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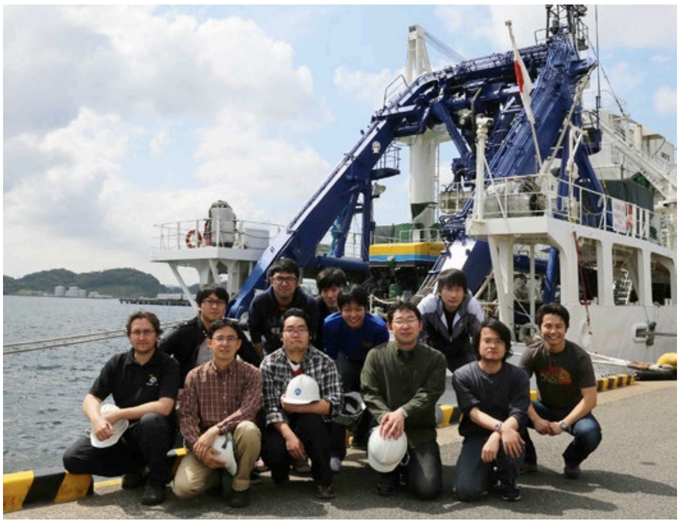
R/V Natsushima "Cruise Report"

NT13-08

Establishment of estimation method for fault activity history using sediment deformation by strong shaking and fluctuation monitoring of cold seep in the Mega-splay fault of the Nankai Trough off Kumano

April 13, 2013 – April 18, 2013



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

Contents

1. Cruise Information

1-1. Cruise ID: NT13-08

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

1-3. Title of the cruise: Deep Sea Research, FY2013, ROV "HyperDolphin" Research Dive, Kumano-nada

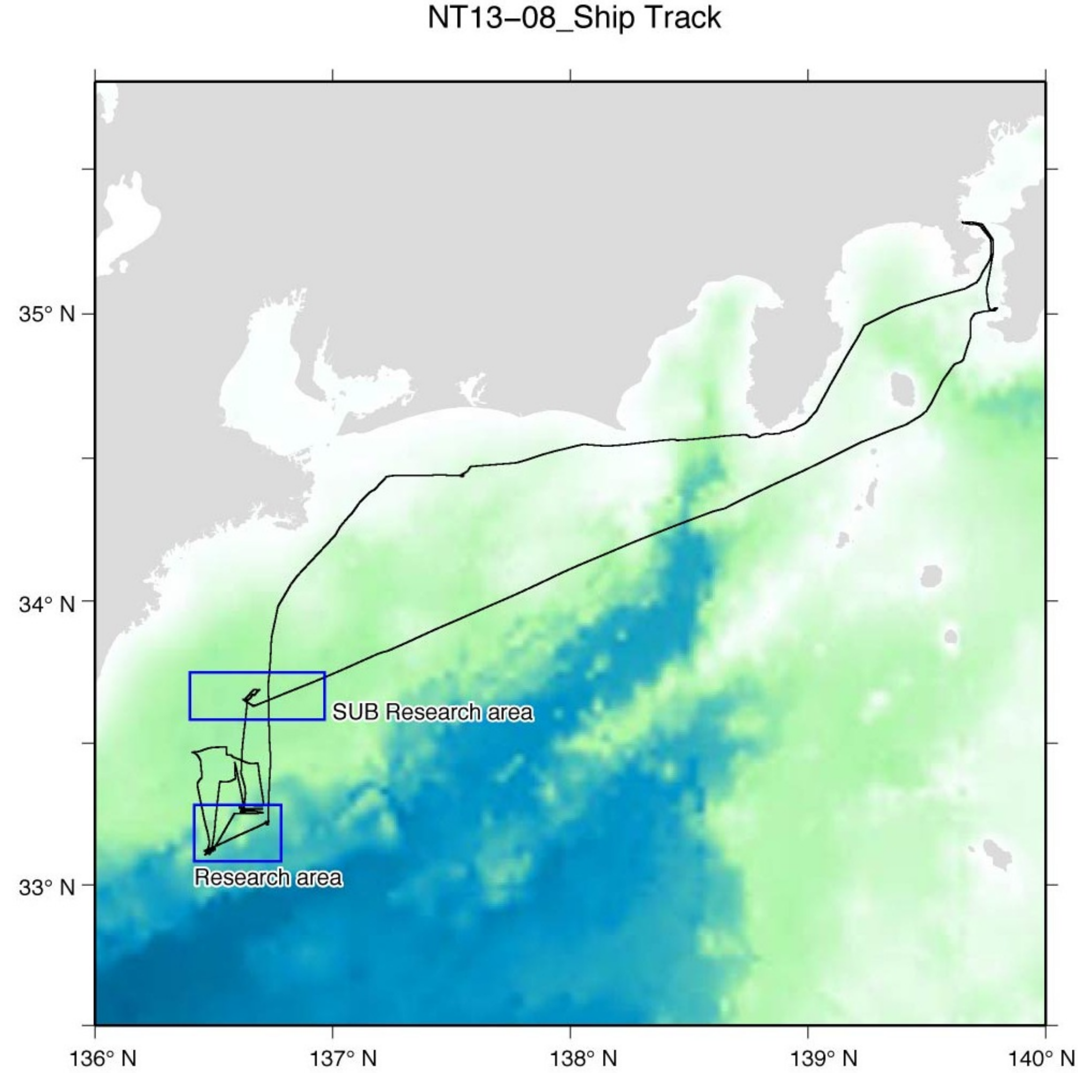
1-4. Title of proposal: Establishment of estimation method for fault activity history using sediment deformation by strong shaking and fluctuation monitoring of cold seep in the Mega-splay fault of the Nankai Trough off Kumano

1-5. Cruise period: April 13, 2013 to April 18, 2013

1-6. Ports of call: Yokosuka April 13, 2013), Yokosuka (April 18, 2013)

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

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



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3. Observation

3-1. Objectives and background

Purpose of this cruise is to establish estimation method for fault activity history using sediment deformation by strong shaking and to conduct fluctuation monitoring of cold seep in the Mega-splay fault of the Nankai Trough off Kumano.

Great earthquakes repeatedly occurred at intervals of around 100 to 200 years along the Nankai Trough. However, there is no geological evidence about which fault actually displaced during each earthquake. Recently, sediment deformations (mud breccia) possibly caused by strong shaking were discovered only at the hanging wall of the mega-splay fault during the IODP NanTroSEIZE drilling (Sakaguchi et al., 2011). Age of the youngest mud breccia layer correspond to 1944 Tonankai Earthquake. This suggests that study on distribution and formation age of mud breccia provides spatial and temporal constrains for earthquake faults. Moreover, our high-resolution subbottom profiling revealed the fault plane of the mega-splay fault that was previously not identified. This study aimed to establish estimation method for fault activity history using sediment deformation by strong shaking on the basis of the quantitative investigation about the distance between the position of the fault and the sampling point.

Another mission is to monitor fluctuations of fluid expulsion along the mega-splay fault using heat-flow measurements. 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. The purpose is to know the stress condition derived from cold seep activity in the great earthquake occurring area off Kumano. 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) by NT12-18 cruise and continued the seep monitoring from the summer of 2012.

Optional mission when we have surplus time after completion of scheduled dives is retrieval of long-term seep-meters installed by SONNE in 2012. The purpose of the monitoring is to obtain fluctuation of cold seep activity at mud volcanoes in the Kumano forearc basin.

3-2. Study Areas

Our primary target area for the studies of sediment deformation by strong shaking is Area A where a series of IODP drillings have been conducted. Area B is our fixed-point observation region where cold seep is active along the expression of the mega-splay fault at the surface of the seafloor. Area C is located at the landslide area where strike slip faults cut the southern margin of the forearc basin. Locations of these areas are the regions enclosed by the following latitudes and longitudes.

Area A （water depth：2,600m～2,850m）

33°11.0’N 136° 41.0’E

33°14.0’N 136° 45.0’E

Area B （water depth：2,400m～2,600m）

33°7.1’N 136° 28.5’E

33°7.5’N 136° 29.0’E

Area C （water depth：2,000m～2,300m）

33°14.5’N 136° 37.0’E

33°16.5’N 136° 39.0’E

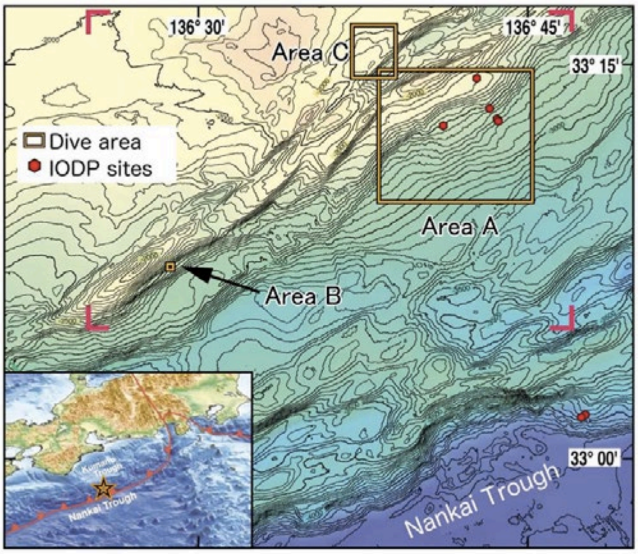


Fig. 3-2.1 Dive survey area map

The locations of CAT-meters deployed at the mud volcanoes are shown below.

CAT-A: 33°39.36’N, 136°38.05’E, 1977 m
CAT-B: 33°39.37’N, 136°38.05’E, 1978 m
CAT-C: 33°38.02’N, 136°40.25’E, 1952 m
CAT-D: 33°40.54’N, 136°55.28’E, 1955 m
CAT-E: 33°40.53’N, 136°55.28’E, 1950 m
CAT-F: 33°38.06’N, 136°40.26’E, 1945 m

We also planed swath bathymetric survey at the following two locations enclosed by the following latitudes and longitudes.

Nankai Trough off Kumano （water depth：2,000m～3,000m）
33°05.0’N 136°25.0’E
33°17.0’N 136°47.0’E

Kumano Forearc Basin （water depth：1,850m～2,050m）
33°35.0’N 136°24.0’E

33°45.0’N 136°58.0’E

3-3. Methods and Instruments

Operation: Our survey using HyperDolphin includes the following operations. More detailed information is presented in Chapter 4.

a. Seafloor observation by TV cameras
b. Sampling of sedimentary rocks
c. Niskin water sampling
d. Surface sediment core sampling by MBARI
e. Heat flow measurements by SAHF
f. Retrieval of long-term observation type SAHF
g. Retrieval of BTMS (Bottom-water Temperature Monitoring System)
h. Retrieval of PHF (Pop-up type heat flow meter)

Payloads carried into the ship by researcher

c. MBARI corer: Four MABRI corers are installed in the front basket of ROV
d & e. SAHF: One SAHF is carried for heat flow measurement and two SAHFs are planed to be retrieved.
f. BTMS: One BTMS is planed to be retrieved.
g. PHF: One PHF is planed to be salvaged.

3-4. Research results

3-4.1. Results of HPD Dive 1513

The purpose of this dive is to establish estimation method for fault activity history using mud breccia on the basis of the high-resolution SBP image. The dive route was planed to climb the slope formed by the mega-splay fault activity. The landing point is completely covered by muddy sediments. Ripple-like seafloor undulations are often observed until the end of the dive. Groove-like structures are also widely developed at the whole slope area. In most case they trend a down slope direction suggesting that some objects dragged the seafloor and left their traces. At a water depth of 2731 m, one MBARI (red, C1) core was taken from the footwall of the splay fault. We passed the estimated location where the splay fault is emergent to the seafloor, but did not find any seafloor expression such as undulation and step. MBARI (blue, C2) core was collected at the hanging wall side of the prism slope at a water depth of 2690 m. Two more cores (black and green, C3 and C4) were taken from the locations at the water depths of 2662 and 2619 meters respectively. There is basically no variation of seafloor morphology and lithology for the whole survey area. At a water depth of 2598 m, a dead shall cluster was found without bacterial mat. Although dead shells were highly fragmented, they seem not to be *Calyptogena* sp. The seafloor observation was suspended at the location 150 m upslope of this shell cluster and restarted from the hanging wall side a a water depth of 2630 m to the shallowest survey point at a water depth of 2474 m. The seafloor was completely covered by soft muddy sediment without specific deformation structure. We jumped down from this site to the location where the dead shell cluster was observed and restarted the seafloor survey along the depth contour line to find out some cold seep indications. The seafloor at a water depth around 2580 m, however, shows no indication of cold seep. We finally conducted Niskin-water sampling to collect the standard seawater for noble-gas analysis (see Chapter 5 for detail).

In conclusion we successfully collected four surface sediment core samples without artificial disturbance for the study of estimation method of fault activity history using mud breccia at the footwall and the hanging wall of the mega-splay fault.

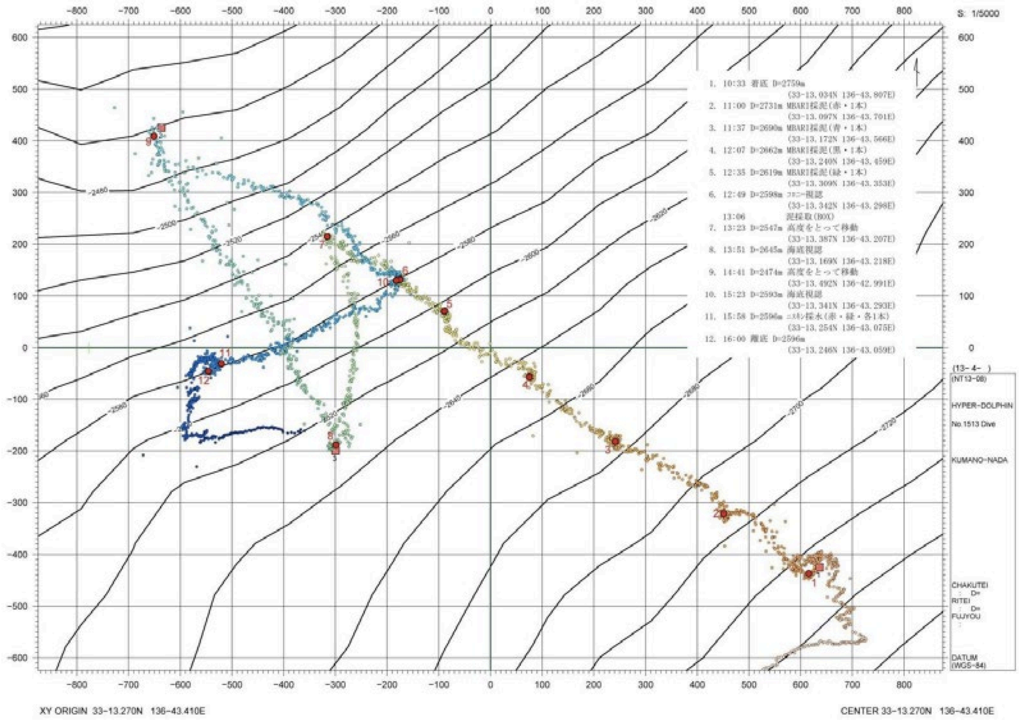


Fig. 3-4.1 ROV track of HPD Dive 1513

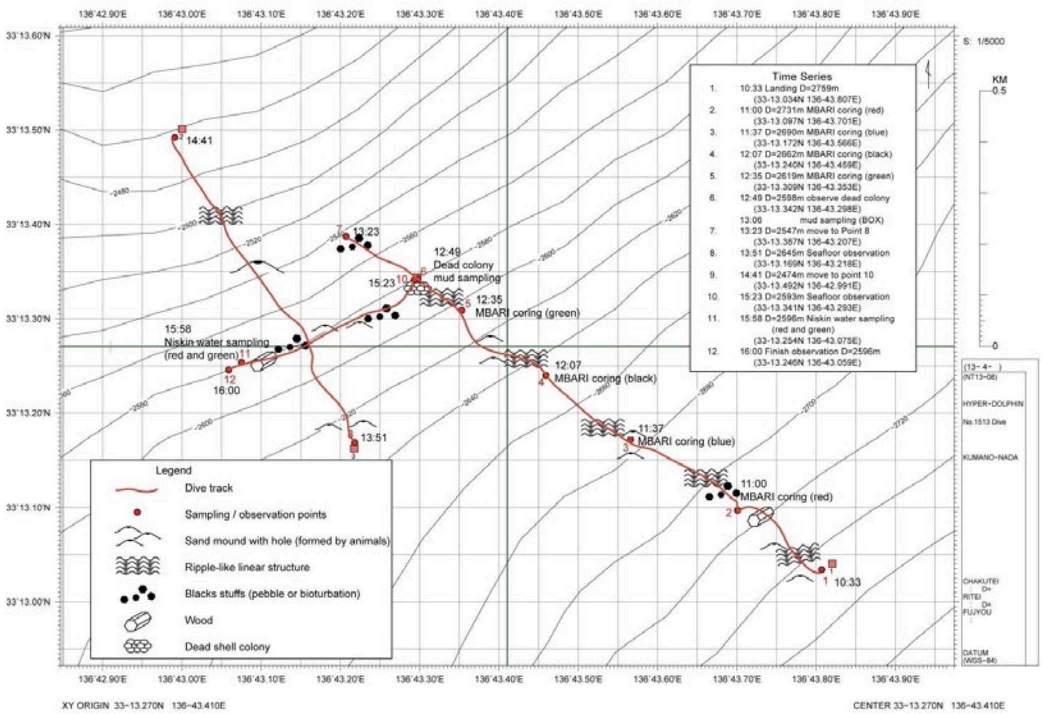
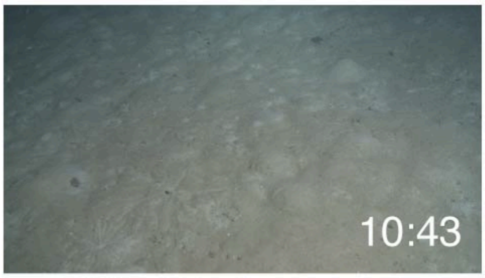


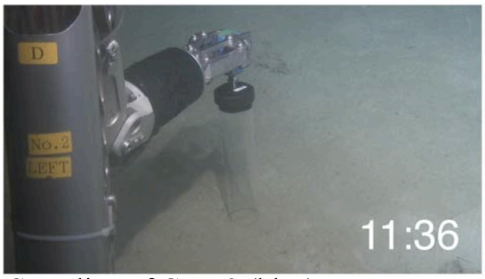
Fig. 3-4.2 Route map of of HPD Dive 1513

Dive #1513

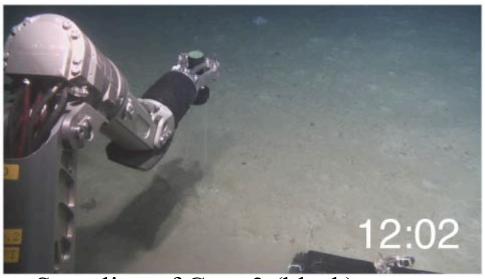


Seafloor of the landing point

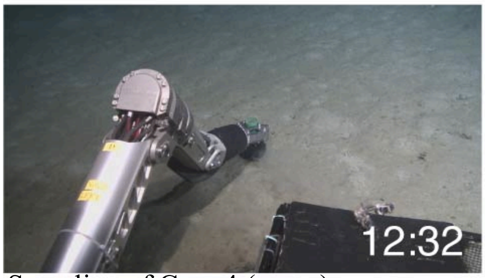
Sampling of Core 1 (red)



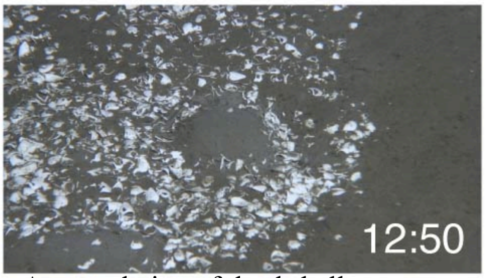
Sampling of Core 2 (blue)



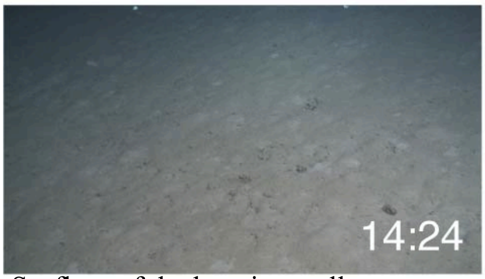
Sampling of Core 3 (black)



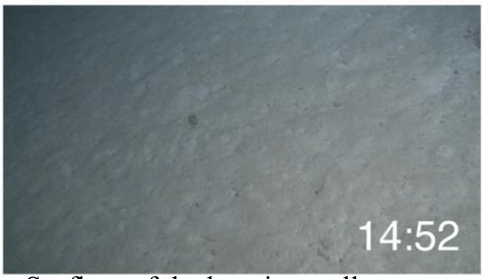
Sampling of Core 4 (green)



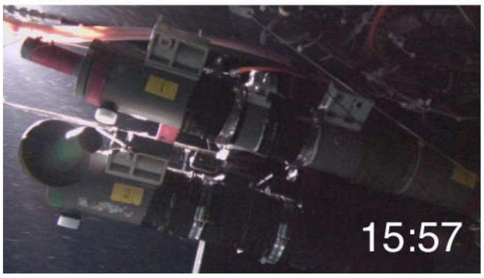
Accumulation of dead shell



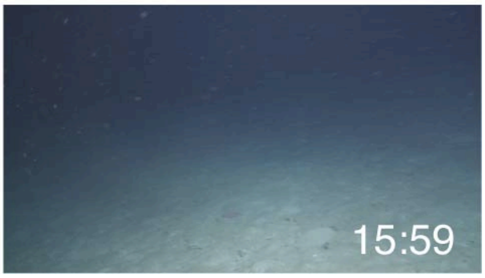
Seafloor of the hanging wall



Seafloor of the hanging wall



Niskin water sampling



Seafloor of the dive end

Fig. 3-4.3 Photos during HPD Dive 1513

3-4.2. Results of HPD Dive 1514

The purpose of this dive is to retrieve temperature-monitoring tools at the cold seep site of the mega-splay fault scarp 20 km southwest of NanTroSEIZE drilling area. In order to compare with the monitoring data, heat flow measurements by SAHF were scheduled. In addition, we planes to take sediment and seawater samples for noble-gas analysis (see Chapter 5 for detail). The landing point located at the footwall of the fault scarp is completely covered by muddy sediments. One Niskin water sampling was conducted at this landing point. We climbed the slope while searching the instruments. Fragments of rocks and shells were gradually increase in the surface sediments toward the uphill. We found SAHF#1 at the reference site 70 m upslope of the landing point. One MBARI core (blue, C1) was collected before retrieving of SAHF#1. Short-term heat flow measurement by SAHF was done at the same locality. The BTMS and SAHF#2 were found from the reference site by the deepsea camera during the retrieval operation. Retrieval of the BTMS and heat flow observation by SAHF were conducted. This site is characterized by patchy distribution of bacterial mats and talus deposits mainly composed of mudstone granules. One Niskin water sampling was done before a series of MAMARI core sampling. Three MBARI cores (Red, Black and Green, C2, C3 and C4) were taken from the bacterial mat area for noble-gas analysis. The last mission of this locality was the retrieval of SAHF#2. To save the dive time we jumped to the estimated position of the Pop-up type Heat Flow Meter (PHF deployment). We successfully found out the PHF and carefully caught it back to R/V “Natsushima”.

In conclusion we successfully retrieved all instruments for long-term heat-flow monitoring, measure current heat flow at two locations (see Chapter 4 for detail), obtained four core samples and bottom water for noble-gas analysis.

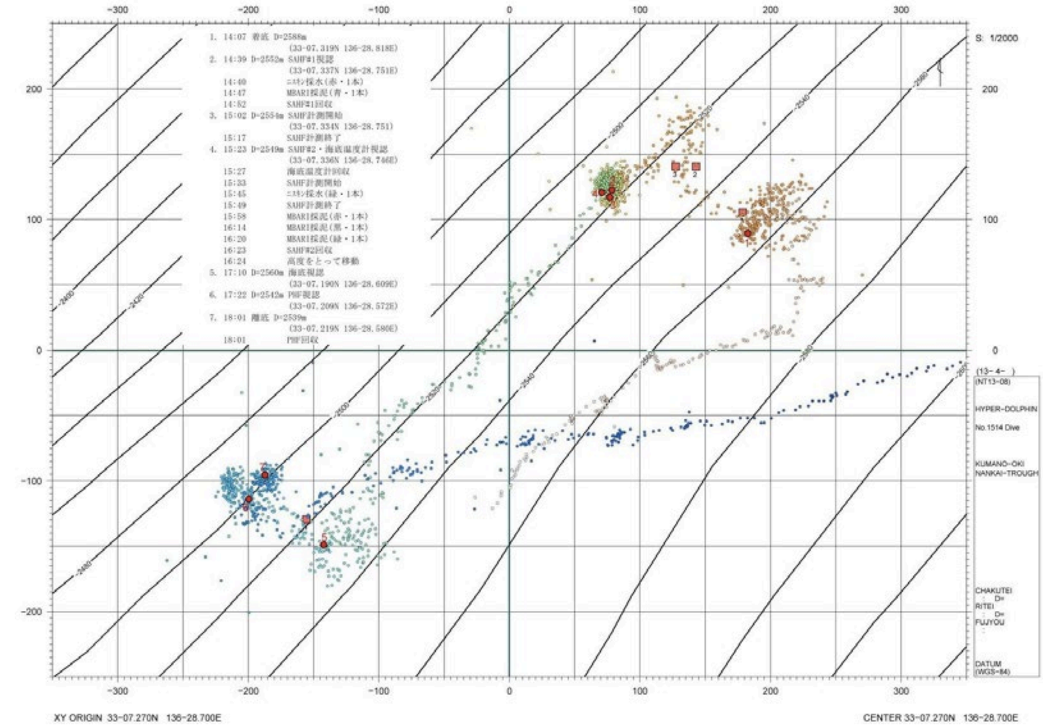


Fig. 3-4.2.1 ROV track of HPD Dive 1514

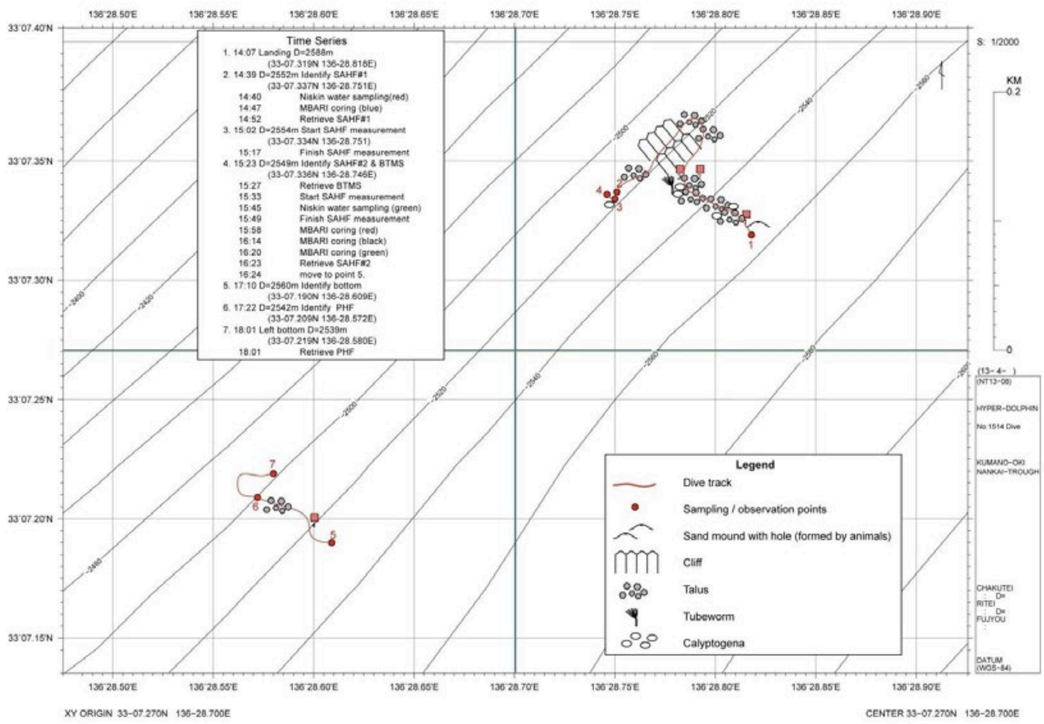
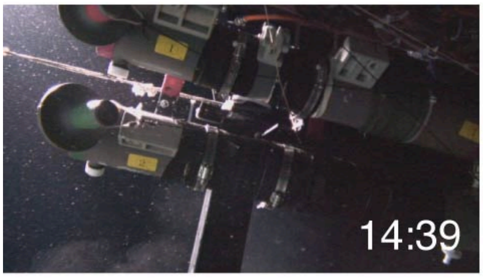


Fig. 3-4.2-2 Route map of of HPD Dive 1514

Dive #1514

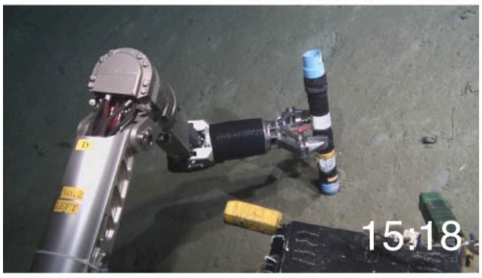
Seafloor of the landing point

Finding of SAHF#1

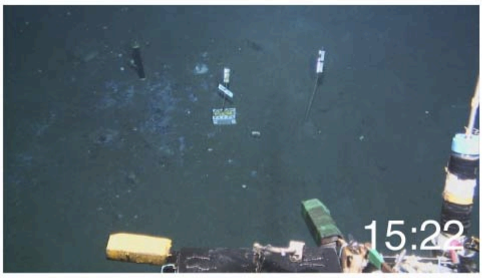


Niskin water sampling

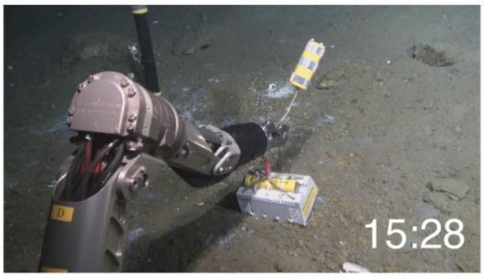
Sampling of Core 1 (blue)



SAHF heat flow measurement

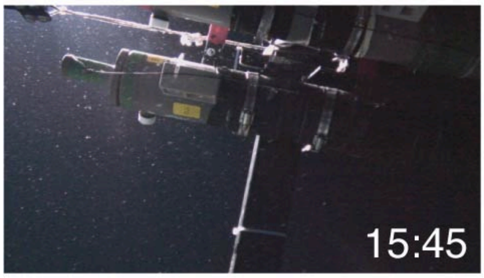


Finding of SAHF#2 and BTMS



Retrieval of BTMS

SAHF heat flow measurement

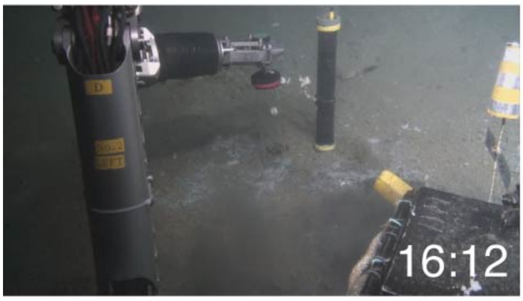


Niskin water sampling

Sampling of Core 2 (red)

Fig. 3-4.2-3 Photos during HPD Dive 1514

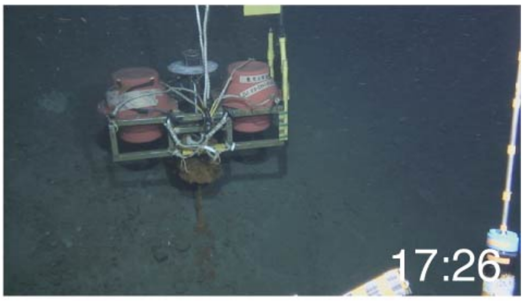
Dive #1514



Sampling of Core 3 (black)

Sampling of Core 4 (green)

Retrieval of SAHF#2



Retrieval of PHF

Fig. 3-4.2-4 Photos during HPD Dive 1514

3-4.3. Results of HPD Dive 1515

Because we completed two missions for core sampling of strong shaking deformations and retrieval of temperature-monitoring tools at the cold seep site along the mega-splay fault, we conducted an auxiliary plan studying the submarine landslide associated with active faults located at the southern margin of the forearc basin. The purpose of this dive is to understand detailed surface deformation structures corresponding to the sidescan sonar images and obtain evidence about the timing of landslide and cold seep activity along a fault or a fracture. The dive route was planed to climb the slope from the depression located at the outer ridge to the southern edge of the forearc basin. The landing point is completely covered by muddy sediments. One Niskin water sampling and one MBARI core (Green, C1) was conducted for sediment logical study at this landing point. Dive observation was conducted toward the upslope from the water depth of 2123 m to 2053 m. Accumulation of mudstone granules were partly observed. Two MBARI cores (Blue and Black, C2 and C3) for sediment logical study were collected from the normal seafloor at water depths of 2080 m and 2073 m, respectively. Because we found a seabottom cable, ROV went across it keeping a safety altitude. Samples were collected from the fallen rock (R1) at a water depth of 1993 m. In order to investigate the middle slope carefully we jumped down to the water depth of 2050 m and restarted the observation toward upslope. Samples were collected from the fallen rock (R2, R3 and R4) at a water depth of 1984 m. An artificial gutter-like structure was observed at the northern end of the slope. One Niskin water sample and one MBARI core (red, C4) were collected for noble-gas analysis at the water depth of 1975 m.

In conclusion we did not get any evidence of landsliding except for gentle undulation of seafloor, but successfully obtained three surface sediment cores for sedimentological study. We also took sediment and bottom water sample for noble-gas analysis (see Chapter 5 for detail).

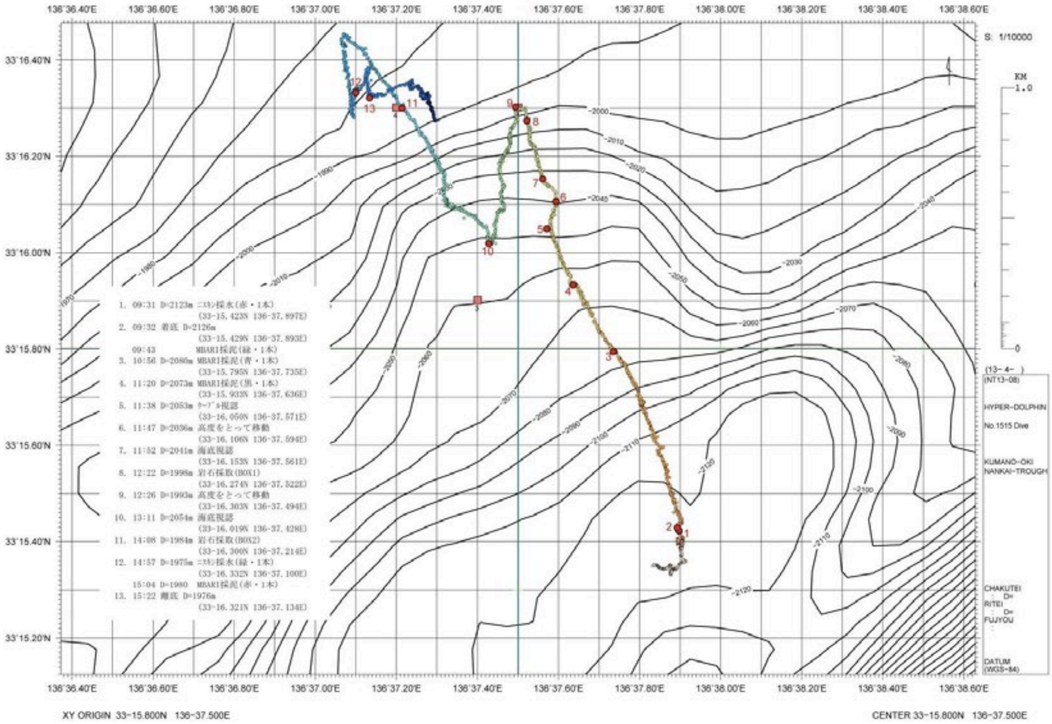


Fig. 3-4.3.1 ROV track of HPD Dive 1515

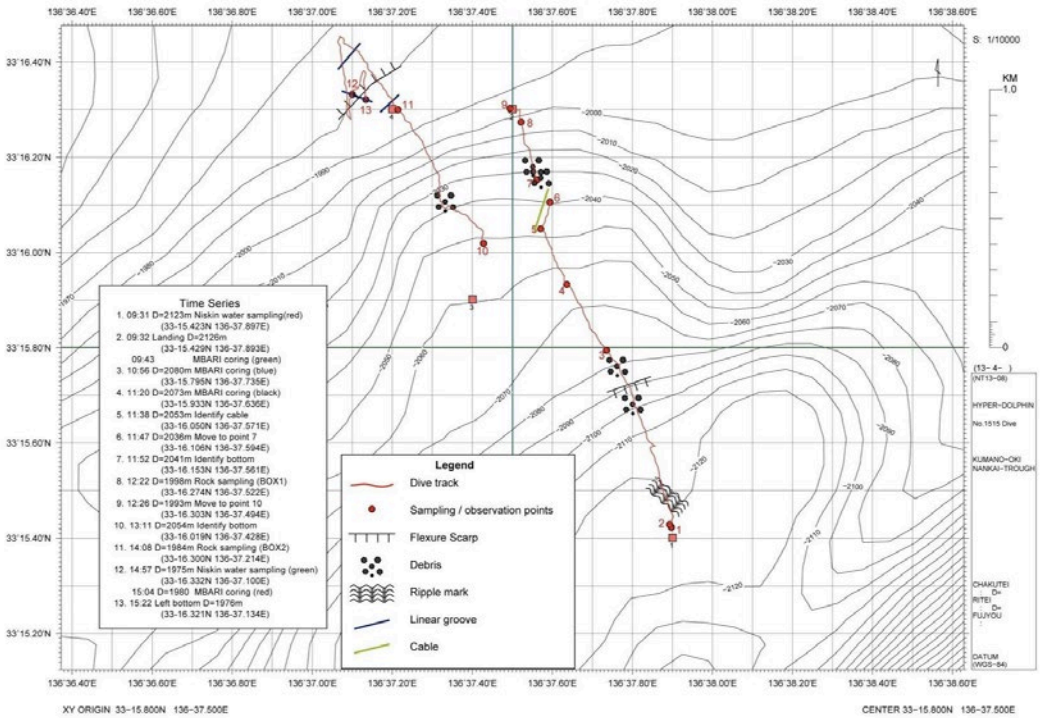
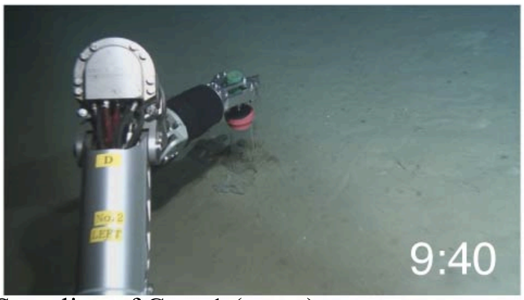
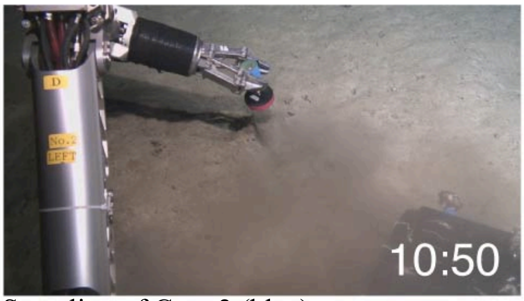


Fig. 3-4.3.2 Route map of of HPD Dive 1515

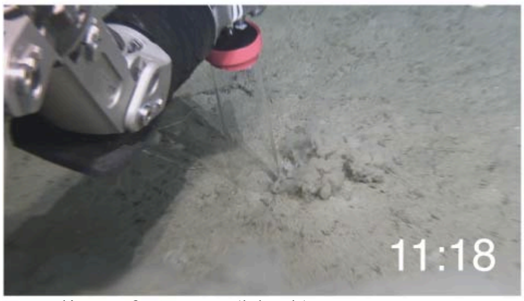
Dive #1515



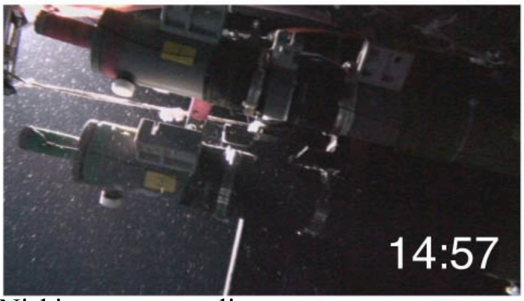
Sampling of Core 1 (green)



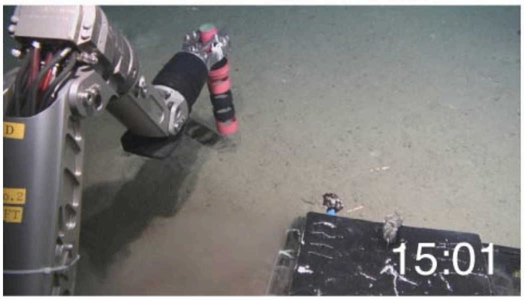
Sampling of Core 2 (blue)



Sampling of Core 3 (black)



Niskin water sampling



Sampling of Core 4 (red)

Unidentified gutter-like mark on the seafloor

Fig. 3-4.3.3 Photos during HPD Dive 1515

3-4.4. Core Sample

Coring List

Dive #	Core #	Long. (+E)	Lat. (+N)	Depth (m)	core length (cm)	MBARI Color	distribution
1513	C1	136°43.701'	33°13.097'	2732	26	Red	AORI
1513	C2	136°43.566'	33°13.172'	2690	25	Blue	AORI
1513	C3	136°43.459'	33°13.240'	2662	27	Black	AORI
1513	C4	136°43.353'	33°13.309'	2619	20	Green	AORI
1514	C1	136°28.751'	33°07.337'	2552	20	Blue	Tomonaga
1514	C2	136°28.746'	33°07.336'	2549	20	Red	Tomonaga/AORI
1514	C3	136°28.746'	33°07.336'	2549	20	Black	Tomonaga/AORI
1514	C4	136°28.746'	33°07.336'	2549	20	Green	Tomonaga
1515	C1	136°37.893'	33°15.429'	2126	18	Green	AORI
1515	C2	136°37.735'	33°15.795'	2080	18	Blue	AORI
1515	C3	136°37.636'	33°15.933'	2073	26	Black	AORI
1515	C4	136°37.100'	33°16.332'	1980	20	Red	Tomonaga

Table 3-4.4.1 Core sample list

3-4.5. Rock Sample

All rock samples are pumices interpreted to be rafted from the Izu-Bonin islands.

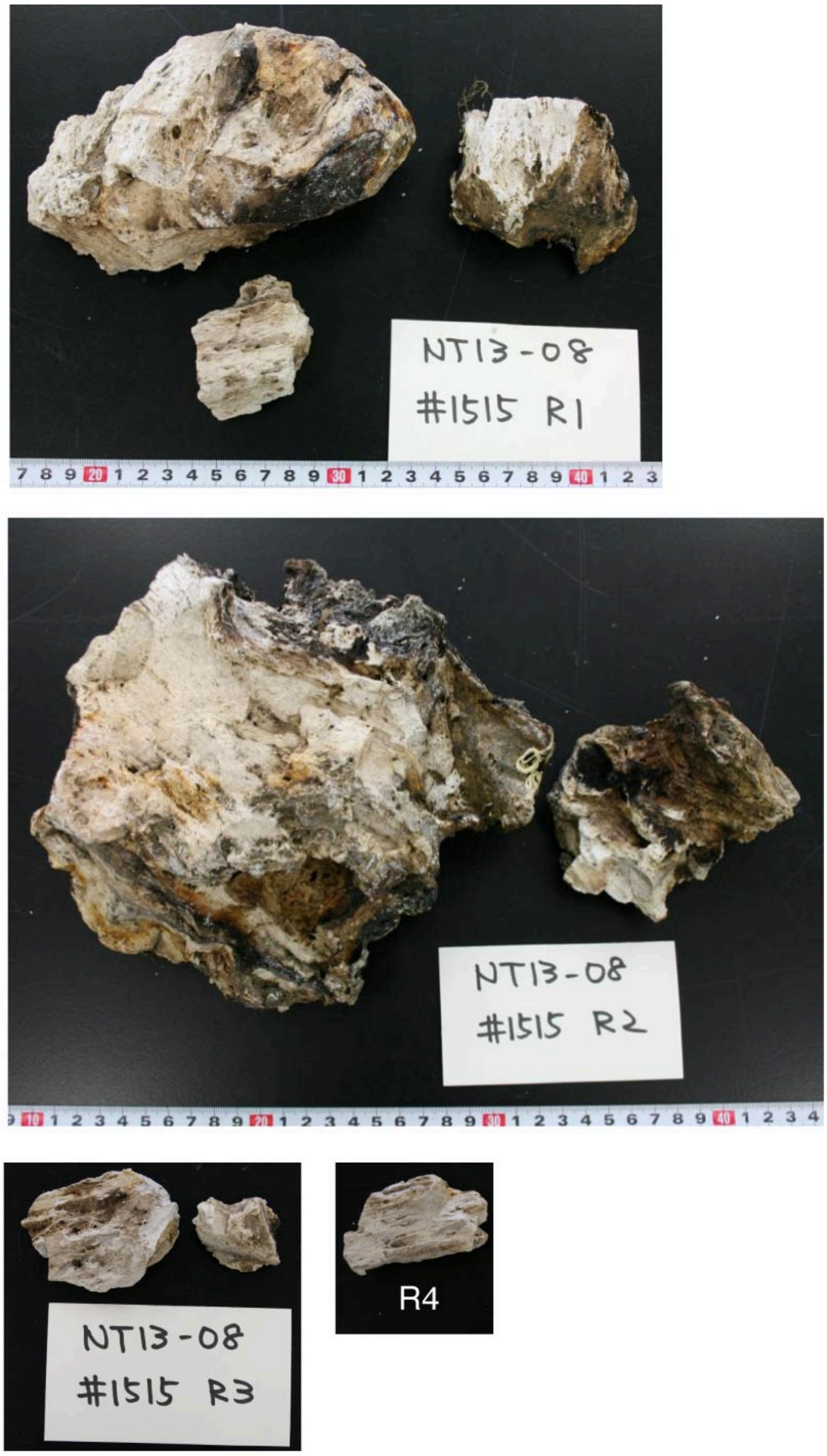


Fig. 3-4.5.1 Photos of rock samples

3-5. CAT-meter retrieval

We conducted retrieval of CAT-meters because we had four hours' extra time before departure from the survey area to the port call. No. 5, 6, 8 and 10 CAT-meters were retrieved by acoustic release from the summits of mud volcanoes. We confirmed that bottom water is successfully sampled in coiled tubes and are working on estimation of cold seep activity by shore-based chemical analysis.

Fig. 3-5.1 One of retrieved CAT-meters

3-6. Bathymetric survey

Swath bathymetric survey of Area C was conducted at the night of April 14. The area is the dive site of HPD 1515 (Fig. 3-5.2).

Acknowledgements

We would like to thank both officers and crew of the R/V Natsushima and the team of ROV HyperDolphin for their skillful shipboard operations. Thanks are due to all shorebased supporting staffs of JAMSTEC for their various kinds of assistance.

References

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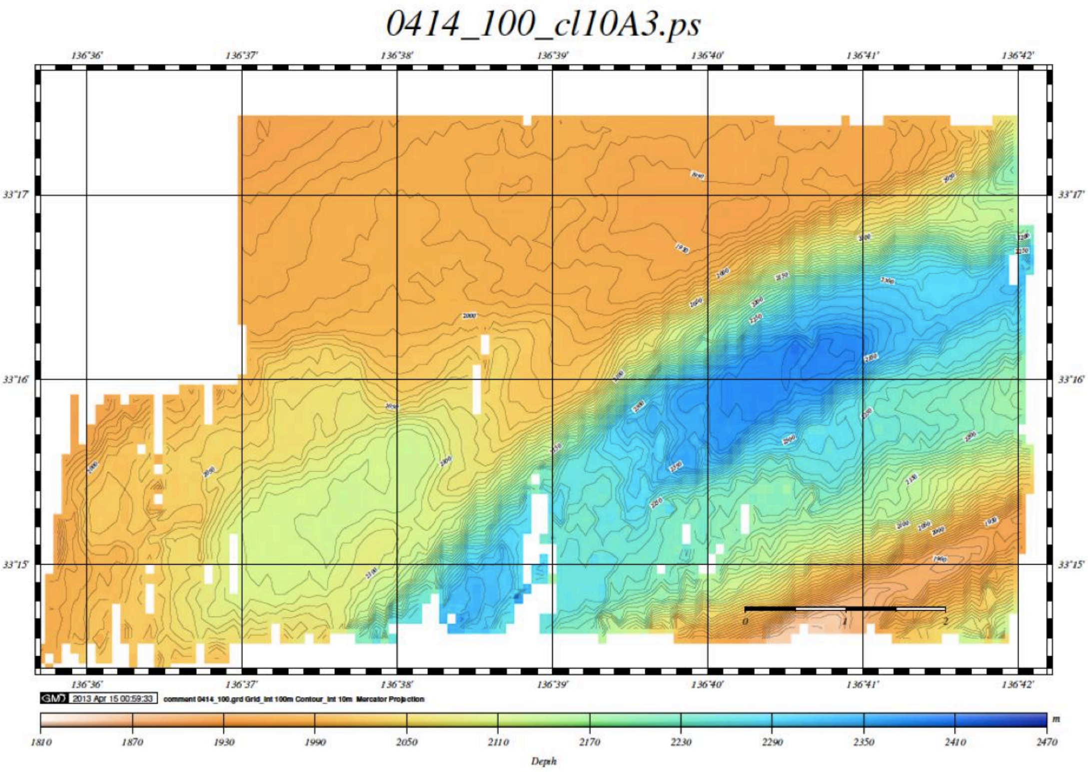

Fig. 3-5.2 Bathymetric map of Area C

4. Long-term temperature measurement

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4-1. Objective

Fluid discharge rate from accretionary prisms gives information on sub-seafloor pore pressure that is crucial to the deformation of accretionary prisms as well as the strength of seismic faults (e.g., Saffer, 2003). Near the deformation front of the Nankai Trough off Kumano, extensive fluid discharge has been observed both by visual surveys (Ashi et al., 2002) and analyses of pore water chemical species (Toki et al., 2004). Since 2010, sub-seafloor temperature at various depths, 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.

In the present cruise, we retrieved two 50-cm long heat-flow probes and a bottom-water thermometer deployed in mid-2012 (NT12-08). In addition, we retrieved a pop-up type heat-flow probe (with a 2-m long probe) deployed in late-2011 (KH-11-9). Because its pop-up mechanism has not been work, a remotely operated vehicle (ROV) was used to rescue the instrument.

4-2. Instruments

4.2.1 Stand-alone heat-flow meter (SAHF)

Stand-Alone Heat Flow meter (SAHF; Kaiyo Denshi Co.) measures both sub-seafloor temperature gradients and in-situ thermal conductivity (Fig. 4.1 and Table 4.1; Kinoshita et al., 2006); the instrument is handled by ROVs or MUVs. Main components of SAHF are a pressure case and a probe. The pressure case contains an electric circuit including a data logger, a two-axis tilt meter, a magnetic switch (for a line heater), and a Li-ion battery pack. A serial port is emplaced at the upper side of the pressure case. The 60 cm long probe includes five post-calibrated thermistors with an 11 cm interval, along which a line heater driven by a constant voltage is installed. The temperature resolution is 1 mK with an accuracy of 10 mK.

The instrument records sub-seafloor temperatures (precisely, electric resistances) at a preset time interval (10-60 minutes for long-term deployments). 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 both 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 is usually used for long-term deployments).

4.2.2 Bottom-water temperature meter (BWT)

Bottom-water thermometer (BWT; Nichiyu Giken Kogyo Co.) records near-seafloor temperature at a specified time interval (set in advance; usually 10-20 minutes). The pressure case contains a temperature sensor, an electric circuit (A/D converting and data logging), and a Li-ion battery pack (Fig. 4.2). BWT is either deployed independently with a polyvinyl chloride (PVC) block and scrap iron (the total weight is *ca.* 10 kg) or deployed with a large instrument (in this case BWT is bundled with the frame of the large instrument).

4.2.3 Pop-up heat-flow meter (PHF)

Pop-up heat flow meter (PHF; Kaiyo Denshi Co.) is designed to measure sub-seafloor temperatures for more than one year. Main components of PHF are a recording unit, a mechanical release unit, a temperature probe, and weight (Fig. 4.3). The release mechanism works in response to the coded acoustic signals. The instruments have been used for heat flow measurement in relatively shallow sea areas where temporal variation of the bottom water temperature significantly disturbs temperature distribution in surface sediment (Hamamoto et al., 2005).

The temperature probe is 2 m long and has eight post-calibrated thermistors at even intervals. The recording unit records measurement time, temperatures (precisely, electric resistance), and two-axis instrument tilts. The temperature resolution is 1 mK. On deployment, the instrument is clamped with a ROV and released from it above several tens of meters above the target seafloor. For accurate determination of the temperature profile in sediment, it is necessary to calibrate the temperature sensors by measuring the deep-water temperature, which is spatially quite uniform. We usually keep PHF at a constant depth and measured the water temperature before penetration into sediment. On recovery, the PHF releases the weight and temperature probe responding to an acoustic command, and the recording unit pops up and can be recovered with a surface ship.

4.3 Operation

4.4.1 Retrieval of SAHF/BWT and short-time measurements of SAHF

Two SAHFs and one BWT were successfully retrieved (Table 4.2) using an ROV, Hyper Dolphin 3000, of JAMSTEC. One of the SAHFs (SHF2) and BWT had been deployed on a bacterial mat since Jul. 2012 (NT12-18) (right panel of Fig. 4.4). The other SAHF (SHF1) had been deployed on a normal seafloor as a reference, where biological activity was not pronounced (left panel of Fig. 4.4).

Short-time temperature measurements were conducted at two points (Table 4.3): one (#1) on a bacterial mat near SHF2 (right panel of Fig. 4.5), and the other (#2) between the bacterial mat and the reference SHF1 (left panel of Fig. 4.5).

4.4.2 Retrieval of PHF/BWT

During the cruise KH-11-9 (Nov. 2011; Table 4.2), a PHF was deployed near an outcrop-sediment interface where fluid discharge is expected, using the navigated sampling system (NSS; an ROV) of AORI, University of Tokyo. The deployment looked successfully at least from the NSS camera view from above; the probe penetrated into the sediment vertically or sub-vertically. The instrument was to have been retrieved during the cruise NT11-23 (Nov. 2012), using the acoustic self-pop-up mechanism. However, the retrieval was failed probably because of an accident within the mechanical release unit. The acoustic system responded to send signals that the release was finished, but the slant range was maintained to constant. At December 2011 during the cruise KT-12-30, the acoustic system still worked to show the original position; the instrument had been stayed at the point of deployment since it received the release signal.

In the present cruise, we planned to retrieve PHF by separating the main body and the probe/weight forcefully, using the ROV, Hyper Dolphin 3000. We found the instrument on the seafloor at the deployed position (Fig. 4.6): the lower three-quarter of the probe was penetrated into the sediment, whereas the remaining probe and the main body were above the seafloor. The probe/weight comprising of steel (not stainless steel) was fully covered by yellow or amber rust, but the main body comprising of titanium was free from rust. First, a number of steel weights was attached to the main body; those can cancel buoyancy of the main body even without the probe/weight. During this operation, the probe/weight was released from the main body, suggesting that a mechanical shock during the operation switched on the mechanical releaser. On ascending, the ROV hanged the main body below it with a nylon rope of several tens of meters long.

4.4 Preliminary Results

4.4.1 SAHF/BWT

Nine-month long temperature records (between Jul. 2012 and Apr. 2013) are obtained from the retrieved SAHFs and BWTs (Fig. 4.7). Fluid flow velocities and thermal diffusivity can be estimated at the deployed points, using the method of Goto et al. (2005) applied to the data. In addition, temperature rise caused by a line-heater was recorded in the SAHFs. In-situ thermal conductivity at these points can be estimated using these records (e.g., Carslaw and Jaeger, 1959).

Short-time temperature measurements of two points were successfully done (Fig. 4.8). Comparing these data with SHF1 and 2 will give information on spatial heterogeneity of sub-seafloor temperature field around the bacterial mat.

4.4.2 PHF/BWT

Temperature record only between the deployment (Nov. 2011) and early 2012 (Mar. 2012) was obtained (Fig. 4.9). Six of eight thermistors were below the seafloor, and they recorded sub-seafloor temperatures during that time. The other two thermistors were above the seafloor, and they recorded bottom-water temperature. We can see that the change in the bottom-water temperature penetrates deep into the seafloor. Precise analysis can derive flow rate and its time dependence at the deployed point (Goto et al., 2005). Between Mar. 2011 and Nov. 2011 at which the release signal was received, the temperature record of all the eight sensors fluctuates around improper values. A thermistor placed at deeper depth tends to brake-down earlier, suggesting that an anoxic environment at deeper depth influences the brake-down of the thermistors. After Nov. 2011, temperature record is over-scaled, suggesting that the thermistor cable was cut from the main body in response to the release signal. Although the release command cut the thermistor wire, it did not move the mechanical releaser.

BWT records the seafloor temperature between Nov. 2011 and Mar. 2013 at which the memory was full (Fig. 4.9).

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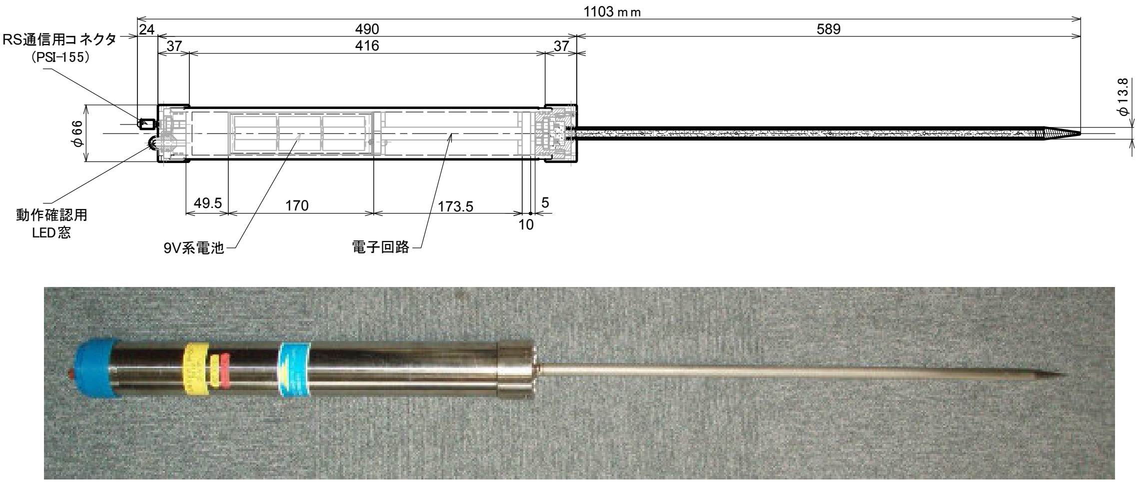

Fig. 4.1 Schematic configuration (top) and a photograph (bottom) of SAHF.

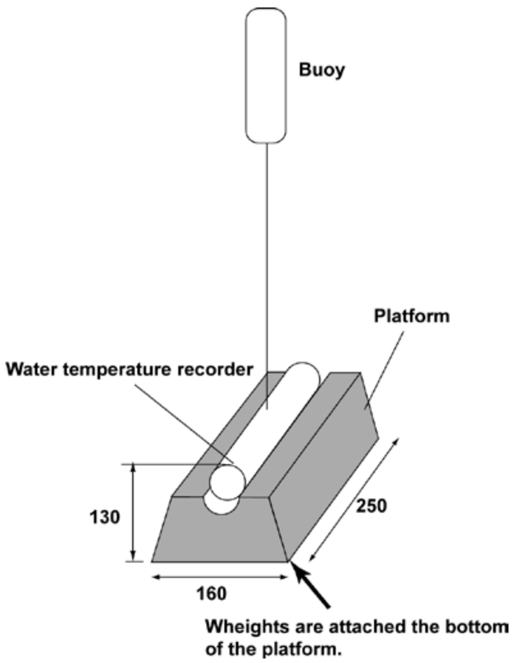

Fig. 4.2 Schematic configuration of BWT.

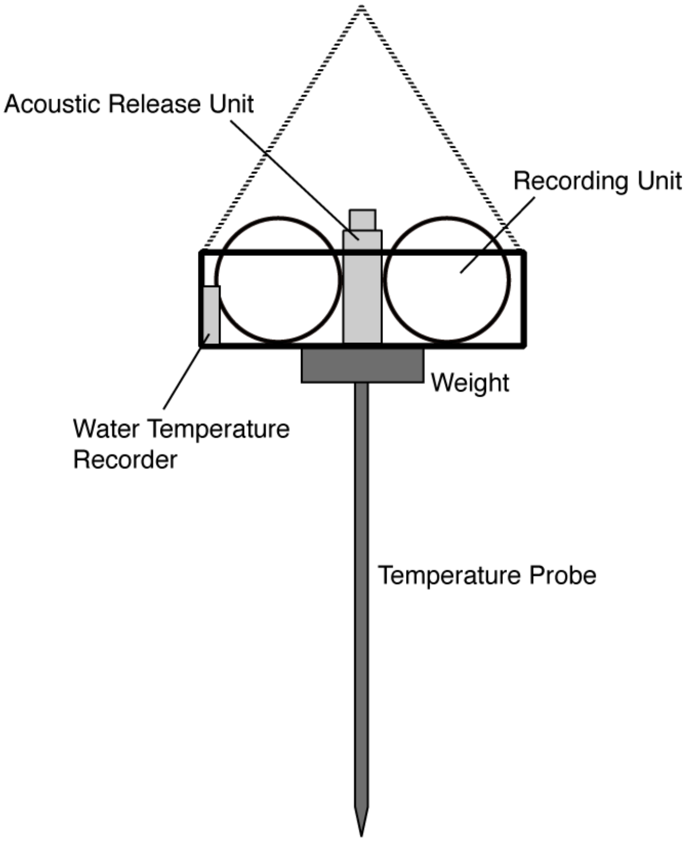

Fig. 4.3 Schematic configuration of PHF.

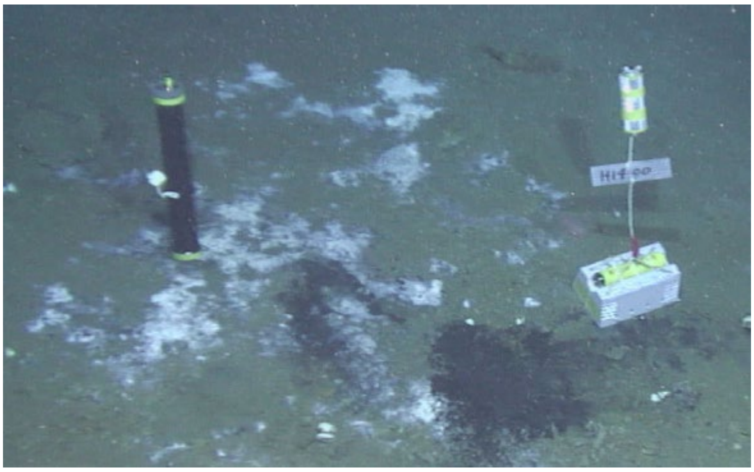

Fig. 4.4 (left) Photo of retrieved SAHF (SHF1) on reference site. (right) Photo of retrieved SAHF (SHF2) and BWT on a bacterial mat.

Fig. 4.5 (left) Short-time SAHF measurement #1. (right) Short-time SAHF measurement #2 (blue-capped one located on the left). Note that the yellow-marked SAHF on the right is the retrieved SAHF (SHF2).

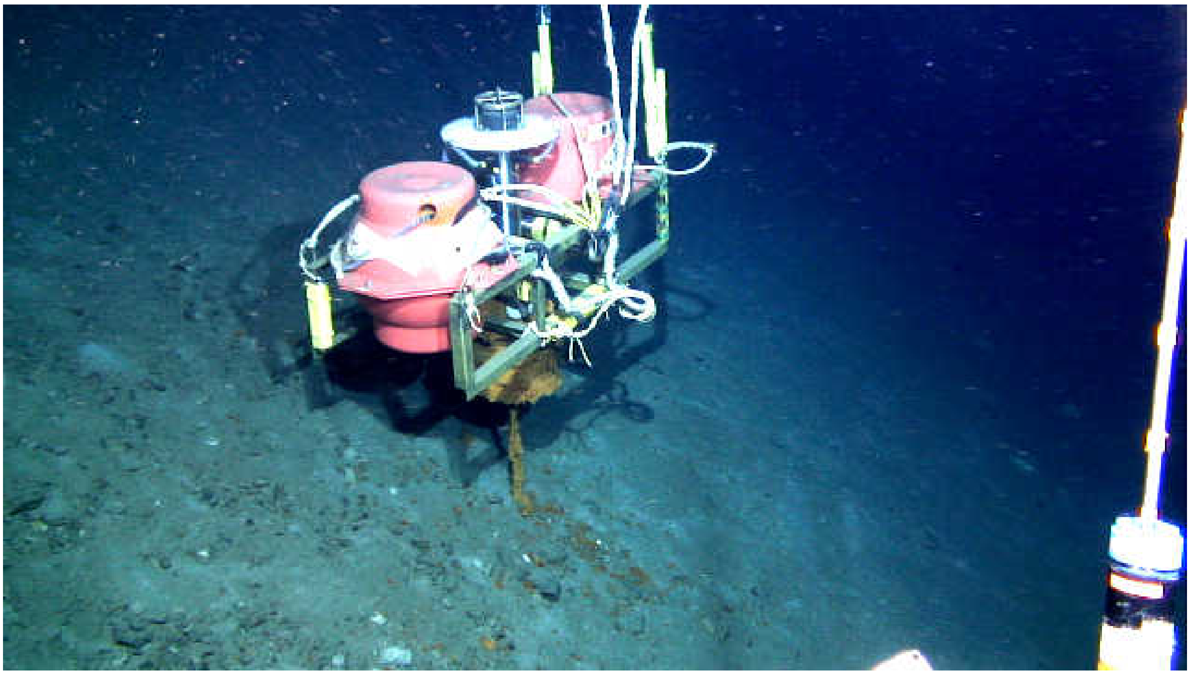

Fig. 4.6 Retrieved PHF.

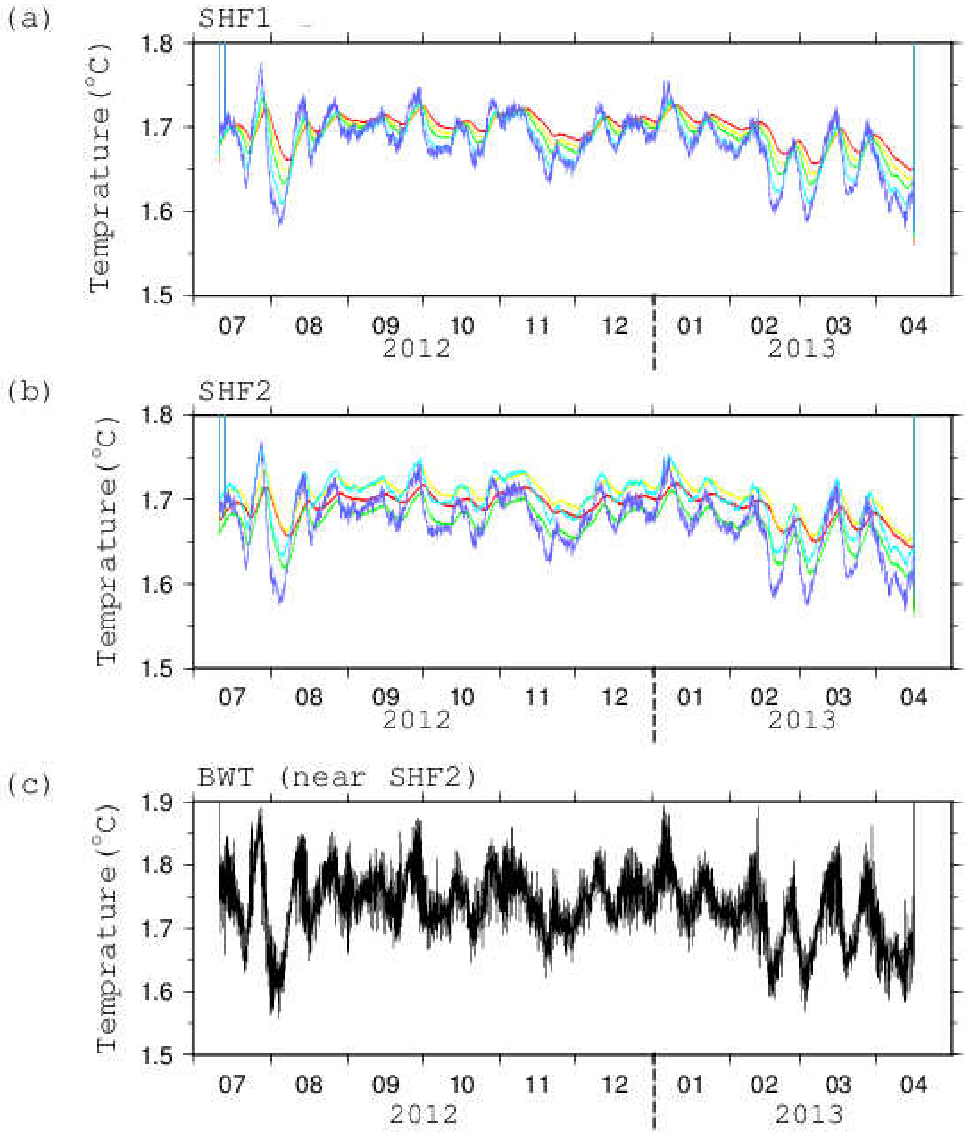

Fig. 4.7 Temperature time series of the retrieved SAHFs and BWT. (b) SAHF deployed at a reference site (SHF1). (a) SAHF deployed on a bacterial mat (SHA2). (c) BWT deployed near SHF2.

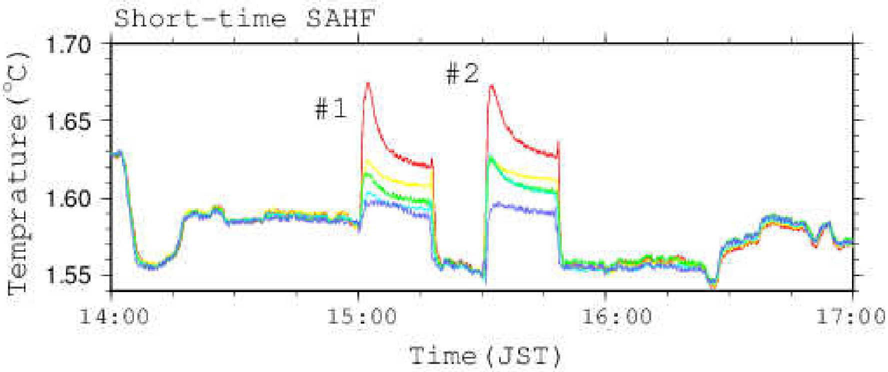

Fig. 4.8 Temperature time series of short-time SAHF measurements. #1 and #2 denotes the two measurements.

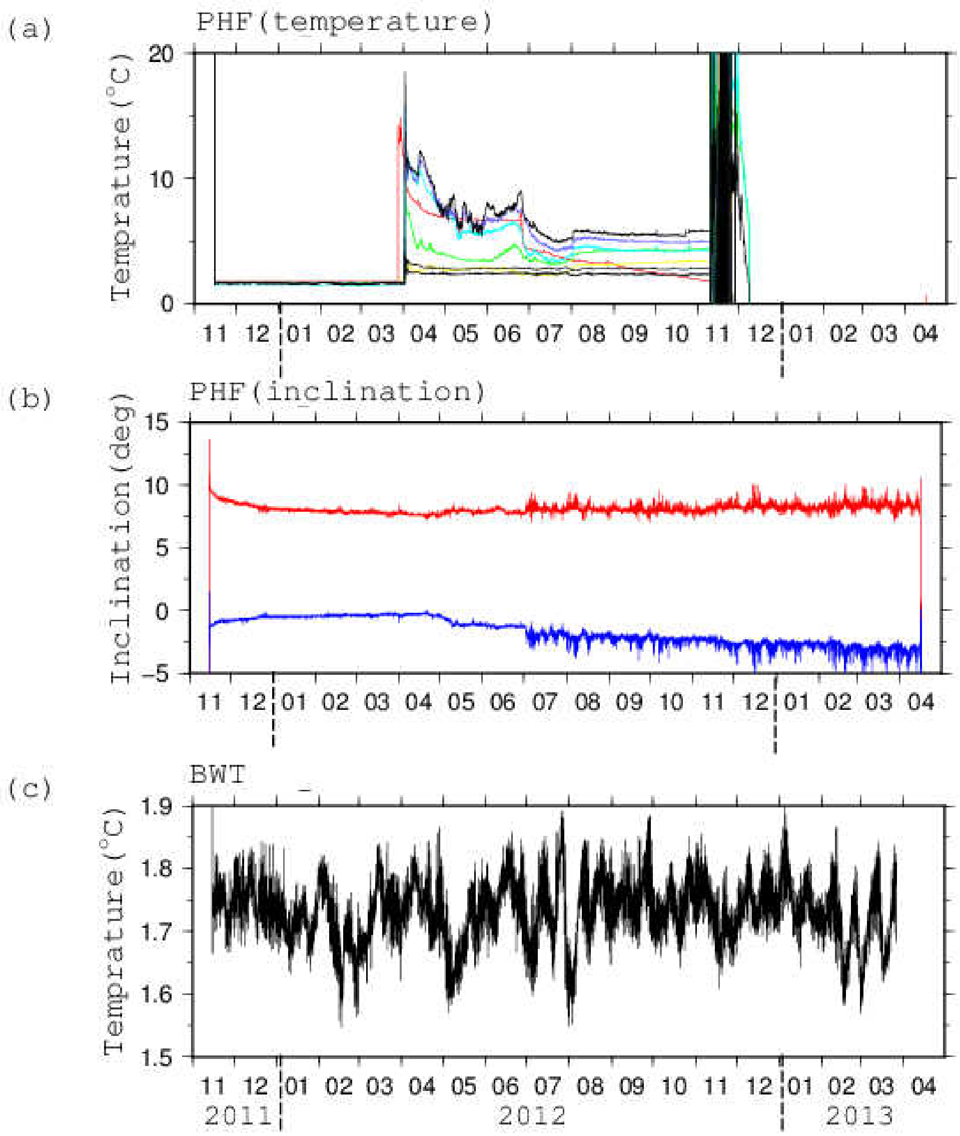

Fig. 4.9 Time series of the retrieved PHF and BWT. (a) Temperature of PHF, (b) two-axis tilt of PHF, and (c) Temperature record of BWT.

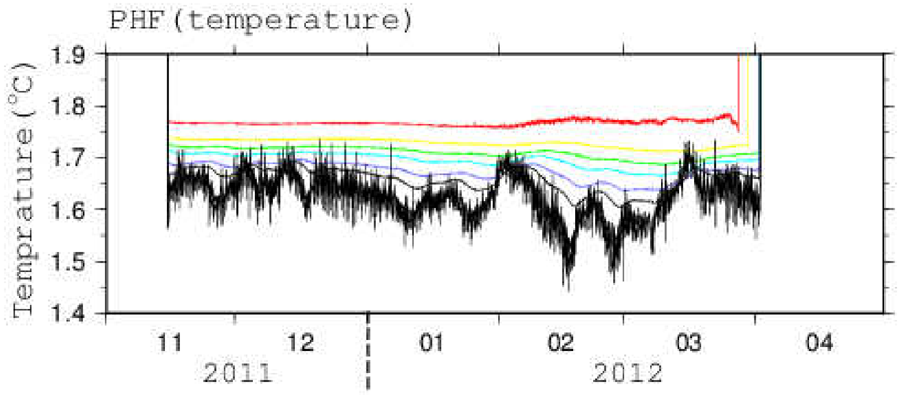

Fig. 4.10 Time series of PHF (close up).

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 Retrieval of instruments

Station	Deployment	Recovery	Coordinates	Depth (m)
SHFn1	Jul. 11, 2012	Apr. 11, 2013	33°07.337'N, 136°28.751E	2552
SHFn2	Jul. 11, 2012	Apr. 11, 2013	33°07.336'N, 136°28.746E	2549
BWT(#164)	Jul. 11, 2012	Apr. 11, 2013	33°07.336'N, 136°28.746E	2549
PHF	Nov. 15, 2011	Apr. 11, 2013	33°07.209'N, 136°28.572E	2542

(w BWT)	

Table 3.3 Short-time SAHF measurements

Station	Date	Start	End	Coordinates	Depth (m)
#1	Apr. 11, 2013	15:02	15:17	33^o07.334'N, 136^o28.751E	2554
#2	Apr. 11, 2013	15:33	15:49	33^o07.336'N, 136^o28.746E	2549

5. Sampling of water and sediments for noble-gas analysis (Project NoGOS)

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In order to widen and further stimulate the use of noble-gas geochemistry in the sediment pore water the project NoGOS (NOble Gases in Ocean Sediments as proxies for fluid transport at subduction zones and past climate conditions, a Marie Curie International Outgoing Fellowship, Grant Agreement 332404) aims to systematically apply the analytical state-of-the-art to ocean sediments.

One of the major goals of the project is to study the fluid transport in forearc regions off shore Japan. A first sampling region is located close to the epicenter of the devastating Tohoku earthquake occurred in 2011 and the second sampling region close to the Nankai Trough which is expected to hit by an earthquake in the future. The He isotopes should allow for the first time studying the release dynamics of deep fluids from solid earth close to these tectonically active regions and the relation to seismic activity. Moreover, the investigation of the noble-gas signature in the pore water will set a first data basis to interpret noble-gas anomalies in regions where major earthquakes occurred or are expected and will be a further step towards the use noble gases in terrestrial fluids as indicator of seismic activity.

During the Hyper-Dolphin dive operations on RV Natsushima cruise NT13-08 the following water and sediment samples have been collected in the region of the Nankai Trough (NG: noble-gas analysis; 3H: tritium analysis):

14.04.2013	Dive #1513	Site A (2596 m):	
			1 water sample NG+3H (ID: 520)
15.04.2013	Dive #1514	Site B, Reference (2552 m):	
			2 water samples NG+3H (ID: 517, Reference)
			2 sediment samples NG (ID: NoGOS 002, NoGOS 010)
			1 short core (3 sections) 3H
		Site B, Seep (2549 m)	
			2 water samples NG+3H (ID: 524, Seep)
			2 sediment samples NG (ID: NoGOS 018, NoGOS 004)
			1 shor core (3 sections) 3H
16.04.2013	Dive #1515	Site C, Landslide bottom (2123 m)	
			2 water samples NG+3H (ID: 503, "C, bottom")
		Site C, Landslide top (1975 m)	
			2 water samples NG+3H (ID: NoGOS 013, "C, top")
			4 sediment samples NG (ID: NoGOS 005, NoGOS 007, NoGOS 009, NoGOS 003)
			1 short core 3H

Sometimes the recovery of sediment samples for noble-gas analysis (by squeezing the short cores into small copper tubes) was hampered by the coarse texture of the sediments (e.g., sand, gravel, shell debris). At Site B the sediments collected from an active venting could only partly fill the copper tubes used as sampling containers.

In general the expedition was successful: 9 water samples and 8 sediment samples for noble-gas analysis, and 3 sediment cores for tritium measurements will provide a solid experimental data basis for the research targeted by the NoGOS project.

6. Cruise Log

NT13-08 Shipboard Log (13.Apr.2013-18.Apr.2013)

Date	Local Time	Note	Position/Weather/Wind/Sea condition
4/13		**Sail out and proceeding to research area**	4/13 12:00(UTC+9h)
	0.41666667	Let go all shore line,left YOKOSUKA.Then com'ced proceeding to research area(Off KUMANO).	35-03.6N 139-34.4E
	10:30-11:15	On board education for scientists.	Fine but cloudy
	18:00-18:35	Scientists meeting.	NNW-2(Light breeze)
			2(Sea smooth)
			1(Low swell sea)
			Visibly:7
4/14		**HPD#1513_OFF KUMANO A point**	4/14 12:00(UTC+9h)
	0.35416667	Arrived at research area.	33-13.2N 136-43.6E
	0.35555556	Released XBT.	Cloudy
	0.38263889	HPD dove & started her operation#1513.	SW-5(Fresf breeze)
	0.42569444	HPD landed on the sea bottom.(D=2759m)	3(Sea slight)
	0.66666667	HPD left the sea bottom.(D=2596m)	1(Low swell sea)
	0.725	Recovered HPD & finished the operation.	Visibly:8
	19:12-19:59	Sent call command to PHF.	
	0.87291667	Com'ced MBES mapping survey.	
4/15		**HPD#1514_OFF KUMANO B point**	4/15 12:00(UTC+9h)
	0.01111111	Finished MBES mapping survey.	33-07.1N 136-28.5E
	0.53402778	HPD dove & started her operation#1514.	Fine but cloudy
	0.58819444	HPD landed on the sea bottom.(D=2588m)	WSW-4(Moderate breeze)
	0.75069444	HPD left the sea bottom.(D=2539m)	3(Sea slight)
	0.82291667	Recovered HPD & finished the operation.	3(Moderate short)
			Visibly:8
4/16		**HPD#1515_OFF KUMANO C point**	4/16 12:00(UTC+9h)
	0.35	HPD dove & started her operation#1515.	33-16.1N 136-37.4E
	0.39722222	HPD landed on the sea bottom.(D=2126m)	Fine but cloudy
	0.64027778	HPD left the sea bottom.(D=1976m)	SW-3(Gentle breeze)
	0.68611111	Recovered HPD & finished the operation.	2(Sea smooth)
	19:00-19:20	Sent call command to CAT meter.	1(Low swell sea)
			Visibly:8
4/17		**Recovered CAT meter & proceeding to YOKOSUKA**	4/17 12:00(UTC+9h)
	5:00-9:39	Recovered CAT meter No5,6,8 & 10.	33-48.0N 137-08.6E
	0.40625	Left research area, then com'ced proceeding to YOKOSUKA.	Overcast
			SW-4(Moderate breeze)
			3(Sea slight)
			1(Low swell sea)
			Visibly:6
4/18		**Arrived at YOKOSUKA**	4/18 12:00(UTC+9h)
	0.35416667	Sent out 1st shore line,then arrived at YOKOSUKA.	

7. 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.