at 0630 h on 21 January. Once the BHA reached 373 mbsf, the cement stand was made up and preparations for cementing began. Cementing the 9% inch casing began at 2200 h

on 21 January and was completed by 0145 h the next morning. Once the cementing was finished, the Activation Kit was unlocked from the casing hanger, the entire string was pulled out of the hole back to 4297 m BRT (397 mbsf), and the UWTV was recovered to the surface.

Once the UWTV was back on the working cart in the moonpool, the drill string was pulled out of the hole to prepare for running the bicenter bit BHA to drill out the cement and deepen the hole. The bit was made up and run in the hole at 1515 h on 22 January. By 0400 h on 23 January, the BHA reached 3853 m BRT. The drillers broke circulation in the string to run the UWTV for reentry in Hole C0006G. The UWTV reached 7 m above the bit at 0530 h, and reentry was completed by 0745 h. The UWTV was recovered in the moonpool at 0930 h. The BHA was run down to 4159 m BRT (259 mbsf) and then washed down to 4223.5 m BRT (323.5 mbsf) to begin drilling out cement. Several Hydrolift Power Swivel (HPS) stalls were observed. At 1445 h, drilling stopped, and the BHA was pulled out of the hole. The bicenter bit BHA was finally laid down at 0200 h on 24 January. The bicenter bit showed some damage, and after >3 h of drilling no appreciable advance was observed. Therefore, a drill-out-cement BHA was made up and run in the hole at 0200 h. The UWTV was lowered to 7 m above the bit, and both it and the bit were run down toward the seafloor. After the bit and the UWTV reached 3895 m BRT, the vessel was shifted to well center, and the Hole C0006G wellhead was reentered at 1400 h on 24 January. The UWTV was again recovered to the moonpool working cart before washing down to the top of cement at 325 mbsf. Drilling out the cement began again at 1715 h, and drilling and reaming continued to 409 mbsf. Five cubic meters (in two separate actions) of saltwater gel were used to sweep out the hole, which was ended by spotting another 5 m³ of saltwater gel. A wiper trip from 409 to 399 mbsf was followed by cleaning and sweeping out the 5 m³ of saltwater gel. The drill-out-cement BHA was pulled out of the hole to the surface and laid down at 0915 h on 25 January. The derrick stopped for HPS and traveling block maintenance while the vessel moved 1 nmi from well center, which was completed by 2145 h on 25 January.

The bicenter bit (Table T2) was made up and run to 3870 m BRT by 0830 h on 26 January. The UWTV was then run down to 7 m above the bit to help with wellhead reentry. After reentering at 1130 h, the bit was run to 407 mbsf. The bit was pulled back to 383 mbsf, and then there was a pause until 1530 h, by which time the UWTV was recovered in the moonpool. The bicenter bit BHA drilled to total depth (495 mbsf) by 2030 h, and the hole was swept twice with 10 m³ of saltwater gel and spotted with another 10 m³ of saltwater gel. A wiper trip to 393 mbsf was completed by 2145 h and showed no excessive drag, indicating that the hole was in good condition. Another sweep and spotting regimen was completed, and a special Protect Zone treatment by Schlumberger was put down at 2400 h on 26 January. Another sweep and spotting regimen was completed before pulling out of the hole and laying down the bicenter bit BHA at 1145 h on 27 January. A scraper run to confirm the casing section was uncontaminated by any cement was finished at 0830 h on 28 January. Once the scraper runs were complete, the remotely operated vehicle (ROV) platform was made up on the working cart in the moonpool in preparation for running with the UWTV. The UWTV with ROV platform began its run at 1330 h on 28 January; landing and confirmation of locking on the wellhead was visually confirmed by UWTV camera and slack off was checked. The two downward-looking cameras each have a light, and both lights failed. The remaining upward-looking camera and light were tilted downward to observe the ROV platform landing. The UWTV was recov-

ered to the surface at 1800 h. The scraper BHA was then pulled out of the hole, and it was laid down at 0200 h on 29 January.

LTBMS completion run preparation started on 29 January with assembling the bull nose, the miniscreen hydraulic port (Port 1), and the cement port on the 3.5 inch tubing backbone of the LTBMS observatory. At 1230 h on 29 January, the strainmeter and instrument carrier were run down to the moonpool cart and the completion guide roller (CGR) working platform on the blowout preventer (BOP) cart, where the sensors were connected to data and power cables. The hydraulic line from Port 1 was connected to a flatpack that was run all the way up to the LTBMS CORK head where the pressure-sensing unit (PSU) was installed. Cable attachments, tie bands, and metal straps were used to secure the hydraulic line to the strainmeter and instrument carrier. Once the strainmeter and other sensors reached the CGR and the sensor cables were attached, a communication test of each sensor cable was performed; all sensors were confirmed to be healthy by 1730 h. The assembly was run into the moonpool to 147 m BRT and then to 409 m BRT, pausing at each stage for another sensor check. At 1400 h on 30 January, the swellable packer was prepared to pass the sensor cables through passages cut into the packer. Preparation was finished at 1630 h, and the sensors were checked again. When this test was successfully completed, the tubing, sensor cables, and flatpack were all run into the moonpool to 448 m BRT, pausing for the final make up and running of the LTBMS CORK head to the rotating guide roller (RGR).

The LTBMS CORK head preparation began with terminating the hydraulic flatpack to the PSU valves and Swagelok hydraulic lines and was completed on 31 January at 0045 h. The three sensor cables were measured and prepared for cutting and then termination with underwater mateable connectors (UMCs) by the Teledyne ODI engineers. The cables were cut, and the connections to the sensors were checked and run into the termination van at 0430 h. ODI engineers then started the molding, soldering, and termination process. After the initial molding and soldering, a sensor communication test confirmed good communication and the termination proceeded. Termination was completed at 0015 h on 1 February, and another sensor communication check confirmed good connection through the UMCs to the sensors. The terminated sensor cables were moved to the BOP cart, and wrapping the sensor cables onto the LTBMS CORK cable bay began at 0100 h. After this was finished, another communication check confirmed that the strainmeter and tilt combo communications were good; the seismometer, however, could not receive any commands. Investigation and troubleshooting began at 0600 h. At 1500 h, the decision was made to cut the ODI connection. Checking sensor communication with the bare cable found that communication was good. Re-termination of the seismometer sensor cable with the only spare ODI UMC splice kit was completed at 0730 h on 2 February. Final sensor checks confirmed that communication with the seismometer was fully functional (sending commands and receiving correct responses). The reterminated cable was fixed to the cable bay of the LTBMS CORK,

and all UMCs were fixed to the acoustic modem bay. Once fixed, the connection to the acoustic modem for each sensor cable was completed, and then sensor checks through the acoustic modem were performed. These checks were completed at 1230 h, and the LTBMS CORK head was run into the moonpool for 5 min with all three-way pressure valves set to "OCEAN" so that remaining air could be bled out and the hydraulic lines could be filled with seawater. The LTBMS CORK head was then picked up, the two-way sampling valves were closed, and all valve handles were fixed in position with plastic tie wraps. The CORK head was set on the working cart so that the Activation Kit could be picked up and charged with N₂ and BOP fluid. These preparations were finished at 1930 h, and the casing (CSG) hanger, Activation Kit, and hydraulically activated running tool (HART) were run into the moonpool to 1400 m BRT. Running was paused to prepare the UWTV for diving, so the scientists performed another sensor check with the acoustic modem. At 0115 h on 3 February, the UWTV reached the Activation Kit and checked to see that the pressure charger was maintaining pressure. Once the pressure was visually confirmed by the UWTV cameras, running the CSG hanger and UWTV continued to 2000 m BRT, where the Activation Kit pressure was checked again. The check was completed at 0400 h, and the CSG hanger was run to 3880 m BRT, near the seafloor, and was paused to let the UWTV catch up. During this pause, scientists took the opportunity to check the sensors before reentering Hole C0006G; all sensors remained healthy. When the UWTV reached the Activation Kit, a circulation test was run; a small leak was discovered in the strainmeter assemblage, possibly from an imperfect or cracked weld on the cement bypass conduit. After discussion among the offshore superintendent (OSI), offshore installation manager (OIM), and Co-Chief scientists, it was decided that this leak would not impact cementing.

The wellhead was reentered at 0930 h on 3 February, and the LTBMS assembly was slowly run into the wellhead; the LTBMS CORK head landed at 1615 h. Postlanding cementing commenced after a final communication and health check with the sensors to confirm that none of them had been affected by reentering. All sensors were healthy. At 2100 h, the UWTV sent the release command by acoustic modem to the Activation Kit. Neither this command nor a following command activated the release mechanism, so mechanical release was attempted by running the UWTV guide funnel over the Activation Kit trigger pins. Between 2100 h on 3 February and 0645 h on 5 February, multiple attempts at triggering the manual release failed. Release was finally activated at 0645 h on 5 February after 2 modifications to the UWTV guide funnel and 14 passes of the UWTV guide funnel past the Activation Kit pins.

The drill string was cleaned, pulled out of the hole, and laid down, and moonpool equipment was secured in preparation for sailing back to Shimizu. The *Chikyu* arrived offshore of Shimizu and anchored at 1630 h on 6 February. At 0900 h on 7 February, the pilot boarded and guided the vessel to quayside. At 1030 h the gangplank was lowered, and the expedition scientists disembarked.

Table T1. Operations log, Expedition 380. Local ship time = UTC + 9 h. CSG = casing, BHA = bottom-hole assembly, CCTV = closed-circuit TV, DAT = drill-ahead tool, BRT = below rotary table, RGR = rotating guide roller, UWTV = underwater TV, SWG = saltwater gel, POOH = pull out of hole, CHRT = casing hanger running tool, RTS = rail transport system, SST = subsea tool, RIH = run in hole, CMTG = cementing, MSL = below mean sea level, ROP = rate of penetration, HPS = Hydrolift Power Swivel, OP = overpull, BOP = blowout preventer, SO = slack off, DOC = drill out cement, ROV = remotely operated vehicle, LTBMIS = long-term borehole monitoring system, HART = hydraulically activated running tool, TBG = tubing, CGR = completion guide roller, (Continued on next three pages.)

[Download table in CSV format.](#)

Operation	Date (2018)	Local ship time (h)		Notes	Total operation time (h)	Cumulative (h)	Days
		Start	Finish				
Science party boards D/V <i>Chikyu</i> at Shimizu harbor	12–15 Jan	0000	0900		81.00	81.00	3.38
<i>Chikyu</i> sails from Shimizu to Site C0006	15 Jan	0900	0000		15.00	96.00	4.00
Arrive at Site C0006	16 Jan	0000	0300		3.00	99.00	
Deploy 4 transponders by free fall	16 Jan	0300	0845		5.75	104.75	
Make up and run 20 inch CSG	16 Jan	0845	2100	Mark CSG yellow 2 m from CSG shoe and white every 1 m above	12.25	117.00	
Make up and run 12-1/4 inch inner string BHA	16 Jan	2100	2330		2.50	119.50	
Troubleshoot CCTV server failure	16 Jan	2330	0000		0.50	120.00	5.00
Troubleshoot CCTV server failure (continued)	17 Jan	0000	0100		1.00	121.00	
Lower string and attach DAT to wellhead	17 Jan	0100	0230	On working cart; confirm sliding sleeve locked at 1500 psi	1.50	122.50	
Pick up 20 inch CSG and confirm jetting BHA to protrude 5 inches from CSG shoe	17 Jan	0230	0400		1.50	124.00	
Troubleshoot CCTV server failure	17 Jan	0400	0530		1.50	125.50	
Continue to run 20 inch CSG to 3800 m BRT	17 Jan	0530	1815		12.75	138.25	
Open RGR door and install UWTV on drill pipe	17 Jan	1815	1930		1.25	139.50	
Run UWTV to 7 m above 20 inch CSG shoe	17 Jan	1930	2145	Paint 50 and 100 m marks on UWTV cable	2.25	141.75	
Adjust vessel position and tag on seabed	17 Jan	2145	2215	Confirm water depth: 3900 m BRT (3871.5 m MSL)	0.50	142.25	
Jet CSG 3900–3932 m BRT (0–32 mbsf)	17 Jan	2215	0000		1.75	144.00	6.00
Continue running 20 inch CSG 3930–3954 m BRT (30–54 mbsf)	18 Jan	0000	0315	Wellhead stickout from seafloor = 6 m	3.25	147.25	
Drill down 3954–3965 m BRT (54–65 mbsf)	18 Jan	0315	0345	Wash down to 65 mbsf, pump 250–400 gal/min × 4.5–7.3 MPa	0.50	147.75	
Retrieve UWTV to surface	18 Jan	0345	0700	Confirm DAT body condition w/NuStar; slow pumping w/75 gal/min during retrieval	3.25	151.00	
Drill down 3965–4299 m BRT (65–399 mbsf)	18 Jan	0700	2300		16.00	167.00	
Sweep out 10 m ³ SWG ×2; spot 12 m ³ SWG	18 Jan	2300	2345	Sweep 5 m ³ SWG every stand; average ROP = 27.1 m/h	0.75	167.75	
Wiper trip 4299–4261 m BRT (399–361 mbsf)	18 Jan	2345	0000	Observe excess drag at 4296 m BRT (160 kN) and 4295 m BRT (200 kN)	0.25	168.00	7.00
Continue wiper trip 4261–3957 m BRT (361–57 mbsf)	19 Jan	0000	0215	4 m below 20 inch CSG shoe	2.25	170.25	
Sweep 10 m ³ SWG ×2; spot 12 m ³ SWG	19 Jan	0225	0315	HPS at 10 rpm × 0.8 kNm	0.83	171.08	
Pick up string to 3966 m BRT (66 mbsf)	19 Jan	0315	0400	No excess drag (4298–3966 m BRT)	0.75	171.83	
Run UWTV to 10 m above wellhead	19 Jan	0400	0700		3.00	174.83	
Recover DAT from wellhead	19 Jan	0700	0815	No damage to DAT; DAT did not release until 120 kNm OP w/400 gal/min × 3 MPa (multiple attempts)	1.25	176.08	
Recover UWTV to surface	19 Jan	0815	1000		1.75	177.83	
POOH to surface	19 Jan	1000	2300	Bit in gauge	13.00	190.83	
Make up/run 9-5/8 inch CSG	19 Jan	2300	0000		1.00	191.83	8.00
Continue to make up/run 9-5/8 inch CSG to 388 m BRT	20 Jan	0000	0745	Fill w/seawater every 10 joints	7.75	199.58	
Pick up CHRT for handling; connect to 9-5/8 inch CSG hanger on RTS	20 Jan	0745	0915		1.50	201.08	
Lower 9-5/8 inch CSG to moonpool and secure on working cart	20 Jan	0915	1000		0.75	201.83	
Release CHRT at working cart and pick up to rotary table and lay out	20 Jan	1000	1045		0.75	202.58	
Lower SST and stab into 9-5/8 inch CSG and secure to CSG hanger	20 Jan	1045	1115		0.50	203.08	
Pick up and run Activation Kit w/CHRT to SSTs/ACME thread and 9-5/8 inch CSG hanger	20 Jan	1115	1330		2.25	205.33	
Charge Activation Kit accumulators	20 Jan	1330	1645	Charge w/7000 psi N ₂ and 10,000 psi BOP fluid	3.25	208.58	
Run 9-5/8 inch CSG to 1410 m BRT	20 Jan	1645	1945	Fill every 10 stands	3.00	211.58	
Run UWTV to Activation Kit for pressure monitoring	20 Jan	1945	2215		2.50	214.08	
Run 9-5/8 inch CSG and UWTV to 2020 m BRT	20 Jan	2215	0000		1.75	215.83	9.00
Continue running 9-5/8 inch CSG w/UWTV to 3854 m BRT	21 Jan	0000	0630	Fill every 10 stands	6.50	222.33	
Reenter Hole C0006G	22 Jan	0630	1000	Adjust vessel position, finding holes drilled during previous Expeditions 314 and 316	3.50	225.83	
RIH 9-5/8 inch CSG to 4273 m BRT (373 mbsf)	23 Jan	1000	1130		1.50	227.33	
Pick up and make up cement stand and adjust Activation Kit so UWTV can view pressure gauges	24 Jan	1130	1145	Confirm accumulator pressure and unlock pressures at 4275.5 m BRT	0.25	227.58	
Land 9-5/8 inch CSG hanger on wellhead	25 Jan	1145	1545	Observed wellhead sinking by 2 m while applying 120 kNm SO weight; wellhead sank by 1 m more while applying 200 kNm SO weight; after 15 min no more sinking observed; applied 230 kNm SO weight for 5 min, no more sinking	4.00	231.58	
Troubleshoot CMTG line leakage 9-5/8 inch CSG CMTG	26 Jan	1545	2200		6.25	237.83	
	27 Jan	2200	0000		2.00	239.83	10.00

Table T1 (continued). (Continued on next page.)

Operation	Date (2018)	Local ship time (h)			Notes	Total operation time (h)	Cumulative (h)	Days
		Start	Finish					
Continue 9-5/8 inch CMTG	22 Jan	0000	0145		Observe top and bottom plug released by pressure drop	1.75	241.58	
Unlock CHRT from 9-5/8 inch CSG hanger by acoustic command from Activation Kit	22 Jan	0145	0215		SO 226 kN and send acoustic signal to release	0.50	242.08	
POOH to 4297 m BRT	22 Jan	0215	0300		Pick up string to clear SST from well head	0.75	242.83	
Break string circulation	22 Jan	0300	0330		Volume w/600 gal/min × 5.0 MPa	0.50	243.33	
Recover UWTV to surface	22 Jan	0330	0430			1.00	244.33	
POOH to surface	22 Jan	0430	1515			10.75	255.08	
Make up and run 8-1/2 inch × 9-7/8 inch bicenter bit BHA to 3870 m BRT	22 Jan	1515	0000		Conduct motor shallow test w/200 gal/min × 0.4 MPa	8.75	263.83	11.00
Make up and run 8-1/2 inch × 9-7/8 inch bicenter bit BHA to 3853 m BRT	23 Jan	0000	0400			4.00	267.83	
Break string circulation	23 Jan	0400	0430		Volume 400 gal/min × 6.2 MPa	0.50	268.33	
Run UWTV to 7 m above bit	23 Jan	0430	0530			1.00	269.33	
Lower bit w/UWTV to 3857 m BRT	23 Jan	0530	0600			0.50	269.83	
Reenter Hole C0006G	23 Jan	0600	0745		RIH to 3924 m BRT and stand by for recovering UWTV	1.75	271.58	
Recover UWTV	23 Jan	0745	0930			1.75	273.33	
RIH to 4159 m BRT (259 mbsf)	23 Jan	0930	1030			1.00	274.33	
Wash down 4159–4223.5 m BRT (259–323.5 mbsf)	23 Jan	1030	1130		Tag top of cement at 4207 m BRT (307 mbsf); tag float collar at 4223.5 m BRT (323.5 mbsf)	1.00	275.33	
DOC 4223.5–4225.5 m BRT (323.5–325.5 mbsf)	23 Jan	1130	1445		Stall HPS at 4225.5 m BRT (325.5 mbsf) repeatedly with no progress	3.25	278.58	
POOH 8-1/2 inch × 9-7/8 inch bicenter bit with motor BHA	23 Jan	1445	0000			9.25	287.83	
Continue POOH 8-1/2 inch × 9-7/8 inch bicenter bit w/motor BHA	24 Jan	0000	0200			2.00	289.83	12.00
Make up and RIH 8-1/2 inch DOC BHA	24 Jan	0200	1015		Fill every 15 stands	8.25	298.08	
Run UWTV to 7 m above bit	24 Jan	1015	1245		Shift RGR to aft and working cart to well center	2.50	300.58	
Lower bit w/UWTV to 3895 m BRT	24 Jan	1245	1315			0.50	301.08	
Reenter Hole C0006G	24 Jan	1315	1400		RIH to 3917.5 m BRT (17.5 mbsf) before recovering UWTV	0.75	301.83	
Recover UWTV to surface	24 Jan	1400	1515			1.25	303.08	
RIH to 4182 m BRT (282 mbsf)	24 Jan	1515	1615			1.00	304.08	
Wash down 4182–4225 m BRT (282–325 mbsf)	24 Jan	1615	1715		Tag top of cement at 4225 m BRT (325 mbsf)	1.00	305.08	
DOC 4225–4291 m BRT (325–391 mbsf)	24 Jan	1715	2115		Sweep out 5 m ³ SWG ×4	4.00	309.08	
Ream down 4291–4299 m BRT (325–399 mbsf)	24 Jan	2115	2145			0.50	309.58	
Drill down 4299–4309 m BRT (399–409 mbsf)	24 Jan	2145	2215		Average ROP = 19.4 m/h	0.50	310.08	
Sweep out 5 m ³ SWG ×2; spot 5 m ³ SWG	24 Jan	2215	2230			0.25	310.33	
Wiper trip 4309–4299 m BRT (409–399 mbsf)	24 Jan	2230	2245		No observed excess drag 4309–4299 m BRT (409–399 mbsf)	0.25	310.58	
Clean and sweep out 5 m ³ SWG	24 Jan	2245	2300			0.25	310.83	
Drop Churchill drift	24 Jan	2300	2330		Chase w/400 gal/min and rotate at 40 rpm; spot 5 m ³ SWG	0.50	311.33	
POOH 8-1/2 inch DOC BHA	24 Jan	2330	0000			0.50	311.83	13.00
Continue POOH 8-1/2 inch DOC BHA to surface	25 Jan	0000	0915		Confirm Churchill drift landed on Churchill drift catcher sub	9.25	321.08	
Lay down DeepSea EXPRESS cement head and rig up Hybrid plug container cement head stand	25 Jan	0915	1430		Move vessel 1 nmi from well center	5.25	326.33	
Slip and cut drilling line	25 Jan	1430	2145		Service HPS and traveling block	7.25	333.58	
Make up and run 8-1/2 inch × 9-7/8 inch bicenter bit BHA to 3870 m BRT	25 Jan	2145	0000		Paint bit and sub yellow; mark every 1 m from bit to 10 m and at 50 and 100 m	2.25	335.83	14.00
Continue to make up/run 8-1/2 inch × 9-7/8 inch bicenter bit with motor BHA to 3870 m BRT	26 Jan	0000	0830		Fill every 15 stands	8.50	344.33	
Run UWTV to 7 m above bit	26 Jan	0830	1000			1.50	345.83	
Lower bit w/UWTV to 3895 m BRT	26 Jan	1000	1015			0.25	346.08	
Reenter Hole C0006G	26 Jan	1015	1130			1.25	347.33	
RIH to 4307 m BRT (407 mbsf)	26 Jan	1130	1330		No observed excess drag 4223–4307 m BRT (323–407 mbsf)	2.00	349.33	
Pick up BHA from 4307 to 4283 m BRT (407–383 mbsf) to retrieve UWTV	26 Jan	1330	1345			0.25	349.58	
Recover UWTV on surface	26 Jan	1345	1530			1.75	351.33	
Drill down to 4395 m BRT (495 mbsf)	26 Jan	1530	2030			5.00	356.33	
Sweep hole with 5 m ³ Hi-vis ×2; spot 10 m ³ Hi-vis	26 Jan	2030	2045		Pump 600 gal/min × 11 MPa; HPS 30 rpm × 0.16 kNm	0.25	356.58	
Wiper trip 4395.0–4293.0 m BRT (495–393 mbsf)	26 Jan	2045	2145		No observed excessive drag; hole condition good	1.00	357.58	
Circulate and reciprocate drill string	26 Jan	2145	2345		HPS 5 rpm × 0–1.5 kNm; pump 200 gal/min × 1.1 MPa	2.00	359.58	
Spot Protect Zone by Schlumberger cement unit	26 Jan	2345	0000		Mix and pump 6.8 bbl liner gel; pump 33.2 bbl Protect Zone	0.25	359.83	15.00
Continue to spot Protect Zone	27 Jan	0000	0115		Pump 1.0 bbl liner gel; pump 294.1 bbl seawater; return = 4.0 bbl	1.25	361.08	
Pull up string to 4328 m BRT (428 mbsf)	27 Jan	0115	0145			0.50	361.58	
Sweep out 10 m ³ SWG; spot 10 m ³ SWG	27 Jan	0145	0230		400 gal/min × 4.5 MPa	0.75	362.33	
POOH to surface	27 Jan	0230	1145		Lay out jar, mud motor, float sub, and bicenter bit	9.25	371.58	
Service HPS	27 Jan	1145	1230			0.75	372.33	
Pick up and make up hybrid cement stand and rack back	27 Jan	1230	1530			3.00	375.33	
Make up and run 9-5/8 inch scraper BHA to 3818 m BRT	27 Jan	1530	0000		Paint bit and sub yellow; paint every 1 m from bit to 10 m and at 50 and 100 m	8.50	383.83	16.00
Continue to make up/run 9-5/8 inch scraper BHA to 3870 m BRT	28 Jan	0000	0015			0.25	384.08	

Table T1 (continued). (Continued on next page.)

Operation	Date (2018)	Local ship time (h)			Notes	Total operation time (h)	Cumulative (h)	Days
		Start	Finish					
Run UWTV to 7 m above bit	28 Jan	0015	0215			2.00	386.08	
Lower bit w/UWTV to 3895 m BRT	28 Jan	0215	0400	Adjust vessel to well center		1.75	387.83	
Reenter Hole C0006G and RIH w/CSG scraper to 4189 m BRT (289 mbsf)	28 Jan	0400	0500			1.00	388.83	
Recover UWTV to surface	28 Jan	0500	0730	Sweep out 5 m ³ SWG; spot 10 m ³ SWG		2.50	391.33	
Scrape 9-5/8 inch CSG 3980–3960 m BRT (80–60 mbsf; swellable packer set depth)	28 Jan	0730	0830	Conduct UWTV postdive checks		1.00	392.33	
Install releaser for ROV platform on UWTV and confirm payload #2	28 Jan	0830	0945	Check releaser resistance		1.25	393.58	
Assemble ROV platform on working cart	28 Jan	0945	1215	Install sensor cables and flatpack on spoolers on forward pipe rack		2.50	396.08	
Pick up UWTV and connect 3 ropes to ROV platform	28 Jan	1215	1330			1.25	397.33	
Run UWTV w/ROV platform	28 Jan	1330	1615	Observe UWTV light malfunction for camera #1; other light OK; confirm ROV platform landing by UWTV and check SO; activate releaser and UWTV pull up to confirm all ropes released w/o OP		2.75	400.08	
Recover UWTV on surface	28 Jan	1615	1800			1.75	401.83	
POOH 9-5/8 inch scraper BHA to 873 m BRT	28 Jan	1800	0000			6.00	407.83	17.00
Continue POOH 9-5/8 inch scraper BHA to surface	29 Jan	0000	0200	Make up bullnose, circulation sub, and float collar w/3-1/2 inch TBG		2.00	409.83	
Prepare LTBMS completion running	29 Jan	0200	0530	Arrange moonpool carts and CGR and RGR for completion sensor cable and flatpack running		3.50	413.33	
Run LTBMS completion to 61 m BRT	29 Jan	0530	1230	Install miniscreens above bullnose; strainmeter health check on middle pipe rack.		7.00	420.33	
Install sensor cables on each sensor in moonpool	29 Jan	1230	1530	Strainmeter, seismometer, tiltmeter/combo, and thermistor		3.00	423.33	
#1 sensor health check	29 Jan	1530	1730	Confirm all sensors still healthy		2.00	425.33	
Continue to run LTBMS to 147 m BRT	29 Jan	1730	0000			6.50	431.83	18.00
Continue to run LTBMS to 147 m BRT	30 Jan	0000	0030			0.50	432.33	
#2 sensor health check	30 Jan	0030	0215	Confirm all sensors healthy at ~100 m MSL		1.75	434.08	
Resume running LTBMS to 409 m BRT	30 Jan	0215	1330	Apply tie wraps and stainless steel bands to flatpack and sensor cables to 3-1/2 inch TBG		11.25	445.33	
#3 sensor health check	30 Jan	1330	1400	Confirm all sensors still healthy		0.50	445.83	
Cable installation through swellable packer	30 Jan	1400	1630			2.50	448.33	
#4 sensor health check	30 Jan	1630	1715	Confirm all sensors healthy after passing cables through swellable packer		0.75	449.08	
Resume running LTBMS to 448 m BRT	30 Jan	1715	2000			2.75	451.83	
Make up and run LTBMS CORK head to moonpool	30 Jan	2000	2300			3.00	454.83	
Set flatpack termination on LTBMS CORK head	30 Jan	2300	0000	Flatpack set so side with printing AGAINST TBG; first hydraulic line to miniscreens on LEFT side, looking AT flatpack against TBG; hydraulic line to strainmeter on RIGHT side, looking AT flatpack		1.00	455.83	19.00
Continue flatpack termination on the LTBMS CORK head	31 Jan	0000	0045	#5 sensor health check; all sensors GOOD		0.75	456.58	
Measure the sensor cable (3 each) for cutting and termination preparation	31 Jan	0045	0430	SO and cut sensor cables 11 m above bottom of CORK cable bay; shift BOP cart and termination container to facilitate termination		3.75	460.33	
Terminate sensor cables by Teledyne ODI engineers	31 Jan	0430	0000	Perform sensor cable splice and curing. #6 sensor check: all GOOD.		19.50	479.83	20.00
Continue sensor cable termination	1 Feb	0000	0015			0.25	480.08	
#7 Sensor check: all GOOD	1 Feb	0015	0100			0.75	480.83	
Install terminated sensor cables on LTBMS CORK head	1 Feb	0100	0515			4.25	485.08	
#8 Sensor check: one cable FAIL	1 Feb	0515	0600	Strainmeter and tiltcombo sensor cable communication GOOD; seismometer cable communication: uplink OK; downlink commands NOGO		0.75	485.83	
Investigate sensor cable failure	1 Feb	0600	1500	Repeated tests of seismometer sensor cable repeat FAIL. Resolve by cutting Teledyne ODI connector and testing bare sensor cable: communication GOOD.		9.00	494.83	
Retetermination of seismometer sensor cable by Teledyne ODI engineers	1 Feb	1500	0000	Initial sensor check: GOOD		9.00	503.83	21.00
Continue retetermination	2 Feb	0000	0730	Two sensor communication checks (#9 and #10): GOOD		7.50	511.33	
Install reteterminated Teledyne ODI sensor cable on LTBMS CORK cable bay	2 Feb	0730	0915			1.75	513.08	
#11 sensor check: reteterminated cable GOOD	2 Feb	0915	1230	All Teledyne ODI connections hooked to acoustic modem and tested: GOOD		3.25	516.33	
Run and secure LTBMS CORK head on wellhead support frame on working cart	2 Feb	1230	1415	CORK head run into moonpool and hydraulic lines filled with seawater; picked up and moved to working cart		1.75	518.08	
Retrieve HART handling tool	2 Feb	1415	1530			1.25	519.33	
Pick up and run Activation Kit w/HART	2 Feb	1530	1700	HART activated and 2 shear pins installed by NuStar		1.50	520.83	
Charge Activation Kit accumulators	2 Feb	1700	1930	Charge N ₂ : 7200 psi; function fluid: 10,000 psi		2.50	523.33	
Run LTBMS completion assembly w/Activation Kit to 1400 m BRT	2 Feb	1930	2245	Fill every 10 stands with seawater; #1 water column sensor test: GOOD		3.25	526.58	

Table T1 (continued).

Operation	Date (2018)	Local ship time (h)			Notes	Total operation time (h)	Cumulative (h)	Days
		Start	Finish					
Run UWTV	2 Feb	2245	0000			1.25	527.83	22.00
Continue to run UWTV w/Activation Kit	3 Feb	0000	0115	Accumulator pressure (acoustic) 8500 psi; (mechanical) 8500 psi		1.25	529.08	
Run LTBMS completion assembly w/Activation Kit to 2400 m BRT	3 Feb	0115	0345	Fill every 10 stands with seawater		2.50	531.58	
Run UWTV to Activation Kit at ~2000 m BRT	3 Feb	0345	0400	Confirm accumulator pressure		0.25	531.83	
Run LTBMS completion assembly w/Activation Kit to 3880 m BRT	3 Feb	0400	0800	Fill every 10 stands with seawater; #2 water column sensor test: GOOD		4.00	535.83	
Run UWTV to 3873 m BRT	3 Feb	0800	0930	Break circulation 350 gal/min × 6.64 MPa; observe leak between instrument carrier and strainmeter		1.50	537.33	
Reenter Hole C0006G and run LTBMS CORK completion to 4357 m BRT (457 mbsf)	3 Feb	0930	1600			6.50	543.83	
Land LTBMS CORK head on wellhead	3 Feb	1600	1615			0.25	544.08	
Postlanding sensor communication test: GOOD	3 Feb	1615	1645			0.50	544.58	
Cement LTBMS CORK completion string assembly	3 Feb	1645	2100			4.25	548.83	
Release HART from LTBMS CORK head by acoustic release of Activation Kit	3 Feb	2100	2215	SO 60 kN and send #1 signal to Activation Kit from UWTV; NO release; send #2 signal to Activation Kit from UWTV; NO release; attempt mechanical release by UWTV, indicator did NOT shift; NO release		1.25	550.08	
Pick up UWTV to surface and tighten UWTV sleeve for mechanical release attempt	3 Feb	2215	0000			1.75	551.83	23.00
Continue retightening UWTV guide funnel for mechanical release attempt	4 Feb	0000	0100			1.00	552.83	
Run UWTV to Activation Kit	4 Feb	0100	0215			1.25	554.08	
Attempt to release HART by mechanical release by Activation Kit	4 Feb	0215	0330	Several passes by the UWTV over the mechanical releases and increase in tension on UWTV observed; no release		1.25	555.33	
Recover UWTV to surface to cock guide funnel	4 Feb	0330	0400	Guide funnel tilted to apply greater pressure to mechanical release.		0.50	555.83	
Run UWTV to Activation Kit	4 Feb	0400	0515			1.25	557.08	
Attempt to release HART by mechanical release by Activation Kit	4 Feb	0515	0630	Several passes by the UWTV over the mechanical releases and increase in tension on UWTV observed; changed vessel heading to 110° port while rotating string 90° clockwise; no release		1.25	558.33	
Recover UWTV to surface to modify guide funnel	4 Feb	0630	1015	Applied rubber sheeting (5 mm) to inside of guide funnel to decrease inner diameter of guide funnel on mechanical release.		3.75	562.08	
Run UWTV to Activation Kit	4 Feb	1015	1130			1.25	563.33	
Attempt to release HART by mechanical release by Activation Kit	4 Feb	1130	1200	Several passes by the UWTV over the mechanical releases and increase in tension on UWTV observed; no release		0.50	563.83	
Recover UWTV to surface to change modifications to guide funnel	4 Feb	1200	2000	Welded metal plates (12 mm) to inside of guide funnel after removing rubber sheeting		8.00	571.83	
Run UWTV to Activation Kit	4 Feb	2000	2145			1.75	573.58	
Attempt to release HART by mechanical release by Activation Kit	4 Feb	2145	2230	UWTV could not pass Activation Kit pins; taper ~45°		0.75	574.33	
Arrange cement head for wireline job	4 Feb	2230	2345			1.25	575.58	
Recover UWTV to surface	4 Feb	2345	0000			1.25	576.83	
Continue recovering UWTV to surface	5 Feb	0000	0415	Recover UWTV and modify guide funnel 12 mm plate taper to ~30°		4.25	581.08	24.00
Run UWTV to Activation Kit	5 Feb	0415	0530			1.25	582.33	
Release HART from LTBMS CORK head by mechanical release by Activation Kit	5 Feb	0530	0645	Pass UWTV past Activation Kit pins ×14; observe hydraulic fluid output from HART		1.25	583.58	
Flush drill string	5 Feb	0645	1115	Rack back cement stand; drop sponge and pump 800 gal/min × 10 MPa		4.50	588.08	
POOH completion string	5 Feb	1115	1400			2.75	590.83	
Drop Churchill drift	5 Feb	1400	1430			0.50	591.33	
POOH and lay down completion string to surface	5 Feb	1430	2300			8.50	599.83	
Secure moonpool equipment for sailing	5 Feb	2300	0000			1.00	600.83	25.00
Sail for Shimizu	6 Feb	0000	2000			20.00	620.83	
Arrive off Shimizu; anchorage	6 Feb	1630	2400			7.50	628.33	26.18
Off Shimizu; board pilot; arrive quayside	7 Feb	0000	1030			10.50	638.83	26.62
Expedition 380 ends	7 Feb	1030	—					

Table T2. Bottom-hole assembly (BHA) record, Expedition 380. XO = crossover, DC = drill collar, DAT = drill-ahead tool, CSG = casing, F/S = float shoe, BTC = buttress thread coupling, ER = easy running, F/C = float collar, HGR = hanger, SST = subsea tool, CHRT = casing hanger running tool, DP = drill pipe, CMT = cement, STB = stabilizer, IF = internal flush. [Download table in CSV format](#).

BHA type	BHA record
Inner string	12-1/4 inch bit, 9-5/8 inch motor, 8 inch screen sub, XO, 8 inch float sub with float, 12-1/4 inch stabilizer, 8-1/2 inch DC (4), 8 inch spacer sub (4), 8 inch pony collar, DAT, 8-1/2 inch coring DC + 6 m pup (1), 8-1/2 inch coring DC (6), XO
9-5/8 inch CSG	(CSG) F/S joint, thread lock BTC (3 joints), XO, thread lock ER (1 joint), XO, F/C joint, 9-5/8 inch CSG (25 joints), 9-5/8 inch CSG + 3 m pup, 9-5/8 inch CSG HGR (string), SST, XO, XO, Activation Kit w/CHRT, 8-1/2 inch coring DC (7), XO, 5 inch DP (30 stands), XO, 5-1/2 inch DP (25 stands + 3 m pup), XO, 6-5/8 inch Z140 (15 stands), 6-5/8 inch UD165 (30 stands), CMT stand
Bicenter bit	8-1/2 inch, 9-7/8 inch bicenter bit, 6-3/4 inch DC (1), XO, 6-3/4 inch mud motor, float sub, 6-3/4 inch DC (3), XO, 8-1/2 inch STB, XO, 6-3/4 inch DC (3), 6-1/2 inch jar, 6-3/4 inch DC (6), XO, Churchill drift sub, XO
Drill-out-cement	8-1/2-inch bit, float sub, 6-3/4 inch DC, 4 inch IF connection (3), 8-1/2 inch stab, XO, 6-3/4 inch DC (6), 6-1/2 inch jar, 6-3/4 inch DC (6), XO, Churchill drift sub
Bicenter bit	8-1/2 inch, 9-7/8 inch bicenter bit, 6-3/4 inch DC (1), XO, 6-3/4 inch mud motor, float sub, 6-3/4 inch DC (3), XO, 8-1/2 inch STB, XO, 6-3/4 inch DC (3), 6-1/2 inch jar, 6-3/4 inch DC (6), XO
Scraper	8-1/2 inch bit, 9-5/8 inch scraper, XO, 6-3/4 inch DC (3), XO, 8-1/2 inch stab, XO, 6-3/4 inch DC (3), jar, 6-3/4 inch DC (3), XO

LTBMS deployment

Initial preparations

Setting up moonpool test area

Prior to LTBMS assembly, an instrument test center (i.e., laptop PCs, cables, etc.) was prepared on the starboard side of the moonpool and near the sensor cable drums for direct connection to the LTBMS instruments (Figure F5). Once we started lowering the observatory into the moonpool, a series of function tests were run to confirm the status of each instrument (see CHECKLISTS in [Supplementary material](#) [Becker et al., 2018] for details). For a full test, we extensively checked all aspects of the performance of the instruments, including power supply, instrument booting, data recording and displaying, sending and receiving commands, and so forth. A complete, full function test took ~40 min to 1 h. A simple function test checked only the power supply and booting function for each instrument; this version of the test took ~15–20 min.

Figure F6 is the connection diagram of the two test rigs. Connection A was used for the direct (wired) connection between the sensor, the sensor cable, and the underwater mateable connectors (UMCs) before LTBMS CORK head deployment. Here, borehole sensors were connected to the borehole cables and/or Teledyne ODI UMCs. RS422/232C and RS232C-USB converters were used to connect the original sensor output (RS422) to a PC port (USB). The converters and GPS receiver were connected by D-sub 9-way straight and cross cables. A DC power supply unit was also used to supply power to the borehole sensors.

Table T3 contains a comprehensive list of troubleshooting events during sensor and instrument carrier running, sensor cable testing, and attachment.

LTBMS assembly

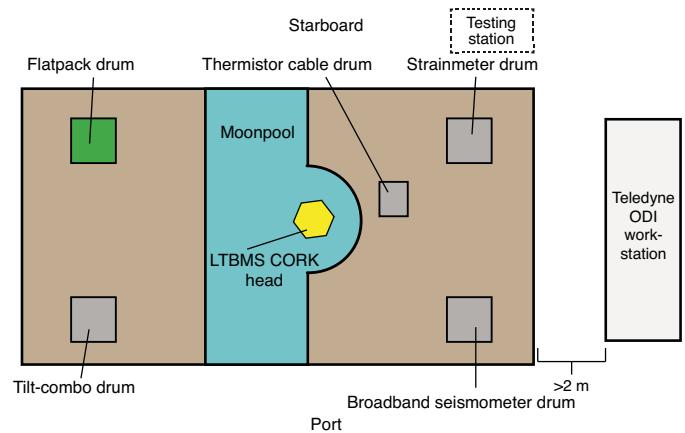
Attaching miniscreens to 3.5 inch LTBMS backbone tubing

The three miniscreens were attached to $\frac{1}{4}$ inch Swagelok hydraulic tubing and to the lowermost portion of the 3.5 inch LTBMS tubing with stainless steel banding. They were protected by two metal centralizers.

Strainmeter testing and attachment

After the 3.5 inch LTBMS tubing with bullnose, miniscreens, and cement port was run into the drilling floor, strainmeter prepa-

Figure F5. Sensor cable and flatpack drum configuration in the moonpool area, Expedition 380.



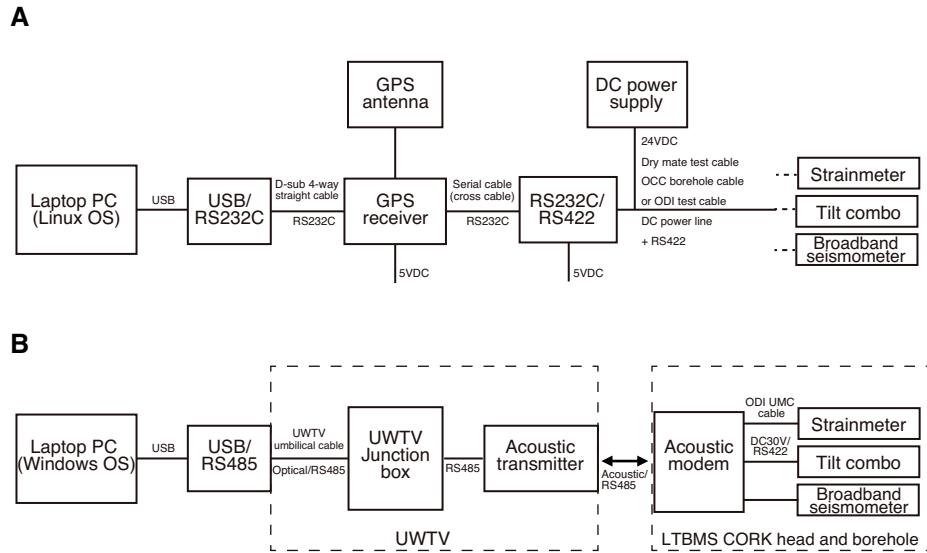
rations began with a full function test. See CHECKLISTS in [Supplementary material](#) [Becker et al., 2018] for the function test check sheets. Several issues were encountered during the first strainmeter test, including problems with the laptop PC screen displays and a communication disruption between the strainmeter and laptop PC caused by a damaged testing cable (see Table T3).

When the test was completed, the strainmeter with a crossover joint attached on the bottom end (for permanent connection to the LTBMS) and top end (used only for lifting the strainmeter for deployment), was loaded onto the riser transport system (RTS) and picked up on the rig floor to attach it to the 3.5 inch LTBMS tubing and $\frac{1}{4}$ inch hydraulic tubing. (Figure F7).

Attaching the instrument carrier

With the strainmeter attached to the 3.5 inch LTBMS tubing, the instrument carrier was loaded onto the RTS. The temporary crossover joint, which connected the top of strainmeter to the HPS, was removed to connect the top of the strainmeter to the bottom of the instrument carrier (Figure F8). Before attachment, the condition of the O-ring between the strainmeter and the instrument carrier was checked (Figure F9).

Figure F6. LTBMS sensor health check connection diagram, Expedition 380. A. Before LTBMS deployment. B. After running the LTBMS CORK assembly into the moonpool.



The two hydraulic tubes that pass through the strainmeter and extend to the miniscreens and the bottom of the strainmeter were not properly labeled. Therefore, it was very hard to distinguish between the tubing that led to the miniscreens and the tubing that led to the strainmeter. A water-pump test confirmed which hydraulic tube was which, and the correct hydraulic connections were made.

Full instrument Test 1

Before the strainmeter and instrument carrier were lowered into the water, a full test (Test 2 in Table T3) for all instruments was performed through dry-mateable connections (DMCs). The results show that all instruments were functioning well; however, several issues occurred during the test:

1. One of the five wire connections of the USB-RS422 Moxa adaptor on the test cable was loose, causing communication problems during the broadband seismometer test. We solved this problem by tightening the wire connection.
2. The voltage of the original power supply from the broadband seismometer-stream server (the “black box”) was not high enough, likely because of the long length of the sensor cables. We solved this problem by directly supplying power through an external power connector.
3. Both PCs used for the test showed delayed response in automatically adjusting their screen brightness, initially causing difficulties in reading the screen outputs. To deal with this issue, we prepared another (the third) PC as an extra spare.

All of these problems led to delays in finishing this test, but the lessons learned helped us to improve the management of our testing equipment. Overall, later tests went much more smoothly.

Attaching the sensor cables and flatpack

When the instrument carrier, strainmeter, and lower tubing section were lowered into the moonpool, the sensor cables and hydraulic flatpack were connected by Center for Deep Earth Exploration (CDEX) engineers and Mantle Quest Japan (MQJ) crew. The flatpack and sensor cables were attached to the 3.5 inch LTBMS tubing using both plastic zip-ties and SUS stainless steel banding (Figure F10). Metal centralizers were spaced at 2.3 m (for open hole) and

4.5 m intervals (for inside of casing) along the tubing joints to protect the sensor cables and flatpack. Aside from a brief crossing of sensor lines while lowering the casing, no major issues occurred.

While the instrument carrier was progressively lowered into the water by adding 3.5 inch LTBMS tubing joints one by one, the flatpack and sensor cables continued to be attached to the tubing using plastic zip-ties and stainless steel bands. The sensor cables and flatpack were strung up for attachment through cable drums and pulleys set up the moonpool area (Figure F5).

Attaching swellable packer, passing sensors cables through the swellable packer, and sensor communication tests

The swellable packer was attached to the 3.5 inch LTBMS tubing at a position that would correspond to 68 mbsf once deployed downhole in Hole C0006G. A Halliburton engineer inserted the sensor cables and flatpack through the swellable packer (Figure F11). Before passing the sensor cables through the swellable packer, a simple test was performed for all instruments through DMCs.

Full instrument Test 2

Immediately after passing the sensor cables through the swellable packer, a full test was performed for all instruments through DMCs. The test results confirmed that communication to all sensors was not affected by running the sensor cables through the swellable packer.

Attaching the LTBMS CORK head

After all instruments and the swellable packer were assembled and lowered, the LTBMS CORK head was connected to the HART while still on the RTS and then raised above the drill floor and attached to the 3.5 inch LTBMS tubing. The sensor cables and hydraulic flatpack were passed through the LTBMS CORK head's hanger. The sensor cables were temporarily attached to the LTBMS CORK head with plastic zip-ties, and the hydraulic flatpack was terminated and attached to the PSU hydraulic tubing, completing the pressure sensing system. No issues occurred during LTBMS CORK head attachment. A full test was performed before cutting the sensor cables.

Table T3. Long-term borehole monitoring system (LTBMS) deployment event sequence and troubleshooting. * = see corresponding sections in text. UMC = underwater mateable connector, UWTV = underwater TV, DONET = Dense Oceanfloor Network System for Earthquakes and Tsunamis, BRT = below rotary table. NA = not applicable. [Download table in CSV format.](#)

Operation*	Location on board	Equipment used	Problem	Solution	Lesson learned
Setting up moonpool test area	Moonpool	Laptop; connection cables (1 per instrument); power source	Setup delay	Properly labeled all equipment after some trial and error	Label all cables and electrical equipment properly
Attaching miniscreens to 3.5 inch LTBMS backbone tubing	Drill floor, moonpool	Zip-ties; metal bands	Could not distinguish between the hydraulic tubes for miniscreens and strainmeter	Water pumping test confirmed which line was which	Properly label tubings, cables, etc., to prevent delay/error
Strainmeter testing and attachment	Middle piperack	Laptop; connection cables; power source	Moving the strainmeter might damage it because great forces are experienced; laptop screens were dark because the light sensor of the laptop was damaged	Moved the instrument with great caution; used spare connection cables and laptops	Be cautious and always have spares for all equipment used
Attaching the instrument carrier	Drill floor	NA	NA	NA	NA
Full instrument Test 1	Moonpool	Laptop; connection cable; power source; extending cable	Loose wires connecting Moxa Box and connection cables; difficulties connecting to broadband seismometer; inefficient operation while connecting/disconnecting cables on the moonpool cart	Reconnected cables; used a bypass cable and provided power for the broadband seismometer directly from the power source; one scientist on the cart was in charge of connecting testing cable with instruments while the other scientists ran tests on the laptop	Recheck testing setup multiple times; test site should be sheltered from weather conditions and other influences (indoors/container); each instrument should have separate testing equipment (e.g., cables with proper labels) because switching cables and connections loses time and causes errors
Attaching sensor cables and flatpack	Moonpool	Zip-ties; metal tie wraps	Crossing of two electrical cables	NA	Label all cables properly
Attaching swellable packer; passing sensor cables through the swellable packer; sensor communication tests	Drill floor, moonpool	Laptop; connection cables; power source	GPS signal too weak; poor antenna placement	Skipped GPS time stamp/offset testing	Find a better position for the GPS antenna
Full instrument Test 2	Moonpool	Laptop; connection cables; power source	GPS signal too weak	Skipped GPS time stamp/offset testing	Find a better position for the GPS antenna
Attaching LTBMS CORK head	Drill floor	NA	NA	NA	NA
Cutting sensor cables; full instrument Test 3; termination of sensor cables	Moonpool	Laptop; connection cable; power source; extending cable	Distance between LTBMS head and Teledyne ODI workstation is greater than 10 m of cable prepared	Lowered LTBMS to be closer to the container; moved workstation closer to the LTBMS CORK head	Have a detailed plan of all procedures in advance
Attaching UMCs; instrument tests	Moonpool/ Teledyne ODI workstation	Laptop; connection cables; power source	NA	NA	NA
Attaching UMCs and cables to LTBMS CORK head; further testing	Moonpool/ Teledyne ODI workstation	Laptop; connection cables; power source	Error communicating with broadband seismometer; downlink connection was damaged	Found source of problem (defective UMC pressure casing) and repaired casing	Handle the UMCs carefully; hold/carry cables by the pressure casing; avoid bending the cable at UMC joint
Acoustic modem instrument testin; final LTBMS CORK head preparations	Moonpool	Laptop; connection to UWTV	NA	NA	NA
Acoustic modem instrument testing at 1400 and 3880 m BRT	Sonar room	Laptop; connection to UWTV	NA	NA	NA
Acoustic modem testing after reentry and landing	Sonar room	Laptop; connection to UWTV	NA	NA	NA
Checking instruments during cementing; final acoustic modem testing	Sonar room	Laptop; connection to UWTV	Small cement leak in instrument carrier; T1 thermistor unresponsive but later confirmed to be functional after connection to DONET	NA	Inspect all instrument and equipment
Releasing the LTBMS	Sonar room	Laptop; connection to UWTV	Activation Kit malfunction; unable to release LTBMS	Mechanical triggering of Activation Kit using modified metal clamp attached to UWTV	Expect the unexpected

Figure F7. Strainmeter above the drill floor, Expedition 380.

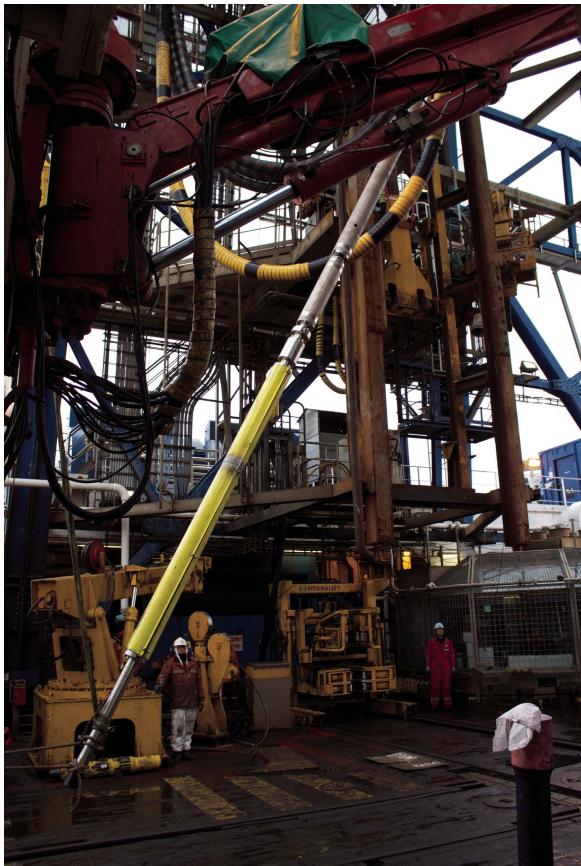
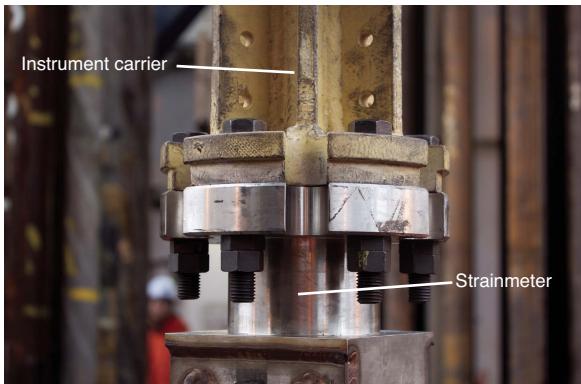


Figure F8. Strainmeter crossover connection, Expedition 380.



Cutting sensor cables and full instrument Test 3: termination of sensor cables

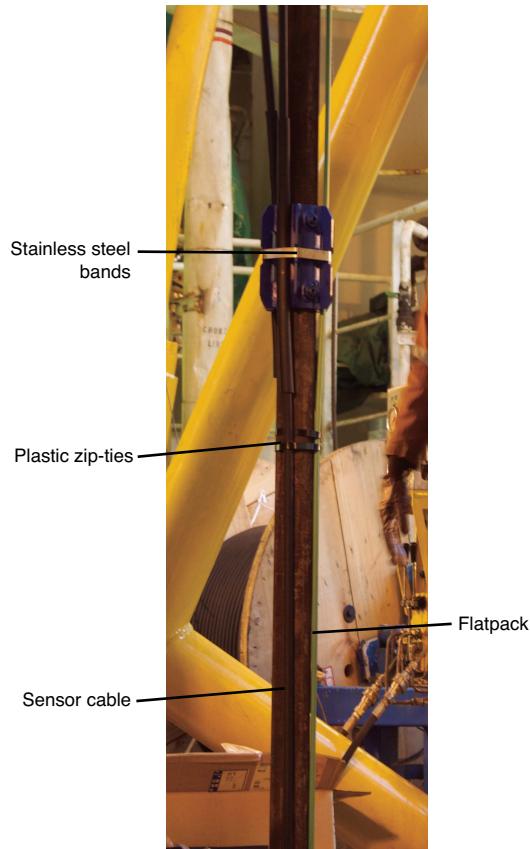
After the LTBMS CORK head was lowered to just above the moonpool and the attachment of sensor cables to the 3.5 inch LTBMS tubing was completed, the sensor cables were cut, leaving ~10 m of extra length for termination. Four UMCs were prepared for the terminated cables (one as a spare).

Immediately after cutting the sensor cables, a full test was performed for all instruments through direct connections of DMCs and the cut wires in each of the three sensor cables. All instruments were fully functional.

Figure F9. Crossover O-ring, Expedition 380.



Figure F10. Cables and flatpack connected to the 3.5 inch LTBMS tubing, Expedition 380.



Attaching UMCs and instrument tests

Teledyne ODI engineers prepared the UMCs for the termination of each of the three sensor cables at a workstation located in the moonpool area. During this process, a series of instrument tests were conducted. A test was conducted after the Teledyne ODI engineers had soldered the wires, and another test was conducted after the engineers completed the final epoxy (resin) pour during UMC construction. The first of these two tests was performed as a full function test, including a broadband seismometer test confirming downlink function. However, the second test after the epoxy had hardened was not a full function test; the downlink function check

Figure F11. Swellable packer reassembled after passing through the flatpack and sensor cables, Expedition 380.

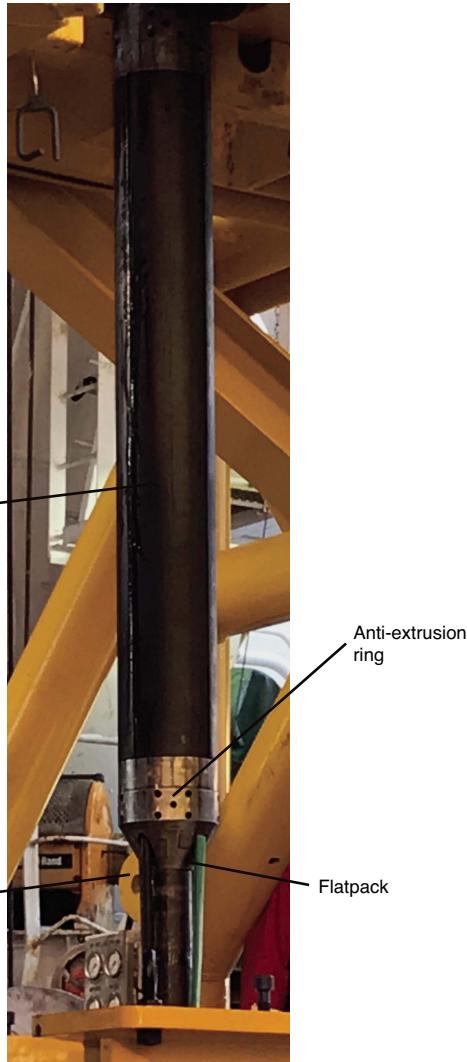
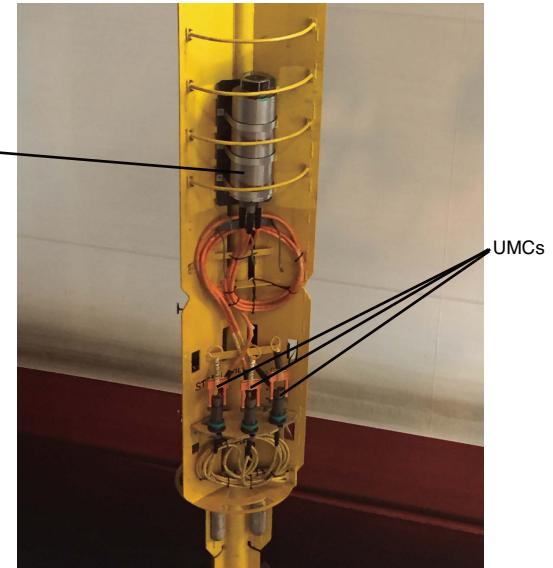


Figure F12. Acoustic modem and UMC cables in LTBMS CORK Bay 2, Expedition 380.



procedures were skipped. The broadband seismometer test procedure was revised to include a downlink function check for all following tests. When the communication cables were spliced midway through UMC termination, a third full instrument test was performed. All instruments were functioning properly, and the Teledyne ODI engineers completed the UMC terminations. A fourth full test was performed through direct connection to the newly fabricated UMCs, and again all instruments proved fully functional.

Attaching UMCs and cables to the LTBMS CORK head and further testing

With the UMCs and instruments fully functional, the cables and UMCs were then attached to the LTBMS CORK head with plastic zip-ties. Once they were fully attached (Figure F12), a full function test of all instruments (including the PSU) was performed through direct connection to the UMCs. A major issue was found when the downlink connection to the broadband seismometer ceased functioning. The cause was isolated to a damaged communication cable, more specifically in the newly built UMC pressure housing. A full

function test, including the downlink function, had not been conducted after epoxy hardened nor after carrying the UMCs to the LTBMS CORK head (see CHECKLISTS in **Supplementary material** [Becker et al., 2018]). The broadband seismometer cable was removed from the LTBMS CORK head and cut just beneath the UMC pressure housing. Communication with the sensor was checked through direct connection between the borehole cable and test equipment. The results confirmed that the broadband seismometer itself was functional, isolating the problem to a damaged communication cable, more specifically in the newly built UMC pressure housing. The Teledyne ODI engineers prepared a new UMC pressure housing (using a spare).

Similar instrument tests, including a downlink function test, were performed again for the seismometer during the new UMC construction: one test each after electrical connection (soldering), epoxy hardening, and completion, with each test proving successful. Upon reattaching the UMC and seismometer cable, one final full test was performed through direct connection to all instruments, and all were functioning properly.

Acoustic modem instrument testing and final LTBMS CORK head preparation

All instruments were then connected to the acoustic modem through UMCs (Figure F12). Once connected, a full test at the moonpool was performed through the modem, which ensured instrument functionality with the acoustic communication system (see Test 18 in *Instrument_tests.xlsx* in CHECKLISTS in **Supplementary material** [Becker et al., 2018]). Upon completing the test successfully, the formation and sampling valves were opened to the ocean (hydrostatic pressure) and the LTBMS CORK head was lowered into the water for 5 min to flush the hydraulic tubing with seawater. The LTBMS CORK head was raised, the valves for Pressure Ports 1 and 3 were closed (see Figure F3 in the Expedition 380 methods chapter [Kinoshita et al., 2018]), and the Activation Kit was then attached to the LTBMS. All valves were zip-tied to ensure the handles did not turn during descent.

Lowering the LTBMS

Acoustic modem instrument testing at 1400 and 3880 m BRT

During descent, two more acoustic modem tests were performed through the UWTV, one when the instrument carrier reached 1400 m BRT and one when it reached 3880 m BRT. Each test showed that all instruments were functioning properly. After the LTBMS CORK head and UWTV were deployed, Connection B (Figure F6) was used for a series of health checks through acoustic communication. The acoustic transmitter and the acoustic modem have internal batteries in their pressure housings and can supply DC power to their internal circuits and to the borehole sensors.

Reentry and landing

Acoustic modem testing after reentry and landing

Prior to reentry, a cement circulation test was performed to inspect the cement tubing in the instrument carrier. A small leak at the connection between the instrument carrier and the strainmeter was detected. This leakage may have been caused by a weak or cracked welding point, and the science team confirmed that the leak would not negatively affect the cementation process. The LTBMS reentered, and the LTBMS CORK head landed smoothly. A full acoustic modem test was performed after landing to ensure that the instruments remained healthy.

Cementing

Checking instruments during cementing and final acoustic modem test

Once the landing of the LTBMS CORK head was completed, the cementing process started. The process was completed without any problems. Brief instrument checks were performed through the acoustic modem every 30 min to ensure functionality during cementing. After cementing, the final full acoustic modem test was performed (see Test 23 in *Instrument_tests.xlsx* in CHECKLISTS in **Supplementary material** [Becker et al., 2018]). Test results suggested that the lowermost thermistor (T1) had stopped recording. After connection to DONET, that sensor seemed to be working properly. The strainmeter contains a temperature sensor that could substitute for a potential loss of the T1 thermistor sensor.

Releasing the LTBMS

After cementing was completed, the UWTV acoustic modem triggered the Activation Kit to release the HART. Although pressure was released (confirmed by the UWTV camera and by checking the gauges on the Activation Kit), the HART did not release. The UWTV was moved up and down past the Activation Kit to trigger the manual release to no effect. Multiple runs with the UWTV also had no apparent effect. The UWTV was recovered to modify the guide funnel by adding 5 mm rubber sheets and welding 12 mm of metal banding to the inside half of the guide funnel door to reduce the inside diameter of the funnel and make better contact with the manual trigger pins on the outside of the Activation Kit. This strategy was finally successful. Upon detaching the HART, the separation was visually confirmed before running one final sensor test with the UWTV acoustic modem.

References

Becker, K., Kinoshita, M., Toczko, S., and the Expedition 380 Scientists, 2018. Supplementary material, <https://doi.org/10.14379/iodp.proc.380supp.2018>.

Supplement to Becker, K., Kinoshita, M., Toczko, S., and the Expedition 380 Scientists, NanTroSEIZE Stage 3: Frontal Thrust Long-Term Borehole Monitoring System (LTBMS). Proceedings of the International Ocean Discovery Program, 380: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.380.2018>

Expedition 314 Scientists, 2009. Expedition 314 Site C0006. In Kinoshita, M., Tobin, H., Ashi, J., Kimura, G., Lallemand, S., Screamton, E.J., Curewitz, D., Masago, H., Moe, K.T., and the Expedition 314/315/316 Scientists, *Proceedings of the Integrated Ocean Drilling Program*, 314/315/316: Washington, DC (Integrated Ocean Drilling Program Management International, Inc.).

<https://doi.org/10.2204/iodp.proc.314315316.118.2009>

Expedition 316 Scientists, 2009. Expedition 316 Site C0006. In Kinoshita, M., Tobin, H., Ashi, J., Kimura, G., Lallemand, S., Screamton, E.J., Curewitz, D., Masago, H., Moe, K.T., and the Expedition 314/315/316 Scientists, *Proceedings of the Integrated Ocean Drilling Program*, 314/315/316: Washington, DC (Integrated Ocean Drilling Program Management International, Inc.).

<https://doi.org/10.2204/iodp.proc.314315316.134.2009>

Expedition 332 Scientists, 2011. Expedition 332 summary. In Kopf, A., Araki, E., Toczko, S., and the Expedition 332 Scientists, *Proceedings of the Integrated Ocean Drilling Program*, 332: Tokyo (Integrated Ocean Drilling Program Management International, Inc.).

<https://doi.org/10.2204/iodp.proc.332.101.2011>

Heki, K., 2007. Secular, transient, and seasonal crustal movements in Japan from a dense GPS array: implication for plate dynamics in convergent boundaries. In Dixon, T.H., and Moore, J.C. (Eds.), *The Seismogenic Zone of Subduction Thrust Faults*: New York (Columbia University Press), 512–539.

Kinoshita, M., Becker, K., Toczko, S., Edginton, J., Kimura, T., Machida, Y., Roesner, A., Senyener, B., and Sun, T., 2018. Expedition 380 methods. In Becker, K., Kinoshita, M., Toczko, S., and the Expedition 380 Scientists, *NanTroSEIZE Stage 3: Frontal Thrust Long-Term Borehole Monitoring System (LTBMS)*. Proceedings of the International Ocean Discovery Program, 380: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.380.102.2018>

Kopf, A., Saffer, D., Toczko, S., Araki, E., Carr, S., Kimura, T., Kinoshita, C., Kobayashi, R., Machida, Y., Rösner, A., and Wallace, L.M., 2017. Expedition 365 summary. With contributions by S. Chiyonobu, K. Kanagawa, T. Kanamatsu, G. Kimura, and M.B. Underwood. In Saffer, D., Kopf, A., Toczko, S., and the Expedition 365 Scientists, *NanTroSEIZE Stage 3: Shallow Megasplay Long-Term Borehole Monitoring System*. Proceedings of the International Ocean Discovery Program, 365: College Station, TX (International Ocean Discovery Program).

<https://doi.org/10.14379/iodp.proc.365.101.2017>

Miyazaki, S., and Heki, K., 2001. Crustal velocity field of southwest Japan: subduction and arc-arc collision. *Journal of Geophysical Research: Solid Earth*, 106(B3):4305–4326. <https://doi.org/10.1029/2000JB900312>

Moore, G.F., Park, J.-O., Bangs, N.L., Gulick, S.P., Tobin, H.J., Nakamura, Y., Sato, S., et al., 2009. Structural and seismic stratigraphic framework of the NanTroSEIZE Stage 1 transect. In Kinoshita, M., Tobin, H., Ashi, J., Kimura, G., Lallemand, S., Screamton, E.J., Curewitz, D., Masago, H., Moe, K.T., and the Expedition 314/315/316 Scientists, *Proceedings of the Integrated Ocean Drilling Program*, 314/315/316: Washington, DC (Integrated Ocean Drilling Program Management International, Inc.). <https://doi.org/10.2204/iodp.proc.314315316.102.2009>

Seno, T., Stein, S., and Gripp, A.E., 1993. A model for the motion of the Philippine Sea plate consistent with NUVEL-1 and geological data. *Journal of Geophysical Research: Solid Earth*, 98(B10):17941–17948. <https://doi.org/10.1029/93JB00782>

Strasser, M., Dugan, B., Kanagawa, K., Moore, G.F., Toczko, S., Maeda, L., Kido, Y., Moe, K.T., Sanada, Y., Esteban, L., Fabbri, O., Geerssen, J., Hammerschmidt, S., Hayashi, H., Heirman, K., Hüpers, A., Jurado Rodriguez, M.J., Kameo, K., Kanamatsu, T., Kitajima, H., Masuda, H., Milliken, K., Mishra, R., Motoyama, I., Olcott, K., Oohashi, K., Pickering, K.T.,

Ramirez, S.G., Rashid, H., Sawyer, D., Schleicher, A., Shan, Y., Skarbek, R., Song, I., Takeshita, T., Toki, T., Tudge, J., Webb, S., Wilson, D.J., Wu, H.-Y., and Yamaguchi, A., 2014. Expedition 338 summary. *In* Strasser, M., Dugan, B., Kanagawa, K., Moore, G.F., Toczko, S., Maeda, L., and the

Expedition 338 Scientists, *Proceedings of the Integrated Ocean Drilling Program*, 338: Yokohama, Japan (Integrated Ocean Drilling Program).
<https://doi.org/10.2204/iodp.proc.338.101.2014>