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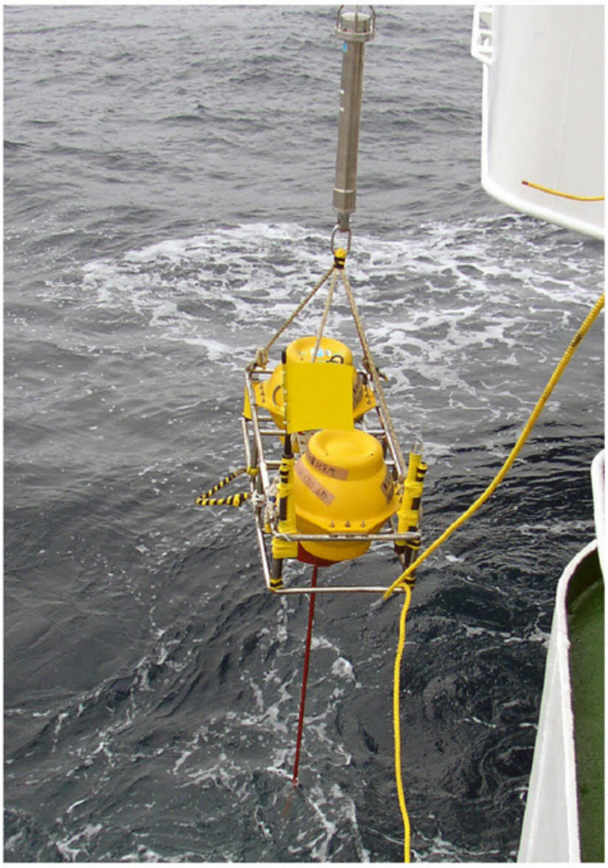
Preliminary Report
of
the R/V KAIREI Cruise KR03-05 Leg 1

May 17 – May 23, 2003

Geophysical and Geological Studies of the Nankai Seismogenic Zone

(Off-Kumano Area, Southeast of the Ki-i Peninsula)



KR03-05 Leg 1 Shipboard Scientific Party

CONTENTS

1. Introduction

The KR03-05 Cruise of R/V KAIREI with ROV KAIKO was conducted in the central Nankai Trough area in May and June, 2003. The cruise was divided into two legs. The leg 1 was for surveys without using KAIKO and the leg 2 was for dive studies with KAIKO. The the objectives of the leg 1 and leg 2 are common; “Integrated studies of the Nankai seismogenic zone”.

Large thrust earthquakes occurred repeatedly along the convergent plate boundary in the Nankai subduction zone. In the last decade, international, multidiscipilinary studies of seismogenic zones of such subduction thrust earthquakes have been actively conducted in many subduction zones. Although the Nankai Trough, the main target of this cruise, is one of the most extensively studied subduction zones, more detailed geophysical and geological surveys are necessary for imaging the structure of the seismogenic zone and understanding physical/chemical processes occurring there.

In this report, we present preliminary results of the leg 1 of the KR03-05 cruise (May 17 to May 23, 2003). On the leg 1, we worked mainly in the off-Kumano area of the Nankai subduction zone, southeast of the Ki-i Peninsula. Recent reflection seismic surveys in this area revealed the existence of prominent splay faults branching from the plate boundary and deep drilling through these splay faults and the plate boundary is being proposed for IODP (Integrated Ocean Drilling Program). To investigate the thermal and electrical conductivity structures of this seismogenic zone, we carried out heat flow measurements and long-term monitoring of temperatures and electromagnetic fields. We also sampled sediment cores for studying normal faults developed in the forearc basin.

2. Leg Summary

2-1. Research items

(1) Heat flow measurement

Heat flow measurement with an ordinary deep-sea heat flow probe.

(2) Recovery and deployment of long-term temperature monitoring instruments

Recovery and deployment of three types of long-term temperature monitoring instruments for heat flow measurement in the Kumano Trough area with relatively shallow water depths.

(3) Piston core sampling with heat flow measurement (HFPC)

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

(4) Recovery of OBEMs

Recovery of two ocean bottom electromagnetometers (OBEMs) deployed in the Kumano Trough area in December, 2002 and January, 2003.

(5) Bathymetry survey

Bathymetry mapping with a multi narrow beam system.

2-2. Leg schedule and operations

Date	Events, Operations
May 17	Leave Yokosuka
May 18	Arrive in the survey area Recovery of a long-term temperature monitoring instrument Operation tests of three long-term temperature monitoring instruments Deployment of two long-term temperature monitoring instruments
May 19	Deployment of a long-term temperature monitoring instrument Piston core sampling with heat flow measurement Operation tests of a long-term temperature monitoring instrument
May 20	Recovery of two OBEMs Piston core sampling with heat flow measurement Deployment of a long-term temperature monitoring instrument
May 21	Bathymetry survey Piston core sampling with heat flow measurement Heat flow measurement
May 22	Bathymetry survey Heat flow measurement Leave the survey area
May 23	Arrive at Shimonoseki

2-3. Site map

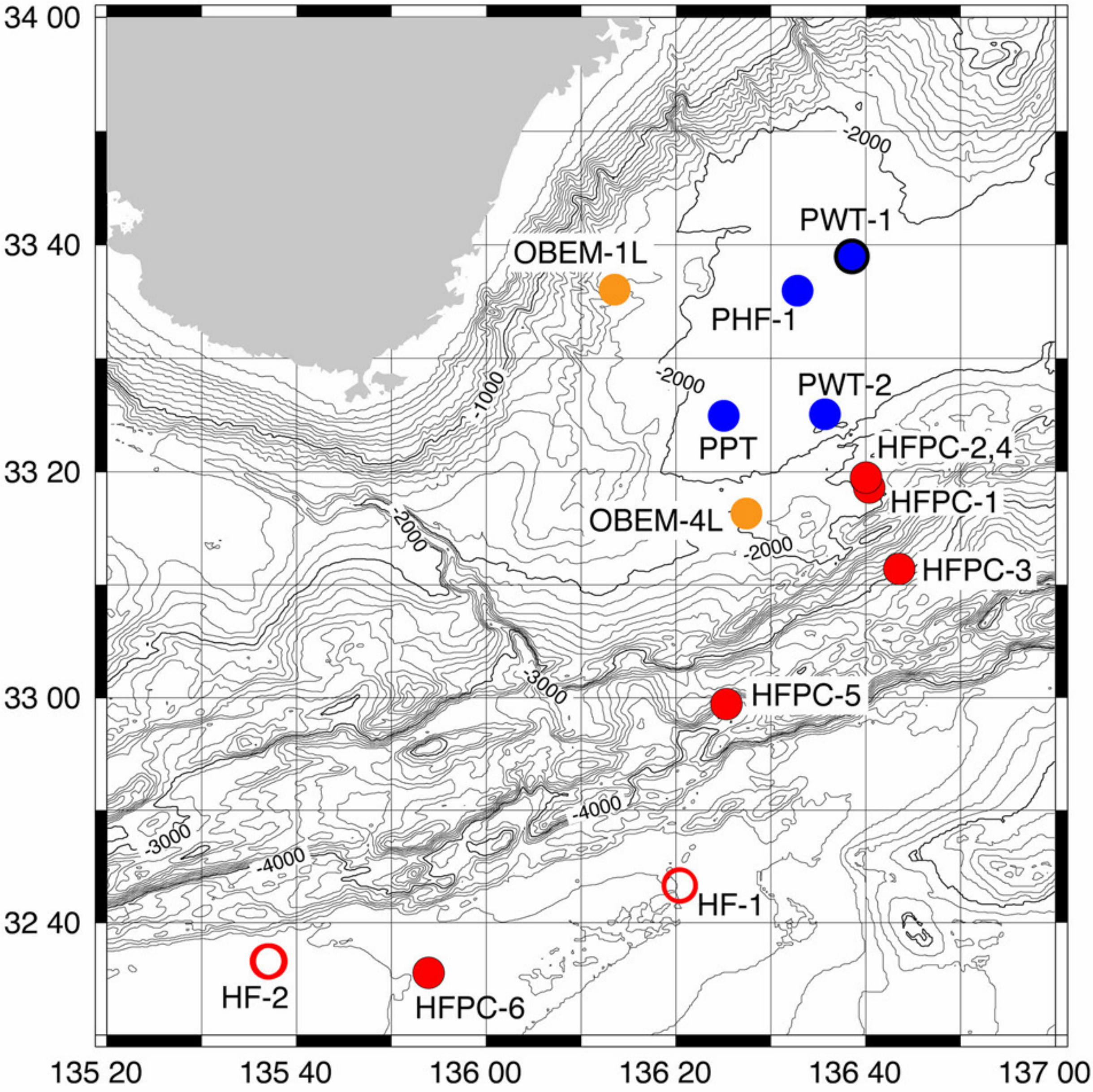


Fig. 2-3-1. Measurement and sampling stations on the leg 1 of the KR03-05 cruise. HF: heat flow, HFPC: heat flow piston corer, PWT: pop-up water temperature measurement system, PHF: pop-up heat flow instrument, PPT: pop-up pore pressure and temperature instrument, OBEM: ocean bottom electromagnetometer.

2-4. Shipboard scientific party

YAMANO, Makoto (Chief scientist)
Specialty: Geothermics
Institute: Earthquake Research Institute, University of Tokyo

BABA, Kiyoshi
Specialty: Marine electromagnetics
Institute: Japan Marine Science and Technology Center

FLEMINGS, Peter B.
Specialty: Hydrogeology and Stratigraphy
Institute: Dept. of Geosciences
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Specialty: heat flow
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MUKOYOSHI, Hideki
Specialty: Geology
Institute: Kochi University

AOKI, Misumi

Institute: Nippon Marine Enterprises, Ltd.

KOIZUMI, Toru

Institute: Marine Works Japan, Ltd.

KONDO, Tomomi

Institute: Marine Works Japan, Ltd.

MAEDA, Rena

Institute: Marine Works Japan, Ltd.

YOSHIDA, Kazuhiro

Institute: Marine Works Japan, Ltd.

2-5. Ship crew

Captain	TANAKA, Hitoshi
Chief Officer	NAKAMURA, Yohiyuki
1st Officer	ISHIWATA, Masayoshi
2nd Officer	SASAKI, Daisuke
3rd Officer	YOKOTA, Testuya
Chief Engineer	SAKAGUCHI, Eiji
1st Engineer	FUKUDA, Akemitsu
2nd Engineer	ABE, Tadashi
3rd Engineer	MATANI, Yasuhiro
Jr. 3rd Engineer	TAKAHARA, Naoyuki
Chief Operator	NASU, Tokinori
2nd Operator	HATTORI, Taketo
3rd Operator	SUENAGA, Jun
Boatswain	NAKAMURA, Makio
Able Seaman	SASAKI, Sakae
Able Seaman	ABE, Kazuo
Able Seaman	ODA, Hatsuo
Able Seaman	YAMAMOTO, Kazuya
Able Seaman	HIROSAKI, Kaname
Sailor	SATO, Harumitu
No.1 Oiler	MASUNAGA, Masayuki
Oiler	NAKAI, Kazuaki
Oiler	HONDA, Kunio
Oiler	HARIMOTO, Tsuneno
Oiler	SONOH, Shuich
Chief Steward	TERANISHI, Kiyotoshi
Cook	MATSUMOTO, Isao
Cook	IZUMI, Kunihiko
Cook	CHIKUBA, Yukihide
Cook	YOSHIKAWA, Teruyuki
Trainee	MURATA, Kaito
Trainee	TANAKA, Sayuki
Trainee	KUBOTA, Hideki

3. Research Objectives

3-1. Heat flow measurement

We have been conducting heat flow measurements in the Nankai Trough area to impose the boundary condition on the thermal model of the Southwest Japan subduction zone. Concentrated measurements made off eastern Shikoku (off Muroto) in 1999 to 2001 revealed that heat flow on the floor of the Nankai Trough is extraordinarily high, almost twice as high as the value expected for the age of the subducting plate (Shikoku Basin). On the other hand, the data recently obtained off the eastern Ki-i Peninsula (off Kumano) suggests that the heat flow on the trough floor is normal. It is important to know whether the high anomaly off Muroto originates in the deep in the Shikoku Basin lithosphere, since the temperature structure of the Shikoku Basin is a critical boundary condition on the subduction plate interface, i.e. the seismogenic zone. One of the objectives of heat flow measurement on the KR03-05 cruise is to investigate the transition between the high heat flow off Muroto and the normal heat flow off Kumano, which gives important information on the origin of the heat flow anomaly.

Seismogenic zones of large subduction plate interface earthquakes are usually located beneath shallow seas. In the off-Kumano area, the Kumano Trough, which a fore-arc basin with a water depth of about 2000 m, lies over the rupture area of the 1944 Tonankai earthquake. It is therefore important to measure heat flow in the Kumano Trough for constraining the thermal structure of this seismogenic zone. However, it is difficult to measure heat flow with an ordinary deep-sea heat flow probe in this relatively shallow sea area, because the temperature distribution in surface sediment is much disturbed by the temporal variation in the bottom water temperature. We have been developing instruments to monitor the temperatures in surface sediments for determination of the heat flow in shallow seas by removing the effect of the bottom water temperature variation. On this cruise, we deployed a pop-up heat flow instrument and a pop-up pore pressure and temperature instrument in the Kumano Trough to obtain long-term records of the sediment temperatures for heat flow measurement. We also deployed pop-up bottom water temperature measurement systems at two stations to investigate characteristics of the bottom water temperature variations in this area.

3-2. Core sampling

The piston coring was performed during the KR03-05 cruise. The purpose of coring was to recover the sediment from the southern edge of Kumano Basin and the middle slope of fore-arc for studies of stratigraphy and interstitial water.

Tsunami inversion modeling and seismic surveys in the Nanaki Trough showed that the out-of-sequence thrust (OST), developing off Kii Peninsula, is a possible fault causing Tonankai earthquake in 1944. The investigating of OST displacement is a direct way to know the past mega earthquake in Nankai area, and provides the important information for earthquake prediction. The seismic profile across the Nankai Trough unveiled the structure of the Kumano fore-arc basin, which is located in the arc-side of outer ridge off Kii Peninsula. (Park et al., 2002, Fig. 3-2-1). The conjugate normal fault systems are clearly recognized in the profile, which cut through the deep sedimentary structure. The thrusting up of OST is considered as the cause of outer ridge in the upper basement of OST. This uplifting might derive the slip down of basin-fill sediment near OST. Consequently it is a possible mechanism for the formation of normal fault system of Kumano Basin. For understanding the origin of fault and the frequency of activity, we collected sediment sample from Kumano Basin. We designed to collect the sediment from both sides of the most southern normal fault (HFPC-1, 2, and 4: see Figures in the chapter 5).

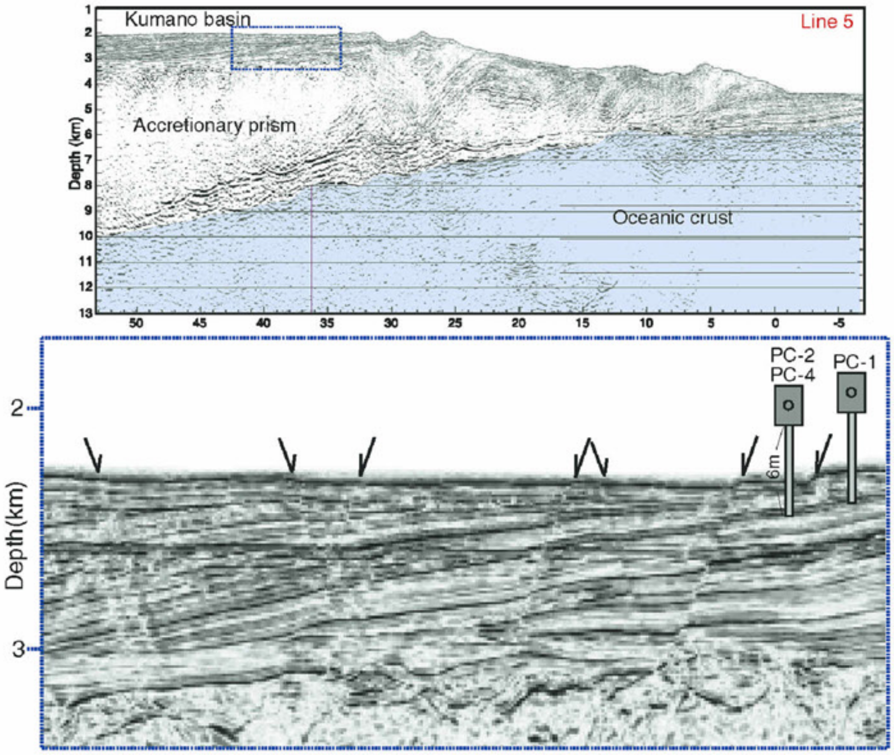


Fig. 3-2-1. Seismic profile of Nankai Trough (Park et al., 2002), and piston coring site in the Kumano Basin.

3-3. Magnetotelluric survey

Great earthquakes (>M8.0) periodically occurred along the Nankai Trough. The rupture region at the 1944 Tonankai earthquake coincided with the slip region with tsunami, so that the off-Kumano region is one of the typical seismogenic zones with great earthquakes. Otherwise, low frequency tremors were observed below Kii peninsula and helium isotope ratio anomaly was detected. It was pointed out that these facts have relation to the fluid flow.

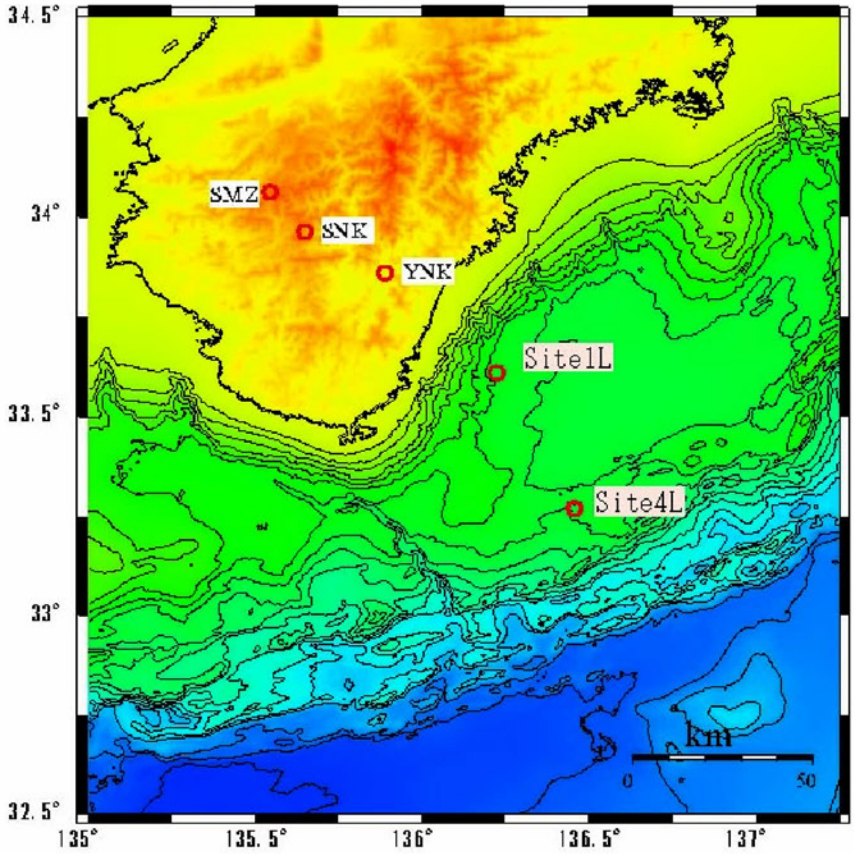


Fig.3-3-1. Locations of recovered OBEMs and on-land magnetotelluric sites in the off-Kumano and Kii region. Site1L and Site4L indicate OBEMs recovered in this cruise.

It is well known that existence of fluid is a key parameter for earthquake occurrence. Also, electrical conductivity of crustal material roughly reflects fluid content at low temperature condition. Therefore, electromagnetic surveys to image a conductivity structure around a seismogenic zone can be useful to discuss mechanisms of earthquake generation and rupture propagation.

In order to obtain the electrical conductivity image around the 1944 Tonankai earthquake region, we have to operate the magnetotelluric survey on land and the ocean bottom because certain important phenomena were observed over wide area. Therefore, We conducted electromagnetic surveys on the Kii peninsula and the ocean bottom around the Kumano Basin (Fig. 3-3-1). Marine magnetotelluric surveys were carried out at 2 sites by using ocean bottom electromagnetometers (OBEMs). Two OBEMs were installed on the seafloor in KY02-12 cruise in December 2002 to January 2003. We will be able to obtain an image of the deep crustal and mantle conductivity structure across the coastline using these marine and on-land electromagnetic data.

4. Instruments and Operation Methods

4-1. R/V KAIREI

R/V KAIREI was built to support the operation of ROV KAIKO, deep-sea research and seismic survey in 1996.

Table 4-1-1. Specifications of R/V Kairei

Length (over all) :	104.9 m
Breadth :	16.0 m
Depth :	7.3 m
Draft :	4.5 m
Gross tonnage :	4,628 t
Cruise speed :	16.0 knots
Range :	9,600 nautical miles
Complement :	60 (29 crew, 31 researchers)
Main Propulsion	Diesel engines 3,000hp×2 units Controllable pitch propeller ×2 units

For operation of dredge and piston coring R/V KAIREI has winch system with a 10,000m steel wire cable. It also has geophysical instruments such as a multi narrow beam echo sounder "Seabeam 2001 series" with sub-bottom profiler, a shipboard gravity meter, a shipboard three-component magnetometer and, a proton magnetometer.

Table 4-1-2. Geophysical survey instruments

Bathymetric survey	Seabeam 2001 series (Seabeam Inc.) bathymetry, back scattering, sub-bottom profiling
Sound velocity measurement	XBT/XCTD: max. depth 1,800m (TSK)
Gravity meter	Shipboard gravity meter (LaCoste & Romberg Gravity Meter, Inc.)
Magnetometer	Three-component magnetometer (Tierra Technica) Proton magnetometer (KGE)

4-2. Heat flow piston coring system

4-2-1. Specification of tools

During Leg 1 of KR03-05 six piston cores were attempted using the heat flow piston coring system (HFPC) (Fig. 2-1). The piston coring system is integrated with a heat flow measurement system such that in a single penetration up to a core is taken and heat flow is measured using a string of temperature sensors along the side of the 6m core barrel (Fig. 4-2-1). The outline of the HFPC is shown in Fig. 4-2-2.

Fig. 4-2-1. HFPC showing 6 m core barrel with nose cone containing core catcher and temperature sensor string in yellow cord along outside of core barrel.

The coring system consists of one stainless steel barrel (6 m long and 89 mm wide) and one vinyl chloride inner liner. Because HFPC must penetrate sediments without bending the barrel, we chose stainless barrel rather than iron or aluminum ones. The barrel is attached to the HFPC head of 0.8 t weights. A 1 m small core at the base of a weight is connected to the main HFPC by a metal arm (balance). Upon reaching the seafloor, the 1 m small core penetrates the sediments triggering the balance, which in turn triggers the HFPC to fire.

The safety panel of JAMSTEC decided that a fuse wire should be used to protect unforeseen cutting of the operation winch wire. The fuse wire is 12 mm wide, and was used between the operation winch wire and balance (trigger system). In order to prevent disturbance of geothermal gradient measurement for 20 minutes, a nylon cross rope of 20 m was attached above the trigger.

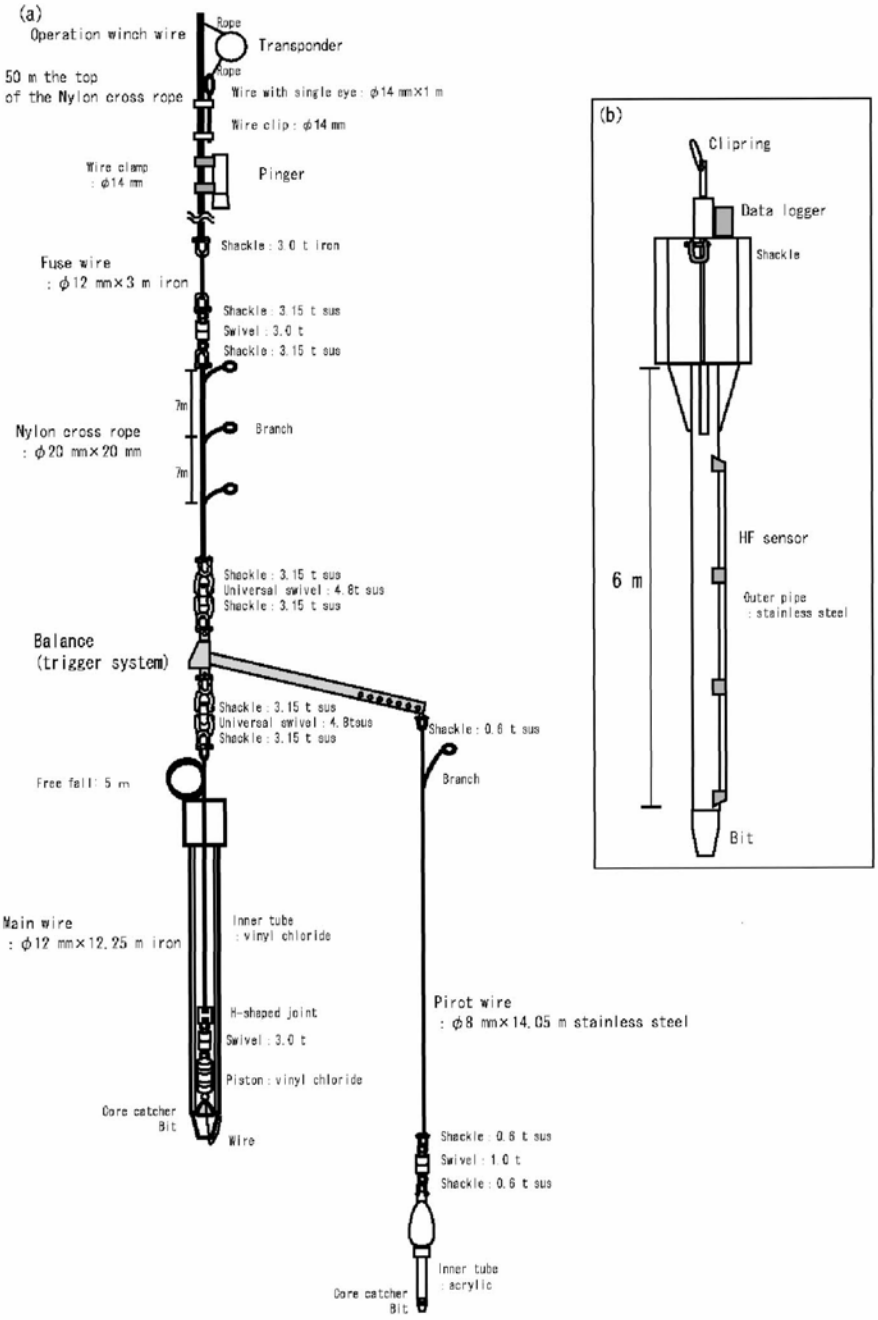


Fig.4-2-2. Components of HFPC system (a) and the main HFPC (b).

4-2-2. General Operations

After the set of the barrel to the HFPC weight on a cart, the main wire is connected, to the piston at the distal end of the barrel. Then core catcher and bit are attached on the barrel end. The trigger below the nylon cross rope was connected to HFPC below the A flame. Before launching of HFPC, water injection is needed to prevent upward moving of the piston by seawater pressure from the bottom of the barrel. Pilot corer was hung on the other trigger end through a pilot wire (14.05 m long and 8 mm wide) after the water injection. Finally, the entire HFPC system was launched from the stern using A frame assemblage (Fig. 4-2-3).

Fig. 4-2-3. Deployment of the HFPC over fantail.

The wire-out speed is usually 60 m/min, and the wire is stopped 100 m above the seafloor for 10 minutes to reduce pendulum motions of the system and to calibrate the temperature sensors using the water temperature near the sea floor. After 10 minutes, the wire-out (60 m/min) was restarted with careful attention to the pen recorder observing the wire tension. When the HFPC attaches to the seafloor, the tension will abruptly decrease by the release of the HFPC weight from the trigger.

After the penetration of HFPC to the seafloor, the wire-out is stopped. After a few seconds from the penetration, an additional wire of 10 m long was released to prevent the disturbance on temperature measurement. After the measurement of the geothermal gradient, rewinding of the wire is started at a speed of 20m/min, until the tension gauge indicate the HFPC detachment from the seafloor. When the HFPC leaves the seafloor the tension gauge shows a sudden decrease of the tension. The total tension after the detachment should be increased by recovered sediments. Finally, the wire-in speed is increased over 70 m/min.

Once back on deck the 6 m HFPC opaque liner is retrieved from inside the core barrel and sectioned into 1 m lengths. If present the core catcher sample was separately described and then stored in a spare HFPC core liner. The 1 m small core is in a clear liner encased in a stainless steel core barrel (Fig. 4-2-4), which was removed from the core barrel and described and sectioned for later analysis of the pore water chemistry. All sectioned cores were stored at 4°C on board.

Fig. 4-2-4. Stainless steel core barrel containing the 1 m small core.

4-3. Deep-sea heat flow measurement

4-3-1. Specification of tools

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. 4-2) into seafloor sediments.

The heat flow probe has a 3m-long lance, along which thermistor temperature sensors are mounted (Fig. 4-3-1). The total weight of the probe is about 800 kg and the lance is strong enough to allow multi penetrations at each station. Temperature of the sensors and two components of the instrument tilt are measured every 30 sec. The data are recorded in the data logger and sent to the surface with acoustic pulses so that we can monitor the status of the probe on the ship.

Fig. 4-3-1. Deep-sea heat flow probe with Ewing type temperature sensors.

On the KR03-05 cruise, we used two different types of temperature sensors; Ewing type sensors mounted in an outrigger fashion and violin-bow type sensors that were used for HFPC as well. We also tested commercial compact temperature recorders (Miniaturized Temperature Data Logger, ANTARES Datensysteme GmbH) as sensors for the heat flow probe (Fig. 4-3-2).

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

Heat Flow Data Logger (Kaiyo Denshi Co.)

Pressure case: anodized aluminum
Case length: 830 mm
Diameter: 100 mm
Pressure rating: 6000 m water depth
Number of temperature channels: 8
Temperature resolution: 1mK
Tilt: two-axis, 0 to ±45°
Data-cycle interval: 30 sec
Pinger frequency: 15.0 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 s to 255 min.

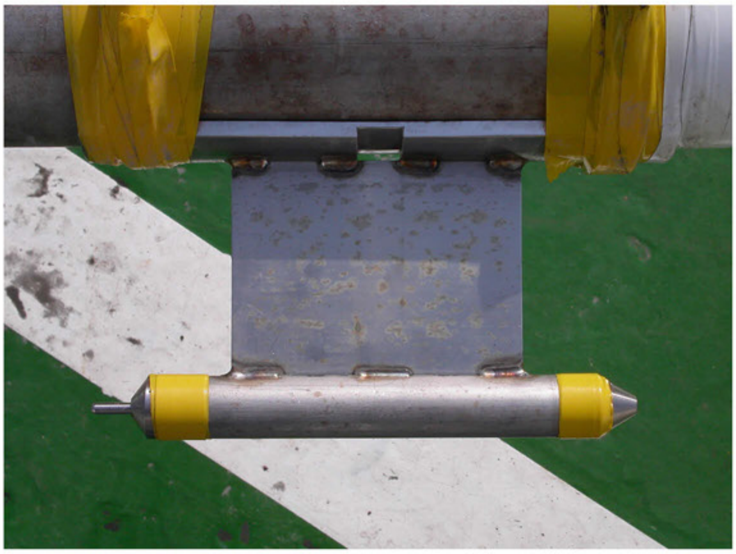


Fig. 4-3-2.
ANTARES Temperature Data Logger mounted on the core barrel of the HFPC.

4-3-2. Operations

A 20 m long fiber rope was put 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 also attached 50 m above the probe for precise determination of the position of the probe (Fig. 4-3-3).

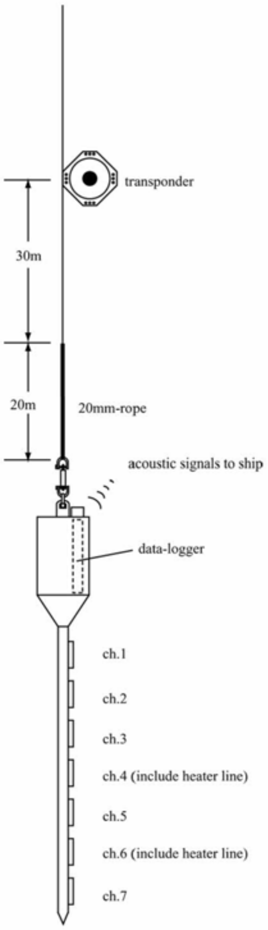


Fig. 4-3-3. Schematic illustration of the heat flow measurement system in deep sea.

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

1. Measure water temperature 50 to 100 m above the sea floor for calibration of temperature sensors.
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 20 min. Monitor the wire tension and pay out the wire when necessary to keep the probe stable.
4. Pull out the probe and move to the next station.

4-4. Long-term temperature monitoring systems

For heat flow measurement in shallow sea (Kumano Trough), we used three types of long-term temperature monitoring systems.

4-4-1. Pop-up heat flow instrument (PHF)

We have been developing pop-up type heat flow probes that can record temperatures in the surface sediment for more than one year. Long-term sediment temperature records up to about 300 days have been obtained with these instruments at 5 stations in shallow sea areas off Shikoku and off Kumano. At two stations where temperature records longer than 200 days were obtained, we could determine the temperature gradient and heat flow by removing the effect of the bottom water temperature variation from the raw temperature data.

We planned to deploy two pop-up heat flow instruments (termed PHFs below). The basic configuration and specification of the two instruments, PHF-1 and PHF-2, are essentially the same. The main components of the PHF are a recording unit, a temperature probe and a weight (Fig. 4-4-1). 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. The temperature resolution is 1 mK. A small water temperature recorder (NWT-DN, Nichiyu Giken Kogyo Co., cf. 4-4-3) is attached to the main frame for monitoring the bottom water temperature. After recording the sediment temperatures, the PHF releases the weight and temperature probe responding to an acoustic command, and then the recording unit pops up and can be recovered with a surface ship.

For accurate determination of the temperature gradient, it is necessary to calibrate the temperature sensors by measuring the water temperature at 1000 m or deeper, which is spatially quite uniform. We thus lowered the PHF down to about 1900 m depth and measured the water temperature for 30 min. This temperature record will be used for analyses of long-term sediment temperature data.

When we deploy the PHF, an additional acoustic releaser is set between the PHF and the winch wire rope (Fig. 4-4-2). The PHF is lowered to about 20 m above the sea floor, monitoring the depth of the instrument using the transponder system. Then an acoustic command is sent to activate the releaser and the PHF falls freely to penetrate into the sediment.

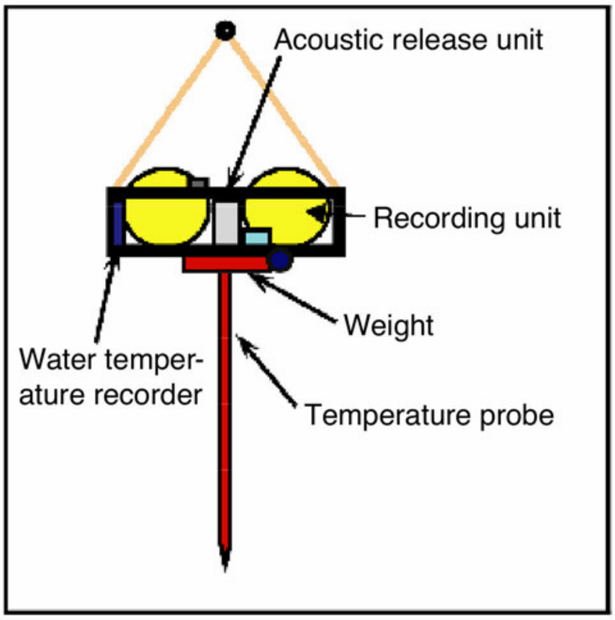


Fig. 4-4-1. Schematic configuration of the pop-up heat flow instrument (PHF).

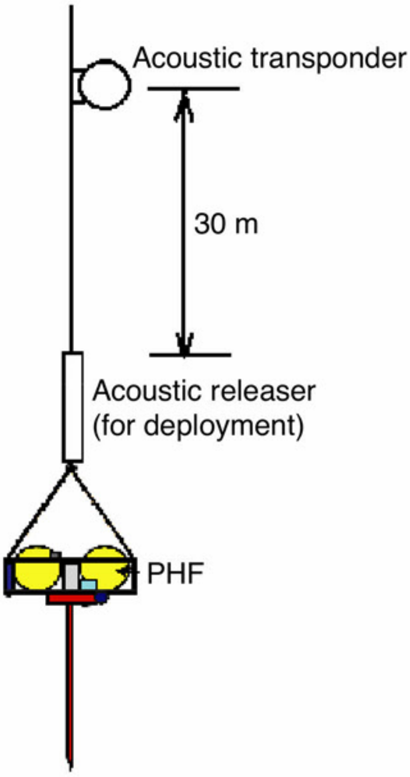


Fig. 4-4-2. Method for deployment of the PHF.

4-4-2. Pop-up pore pressure and temperature instrument (PPT)

The pop-up pore pressure and temperature instrument (termed PPT below) is also an instrument that can monitor the temperature distribution in surface sediment for one year or more (Fig. 4-4-3). In addition to temperatures, however, it measures sediment pore pressures as well. Four temperature sensors and two pressure ports are installed along a 2-m long probe. The differences between the pressures at the ports along the probe and those on the sea floor are recorded with a resolution of about 0.1 mmH_2O.

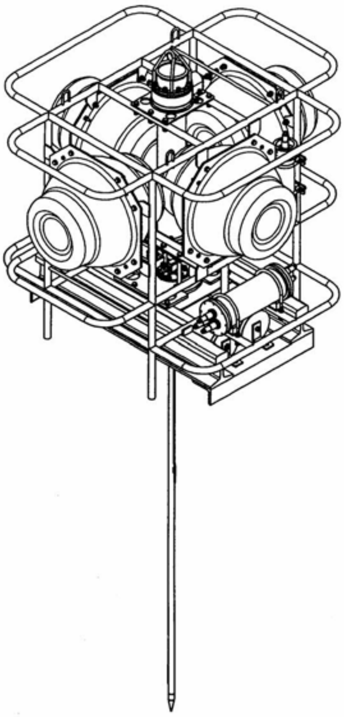


Fig. 4-4-3. Pop-up pore pressure and temperature instrument (PPT)

We have been developing this instrument to study pore fluid flows in accretionary prisms by measuring both the temperature profile and pore pressures at the same station. It is still an immature instrument and we need to test its performance for long-term deployment, especially on pore pressure measurement. On the KR03-05 cruise, we deployed the PPT as a long-term temperature monitoring instrument for heat flow measurement, though it would be a long-term running test of the pressure ports in sediment. The procedure for deployment was the very same as the one for the PHF.

4-4-3. Pop-up water temperature measurement system (PWT)

We have already obtained heat flow data in shallow sea areas through long-term temperature monitoring with PHFs. It is not easy, however, to conduct measurements with PHFs at many stations, since the monitoring period should be longer than half a year and the instruments are relatively expensive. If we obtain bottom water temperature records at additional stations, we may be able to clarify the general pattern and features of bottom water temperature variations in the Kumano Trough. Such information will be helpful in shortening the monitoring period for PHFs. Moreover, we may be able to determine heat flow from the temperature profile measured with ordinary deep-sea probes in combination with the preceding bottom water temperature records.

We developed a pop-up water temperature measurement system (termed PWT below) in order to obtain long-term bottom water temperature records. The PWT consists of an acoustic releaser, weights, floats (grass spheres), and a small temperature recorder (Fig. 4-4-4). As a small temperature recorder, we used Nichiyu Giken NWT-DN and ANTARES MTL. For deployment, the whole system is released at the sea surface and it sinks freely down to the sea floor, which means we do not need a deep-sea winch. The system is recovered by activating the acoustic releaser with a command sent from a surface ship.

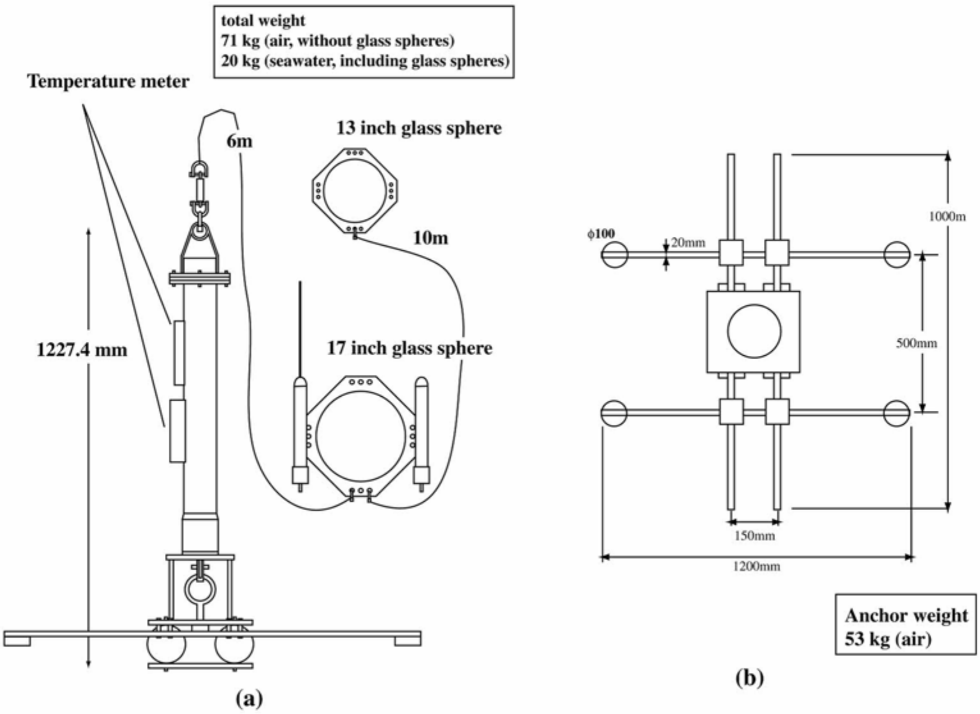


Fig. 4-4-4. Pop-up water temperature measurement system (PWT).
(a) Schematic drawing of the whole system, (b) weights.

Specifications of the PWT and NWT-DN are summarized below (cf. 4-4-1 for ANTARES MTL).

Pop-up water temperature measurement system

Acoustic releaser: model MX-1208 (Kaiyo Denshi Co.)

Pressure case: titanium alloy

Case length: 1227 mm

Pressure rating: 6000 m water depth

Total weight: 71 kg in the air, 20kg in the water

Water temperature recorder NWT-DN (Nichiyu Giken Kogyo Co.)

Pressure case: titanium alloy

Case length: 212 mm

Diameter: 41 mm

Pressure rating: 6000 m water depth

Number of temperature channel: 1

Temperature resolution: 1 mK

Sample rate: variable from 2 s to 1 day

The first deployment of the PWT was conducted on the KY02-12 cruise of R/V KAIYO On the KR03-05 cruise, we recovered this system and deployed it again. We also deployed another PWT.

4-5. Ocean bottom electro-magnetometers

Two ocean bottom electro-magnetometers (OBEMs) were deployed during the KY02-12 cruise in the off-Kumano area in December 2002 and January 2003. We used two type OBEMs in this survey, MELT-type and OBEM99-type from Earthquake Research Institute (ERI), University of Tokyo. The locations of thetwo OBEMs are shown Table 4-5-1. Our objective on this cruise is to recover these OBEMs.

Fig .4-5-1 shows the OBEMs. MELT-type OBEM deployed at Site1L has three glass spheres. Transponder is packed in the top glass sphere and battery is stored in the bottom one. Fluxgate sensor, mangnetometer, voltmeter and tilt meter are packed in the other one. On the other hand, OBEM99-type OBEM has two glass spheres. All sensors are packed in the left sphere in the right panel of Fig.4-5-1. Acoustic unit and battery are installed in the right sphere. Furthermore, transducer is mounted on the top of the flame. Both OBEMs have four pipes for measuring the electric field and silver-silver chloride electrodes are attached to the tips of pipes.

Table 4-5-1. Locations for two recovered OBEMs in this cruise.

	Deployed position (KY02-12)			Estimated settled position (KY02-12)		
Site No.	Lat (N)	Lon (E)	Depth (m)	Lat (N)	Lon (E)	Depth (m)
1L	33-36.1304	136-13.5268	1858	33-36.0748	136-13.5416	1795
4L	33-16.2013	136-26.6691	1993	33-16.2989	136-27.4164	1964

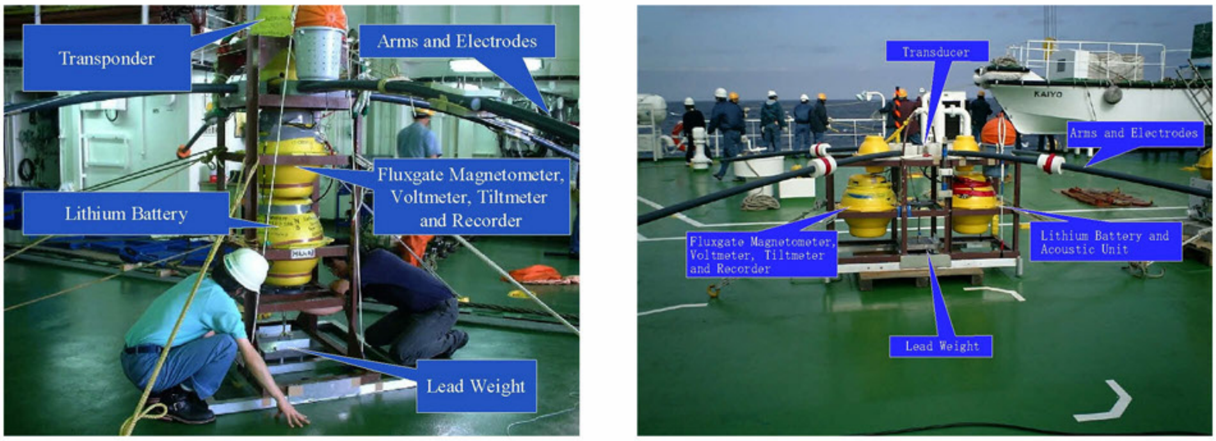


Fig.4-5-1. Left panel is MELT type(TT4) and Right panel is OBEM99 type(TT6)

Measurement parameters and detailed features of the OBEMs are listed in Tables 4-5-2 and 4-5-3. Sampling interval is set to 30 second and both OBEMs started to record at the same time. Electric dipole length is 5.21 m and 5.26 m for MELT-type and OBEM99-type respectively.

Table 4-5-2. Recording information of recovered OBEMs.

Site No.	OBEM ID	Start time (JST)	Sampling int. (sec)	Electric dipole length (m)	Electrode type
1L	TT4	2002.12.25 12:00:00	30	5.21	Silver-Silver chloride
4L	TT6	2002.12.25 12:00:00	30	5.26	Silver-Silver chloride

Table 4-5-3. Details of the recording instruments.

OBEM Type	Site No.	Fields	Dynamic Range	LSB	Note
MELT	Site 1L	Magnetic field		0.1nT	N,E positive
		Electric Field	2bytes (16bits)	0.3051758_V	N,E positive
		Tilt		1/600degree	N down, E down positive
OBEM99	Site 4L	Magnetic field		10pT	N,E positive
		Electric Field		0.3051758_V	N,E positive
		Tilt		0.00026degree	N down, E down positive
		Temperature		0.01_	Non negative

Radio beacon and flushing light are mounted on each OBEM and have pressure switches which are turned off under water pressure. Table 4-5-4 shows their information. In recovery time, they are useful for finding the OBEM because they work when the OBEM pop up to sea surface.

Each OBEM has a different acoustic unit. The acoustic transponder and release system of the MELT-type OBEM is made by Benthos Inc. The OBEM99-type has an acoustic transponder made by Nichiyu Giken Kogyo Co., while the Benthos release system was adopted.

Table 4-5-4. Information on acoustic units.

Site No.	OBEM ID	Flashing light	Radio Beacon		Acoustic release system	
			Frequency	Radio Beacon No.	Vender	Release code
1L	TT4	mounted	43.528MHz	ERI No.6	Benthos	C (Tx: 10.0kHz, Rx: 11.0kHz)
4L	TT6	mounted	43.528MHz	ERI No.3	Nichiyu	3D

4-6. Pinger signal receiving system

4-6-1. Outline

The height of pinger is estimated by the two way travel time between direct signal from the pinger and the bottom reflection. There is not PRD receiver on R/V KAIREI. We try to detect two way travel time with following method.

(1) Instruments

- Acoustic Navigation System of KAIREI (OKI Electric Industry Co., Ltd.)
- Heat Flow Data Logger (Kaiyo Denshi, Co.)
- SSBL transponder (Benthos, Inc.)
- Acoustic pinger (Kaiyo Denshi, Co.)
- Pinger receiver (Kaiyo Denshi, Co.)
- Personal note book computer (SONY)
- Digital oscilloscope (Tektronix)

(2) Signal Frequency

Acoustic Navigation System of KAIREI

Receive : 13.0, 13.5, 14.0, 14.5, 15.0, 15.5kHz
Interrogate: 13kHz

/ kHz	12.0	13.0	13.5	14.0	14.5	15.0	15.5	Remarks
Interrogate		◎						
Receive		○	○	○	○	○	○	
Transponder XT				◎				
Pinger XT	○					○		12 or 15kHz band
Data logger XT	○					○		
Seabeam	◎							

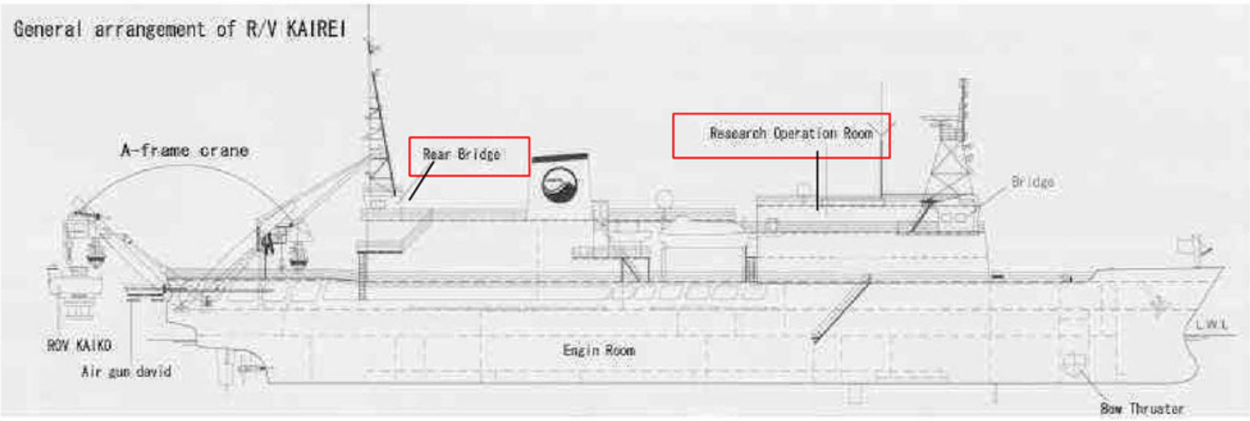
XT: transmit frequency
○: selectable
◎: fixed

The 15kHz band is selected for the transmit signal of pinger and data logger system during this cruise.

4-6-2. Arrangement and wiring

Fig. 4-6-1 shows the place of Acoustic Navigation System (Research Operation Room) and winch operation console (Rear Bridge).

Fig. 4-6-1



(1) Research Operation Room

Fig. 4-6-2 Acoustic Navigation System of the KAIREI

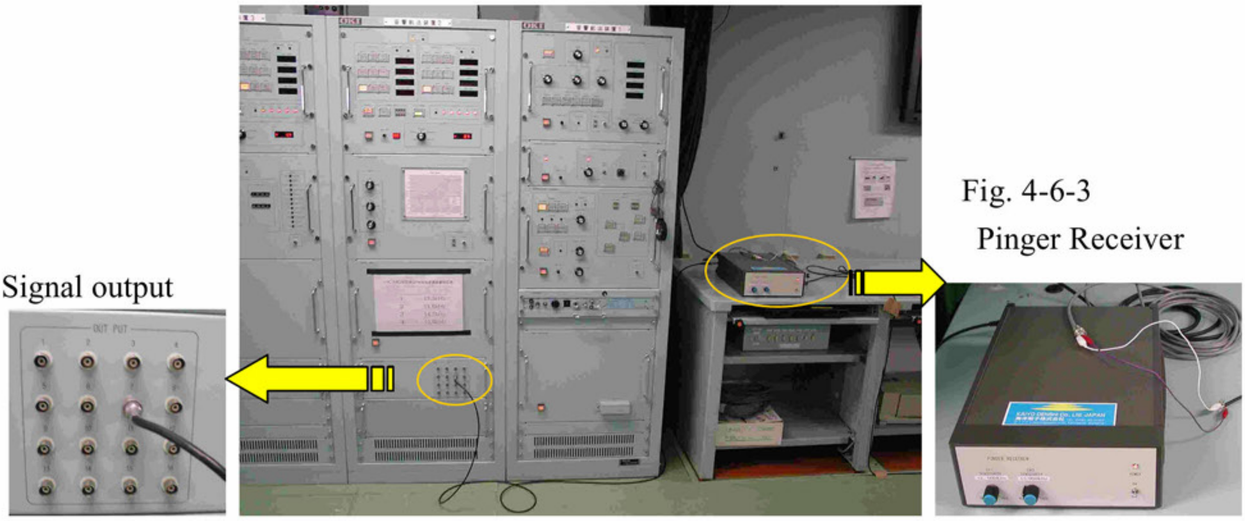
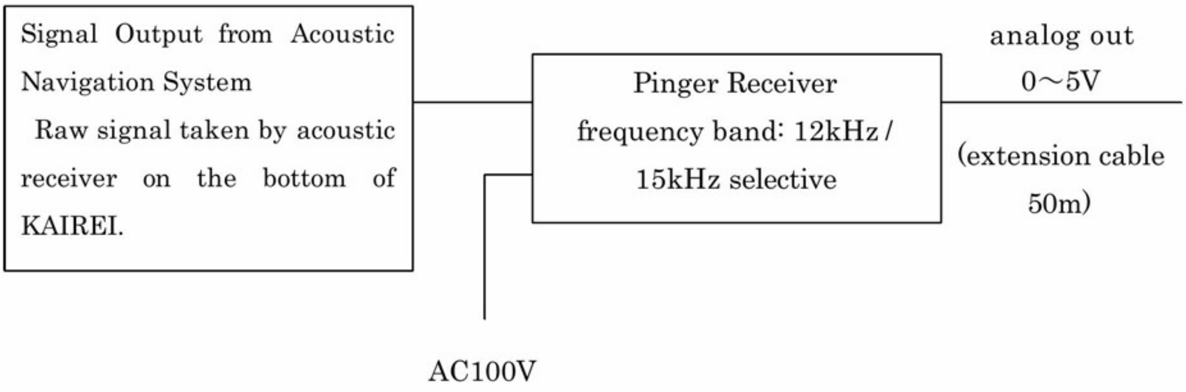


Fig. 4-6-3 Pinger Receiver



(2) Rear Bridge

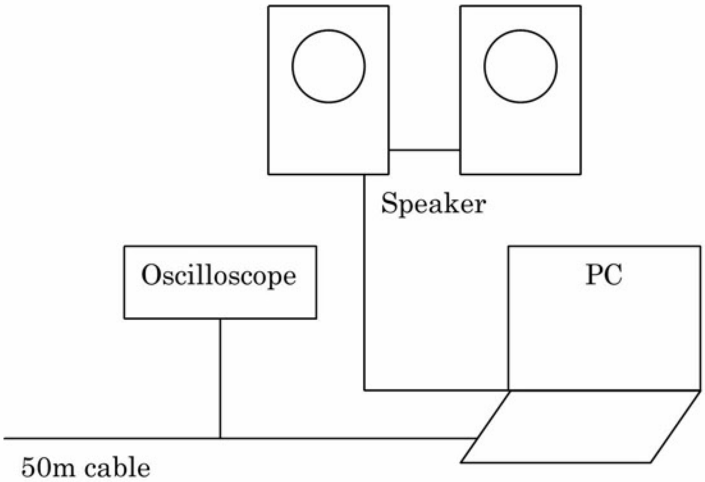
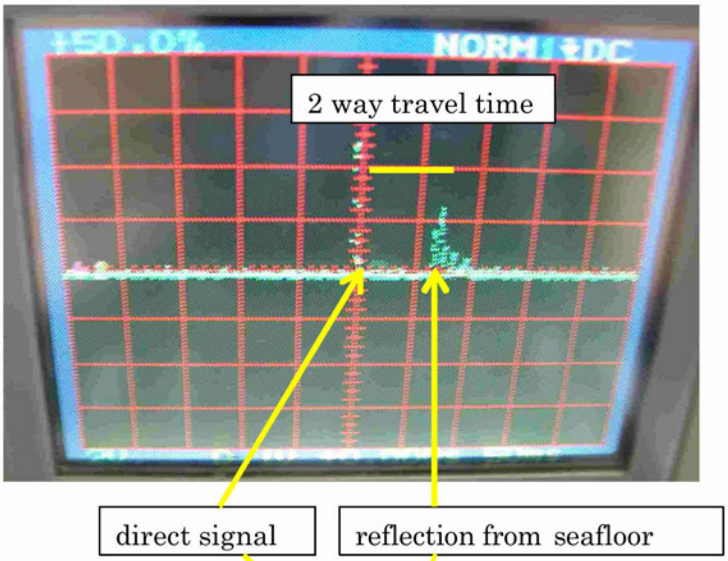
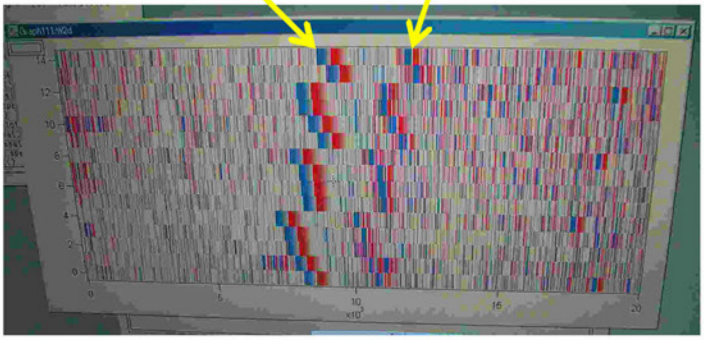


Fig. 4-6-4

Fig. 4-6-5 Digital oscilloscope



Horizontal grid 0.1sec =75m
This picture shows pinger height is about 90m from the bottom



Horizontal range = about 1 sec.

Fig. 4-6-6 "BG Plot " on PC

4-6-3. Under water system

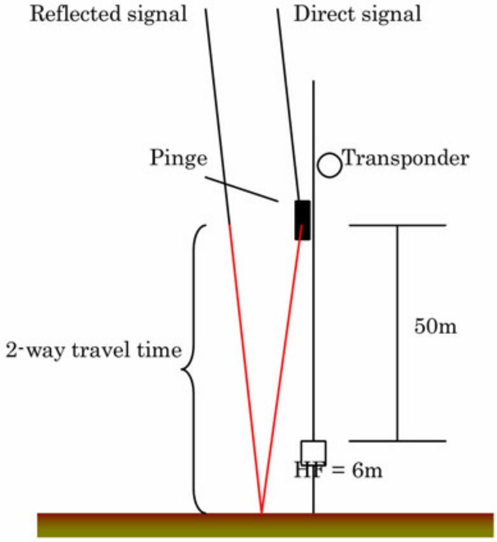


Fig. 4-6-7 Image of ranging with pinger

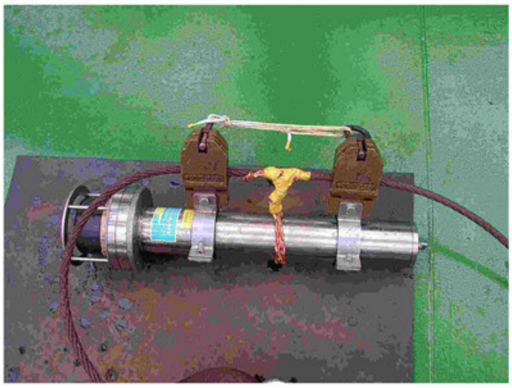


Fig. 4-6-8

Pinger (KAIYO DENSHI Co., Ltd.)

Transmit: 15.0kHz

Fig. 4-6-9

Transponder XT6000 (Benthos, Inc.)

Receive: 13.0kHz,

Transmit:14.0kHz

Fig. 4-6-10 Data logger

Transmit: 15kHz

Fig. 4-6-11

Transponder and pinger on the wire.

The distance of pinger from piston core weight is about 50m.

5. Preliminary Results

5-1. Piston coring

5-1-1. Sampling sites

Core sampling with the HFPC (heat flow piston coring system) were attempted at six sites listed in Table 5-1-1. Detailed logs of coring operations are presented in Appendix A-3.

The locations of HFPC-1, 2, and 4 are plotted on a detailed bathymetry map in Fig. 5-1-1. Because the recovery of HFPC-2 was too short, we tried coring at the same site (HFPC-4). But the recovery was almost the same as that of HFPC-2 (Table 5-1-2). As we designed to measure the physical properties and obtain the images using CT-scan on whole round cores in the post-cruise, any core were not split during the cruise.

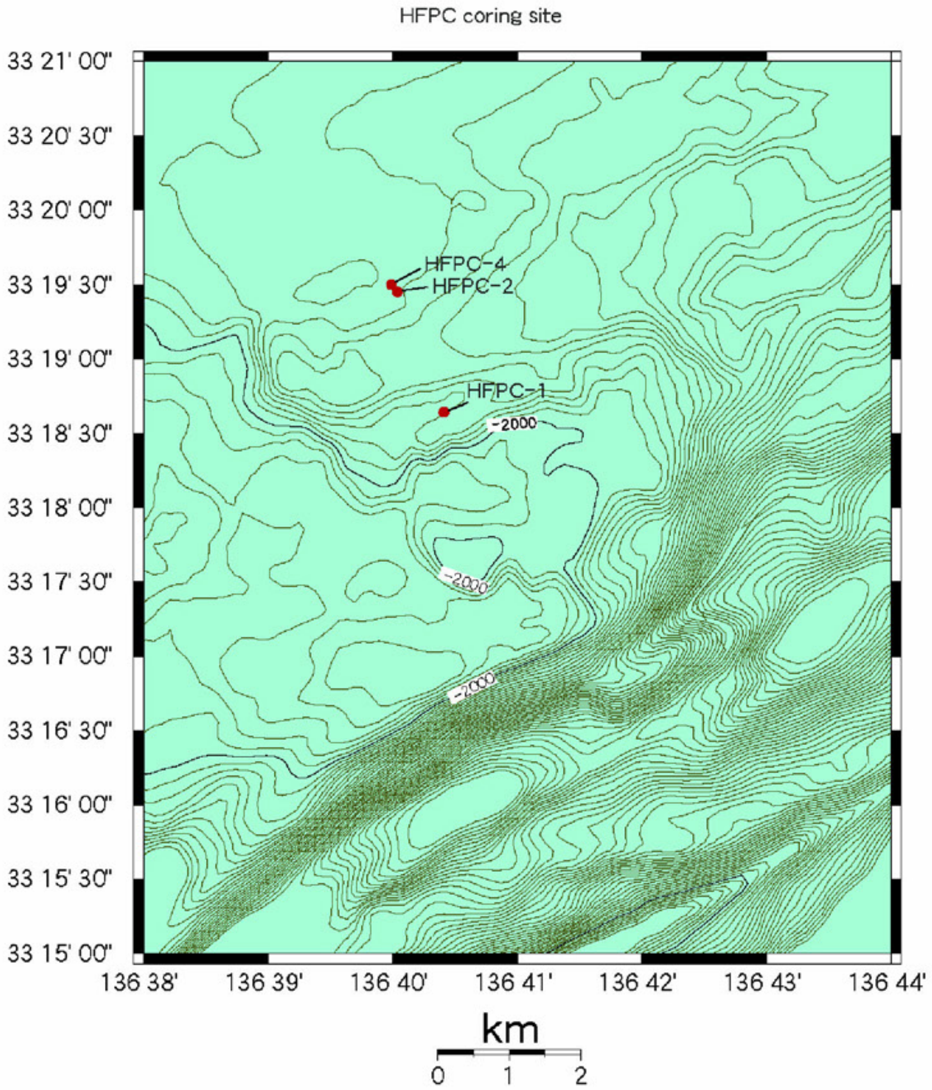


Fig. 5-1-1. Locations of the core sampling sites, HFPC-1, 2, and 4.

Table 5-1-1. Core sampling stations

KR03-05 Heat flow piston cores points

Date(JST)	Station No.	Time Surfaced	Hit the Bottom						Leave the Bottom				Time Surfaced
		(h:m)	Time(h:m)	Lat. (N)	Long. (E)	WD(m)	WL(m)	Max WL(m)	Time(h:m)	Lat. (N)	Long. (E)	WD(m)	(h:m)
05.19.03	HFPC-1	11:13	12:18	33 -18.64	136 -40.41	2,025	2,022	2,036	12:40	33 -18.62	136 -40.40	2,026	13:24
	HFPC-2	14:31	15:32	33 -19.45	136 -40.04	2,041	2,036	2,046	15:54	33 -19.46	136 -40.04	2,040	16:36
05.20.03	HFPC-3	11:39	12:53	33 -11.47	136 -43.52	2,928	2,944	2,955	13:15	33 -11.45	136 -43.53	2,935	14:11
	HFPC-4	15:37	16:38	33 -19.50	136 -39.99	2,047	2,030	2,041	16:59	33 -19.50	136 -40.00	2,049	17:40
05.21.03	HFPC-5	6:21	8:01	32 -59.43	136 -25.31	3,948	3,976	3,997	8:25	32 -59.43	136 -25.33	3,947	9:38
	HFPC-6	17:47	19:33	32 -35.53	135 -53.93	4,678	4,731	4,746	19:54	32 -35.54	135 -53.93	4,682	21:23

WD:Water Depth WL:Wair Length

5-1-2. Description of small cores

The 1 m small cores taken with the HFPC were described based on length, color, and sediment type. Each small core was photographed digitally through the clear liner before sectioning. Table 5-1-2 is a list of coring results during Leg 1 of KR03-05. One unfortunate event was that during the collection of the last core HFPC-6 the core barrel was badly bent (Fig. 5-1-2). No sediment was recovered (Table 5-1-2), however the sediment on the exterior of the core barrel near the nose cone was a dark olive silt which was much coarser than sediments found elsewhere during the cruise.

Fig. 5-1-2. Bent core barrel of HFPC during attempted collection of HFPC-6.

Table 5-1-2. Piston core recoveries

Sample	Sediment recovered in large core barrel	Sediment recovered in small core barrel
HFPC-1	~3.5 m	~6 cm
HFPC-2	~1.67 m	50 cm
HFPC-3	4.5 m	68 cm
HFPC-4	2.0 m	40 cm
HFPC-5	3.5 m	14.5 cm
HFPC-6	0 cm	0 cm

Core KR03-05-HFPC-1

Core KR03-05-HFPC-1 came on deck at 13:48 on 5/19/03. The core was taken at shotpoint 2365 on MCS line KR108 (Table 5-1-1, Fig. 5-1-1). HFPC-1 was taken to date sediments on the downthrown side of a normal fault on the seaward edge of the Kumano forearc basin.

The core catcher for the big corer was empty. Sections 6,5, and 4 for the big corer were filled with sediment; section 3 was 50% filled. In the small corer, a 6 cm core was recovered and the core catcher was empty.

Small core description (Fig. 5-1-3):

0.0-1.0 cm. Grayish Olive silty clay. Hue 7.5 Y, Value 5, Chroma 2. This zone has fibrous texture. It is a brown thready material. Sample is a very slightly silty clay.

1.0-6.0 cm. Dark Greenish Gray silty claystone. Hue 10G, Value 5, Chroma 11.

Small core sample:

The small core from HFPC-1 was stored as one sample entitled ‘HFPC-1’.

Fig. 5-1-3. HFPC-1 Small Core with blue tape marking down direction.

Core KR03-05-HFPC-2

Core KR03-05-HFPC-2 came on deck on 5/19/03. The core was taken at shotpoint 2345 on MCS line KR108 (Table 5-1-1, Fig. 5-1-1). HFPC-2 was taken to date sediments on the upthrown side of a normal fault on the seaward edge of the Kumano forearc basin. In the Big Core, Sections 6 and 5 were full.

The core catcher for the big corer was empty. Sections 6, for the big corer were filled with sediment; section 5 was 67% filled. In the small corer, a 50 cm core was recovered.

Small core description (Fig. 5-1-4a-e):

0.0-3.5 cm. Grayish Olive silty clay. Hue 7.5 Y, Value 5, Chroma 2. This zone has fibrous texture. It is a brown thready material. Sample is a very slightly silty clay.

3.5-40 cm. Dark Greenish Gray silty claystone. Hue 10G, Value 5, Chroma 11.

Small core Samples:

The small core from HFPC-2 was sectioned into 3 sections: 0-15, 15-30, 30-48 cm.

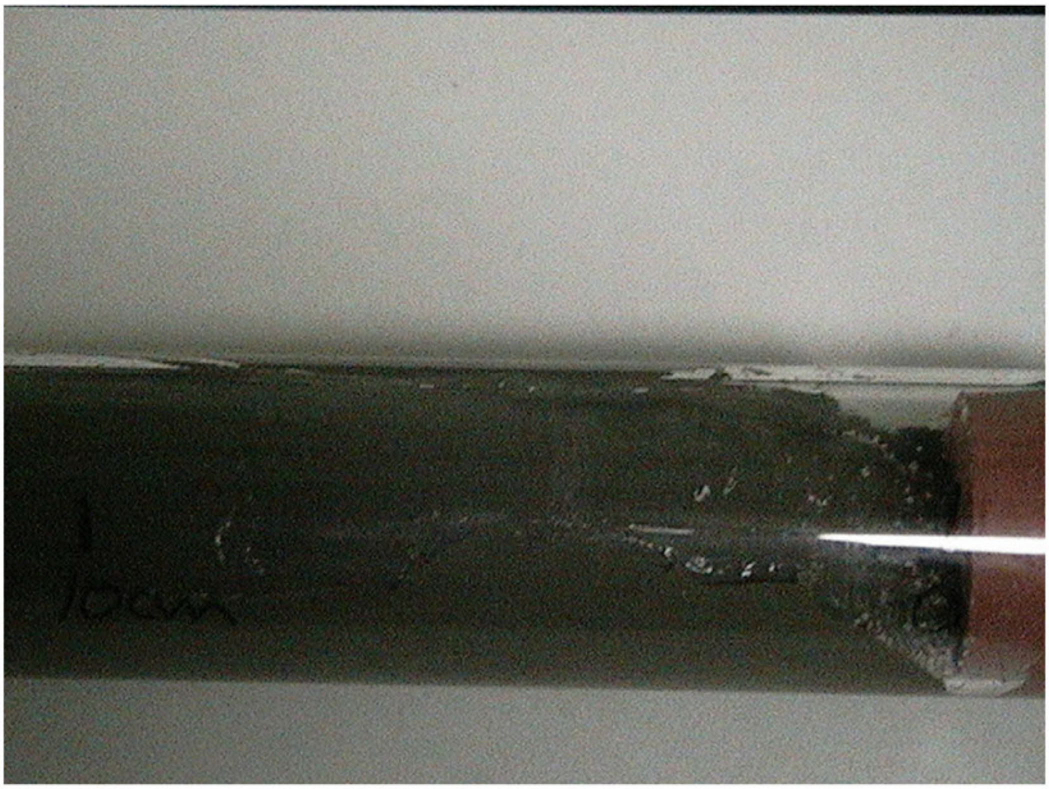


Fig. 5-1-4a.   0-10 cm of HFPC-2 with up to the right.

Fig. 5-1-4b.   10-20 cm of HFPC-2 with up to the right.

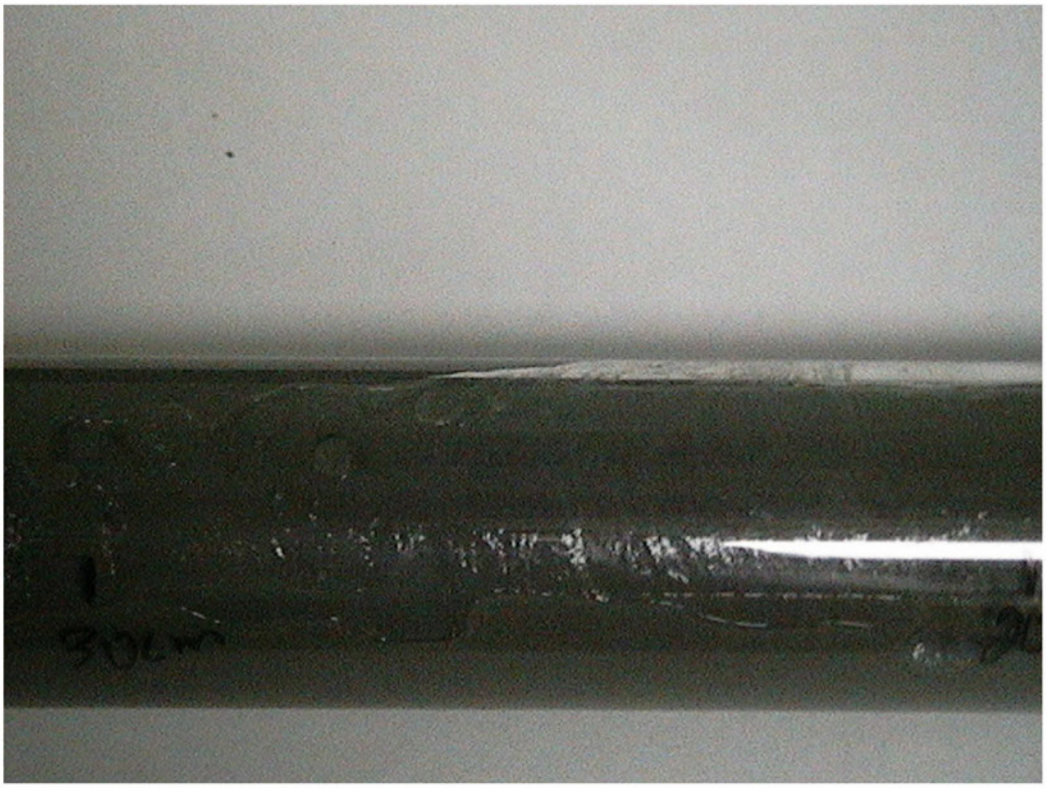


Fig. 5-1-4c. 20-30 cm of HFPC-2 with up to the right.

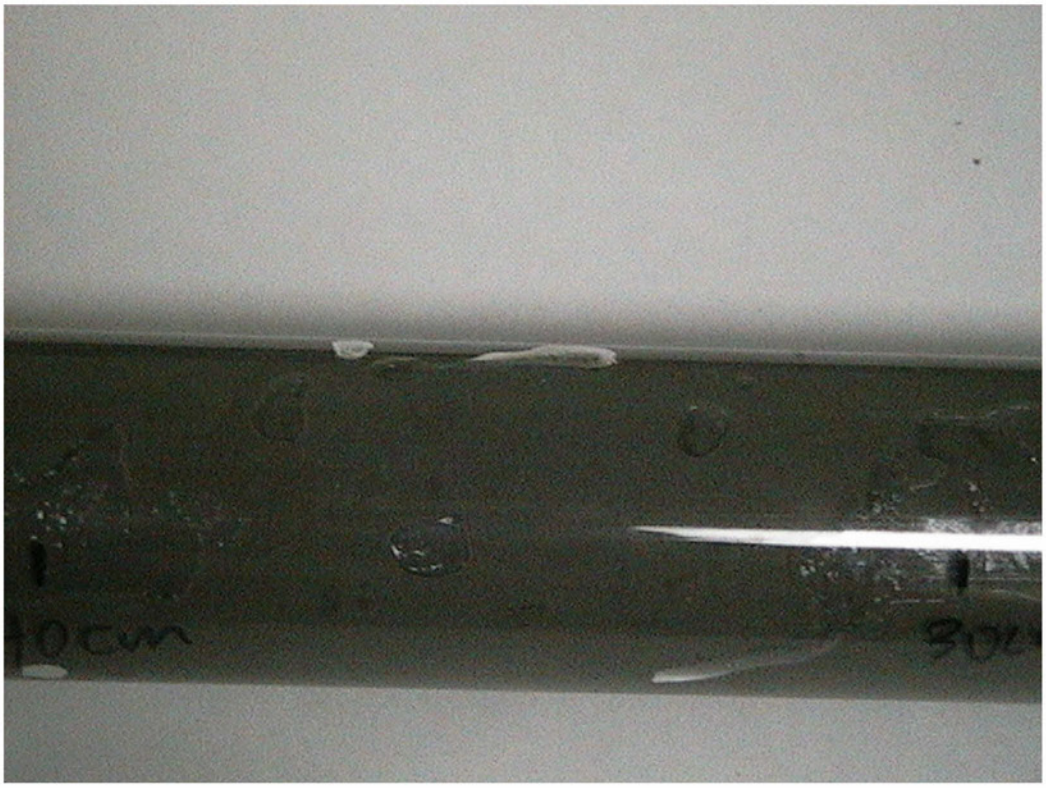


Fig. 5-1-4d. 30-40 cm of HFPC-2 with up to the right.

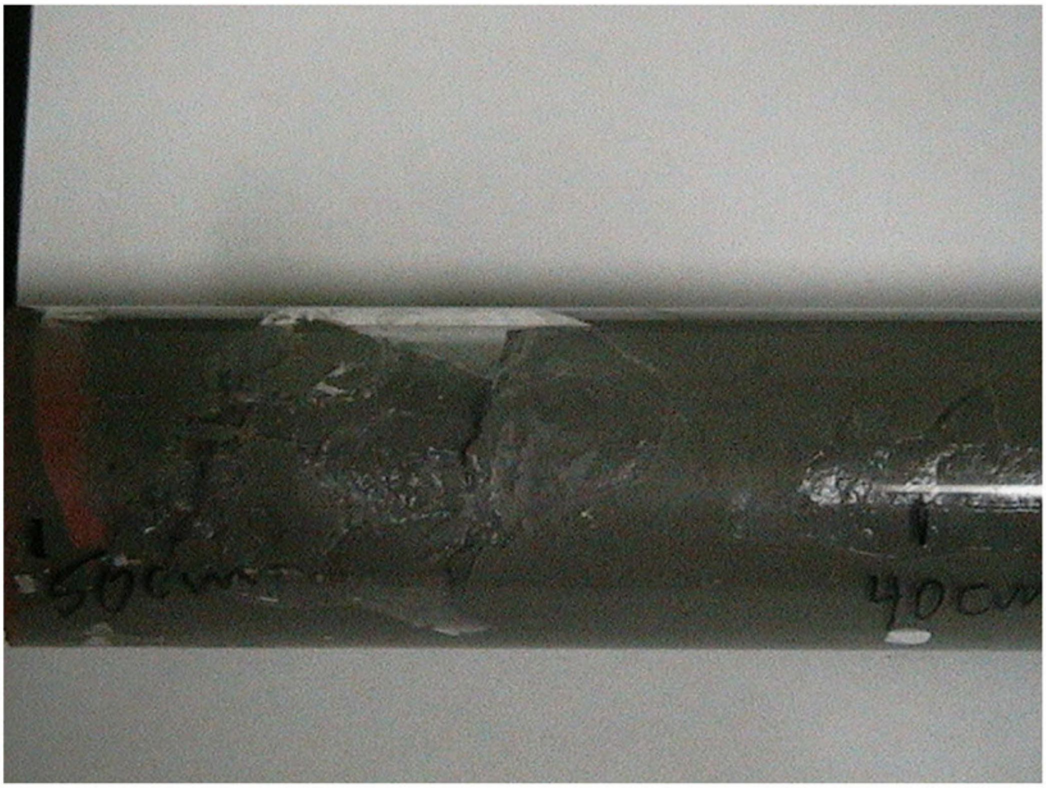


Fig 5-1-4e. 40-50 cm of HFPC-2 with up to the right.

Core KR03-05-HFPC-3

Core KR03-05-HFPC-3 came on deck on 5/20/03. The core was taken at shot point 2050 on MCS line KR108 (Table 5-1-1, Fig. 2-1). HFPC-3 was taken to date sediments overlying the out-of-sequence thrust in the vicinity of the proposed IODP riser drilling site. In the Big Core, Sections 6,5,4, and 3 were full and Section 2 was 1/2 full.

The core catcher for the big corer was empty. We noted that at the base of the Big core there was a grayish white silty material that was possibly ash. In the small corer, a 68 cm core was recovered.

Small core description (Fig. 5-1-5a-f):

0.0-3.0 cm. Grayish Olive clay. Hue 7.5 Y, Value 5, Chroma 2. This zone has fibrous texture. It is a brown thready material. Sample is a very slightly silty clay.

3.0-68 cm. Dark Greenish Gray clay. Hue 10G, Value 5, Chroma 11.

Small core Samples:

The small core from HFPC-3 was sectioned into 4 sections: 0-15, 15-30, 30-45, 45-68 cm.

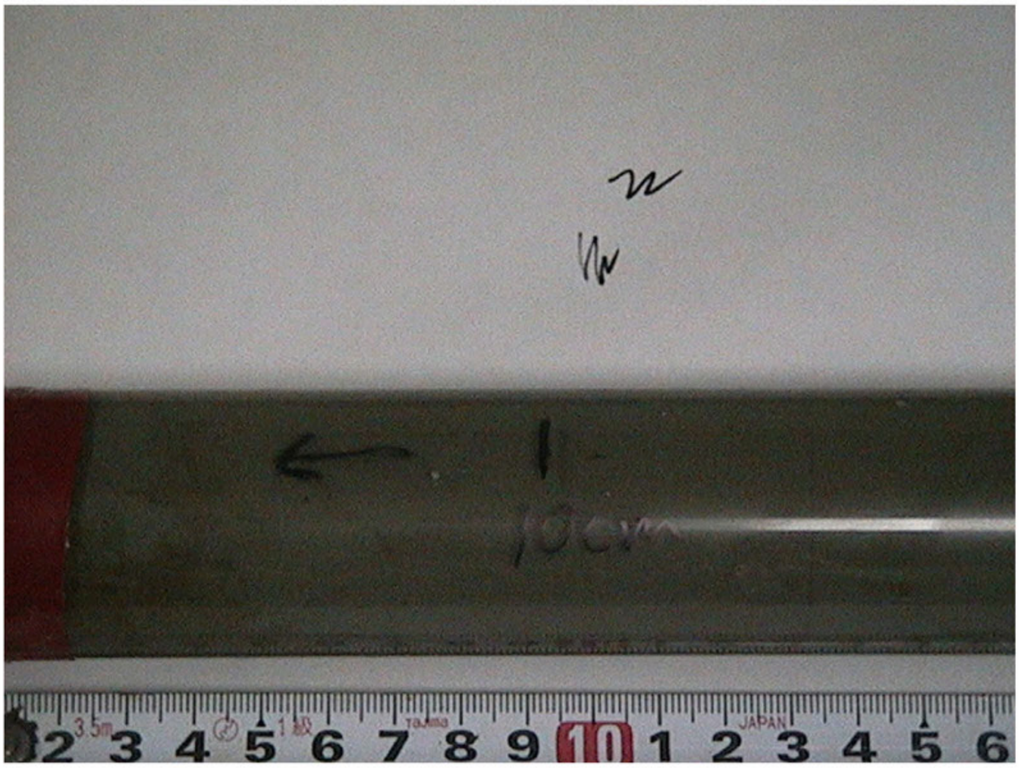


Fig. 5-1-5a. 2-16 cm of HFPC-3 with up to the left.

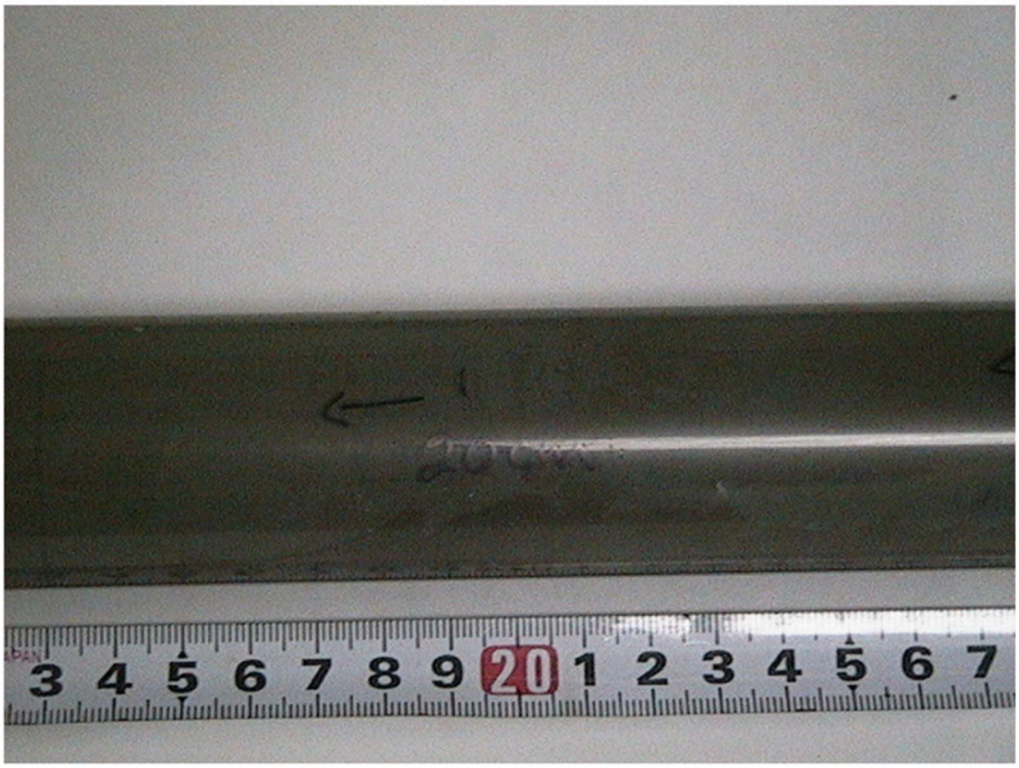


Fig. 5-1-5b. 13-27 cm of HFPC-3 with up to the left.

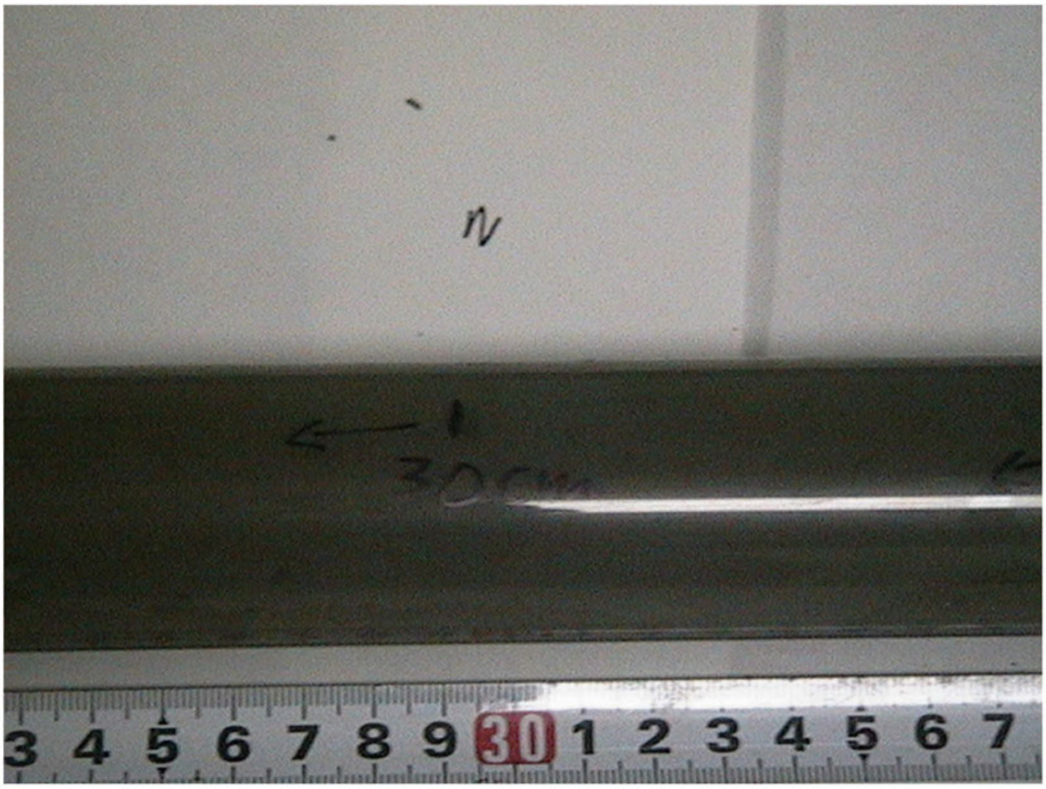


Fig. 5-1-5c. 23-37 cm of HFPC-3 with up to the left.

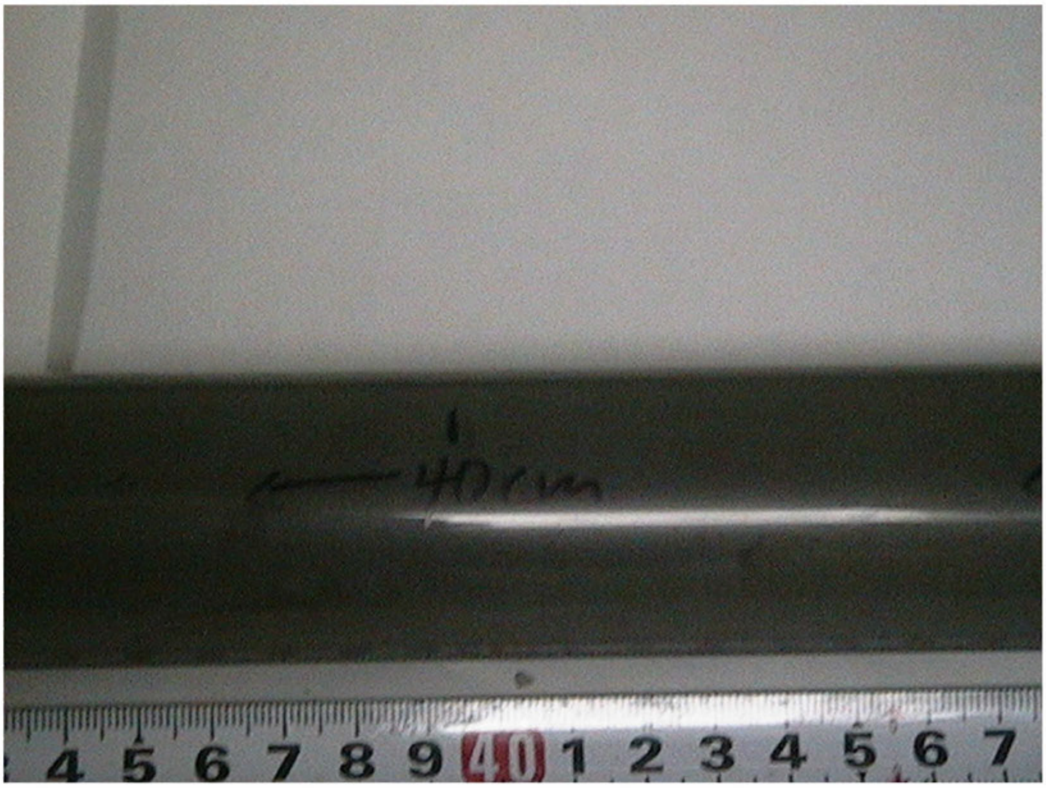


Fig. 5-1-5d. 33-37 cm of HFPC-3 with up to the left.

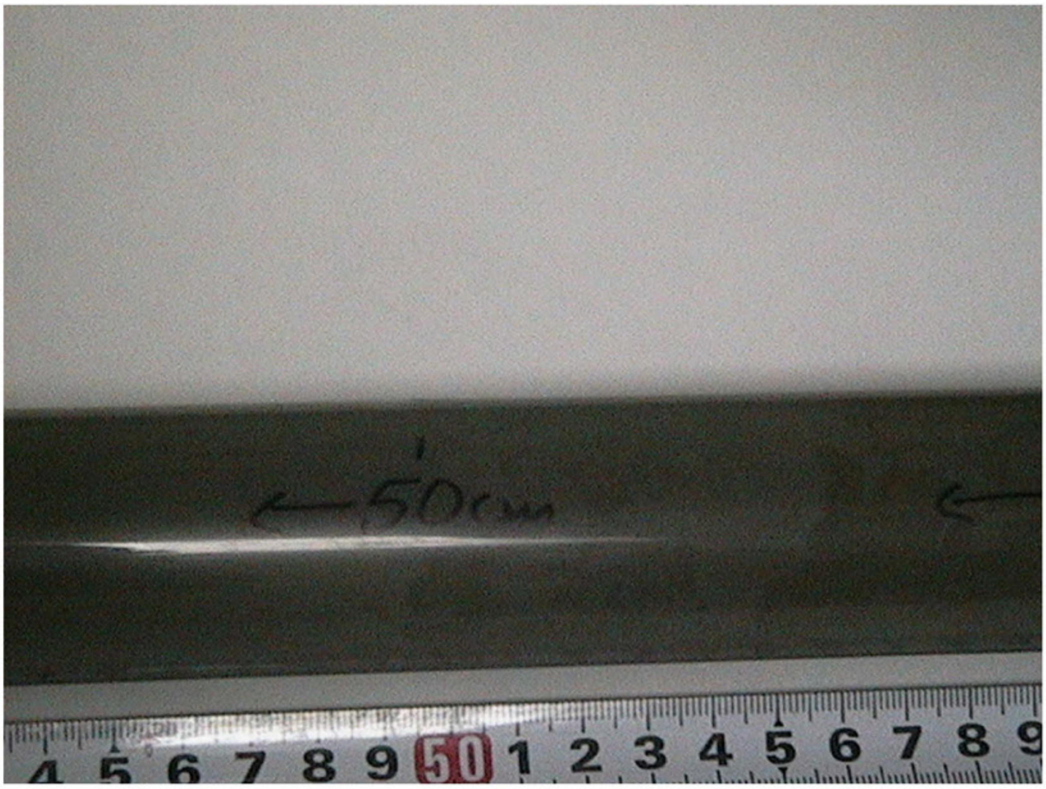


Fig. 5-1-5e. 44-49 cm of HFPC-3 with up to the left.

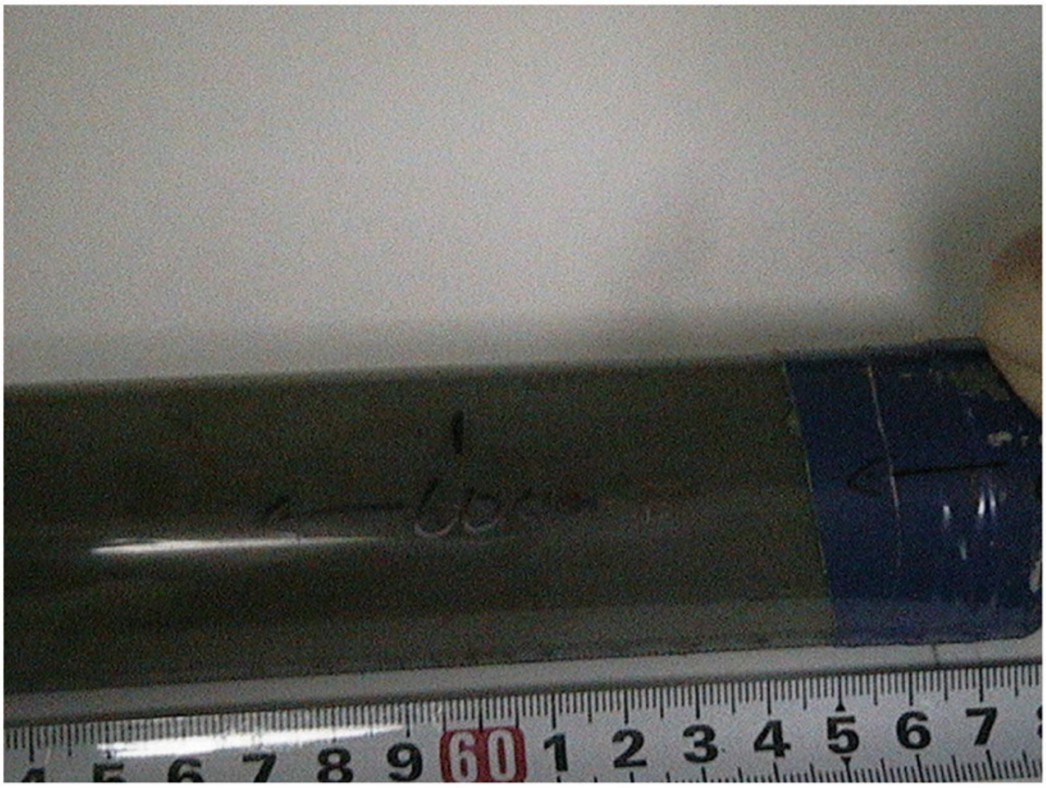


Fig. 5-1-5f. 54-68 cm of HFPC-3 with up to the left.

Core KR03-05-HFPC-4

Core KR03-05-HFPC-4 came on deck on 5/20/03 at 18:33. This was collected at the close to HFPC-2 in an attempt to get greater core recovery in the large core. The core was taken at near shotpoint 2345 on MCS line KR108 (Table 5-1-1, Fig. 5-1-1).

The core catcher for the big corer was empty. In the small corer, a 40 cm core was recovered.

Small core description (Fig. 5-1-6a-d):

0.0-3.0 cm. Grayish Olive silty clay. Hue 7.5 Y, Value 5, Chroma 2. This zone has fibrous texture. It is a brown thready material. Sample is a very slightly silty clay.

3.-40 cm. Dark Greenish Gray silty claystone. Hue 10G, Value 5, Chroma 11.

Small core Samples:

The small core from HFPC-4 was sectioned into 3 sections: 0-5, 5-20, 20-40 cm.

Fig. 5-1-6a. 0-10 cm of HFPC-4 with up to the left.

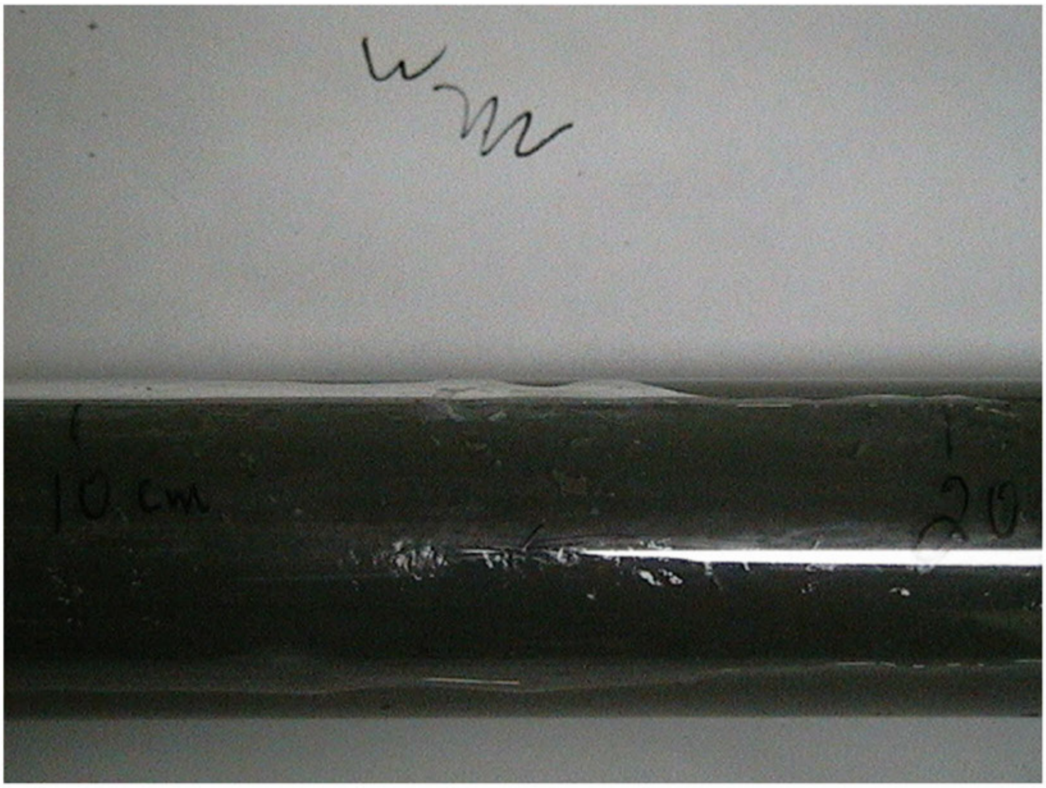


Fig. 5-1-6b. 10-20 cm of HFPC-4 with up to the left.

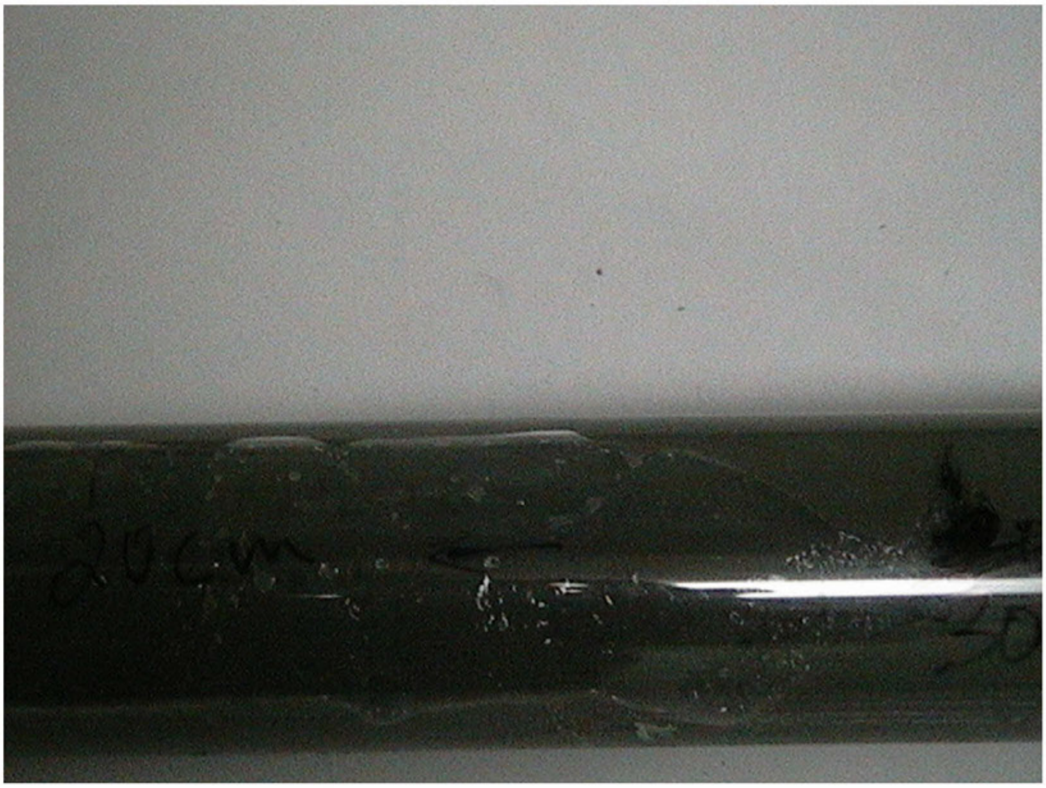


Fig. 5-1-6c. 20-30 cm of HFPC-4 with up to the left.

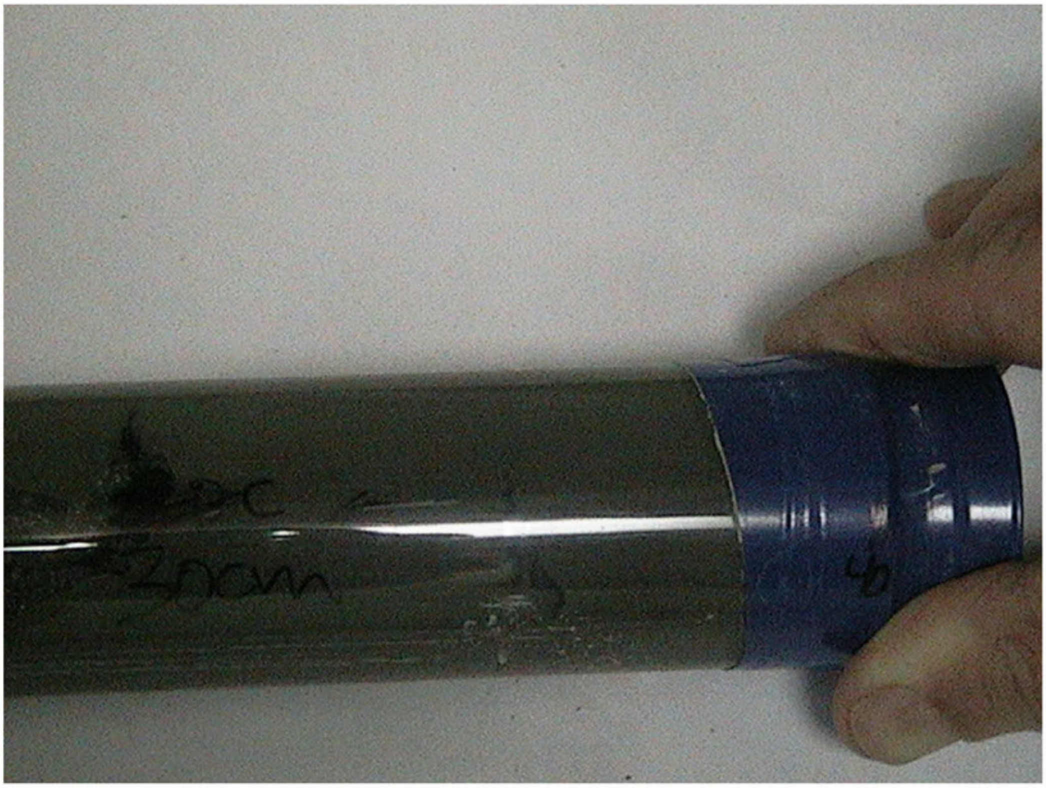


Fig. 5-1-6d. 30-40 cm of HFPC-4 with up to the left.

Core KR03-05-HFPC-5

Core KR03-05-HFPC-5 came on deck on 5/21/03 at 10:00. This was collected in the Nankai Trough off Kii Peninsula for the purposes of analyzing heat flow and thermal conductivity in the trench.

The core catcher for the Big corer was full (12 cm). Sections 6, 5, 4 and _ of 3 recovered sediment.

Small core description (Fig. 5-1-7):

0.0-2.0 cm. Grayish Olive silty clay. Hue 7.5 Y, Value 5, Chroma 2. This zone has fibrous texture. It is a brown thready material.

2.-14.5 cm. Dark Greenish Gray silty claystone. Hue 10G, Value 5, Chroma 11.

Big Core Catcher description: Greenish Gray Silty clay.

Small core Samples:

The small core from HFPC-5 was preserved as one sample.

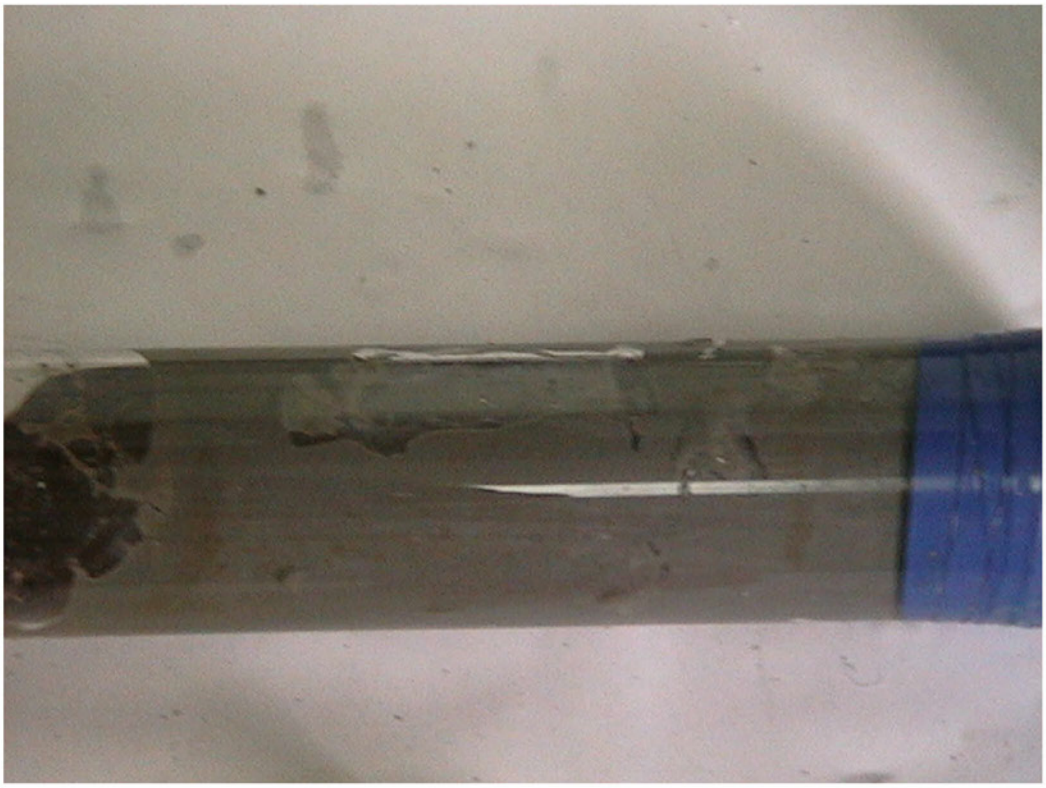


Fig. 5-1-7. 0-14.5 cm of HFPC-5 with up to the left.

Core KR03-05-HFPC-6

Core KR03-05-HFPC-6 came on deck on 5/21/03 at 21:00. This was collected in the Nankai Trough off Kii Peninsula for the purposes of analyzing heat flow and thermal conductivity in the trench. The core barrel was severely bent. There was no recovery in anything. We noted on the outside at the base of the Big corer, sediments were a dark greenish color and silty.

5-2. Heat flow measurement

We carried out heat flow measurements at six sites with the HFPC and at two sites with the deep-sea heat flow probe (Tables 5-1-1 and 5-2-1, Fig. 2-1). Detailed logs of heat flow probe operations are presented in Appendix A-4.

HFPC-1, 2, and 4 are the stations for investigation of the activity of the normal fault system located on the seaward edge of the Kumano Trough. The water depths of these stations are relatively shallow, about 2000 m, and thus the measured temperature profile is expected to have been disturbed by the bottom water temperature variation. In the off-Kumano area, there were few heat flow data on the slope between the deformation front and the Kumano Trough. HFPC-3 is located in the middle of this slope and HFPC-5 is at the lower part of the slope. These stations would therefore give valuable heat flow data on the accretionary prism off Kumano. HFPC-6, HF-1 and 2 are stations on the floor of the Nankai Trough.

Table 5-2-1. Heat flow measurements with the deep-sea probe

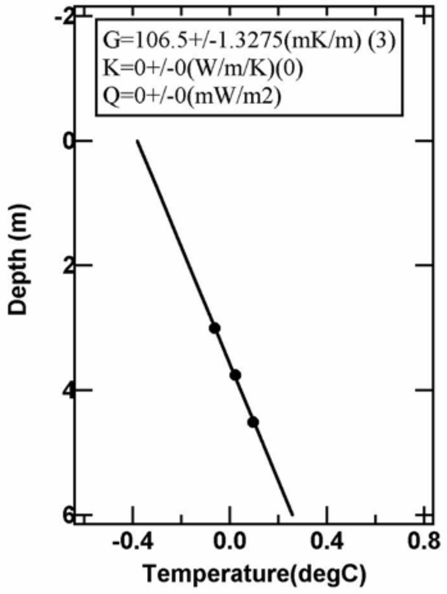
KR03-05 Heat flow points

Date(JST)	Station No.	Time Surfaced (h:m)	Hit the Bottom						Leave the Bottom				Time Surfaced (h:m)
			Time(h:m)	Lat. (N)	Long. (E)	WD(m)	WL(m)	Max WL	Time(h:m)	Lat. (N)	Long. (E)	WD(m)	
05.21.03	HF-1A	11:15	13:04	32 -43.34	136 -20.19	4,569	4,664	4,660	13:27	32 -43.33	136 -20.19	4,541	
	HF-1B		14:04	32 -43.21	136 -20.22	4,640	4,636	4,646	14:26	32 -43.22	136 -20.20	4,566	15:48
05.22.03	HF-2A	6:16	8:16	32 -36.42	135 -36.94	4,740	4,815	4,844	8:38	32 -36.42	135 -36.93	4,740	
	HF-2B		9:15	32 -36.42	135 -37.06	4,742	4,832	4,852	9:38	32 -36.42	135 -37.06	4,746	
	HF-2C		10:13	32 -36.42	135 -37.19	4,740	4,828	4,848	10:35	32 -36.43	135 -37.19	4,739	12:11

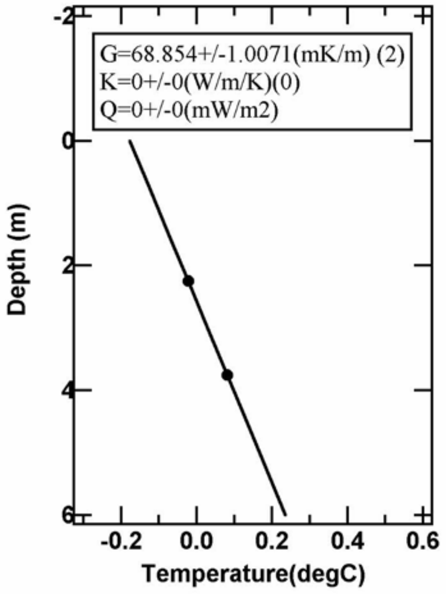
WD:Water Depth WL:Wair Length

We could successfully penetrate the HFPC core barrel or heat flow probe into sea-floor sediments at all the stations except HFPC-6. At HF-1 and HF-2, the probe was penetrated twice and three times respectively. The obtained temperature data are plotted versus depth in Fig. 5-2-1. Most of the profiles appear to be linear and the temperature gradient values calculated from the profiles are summarized in Table 5-2-2. It should be noted that the temperature profiles at HFPC-1, 2, and 4 are probably affected by the bottom water temperature variation. The profile measured at HFPC-3 is slightly non-linear, suggesting the temperature gradient at this station is less reliable. At HF-1, we could use data from only two or three temperature sensors due to trouble with the other sensors. The large difference in the temperature gradient between the first and second penetrations indicates these values may not be reliable.

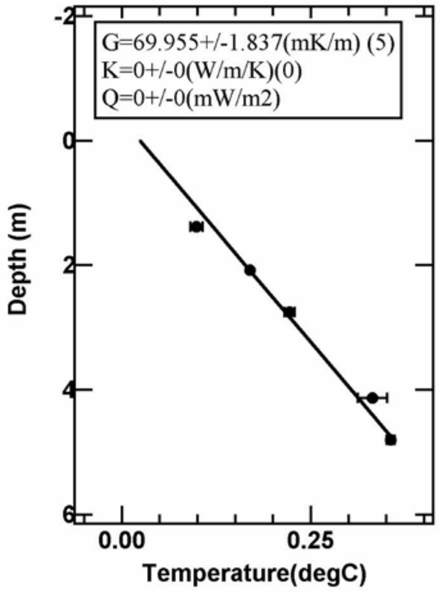
Thermal conductivity of sediments will be measured on piston core samples in a laboratory on shore. Assuming that the thermal conductivity of the surface sediment is 1.0 W/m/K, the average value in the off-Muroto area, we calculated preliminary heat flow values and plotted them in Fig. 5-2-2.



HFPC-1



HFPC-2



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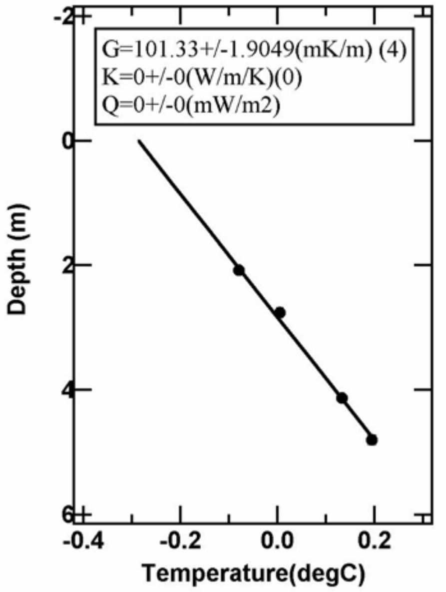

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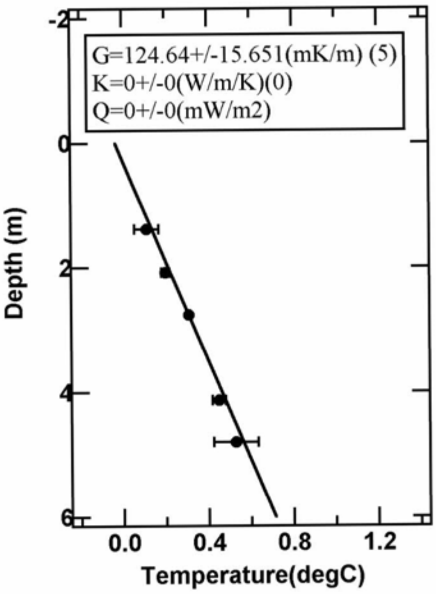

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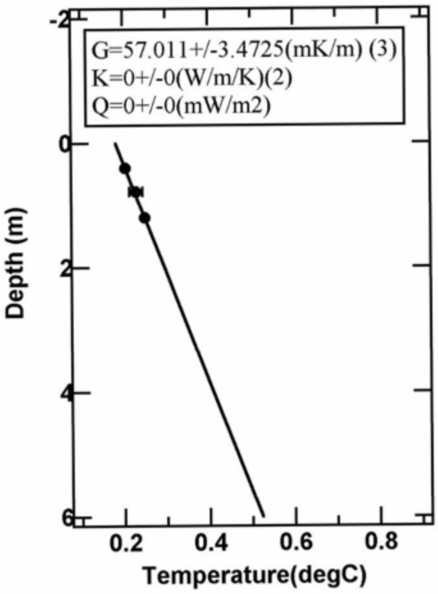

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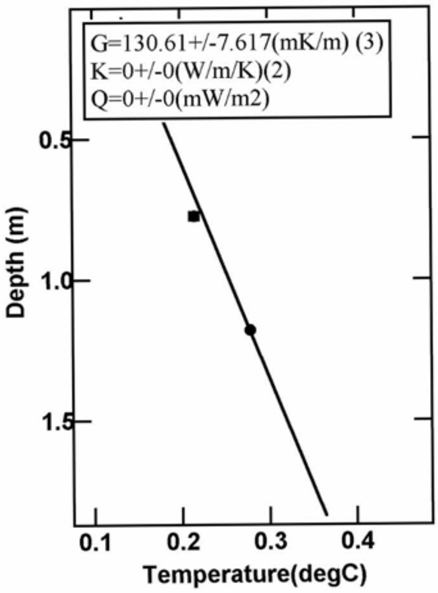
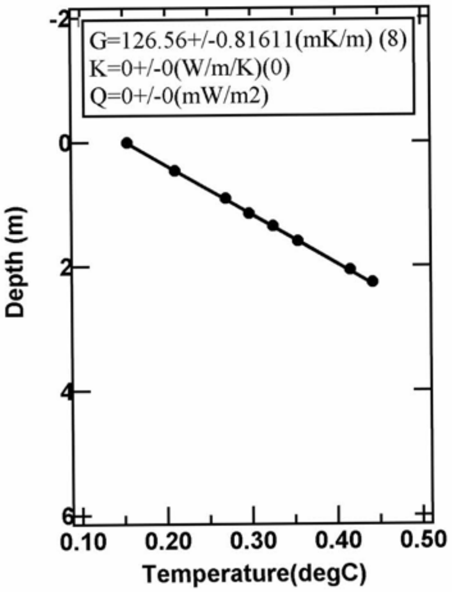
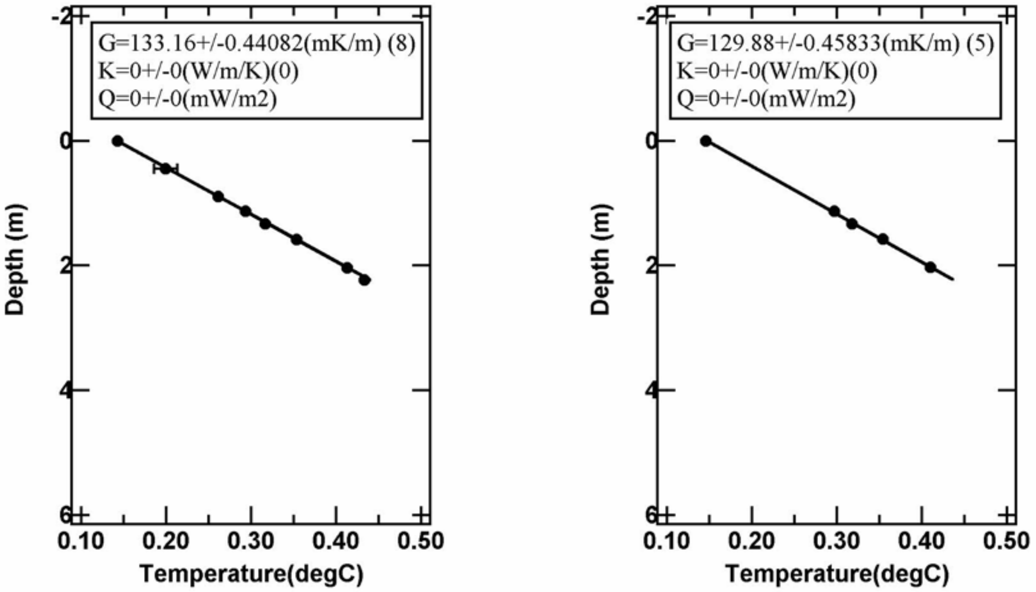


HF-1B



HF-2A



HF-2B HF-2C

Fig. 5-2-1. Temperature profiles measured with the HFPC and the deep-sea probe.

Table 5-2-2. Temperature gradient obtained for each penetration

Stations	Latitude	Longitude	Temperature Gradient (mK/m)
HFPC-1	33°19.39’N	136°40.04’E	107
HFPC-2	33°18.62’N	136°40.37’E	69
HFPC-3	33°11.40’N	136°43.43’E	70
HFPC-4	33°19.49’N	136°40.40’E	101
HFPC-5	32°59.43’N	136°25.25’E	125
HF-1A	32°43.35’N	136°20.39’E	57
HF-1B	32°43.31’N	136°20.42’E	131
HF-2A	32°36.57’N	135°36.94’E	126
HF-2B	32°36.56’N	135°37.02’E	133
HF-2C	32°36.57’N	135°37.15’E	130

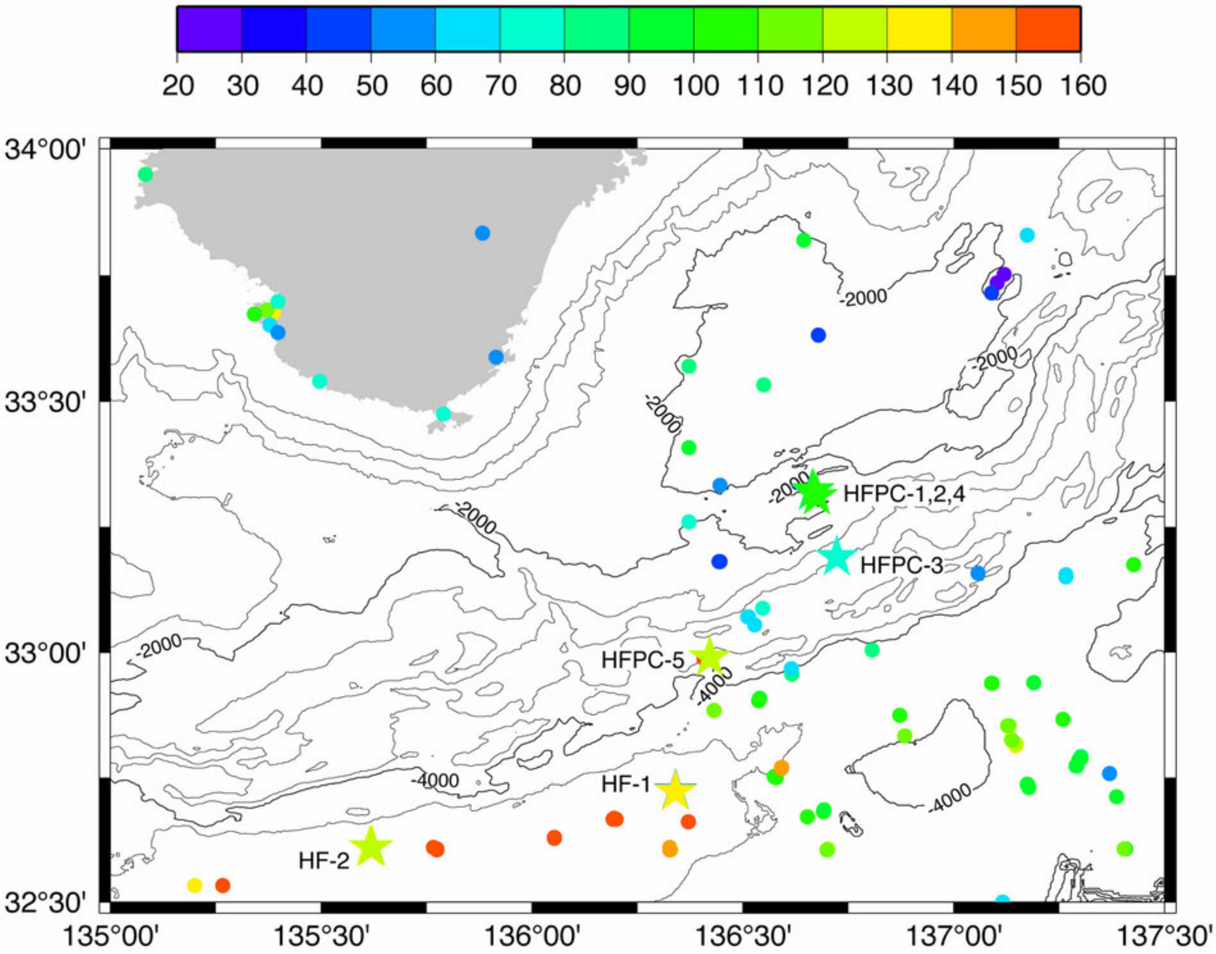


Fig. 5-2-2. Heat flow data obtained on the KR03-05 cruise (stars). Circles are existing data. It should be noted that the data in shallow sea (shallower than 2500 m) are less reliable.

5-3. Long-term temperature monitoring

5-3-1. Monitoring of sediment temperatures

We deployed a pop-up heat flow instrument (PHF) and a pop-up pore pressure and temperature instrument (PPT) in the Kumano Trough for heat flow measurement (Table 5-3-1, Fig. 2-1). For both instruments, the sampling interval was set as 20 min. A small water temperature recorder (NWT-DN) was attached to the PHF for monitoring of the bottom water temperature. Deployment of another PHF was planned but was not conducted, because we found a serious problem with its temperature probe through sensor calibration tests. The deployed instruments will be recovered after long-term monitoring for six months or longer and the sediment temperature records will be analyzed to determine the heat flow.

Table 5-3-1. Deployment of PHF and PPT

	Date of deployment	Coordinates	Water depth (m)
PHF	May 18, 2003	33°35.98’N, 136°32.83’E	2085
PPT	May 19, 2003	33°24.92’N, 136°25.05’E	2055

5-3-2. Monitoring of bottom water temperatures

We successfully recovered a pop-up water temperature measurement system (PWT), which was deployed in the Kumano Trough (PWT-1 in Fig. 2-1) on the KY02-12 cruise of R/V Kaiyo in January, 2003. After the temperature data was read out, this instrument was deployed again in the Kumano Trough (PWT-2, Fig. 2-1). Another PWT was deployed at PWT-1 in order to obtain a continuous record of the bottom water temperature at this station. The temperature measurement interval is 10 min. for both PWTs.

We could also recover small temperature recorders (NWT-DN and ANTARES MTL) attached to the OBEMs which were deployed in the Kumano Trough (OBEM-1L and 4L in Fig. 2-1) on the KY02-12 cruise in December, 2002. The dates of deployment and recovery and the coordinates of the stations are summarized in Table 5-3-2.

Table 5-3-2. Monitoring of the bottom water temperatures

Station	Temperature recorder	Deployment	Recovery	Coordinates	Water depth (m)
PWT-1	NWT-DN ANTARES MTL	Jan. 2, 2003	May 18, 2003	33°38.97’N, 136°38.54’E	2070
PWT-1	NWT-DN	May 18, 2003		33°39.03’N, 136°38.48’E	2070
PWT-2	NWT-DN	May 20, 2003		33°25.06’N, 136°35.66’E	2015
OBEM-1L	ANTARES MTL	Dec. 22, 2002	May 20, 2003	33°36.07’N, 136°13.54’E	1795
OBEM-4L	NWT-DN	Dec. 23, 2002	May 20, 2003	33°16.30’N, 136°27.42’E	1965

Records of the bottom water temperatures for about five months were obtained at three stations in the Kumano Trough, PWT-1, OBEM-1L, and OBEM-4L (Fig. 5-3-1). The temperature data at these stations are plotted against time in Fig. 5-3-2.

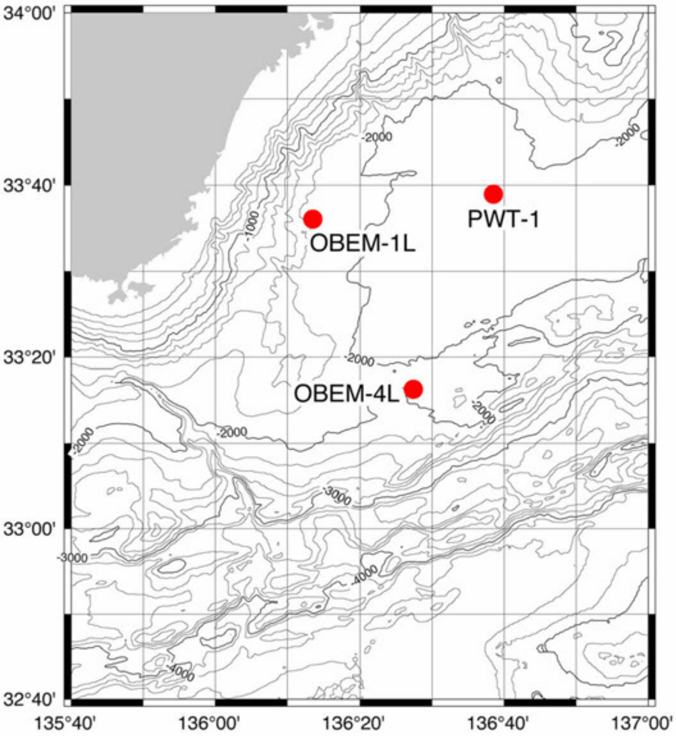


Fig. 5-3-1. Stations where long-term bottom water temperature records were obtained.

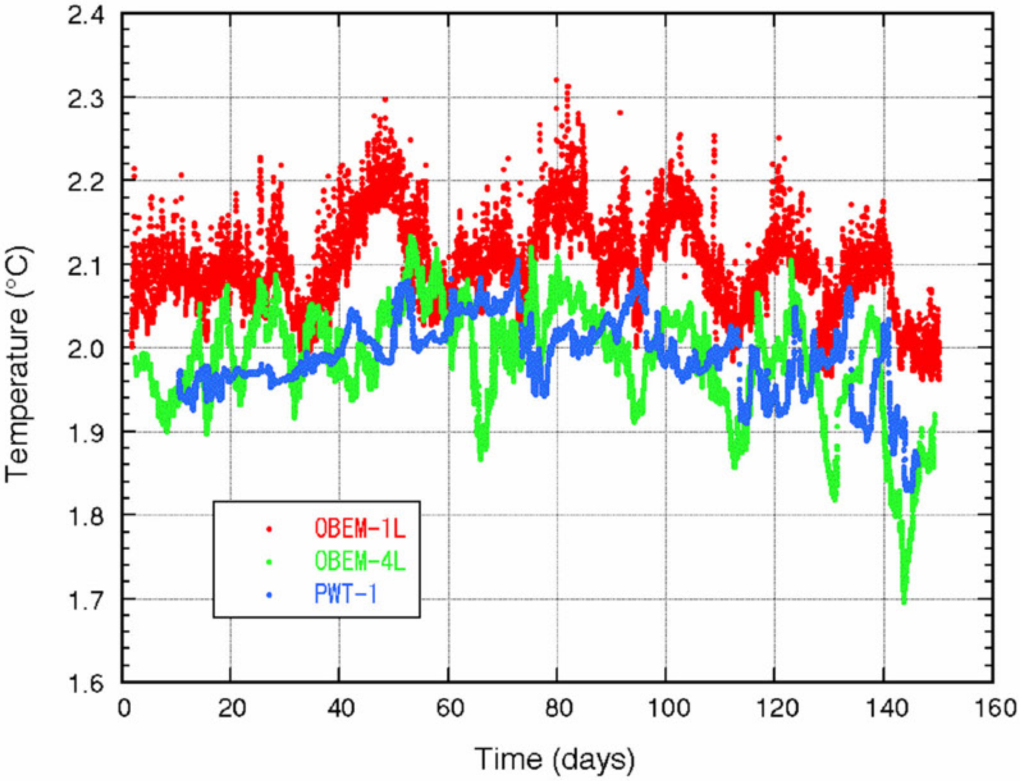


Fig. 5-3-2. Bottom water temperature records at OBEM-1L, OBEM-4L, and PWT-1.

5-4. Electromagnetic survey

In this section, we describe the data acquired by the recovered OBEMs and result of the initial analysis based on magnetotelluric (MT) and geomagnetic depth sounding (GDS) method. The binary data were downloaded from the instrument through RS-232C to a PC, and then converted to ASCII on the PC. Table 5-4-1 shows the duration that available data were recorded and Figs. 5-4-1 and 5-4-2 show plots of the time series data. The two OBEMs successfully recorded time variations of magnetic field and voltage difference between electrodes and instrument tilt with some exceptions.

Table 5-4-1. The duration that available data were recorded. X, y, and z are the orthogonal coordinate system fixed to the magnetic sensor.

TT4	Magnetic field	Bx	2002/12/25 – 2003/03/19	recording error on 2003/02/02
		By	2002/12/25 – 2003/03/19	recording error on 2003/02/02
		Bz	2002/12/25 – 2003/03/19	recording error on 2003/02/02
	Electric field	Ex	2002/12/25 – 2003/04/07	
		Ey	2002/12/25 – 2003/04/07	
	Intrument tilt	Ix	2002/12/25 – 2003/04/07	
		Iy	not available	recording error on 2003/02/02
TT6	Magnetic field	Bx	2002/12/25 – 2003/05/20	
		By	2002/12/25 – 2003/05/20	
		Bz	2002/12/25 – 2003/05/20	
	Electric field	Ex	2002/12/25 – 2003/05/20	
		Ey	2002/12/25 – 2003/05/20	
	Intrument tilt	Ix	2002/12/25 – 2003/05/20	
		Iy	2002/12/25 – 2003/05/20	

The record of TT4 at Site1L ends on Apr.7th because of the exhaustion of power. The electric field data are available to the end of the record (Figs. 5-4-1a and 5-4-2a). One component of the tilt data (Iy) is not available because it is out of range for measurement from the beginning to the end. The other component of tilt data (Ix) indicates that the instrument had quaked frequently during the measurement. There are coherent variations in the magnetic field with the tilt variation. The magnetic field data shows abnormal undulation after Mar. 19th so that it is impossible to use for the analysis. The Bx and By components largely shifted on Feb. 2nd and their sign were reversed. At the same time, Ix went out of the range for measurement and came back to the previous level after 105 minutes. This seems to be caused by temporal error of power supply for ±15V system. The OBEM could not success to measure the DC component of magnetic field and caused the recording error. However, we can analyze the data after this event carrying out proper correction to the Bx and By data.

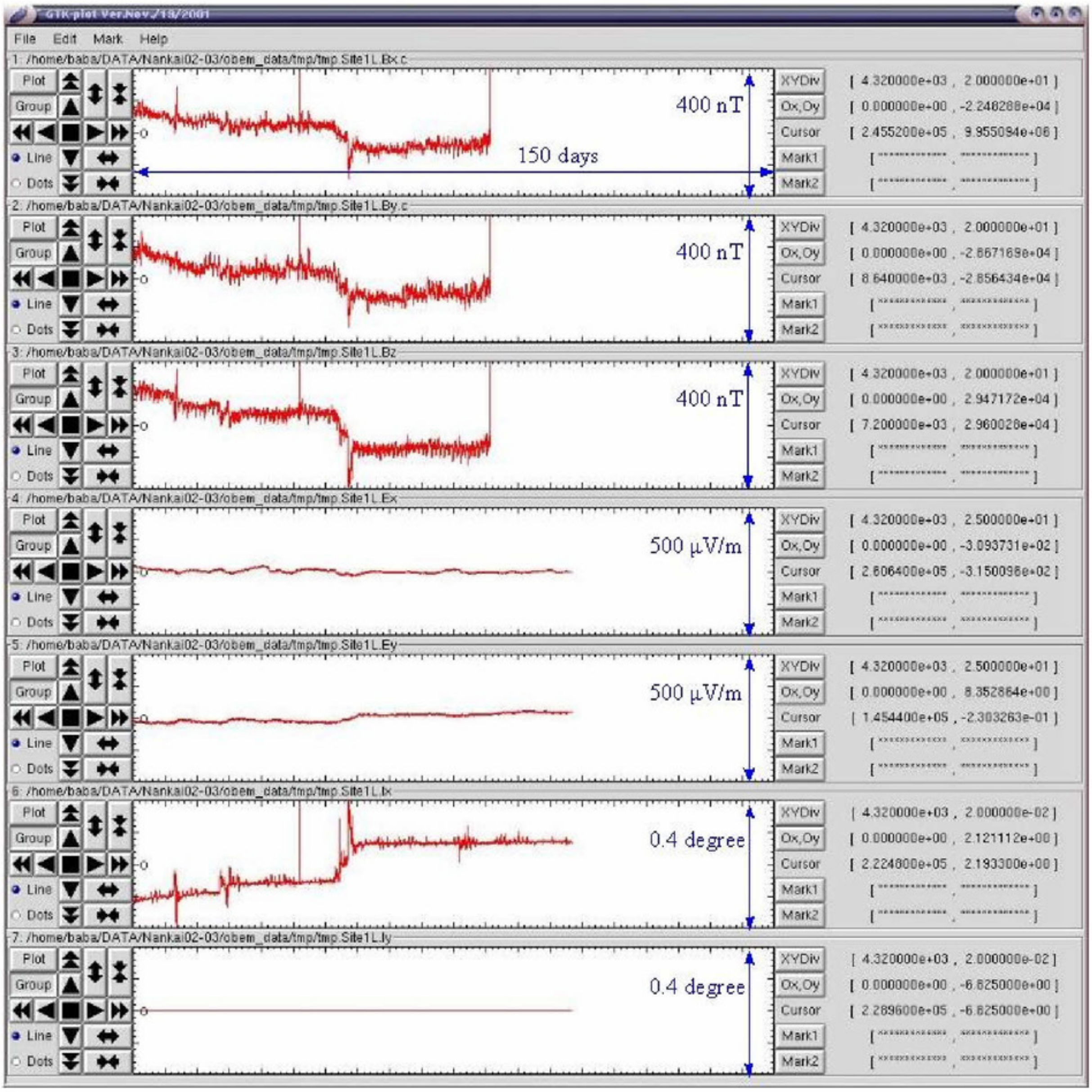


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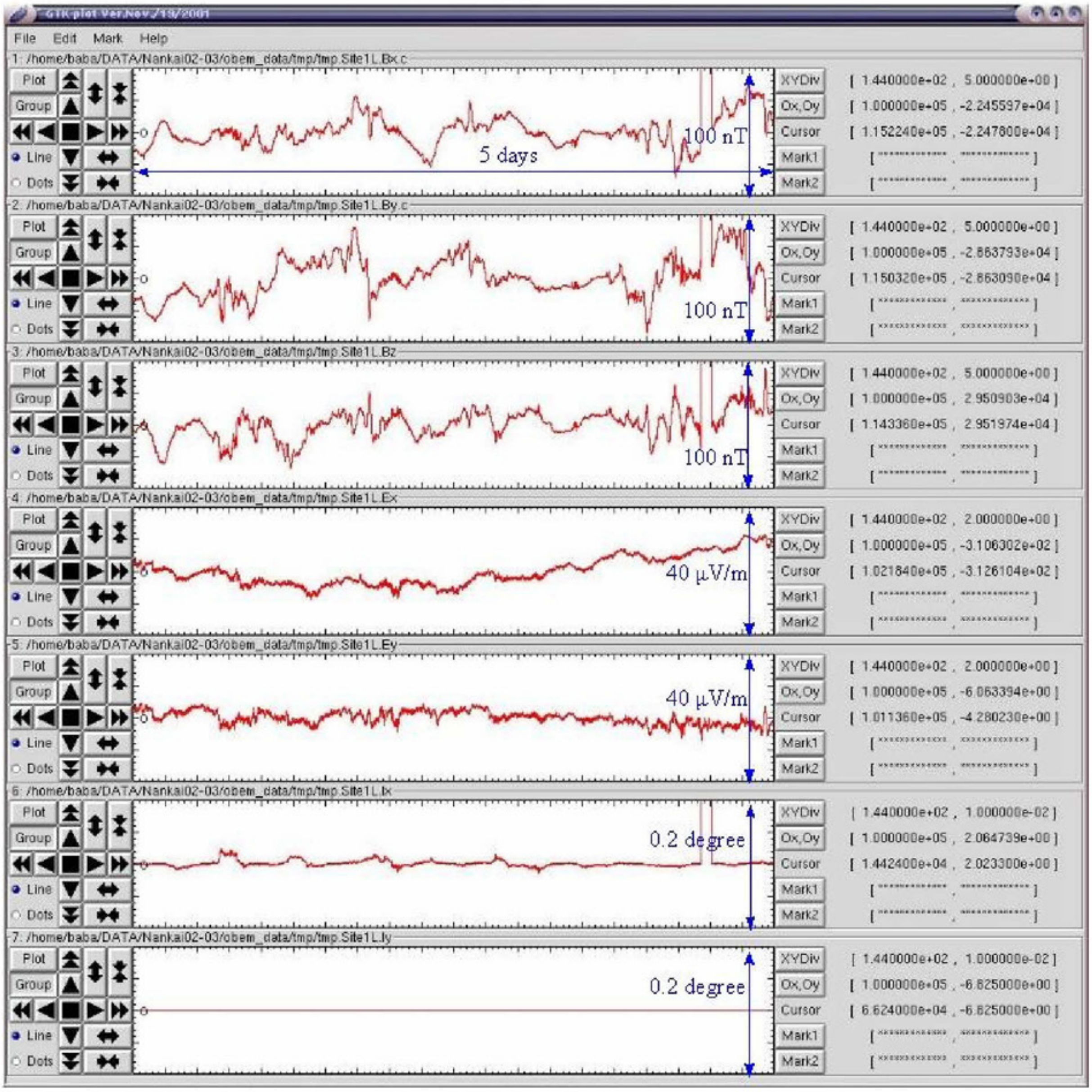
Figure 5-4-1a. Time series data of TT4. The large shift and sign reversal of Bx and By are corrected.



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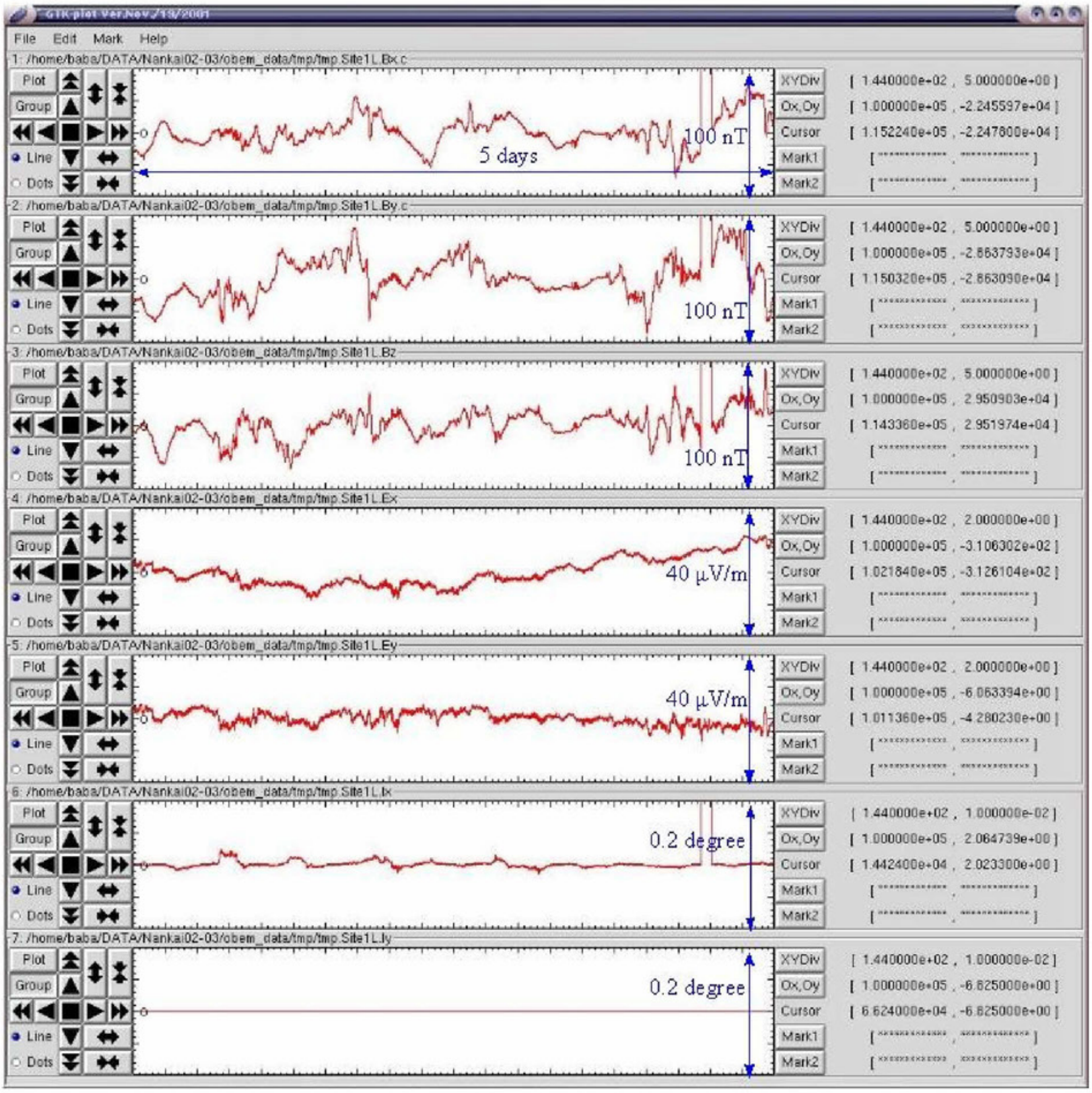
Mark2 [************ , ************]

Fig. 5-4-1b. Time series of data TT6. Note that the coordinate system is different from that of TT4 because it is fixed to the instrument.



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Ox,Oy   [ 1.000000e+05 ,  2.064739e+00 ]
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Fig. 5-4-2a. Zoom of middle 5 days of the TT4 data. Short period variations in the magnetic field originated from magnetosphere and coherent electric field variations are conspicuous. The duration which magnetic field and Ix are dropped out is not available because of the recording error. Bx and By after this event are corrected in this plot although they were originally shifted and their sign were reversed (See text).

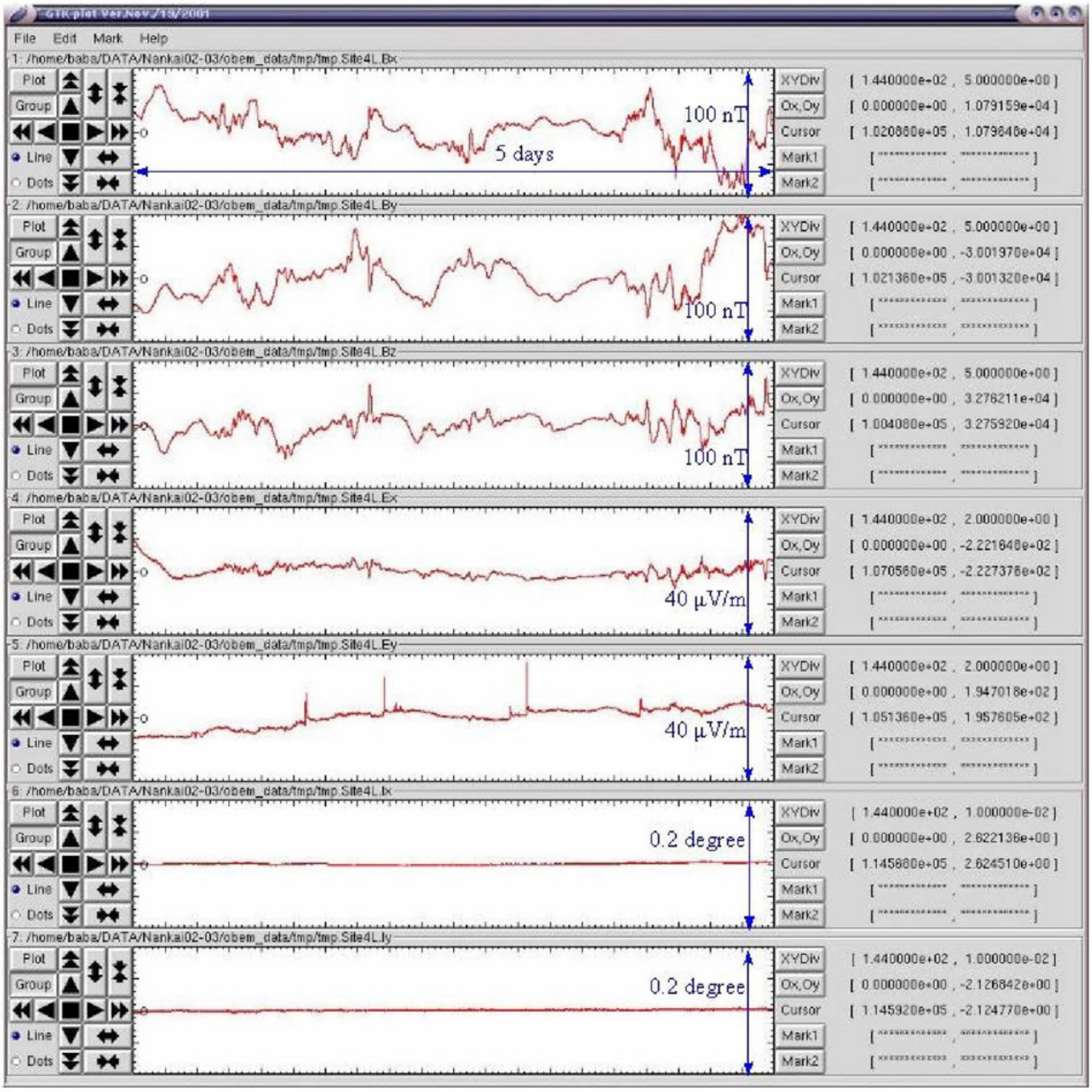

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Fig. 5-4-2b. Zoom of middle 5 days (same as Fig. 5-4-2a) of the TT6 data. The abnormal signals are probably due to electrode noise are visible in Ey data (See text).

The data of TT6 at Site4L is very clean compared to that of TT4 and is available until the day it recovered. However, there are some abnormal signals in Ey data that change abruptly and return to the previous level gradually (Fig. 5-4-1b). This kind of signal is frequently observed in marine electric field measurements probably due to the noise made by electrode. The electric field data drift larger than those of TT4 but is not significant problem for the analysis. The tilt data is more stable than those of TT4.

In advance of the MT analysis, we processed the time series data. First, the voltage difference data, which is original recorded for electric field measurement, were converted to electric field values dividing by the dipole length. The error in magnetic field of TT4 is corrected. Second, geomagnetic coordinate system was recovered using the DC magnetic field and DC tilt data. For TT4, however, the instrument tilt is not recovered because only one component of the tilt data is available. Third, drift of the data is removed by fitting polynomial. Daily and tidal variations are also removed.

After these processing, we estimate MT and geomagnetic transfer functions using robust remote reference method by Chave et al. (1987). The prediction coherences (Fig. 5-4-3), which indicate quality of the transfer functions, are higher than 0.5 for TT4 and than 0.7 for TT6 in the period range from several hundred seconds to several tens thousand seconds. These values indicate moderate quality for preliminary analysis of general marine EM data. The MT transfer functions are plotted as apparent resistivity and phase in Fig. 5-4-4 and the geomagnetic transfer functions also plotted as induction vector in Figure 5-4-5. The induction vectors trends about N130E to N150E which is approximately perpendicular to the axis of Nankai trough. We expect that we can obtain better result after complete analysis and that the data is very useful to model the crustal and mantle electrical structure.

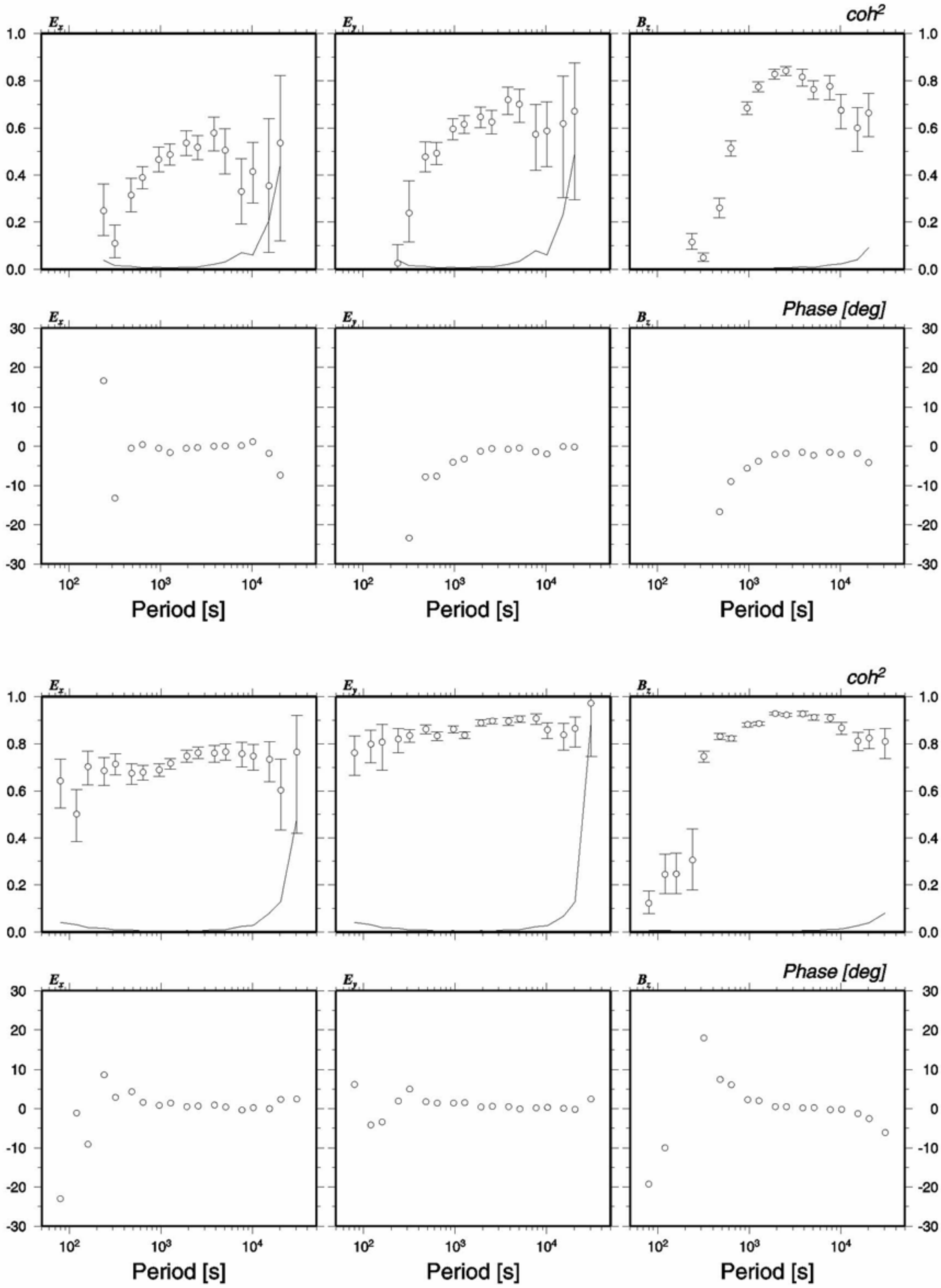

Fig. 5-4-3. Prediction coherences for TT4 (top) and TT6 (bottom). The left two box are the coherences between observed and predicted electric field with the estimated MT transfer functions. The right one is the coherence between observed and predicted vertical component of magnetic field with the estimated geomagnetic transfer function.

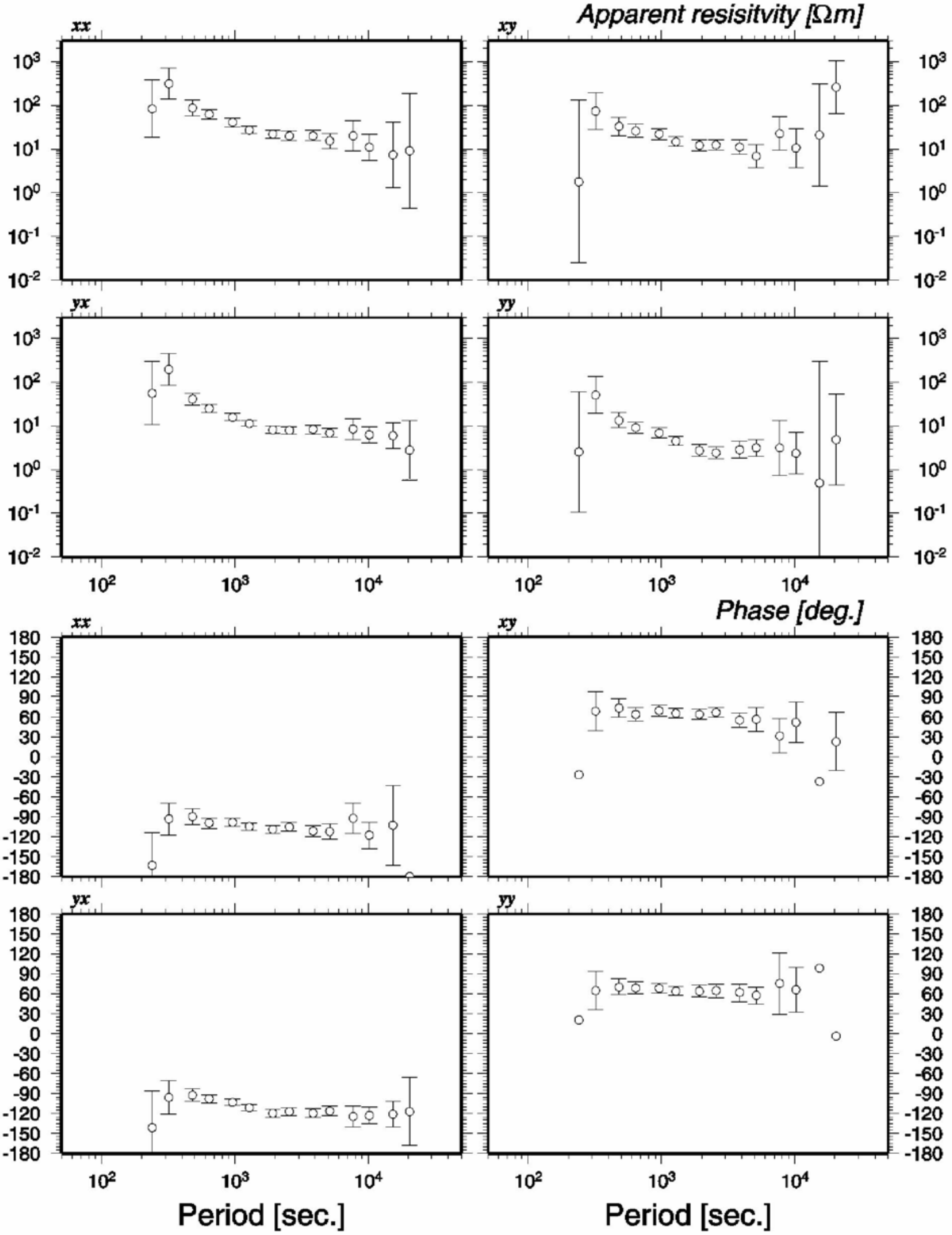

Fig. 5-4-4a. Apparent resistivity and phase for TT4. Error bars indicate 95% confidence level.

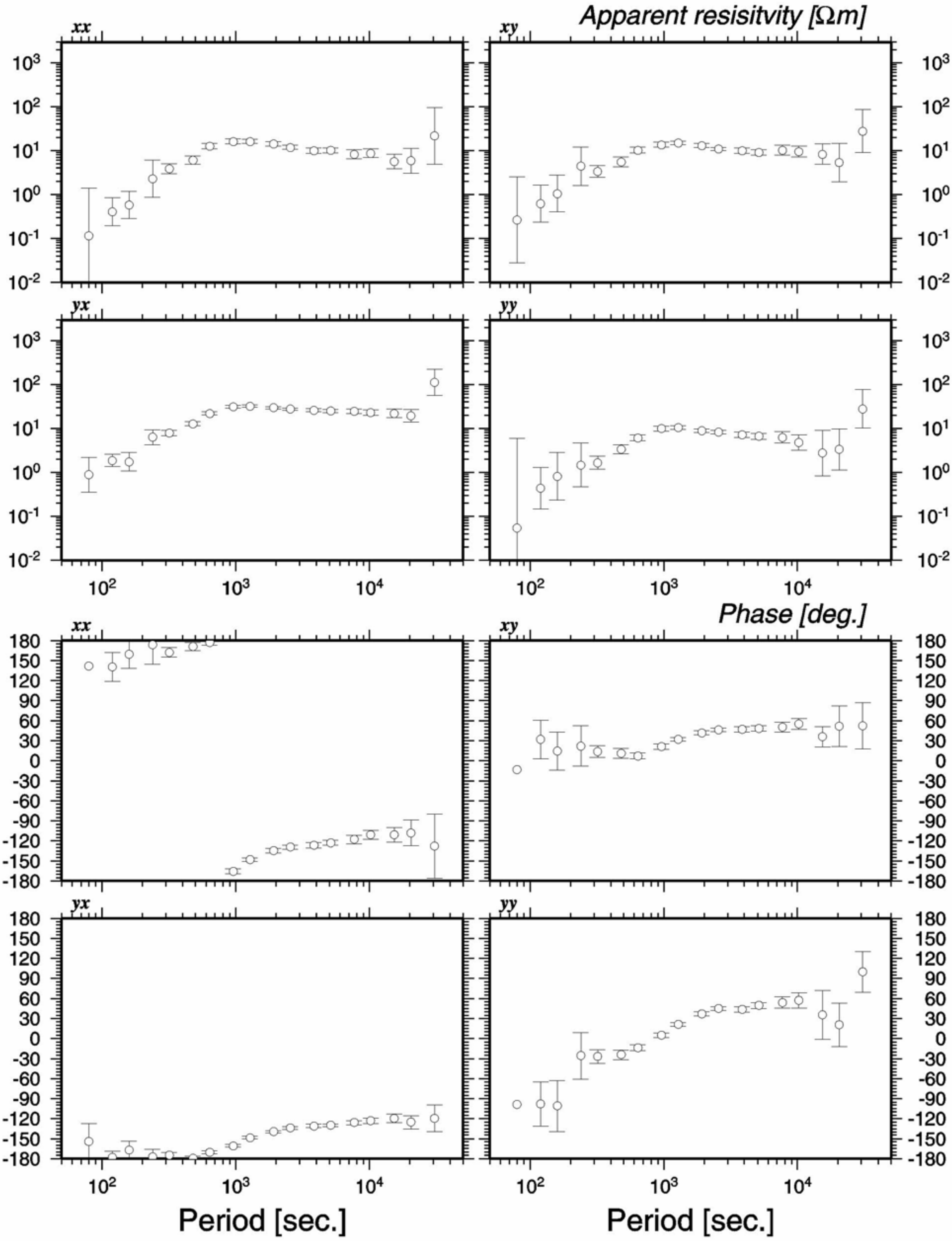

Fig. 5-4-4b. Apparent resistivity and phase for TT6.

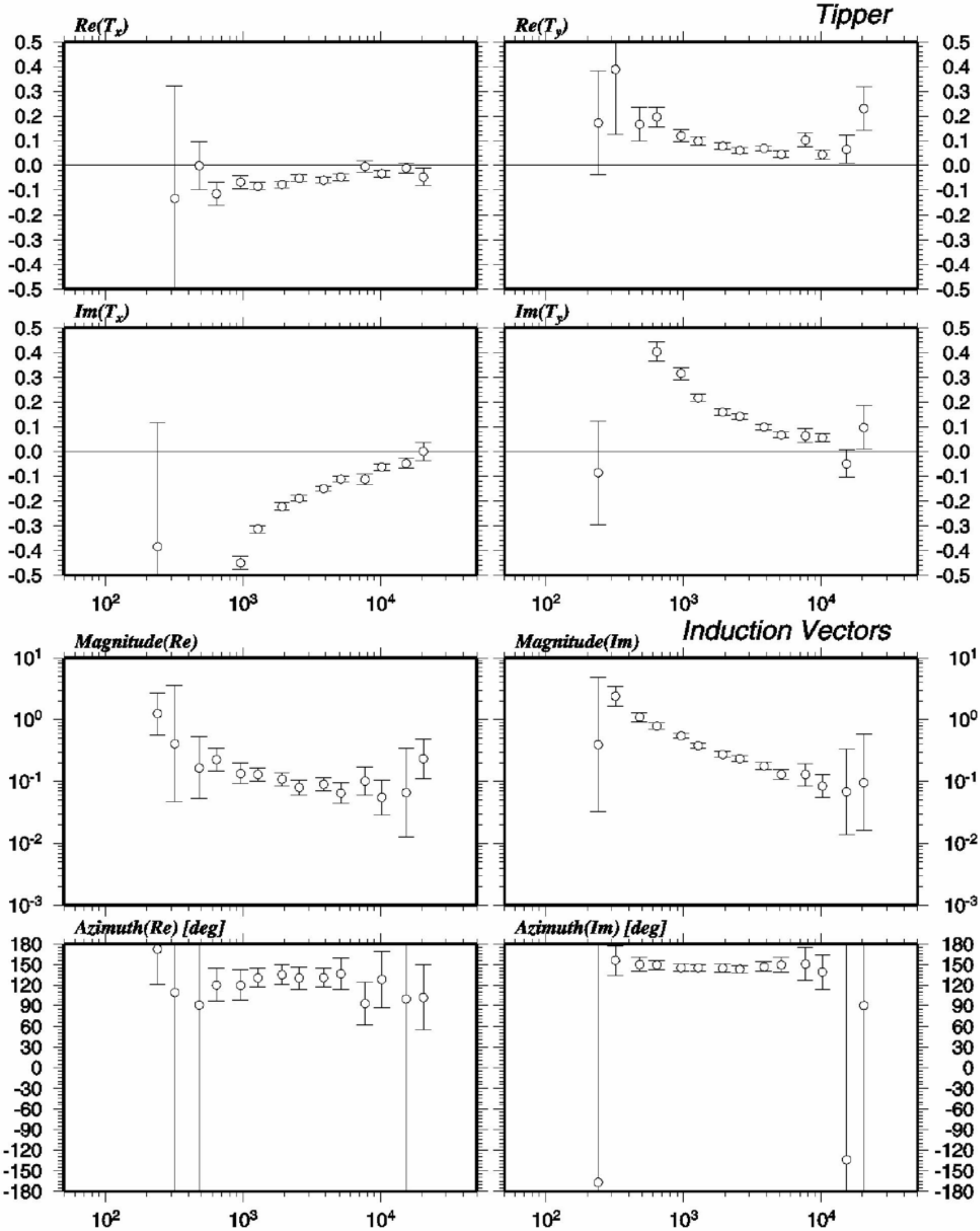

Fig. 5-4-5a. Geomagnetic transfer function (top 4 panels) and its representation as induction vectors (bottom 4 panels) for TT4. Error bars indicate 95% confidence level.

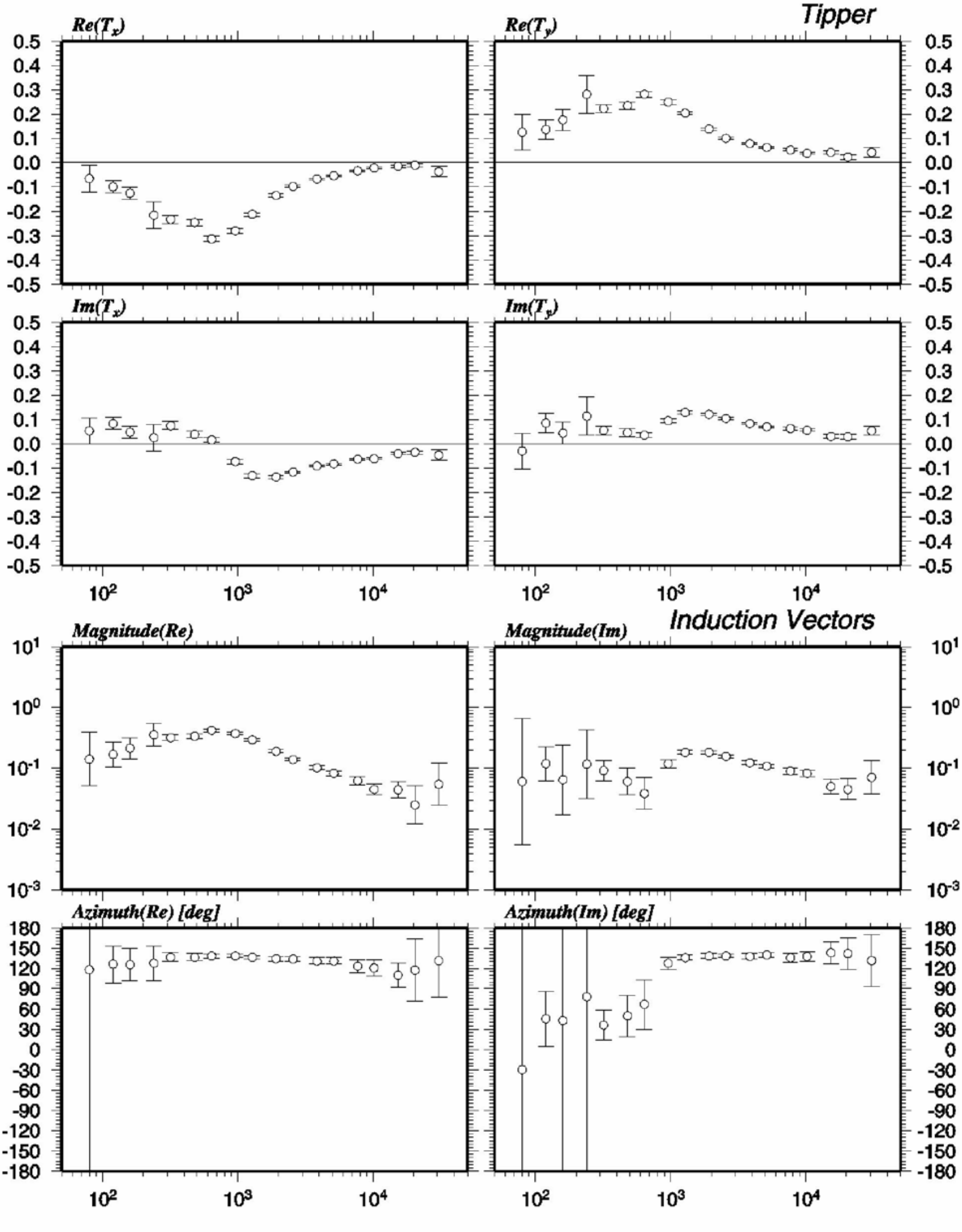

Fig. 5-4-5b. Geomagnetic transfer function (top 4 panels) and its representation as induction vectors (bottom 4 panels) for TT6.

5-5. SeaBeam survey

During the nighttime operations on May 20 and 21, 2003, SeaBeam 2100 (50m grid) surveying was completed. The purpose of this surveying was to complete the mapping of seafloor bathymetry off Kii Peninsula, Honshu Island, Japan to a latitude of 32°30’N. A total of two east west transects were completed during these two nights that filled in a box from 135°59’W to 137°22’W, and from 32°30’N to 32°42’N. No further SeaBeam surveying needs to be completed off Kii Peninsula and it is now recommended further surveys attempt to fill in the offshore region between Cape Muroto, Shikoku Island, and Kii Peninsula, Honshu Island.

6. Acknowledgements

We are grateful to Captain H. Tanaka, the officers and the crew of the R/V KAIREI for skillful operations of the ship and research equipment. We also extend our thanks to M. Aoki for giving us great assistance in research works throughout the leg. M. Kinoshita, the leader of the KR03-05 scientific team, and JAMSTEC staff for research vessel operation, especially N. Kimura, made excellent arrangements for the cruise.

Appendices

A-1. Cruise log

Date/Time (Local Time, UTC-9)		Operation and Note	Remarks	Weather/Wind Direction & force /swell/visibility (at noon)
Sat.	2003/5/17			Cloudy/NE,4/3/5
	09:00	Scientists on board		
	10:00	Departure	from JAMSTEC,Yokosuka	
	10:30	Briefing for life and safety	transit to research area	
	11:30	Scientific meeting		
	16:40	Konpira ceremony		
Sun.	2003/5/18			Cloudy/NE,5/3/5
	07:12-07:58	Recovery of PWT	Kumano-nada	
	08:28-10:51	Calibration of PHF sensor		
	11:10	Deploy PWT		
	11:19-11:59	positioning		
	13:22-15:28	Deploy PHF		
	18:30-20:38	Calibration of PHF sensor		
Mon.	2003/5/19			Rain/NE,6/4/4
	06:20-08:16	Deploy PPT	Kumano-nada	
	09:20-10:40	SBP survey		
	11:02-13:38	FHPC-1		
	14:28-16:48	FHPC-2		
	17:36-18:16	SBP survey		
	18:46-21:01	Calibration of PHF sensor		
Tue	2003/5/20		Kumano-nada	Cloudy/NE,4/3/6
	06:32-06:56	Recovery OBEM(Site 1L)		
	08:52-10:13	Recovery OBEM(Site 4L)		
	11:32-14:26	HFPC-3	Nankai Trough	
	15:34-17:51	HFPC-4		
	18:44	Deploy PWT-1		
	22:53-02:06	Seabeam survey		
Wed	2003/5/21			Cloudy/NE,4/3/7
	06:21-09:54	HFPC-5	Off Kii Peninsula	
	11:13-15:51	HF-1A,B		
	17:47-21:38	HFPC-6		
	22:03-04:27	Seabeam survey		
Thu	2003/5/22			Cloudy/SE,2/2/7
	06:13-12:13	HF-2A,B,C	Off Kii Peninsula	
			Transit to Shimonoseki	
Fri	2003/5/23			Fine/NE,3/1/5
	09:00	arrive at Shimonoseki		

PWT = Pop-up bottom Water Temperature measurement system
PHF = Pop-up Heat Flow instrument
PPT = Pop-up Pore pressure and Temperature instrument
SBP= Sub-bottom profiler
HFPC= heat-flow piston corer
OBEM= Ocean Bottom Electric Magnetometer
FH= Heat Flow measurement system

A-2. Survey lines

KR03-05 (Leg 1) List of survey lines

Line No.			Date & Time(UTC)		Longitude	Latitude	Remarks
(no No.)	Seabeam	Start	2003.5.17	7:11	138-51.9635’E	34-28.3109’N	transit from Yokosuka to Kumano
		End	2003.5.17	20:20	136-13.7211’E	33-39.9203’N	
SBP-1	SBP	Start	2003.5.19	0:19	136-39.6257’E	33-20.2928’N	
		End	2003.5.19	1:14	136-41.8423’E	33-15.2481’N	
SBP-2	SBP	Start	2003.5.19	8:36	136-43.3457’E	33-11.9099’N	
		End	2003.5.19	8:51	136-43.8322’E	33-10.7239’N	
SBP-2’	SBP	Start	2003.5.19	8:59	136-43.7509’E	33-10.8418’N	same track as SBP-2
		End	2003.5.19	9:19	136-43.2986’E	33-12.0083’N	
Line-A	Seabeam	Start	2003.5.20	13:35	136-51.0456’E	32-38.9966’N	
		End	2003.5.20	16:54	136-05.6254’E	32-39.0076’N	
Line-B	Seabeam	Start	2003.5.21	13:03	136-05.6254’E	32-33.0426’N	
		End	2003.5.21	14:35	136-45.1066’E	32-33.0026’N	
Line-C	Seabeam	Start	2003.5.21	16:17	136-45.6914’E	32-32.5851’N	
		End	2003.5.21	16:28	136-45.7247’E	32-32.2704’N	
Line-D	Seabeam	Start	2003.5.21	16:30	136-54.3582’E	32-27.0404’N	
		End	2003.5.21	19:27	135-58.9708’E	32-27.0039’N	

Gravity and 3-compoments magnetometer data are aveirable.

A-3. Piston coring log

HFPC-1

Core:	HFPC-1			
Pilot:	HFPL-1			
Area:	Off Kumano			
Date:	19.May.03			
Length of pipes:		6 m		
Length of Pilot wire:		14.05 m		
Length of main wire:		12.25 m		
Length of free fall:		5.0 m		
Weather:		Cloudy		
Wind:		52 deg ,	10 m/s	
Current:		277.4 deg,	0.1 m/s	

Time	Wire-length (m)	Latitude*	Longitude*	Depth (m)	Tension (kN)	Wire-speed (m/min)		Remarks
10:50								Started operation
11:13	0	33°18.64'N	136°40.39'E	2025	0	↓	0.0	Started wire-out
11:19	50			2025	1	-	0.0	Attached transponder and pinger
11:24	48			2028	2	↓	16.2	Restarted wire-out
11:25	62			2026	1	↓	0.0	Replaced winch control panel
11:26	62			2027	2	↓	19.2	Restarted wire-out
11:33	200			2024	3	↓	19.6	Raised wire speed
11:47	1000			2048	9	↓	61.6	
12:03	1900			2025	15	-	0.0	Stopped wire-out
12:12	1900			2026	15	↓	20.0	Restarted wire-out slowly
12:18	2022	33°18.64'N	136°40.41'E	2025	11	↓	20.4	PC reached to the bottom
12:18	2036			2026	11	-	0.0	Stopped wire-out
12:39	2035			2029	12	↑	20.2	Started wire-in slowly
12:40	2017	33°18.62'N	136°40.40'E	2026	22	↑	20.5	PC left the bottom (Max. 22kN)
12:42	1985			2028	18	↑	20.8	Raised wire speed
12:58	1000			2025	11	↑	60.4	
13:14	100			2026	5	-	0.0	Replaced winch control panel
13:14	100			2026	5	↑	25.6	Restarted wire-in
13:17	44			2025	3	↑	0.0	Removed transponder and pinger
13:22	20			2023	2	↑	35.2	Restarted wire-in
13:24	-30	33°18.64'N	136°40.40'E	2025	2	↑	18.0	Zero point surfaced
13:38								HFPC on deck

*GPS: WGS84

HFPC-2

Core:	HFPC-2			
Pilot:	HFPL-2			
Area:	Off Kumano			
Date:	19.May.03			
Length of pipes:	6	m		
Length of Pilot wire:	14.05	m		
Length of main wire:	12.25	m		
Length of free fall:	5.0	m		
Weather:	Cloudy			
Wind:	36	deg ,	9.7	m/s
Current:	211.4	deg ,	0.3	m/s

Time	Wire-length (m)	Latitude*	Longitude*	Depth (m)	Tension (kN)	Wire-speed (m/min)		Remarks
14:19								Started operation
14:31	0	33°19.39'N	136°40.06'E	2042	-	↓	-	Started wire-out
14:35	-			-	-	-	0.0	Attached transponder
14:39	-			-	-	↓	-	Restarted wire-out
14:40	-			2040	2	-	0.0	Replaced winch control panel, Restarted wire-out
14:48	212			2044	3	↓	23.7	Raised wire speed
15:01	1000			2042	8	↓	62.1	
15:16	1910			2039	15	-	0.0	Stopped wire-out
15:26	1910			2040	15	↓	0.0	Restarted wire-out slowly
15:32	2036	33°19.45'N	136°40.04'E	2041	11	↓	20.2	PC reached to the bottom
15:33	2046			2041	11	-	0.0	Stopped wire-out
15:53	2046			2040	12	↑	3.6	Started wire-in slowly
15:54	2035	33°19.46'N	136°40.04'E	2040	19	↑	19.8	PC left the bottom (Max. 24kN)
15:55	2000			2035	19	↑	19.6	
15:56	1980			2041	19	↑	24.3	Raised wire speed
16:13	1000			2038	11	↑	61.5	
16:28	100			2037	3	-	0.0	Replaced winch control panel, Restarted wire-in
16:31	47			2038	2	-	0.0	Removed transponder
16:33	48			2038	3	↑	5.7	Restarted wire-in
16:36	-34	33°19.44'N	136°39.98'E	2039	2	↑	16.2	Zero point surfaced
16:49						-	-	HFPC on deck

*GPS: WGS84

HFPC-3

Core: HFPC-3
Pilot: HFPL-3
Area: Off Kumano
Date: 20.May.03
Length of pipes: 6 m
Length of Pilot wire: 14.05 m
Length of main wire: 12.25 m
Length of free fall: 5.0 m
Weather: Cloudy/Rain
Wind: 58 deg , 5.0 m/s
Current: 118.8 deg , 0.9 m/s

Time	Wire-length (m)	Latitude*	Longitude*	Depth (m)	Tension (kN)	Wire-speed (m/min)		Remarks
11:20								Started operation
11:39	0	33°11.48' N	136°43.47' E	2923	0	↓	0.0	Started wire-out
11:42	50			2932	1	-	0.0	Attached transponder
11:45	50			2923	1	↓	19.5	Restarted wire-out
	74			2923	1	-	0.0	Replaced winch control panel
11:46	75			2937	1	↓	20.0	Restarted wire-out
11:53	200			2926	2	↓	20.7	Raised wire speed
12:06	1000			2935	7	↓	60.0	
12:22	2000			2931	15	↓	60.0	
12:36	2800			2931	22	-	0.0	Stopped wire-out
12:46	2800			2927	22	↓	20.5	Restarted wire-out slowly
12:53	2944	33°11.47' N	136°43.52' E	2928	18	↓	20.4	PC reached to the bottom
12:54	2955			2926	18	-	0.0	Stopped wire-out
13:14	2955			2931	19	↑	12.4	Started wire-in slowly
13:15	2941	33°11.45' N	136°43.53' E	2935	29	↑	18.9	PC left the bottom (Max. 32kN)
13:19	2860			2934	25	↑	22.5	Raised wire speed
13:34	2000			2930	20	↑	47.5	
13:50	1000			2931	11	↑	65.7	
14:04	98			2923	3	-	0.0	Replaced winch control panel
14:05	98			2931	3	↑	40.6	Restarted wire-in
14:07	48			2928	2	-	0.0	Removed transponder
14:10	48			2934	2	↑	40.8	Restarted wire-in
14:11	-32	33°11.47' N	136°43.50' E	2928	2	↑	19.5	Zero point surfaced
14:25								HFPC on deck

*GPS: WGS84

HFPC-4

Core:	HFPC-4	
Pilot:	HFPL-4	
Area:	Off Kumano	
Date:	20.May.03	
Length of pipes:	6 m	
Length of Pilot wire:	14.05 m	
Length of main wire:	12.25 m	
Length of free fall:	5.0 m	
Weather:	Cloudy	
Wind:	53 deg ,	3.9 m/s
Current:	136.2 deg ,	0.9 m/s

Time	Wire-length (m)	Latitude*	Longitude*	Depth (m)	Tension (kN)	Wire-speed (m/min)		Remarks
15:20								Started operation
15:37	0	33°19.48'N	136°39.98'E	2045	0	↓	19.6	Started wire-out
15:41	50			2051	1	-	0.0	Attached transponder
15:44	64			2046	1	↓	20.4	Restarted wire-out
15:46	76			2043	2	-	0.0	Replaced winch control panel, Restarted wire-out
15:51	200			2047	3	↓	19.3	Raised wire speed
16:05	1000			2047	8	↓	60.0	
16:21	1920			2049	15	-	0.0	Stopped wire-out
16:32	1920			2049	16	↓	20.5	Restarted wire-out slowly
16:38	2030	33°19.50'N	136°39.99'E	2047	12	↓	20.2	PC reached to the bottom
16:38	2041			2044	13	-	0.0	Stopped wire-out
16:58	2041			2049	13	↑	19.3	Started wire-in slowly
16:59	2028	33°19.49'N	136°40.00'E	2049	19	↑	21.3	PC left the bottom (Max. 25kN)
17:00	2000			2046	19	↑	20.5	
17:01	1968			2046	21	↑	20.8	Raised wire speed
17:18	1000			2044	11	↑	61.3	
17:33	100			2050	4	-	0.0	Replaced winch control panel, Restarted wire-in
17:35	48			2044	3	-	0.0	Removed transponder
17:37	49			2050	2	↑	0.0	Restarted wire-in
17:40	-34	33°19.49'N	136°39.99'E	2045	0	↑	0.0	Zero point surfaced
17:57						-	-	HFPC on deck

*GPS: WGS84

HFPC-5

Core:	HFPC-5	
Pilot:	HFPL-5	
Area:	Off Kumano	
Date:	21.May.03	
Length of pipes:	6 m	
Length of Pilot wire:	14.05 m	
Length of main wire:	12.25 m	
Length of free fall:	5.0 m	
Weather:	Fine	
Wind:	333 deg ,	7.5 m/s
Current:	115.1 deg ,	3.7 m/s

Time	Wire-length (m)	Latitude*	Longitude*	Depth (m)	Tension (kN)	Wire-speed (m/min)		Remarks
6:00								Started operation
6:21	0	32°59.44' N	136°25.09' E	3942	0	↓	0.0	Started wire-out
6:26	50			3950	1	-	0.0	Attached transponder
6:28	50			3946	1	↓	8.2	Restarted wire-out
6:29	58			3954	1	-	0.0	Replaced winch control panel
6:30	63			3947	1	↓	22.5	Restarted wire-out
6:36	200			3947	3	↓	20.4	Raised wire speed
6:50	1000			3950	7	↓	61.2	
7:06	2000			3946	15	↓	60.6	
7:23	3000			3943	20	↓	59.5	
7:39	3820			3942	29	-	0.0	Stopped wire-out
7:54	3824			3944	28	↓	21.3	Restarted wire-out slowly
8:01	3976	32°59.43' N	136°25.31' E	3948	21	↓	19.6	PC reached to the bottom
8:02	3986			3944	25	-	0.0	Stopped wire-out
8:10	3992			3943	24	↓	13.6	Wire-out 5m plus
8:16	3997			3943	24	↓	18.9	Wire-out 5m plus
8:22	3997			3949	24	↑	7.2	Started wire-in slowly
8:25	3971	32°59.43' N	136°25.33' E	3947	33	↑	10.6	PC left the bottom (Max. 34kN)
8:26	3961			3950	30	↑	9.3	Raised wire speed
8:29	3900			3945	33	↑	20.1	Raised wire speed
8:44	3000			3948	29	↑	61.8	
9:00	2000			3941	21	↑	63.6	
9:16	1000			3942	11	↑	61.2	
9:31	100			3964	3	-	0.0	Replaced winch control panel
9:32	100			3961	4	↑	19.3	Restarted wire-in
9:34	48			3994	3	-	0.0	Removed transponder
9:35	48			3996	3	↑	13.1	Restarted wire-in
9:38	-33	32°58.57' N	136°26.22' E	3993	2	↑	16.3	Zero point surfaced
9:54								HFPC on deck

*GPS: WGS84

HFPC-6

Core:	HFPC-6	
Pilot:	HFPL-6	
Area:	Off Kumano	
Date:	21.May.03	
Length of pipes:	6 m	
Length of Pilot wire:	14.05 m	
Length of main wire:	12.25 m	
Length of free fall:	5.0 m	
Weather:	Fine	
Wind:	67 deg ,	2.5 m/s
Current:	87.2 deg ,	1.4 m/s

Time	Wire-length (m)	Latitude*	Longitude*	Depth (m)	Tension (kN)	Wire-speed (m/min)		Remarks
17:25								Started operation
17:47	0	32°35.45' N	136°53.30' E	4686	0	↓	21.7	Started wire-out
17:51	50			4678	2	-	0.0	Attached transponder
17:54	50			4681	1	↓	21.1	Restarted wire-out
17:55	72			4681	1	-	0.0	Replaced winch control panel
17:55	72			4681	1	↓	23.2	Restarted wire-out
18:02	200			4686	4	↓	21.1	Raised wire speed
18:15	1000			4676	9	↓	60.0	
18:32	2000			4686	16	↓	60.7	
18:48	3000			4678	20	↓	59.7	
19:05	4000			4678	29	↓	60.0	
19:14	4550			4682	38	-	0.0	Stopped wire-out
19:24	4550			4687	38	↓	19.9	Restarted wire-out slowly
19:33	4731	32°35.53' N	136°53.93' E	4678	33	↓	21.6	PC reached to the bottom
19:34	4741			4685	31	-	0.0	Stopped wire-out
19:36	4746			4686	32	↓	22.6	Wire-out 5m plus
19:53	4746			4685	30	↑	7.5	Started wire-in slowly
19:54	4719	32°35.54' N	136°53.93' E	4682	32	↑	29.2	PC left the bottom (Max. 45kN)
19:56	4673			4677	36	↑	33.7	Raised wire speed
20:09	4000			4679	34	↑	60.9	
20:26	3000			4678	29	↑	61.8	
20:43	2000			4677	19	↑	59.7	
21:00	1000			4677	11	↑	60.9	
21:16	51			4676	3	-	0.0	Replaced winch control panel, Restarted wire-in
21:18	47			4678	2	-	0.0	Removed transponder
21:20	47			4679	3	↑	13.5	Restarted wire-in
21:23	-33	32°35.44' N	136°54.37' E	4675	2	↑	11.1	Zero point surfaced
21:38								HFPC on deck

*GPS: WGS84

A-4. Heat flow measurement log

HF-1, 2

Core: HF-1.2
Area: Off Kumano
Date: 21.May.03
Length of pipe: 3 m
Weather: Fine
Wind: 55 deg , 6.1 m/s
Curret: 122.8 deg, 1.4 m/s

Time	Wire-length (m)	Latitude*	Longitude*	Depth (m)	Tension (kN)	Wire-speed (m/min)	Remarks
11:08							Started operation
11:15	0	32°43.48' N	136°19.83' E	-	0	↓ 0.0	Started wire-out
11:22	50			4568	3	- 0.0	Attached transponder and pinger
11:27	49			4571	3	↓ 0.0	Restarted wire-out
11:29	72			4569	3	↓ 21.9	Replaced winch control panel, Restarted wire-out
11:36	200			4565	4	↓ 25.9	Raised wire speed
11:49	1000			4569	9	↓ 63.0	
12:21	3000			4567	22	↓ 60.1	
12:46	4450			4613	35	- 0.0	Stopped wire-out
12:56	4450			4544	36	↓ 48.4	Restarted wire-out
13:04	4664	32°43.34' N	136°20.19' E	4569	30	↓ 0.0	HF-1 reached to the bottom
13:05	4654			4566	31	- 0.0	Stopped wire-out
13:19	4660			4567	28	↓ 50.4	Wire-out 5m plus
13:25	4660			4566	32	↑ 20.2	Started wire-in slowly
13:27	4635	32°43.33' N	136°20.19' E	4541	38	↑ 19.2	HF-1 left the bottom (Max. 43kN)
13:28	4590			4563	38	↑ 62.7	Raised wire speed
13:32	4335			4568	32	- 0.0	Stopped wire-in, Moved to St. HF-2
13:55	4335			4566	35	↓ 60.9	Restarted wire-out
14:04	4636	32°43.21' N	136°20.22' E	4640	32	↓ 60.4	HF-2 reached to the bottom
14:05	4646			4640	30	- 0.0	Stopped wire-out slowly
14:26	4636	32°43.22' N	136°20.20' E	4566	36	↑ 20.5	HF-2 left the bottom (Max. 43kN)
14:50	3000			4565	32	↑ 73.8	
15:21	1000			4567	13	↑ 67.0	
15:42	48			4570	3	- 0.0	Removed transponder and pinger
15:42	48			4570	3	↑ 0.0	Restarted wire-in
15:48	0	32°43.34' N	136°20.20' E	4568	0	↑ 0.0	Zero point surfaced
15:53							HF on deck

*GPS: WGS84

HF-3, 4, 5

Core:	HF-3,4,5	
Area:	Off Shionomisaki	
Date:	22.May.03	
Length of pipes:	3 m	
Weather:	Cloudy	
Wind:	89 deg ,	4.2 m/s
Current:	95.1 deg ,	1.7 m/s

Time	Wire-length (m)	Latitude*	Longitude*	Depth (m)	Tension (kN)	Wire-speed (m/min)		Remarks
6:00								Started operation
6:16	11	32°36.50' N	135°36.11'E	4750	0	↓	0.0	Started wire-out
6:32	50			4742	2	-	0.0	Attached transponder and pinger
6:36	48			4745	2	↓	20.8	Restarted wire-out
6:38	67			4747	2	-	0.0	Replaced winch control panel, Restarted wire-out
6:44	200			4748	4	↓	19.9	Raised wire speed
6:58	1000			4748	9	↓	61.3	
7:31	3000			4746	22	↓	60.1	
7:58	4620			4749	34	-	0.0	Stopped wire-out
8:08	4620			4743	35	↓	16.3	Restarted wire-out
8:11	4750			4738	37	-	0.0	Stopped wire-out
8:13	4750			4745	37	↓	13.8	Wire-out 30m plus
8:14	4780			4751	37	-	0.0	Stopped wire-out
8:15	4780			4741	36	↓	2.7	Restarted wire-out
8:16	4815	32°36.42' N	135°36.94'E	4740	34	↓	61.9	HF-3 reached to the bottom
8:17	4834			4742	30	-	0.0	Stopped wire-out
8:27	4834			4741	31	↓	1.2	Wire-out 5m plus
8:28	4839			4742	31	↓	0.1	Wire-out 5m plus
8:37	4844			4739	31	↑	16.5	Started wire-in slowly
8:38	4820	32°36.42' N	135°36.93'E	4740	39	↑	19.8	HF-3 left the bottom (Max. 39kN)
8:40	4775			4739	39	↑	44.1	Raised wire speed
8:45	4500			4741	41	↑	0.0	Stopped wire-in, Moved to St. HF-4
9:04	4501			4742	36	↓	0.0	Restarted wire-out
9:10	4750			4742	36	-	0.0	Stopped wire-out
9:11	4750			4741	38	↓	0.4	Wire-out 30m plus
9:13	4780			4742	37	-	0.0	Stopped wire-out
9:14	4780			4740	37	↓	0.4	Restarted wire-out
9:15	4832	32°36.42' N	135°37.06'E	4742	33	↓	59.4	HF-4 reached to the bottom
9:17	4842			4741	32	-	0.0	Stopped wire-out
9:25	4842			4747	32	↓	4.2	Wire-out 5m plus
9:26	4847			4742	33	↓	11.5	Wire-out 5m plus
9:36	4852			4746	33	↑	3.0	Started wire-in slowly
9:38	4818	32°36.42' N	135°37.06'E	4746	37	↑	19.0	HF-4 left the bottom (Max. 40kN)
9:49	4300			4747	34	-	0.0	Stopped wire-in, Moved to St. HF-5
9:59	4300			4747	33	↓	0.0	Restarted wire-out
10:07	4700			4739	38	-	0.0	Stopped wire-out
10:08	4700			4742	37	↓	6.4	Wire-out 80m plus
10:11	4780			4744	38	-	0.0	Stopped wire-out
10:12	4780			4740	37	↓	15.9	Restarted wire-out
10:13	4828	32°36.42' N	135°37.19'E	4740	33	↓	59.2	HF-5 reached to the bottom
10:14	4838			4745	33	↓	0.0	Stopped wire-out
10:17	4838			4742	33	↓	0.6	Wire-out 10m plus
10:34	4848			4742	34	↑	0.0	Started wire-in slowly
10:35	4824	32°36.43' N	135°37.19'E	4739	39	↑	20.7	HF-5 left the bottom (Max. 40kN)
10:36	4798			4739	39	↑	37.5	Raised wire speed
11:11	3000			4743	29	↑	60.7	
11:45	1000			4746	14	↑	72.4	
11:59	51			4748	5	-	0.0	Replaced winch control panel, Restarted wire-in
12:01	43			4740	4	↑	0.0	Removed transponder and pinger
12:07	46			4749	4	↑	0.0	Restarted wire-in
12:11	-5	32°36.55' N	135°37.19'E	4741	0	↑	0.0	Zero point surfaced
12:13						-	-	HF on deck

*GPS: WGS84