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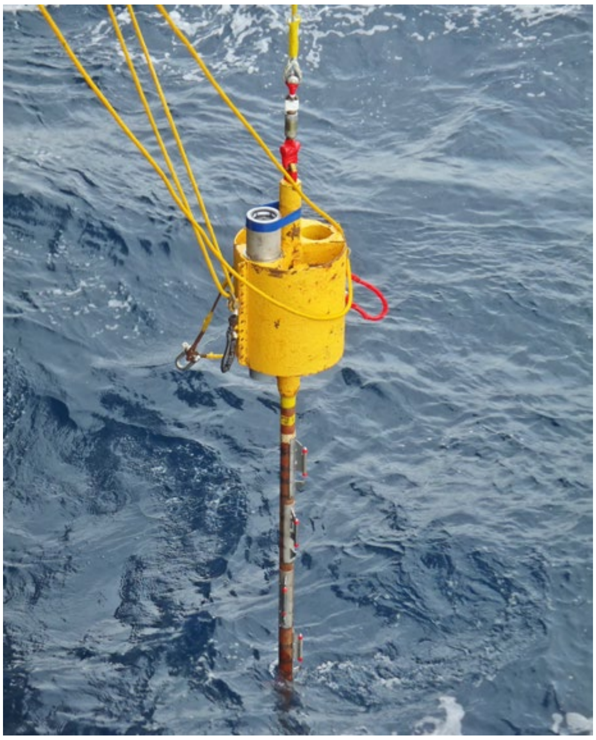
KAIYO Cruise Report

KY12-14

Thermal structure of the Philippine Sea plate subducting along the Nankai Trough and its relation to seismic activity



Nankai Trough and Shikoku Basin

December 3, 2012 – December 8, 2012

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

Contents

1. Cruise Information

Cruise number:

KY12-14

Ship name:

R/V KAIYO

Title of the cruise:

2012 Deep Sea Research

Thermal structure of the Philippine Sea plate subducting along the Nankai Trough and its relation to seismic activity

Title of proposal:

S12-57

Thermal structure of the Philippine Sea plate subducting along the Nankai Trough and its relation to seismic activity

Cruise period:

December 3, 2012 – December 8, 2012

Port call:

2012	Dec. 3	Dept. from Yokosuka (JAMSTEC)
	Dec. 8	Arriv. at Shingu

Research area:

Nankai Trough and Shikoku Basin

Research map:

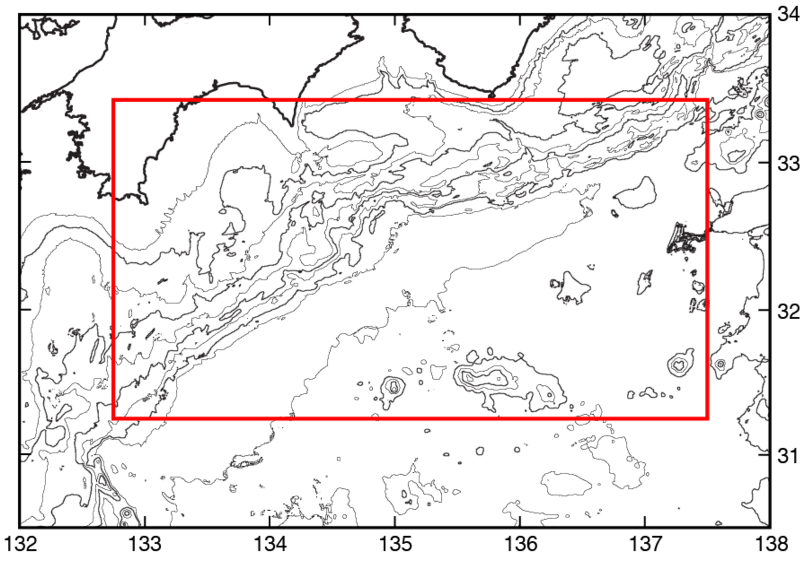


Figure 1-1. Proposed research area of KY12-14 cruise.

Ship track and observation points are shown in 3.2.3.

2. Researchers

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3. Observation

3.1. Introduction

The temperature structure of the subducting oceanic plate, generally determined by the seafloor age, is one of the most important factors controlling the subsurface thermal structure of subduction zones. In the Nankai subduction zone, the age of the subducting Philippine Sea plate (Shikoku Basin) significantly varies along the trough in a range of about 15 to 30 m.y. (e.g., Okino et al., 1994). The thermal structure of the plate interface and the overriding plate should accordingly vary along the trough. Surface heat flow observed on the floor of the Nankai Trough is, however, not consistent with the age of the Shikoku Basin, indicating that the temperature structure of the Shikoku Basin lithosphere may be different from that expected from the seafloor age. Off eastern Shikoku (off Muroto), the mean of heat flow on the trough floor is extremely high, about 200 mW/m^2, twice as high as the value corresponding to the age (15 m.y.) taking account of the effect of sedimentation (Yamano et al., 2003). In contrast, the values observed in the area southeast of the Kii Peninsula (off Kumano) are around 100 mW/m^2, close to the value estimated from the age (20 m.y.) with the sedimentation effect (Hamamoto et al., 2011). It is important to investigate what is the cause of this difference for studies of the thermal structure of the Nankai subduction zone.

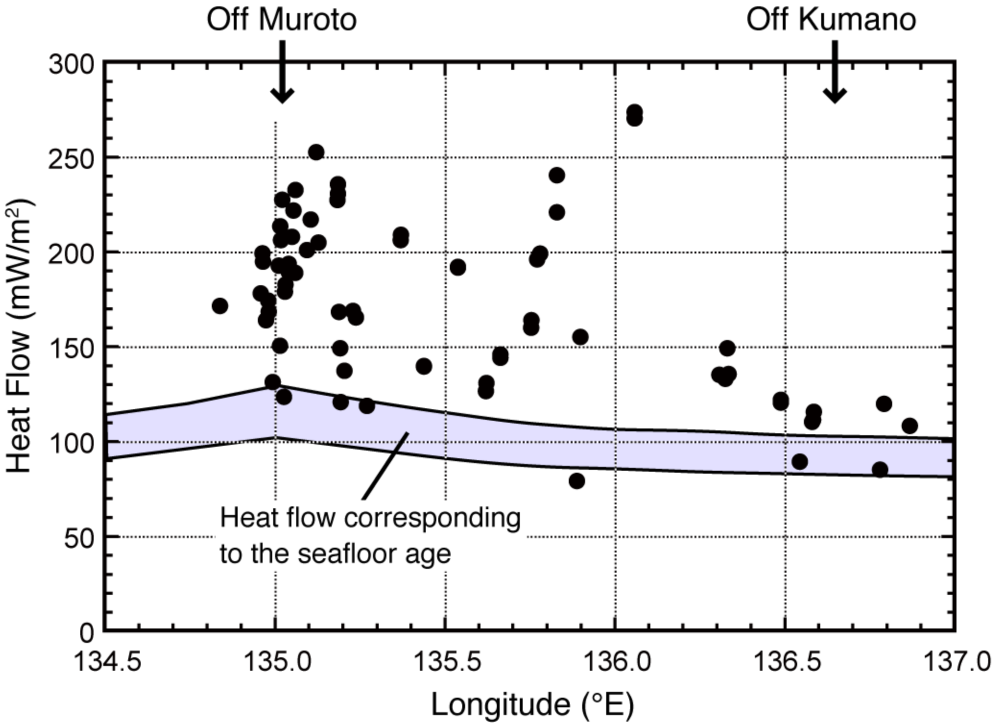


Figure 3.1-1. Heat flow data on the floor of the Nankai Trough plotted versus the longitude. Compared to the value estimated from the age of the subducting Shikoku Basin, heat flow is anomalously high off Muroto, while it is normal off Kumano.

We conducted heat flow measurements on the floor of the Nankai Trough between the off-Muroto and off-Kumano areas (south of the Kii Peninsula) in order to examine the transition from high to normal heat flow for investigation of the cause of the high anomaly and the thermal structure of the Shikoku Basin lithosphere. The obtained data show that extremely high heat flow is observed in the area west of 136°E, where heat flow is highly variable and the mean value is comparable to that in the off-Muroto area (Fig. 3.1-1). The boundary between the western high heat flow area and the eastern normal heat flow area was not clear because the data was still sparse.

In 2011, we made concentrated heat flow measurements on the trough floor south of the Kii Peninsula. The preliminary results suggest that the heat flow distribution boundary is rather sharp and located in the close vicinity of 136°E. The 136°E boundary is close to the rupture segmentation boundary between the 1944 Tonankai and the 1946 Nankai earthquakes, across which seismicity on the landward side of the trough conspicuously changes (Mochizuki et al., 2010). It also coincides with the transform boundary between the youngest part of the Shikoku Basin formed by spreading in NE-SW direction and the older part formed by E-W spreading, indicating that some physical difference between the younger and older Shikoku Basin may have yielded a contrast in the thermal structure. This possible relationship can be examined through heat flow measurements on the trough floor to the west of the off-Muroto area, where another boundary between the younger and older Shikoku Basin is located.

A likely cause of the anomalous high heat flow in the area off Muroto and west of 136°E is advective heat transfer by hydrothermal circulation in the Shikoku Basin oceanic crust. The uppermost several hundred meters of the basaltic basement of the oceanic crust generally has high permeability and allows extensive pore fluid flow (e.g., Fisher, 2005). Hydrothermal circulation may therefore be occurring in a high permeability layer just below impermeable sediments in the Shikoku Basin crust as well, influencing the temperature structure of the upper part of the plate and surface heat flow (Yamano et al., 1992). For example, sharp landward decrease in heat flow in the frontal part of the accretionary prism off Muroto (Fig. 3.1-2) cannot be caused by a conductive process and must be associated with some advective heat transfer.

Spinelli and Wang (2008) proposed the following model to explain the high heat flow anomaly off Muroto. The topmost part of the Shikoku Basin oceanic crust retains high permeability even after subduction and allows vigorous hydrothermal circulation which efficiently transfer heat along the plate interface from deeper part of the subduction zone. The upward advective heat transfer results in high heat flow on the Nankai Trough floor (Fig. 3.1-2) and cools down the plate interface (seismogenic zone of great subduction thrust earthquakes). If we apply this model to the heat flow distribution on the trough floor, the transition from the high heat flow off Muroto to the normal heat flow off Kumano may correspond to variation in vigor of hydrothermal circulation, which should be related to variation in permeability of the subducting oceanic crust. Heat flow measurements in the northernmost part of the Shikoku Basin (seaward of the trough floor) will enable us to test the validity of the model by comparing the calculated heat flow with the observation (Fig. 3.1-2).

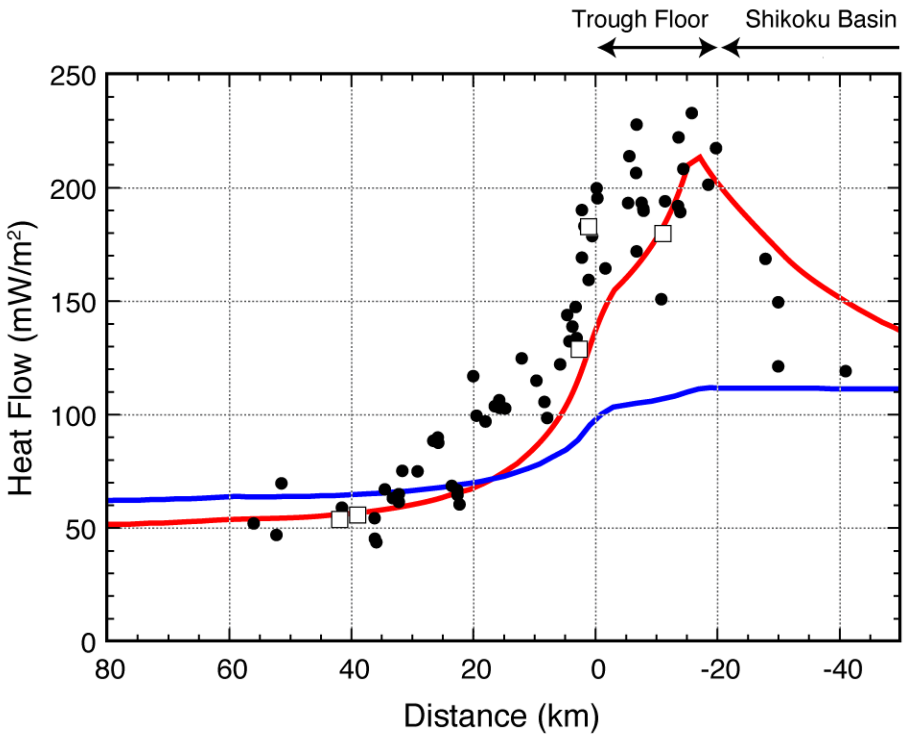


Figure 3.1-2. Heat flow profile across the Nankai Trough off Muroto (Yamano et al., 2003). The horizontal axis is the distance from the deformation front (positive landward). Red and blue curves are surface heat flow calculated with the model of Spinelli and Wang (2008) with vigorous fluid circulation in the subducting crust and with no circulation respectively.

3.2. Summary of the Cruise

3.2.1. Research items

(1) Heat flow measurement (HF)

Measurement of temperature profiles in surface sediment with ordinary deep-sea heat flow probes for determination of terrestrial heat flow.

(2) Sediment core sampling with heat flow measurement (HFPC)

Sampling of surface sediments with a piston corer and heat flow measurement at the same site using small temperature recorders mounted on the core barrel.

(3) Status check of long-term monitoring instrument

Checking the status of a long-term temperature monitoring instrument deployed in 2011 through acoustic communication.

(4) Bathymetry survey

Bathymetry mapping with a multi narrow beam system (not conducted due to rough sea condition).

3.2.2. Cruise schedule and operations

Date	Events, Operations
Dec. 3	Leave Yokosuka (JAMSTEC) Transit to the survey area
Dec. 4	Take refuge from rough sea (Owase Bay)
Dec. 5	Arrive in the survey area Status check of pop-up heat flow instrument (PHF01) Piston core sampling with heat flow measurement (HFPC01) Heat flow measurement (HF01)
Dec. 6	Take refuge from rough sea (Owase Bay)
Dec. 7	Heat flow measurement (HF02) Transit to Shingu
Dec. 8	Arrive at Shingu (disembarkation)

Detailed cruise log is given in 7.1.

3.2.3. Ship track and observation points

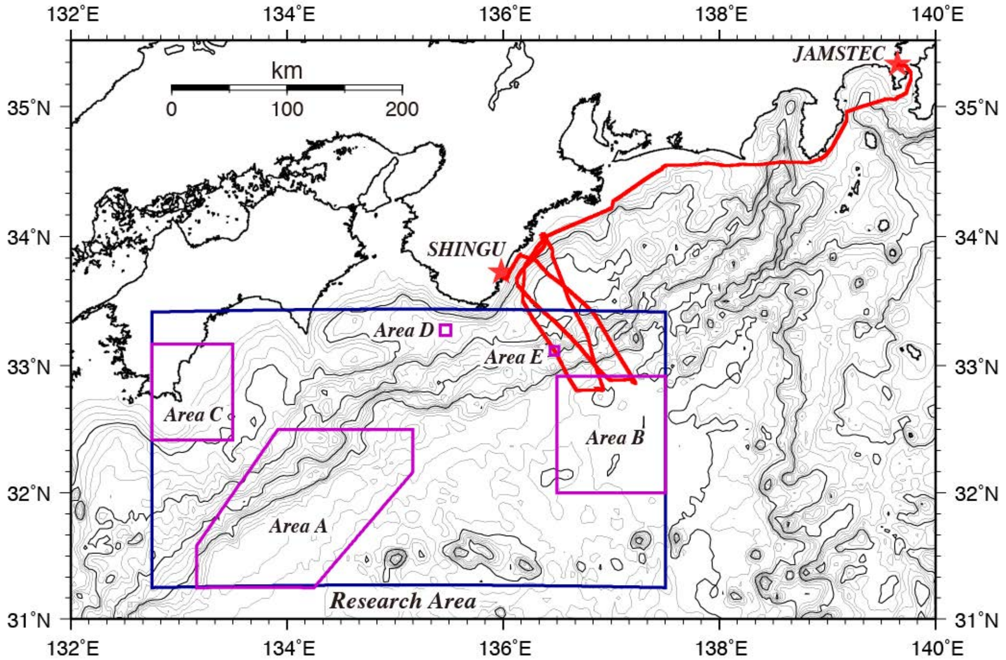


Figure 3.2-1. Research area and ship track of KY12-14 cruise.

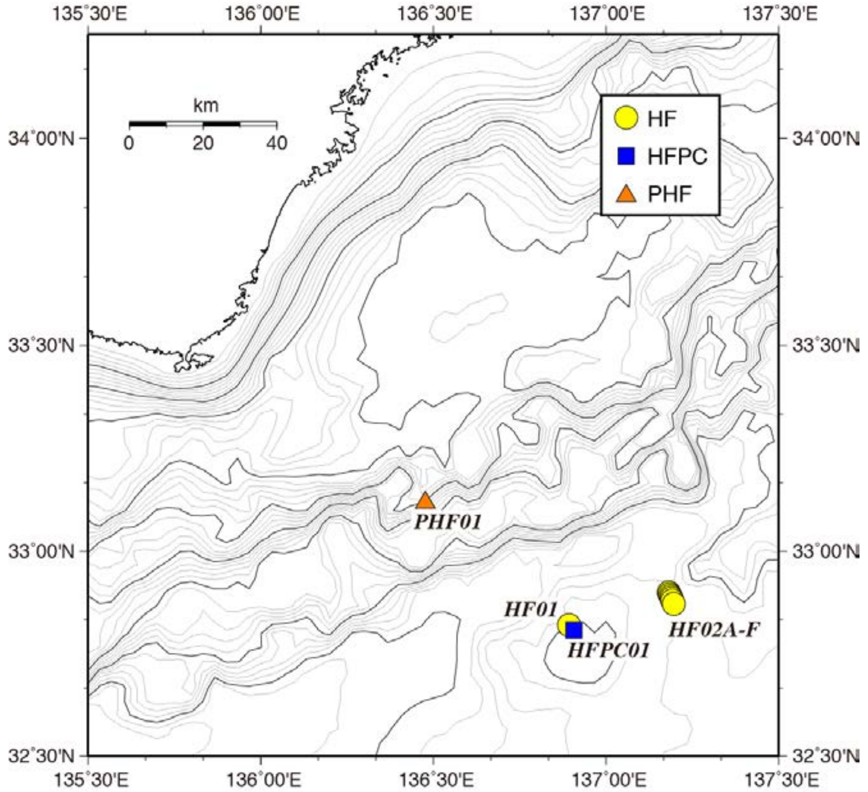


Figure 3.2-2. Measurement and sampling stations on KY12-14 cruise.

3.3. Research Objectives

We conduct heat flow measurements in the Nankai Trough off Shikoku and the Kii Peninsula and in the northernmost part of the Shikoku Basin. Detailed measurements on the floor of the Nankai Trough allow us to delineate the extent of the high heat flow anomaly observed offshore Muroto, which may be related to the structure of the subducting Shikoku Basin crust. In the Shikoku Basin, heat flow variation with the distance from the trough axis is examined for evaluation of influence of advective heat transfer by pore fluid flow in the uppermost part of the oceanic crust. Based on the obtained data, we investigate how seismic activity and deformation process in the Nankai subduction zone is related to the temperature structure around the subduction plate interface, which may be controlled by the structure of the subducting plate. Sediment core samples taken for thermal property measurements are used for studies on the past variation of the Kuroshio current as well.

Specific objectives of this research cruise

(1) Heat flow measurement on the Nankai Trough floor

We investigate the extent of the high heat flow anomaly observed in the area off Muroto through detailed measurements on the floor of the Nankai Trough south of Shikoku, west of 135°E (Area A in Fig. 3.2-1). The result will be compared with along-arc variations in other geophysical features of the subduction zone, e.g., seismicity (e.g., Obana et al., 2006), slow earthquakes (Obara, 2011), age and crustal structure of the subducting Shikoku Basin (Okino et al., 1994; Ike et al, 2008), and magnetic anomaly (Kido and Fujiwara, 2004).

(2) Heat flow measurement in the Shikoku Basin

To examine the validity of the thermal model proposed by Spinelli and Harris (2011), which takes into consideration the effect of hydrothermal circulation in the subducting crust, we conduct heat flow measurements in the northernmost part of the Shikoku Basin off the Kii Peninsula (Area B in Fig. 3.2-1). The obtained data can be compared with surface heat flow calculated with the model, which enables us to evaluate and improve the model.

(3) Status check of long-term monitoring instrument

We check the status of a pop-up heat flow instrument (PHF; cf. 3.4.3) deployed on the Nankai accretionray prism (Area E in in Fig. 3.2-1) in 2011. The instrument failed to pop up in response to acoustic commands in Nov. 2012. We send acoustic commands to the instrument again to examine if it is still operating.

(4) Measurement of thermal properties of sediment core samples

We take sediment core samples using a piston corer and measure thermal properties of core samples (Areas A and B in in Fig. 3.2-1). Measurement of thermal conductivity is particularly important for determination of heat flow. Information on sedimentation rate and depositional environment deduced from samples is also useful for interpretation of the obtained heat flow values.

(5) Geochemical and micropaleontological studies of sediment core samples

The Kuroshio is a western boundary current of the North Pacific subtropical gyre and plays a role of main heat transport from the tropical ocean to the subarctic Pacific. Therefore, it seems that the changes of path and intensity of the Kuroshio in the Northwest Pacific influenced the climate changes in the East Asia, upper ocean thermal structure and distribution of marine sediments in this region. We take sediment cores using a piston corer in the Nankai Trough and the surrounding area (Areas A, B and C in in Fig. 3.2-1). The taken sediment cores will be provided for geochemical and micropaleontological studies in order to understand past variations of the Kuroshio flow axis, meandering history of the Kuroshio, marine productivity, and carbonate dissolution.

3.4. Instruments and Operation Methods

3.4.1. Deep-sea heat flow probe

Heat flow is obtained as the product of the geothermal gradient and the thermal conductivity. We measured the geothermal gradient by penetrating an ordinary deep-sea heat flow probe or a heat flow piston corer (HFPC, cf. 3.4.2) into seafloor sediments.

[Specification of tools]

The deep-sea heat flow probe (Fig. 3.4-1) weighs about 800 kg and has a 3.0 m-long lance, along which seven compact temperature recorders (Miniaturized Temperature Data Logger, ANTARES Datensysteme GmbH; Fig. 3.4-2) are mounted in an outrigger fashion (Ewing type). A heat flow data logger (Kaiyo Denshi Co., DHF-650) placed inside the weight head (cf. Fig. 3.4-3) was used for recording the tilt and the depth of the probe. Tilt and depth data were sent to the surface with acoustic pulses so that we can monitor the status of the probe on the ship.

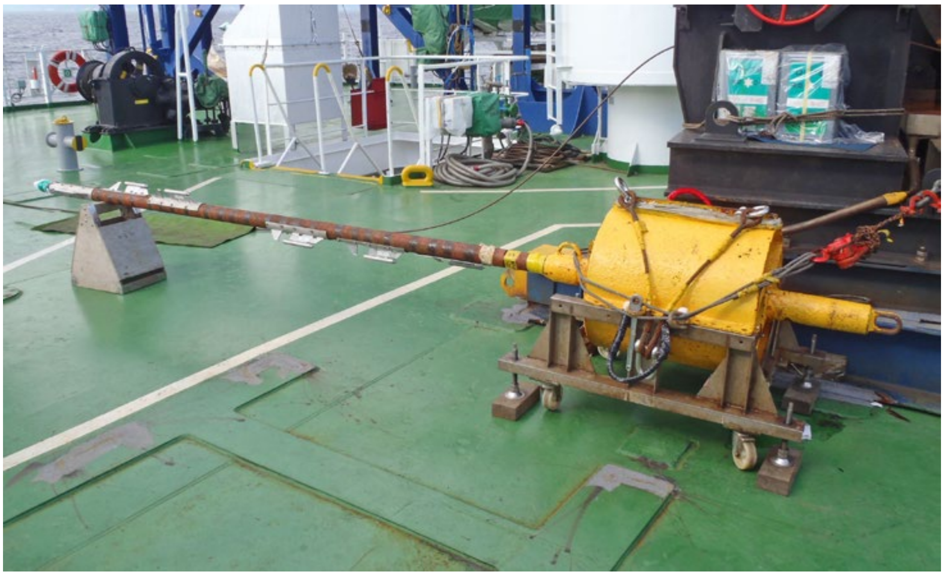


Figure 3.4-1. Deep-sea heat flow probe.

Figure 3.4-2. ANTARES Miniaturized Temperature Data Logger (MTL).

Specifications of the heat flow data logger and the ANTARES Miniaturized Temperature Data Logger (MTL) are summarized below:

Heat Flow Data Logger DHF-650 (Kaiyo Denshi Co.)
Pressure case: titanium alloy
Case length: 725 mm
Maximum diameter: 145 mm
Pressure rating: 7000 m water depth
Tilt: two-axis, 0 to ±45°
Data-cycle interval: 30 sec
Pinger frequency: 15.0 kHz (or 12.0 kHz)

Miniaturized Temperature Data Logger (ANTARES Datensysteme GmbH)
Pressure case: stainless steel
Case length: 160 mm
Diameter: 15 mm
Pressure rating: 6000 m water depth
Number of temperature channel: 1
Temperature resolution: 1.2 mK at 20°C, 0.75 mK at 1°C
Sample rate: variable from 1 sec to 255 min.

[Operations]

A 15 m long nylon rope was inserted between the heat flow probe and the winch wire rope in order not to kink the wire rope during probe penetrations. An acoustic transponder was attached about 70 m above the probe for precise determination of the position of the probe (Fig. 3.4-3).

Multi-penetration heat-flow measurement operations were conducted following the procedures described below.

1. Measure water temperature about 50 m above the seafloor for calibration of the temperature recorders.
2. Lower the probe at a speed of about 1 m/sec until it penetrates into the sediment.
3. Measure temperatures in the sediment for about 15 min. Monitor the wire tension and pay out the wire when necessary to keep the probe stable.
4. Pull out the probe.
5. Move to the next station keeping the probe about 300 m above the seafloor.
6. Repeat penetrations.

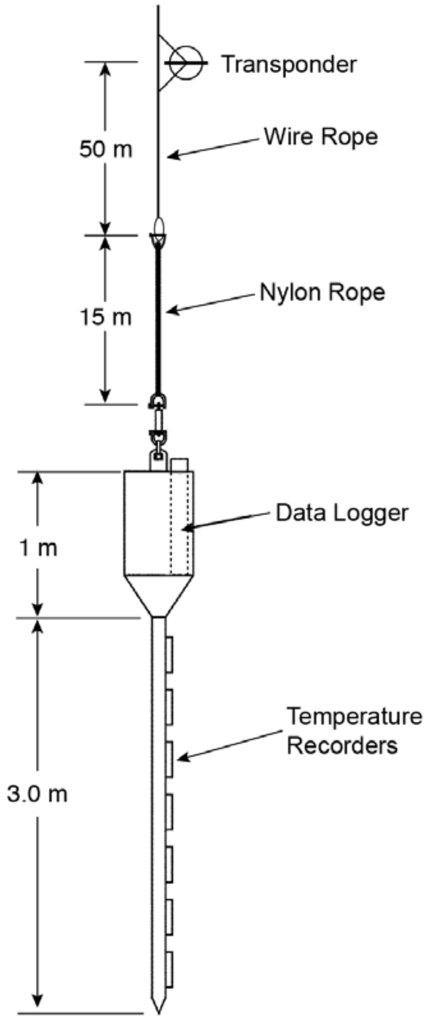


Figure 3.4-3. Configuration of the heat flow measurement system using a deep-sea probe.

3.4.2. Heat flow piston coring system

[Specification of tools]

During this cruise, sediment core samples were taken with the heat flow piston coring system (HFPC) (Fig. 3.4-4). This coring system was used for combined operation of measuring heat flow and recovering sediments. The general outline of the system is shown in Fig.3.4-5.

A stainless steel barrel was attached to a piston core head of 800 kg weight. The core head has a space for mounting the heat flow data logger to record the temperatures of thermistor sensors mounted along the barrel. On this cruise, seven ANTARES MTLs (cf. 3.4.1) were mounted helically on the outside of barrel, between the base of the weight stand and the core catcher bit. A transponder was also mounted on the winch wire to obtain the water depth and position of this equipment. The stainless steel barrel with this system is 4 m in length and liner is used for recovering sediments. The balance and pilot corer are the same as ones for ordinary

Figure 3.4-4. HFPC with compact temperature data loggers (MTLs).

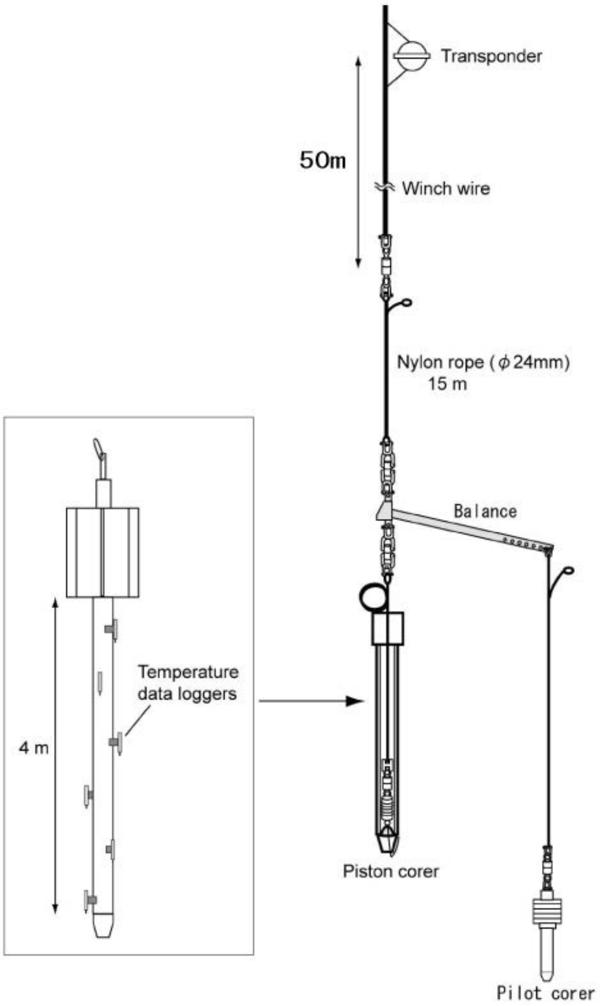


Figure 3.4-5. Configuration of the heat flow piston coring (HFPC) system.

piston core systems. Nylon rope was placed between the balance and winch wire for additional wire out and/or increased tension after hitting sea bottom. Because the system must be kept in the sediment for 15 minutes to obtain stable temperature, additional wire out is necessary for avoiding pulling the barrel out of the sea floor by either heaving or drifting of the ship during the measurement.

[Operations]

Preparation for the piston coring

After barrels are attached to the head (weight stand), the main wire is connected, through the barrel, to the piston at the bottom of the barrel. The core catcher and bit are then attached. The balance is connected to the end of the main wire. The entire assemblage is carried under the A-frame using a cart and is lifted over the edge of the deck by the winch, A-frame and capstan winches The pilot core and it's wire are then connected to the balance. The system is then lowered through the water to the sea floor.

Hit the bottom and off the bottom

The piston core system starts lowering at a winch speed of 20 m/min, which is gradually increasing to a maximum 50 m/min. The piston core is stopped at a depth about 100 m above the sea floor for 5 minutes to reduce any pendulum motion and to calibrate the temperature sensors on the outside of barrel.

After 5 minutes, the wire is lowered at a speed of about 20 m/min., at the same time carefully watching the pen recorder of the strain gauge tension meter. When the piston core hit the bottom the tension will abruptly decrease by the amount of the piston core weight. Therefore, it is easy to detect the bottom hit.

After the recognition of hit the bottom, add about 5 m to wire out, stopped and keep the position for 15 minutes. And then, rewinding of the wire is started at a dead slow speed (～20 m/min.), until the tension gauge indicate that the core has lifted off the bottom. The tension meter shows a small increase in tension when the core is being pulled out of the sea floor and then a steady value. After we can recognize absolutely that the piston core is above the sea floor, the winch speed is increased to 50 m/min., and then gradually to maximum speed.

3.4.3. Long-term temperature monitoring system

Pop-up type heat flow probes, termed "pop-up heat flow instruments (PHFs)" below, can record temperatures in the surface sediment for over one year. PHFs have been used for heat flow measurements at stations with water depths less than about 2500 m, where temporal variation in the bottom water temperature significantly affects the temperature distribution in surface sediments. Analysis of long-term temperature records obtained with PHFs allows us to remove the influence of the bottom water temperature variation (Hamamoto et al., 2005). PHFs may also be used for monitoring of pore fluid flow through sediment in active hydrothermal or cold-seep areas.

Main components of PHF are a recording unit, a temperature probe and a weight (Fig. 3.4-6). The temperature probe is 2 m long and has six or seven temperature sensors set at even intervals. The recording unit records the measurement date and time, temperatures, and two-axis instrument tilts. After recording the sediment temperatures, the PHF releases the weight and temperature probe in response to an acoustic command, and the recording unit pops up and can be recovered with a surface ship.

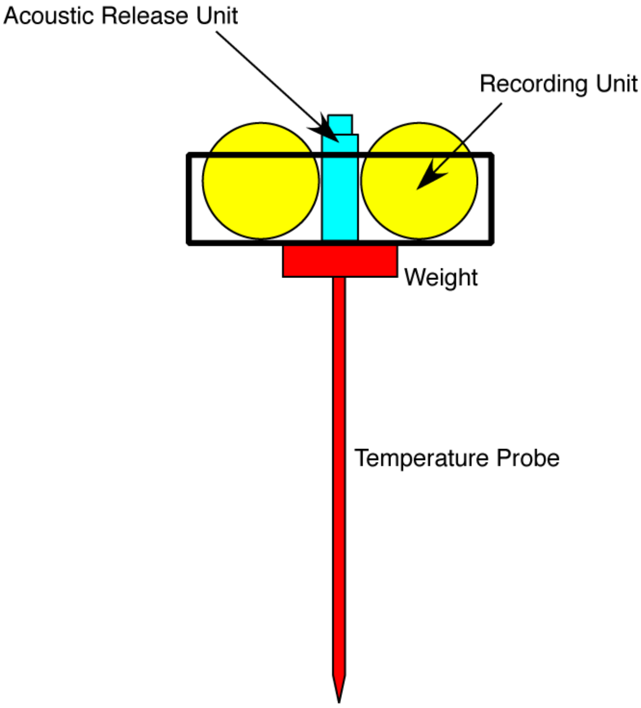


Figure 3.4-6. Schematic configuration of PHF.

3.4.4. Measurement on core samples

[Thermal property]

Thermal properties (thermal conductivity, heat capacity, and thermal diffusivity) of earth materials are important parameters for calculating heat flow, modeling the thermal structure and transport of heat and fluid under the ground. For thermal conductivity measurements, we used two instruments. One is Model QTM-500 (Kyoto Electronics Manufacturing Co., Japan; Fig. 3.4-7), which measures thermal conductivity of sediment with a half space box-type probe (Sass et al., 1984). Measurements with this instrument were made on split core samples (Fig. 3-4-7). The other is KD2 Pro Thermal Properties Analyzer (Decagon Devices, Inc., USA) with a single needle probe sensor (KS-1 probe) (Von Herzen and Maxwell, 1959) or a dual needle probe sensor (SH-1 probe) (Bristow et al., 1994; Fig. 3.4-8). On this cruise, we inserted dual needle probes into split core samples and measured thermal conductivity, heat capacity, and thermal diffusivity simultaneously.

Figure 3.4-7. Thermal conductivity measurement with QTM-500.

Figure 3.4-8. Thermal conductivity, heat capacity and thermal diffusivity measurement with dual probes of KD2 Pro.

[Sediment color reflectance]

Color reflectance measurements were made onboard at 1 cm resolution on the surface of split cores of KY12-14 HFPL01 and HFPC01. The Minolta CM-2022 spectrophotometer was used to measure the hue and chroma attributes of the sediments as well as the reflected visible light in 31, 10-nm-wide bands ranging from 400 to 700 nm. The sediment colors were expressed in the L*, a* and b* color space indexes. The lightness (variable L*) is ranging from 0% (black) to 100% (white). Variable a* is the green (negative) to red (positive) axis, and variable b* is the blue (negative) to yellow (positive). Color measurement was done within a few hours after split the cores, because color of the surface sediment touched with air is changed rapidly by oxidizing of the organic materials and volatilization of pore water in the sediments.

Before measurement of sample, two calibrations: "the zero calibration" and "white calibration" were carried out. The first one is performed to compensate for the effects of stray light owning to flare characteristics. In addiction, zero calibration may also compensate variations on the ambient such as temperature and humidity. It was performed in the air. The white calibration sets the maximum reflectance to 100%. Each time the camera is switched on and after zero calibration, white calibration was performed. After the regular calibration and white calibration (used in each core measure), the process of measure starts, getting one measure in each 1 cm of the core. After each core section measure, the data was saved and processed by software "Sai-check", and exported to text file that could be loaded by any spreadsheet software such as MS Excel.

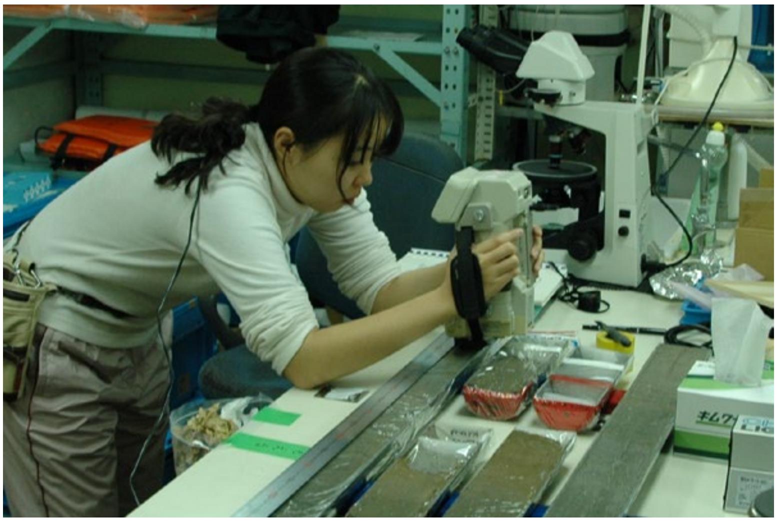


Figure 3.4-9. Sediment color reflectance measurement on the sample KY12-14 HFPC01 with CM-2022 photospectorometer.

3.5. Preliminary Results

3.5.1. Heat flow measurement

We carried out heat flow measurements at two sites with the deep-sea heat flow probe (Fig. 3.5-1) and at one site with the HFPC (Table 3.5-1; Fig. 3.2-2). At HF02, multiple penetrations were made for examining local variability of heat flow. The coordinates of the stations listed in Table 3.5-1 are the positions of the acoustic transponder attached above the probe or HFPC determined with the SSBL system of the ship. The water depth in the table is the depth right below the ship determined with the multi-narrow beam echo sounder and may be slightly different from the depth at the station. The probe or corer penetrated into sediments at all the sites and temperature gradient data of good quality was obtained. Monitoring of acoustic signals from the data logger using the ship's transducer was not successful for unknown reason.

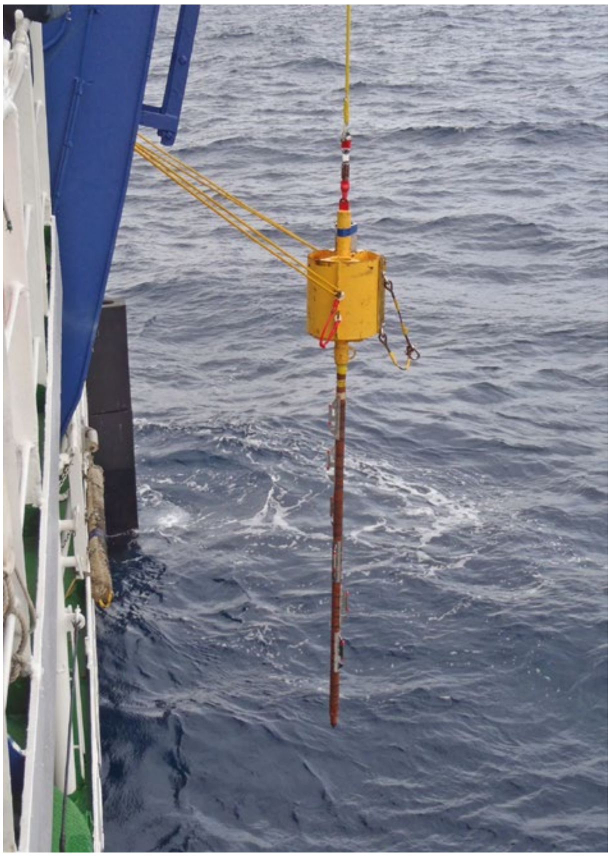


Figure 3.5-1. Heat flow measurement operation.

All of the three sites are located on the northern margin of the Shikoku Basin seaward of the Nankai Trough offshore the Kii Peninsula (Fig. 3.3-2), close to the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) transect, along which a series of IODP drilling has been conducted (Tobin and Kinoshita, 2006).

HFPC01 and HF01 are on the northern flank of a bathymetric high, the Kashinozaki Knoll and lie between IODP Sites C0011 and C0012. Measurements in IODP drill holes revealed that heat flow is higher at C0012 near the crest of the knoll than at C0011 at the foot of the knoll, suggesting that significant amount of heat is transferred by pore fluid flow in the basement of the knoll (Henry et al., 2012). Surface heat flow measured between the two drill sites should provide information on the fluid flow scheme on and around the Kashinozaki Knoll.

HF02 is located on a flat seafloor between the Zenisu Ridge and the Kashinozaki Knoll. We can therefore avoid thermal influence of these bathymetric highs, the topographic effect and advective heat transfer by possible local fluid flow systems. Heat flow measured at this site may give constraints on the thermal structure of the Shikoku Basin lithosphere and large-scale pore fluid flow in the oceanic crust.

The main target of heat flow measurement on this cruise was the floor of the Nankai Trough offshore Shikoku (Area A in Fig. 3.2-1; cf. 3.3). We could, however, make no measurement in this area since rough sea condition prevented the ship from reaching the area.

Table 3.5-1. Results of heat flow measurements

Date	Station	Latitude (N)	Longitude (E)	Depth (m)	N
Deep-sea heat flow probe					
Dec. 5	HF01A	32°49.20'	136°53.73'	3980	3
Dec. 7	HF02A	32°53.98'	137°10.97'	4165	7
	B	32°53.74'	137°11.08'	4170	7
	C	32°53.45'	137°11.27'	4165	7
	D	32°53.15'	137°11.41'	4165	7
	E	32°52.83'	137°11.57'	4160	7
	F	32°52.35'	137°11.83'	4180	7
HFPC					
Dec. 5	HFPC01	32°48.49'	136°54.47'	3945	3

N: number of temperature sensors used to obtain temperature profile in sediment.

Heat flow values will be obtained by combining the measured temperature profiles with thermal conductivity of surface sediment. Thermal conductivity at each site needs to be estimated from the values measured on piston core samples and the existing data at nearby stations.

3.5.2. Piston core samples

One piston core sample was collected from the Kashinozaki Knoll, seaward of the Nankai Trough off the Kii Peninsula using a 4-m-piston-corer system operated by Marine Works Japan Co. Ltd (3.4.2). Seven temperature recorders for heat flow measurements were attached on the core barrel of the piston corer. The piston corer system has a pilot corer (so-called a Marine Work 74 Gravity corer). We call this system as a heat-flow piston corer (hereafter HFPC). Sample name of piston core is KY12-14 HFPC01 in this description, and the formal sample name in the Kochi Core Center is KY12-14 PC01.

The piston core sample was processed as follows;

1) Cut the whole core into 1-m sections.
2) Split the whole core into Working and Archive halves.
3) Archive half: take photographs, describe sedimentary structures by naked eyes and smear slides.
4) Measure sedimentary color using a Minolta CM-2022 spectrophotometer (cf. 3.4.4).
6) Working half: take photographs, measure thermal properties using a half-space probe and needle probes (cf. 3.4.4).
7) Pack cores into plastic cases (D-tubes) for storage, then transport to the Kochi Core Center.

The recovered core sample is described in detail below.

[HFPC01]

To measure heat flow on the flank of the Kashinozaki Knoll, HFPC01 was conducted at 32°48.49'N and 136°54.47'E. The water depth was 3945 m. The longitude and latitude of the coring site are the average position of the acoustic transponder attached above the HFPC determined with the SSBL system of the ship. The water depth at the coring site is the depth right below the ship determined with the multi-narrow beam echo sounder.

The recovered core sample is 229.5 cm long. The piston core sediments are predominantly homogenous gray (7.5Y4/1) silty clay (Figs. 3.5-2 and 3.5-3). Uppermost sediments above ~ 17 cm are olive brown (2.5Y4/3) silty clay, which corresponds to the oxidized layer on the seafloor. Coarse sand sized white pumice layer is observed at interval from 214.5 cm to 216.5 cm. Pebble sized black scoria is found in this pumice layer. Color indices L*, a* and b* show that sedimentary color significantly changes at approximately 17 cm and 52.5 cm, respectively (Fig. 3.5-4).

[HFPL01]

The recovery of pilot core HFPL01 is 46 cm long (Fig. 3.5-3). The sediments are composed of homogeneous olive brown (2.5Y4/3) silty clay. Upper ~ 20 cm brownish interval corresponds to the oxidized layer on the seafloor (Figs. 3.5-2 and 3.5-3).

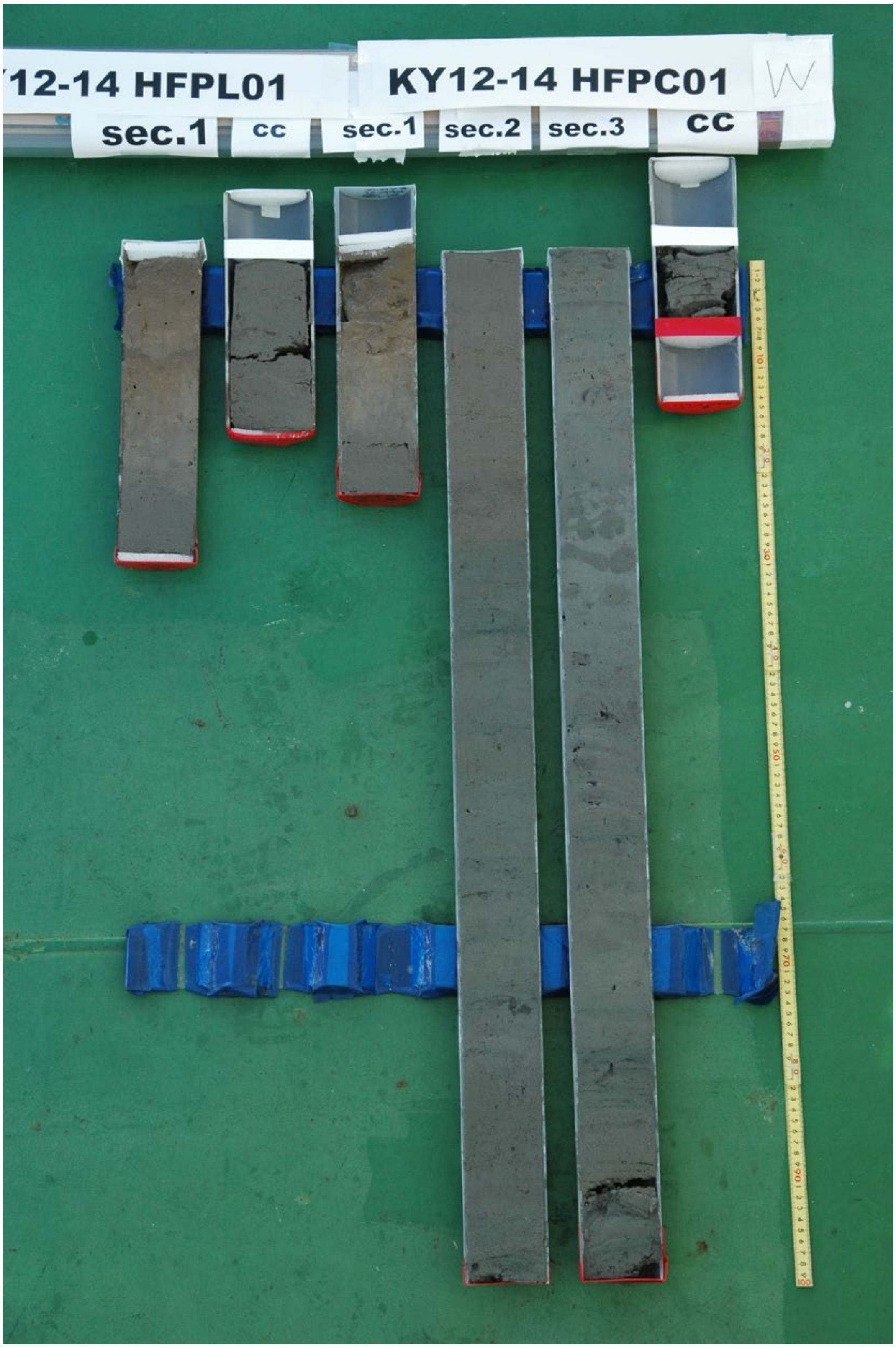
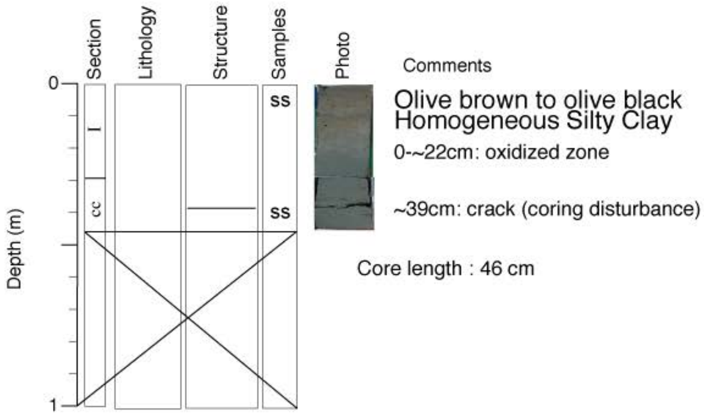


Figure 3.5-2. Photograph of the working halves of core HFPL01 and HFPC01.

KY12-14 HFPL01



Comments

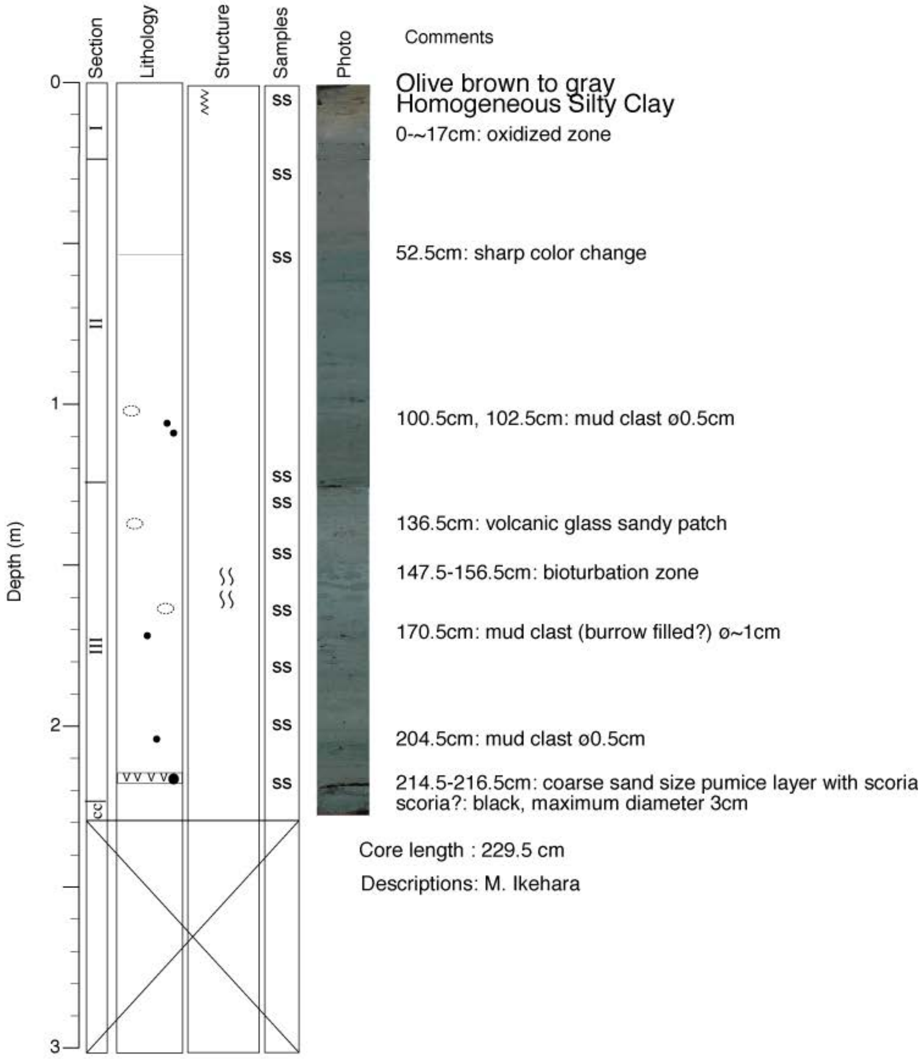
Olive brown to olive black
Homogeneous Silty Clay

0-~22cm: oxidized zone

~39cm: crack (coring disturbance)

Core length : 46 cm

KY12-14 HFPC01



Comments

Olive brown to gray
Homogeneous Silty Clay

0-~17cm: oxidized zone

52.5cm: sharp color change

100.5cm, 102.5cm: mud clast ø0.5cm

136.5cm: volcanic glass sandy patch

147.5-156.5cm: bioturbation zone

170.5cm: mud clast (burrow filled?) ø~1cm

204.5cm: mud clast ø0.5cm

214.5-216.5cm: coarse sand size pumice layer with scoria
scoria?: black, maximum diameter 3cm

Core length : 229.5 cm

Descriptions: M. Ikehara

Figure 3.5-3. Summary of visual core description of core HFPL01 and HFPC01.

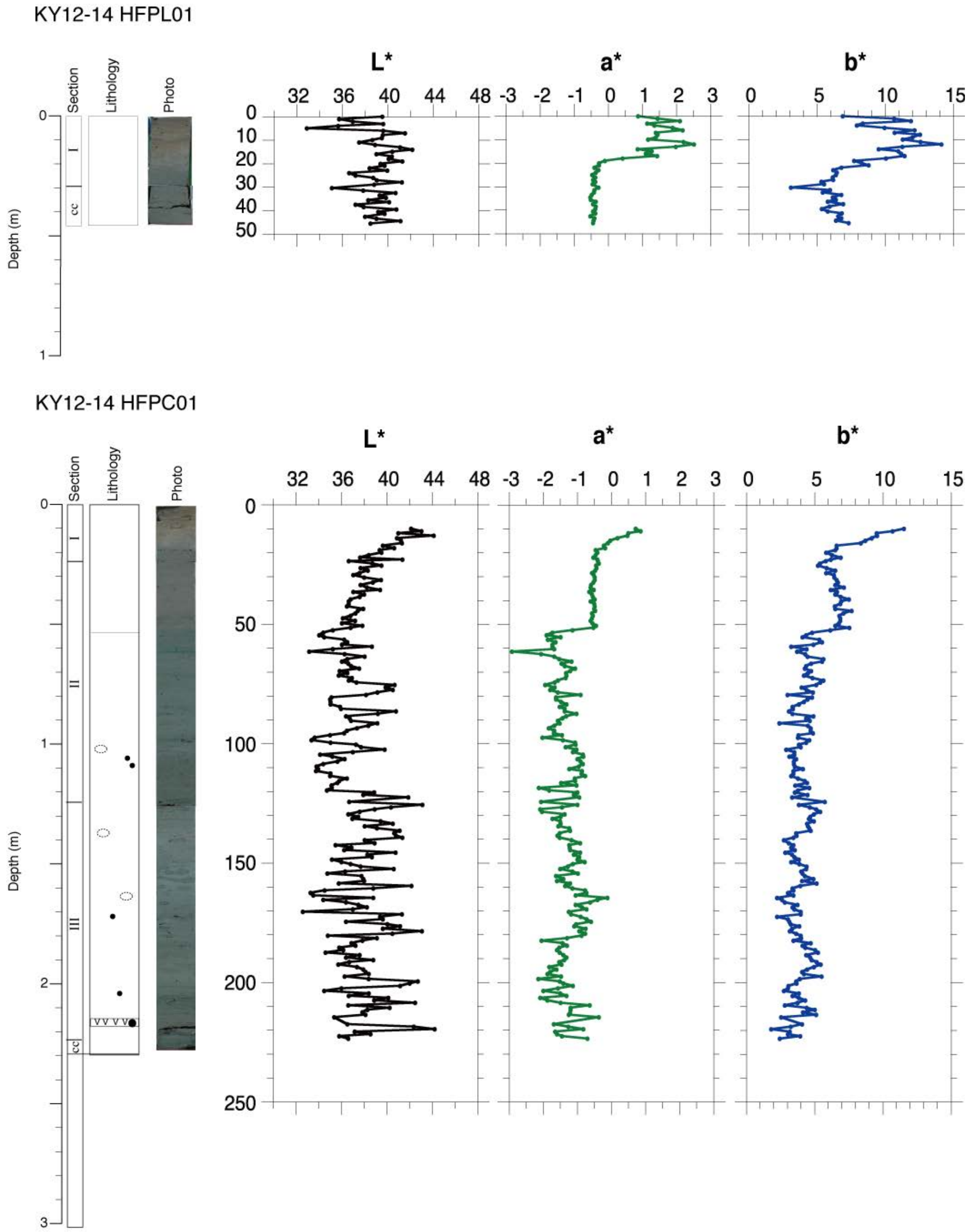


Figure 3.5-4. Color reflectance profiles of core HFPL01 and HFPC01.

Thermal properties (thermal conductivity, heat capacity and thermal diffusivity) were measured with dual probes of KD2 Pro (cf. 3.4.4) at 10 locations and 1 location on split core samples of HFPC01 and HFPL01 respectively. Thermal conductivities was also measured with QTM-500 (cf. 3.4.4) at the same 10 locations on HFPC01.

3.5.3. Long-term temperature monitoring system

We checked the status of a pop-up heat flow instrument (PHF) at PHF01 on the landward slope of the Nankai Trough off the Kii Peninsula (Fig. 3.2-2; Table 3.5-2). The instrument was deployed in November 2011 during KH-11-9 cruise of R/V HAKUHO MARU. The observation site is located in the close vicinity of a fault scarp along which active cold-seep sites were found. Recovery of the instrument was attempted in November 2012 during KT-12-30 cruise of R/V TANSEI MARU. The instrument accepted acoustic commands for release of weight but did not leave the seafloor for unknown reason.

On this cruise, we sent acoustic signal from the ship to wake the instrument up. The instrument responded to the signal and the distance between the ship and the instrument was determined to be about the same as the water depth. These results indicate that the instrument is still active and staying at the original position. We plan to recover the instrument using ROV HYPER-DOLPHIN in April 2013.

Table 3.5-2. Status check of pop-up heat flow instrument

Station	Date	Coordinates	Depth (m)
PHF01	Dec. 5, 2012	33°07.2’N, 136°28.6’E	2525

4. 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.

5. Acknowledgements

We are grateful to Captain Y. Nakamura, the officers and the crew of the R/V KAIYO for skillful operations of the ship and research equipment. We also extend our thanks to M. Toizumi, S. Kawamura, Y. Nakano, T. Mori, and Y. Miyajima for giving us great assistance in research works throughout the cruise. The staff of the Research Fleet Department, Marine Technology and Engineering Center, especially K. Yatsu, made excellent arrangements for the cruise.

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7. Appendices

7.1. Cruise Log

Date	Local Time	Note	Position/Weather/Wind/Sea condition
03-Dec-12		**Sail out, proceeding to research area**	12/3 12:00 (UTC+9h)
	08:00	Boarded.	35-01.9'N, 139-26.4'E
	09:00	Let go all shore line, left JAMSTEC for survey area.	Sagami Bay
	10:00 - 10:45	Briefing about ship's life and safety.	Overcast
	10:45 - 11:15	Scientific meeting (Research room).	North-6 (Strong breeze)
			4 (Sea Moderate)
			3 (Slight)
			Visibility: 7'
04-Dec-12		**Drifting for avoiding rough sea at Owase Bay**	12/4 12:00 (UTC+9h)
	02:00	Stopped engine & commenced drifting at Owase Bay for avoiding rough sea.	34-00.0', 136-23.0'E
	18:00 - 18:30	Scientific meeting (Research room).	off Owase Bay
	16:40 - 17:00	Praying for the safety of this cruise (Konpira ceremony).	Fine but Cloudy
	22:00	Finished drifting & commenced proceeding to research area <Nankai Trough>.	NNW-5 (Fresh breeze)
			3 (Sea Moderate short)
			3 (Slight)
			Visibility: 7'
05-Dec-12		**Accostic communication in Area E, and HFPC & HF in Area B**	12/5 12:00 (UTC+9h)
	04:00	Arrived at research area (E-1).	32-48.3', 136-55.2'E
	04:03 - 04:07	Carried out accostic communication with heat flow instrument.	Nankai Trough
	04:15	Proceed to next survey area (Area B).	Cloudy
	06:25	Arrived at research area B.	WNW-5 (Fresh breeze)
	06:28	Released XBT at <32-48.4726N, 136-49.4266'E>.	3 (Sea Moderate short)
	08:01 - 12:01	Carried out heat flow piston coring (HFPC01).	3 (Slight)
	13:12 - 16:53	Carried out heat flow measurement (HF01).	Visibility: 8'
	17:00	Proceed to Owase Bay for avoiding rough sea.	
	19:00 - 19:30	Scientific meeting (Research room).	
06-Dec-12		**Drifting for avoiding rough sea at Owase Bay**	12/6 12:00 (UTC+9h)
	00:30	Arrived at Owase Bay, then stopped engine & commenced drifting.	34-00.0', 136-23.0'E
	13:00 - 13:50	Tour of ship [Bridge, engine room, etc.].	off Owase Bay
	18:00	Finished drifting & commenced proceeding to research area <Nankai Trough>.	Fine but Cloudy
			West-4 (Moderate breeze)
			3 (Sea Moderate short)
			2 (Smooth)
			Visibility: 8'
07-Dec-12		**HF operation at Area B, and proceeding to Shingu port**	12/7 12:00 (UTC+9h)
	05:30	Arrived at research area B.	32-53.1', 137-11.4'E
	06:55 - 18:05	Carried out heat flow measurement (HF02).	Nankai Trough
	18:55	Proceeding to Shingu port.	Fine but Cloudy
			West-5 (Fresh breeze)
			3 (Sea Moderate short)
			4 (Moderate)
			Visibility: 8'
08-Dec-12		**Disembarked at Shingu port**	
	09:00	Disembarked by boat off Shingu port.	

7.2. R/V KAIYO Crew

Captain	NAKAMURA YOSHIYUKI
Chief Officer	KIMURA NAOTO
2nd Officer	MIYAKE KAZUKI
3rd Officer	IJICHI KAKERU
Chief Engineer	KANEDA KAZUHIKO
1st Engineer	KATO KENZO
2nd Engineer	INOMOTO TAKAATSU
3rd Engineer	NAGANO SHOTA
Jr.3rd Engineer	EBISUNO ARISA
Chief Radio Operator	SAITAKE HIROYASU
2nd Radio Operator	HATA MISATO
3rd Radio Operator	KOMATSU RYOSUKE
Boat Swain	ISOBE HIDEO
Able Seaman	YAMAMOTO SHUICHI
Able Seaman	CHIMOTO TSUYOSHI
Able Seaman	ISHIZUKA NAO
Sailor	IKEDA KAZUHO
Sailor	UENO SHINYA
Sailor	MOTOOKA YUTA
No.1 Oiler	YAHATA KIYOSHI
Oiler	YOSHIDA KATSUYUKI
Oiler	IKEDA TOSHIKAZU
Oiler	MISAGO SOTA
Assistant Oiler	SATO RYO
Assistant Oiler	SHIMOHATA SHOTA
Chief Steward	TACHIKI YUKIO
Steward	TANAKA SHINSUKE
Steward	ONOUE TASUNARI
Steward	MIKAMI RIKAKO
Steward	KINOSHITA HARUKA
Steward	EBIKO YOHEI