



R/V Natsushima “Cruise Report”

NT12-18

Research on sediment deformation by strong shaking
and cold seep in the Mega-splay fault
of the Nankai Trough off Kumano

July 10, 2012 – July 13, 2012



Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

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1. Cruise Information

1-1. Cruise ID: NT12-18

1-2. Name of vessel: R/V Natsushima

1-3. Title of the cruise: Deep Sea Research, FY2012, ROV “HyperDolphin” Research Dive,
Kumano-nada

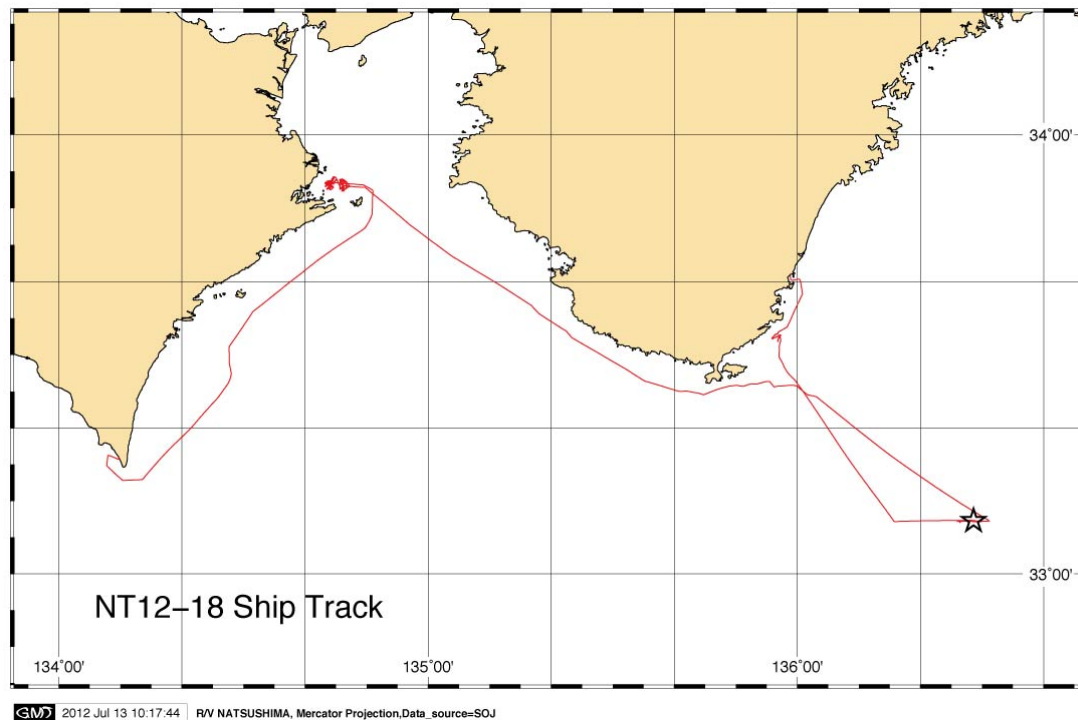
1-4. Title of proposal: Research on sediment deformation by strong shaking and cold seep
in the Mega-splay fault of the Nankai Trough off Kumano

1-5. Cruise period: July 10, 2012 to July 13, 2012

1-6. Ports of call: Shingu (July 10, 2012), Muroto-misaki Gyoko (July 13, 2012)

1-7. Research area: Kumano-nada (Nankai Trough off Kumano)

1-8. Research Map: Ship track and survey area (star)



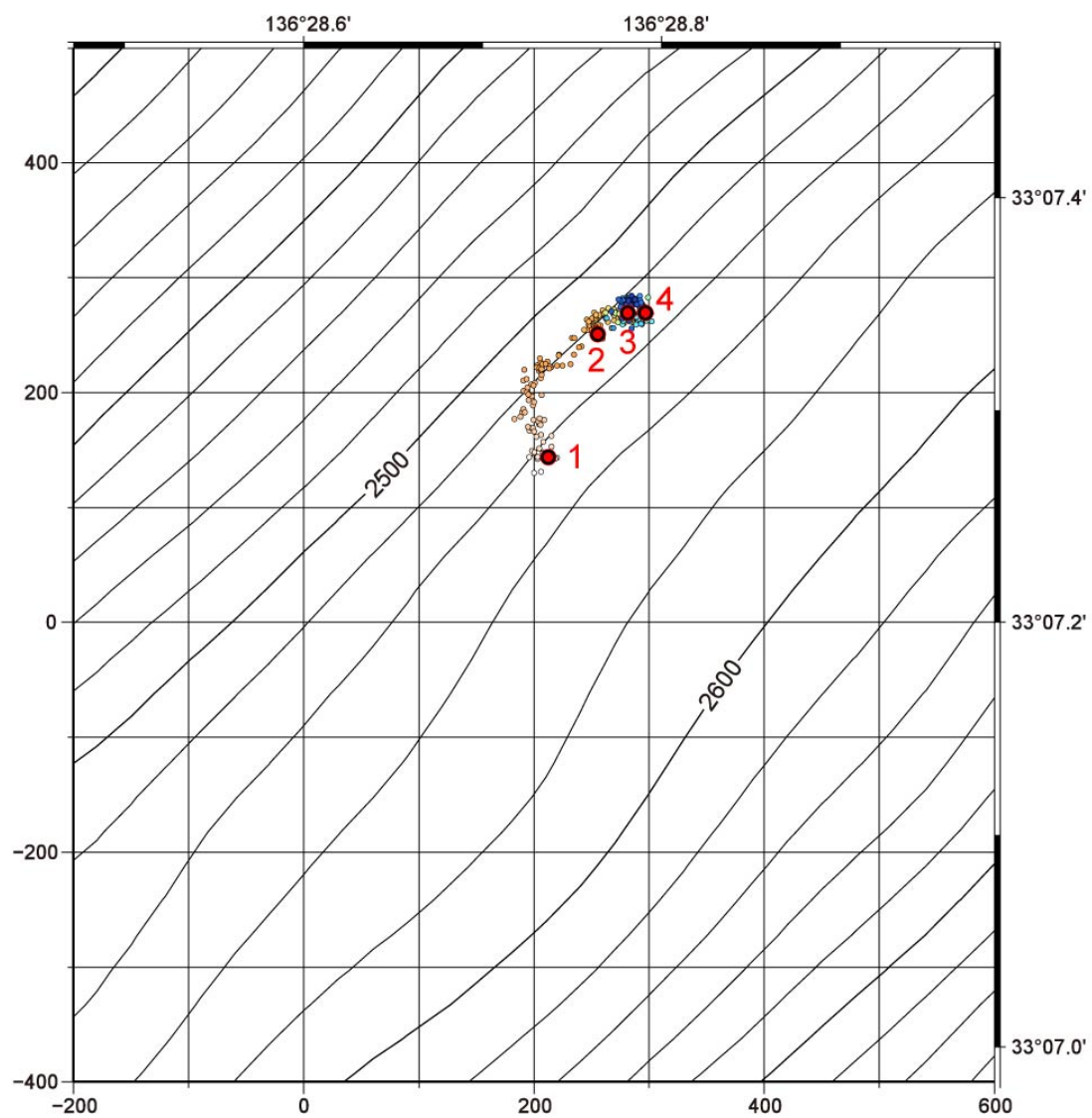


Fig. 1-1 Dive track and study sites.

2. Researchers

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3. Outline of this study

3-1. Objectives and background

Fluids in plate subduction zones strongly influence on rock deformation, diagenesis, temperature, methane hydrate formation, mud diapirism and so on. Shallow VLF (very low frequency) events in subduction zones, moreover, distribute along splay faults (Ito and Obara, 2006; Obana and Kodaira, 2009), correspond to pressure fluctuation in the borehole of a prism toe (Davis et al., 2006), and correlate with cold seep activity (Brown et al., 2005) suggesting close relationship between accretionary prism

deformation and fluid behavior.

3-2. Methods and Instruments

Our group has conducted cold seep monitoring by seep meters and heat flow probes in a mega-splay fault off Kumano to know the stress condition derived from cold seep activity. One year seep monitoring since 2006 after the 2004 off the Kii Peninsula earthquake indicates fading with synchronizing fluctuation between two seep sites at intervals of 200 m. This suggests some effects from the large earthquake and the successive VLF event. We developed seep meters to record for two years and deployed them along the splay fault in 2008. Although the short period VLF event occurred during our monitoring term, no data was obtained due to instrument trouble. Therefore, we developed long recording type SAHF (heat flow probe with battery and recorder) and continued the seep monitoring. Detailed information about heat flow tools are described in Chapter 4-2.

3-3. Research results

We only conducted one-hour mission at the seafloor during one dive (#1400) due to bad sea condition although two dives by “HyperDolphin” were scheduled for NT12-18. This mission included retrieve and deployment of SAHF and Bottom-Water Thermometer (BWT) and sampling of sediments core and rocks. The instruments planned for retrieve were installed during NT10-5 Leg 1 (BWT) and YK10-9 (SAHF). The followings are outline of our dive mission with time-line (Table 3-1).

The ROV “HyperDolphin” moved toward the monitoring sites after reaching to the bottom (Fig. 1-1). We observed the fault scarp exposing the stratified mudstone (Fig. 3-1). After retrieving the Bottom-Water Thermometer (BWT) from Site 2 (Fig. 3-1), we moved to Site 3 where SAHF was installed, and deployed SAHF#2 at a bacterial mat. After retrieving SAHF#4, ROV moved to Site 4 to retrieve SAHF#3 and installed SAHF#1 at the normal seafloor without a bacterial mat for reference. We backed to Site 3 and obtained three MBARI cores at bacterial mats and one MBARI core from the normal seafloor for reference (Fig. 3-2). One rock sample was also obtained at the same site (Fig. 3-2).

Recorded data were confirmed onboard (SAHF#1) and shore laboratory (SAHF#2 and BWT). The MBARI cores derived from the bacterial mats have strong hydrogen sulfide smell. We took the sub-samples from two cores for helium isotope study and kept one for archive. The rock sample is well-consolidated siltstone.

As mentioned above, we successfully conducted 1) retrieve of two SAHFs installed during YK10-9, 2) retrieve of one BWT deployed during NT10-5 Leg 1, 3) installation of two SAHF, 4) installation of one BWT, 5) sampling of four MBARI cores, and 6) sampling of one rock sample. Long-term recording by two SAHFs and one BWT would provide us with information about fluctuation of cold seep activity.

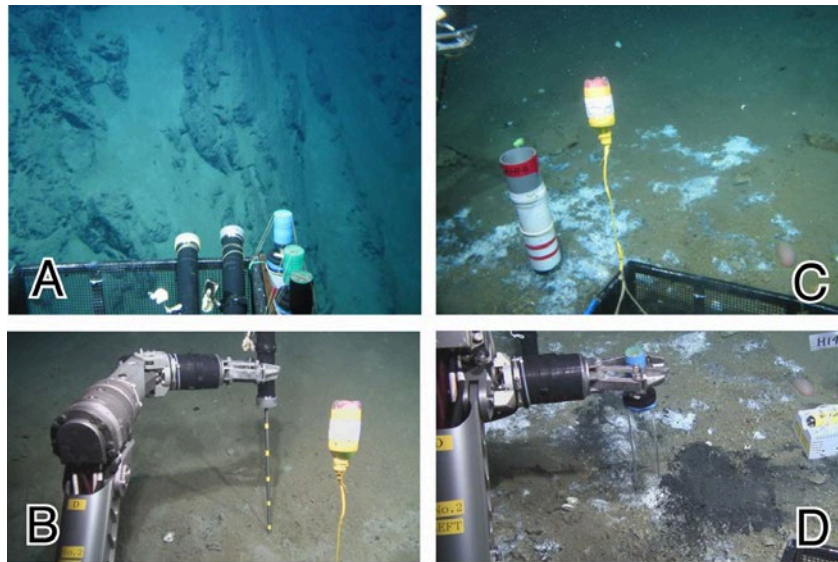


Fig. 3-1 Dive photos. A) Outcrop of the fault scarp, B) Installation of SAHF, C) Bacterial mat, D) MBARI core sampling operation.

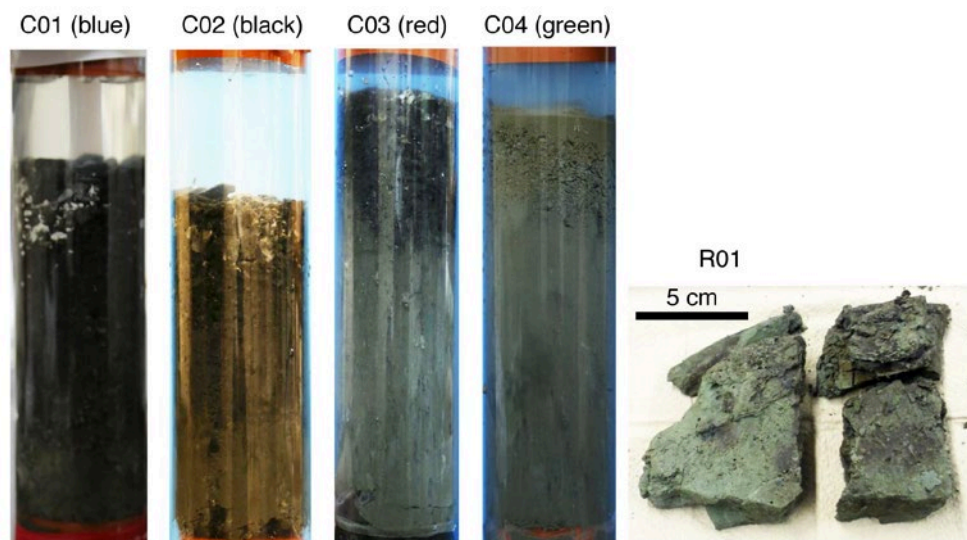


Fig. 3-2 Photographs of MBARI cores and a rock sample.

Table 3-1 Dive #1400 Log.

Time (JST)	Depth (m)	Pos. X (m)	Pos. Y (m)	Description
7:00:45	2100.0	-57.3	-216.0	
7:06:45	2300.0	-64.7	-206.7	
7:12:33	2500.0	-75.8	-211.4	
7:13:30		-73.9	-212.9	Video recording start
7:14:20		-68.4	-214.5	Confirmation of seafloor
7:14:50	2562.0	-62.8	-216.0	Landing/mud bottom/start of moving northward
7:19:31	2551.0	-35.1	-223.8	Releasing the weight/mud containing pebbles
7:23:50	2537.0	-16.6	-237.8	Large breccia (in rather footwall part)
7:25:00	2533.0	-16.6	-239.3	Large breccia covered with mud (in slope area)
7:29:20	2538.0	-25.9	-240.9	Confirmation of BTMS
7:30:00	2544.0	-25.9	-240.9	Start of landing near BTMS point/mud with some clasts
7:32:12	2544.0	-25.9	-240.9	Landing/operation start of retrieval of the BTMS/some bacterial mats
7:34:30	2544.0	-16.6	-239.3	Starts moving to find the already installed SAHF#4/some bacterial mats
7:38:18	2544.6	-22.2	-237.8	Confirmation of SAHF#4/mud, bacterial mats (westward position of SAHF#4)
7:39:57	2546.3	-24	-240.9	Start of landing/installation of SAHF#2
7:43:03	2546.3	-27.7	-245.6	SAHF#2 (33° 07.285'N, 136° 28.642E)
7:48:39	2546.3	-29.6	-244	Installation of thermometer/moving eastward to find SAHF#3
7:52:11	2546.6	-22.2	-237.8	Confirmation of SAHF#3
7:54:00	2550.2	-14.8	-233.1	Landing
7:56:32	2550.2	-16.6	-228.5	Pulling out of SAHF#3 (pull out with left-arm, rehandled with right-arm)
7:59:00	2550.2	-12.9	-223.8	Preparation of SAHF#1 installation (wait for lamp flashing)
8:02:49	2550.3	-7.4	-216	Installation of SAHF#1 (could not confirm the lamp flashing, owing to oversight?)
8:04:55	2550.4	-5.5	-212.9	Retrieval of SAHF#3/turning back to SAHF#1 point
8:12:05	2546.4	-5.5	-202	Landing/preparation of MBARI C01 (blue)
8:14:00	2546.8	0	-203.6	Coring of MBARI C01 (blue) at bacterial mats
8:14:50	2546.7	1.8	-203.6	End of MBARI C01 coring (blue)
8:17:09	2546.6	5.5	-203.6	Coring of MBARI C02 (black) in the vicinity of MBARI C01 point

8:19:35	2546.7	7.4	-203.6	End of MBARI C02 coring (black)
8:22:18	2546.8	1.8	-198.9	Coring of MBARI C03 (red)
8:23:10	2547.4	1.8	-197.4	End of MBARI C03 (red)
8:24:10	2547.4	3.7	-195.8	Coring of MBARI C04 (green) at brown-colored area (reference site)
8:24:55	2547.5	1.8	-194.3	End of MBARI C04 (green)
8:27:10	2547.0	0	-195.8	Sampling of rock R01 (for the use at "Summer School"). Disruption during operation
8:27:35	2547.0	1.8	-195.8	Finish of seafloor survey
8:28:30	2546.0	1.8	-195.8	vehicle left the seafloor
8:31:30	2495.0	-3.7	-192.7	Start of winding up/End of recording
8:43:09	2000.0	-7.4	-183.4	
8:54:42	1500.0	7.4	-211.4	
9:05:14	1000.0	-7.4	-265.8	Change of head from 90 to 270 degree
9:10:47	750.0	9.2	-264.2	Change of head from 270 to 90 and to 270 degree
9:17:26	500.0	64.7	-188.1	Change of head from 270 to 135 degree
9:17:50	480.4	64.7	-184.9	Stop of winding up (change of head from 135 to 270 degree)
9:21:53	471.5	11.1	32.6	Restart of winding up/swept away to the east (change of head from 270 → 90 degree)
9:32:50	100.0	-66.5	957.4	
9:34:35	44.0	-64.7	1108.1	Vehicle surfacing
9:36:36	0.8	-	-	Confirmation of vehicle surfacing
9:45:32	1.2	-	-	Change of head from 90 to 180 degree
9:46:07	0.9	-	-	Retrieving vehicle
9:51:54	-	-	-	Vehicle on deck. End of operation.

4. Long-term Temperature Measurement [reported by Kawada, Y.]

4-1. Objective

Fluid discharge from accretionary prisms relates to fluid drainage and pore pressure buildup at depth, and is important for understanding the activity of seismic faults (e.g., Saffer, 2003). Extensive fluid discharge has been observed near the deformation front of the Nankai Trough off Kumano both by visual surveys (Ashi et al., 2002) and analyses of pore water chemical species (Toki et al., 2004). Since 2010, sub-seafloor temperature gradient, a proxy for fluid flow, has been monitored at one of the fluid discharge areas called the Omine Ridge, in order to quantify the fluid discharge velocity and its time dependence. Long-term monitoring is crucial for both eliminating the effect of temperature variations due to the change in bottom-water temperature (Hamamoto et al., 2005) and detecting the changes in the discharge velocity (Hatch et al., 2006). In the present cruise, temperature probes and a bottom-water thermometer deployed in 2010 were recovered, and new instruments were deployed that would record temperature data for two more years.

4-2. Instruments

SAHF: Stand-Alone Heat Flow meter (SAHF) is designed to measure sub-seafloor temperature gradients and in-situ thermal conductivity (Fig. 4-1 and Table 4-1; Kinoshita et al., 2006). The pressure case contains an electric circuit including a data logger, tilt meters, a magnetic switch (for a line heater), and a Li-ion battery pack. A serial port is emplaced at the upper side of the case. The 60 cm long probe includes five thermistors with an 11 cm interval, along which a line heater driven by a constant electric current is installed.

The instrument measures the temperatures at a preset time interval (60 minutes in this cruise). A pilot lamp outside the pressure case informs the timing of temperature recording. The line heater is used to measure in-situ thermal conductivity; the recorded temperature rise during the heating and the temperature decay after the heating can be used for the estimation (Carslaw and Jaeger, 1959). The heater can be switched on either by a timer being set in advance, or the magnetic switch being accessed outside the pressure case by a small magnet. The former choice was used in this cruise.

BWT: Bottom-water thermometer (BWT) records near-seafloor temperature at a specified time interval (set in advance; 20 minutes in this cruise). The pressure case contains a temperature sensor, an electric circuit, a data logger, and a battery pack (Fig. 4-2). BWT is usually deployed with a weight of PVC and scrap iron (the total weight is *ca.* 10 kg).

4-3. Operation

SAHF: Before penetrating each probe into the seafloor, the instrument measured ambient temperature once (in the basket of Hyper-Dolphin or held by the manipulator), the record of which can be used in the analysis as reference temperatures. Then the probe was penetrated into the seafloor by Hyper-Dolphin's manipulator. Full penetration of the probe was confirmed from the video. For recovering, pulling out of the probe was also done by the manipulator.

BWT: The instruments were just placed onto or recovered from the seafloor by the manipulator.

4-4. Preliminary results

Recovery and deployment: During Dive H1400 held on Jul. 11, 2012, two SAHFs (SHFn1 and SHFn2) and one BWT (#165) were deployed (Fig. 4-3, Table 4-2), and two SAHFs (SHFs 3 and 4 deployed during NT10-5) and one BWT (#164 deployed during YK10-9) were recovered (Fig. 4-4, Table 4-3). The locations of the deployed SAHFs are almost the same (within ca. 50 cm) as those of the recovered SAHFs. The location of the deployed BWT is close to SHF4. Note that we could not confirm the pilot lamp turning on during the deployment.

Data recovery: The temperature time-series of the recovered BTW (Fig. 4-5) shows fluctuations with peak-to-peak temperature difference of more than 0.3°C. The temperature data were downloaded from two SAHFs. We are going to analyze the temperature time-series of the recovered two SHAFs together with the temperature record of the BWT using the methods of Hamamoto et al. (2005) and Hatch et al. (2006).

References

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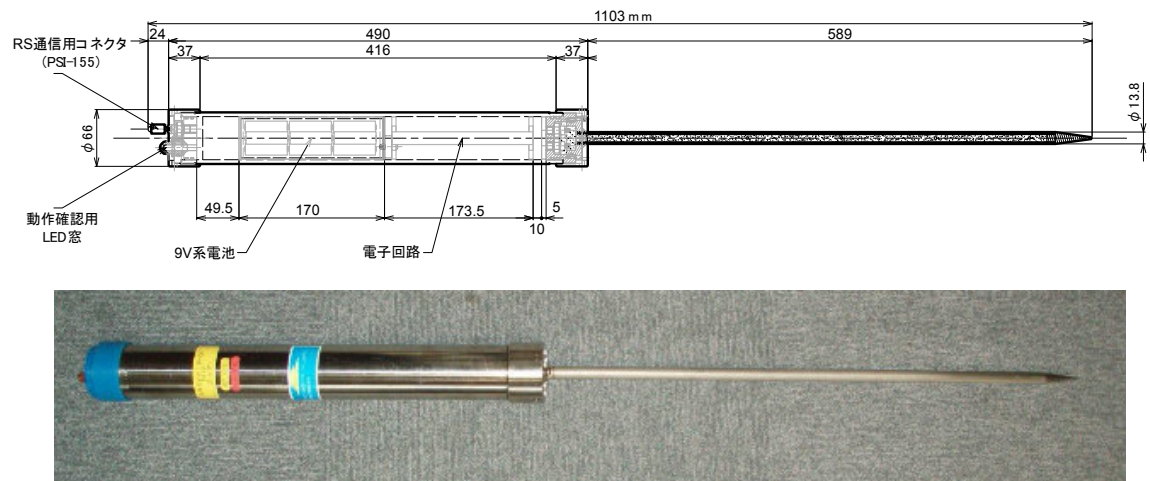


Fig. 4-1 A Schematic diagram (top) and a photograph (bottom) of SAHF.

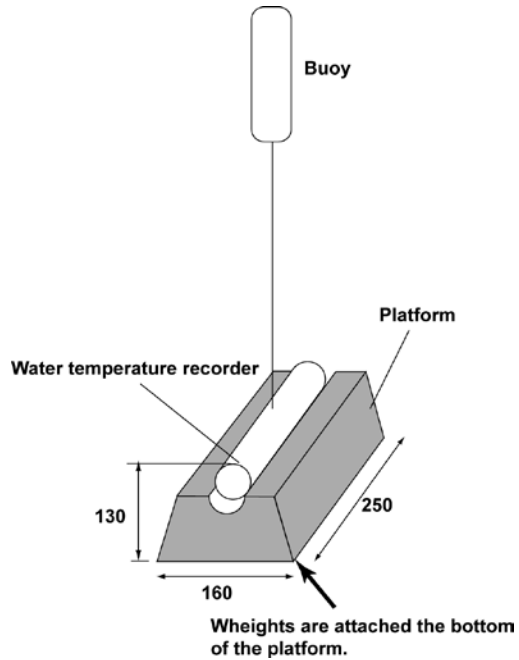


Fig. 4-2 A Schematic diagram of BWT.

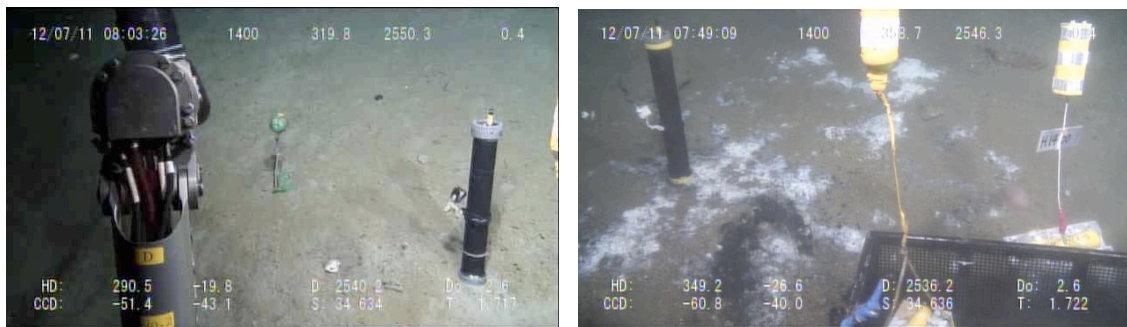


Fig. 4-3 Deployed instruments: (left) SHFn1 deployed near the location of SHF3, the reference site, (right) SHFn2 and BTW (#164) deployed near the location of SHF4, the bacteria-mat site.

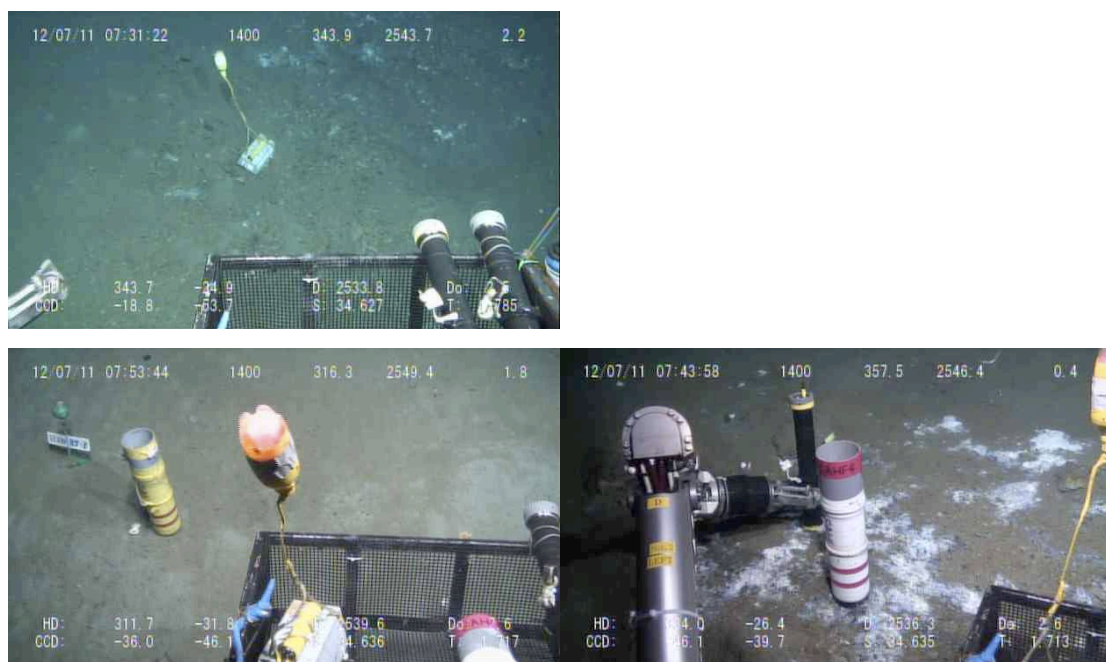


Fig. 4-4 Recovered instruments: BWT (#165, top), SHF3 (bottom-left), and SHF4 (white one in bottom-right).

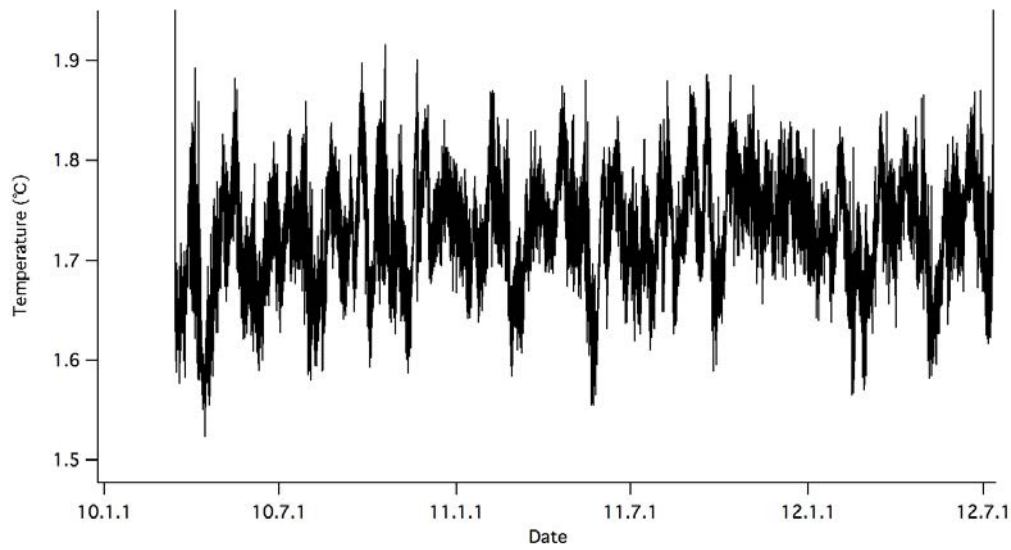


Fig. 4-5 Temperature recode of BWT (#165).

Table 4-1 Specification of SAHF.

Material	Alloy of titanium
Weight	3.0 kg in air, 1.5 kg in seawater
Length of pressure case	525 mm
Diameter of pressure case	58 mm
Length of probe	600 mm
Diameter of probe	13.8 mm (filled by silicon oil inside)
Number of thermistors	5
Intervals of thermistors	110 mm
Accuracy	0.01 °C
Resolution	0.001 °C
External Interface	RS232C (9600BAUD, 8 BIT, Non-Parity, 2 STOP BIT)

Table 4-2 Deployment

Station	Date of deployment	Coordinates	Water depth (m)
SHFn1	Jul. 11, 2012	33°07.346'N, 136°28.792E	2550
SHFn2	Jul. 11, 2012	33°07.346'N, 136°28.782E	2546
BTW(#164)	Jul. 11, 2012	33°07.346'N, 136°28.782E	2546

Table 4-3 Recovery

Station	Deployment	Recovery	Coordinates	Depth (m)
SHF3	Aug. 5, 2010	Jul. 11, 2012	33°07.346'N, 136°28.792E	2550
SHF4	Aug. 5, 2010	Jul. 11, 2012	33°07.346'N, 136°28.782E	2546
BWT(#165)	Mar. 15, 2010	Jul. 11, 2012	33°07.336'N, 136°28.765E	2545

5. Cruise Log

Date	Local Time	Note	Position/Weather/Wind/Sea condition
11-Jul-12		Sail out, proceeding to research area	07/10 12:00 (UTC+9h)
	16:00	Let go all shore lines & left Shingu for research area	33-40.8N 135-58.8E
	17:30-18:00	Carried out shipboard education & training for scientists.	Shingu Ko.
	18:05-19:20	Scientists meeting.	Fine but cloudy
			ENE-2(Light breeze)
12-Jul-12		HPD#1400Dive at KUMANO NADA	07/11 12:00 (UTC+9h)
	04:00	Arrived at research area(KUMANO NADA).	33-15.4N 136-15.0E
	04:10-04:21	Carried out MBES mapping survey.	Shionomisaki Southeast ward.
	04:33	Released XBT.	Fine but cloudy
	05:09	Hoisted up H.P.D.	South-6(Strong breeze)
	05:14	Launched H.P.D.	4(Sea moderate)
	05:27	H.P.D dove and started her operation #1400.	3(Moderate short)
	07:14	H.P.D landed on the sea bottom(D=2562m).	Visibly: 7'
	08:28	H.P.D left the sea bottom(D=2564m).	
	09:36	H.P.D floated.	
	09:47	Hoisted up H.P.D.	
	09:51	Recovered H.P.D and finished her operation.	
	10:00	Left research area for TANABE KO.	
	18:00-18:30	Scientists meeting.	
	21:30	Arrived at TACHIBANA URA and started drifting.	
13-Jul-12		Drifting at TACHINA URA to avoid rough sea and proceeding to MUROTOMISAKI GYOKO.	07/12 12:00 (UTC+9h)
	09:00-09:40	Scientists meeting.	33-53.4N 134-44.4E
			TACHIBANA URA.
			Rain, SW-8(Strong Gale)
14-Jul-12		Completed NT12-18.	
	10:00	Arrived at MUROTOMISAKI GYOKO and completed NT12-18.	

6. Notice on Using

This cruise report is a preliminary documentation as of the end of the cruise.

This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientist for latest information.

Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.