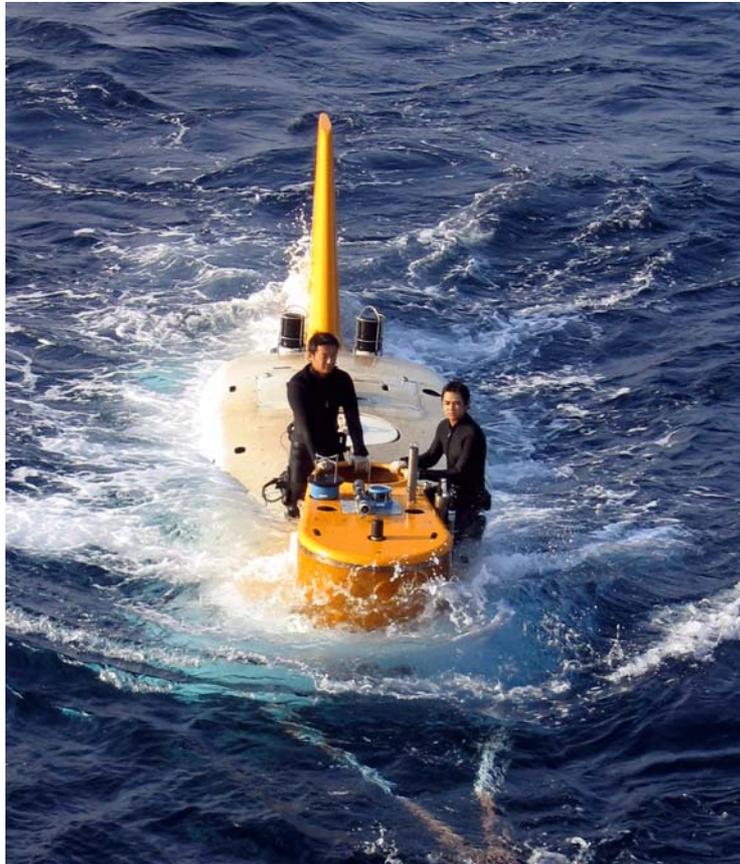


# Nankai Trough

## YK05-08 Leg 2 Cruise

### *Shinkai 6500/Yokosuka* Onboard Report

**June 20 - July 8, , 2005**  
**(Wakayama - Yokosuka)**



**Captain: Sadao ISHIDA**  
**Operation Manager: Yoshiji IMAI**  
**Chief Scientist: Yujiro OGAWA (Univ. Tsukuba)**

**SHIPBOARD SCIENTISTS:** Yujiro OGAWA , Kiichiro KAWAMURA, Ryo ANMA, Ken-ichiro HAYASHI, Ryota ENDO, Yuji YAGI, Teppei OTA, Tomoyuki SASAKI, Tomohiro TOKI, Asuka YAMAGUCHI, Gregory MOORE, Yildirim DILEK, Shunsuke KAWAKAMI, Shunji YOKOYAMA, Mamoru SANO

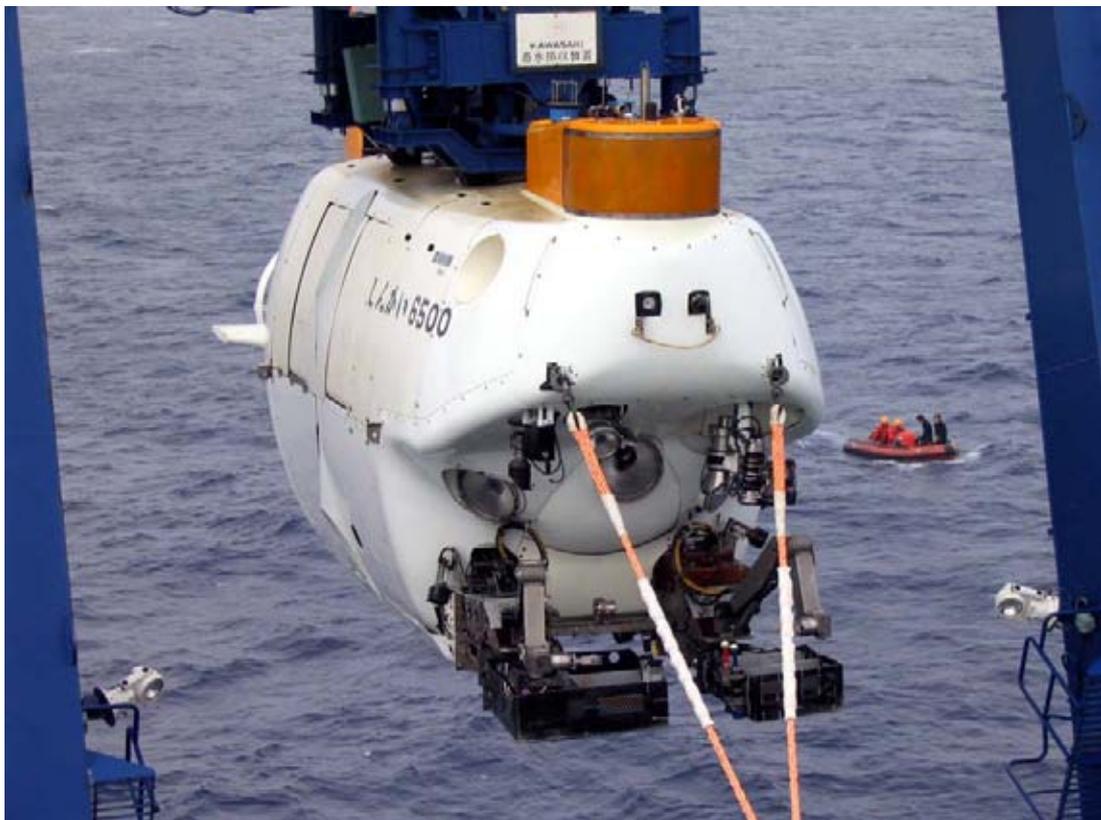
# Group Photograph of Shipbord Scientific Party YK05-08 Leg 2



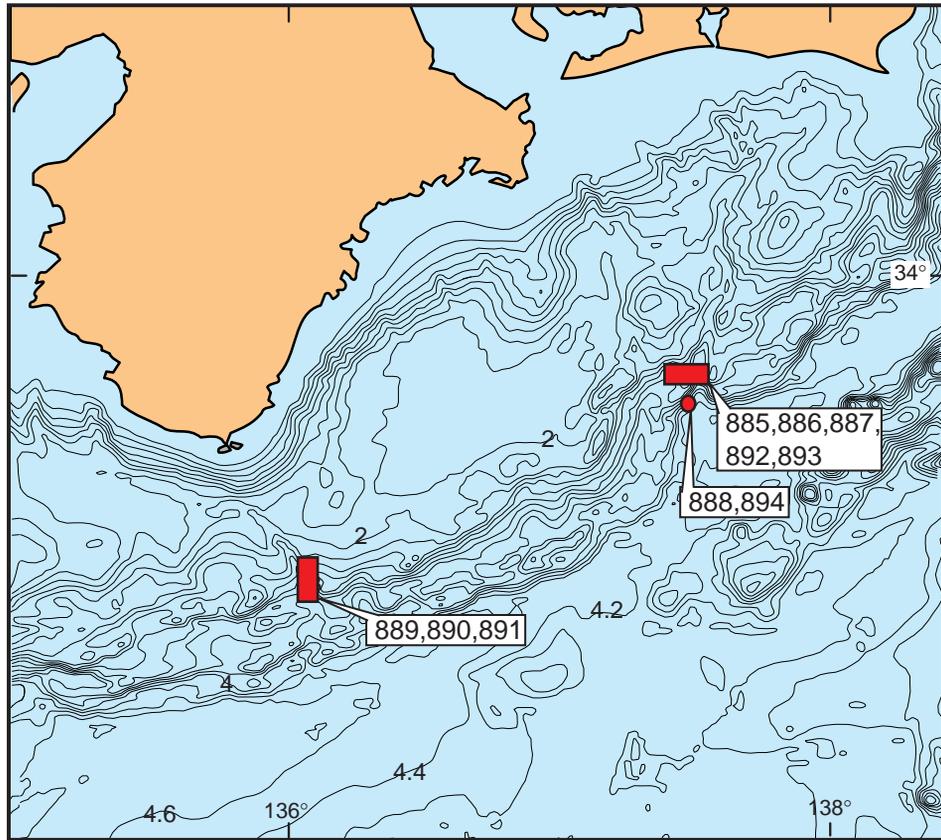
M. SANO, A. YAMAGUCHI, T. OTA, T. TOKI, Y. DILEK, G. MOORE, Y. YAGI, R. ENDO  
T. SASAKI, S. YOKOYAMA, K. KAWAMURA, K. HAYASHI, S. KAWAKAMI, R. ANMA, Y. OGAWA



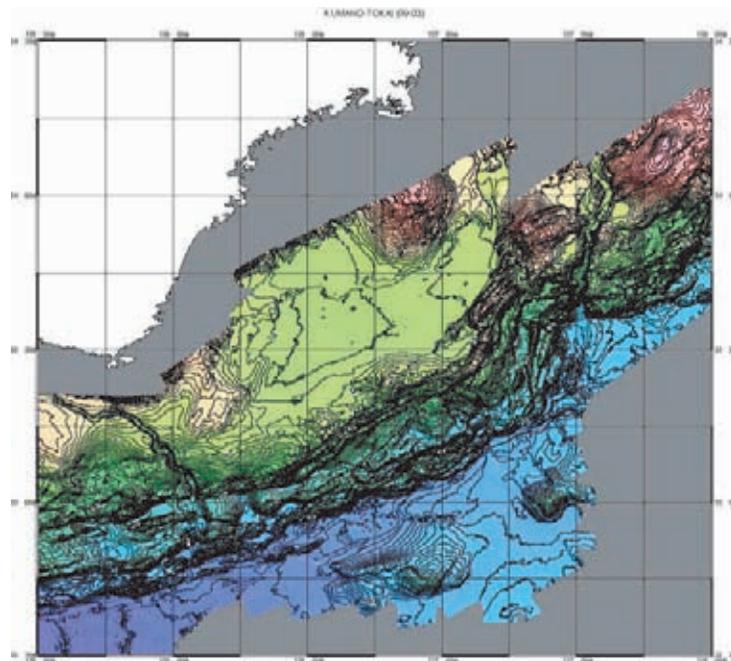
***R/V Yokosuka***



***Shinkai 6500***



Map showing locations of *Shinkai 6500* dives during YK05-08 Leg 2



SeaBEAM map of the eastern Nankai Trough  
See "Appendix" for better quality figure and  
grid data. (adopted from YK03-03)

On Board Report of YK05-08 Leg 2  
– NTSCan (Nankai Trough Submersible to Canyons) Project –

June 20 – July 8, 2005

(Wakayama – Yokosuka)

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## 1. Preface

NTSCan Project (Nankai Trough Submersible to Canyons Project) was held by R/V Yokosuka and the manned submersible Shinkai 6500 of Japan Agency for Marine-Earth Science and TEChnology (JAMSTEC). The mother vessel Yokosuka embarked on June 20, 2005, from Wakayama harbor, and disembarked on July 8 at JAMSTEC pier in Yokosuka. This is the preliminary onboard report of the cruise.

Our shipboard scientific party is composed of mostly field geologists who have been engaged in structural geology and tectonics in the Japanese and other convergent margins both onland and under the sea. In addition we invited some seismologists, geochemists, geomorphologists, biostratigraphers, and applied geologists. The dive schedules were critically planned before the cruise, but due to the temporal changes of various conditions of the sea, mainly the Kuroshio current (Black current) which is of a meandering pattern with high velocity (sometimes close to 4 knts, averagely around 2 knts) in the Shionomisaki area in spring-summer, 2005 (Fig. 1), and occasional strong wind and high swell, we were obliged to change the general schedule, and to move to the optional sites. However, among the 12 admitted dive numbers, we could perform 10 dives in total. The success is due mostly to the devoting efforts of Captain Ishida, the officers and crew, and to the careful operation of the Shinkai 6500 team under the judicious decision of Commander Imai. We acknowledge those people deeply in heart and soul.

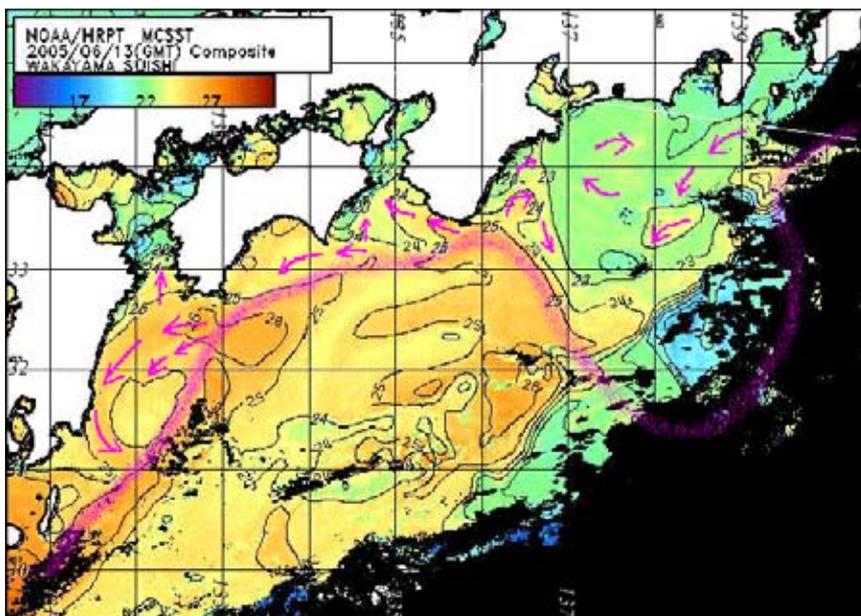


Fig. 1 Kuroshio current around the Nankai trough region of June 13, 2005

(Adopted from <http://www.pref.wakayama.lg.jp/prefg/070100/070101/index.htm>)

## 2. Background, purpose and scope of the project

As one of the typical accretionary prisms under the sea, the Nankai accretionary prism (Nankai Trough accretionary prism) (Fig. 2) has been studied since the beginning of the modern marine geoscience from the age of DSDP-ODP (Legs 31, 87 through Legs 190, 196 etc.) (See the reference figures in Figs. 3, 4, and 5). It is also very well known as the place of the periodic large seismics of subduction type. Through the stage of MCS (Multi-Channel Seismic Profiling), many multi and single channel profiles have been obtained by many groups including Ocean Research Institute, University of Tokyo, and Hydrographic Department of Maritime Safety Agency of Japan (now Japan Coastal Guard), Geological Survey of Japan and other commercial bases (JAPEX, JNOC etc.). The MCS profiles issued by G. Moore et al. (1990) resulting in knowing the precise structures inside the prism, and finally semi-3D profiles were obtained by JAMSTEC-IFREE teams for the coming IODP deep drilling. The last sets of profiles are very useful but because of the unpublished data, we cannot refer to, so that we just saw the figures as the references. We used the seismic profiles from HP of JAMSTEC and ODP.

In addition, refraction seismic profiles by operating Ocean Bottom Seismometers (OBS) were obtained by Park et al. (2002, 2003), Kodaira et al. (2003) etc. in the central and eastern Nankai Trough area (Fig. 2). In such precise and deep reflection and refraction profilings, they verified the splay thrust in the outer ridge zone, which is interpreted to be an out-of-sequence thrust zone. Also they identified that subducting ridge in the eastern Nankai case (the Paleo-Zenisu ridge) play an important role for the modification of the regular type of accretionary prism which might be better developed in the western Nankai Trough area.

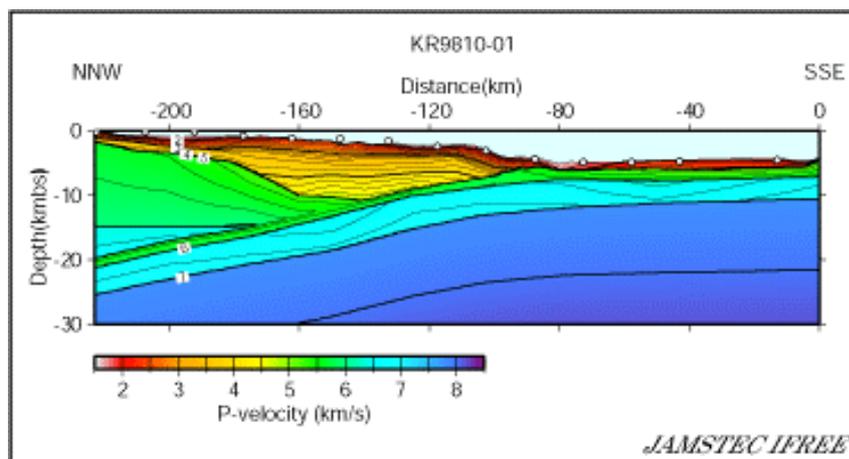


Fig. 2 OBS refraction profile off Muroto Peninsula, Shikoku, adopted from JAMSTEC Home Page.

Unfortunately, because our targeted areas, the Shionomisaki and Tenryu canyon areas (see the cover figures, and Figs. 3, 4, and 5 below), were not yet analyzed by any profiles except for the single channel profiles obtained at the site survey for the Kaiko project (Taira and Tokuyama, 1994; Chamot-Rooke et al., 1987, 1992), we used the reference profiles the nearest available ones (Figs. 6 and 7).

In another sense of research, as for the topography and controlling factor of the shape of the prism, the side scan sonar (IZANAGI) images were studied by Ashi and Taira (1992) off Shikoku in the western area of the trough. They know the very constant development of deformation at the toe of the prism as one kilometer-spacing regular formation of a fold and thrust belt by accretionary prism formation of the Philippine Sea plate subduction, offscraping the Shikoku basin and trough sediments. They are successful to discuss the slope angle of the surface of the accretionary prism as the function of the frictional coefficient that is largely controlled by the pore-fluid pressure along the decollement zone (subducting plate upper boundary) under the assumption of a bulldozer model of Davis et al. (1983)'s balance of stress inside the prism.

For the purpose of obtaining the visual observation, the Kaiko project, which began from 1994 as the international cooperative program between France and Japan, brought a volume of results by SeaBeam swath mapping and later submersible mission to the Nankai Trough area (Le Pichon et al., 1987 etc.). Throughout the long-lasting projects, the topographic maps and single channel seismic profiles were obtained as the preliminary results (1987), and submersible research results were published in several series of reports (Le Pichon et al., 1987; Kobayashi et al., 1994; Cadet and Uyeda, 1989; Okada and Cadet, 1989; Kastner and Le Pichon (1992)). The results are striking, verifying many examples of the geology, topography and geophysics in the Japanese trench areas and related tectonics, particularly the methane-bearing fluid advection and associated chemosynthetic biocommunities.

The research continues to some additional phases as the Kaiko-Nankai project, and further Kaiko-Tokai project. In the later half of the series of projects, the Nankai Trough area was targeted by various methods of study, but mostly submersible observation was done by Japanese submersible (JAMSTEC three vessels; Shinkai 2000, Shinkai 6500, and KAIKO; the latter is only unmanned). The results were published by various reports (Ashi et al., 1995, 1996 etc.), and as the summarizing report by Kobayashi (2002). Most recent project using the submersible Shinkai 6500 was operated as YK03-03, and the onboard report was published by CDR (Ashi et al., 2003).

They observed many sites of the outer ridge, named as the Kumano and Ohmine ridges off Kii Peninsula between the Shionomisaki and Tenryu canyons. They

verified mostly the seepage zones along thrust and strike-slip faults in these areas with some additional observation of the prism toe areas. The total results of seepage and related implications are summarized by Kobayashi (2002).

However, no or very few submersible observations have ever been done except for our team's examples on the profiles of the prism along the canyons. The exceptions are by Kawamura et al. (1999) and Anma et al. (2002), the former on the Tenryu canyon and the latter on the Shionomisaki canyon.

Under such a situation, we planned the submersible mission to the canyons which dissect inside the prism, and we named this project as the "NTSCan Project" (Nankai Trough Submersible to Canyons Project). The scope is explained as follows.

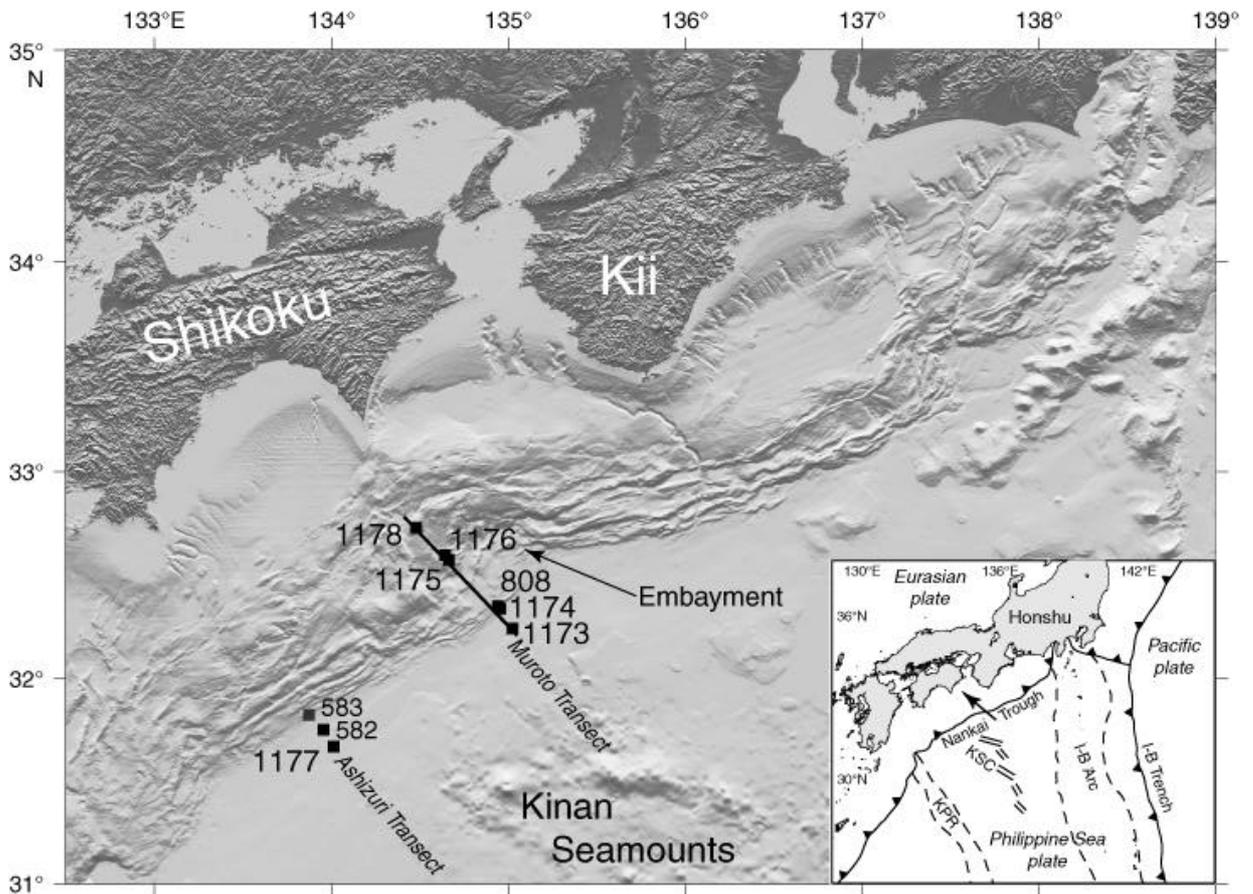


Fig. 3 Bathymetric image of the Nankai trough region, adopted from HomePgae of ODP Legs190/196 (G. Moore et al., 2005). Previous ODP sites are shown. Note that two distinct canyons, one the Shionomisaki canyon, just south off the Kii Peninsula, another the Tenryu canyon east off the Kii Peninsula, are only canyons dissected the Nankai accretionary prism.

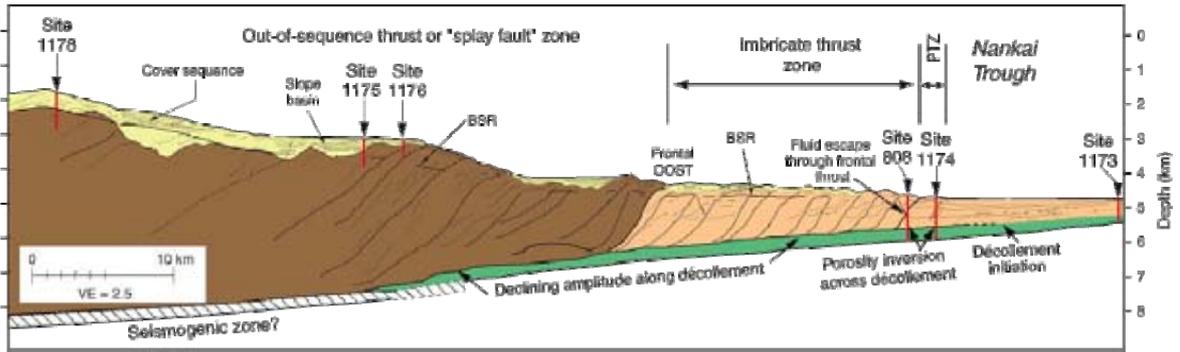


Fig.4 Profiles of the typical accretionary prism process along the line off Muroto Peninsula, Shikoku. This line is to the west of the Shionomisaki canyon. Adopted from G. Moore et al. (2005) [http://www-odp.tamu.edu/publications/190196SR/synth/syn\\_f2.htm#1002489](http://www-odp.tamu.edu/publications/190196SR/synth/syn_f2.htm#1002489). Attention that the sediments in front of Frontal OOST are young around 1 Ma.

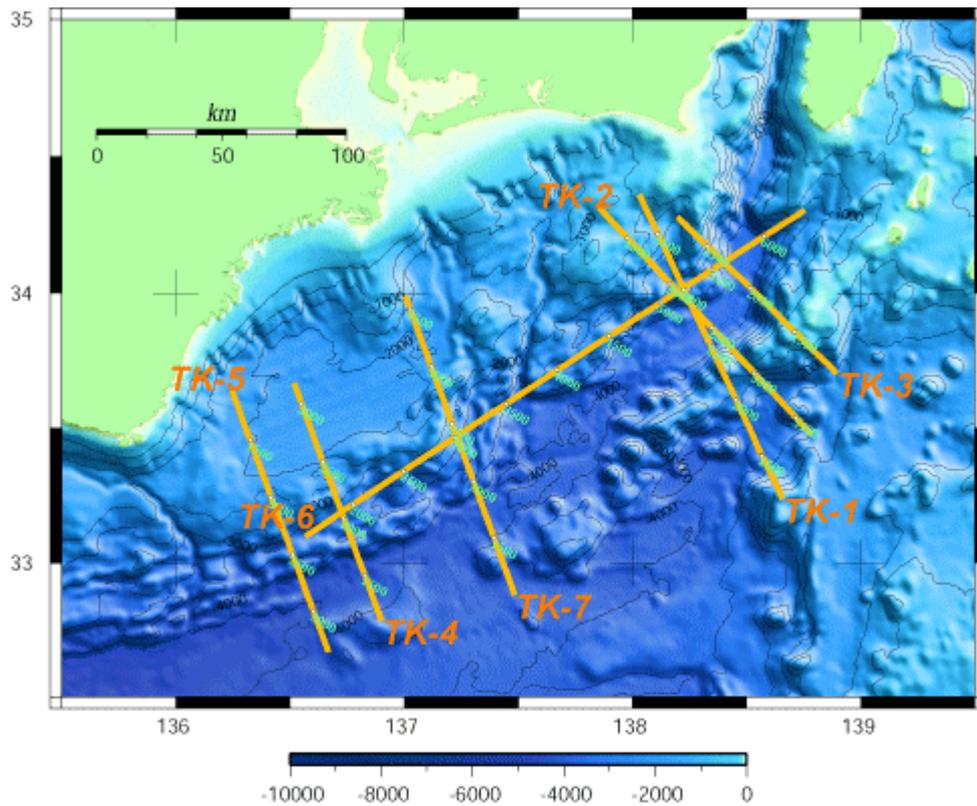


Fig. 5 Reference lines of seismic profiles around the study area. See Figs. 6 and 7 for lines TK-5 and 7. Adopted from HP of JAMSTEC.

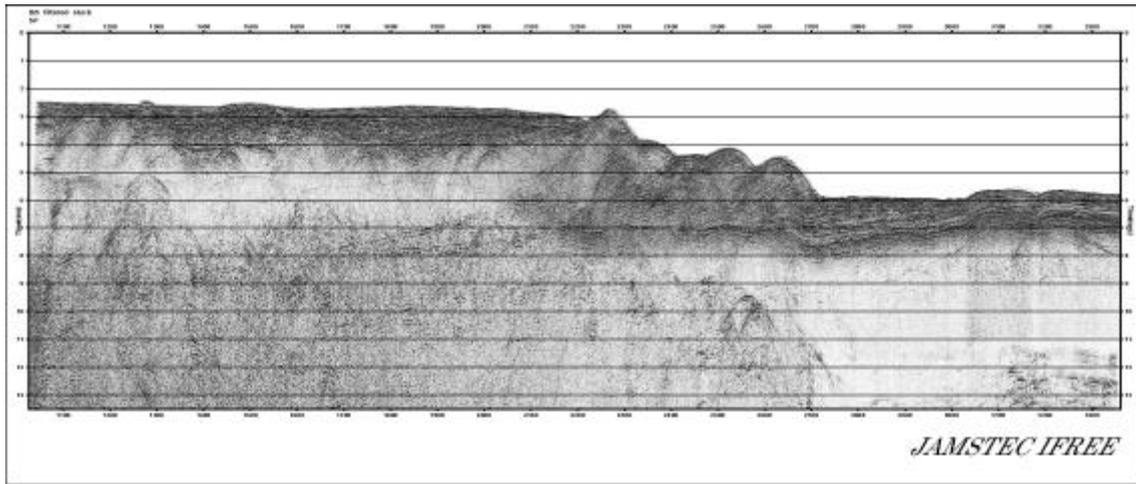


Fig. 6 KR108 TK-5 Line (adopted from JAMSTEC HP). This line is just to the east of the Shinomisaki canyon. The sharp peak is the extension of the Kumano and Ohmine ridges, that correspond to the out-of-sequence thrust zone.

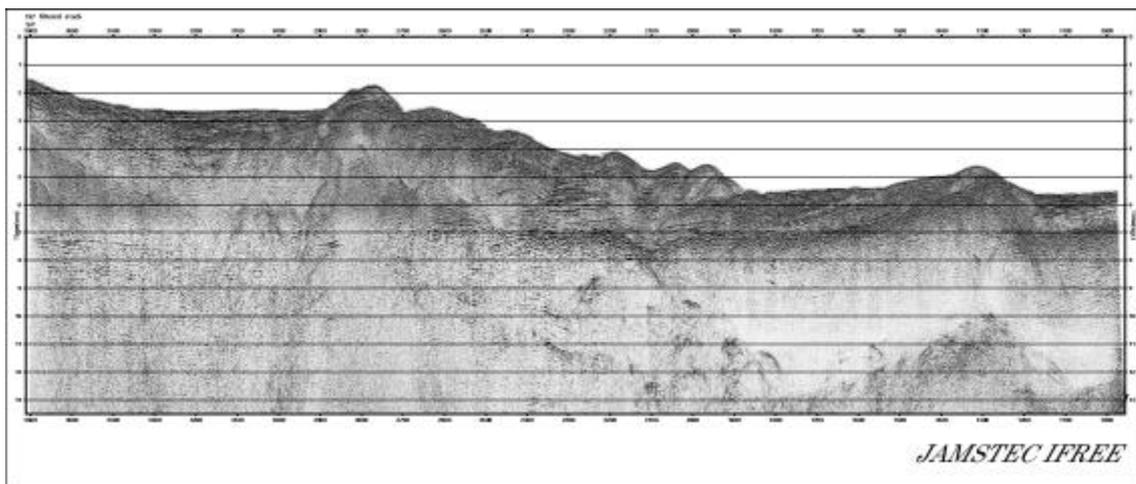


Fig. 7 KR108 TK-7 Line (adopted from JAMSTEC HP). This line is to the west of the Tenryu canyon. This part is underlain by the Paleo-Zenisu ridge which is subducted underneath the accretionary prism.

This project aims to verify the geologic structures and tectonics of the Nankai accretionary prism from new viewpoints and scopes. The general idea of the development of the modern (or young) accretionary prisms has been almost understood by minor and major scale analyses through studies of drilling and seismic profiling in particular from those from Barbados and Nankai. However, such methods can identify only large scale and micro or small-scale variation in mostly 2D. It is of prime

importance to study the outcrop scale structures in order to understand detail tectonics development. However, the real geology by observation of the outcrops under the sea is used to be very difficult (but necessary to know the 3D informations), it is only given by submersible observation.

On land, 3D geological survey is done along canyons, rivers or cliffs where continuous exposures are obtained. Under the sea if dissected canyons are developed cutting the accretionary prism, they must provide the best places to study the 3D geology.

We planned such expeditions to the two canyons, and submitted the proposal for the Shinkai 6500 dive research to JAMSTEC, under the title of “Transects to the Nankai accretionary prism: A new view of the prism research”, and was fortunately approved. Our general proposal is as follows. We will do submarine field survey to obtain the distribution of strata, disposition of geologic structures, and to know the age and structural features of the strata exposed in the canyons by means of structural geology and physical properties study. The sedimentation age is mostly by radiolarian biostratigraphy.

We will compare the geology between canyons, and will analyze the tectonic and mechanical history of accretionary prism in different parts: the former as of a typical type, whereas the latter is of the collapsed or modified type by a ridge subduction (Soh et al., 2002). Physical properties of the sediments and sedimentary rocks, chiefly the mechanical properties such as needle test and compaction-shear test under pore-fluid pressure control. Also the most important basic measurement is to know the orientation of the samples. We will try to put the orientation of the sample on the outcrop during sampling. The measurement by magnetometer will be planned.

In addition we will study geochemistry of cold seepage on the faults along which methane bearing fluid is advecting. General inorganic chemistry is applied both for the sediments under oxidized and particularly redoxed conditions. Isotope geochemistry is also planned for the clam shells along the seepage zones. We will further study relationship of topography on the accretionary prism surface either by gravity sliding or tectonics.

The targeted two area, the Shionimisaki canyon area is almost to the west of the line of Fig. 6, and the other area, the Tenryu canyon area is to the east of the line of Fig. 7. For the bathymetric map of each area, please refer to Fig. 8 and 9, respectively. They show our team's previous dive sites as well. Also many detailed bathymetric maps obtained during the cruise are filed in Appendix.

The planned sites of each area are shown in Fig. 10 and 11, respectively. In fact

our dives were controlled by severe weather conditions including the current velocity, and cables on the seafloor.

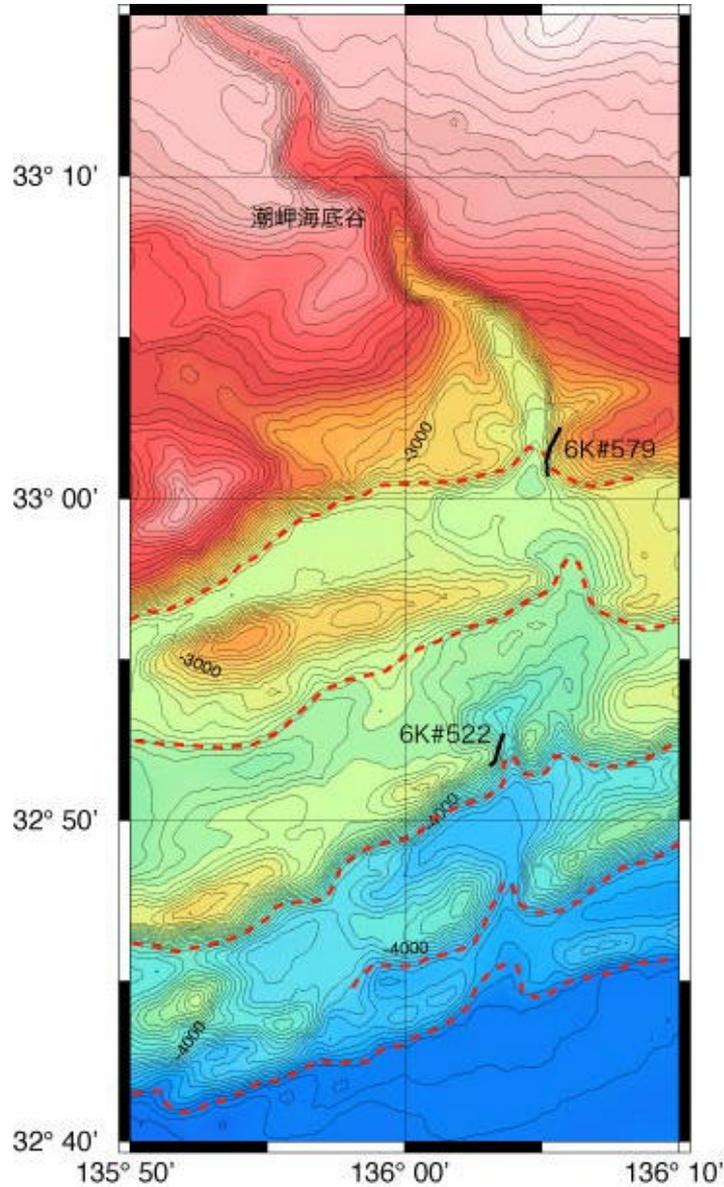


Fig. 8 Bathymetric map with major thrust faults in the Shionomisaki canyon area. Previous dives by R. Anna are shown. See Anna et al. (2002). The ridges are named from the trough side (south), the first, second, third, fourth, and the fifth ridge. Contour interval is 50 m.

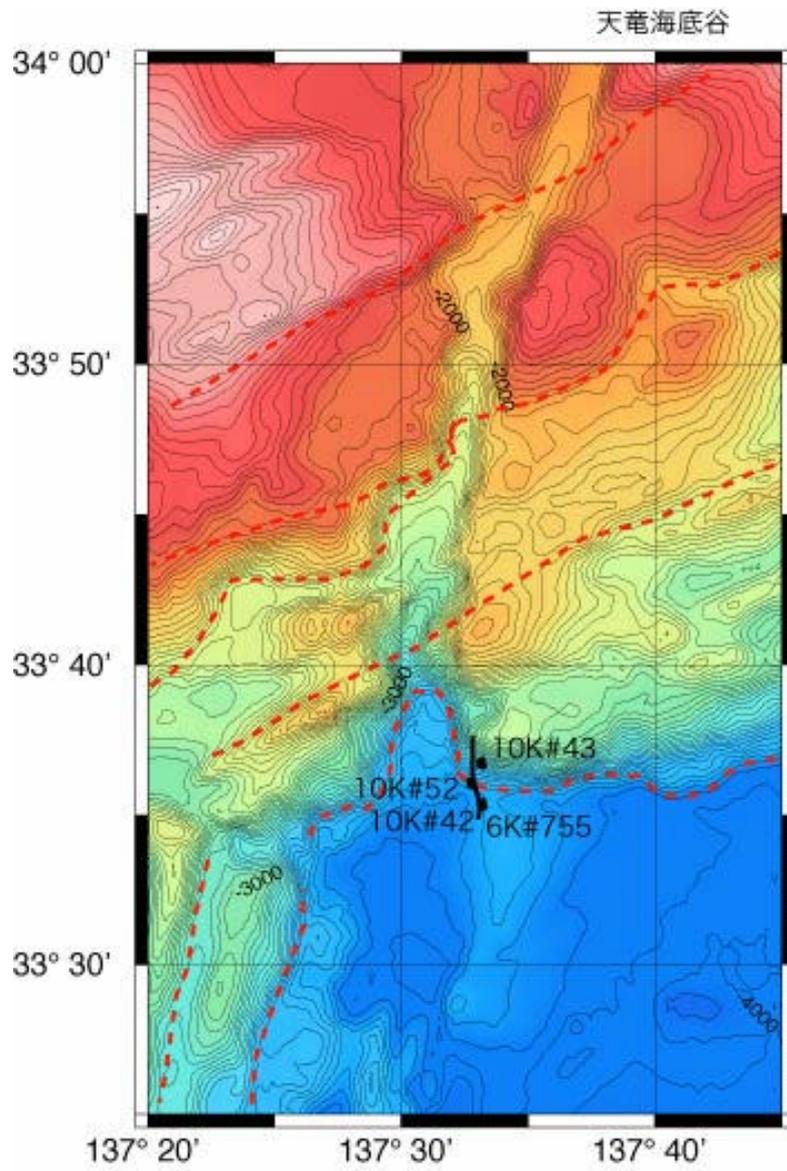


Fig. 9 Bathymetric map of the Tenryu canyon area, showing the previous dives.  
See Kawamura et al. (1999). Contour interval is 50 m.

# Shionomisaki canyon

Shionomisaki Canyon Area 10 m contours

(A)

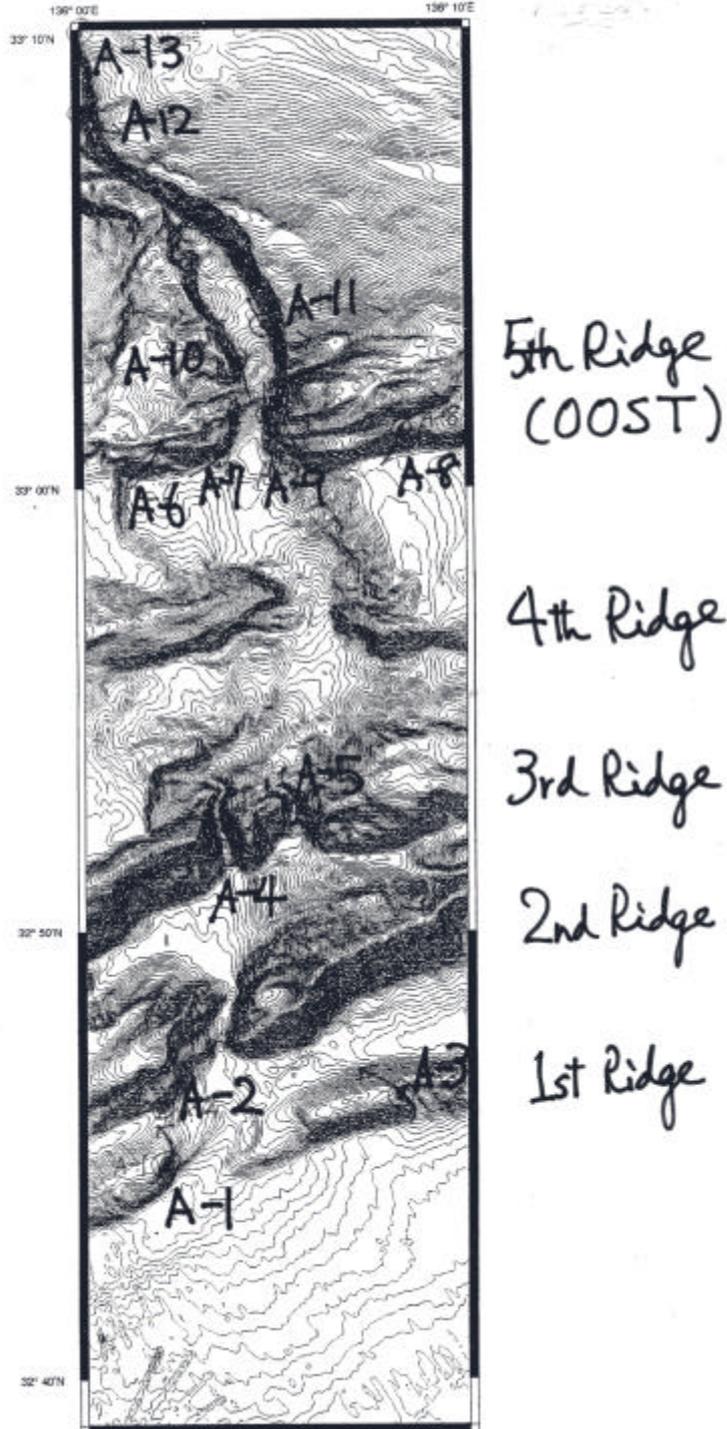


Fig. 10 Detail bathymetric map of the Shionomisaki canyon area, showing the proposed dive sites, A-1 to A-13. As a result, A-9 was dived three times.

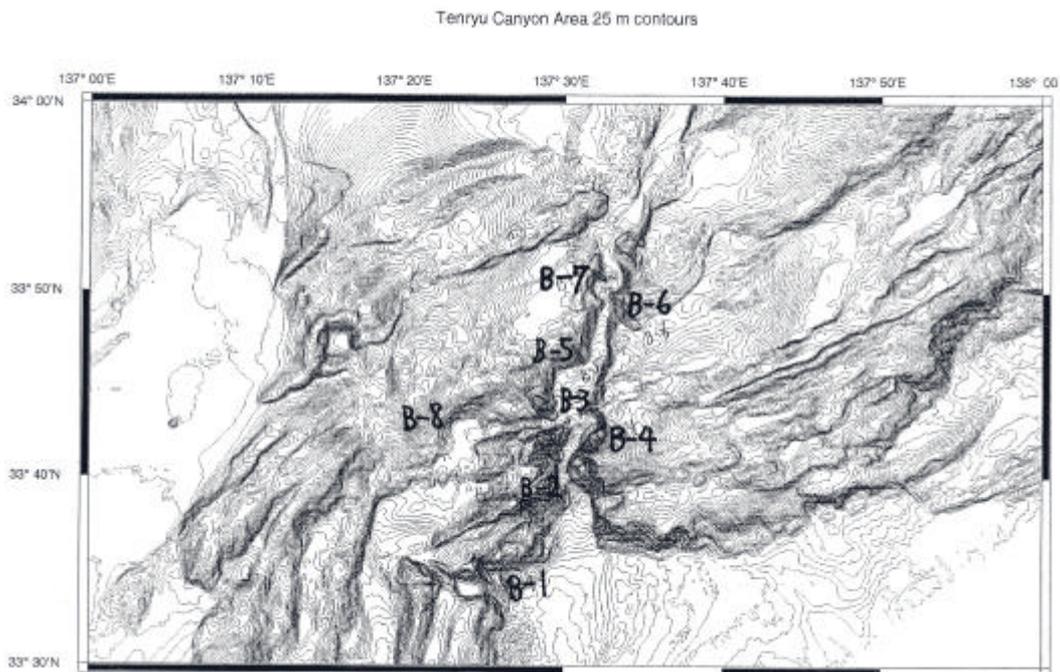


Fig. 11 Detail bathymetric map of the Tenryu canyon area, showing the proposed dive sites, B-1 to B-8. As a result, B-1,3, 4, , 5 and 8 were dived three.

We planned such expeditions to the two canyons, and submitted the proposal for the Shinkai 6500 dive research to JAMSTEC, and was fortunately approved. Our general proposal is as follows. We will submarine field survey to obtain the distribution of strata, disposition of geologic structures, and to know the age and structural features of the strata exposed in the canyons. We will compare the geology between canyons, and will analyse the tectonic and mechanical history of accretionary prism in different parts; the former as of a typical type, whereas the latter is of the collapsed or modified type by a ridge subduction (Soh et al., 1999??).

In addition we will study cold seepage area on the fault along which methane bearing fluid is advecting. We will further study relationship of topography on the accretionary prism surface either by gravity sliding or tectonics.

### 3. Participants

#### 3.1 R/V Yokosuka Ship Crew

Sadao ISHIDA Captain

Takafumi AOKI Chief Officer

Tsutomu SATO 2nd Officer  
Takashi EGASHIRA 3rd Officer  
Kuniharu TABUCHI Chief Engineer  
Kimio MATSUKAWA 1st Engineer  
Takashi OTA 2nd Engineer  
Daisuke GIBU 3rd Engineer  
Satoshi WATASE Chief Electric Operator  
Katsutoshi KITAMURA 2nd Electric Operator  
Makio NAKAURA Boatswain  
Mikio ISHIMORI Able Seaman  
Katsumi SHIMIZU Able Seaman  
Takao KUBOTA Able Seaman  
Keiji SHIKAMA Able Seaman  
Shozo FUJII Able Seaman  
Toshiki OKUYAMA Sailor  
Kiyoshi YAHATA No.1 Oiler  
Kozo MIURA Oiler  
Tomoyuki HASHIMOTO Oiler  
Ryota SUZUKI Oiler  
Yoshinori YAMAOKA Oiler  
Kyoichi HIRAYAMA Chief Steward  
Shinsuke TANAKA Steward  
Toyonori SHIRAISHI Steward  
Kazuhiro HIRAYAMA Steward  
Tadayuki TAKATSU Steward

### 3.2 Shinkai 6500 Team Personnel

Yoshiji IMAI Operation Manager (Commander)  
Toshiaki SAKURAI Assistant Operation Manager  
Yoshitaka SASAKI Submersible staff  
Kazuki IJIMA Submersible staff  
Itaru Kawama Submersible staff  
Fukuo Suda Submersible staff  
Yoshinari Ohno Submersible staff  
Masanobu Yanagitani Submersible staff  
Keita Matsumoto Submersible staff

Hirofumi Ueki Submersible staff

Yosuke Chida Submersible staff

Fumiyo Saito Submersible staff

### 3.3 Scientific party

Yujiro OGAWA (Univ. Tsukuba)

Kiichiro KAWAMURA (Fukada Geological Inst.)

Ryo ANMA (Univ. Tsukuba)

Ken-ichiro HAYASHI (Univ. Tsukuba)

Ryota ENDO (Univ. Tsukuba)

Yuji YAGI (Univ. Tsukuba)

Tepei OTA (Univ. Tsukuba)

Tomoyuki SASAKI (Univ. Tokyo)

Tomohiro TOKI (Univ. Tokyo)

Asuka YAMAGUCHI (Univ. Tokyo)

Gregory MOORE (Univ. Hawaii, U.S.A.)

Yildirim DILEK (Miami Univ., U.S.A.)

Shunsuke KAWAKAMI (Geological Survey of Japan)

Shunji YOKOYAMA (Kochi Univ.)

Mamoru SANO (Japan Marine Enterprise)

## 4. Ship and observation (adopted from YK03-03 cruise report)

### 4.1 Research Vessel “Yokosuka” (adopted from YK03-03 cruise report)

R/V Yokosuka is designed to serve as the mother vessel for Shinkai 6500 and has silent engine, an advanced acoustic navigation systems and an underwater telephone for its state-of-the-art operations. It is also equipped with various kinds of underway-geophysical equipment, i.e., Multi Narrow Beam Echo Sounder (Sea Beam 2112.04, SeaBeam Instruments, Inc.), gravity meter (Type S-63, LaCoste & Romberg Gravity Meters Inc.), ship-borne three-components magnetometer (Type.SFG-1212, Tierra Tecnica Inc.), and proton magnetometer (Type.STC10, Kawasaki Geological Engineering Co.,Ltd.). The wet-lab is equipped with a fumigation chamber, “Milli-Q” water purifier, -80 °C deep freezer, incubator, and rock saw. In addition, YOKOSUKA has on-board video editing capability for DVCAM, S-VHS, VHS, system.

Research Vessel “Yokoska” The principal specifications (Fig.12)

Length : 105.22 m

Breadth: 16.0 m

Height : 7.3 m

Draft : 4.5 m

Gross tonnage : 4439 t

Cruising speed : about 16 kts

Cruising range : about 9000 mile

Accommodation: 15 reserchers' beds

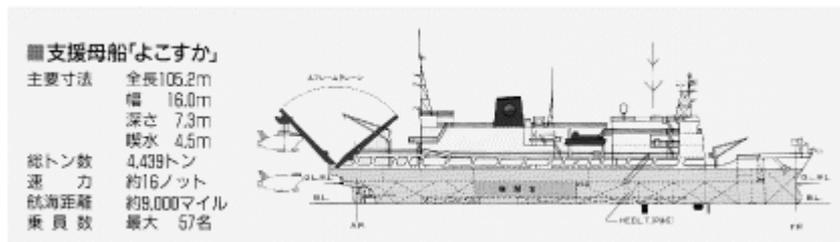


Fig. 12  
Research Vessel  
“Yokoska”

### 4.2 SEA BEAM 2112 -Outline of system –

Bathymetric data were collected by the SEA BEAM 2112 (Sea Beam Instruments). The SEA BEAM 2112 is a multibeam survey system that generates data for and produces wide-swath contour maps and side scan images. It transmits a sonar

signal from projectors mounted along the keel of the ship. The sonar signal travels through the sea water to the seafloor and is reflected off the bottom. Hydrophones mounted across the bottom of the ship receive the reflected sonar signals. The system electronics process the signals, and based on the travel time of the received signals as well as signal intensity, calculate the bottom depth and other characteristics such as S/N ratio for echoes received across the swath. Positioning of depths on the seafloor is based on GPS and ship motion input. The data is logged to the hard disk for post processing which allows for additional analysis. Plotters and side scan graphic recorder are also included with system for data recording and display. The hardware system consists of two main subsystems, transmitter and receiver respectively. Fig. 13 shows a basic diagram of the system. The basic 12 kHz projector array is a 14-foot long linear array positioned fore and aft along the ship's keel. It forms a downward projected acoustic beam whose maximum response is in a plane perpendicular to its axis. The beam angle is narrow, 2° in the fore/aft direction. The receiver array detects and processes the returning echoes through stabilized multiple narrow athwartship beams in a fan shape. The hydrophone array has a flat shape in the case of R/V "KAIREI", although the standard SEA BEAM 2000 series system has a V-shaped array (Fig. 13). The system synthesizes 2×2 degree narrow beams at the interval of 1 degree, and the swath width varies from 120 degrees at depths from 1500 m to 4500 m, 100 from 4500 m to 8500 m and deeper than 8500 m, as shown in Fig. 14. The transmit interval of the sonar signal ping interval increases with water depth, for example about 20 sec. at 6500 m. So, the horizontal resolution of the bathymetry data depends on the depth and ship's speed. The accuracy of the depth measurement is reported at 0.5% of the depth. The software which controls the system is called the Sea View. It employs the Lynx Operating System. Indy Work Stations (SGI) are used for operation. The obtained raw data includes data records of each ping (bathymetry, side scan image, position), nautical information and correction parameters such as water velocity structure. Post processing consists of editing data (deletion of bad data, correction of position etc.), making grid data files and various maps. Software used is Sea View and GMT Ver.3.0 (Wessel and Smith, 1995).

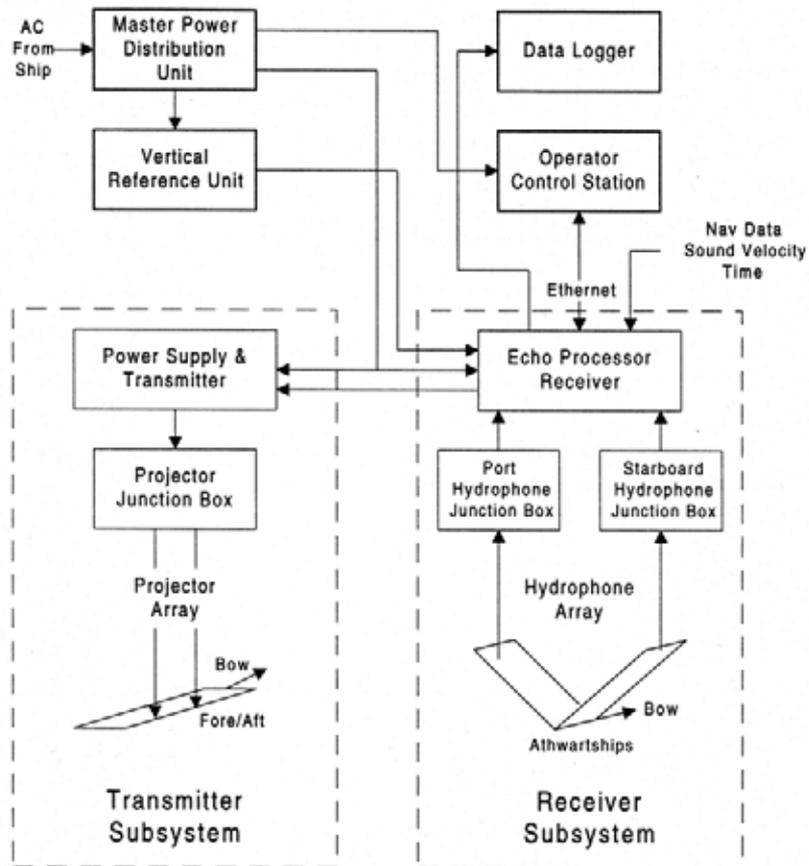


Fig. 13 Flow chart

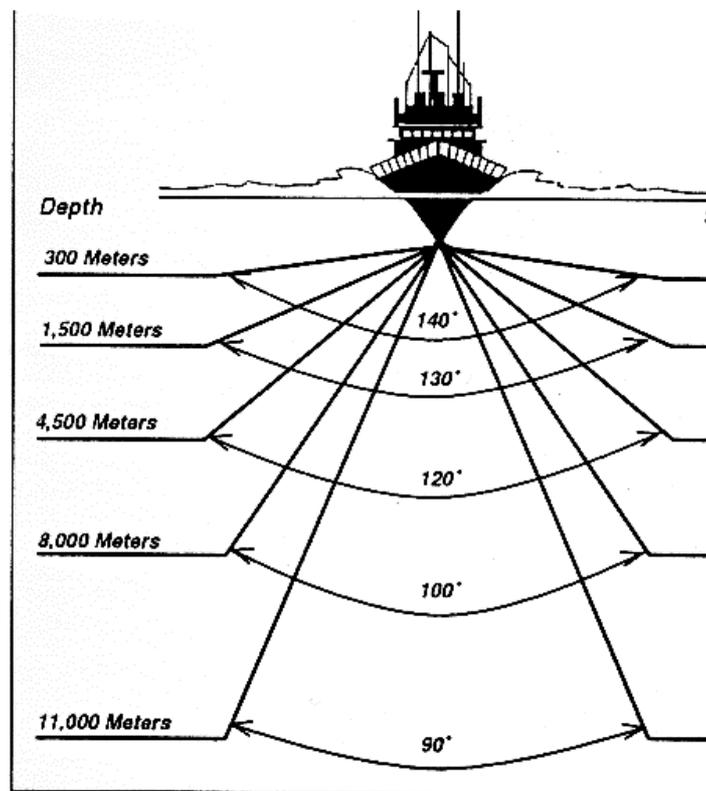


Fig. 14 Relationship between seabeam range and depth.

### 4.3 Submersible “Shinkai 6500”

Shinkai 6500 is a manned submersible with dive capability of the world deepest 6,500 meters. Two pilot and one scientist stay in a pressure hull 2 meters in diameter which has three viewing windows. It is equipped with two manipulators, pan-tilt-zoom color video camera, a fixed-view color video camera, a 35 mm still camera, two retractable sample baskets, CTD sensors, Gamma ray spectrometer, CTFM sonar, and a video-image transmission system which enable us to watch full-color seafloor images every 8 seconds onboard the mother vessel Yokosuka. Recent innovation of the Shinkai hardware, which includes two 7-freedom manipulators (Schilling Co., USA) and two retractable baskets, made this submersible even powerful as a tool for deployment of various instruments. The total allowable weight for an observer is less than 150kg (in the air) including collected materials. The underwater speed of the submersible is 0-2.5kts and the speed can be controlled continuously. The top speed of 2.5kts is just for emergency situations. There are two ways to find the position of Shinkai 6500; Long Base line system (LBL) and Super Short Base Line system (SSBL). The LBL system needs 3 bottom mounted transponders to be deployed in the survey area. The Shinkai 6500 locates her position by herself and the mother ship determines the position and her position based on the position of transponders. The LBL system has the advantages of given very accurate position and the submersible can measure her own position in real time. The disadvantage of the LBL system is the additional time it takes to deploy and recover the transponders. Normally, LBL system covers the area within a circle whose radius is similar to the depth. The SSBL system does not require any transponder but the accuracy is inferior to the LBL system, and only the mother vessel can locate the position of Shinkai 6500. In this case, Shinkai 6500 must be notified of her position by the mother vessel. However, coverage range is similar to that in LBL system. General payload of this cruise is shown in Fig. 15.



Fig. 15 General setting of payload

## 5. Dive areas

Two major areas were selected, Shionomisaki submarine canyon (Area A) (Figs. 12 and 13) and Tenryu submarine canyon (Area B) (Figs. 14 and 15). Several dive sites were planned before the cruise, but because of selecting the priorities, the following ten dives were done as a result.

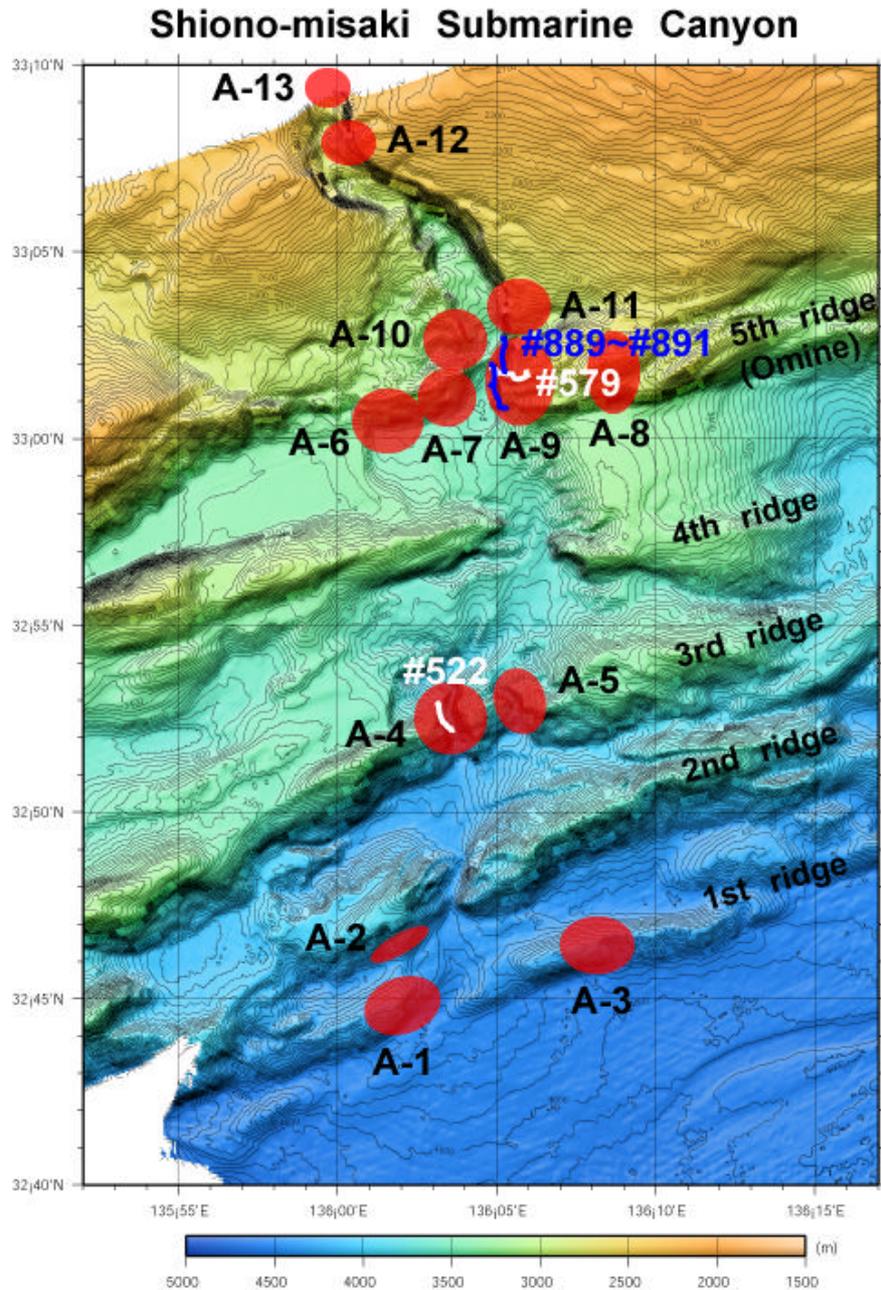


Fig. 16 Bathymetric map of dive sites of 6K#889, 890 and 891 at Shionomisaki canyon, 5<sup>th</sup> ridge area (Kuroshio gorge).

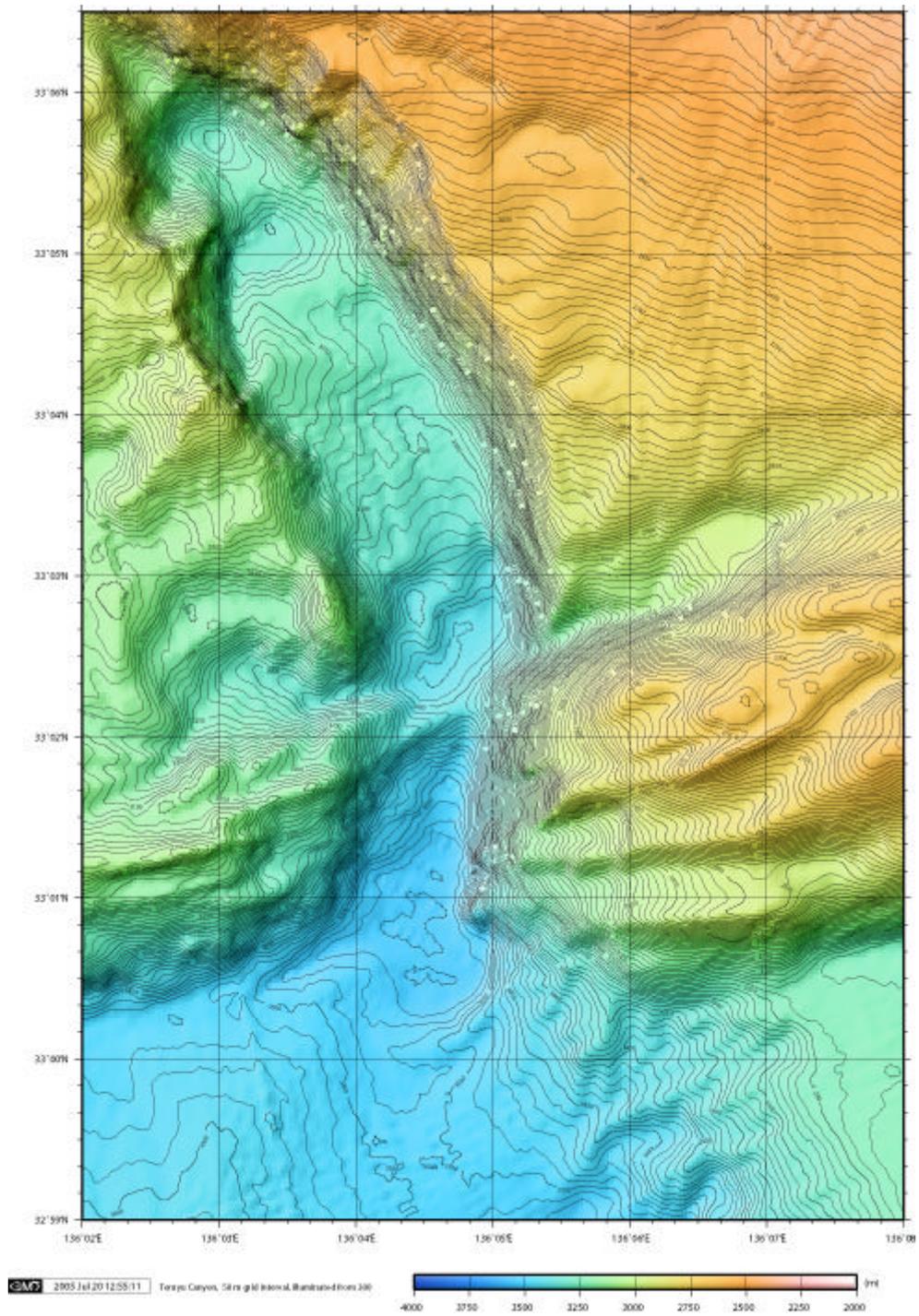


Fig.17 Detailed bathymetric map of the dive sites of Shionomisaki canyon, 5<sup>th</sup> ridge area, Kuroshio gorge (west-facing slope; Yoriko slope).

# Tenryu Submarine Canyon

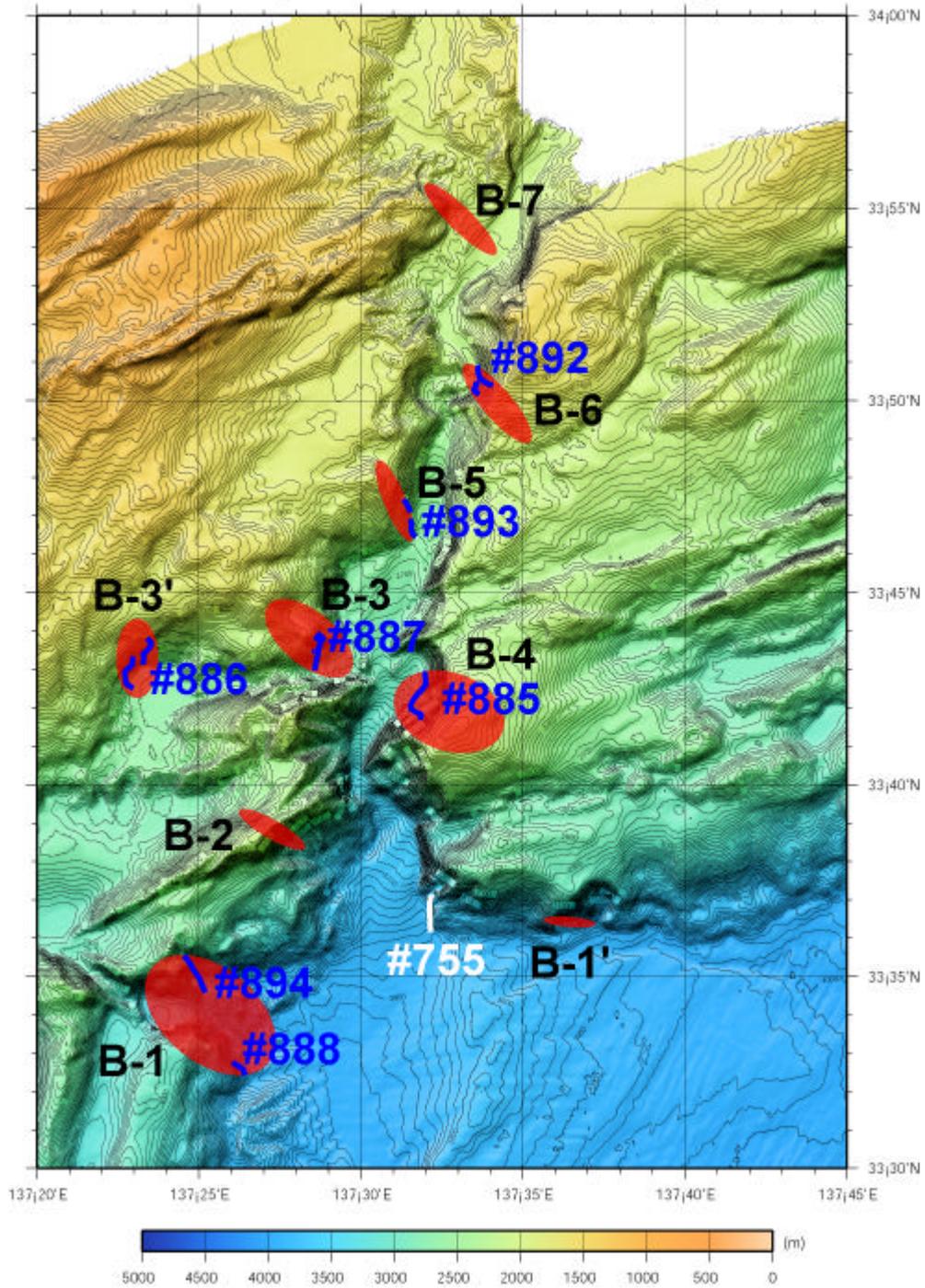


Fig.18 Bathymetric map of dive sites 6K#885, 886, 887, 888, 892, 893 and 894 in the Tenryu Canyon area.

## 6. Ship log

Date / Time	Note	Weather/ Sea State/ Winds Dir. & Force
19-Jun-01	Noon Position; WAKAYAMA SHIMOTSU BAY Time Zone; UTC+9h	bc / 1/ SW-3
14:30	Guidance of ship's life for new participants in meeting room by chief officer and chief radio officer	
15:00	Science Meeting in No.1 Laboratory	
16:00	Depart WAKAYAMA SHIMOTSU BAY for the research area Transit to off Dive#885 point	
16:00	6K team meeting in meeting room	
19:00	Science Meeting in No.1 Laboratory	
20-Jun-01	Noon Position; 33-07'N, 136-27'E Time Zone; UTC+9h	r / 5 / E-6
02:00	Arrived at Dive#885 point	
05:23	Released to XBT	
06:06-07:00	MNBES swath mapping survey	
11:00	Suspended <i>Shinkai 6500</i> research dive due to rough sea	
13:45-15:05	MNBES swath mapping survey	
14:00-15:00	Science Meeting in No.1 Laboratory	
16:28-17:06	MNBES swath mapping survey	
16:40-17:00	"Konpira-san" on Bridge	
1733-1809	MNBES swath mapping survey	
18:09	Started to MNBES swath mapping survey	
19:00-20:00	Science Meeting in No.1 Laboratory	
21-Jun-01	Noon Position; 33-32'N, 137-27'E Time Zone; UTC+9h	o / 4 / WSW-5
07:08	Finished MNBES swath mapping survey	
09:00	Suspended <i>Shinkai 6500</i> research dive due to rough sea	
14:00-15:30	Science Meeting in No.1 Laboratory	
19:28	Started to MNBES swath mapping survey	

22-Jun-01	Noon Position; 33-43'N, 137-32'E      Time Zone; UTC+9h	o / 2 / Calm
07:09	Finished MNBES swath mapping survey	
09:17	Swimmers standing by (Able seaman, 3E)	
09:59	<i>Shinkai 6500</i> opened vent, start test Dive#885	
11:18	<i>Shinkai 6500</i> on bottom (33-42.9305'N, 137-32.0221'E, D=2,778m)	
16:02	<i>Shinkai 6500</i> leave bottom (33-41.6884'N, 137-31.9565'E, D=2,525m)	
16:33	Swimmers standing by (Able seaman, Oiler)	
16:55	<i>Shinkai 6500</i> on surface	
19:18-20:37	MNBES swath mapping survey	
19:30-20:30	Science Meeting in No.1 Laboratory	
20:37	Started to MNBES swath mapping survey	
23-Jun-01	Noon Position; 33-43'N, 137-23'E      Time Zone; UTC+9h	bc / 2 / WSW-2
07:13	Finished MNBES swath mapping survey	
09:17	Swimmers standing by (Sailor, 3E)	
09:56	<i>Shinkai 6500</i> opened vent, start test Dive#886	
11:14	<i>Shinkai 6500</i> on bottom (33-42.5249'N, 137-22.9486'E, D=2,591m)	
16:00	<i>Shinkai 6500</i> leave bottom (33-43.5896'N, 137-23.1446'E, D=2,234m)	
16:27	Swimmers standing by (Able seaman, Assistant Oiler)	
16:48	<i>Shinkai 6500</i> on surface	
19:30-21:00	Science Meeting in No.1 Laboratory	
17:41	Started to MNBES swath mapping survey	
24-Jun-01	Noon Position; 33-43'N, 137-29'E      Time Zone; UTC+9h	bc / 2 / SSW-3
07:15	Finished MNBES swath mapping survey	
09:15	Swimmers standing by (Able seaman, 3E, intern)	
10:02	<i>Shinkai 6500</i> opened vent, start test Dive#887	
11:17	<i>Shinkai 6500</i> on bottom (33-42.9772'N, 137-28.6068'E, D=2,688m)	
16:12	<i>Shinkai 6500</i> leave bottom (33-43.4645'N, 137-'E,	

	D=2,234m)	
16:44	Swimmers standing by (Able seaman, Assistant Oiler)	
17:09	<i>Shinkai 6500</i> on surface	
19:30-21:00	Science Meeting in No.1 Laboratory	
19:46	Started to MNBES swath mapping survey	
25-Jun-01	Noon Position; 33-32'N, 137-26'E      Time Zone; UTC+9h	bc / 3 / SW-4
07:09	Finished MNBES swath mapping survey	
09:16	Swimmers standing by (Able seaman, 3E, intern)	
09:57	<i>Shinkai 6500</i> opened vent, start test Dive#888	
11:43	<i>Shinkai 6500</i> on bottom (33-32.4370'N, 137-26.4323'E, D=3,757m)	
13:46	<i>Shinkai 6500</i> leave bottom (33-32.7262'N, 137-26.0636'E, D=3,611m)	
14:41	Swimmers standing by (Able seaman, Assistant Oiler)	
15:08	<i>Shinkai 6500</i> on surface	
19:00-19:50	Science Meeting in No.1 Laboratory	
17:30	Started to MNBES swath mapping survey	
26-Jun-01	Noon Position; 33-00'N, 136-06'E      Time Zone; UTC+9h	bc / 4 / W-6
04:00	Finished MNBES swath mapping survey	
10:30	Suspended <i>Shinkai 6500</i> research dive due to rough sea	
13:31	Started MNBES swath mapping survey	
19:00-20:00	Science Meeting in No.1 Laboratory	
27-Jun-01	Noon Position; 33-00'N, 136-06'E      Time Zone; UTC+9h	bc / 5 / WSW-7
07:11	Finished MNBES swath mapping survey	
10:30	Suspended <i>Shinkai 6500</i> research dive due to rough sea	
11:24	Started MNBES swath mapping survey	
14:00-15:00	Science Meeting in No.1 Laboratory	
28-Jun-01	Noon Position; 33-02'N, 136-05'E      Time Zone; UTC+9h	bc / 4 / W-6
07:10	Finished MNBES swath mapping survey	
09:38	Swimmers standing by (Able seaman, 3E, intern)	
10:14	<i>Shinkai 6500</i> opened vent, start test Dive#889	

11:46	<i>Shinkai 6500</i> on bottom (33-1.8961'N, 136-4.7172'E, D=3,443m)	
15:54	<i>Shinkai 6500</i> leave bottom (33-1.3536'N, 136-4.9429'E, D=3,370m)	
16:43	Swimmers standing by (Able seaman, Assistant Oiler)	
17:06	<i>Shinkai 6500</i> on surface	
19:00-20:00	Science Meeting in No.1 Laboratory	
18:34	Started to MNBES swath mapping survey	
29-Jun-01	Noon Position; 33-01'N, 136-05'E      Time Zone; UTC+9h	bc / 4 / WSW-6
07:12	Finished MNBES swath mapping survey	
09:18	Swimmers standing by (Sailor, 3E)	
09:45	<i>Shinkai 6500</i> opened vent, start test Dive#890	
11:28	<i>Shinkai 6500</i> on bottom (33-01.3792'N, 136-04.7909'E, D=3,498m)	
15:52	<i>Shinkai 6500</i> leave bottom (33-0.8793'N, 136-5.2482'E, D=3,292m)	
16:38	Swimmers standing by (Able seaman, Assistant Oiler)	
17:00	<i>Shinkai 6500</i> on surface	
19:30-20:30	Science Meeting in No.1 Laboratory	
19:73	Started to MNBES swath mapping survey	
30-Jun-01	Noon Position; 33-01'N, 136-05'E      Time Zone; UTC+9h	bc / 4 / WSW-6
07:05	Finished MNBES swath mapping survey	
09:16	Swimmers standing by (Sailor, 3E, intern)	
09:56	<i>Shinkai 6500</i> opened vent, start test Dive#891	
11:27	<i>Shinkai 6500</i> on bottom (33-02.6536'N, 136-5.0889'E, D=3,392m)	
15:51	<i>Shinkai 6500</i> leave bottom (33-01.7277'N, 136-05.3462'E, D=3,083m)	
16:37	Swimmers standing by (Able seaman, Assistant Oiler)	
17:02	<i>Shinkai 6500</i> on surface	
19:30-20:30	Science Meeting in No.1 Laboratory	
19:27	Started to MNBES swath mapping survey	
1-Jul-01	Noon Position; 33-02'N, 136-02'E      Time Zone;	o / 5 / NE-6

	UTC+9h	
04:00	Finished MNBES swath mapping survey	
10:06	Swimmers standing by (Able seaman, intern) Put a stop due to foul weather	
10:45	Suspended <i>Shinkai 6500</i> research dive due to rough sea	
2-Jul-01	Noon Position; 33-51'N, 137-37'E      Time Zone; UTC+9h	r / 4 / E-5
07:00	Arrived at Dive point (#892)	
09:15	Swimmers standing by (3O, 3E, intern)	
09:59	<i>Shinkai 6500</i> opened vent, start test Dive#892	
11:01	<i>Shinkai 6500</i> on bottom (35-50.8558'N, 137-33.5739'E, D=2,203m)	
16:15	<i>Shinkai 6500</i> leave bottom (33-50.2103'N, 137-33.7001'E, D=2,048m)	
16:37	Swimmers standing by (Able seaman, Assistant Oiler)	
17:01	<i>Shinkai 6500</i> on surface	
19:00-20:00	Science Meeting in No.1 Laboratory	
18:36	Started to MNBES swath mapping survey	
3-Jul-01	Noon Position; 33-35'N, 137-32'E      Time Zone; UTC+9h	0 / 5 / WSW-6
07:09	Finished MNBES swath mapping survey	
10:30	Suspended <i>Shinkai 6500</i> research dive due to rough sea	
12:48	Started MNBES swath mapping survey	
14:00-15:00	Science Meeting in No.1 Laboratory	
4-Jul-01	Noon Position; 33-46'N, 137-32'E      Time Zone; UTC+9h	r / 2 / WNW-1
07:42	Finished MNBES swath mapping survey	
09:30	Swimmers standing by (Able seaman, Assistant Oiler)	
10:11	<i>Shinkai 6500</i> opened vent, start test Dive#893	
11:25	<i>Shinkai 6500</i> on bottom (33-46.2296'N, 137-31.5917'E, D=2,652m)	
15:51	<i>Shinkai 6500</i> leave bottom (33-47.3102'N, 137-31.3140'E, D=2,326m)	
16:10	Swimmers standing by (Able seaman, Assistant Oiler)	
17:01	<i>Shinkai 6500</i> on surface	

19:30-20:30	Science Meeting in No.1 Laboratory	
19:28	Started to MNBES swath mapping survey	
5-Jul-01	Noon Position; 33-43'N, 137-30'E      Time Zone; UTC+9h	r / 3 / SW-3
07:05	Finished MNBES swath mapping survey	
11:20	Suspended <i>Shinkai 6500</i> research dive due to rough sea	
13:22	Started MNBES swath mapping survey	
18:00-19:00	Science Meeting in No.1 Laboratory	
6-Jul-01	Noon Position; 33-35'N, 137-25'E      Time Zone; UTC+9h	bc / 2 / SSW-2
07:07	Finished MNBES swath mapping survey	
09:16	Swimmers standing by (Able seaman, Assistant Oiler)	
09:54	<i>Shinkai 6500</i> opened vent, start test Dive#894	
11:29	<i>Shinkai 6500</i> on bottom (33-34.6034'N, 137-25.1740'E, D=3,433m)	
15:57	<i>Shinkai 6500</i> leave bottom (33-35.3457'N, 137-24.5470'E, D=2,839m)	
16:36	Swimmers standing by (Able seaman, Assistant Oiler)	
17:01	<i>Shinkai 6500</i> on surface	
18:00	Transit to the JAMSTEC	
21:00-22:00	Science Meeting in No.1 Laboratory	
7-Jul-01	Noon Position; JAMSTEC      Time Zone; UTC+9h	
07:00	Arrived at the JAMSTEC	
09:30	Scinetist get off R/V "YOKOSUKA"	

Weather ; b (Blue sky), bc (Fine but Cloudy), c (Cloudy), o (Overcast), r (Rain)  
Sea State ; 1 (Rippled Calm), 2 (Smooth), 3 (Slight), 4 (Moderate), 5 (Rough)  
Wind Force 0 (Calm), 1 (Light air), 2 (Light breeze), 3 (Gentle breeze; 3.4-5.4m/sec), 4 (Moderate breeze; 5.5-7.9m/sec), 5 (Fresh breeze; 8.0-10.7m/sec), 6 (Strong breeze; 10.8-13.8 m/sec), 7 (Near gale; 13.9-17.1 m/sec)

## 7. Dive report

We dived ten times during the cruise. The dive number and area (Area A, Shionomisaki canyon; Area B, Tenryu canyon) are listed below. See also the dive site maps in Figs. 16-18.

### 7.1 Dive list

Dive#	Observer	Site
Dive 885	Kawamura, K.	B-4
Dive 886	Yokoyama, S.	B-9
Dive 887	Dilek, Y.	B-3
Dive 888	Kawakami, S.	B-1
Dive 889	Anma, R.	A-9
Dive 890	Moore, G.	A-9
Dive 891	Ogawa, Y.	A-9
Dive 892	Kawamura, K.	B-6
Dive 893	Anma, R.	B-5
Dive 894	Ogawa, Y.	B-1



## Dive #885 report

Kiichiro Kawamura (Fukada Geological Institute)

Date: June 23, 2005

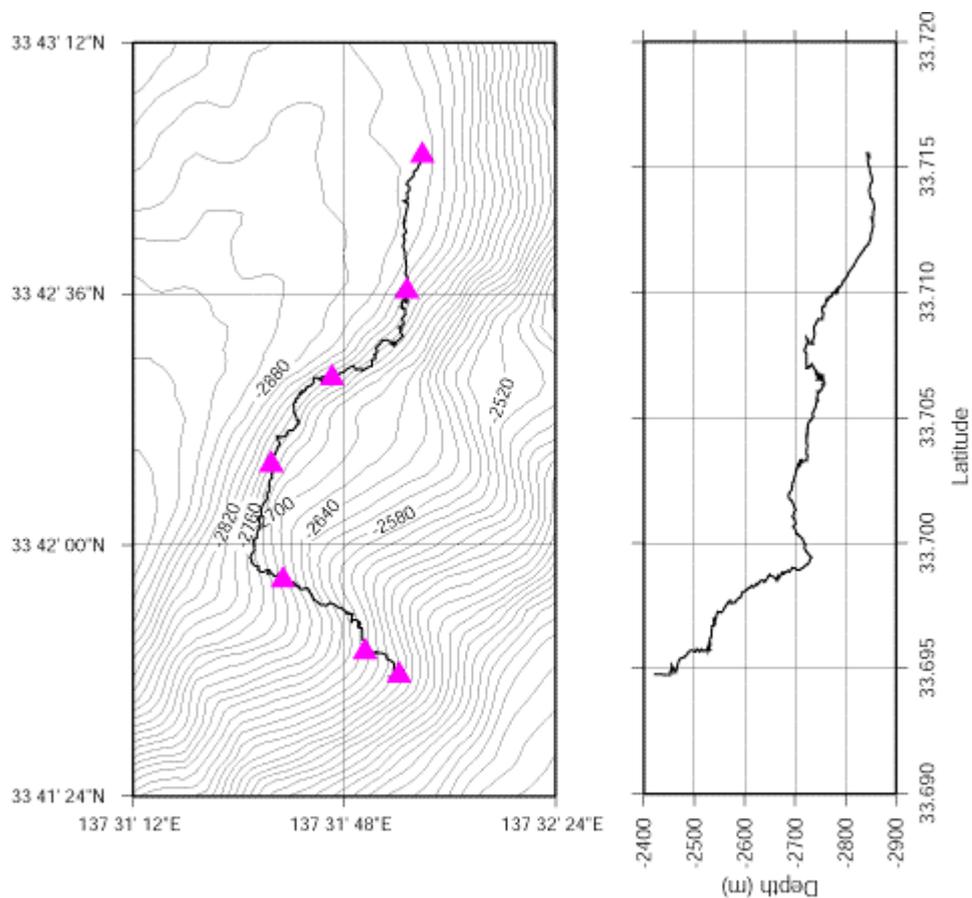
Site Name: Eastward wall of Tenryu Canyon (B-4 area)

Landing: 33° 42.9305' N, 137° 32.0221' E, 2842 m

Leaving: 33° 41.6884' N, 137° 31.9565' E, 2448 m

Observer: Kiichiro Kawamura (Fukada Geological Institute)

Pilot: Yanagitani, M., Co-Pilot: Matsumoto, K.



GMT 2005 Jun 29 21:34:45 Data=JYK0508grd\_data/tenryu\_50m\_C5.grd,Grd\_int=50m/50m,Scale=1:30000,Cont\_int=20m,Anot\_int=60f8

### Objectives:

The objectives of this dive are to observe strata distribution, structures, deformation styles, hydrogeological features along the Tenryu Canyon. To sample rocks and sediments; the MBARI and push core samples for metal

and fluid chemistry at cold seep sites. Also to sample chemosynthetic clams and/or tube worms for geochemical and/or biological research. Gamma Ray Monitoring System (GRAMS) at cold seep sites.

Keywords:

Accretionary prism, cold seep, fractures, imbricate thrust, fault, fold.

Payloads:

Ordinary type core sampler (short) x2

MBARI core sampler (long) x2

Push cores x2

Sample basket x2 (one black box, two green cloth bags inside)

Net scoop

Location of Events:

Time Position Depth Event

Landing: 33° 42.9305' N, 137° 32.0221' E, 2842 m

Leaving: 33° 41.6884' N, 137° 31.9565' E, 2448 m

Video Digest:

11:15, 2842 m, reach bottom, seabed mud, 1.6 C degrees, current to 30 with 6 cm/sec, visibility 5 m (33-42.9305N,137-32.0221E).

11:15-11:34, 2850 m, seabed mud

11:34-11:42, 2840 m, seabed debris and gully

11:42-12:00, 2800 m, base of the canyon wall, debris

12:03, 2778 m, R-001 sampling

12:10-, gentle dipping turbidite layers (see sketch map)

13:01, 2742 m, R-002 sampling

14:02, 2707 m, R-003 sampling

14:53, 2660 m, R-004 sampling

15:46, 2525 m, C-001, -002 sampling

16:01, 2448 m, Left bottom (33-41.6884N,137-31.9565E).

List of samples:

R-001; 12:03, 2778 m (33-42.6059N,137-31.9790E)

R-002; 13:01, 2742 m (33-42.3985N,137-31.7658E)

R-003; 14:02, 2707 m (33-42.1904N,137-31.5932E)

R-004; 14:53, 2660 m (33-41.9163N,137-31.6277E)

C-001, -002; 15:46 2525 m (33-41.7443N,137-31.8594E)

Future studies

Dive 6K#885 may provide various types of studies. Rock samples are interesting from view point of structural geology. Turbidite of younging direction may give the structural information of direction. If the samples are oriented by magnetic direction, the fabrics of cleavage, fractures, joints must give us the deformation history. Even soft, all the mudstones samples are foliated, some weak, some strong. They may show several stages of deformation. Thin section and SEM analysis will be done by Tsukuba people, R. Anma, T. Ota, R. Endo and Y. Ogawa in addition to K. Kawamura and Yildirim Dilek. Sedimentation age by various fossils, particularly radiolarian by S. Kawakami is an important. Sediments from the corers are used for isotope and metal concentration study by K. Hayashi. Pore fluid squeezed is analyzed by T. Tōki. Hopefully all the structural geologists may make several papers from each site of the Tenryu Canyon area, and may integrate into an interesting fashion.

(The End)

## Dive 886 Report

Shunji Yokoyama (Kochi Univ.)

**Date:** June, 24, 2005

**Site Name:** Westward slope of the Tenryu Canyon

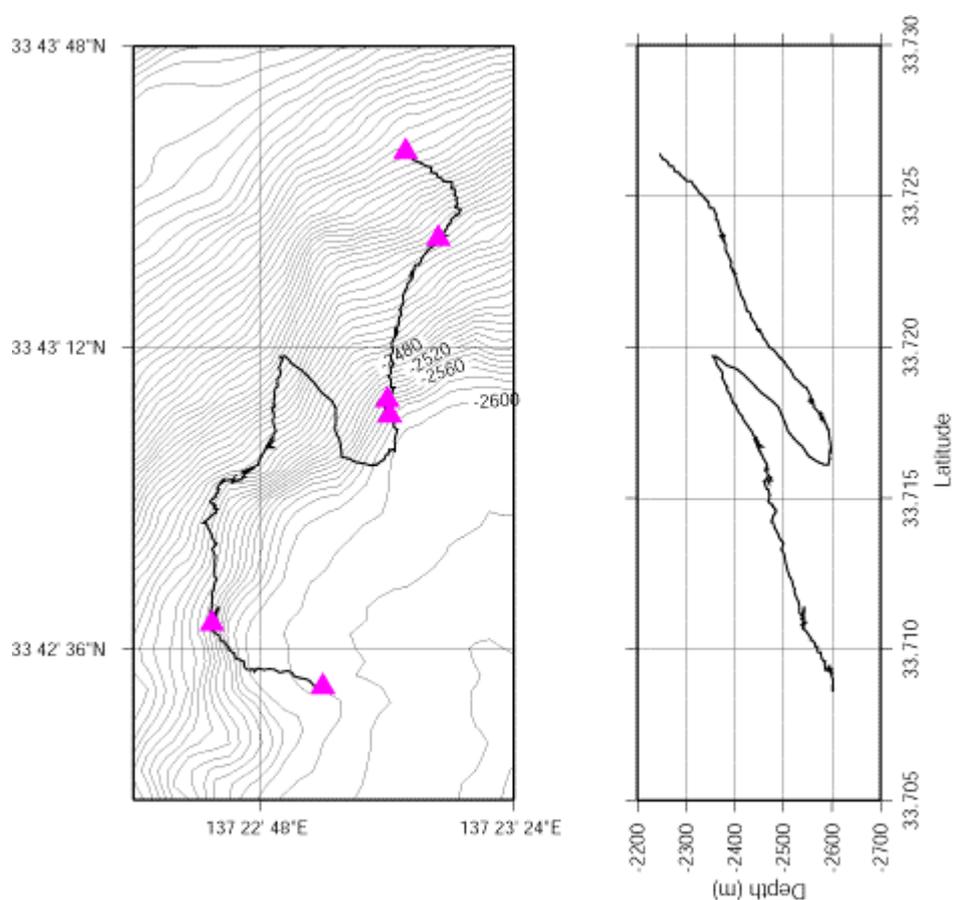
**Land:** 11:14 (33 ° 42.5249 N 137 ° 22.9486 E) Depth=2591m

**Left Bottom:** 16:00 (33 ° 43.5896 N 137 ° 23.1446 E) Depth=2234m

**Observer:** Shunji Yokoyama (Kochi Univ.)

**Pilot :** Itaru Kawama

**Co-pilot:** Hirobumi Ueki



GMT 2005 Jun 29 18:52:12 Data=.:YK0506grd\_data\tenryu\_50m\_C5.grd,Grid\_int=50m/50m,Scale=1:25000,Co\_int=20m,Anot\_int=40ft

### Keywords

Landslide landform, Out-Of-Sequence Thrust (OOST)

### Payloads

Same as a previous 6k 885 dive

## Location and Events

<i>Time</i>	<i>Position</i>	<i>Depth</i>
11:14	33 ° 42.5249 N 137 ° 22.9486 E	2591 m
	<i>Event: Landing</i>	
12:05	33 ° 42.6511 N 137 ° 22.6863 E	2531 m
	<i>Event: Sampling MBARI (black, C-001), push core (blue, C-002)</i>	
14:17	33 ° 43.0652 N 137 ° 22.1066 E	2584 m
	<i>Event: Sampling fallen boulder of mudstone (R-001)</i>	
14:36	33 ° 43.0958 N 137 ° 22.1014 E	2566 m
	<i>Event: Sampling mudstone (R-002)</i>	
15:28	33 ° 42.4168 N 137 ° 22.2218 E	2531 m
	<i>Event: Sampling MBARI (yellow, C-003), push core (red, C-004)</i>	
16:00	33 ° 43.5896 N 137 ° 23.1446 E	2234 m
	<i>Event: Left Bottom</i>	

## Objectives

The route that dive 886 surveyed is located at a large landslide on the westward slope of the Tenryu Canyon. Thrust related to OOST (Out-of-sequence thrust) may run through the landslide.

First, the objective of the Shinkai dive is description of topographical and geological characteristics of the large landslide and debris flows and mud flows occurring on the landslide landform. Second, the important objective is to find the outcrop of the thrust and collect rock samples.

## Dive summery

Dive 886 route map is shown in Fig. 1. We landed on the northwest-most bottom of abandoned consequent valley where seawater depth is 2591 m. The bottom is covered by unconsolidated soupy mud. We went up obliquely in the landslide landform until about 2360m in depth. The mean angle of the slope ranges from about 19 °, but the slope near the foot of landside is more steep and sometimes about 30 °. The landslide landform suggests that the slide block may fall away from the source area and the surveyed slope may be a slip surface. The route is almost covered by grayish clay of less than 1 m thick, but the soupy mud covered the clay at the lower angled slope. At the landing point of 2531m deep, the sampling of MBARI (black, C-001) and push core (blue, C-002) were conducted. During going-up, we

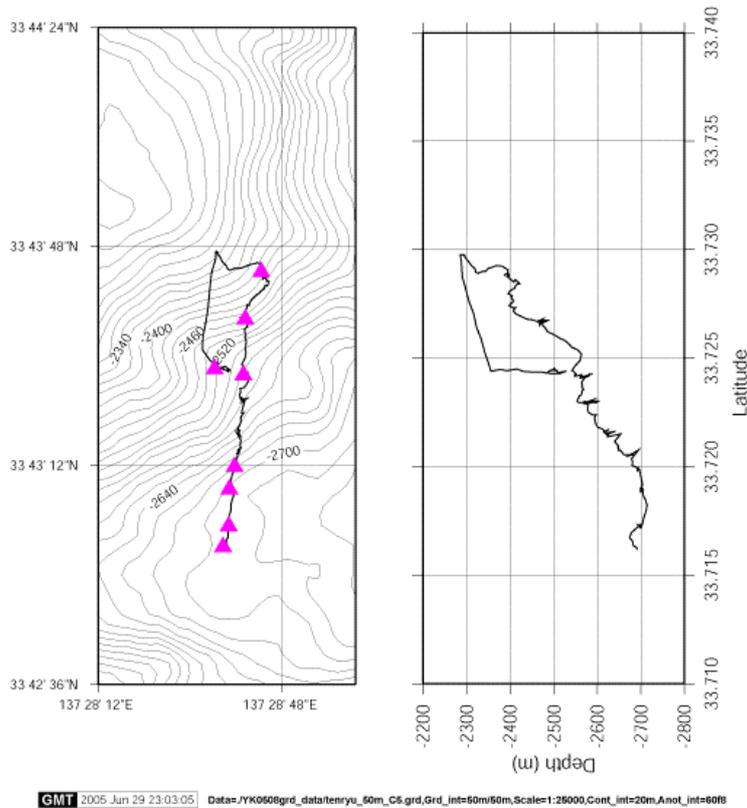
found many gutters with 50cm wide which mudflows had run off. In the floor of the gutters numerous scratches cut parallel to the elongation. We found rockslide landforms of about 2-3m wide controlled by bedding plane and vertical joints of mudstone. The bed trends northeast to east-northeast and dips about 20 ° southeastward.

From the point of 2360m deep, we came down to the bottom of 2591m deep and again went up until 2238 m deep. At the bottom we found current ripples and dunes of linguoid type which indicate that current direction is toward NW 30-40 ° . At the landing point of 2584m deep near the foot, the rock-sampling (R-001) from fallen boulders of mudstone were conducted. The mudstone is very soft with uniaxial compression strength less than 1KN/m<sup>2</sup> by a needle penetration test. The depositional age indicates the Late to Middle Pleistocene by a radiolarian biostratigraphy. The rock samples(R-002) collected from outcrop of 2566m deep are composed of soft massive mudstone with uniaxial compression strength less than 1KN/m<sup>2</sup>. The depositional age of the mudstone indicates the Middle Pleistocene by a radiolarian biostratigraphy. The route is almost covered by soupy mud and grayish clay. At the landing point of 2379m deep, the sampling of MBARI (black, C-003) and push core (blue, C004) were conducted. Because of the absence of well-exposures, we could not find outcrop of fault, and as reaching the limit of time, we left bottom at the point of 2234m deep.

Report of dive #887

Yildirim Dilek (Miami Uni., OH)

Day: 25 June 2005  
Launching time: 9:50 am  
Vent open: 10:02 am  
Landing time: 11:18 am  
Landing depth: 2688 m, 33 42.9792, 137 28.6068  
Landing mud T °C: 1.6  
Visibility: 7  
Current direction: 107  
Current velocity: 10 cm/sec  
Origin: Lat 33° 43.3000'N; Lon 137° 29.0000'E  
Left bottom: 16:12 Hours; 33° 43.4645'N and 137° 28.5796'E  
Reached surface: 17:12 Hours  
Samples collected: Six (6) rock samples, two (2) push-core samples (blue and red); one (1) MBARI core sample (black)  
Dive scientist: Yildirim Dilek, Miami University, U.S.A.  
Pilot: Kazuki Iijima  
Co-Pilot: Yousuke Chida



## DIVE OBJECTIVES

To verify rock and sediment types, geological structures, and tectonic features at the lower stream of the Tenryu submarine canyon (West Wall).

## DIVE SUMMARY

Dive #887 took place along a N-S path starting from the bottom (~ -2700 m) of an E-W-trending, narrow valley opening in the east to the Tenryu Canyon. Shinkai landed at about -2700 m depth in the bottom mud and then moved to the North just below -2700 m depth. At 11:32 am and in location [-491; -572] we spotted an isolated exposure of deformed, black-gray mudstone, covered by soft, unconsolidated mud. The outcrop has a gently south-dipping surface, which also marks a bedding plane and a bedding-parallel cleavage. This rock has visible small-scale tight folds deforming both the bedding plane and the bedding – parallel cleavage. Rock samples were taken from this outcrop (RS#1). The sudden drop in the seabottom topography immediately North of this mudstone outcrop is likely to be a result of a fault zone dipping North beneath relatively undeformed looking turbiditic rocks.

Moving further North near the northern end of the E-W-trending side canyon, we saw mudstone – siltstone intercalation with gently N-dipping (~25°) beds that locally display vertical to oblique burrow holes. These beds are ~5 to 10-cm in thickness and are cut by bedding – perpendicular, nearly mutually orthogonal joint systems. There is also a hint of the existing of a fracture cleavage, cutting across the bedding planes at an oblique angle. We sampled these rocks at ~ -2701 m (-187; -553). We took RS#2 and a push core sample at this spot.

Climbing up on the southern slope, we saw the same mudstone – siltstone rocks gently folded along NW – SE – trending and gently SE – plunging fold axes. Again, two mutually perpendicular joint systems are common in these rocks, crosscutting the bedding planes at high to oblique angles. Rock samples (RS#3) were taken at -2693 m (197; -550) around 12:37 pm.

Continuing climbing North on this slope, we went through several, sub-parallel narrow ridges and troughs that are likely controlled by N-dipping faults. One of these faults was observed at ~ -2560 m, crosscutting turbiditic rocks and downdropping a thick sandstone unit that contains boudinaged and deformed white volcanic ash (?) layer. Based on observed kinematic indicators and the existence of a series of rolling anticline-syncline structures in the hanging wall, I interpreted this fault as a steeply North-dipping normal fault. The rocks in the hanging wall of this fault are made mainly of coarse-grained sandstone.

Further up on the slope same turbiditic rocks continue all the way up to ~ -2350 meters, with local switchovers in dip directions, interpreted to be a manifestation of gentle to open folding along SE – plunging fold axes. Rock samples RS#4, 5, and 6 were taken from these turbiditic rocks in ~100 meter intervals near the -2600 m, -2500 m, and -2400 m contours.

The steeply South-dipping slope between -2400 m and -2300 m at depth is covered by soft mud and silt with no rock exposures. Therefore, instead of climbing further up, we decided to drop down from -2291 m to -2514 m depth along a path that was subparallel to our ascent line in order to encounter different outcrops. However, because of the time constraints we had to stop our exploration; we took one MBARI and one additional push core (PC#2) sample at -2489 m and then prepared to return to the surface at 16:12 Hours (307; -659).

#### DIVE EVENTS:

9:50	Launched
10:02	Vent open; submerged
11:18	Landing
11:27	First outcrop (X: -491, Y: -572, 2697 m)
11:32	Sampling rocks
11:41	Finish sampling rocks (RS# 1)
11:53	Outcrop and cliff; observations (X: -307, Y: -575, 2702 m)
11:56	Sampling
12:01	Finish sampling five (5) rock blocks (RS# 2)
12:10	Taking push-core sample (PC# 1 – Blue)
12:26	Outcrop; observations (X: -200, Y: -538, 2694 m)
12:22	Sampling rocks (RS# 3)
12:36	Finish sampling four (4) rock blocks
12:48	Outcrop observations (X: -134, Y: -535, 2663 m)
13:01	Outcrop observations (X: -16, Y: -532, 2628 m)
13:15	Outcrop observations (X: -9, Y: -526, 2610 m)
13:30	Outcrop observations (X: 146, Y: -514, 2579 m)
13:50	Rock sampling, RS# 4 (X: 265, Y: -485, 2556 m)
14:04	Finish sampling two (2) rock blocks (X: 285, Y: -509, 2558 m)
14:36	Finish sampling two (2) rock blocks, RS# 5 (X: 554, Y: -498, 2467 m)
14:44	Sampling one block (X: 618, Y: -478, 2414 m)
15:04	Rock sampling, RS# 6 (X: 788, Y: -411, 2396 m)
15:12	Finish sampling two (2) rock blocks
15:42	Moving Co. = 190
16:09	Sampling MBARI (black) and one push core (red) samples (X: 306, Y: -660, 2489 m)
16:12	Left bottom for the surface.

#### ROCK SAMPLE DESCRIPTION

RS# 1: Sample-A: Grayish-black siltstone – mudstone; tightly folded with fold axes forming a distinctive lineation; mini folds also forming a crenulation cleavage (this rock was in the footwall of a S-vergent thrust fault).

Sample-B: Yellowish glassy tuffaceous mudstone – olive gray sandstone intercalation.

RS# 2: Olive-gray mudstone with laminated sandstone intercalations (Mn – coated surface both on the outcrop and hand samples).

RS# 3: Olive-gray mudstone – fine-grained sandstone intercalation (with primary sedimentary structures (i.e., flame structures, load cast, etc.).

RS# 4: Blue-gray fine- to medium-grained rounded sandstone.

RS# 5: Olive gray coloured, fine- to medium-grained sandstone with an incipient cleavage.

RS# 6: Light-olive brown coloured, mudstone – sandstone intercalation; finely laminated rock with a well-developed fracture cleavage.

RS#1 33 43.0342, 137 28.6088, 2696 m

RS#2 33 43.1352, 137 28.6275, 2700 m

RS#3 33 43.1965, 137 28.6444, 2690 m

RS#4 33 43.4479, 137 28.6737, 2560 m

RS#5 33 43.6008, 137 28.6793, 2454 m

RS#6 33 43.7306, 137 28.7315, 2394 m

## Dive #888 Report

KAWAKAMI, Shunsuke (AIST, GSJ)

**Date:** June 26, 2005

**Site Name:** Western mouth of the Tenryu Canyon

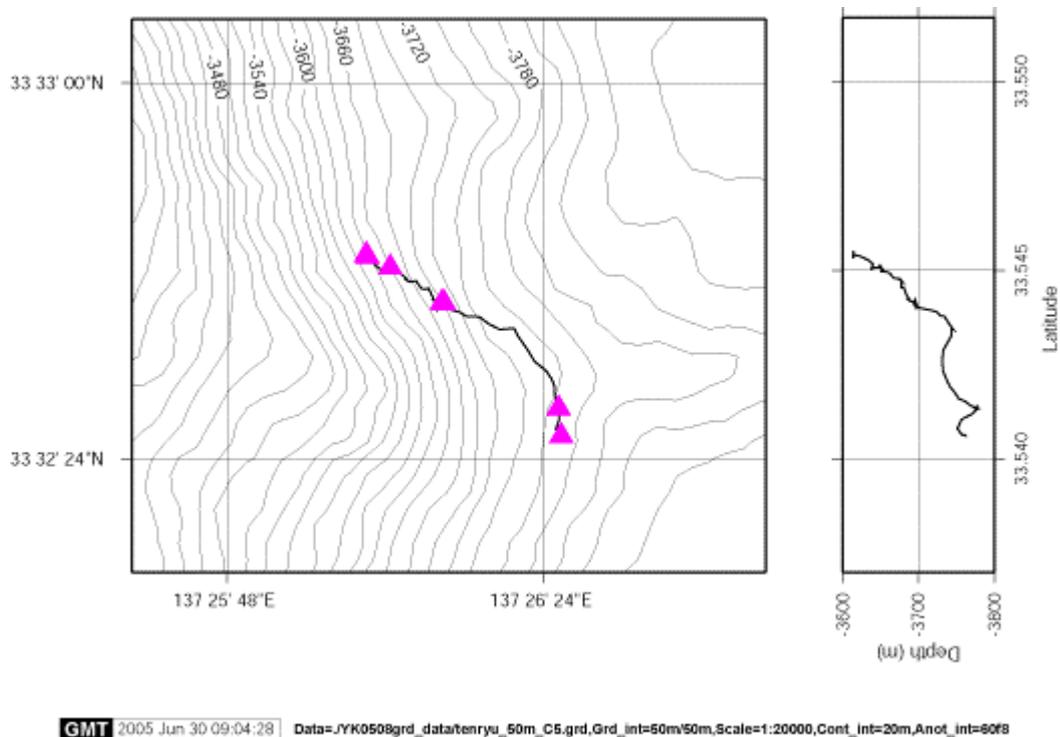
**Landing:** 11:43, (33 ° 32.4370 N, 137 ° 26.4323 E), Depth=3757m

**Left bottom:** 13:46, (33 ° 32.7262 N, 137 ° 26.0636 E), Depth=3611m

**Observer:** Shunsuke Kawakami (GSJ, AIST)

**Pilot:** Yoshio Ohno

**Co-Pilot:** Keita Matsumoto



### Objective and Summary:

This dive site was located in the westward extended area of previous dive 6K#755, and this site was a maiden land of a submersible survey. The objective of this 6K#888 dive was to clarify the stratigraphy of the western mouth of the Tenryu submarine canyon.

The dive #888 was started from a bottom of the slope in the western mouth of the Tenryu canyon, and went up the slope to north-west direction.

In the morning of the day of the dive, it was windy and there was some strong swell. The weather condition was becoming too hard to go on a survey, and so, we gave up the survey on a half way.

We observed the clump of clams that was as close as a colony of a living Calyptogena in the early stage of our investigation (Digest: 00:12, Stop 1). We tried to collect samples, but it was too slack to operate. Some fragments of a Calyptogena clams, which were pierced and dissolved, were scattered as debris flow deposits on the muddy bottom of the lower slope (Digest: 00:45, Stop 2). These clams may imply existence of colonies on the upper part of the slope. The middle part of the surveyed slope, there were almost horizontal coherent turbidite beds, and no clams (Digest: 01:08, Stop 3). We collected the four rock samples for a chronostratigraphy so far as time permits, and left the bottom.

**Keywords:**

Chronostratigraphy, Calyptogena colony, western mouth of Tenryu submarine canyon

**Payloads:**

Same as a previous 6K#887 dive.

**Location and Events:**

Time	Position	Depth	Event
11:43	33 ° 32.4370 N 137 ° 26.4323 E	3757 m	Landing
12:01	33 ° 32.4813 N, 137 ° 26.4276 E	3771 m	Calyptogena colony?
12:43	33 ° 32.6491 N, 137 ° 26.2109 E	3691 m	Sampling rock (R-001: outcrop)
12:49	33 ° 32.6498 N, 137 ° 26.2066 E	3690 m	Sampling rock (R-002: float)
13:20	33 ° 32.7057 N, 137 ° 26.1088 E	3649 m	Sampling rock (R-003: outcrop)
13:43	33 ° 32.7234 N, 137 ° 26.0636 E	3610 m	Sampling rock (R-004: float)
13:46	33 ° 32.7262 N, 137 ° 26.0636 E	3611 m	Left bottm

**Video Digest:**

11:53 (00:12), 3771m, CAM2, Stop 1,

Observed the clump of Calyptogena clams that looked like a living colony.

13:05 (00:45), 3674m, CAM2, Stop 2,

Observed the recent debris flow deposits. Dissolved and pirced Calyptogena clams were scattered on the muddy bottom.

13:15 (01:08), 3648m, CAM2, Stop 3,

Observed the almost horizontal turbidite beds, this series of rocks were collected as the sample R-003 and R-004.

13:17 (01:44), 3649m, CAM2, R-003 sampling.

## Dive 6K#889 report

Ryo Anma (University of Tsukuba)

Date: June 27, 2005

Site Name: OOST in Shiono-misaki Submarine Canyon (A-9 site)

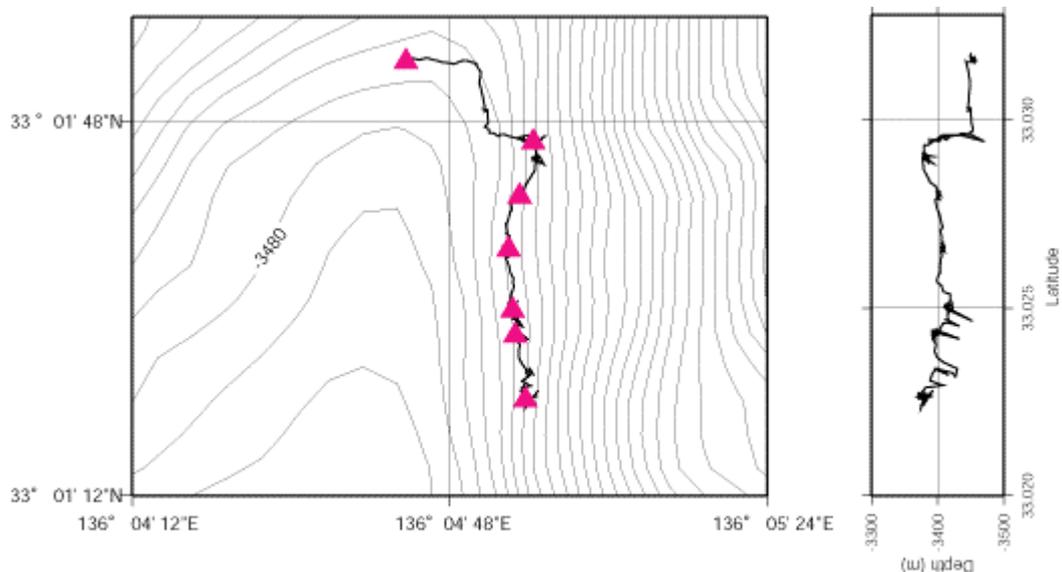
Landing point: 33° 01.90' N, 136° 04.72' E Depth: 3,443 m

Left bottom: 33° 01.35' N, 136° 04.94' E Depth: 3,370 m

Observer: Ryo Anma (University of Tsukuba)

Pilot: Masanobu Yanagitani (JAMSTEC)

Co-pilot: Hirofumi Ueki (JAMSTEC)

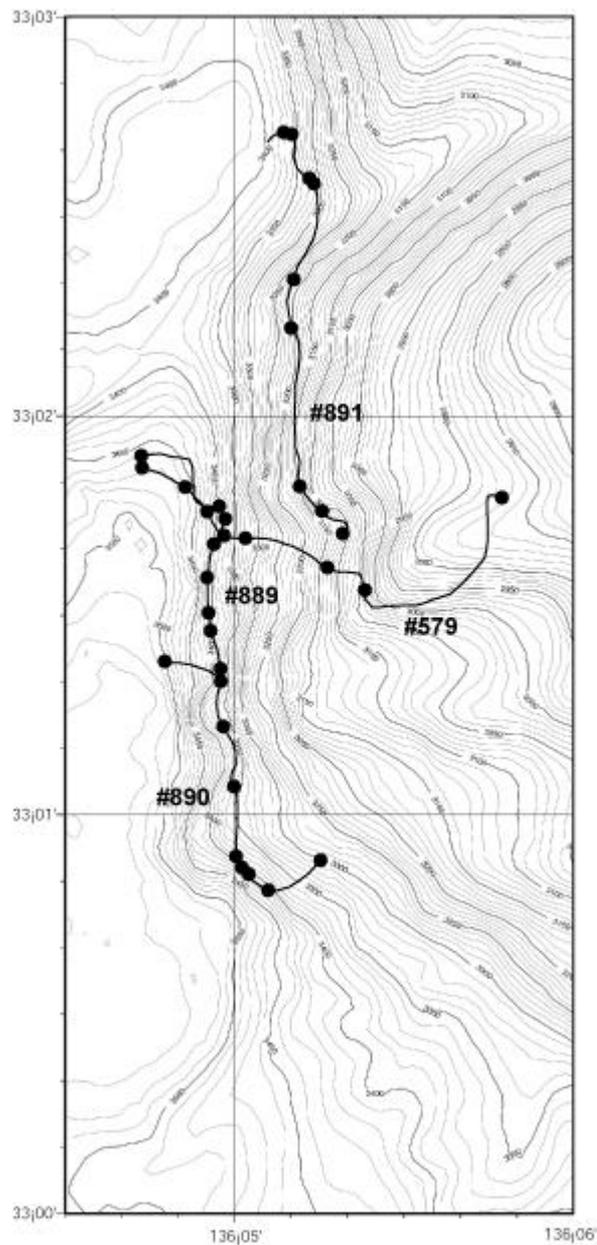


GMT 2005 Jun 30 10:18:49 Data:./YK0508grd\_data/previous\_cruises\_data\_100m.grd,Grd\_int=60m/50m,Scale=1:20000,Cont\_int=20m,Ano\_int=60f8

### Objectives:

This dive, together with the following two dives #890 and #891 nearby, aims to reveal deformation structures, especially those related to the out-of-sequence thrust (OOST), developed in the Nankai accretionary prism exposed along the eastern slope of the Shiono-misaki submarine canyon, and to sample rock/sediment specimens systematically across the OOST for quantitative arguments based on laboratory studies (density, porosity, AMS, NRM, rock strength measurements and etc.). The dive site was once covered by 6K#579 dive in September 25, 2000 and presence of an active thrust

system were suggested based on distribution of *Calyptogena* colonies (Anma et al., 2002). This cold seepage zone is supposedly a continuation of those observed in the southward slope of the Omine ridge (YK03-03 cruise report) in the east of the dive sites #899-#891.



**Dive #579, #889 ~ #891**

#### Dive Summary:

The dive 6K#889 sets the course to the east from the landing point and then to south from the first main outcrop in the eastern slope to intersect the dive track of 6K#579. An outcrop was exposed even in the central axis of the submarine canyon at the landing point, implying the active displacement of the canyon bottom. The first main outcrop was observed at 3,400 m bsl on the eastern slope of the canyon. Outcrops were nicely exposed in this level and we succeeded with systematic sampling. In the north, bedding planes dip gently to north. Dip direction swing to NW and then to SW as we proceeded southward. Southward dipping strata of thick turbidite sequence were mainly developed in the middle part of the dive track. Keeping the depth around 3,400 m bsl, we crossed several EW trending gulleys that most likely mark the locations of spray faults of supposedly out-of-sequence thrust (OOST) that continues from the Omine ridge in the east. *Calyptogena* and dead shells of tube worm were commonly observed on the bottom of the EW trending gulleys suggesting activities of cold seepage. In further south, the orientations of the bedding plane change to northward dipping and then change back to southward dipping. Rock samples were collected from 6 localities and two of them were oriented and had enough quantity for laboratory testing. Among them, R-007 sample exhibit the web structures. A sample of *Calyptogena nautiliei* was collected. Core samples were obtained nearby *Calyptogena* colonies.

#### Keywords:

OOST (Out-of-sequence thrust), cold seepage, *Calyptogena*

#### Payloads:

MBARI core sampler x2

Push cores x2

Sample Box x2

#### Location of Events:

Time	Position	Depth	Event
11:46	33° 01.8961'N 136° 04.7172'E	3443m	Landing
11:46	33° 01.8961'N 136° 04.7172'E	3443m	Sample #R-001

12:39	33° 01.7666'N	136° 04.9579'E	3379m	Sample #R-002
13:14	33° 01.6801'N	136° 04.9322'E	3394m	Sample #R-003
13:51	33° 01.5946'N	136° 04.9122'E	3400m	Core #C-001 (MBARI;black) Core #C-002 (push; red) Sample #B-001 ( <i>Calyptogena</i> )
14:44	33° 01.4976'N	136° 04.9189'E	3407m	Sample #R-004 Sample #B-002 (Tube worm)
15:16	33° 01.4568'N	136° 04.9236'E	3387m	Sample #R-006
15:54	33° 01.3536'N	136° 04.9429'E	3370m	Sample #R-007
15:54	33° 01.3536'N	136° 04.9429'E	3370m	Left Bottom

Video Digests:

11:44 Central axis of the Shiono-misaki submarine canyon at the landing point. Ridge-shaped outcrops were distributed in SSW-NNE direction in muddy bottom. They dip gently (~ 10°) to NW. R-001 was sampled. Trashes were commonly seen along the bottom of the canyon.

12:02 Heading 90. Trails of *Calyptogena* (or sea cucumber) were commonly seen from this point.

12:04 Debris covered by thin layer of marine snow were observed.

12:33 The first of main outcrops that exposed along ~3,400 m bsl. Fractures were developed in various orientations. R-002 were collected.

12:41 Northward dipping (~40°) structures were observed.

12:42 They swing to NW.

12:44 *Calyptogena* colonies and debris were distributed along the bottom of EW trending gulley

13:05 *Calyptogena* colonies along the bottom of EW trending gulley.

13:06 Bedding cleavages dip moderately (~ 40°) to SW. R-003 was collected. Fracture cleavage dip moderately (~30°) to north. Turbidite.

13:15 Nicely exposed turbidite sequence dipping moderately (~40°) to south.

13:30 *Calyptogena*

13:38 Push core and MBARI core at a site just beside alive *Calyptogenas* were observed. B-001 sample (*Calyptogena*) was collected.

14:04 Thick (> 30 cm) turbidite sequence dip moderately (~50°) to south (~200°).

R-004 was collected.

14:28 Shell of tube worm. Cold seepage zone? B-002 (tube worm) was sampled.

14:34 Calyptogenia (sediment feeder?)

14:51 Calyptogenia and cold seepage zone.

14:58 SW dipping ( $\sim 30^\circ$ ) strata with oblique fractures. Thick ( $>30$  cm) turbidite sequences. Fish-like fracture cleavages (estimated to orient N70E70N) orthogonal to the bedding planes were developed in siltstone (?). R-006 was collected.

15:17 Almost vertical strata in the nearby outcrop.

15:29 Dip moderately ( $30^\circ \sim 40^\circ$ ) to NNE.

15:33 Highly deformed sequence. Dip moderately ( $\sim 45^\circ$ ) to SSW. R-007 was sampled. Oxidized zone were distributed along the surface.

#### Description of samples:

R-001: Olive-gray siltstone-very fine-grained sandstone with slicken line on fracture surfaces and spacing fabrics ( $\sim 0.5$  mm spacing).

R-002: Olive-gray fine-grained sandstone (12 x 5 x 2 cm), include fine pebbles ( $\sim 1$  cm) of siltstone.

R-003 (2 pieces): 1; Bluish gray siltstone (16 x 10 x 6 cm) with oxidized layer (yellowish gray) and thin ( $< 1$  mm) manganese coating on surfaces. Slicken-like lineation developed on the surface. 2; Bluish-gray massive siltstone (27 x 16 x 12 cm) with oxidation layer (yellowish-gray) and thin dark-brown coating on the surfaces. Thin layer of sandstone was recognized on an edge providing bedding direction. Numerous fracture fabrics (?) were developed. Bioturbation was recognized.

R-004 (3 pieces): 1; Medium-grained consolidated sandstone (9 x 6 x 6 cm) with fine pebbles of siltstone with oxidized layer (yellowish-gray). Black seams were developed. 2; Medium-grained consolidated sandstone (10 x 9 x 5 cm). 3; Fine-medium-grained sandstone (30 x 20 x 14 cm). Dark gray in color and consolidated. Altered along surface and fractures.

R-006: Dark brown fine- medium-grained massive sandstone. Moderately consolidated.

R-007 (5 pieces): Alternation of medium- fine-grained sandstone (with cross laminae) / siltstone / medium-grained dark-gray sandstone / siltstone with web structure (14 x 10 x 10 cm). 2; Consists of alternation of bluish-gray and olive-gray

siltstone and medium-grained sandstone (10 x 7 x 7 cm). Bioturbation was recognized. Orthogonal fracture set was developed, one being stopped by the other. 3; Bluish-gray very fine-grained sandstone (12 x 7 x 6 cm) with dark-brown oxidation layer. Contains mica. 4; Fine-grained sandstone (15 x 6 x 4 cm) with dark-brown oxidized layer. Mica bearing. 5; Alternation of fine-grained sandstone and siltstone (olive-gray). 11 x 8 x 7 cm in size.

C-001: MBARI (black); see appendix

C-002: push core (red); see appendix

B-001: *Calyptogena nautiliei*; see appendix

B-002: shell of tube worm; see appendix

#### Future studies

Rock samples will be used for laboratory studies at U. Tsukuba. Those include measurement of natural remanent magnetization to orientate samples, thin section observation and AMS for fabric analysis to understand rock deformation history, test for rock strength to estimate maximum burial. Radiolarian fossils will be studied by S. Kawakami to determine age of sedimentation. Sediments from the corers are used for isotope and metal concentration study by K. Hayashi. Pore fluid will be analyzed by T. Toki. *Calyptogena* (B-001) shell will be provided to Y. Fujiwara for identification and then to R. Anma for detailed study of growth pattern in relation to the activities of cold seepage. Soft tissue will be provided to Y. Fujiwara. Preliminary, the sample was identified as *Calyptogena nautiliei* by Okudera.

## Dive #890 Report

Gregory F. Moore (University of Hawaii, USA)

Date: June 30, 2005

Site Name: **OOST in Shionomisaki Canyon (A-9 area)**

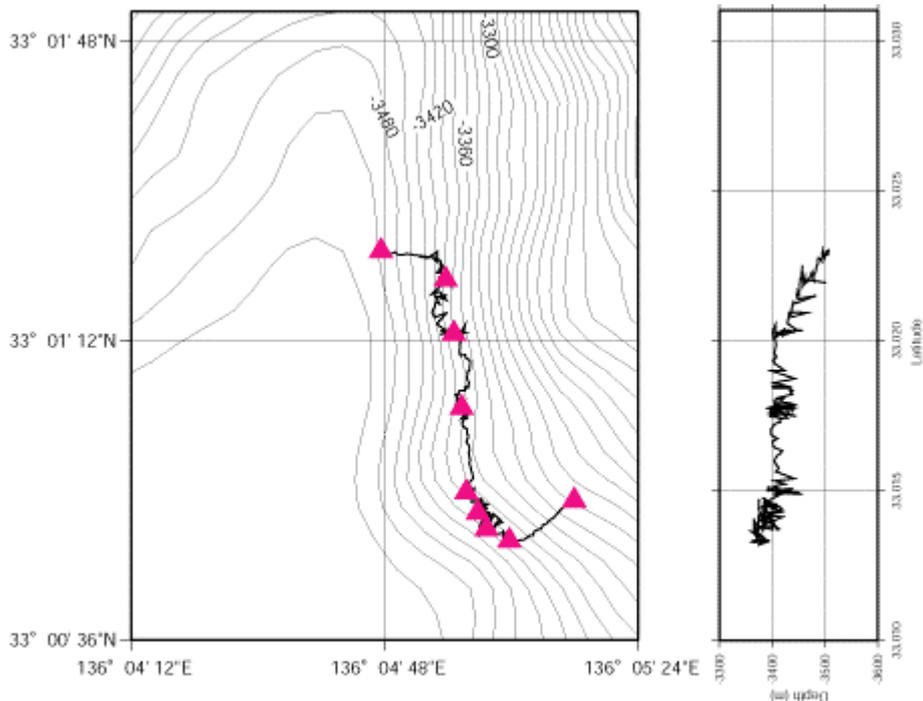
Landing: 33° 01.3728' N, 136° 04.7909' E, 11:28, 3498 m

Leaving: 33° 00.8793' N, 136° 05.2482' E, 15:52, 3292 m

Observer: Gregory F. Moore (SOEST, University of Hawaii)

Pilot: Kawama, I.

Co-Pilot: Chida,



GMT 2005 Jul 01 14:25:08 | Data=/YK0508/grd\_data/previous\_cruises\_data\_100m.grd,Grd\_int=50m/50m,Scale=1:25000,Cont\_int=20m,Anot\_int=60m

### Objectives:

The objectives of this dive were to clarify the structural geological and hydrological features related to the out-of-sequence thrust (OOST) exposed in Shionomisaki Canyon off Kii Peninsula. We collected rock samples for age dating and laboratory analyses (physical properties, chemistry, sediment provenance, etc.). We also collected samples of *Calypogena* clams for biological and geochemical analyses. This is the 3<sup>rd</sup> in a series of 4 dives (including #755, 889 and 891) carried out during YK0508.

## Dive Summary:

Dive 890 route map is shown in Fig. 890-1. This dive was on the eastern slope of the OOST zone of the Shionomisaki Canyon area. We tried to begin our study at the point where Dive #889 finished. Our traverse mostly followed a southerly course, with a few short deviations up the slope to the east.

Rock exposures are mostly continuous, with several gulleys that cut perpendicular the main slope. Exposed strata include highly fractured, relatively soft sandstone, usually grey or brown in color from the submersible, and thin bedded, white to brown, hard (well cemented) mudstone. The sandstones are similar in lithology to those collected on the other two dives in this area during the YK0508 cruise (#889, 891). Bedding of the strata is either relatively flat or dipping gently to the south or southwest, but steeper northward dips were observed, although they were relatively rare. Fractures in the sandstones mostly had high dip angles relative to bedding. Chemosynthetic clams, *Calyptogene*? were seen in two gulleys near the end of the drive track and may indicate the position of the basal OOST. This dive transect was probably just above the basal part of the splay fault zone.

We collected rock samples at four sites and biological samples at two sites. We also took two MBARI-type cores (the two ordinary push type corers were disabled when the mechanical arm hit them during a sampling operation).

**Keywords:** OOST (Out-of-sequence thrust), cold seep, *Calyptogene*

**Payloads:** MBARI core sampler x2, Push cores x2, Sample Box x2

## Location of Events:

<i>Time</i>	<i>Position</i>	<i>Depth</i>	<i>Event</i>
11:28	33° 01.3792'N 136° 4.7909'E	3498m	Landing
12:02	33° 01.3226'N 136° 4.9446'E	3396m	Sample #R001
12:35	33° 01.2140'N 136° 4.9639'E	3380m	Sample #R002
13:32	33° 01.0654'N 136° 4.9823'E	3361m	Sample #R003
14:19	33° 00.8955'N 136° 4.9930'E	3362m	Sample #R004
14:51	33° 00.8551'N 136° 5.0204'E	3409m	Sample #B001 ( <i>Calyptogene</i> ) Core #1 MBARI(red)
15:12	33° 00.8220'N 136° 5.0409'E	3421m	Sample #B002 ( <i>Calyptogene</i> ) Core #2 MBARI(yellow)
15:35	33° 00.7989'N 136° 5.0953'E	3391m	Sample #R005
15:52	33° 00.8793'N 136° 5.2482'E	3292m	Left Bottom

## **Video Digest:**

11:23.28, on the bottom can see many boulders just in front of us; probably the surface of a debris flow.

11:26.05, heading 114, depth 3498, just off the bottom. We now have the automatic still camera set to fire every one min. Appears to be almost no current at this point; all of the clay and silt in suspension is just hanging.

11:30, heading off directly east up the slope to hit the point where the previous the left off.

11:33, heading up slope; still looks like the surface of an old debris flow.

11:34.15, still many fragments covering the seafloor; lots of little small white fragments that look like they could be some kind of carbonate or shells.

11:38.09, climbing fairly steeply up; still looks like mostly talus at the bottom of the slope.

11:40.41, just a passing 3448 m; still lots of blocks on the seafloor mostly covered by very young sediment.

11:41.27, 3,444 m, very large outcrop in front of us now. The surface is very fractured -- many different orientations and it is hard to know right now what the orientations are and which surface might be bedding. It looks like the overall strike in the outcrop is just about perpendicular to our heading which is 105°.

11:43.58, changing heading -- we are heading about 101°, 3431m depth.

11:45.42, 3421 m, coming up on another outcrop that is still fairly covered by young silt.

11:47.18, there is a very steep drop-off on our left that looks like some kind of a debris flow chute.

11:48.38, depth 3403 m, very steep drop-off on the right side. There is a steep slope directly in front of us. We are now changing course to go due south to go along the outcrop.

11:49.45 depth 3400 m, we now are going along a very steep cliff with a very

very steep drop-off. This seems to be one of the small side canyons that Anma-san mentioned. Bedded sediments coming in to view; very thin bedded; we are now going across several of the channels.

11:51.43, bedding looks like it is now dipping down towards us; our heading is 148 degrees.

11:52.52, now see what looks like a surface flow of lots of rounded, whitish cobbles.

11:55.23, now stopping to try to collect the sample from a steep slope that looks highly fractured.

11:59.38, trying to collect a sample of a highly fractured rock that looks very friable, but the pilot is now successful in picking up the rock (#R-001). The sample is going into the box in the first hole. Now panning the camera across the very steep, highly fractured slope.

12:02, zooming in on some of the fractures.

12:04, coming up on another very steep slope directly in front of us.

12:08.18, again a very steep with lots of fractures on it. I can't really tell which is the bedding plane, but it seem to be pretty much parallel to the slope. There is a lot of fracturing with conjugate sets.

12:09.27, again over another steep drop off.

12:10.37, dropping down in depth from 3390 to 3395m; trying to look at this very fractured slope. Looks like the dip of the beds is into the slope and the strike is nearly parallel to the slope. Looks like interbedded finer grained material and perhaps coarser-grained turbidites.

12:13.52, very steep slope underneath us again; Looks like a ~5-10 m drop.

12:21.53, dropping off again.

12:22.50, trying to drop down one of the steep slopes to get a look back to see what the structure is.

12:24, changing course to about 090 to go up one of these steep canyons.

12:27.06, on the side of the steep slope seeing very thinly bedded and very highly fractured rocks.

12:29, stopping to take a sample of this fractured rock. Collected three samples; kind of reddish surface on this thin-bedded rock; them into the second slot back, so the samples are in location number 11 -- three pieces (#R-002).

12:37.09, starting up again, turning to head south parallel to the slope.

12:40.59, on a slope that has very strongly fractured rocks; looks very much like a fault zone here.

12:44.28, bedding now dipping towards us; we are heading 178 deg.

12:45.36, going over a series of benches dropping down, with the bedding still dipping back towards us, so we should be going down section.

12:47.59, see another debris flow chute with lots of coarse debris coming down the slope; directly in front of us is an out crop with beds dipping steeply back towards us; our heading is 155 deg.; surface is highly fractured, thin bedded sediment.

12:50.56, again over another side canyon.

12:53.20, over a sedimented slope; no out crops here at all; nothing poking through the smooth sediment cover. Now coming up over another steep cliff; these rocks are very light colored and again very highly fractured. Now looks like a series of thin bedded debris flows with lots of coarse material interbedded with finer grained material. Now hovering very close to the cliff; can see the very small fragments in the debris flows.

12:58.43, back onto a shallower, more sedimented slope out away from the debris flow face.

13:04.25, approaching a series of out crops with talus at the bottom of the slope; can see that we're starting to come up to a steeper slope.

13:05.10, coming up on another steep drop off directly below us.

13:12, on a slope that is fairly well sedimented but has a few interesting, thin, light colored layers poking through; stopping to sample a piece of one of these lighter colored layers. Sample #R-003 went in to box number 15.

- 13:34.10, finished sampling and now heading back to the south.
- 13:37.10, another series of the benches dropping down directly in front of us.
- 13:40.32, the slope seems to be covered by lots of pieces of fractured material that are slowly creeping down slope.
- 13:41.35, beds now dipping back towards us.
- 13:44.25, over another pretty much sediment covered slope; now changing heading around to the south again; we had followed the slope a little way to the east and are now heading south.
- 13:50.38, this is another shallow-dipping, sediment-covered slope so we're going to change and go straight south down the slope to about the 3400 m contour to see if we can get blow this little bench.
- 13:52.40, just passed over directly a small outcrop, but everything else here looks like a pretty shallow surface slope with lots of sediment cover.
- 13:59, heading down a very steep slope; we've come out of the flat area that was heavily sedimented and got into some kind of outcrop and there now is a very steep slope that we will try to go down a bit to see if we can collect a sample.
- 14:05, stopped to sample; this area looks like it is nicely bedded. Pilot broke off a sample and is now trying to get a second piece (#R-004). The rocks are very very friable, and thus very difficult to pick up. Gave up trying to get a second sample because the rocks are just too soft.
- 14:21.50, decided to drop down in depth by about 10-20 m and then head along a contour.
- 14:23.20, out over a steep cliff face and are dropping down to a depth of 3362 m.
- 14:27.32, back in contact it with the steep slope; again, although somewhat sediment covered, it looks the rocks are very highly fractured many different directions of fractures.
- 14:29, dropping down from steep slope; just as we hit the seafloor, it looked

like there were a couple clams that were in growth position, although it was very difficult to tell whether or not they were transported down slope. We are going to try to look around this area to see if we can see more clams. We can see some clams now and will attempt to sample some of them.

14:34, we can now see a nice colony of 4 or 5 clams altogether; one of them has a large black area on its top, so seems to be dead, but the rest of seem to be in the living positions; will try to scoop some up.

14:44, taking a core adjacent to the clam sample (MBARI Red).

14:49, also taking some hand-held digital photographs of some of the clams.

14:54.42, back on another steep slope that is fairly sediment covered with a couple of big blocks; small clam colony adjacent to the blocks.

14:57.30, colonies of dead (?) clams on the left. Now coming into view in front of us are more clams.

14:59, stopping to collect one more clam sample (#B-002); also taking push core (MBARI Yellow).

15:24, stopping to sample massive sandstone (#R-005). There appears to be some kind of lamination or thin bedding. Orientation is ~flat.

15:37, we are looking directly up a dip slope; the sub is heading 080; beds are dipping directly down to us, so we are on pretty much of a dip slope.

15:39.19, about 15 minutes or so left in the dive, so we are going to change course at 045deg and head directly up the slope.

15:42.47, depth 3359m; still just a gentle, sedimented slope.

15:50, depth is 3290 meters; leaving the bottom.

Dive #891 report

Yujiro Ogawa (University of Tsukuba)

Date: July 1, 2005

Site Name: OOST of Shionomisaki Canyon (A-9 area)

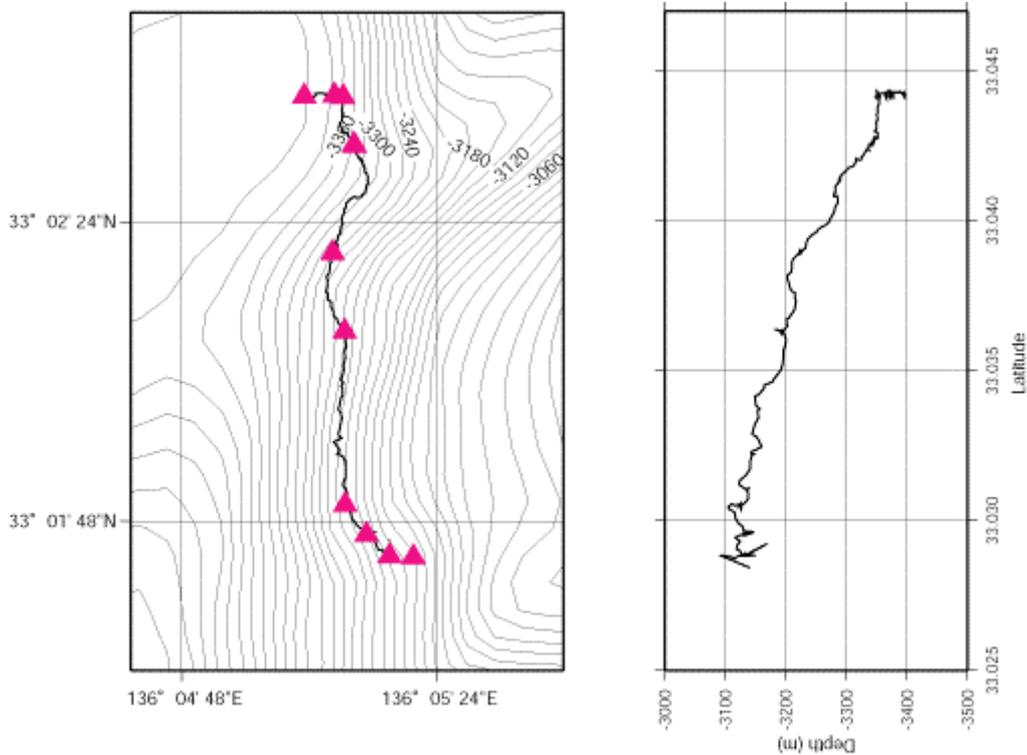
Landing: 33° 02.6518' N, 136° 05.0889' E, 11:27, 3392 m

Leaving: 33° 01.7277' N, 136° 05.3462' E, 15:51, 3083 m

Observer: Yujiro Ogawa (University of Tsukuba)

Pilot: Iijima, K.

Co-Pilot: Matsumoto, K.



GMT 2005 Jul 02 08:54:58 Data=../YK0508grd\_data/previous\_cruises\_data\_100m.grd,Grd\_int=50m/50m,Scale=1:25000,Cont\_int=20m,Anot\_int=60fs

Objectives:

The objectives of this dive are to observe strata distribution, structures, deformation styles, hydrogeological features related to the out-of-sequence thrust (OOST) off Kii Peninsula along the Shionomisaki Canyon. To sample rocks and sediments; the MBARI and push core samples for metal and fluid chemistry at cold seep sites. Also to sample

chemosynthetic clams and/or tube worms for geochemical and/or biological research. Gamma Ray Monitoring System (GRAMS) at cold seep sites.

#### Dive Summary:

Dive 891 route map is shown in Fig. 891-1. I dived the eastern slope of the OOST zone of the Anma gorge, tentatively named the Yoriko slope from the northern end to the middle, gently upslope to the middle slope area. Rocks are exposed mostly continuously, with rather many perpendicular galleys which cut the gorge and slopes. Chemosynthetic animals, Calyptogene? And tube worms, were seen in places mostly just underneath the steep cliff on the galleys or within the galleys. Strata exposed are divided into two, relatively soft mudstone with white in color from the submersible, in fact blue-green on board, and fractured, indurated mudstone (or sandy to muddy turbidite), olive in color, Mn-coated on the surface. The latter is the similar in lithology from other two dives during the cruise (#889, 890). Seepage zones may correspond to the galley distribution, which attain more than ten or so. The dive area probably just on the splay fault zone from the northernmost edge to the middle.

I samples four cores, two ordinary push type, two MBARI type, but the results are poor, because most of the sediments around the colonies were compacted. Rock samples attain eight in numbers, but R-003 was missing.

Geologic cross section is thought to be an imbricate thrust zone with repetition of the two different types of lithology, but the exact fault boundaries were not recognized but represented by Calyptogena? colonies or individuals, or tube worms. Bedding of the strata is more or less dipping to the south or southwest with gentle angle, but the northward dipping was rarely observed. Fractures in the second lithology were mostly of high angle of dip, making wedge-shaped edge, so that the field name to this lithology could be wedge-fractured mudstone. Very soft, fragile, scaly cleaved mudstone was obtained in the southern edge, and it could correspond to the same parts of the previous three dives, #579, 589, 590.

We may make a continuous section combining these four dives.

Keywords:

OOST (Out-of-sequence thrust), cold seep, fractures, imbricate thrust

Payloads:

Ordinary type core sampler (short) x2

MBARI core sampler (long) x2

Push cores x1

Sample basket x2 (one black box, two green cloth bags inside)

Net scoop

Location of Events:

((NOT YET WRITTEN; BUT As BELOW))

Time Position Depth Event

11:26 33° 02.6518' N, 136° 05.0889' E, 11:27, 3392 m Landing

15:51 33° 01.7277' N, 136° 05.3462' E, 15:51, 3083 m Left bottom

Video Digest:

11:40, 3367 m, Stop 1. Calyptogena? colonies, Scattered blocks of light-colored mudstone. Core sampling (C-001; C-002), Rock sampling (R-001).

12:12, 3349 m, Stop 2. Outcrop of fractured mudstone. Bedding dips ca. 30 to S. Fractures (joints?) dip steeply to N or S. Rock sampling (R-002).

12:56, 334? m, Some colonies around here in the galleys. Colonies trend ENE.

12:47, 3337 m. Stop 3. Soft mudstone, rock sampling (R-003), but missing.

12:52, 3337 m (same place above). Rock sampling from outcrop of fractured mudstone (R-004).

13:05, 3309 m, Fragile mudstone, fractured. Debris of light colored mudstone in some galleys. Tube worms on the walls (13:13). Some bacterial mats and scattered Calyptogena (13:14, 13:31).

13:20, Outcrop of fractured mudstone, dipping gently to south. Calyptogena colonies on slope of galley.

13:34, 3219 m, Stop 4. Fractured mudstone, rock sampling (R-005). Around here, many galleys of E-W trend repeated. Steep cliffs ahead, giving a view of the "hell" (Naraku in Japanese).

13:50, 3201 m. Continuous exposures of fractured mudstone (or turbidite) until 13:58, dipping gently to south. Fractures (joints) dip steeply to north. Tube worms on the edge of the southern corner of wall, just below to the south is the "hell" (13:50).

13:58, 31// m. Many galleys and ridges, the former has light-colored mudstone debris, whereas the latter is composed of fractured mudstone (or turbidite) continue.

14:03, 3190 m. Stop 5. Blocky but fractured mudstone with joints. Rock sampling (R-006). Joints (fractures) dip moderately to steeply to north (2 or 3 directed planes, forming wedge-shaped fragments. Bedding seems to dip gently to south.

14:25, Similar slopes of south dipping strata continue until 14:40 (3138 m). Many galleys (or concave cliffs) developed with E-W trend.

14:47, 3138 m. Large concave valley, a deep, wide galleys.

15:02, 3119 m. Stop 6. On the south wall of the large valley, highly cleaved scaly(?) mudstone; sampling (R-007).

15:15, 3119 m. Stop 7 after a traverse of some small ridges and galleys. Sampling of fractured mudstone (R-008).

15:20, 3129 m. Stop 8. En echelon Calyptogena colonies with en echelon individual rows. Core sampling (C-003, C-004).

15:40-51, Climbing steep slopes or cliffs.

15:51, Left bottom.

Description of samples (on submersible before retrieval)

R-001 white mudstone block (white means hereafter light-colored)

33 02.6597, 136 05.1810, 3349 m

R-002 big brown mudstone

33 02.5544, 136 05.2058, 3338 m

R-003 soft mudstone

33 02.5526, 136 05.2084, 3336 m

R-004 white mudstone

33 02.5526, 136 05.2084, 3336 m (same to R-003)

R-005 brown fractured or jointed mudstone

33 02.3376, 13605.1561, 3220 m

R-006 brown fractured or jointed mudstone

33 02.1800, 136 05.1840, 3190 m

R-007 scaly mudstone

33 01.8223, 136 05.1857, 3120 m

R-008 fractured mudstone

33 01.7728, 136 05.1600, 3367 m

C-001 MBARI

33 02.6536, 136 05.1600, 3367 m

C-002 (same to C-001)

C-003

33 01.7299, 136 05.2906, 3129 m

C-004 MBARI

(same to C-003)

Future studies

Dive 6K#891 may provide various types of studies. One is biological of Calyptogena samples; both hard shell for isotope study, another is the soft tissue for DNA analysis. The former would be studied by R. Anma, and the latter by T. Sato and C. Kato. Rock samples are interesting from view point of structural geology. Turbidite of younging direction may give the structural information of direction. If the samples are oriented by magnetic direction, the fabrics of cleavage, fractures, joints must give us the deformation history. Even soft, all the mudstones samples are foliated, some weak, some strong. They may show several stages of deformation. Thin section and SEM analysis will be done by Tsukuba people, R. Anma, T. Ota, R. Endo and Y. Ogawa in addition to K. Kawamura. Sedimentation age by various fossils, particularly radiolarian by S. Kawakami is important. Sediments from the corers are used for isotope and metal concentration study by K. Hayashi. Pore fluid squeezed is analyzed by T. Toki.

## Dive #892 report

Kiichiro Kawamura (Fukada Geological Institute)

Date: July 3, 2005

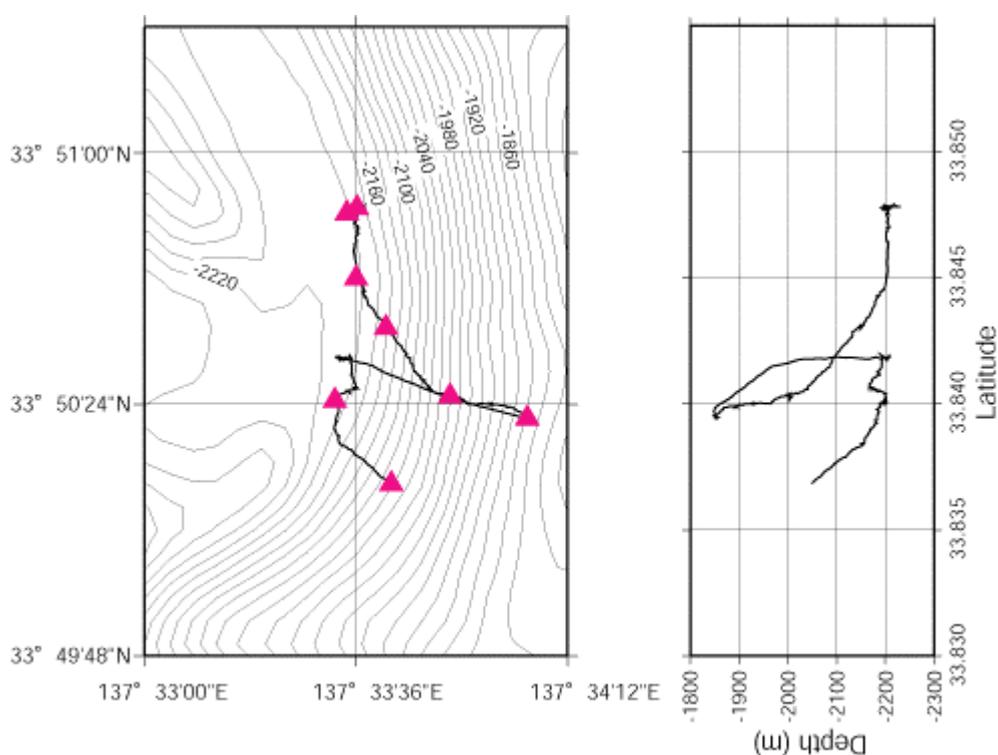
Site Name: Tokai thrust of Tenryu Canyon (B-6 area)

Landing: 33° 50.8558' N, 137° 33.5739' E, 2203 m

Leaving: 33° 50.2103' N, 137° 33.7001' E, 2048 m

Observer: Kiichiro Kawamura (Fukada Geological Institute)

Pilot: Sakurai, T., Co-Pilot: Chida, Y.



 2005 Jul 04 09:10:05 Data=/YK0508grd\_data/previous\_cruises\_data\_100m.grd,Grd\_int=50m/50m,Scale=1:30000,Cont\_int=20m,Anot\_int=8008

### Objectives:

The objectives of this dive are to observe strata distribution, structures, deformation styles, hydrogeological features related to one of the large out-of-sequence thrusts (OOST) Tokai thrust off Omaezaki along the Tenryu Canyon. To sample rocks and sediments; the MBARI and push core samples for metal and fluid chemistry at cold seep sites. Also to sample chemosynthetic clams and/or tube worms for geochemical and/or biological research. Gamma Ray Monitoring System (GRAMS) at cold seep sites.

Keywords:

Tokai thrust, cold seep, fractures, imbricate thrust, fault, fold.

Payloads:

Ordinary type core sampler (short) x2

MBARI core sampler (long) x2

Push cores x2

Sample basket x2 (one black box, two green cloth bags inside)

Net scoop

Location of Events:

Time Position Depth Event

Landing: 33° 50.8558' N, 137° 33.5739' E, 2203 m

Leaving: 33° 50.2103' N, 137° 33.7001' E, 2048 m

Video Digest:

11:01, 2203 m, reach bottom, seabed mud, 1.8 C degrees, current to 140 with 13 cm/sec, visibility 4 m (33-50.8558N,137-33.5739E)

11:10, 2195, find banana

11:15, C-001 (push red)

11:17, C-002 (MBARI)

11:21, sampling Banana

11:33, fault ? outcrop

11:25, R-001 sampling

11:50, white walls, probably turbidites deposited on the canyon

12:15, 2150 m, outcrop vertical dipping

12:23, sampling R-002

12:39, 2086 m, endless sea cucumbers

13:02, 2002 m, outcrop, horizontal strata

13:30, sampling R-003

13:40, sandy sea bed

13:51, 1906 m, steep cliff

13:54, 1888 m, two octopuses

13:59, 1877 m, gulley field, horizontal strata  
14:16, 1852 m, sampling R-004  
14:20- back to the canyon bottom  
14:51, 2206 m, reach bottom again, seabed mud.  
15:44, 2194 m, sampling R-005 (but mud)  
15:58, climb up the slope again.  
16:05, 2048 m, Left bottom 33-50.2103N,137-33.7001E.

List of samples:

B-001, C-001, -002 and R-001; 11:41, 2194 m  
(33-50.8677N,137-33.6037E)  
R-002; 12:23, 2149 m (33-50.5828N,137-33.6858E)  
R-003; 13:30, 2001 m (33-50.4194N,137-33.8669E)  
R-004; 14:16, 1852 m (33-50.3664N,137-34.0864E)  
R-005; 15:44, 2194 m (33-50.4083N,137-33.5406E)

Future studies

Dive 6K#892 may provide various types of studies. One is interstitial water and biological study using core samples collected from deep-sea banana. Around the banana, bacterial mats and some deep-sea creatures are colonized as a chemosynthetic community. Although such community has known as a whalebone community, the deep-sea banana community was found for the first time. The banana community site may give us an important information for interstitial water and biological study. Rock samples are interesting from view point of structural geology. Turbidite of younging direction may give the structural information of direction. If the samples are oriented by magnetic direction, the fabrics of cleavage, fractures, joints must give us the deformation history. Even soft, all the mudstones samples are foliated, some weak, some strong. They may show several stages of deformation. Thin section and SEM analysis will be done by Tsukuba people, R. Anma, T. Ota, R. Endo and Y. Ogawa in addition to K. Kawamura and Yildirim Dilek. Sedimentation age by various fossils, particularly radiolarian by S. Kawakami is important. Sediments from the corers are used for isotope and metal concentration study by K. Hayashi. Pore fluid squeezed is analyzed by T. Toki. Hopefully all the structural geologists may make several papers from each site of the Tenryu Canyon area, and may integrate into an interesting fashion.

(The End)

## Dive 6K#893 report

Ryo Anma (University of Tsukuba)

Date: July 5, 2005

Dive location: Tokai Fault (?) in the western slope of the Tenryu Submarine Canyon

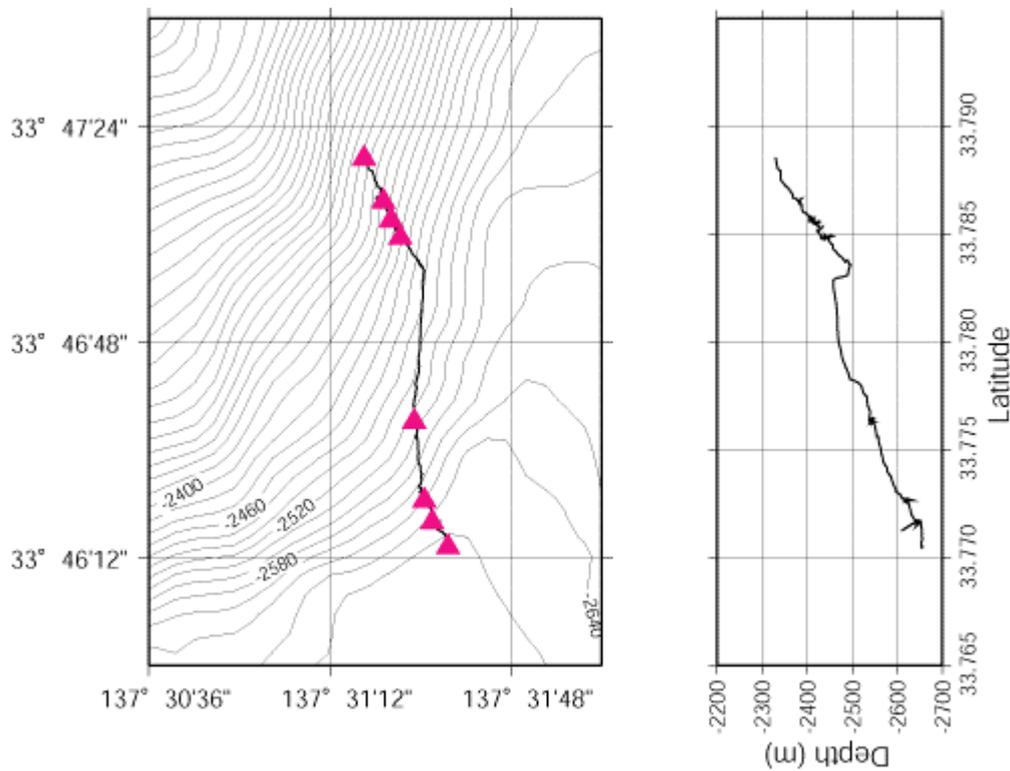
Landing point: 33: 46.23 N, 137: 31.59 E Depth: 2,652 m

Left bottom: 33: 47.31 N, 137: 31.31 E Depth: 2,326 m

Observer: Ryo Anma (University of Tsukuba)

Pilot: Itaru Kawama (JAMSTEC)

Co-pilot: Hirofumi Ueki (JAMSTEC)



 2005 Jul 05 20:01:42 Data=JYK0500grd\_data/previous\_cruises\_data\_100m.grd,Grid\_int=50m50m,Scale=1:35000,Cont\_int=20m,Anot\_int=60f8

### Objectives:

This dive aims to reveal structures developed in accretionary prism sediments exposed along the Tenryu submarine canyon. The structures and morphologies of the Tenryu canyon were somewhat complicated compare to those of the Shiono-misaki canyon because of collision of seamounts. To complete the structural transect along the Tenryu

canyon, we set the diving point in between 6K#887 (also 6K#885) and 6K#892 along a ridge that extend to ENE from the 6K#886 dive point. Extension of the Tokai thrust were expected in the southern foot of the ridge. We aim to observe the section of the ridge, whereas 6K#886 observed structures along the trench slope of the same ridge.

#### Dive Summary:

Landing site in the bottom of the Tenryu canyon was covered by mud and NE-SW trending dunes were developed. At the base of the NNE-SSW trending cliff, we observed highly sheared strata dipping gently (less than 20 degree) to NE. R-001 collected in this outcrop contains calcite vein. R-001 seems cataclastic breccia encased in sheared mudstones. Around 2,620 m deep, we observed an outcrop composed of firmly consolidated sandstone, standing high up in NW-SE direction. R-002 recovered from this outcrop has horizontal bedding plane and black seams and develops brittle fractured in various directions. Calcite veins are observed. Overlying these, thick outcrop of laminated mud were distributed around 2,550 m bsl forming a steep cliff. We collected R-003 sample composed of loose, unconsolidated mud layer. They seem to develop subhorizontal fabrics. However, they were broken into pieces completely during the sampling. Moving to the middle of the cliff wall, we collected R-004 sample at the depth of ~ 2,440 m. They are composed of fine-grained sandstones and are moderately consolidated. Loose stone of highly consolidated sandstone was also collected in the same outcrop. The bedding planes seem to steeply dip toward NW and NE around the outcrop. Above them, loosely consolidated fine-grained sand-siltstones dipping gently to NW were distributed. They were fractured and easily broken to pieces during sampling.

Tube worms were commonly observed along the dive track, indicating high activity of cold seepage. However, no *Calyptogena* colony was observed, except for dead shells.

Sheared strata and highly fractured rocks observed along the dive track indicate existence of the major fault along the base of the cliff. R-002 and R-004 samples were appeared to be strongest among the rock samples collected during this leg. By assuming that the strength obtained through needle penetration test reflecting consolidation alone (and not concretion) due to maximum burial, a big gap could be expected in between 6K#893 ridge and ones in the south. R-001 and R-003 samples yielded radiolarian fossils that indicate Middle to Late Pleistocene ages (according to Kawakami).

Keywords:

Tokai thrust, consolidation

Payloads:

MBARI core sampler x2

Push cores x2

Sample Box x2

Location of Events:

Time	Position	Depth	Event
11:25	33° 46.2296'N 137° 31.5917'E	2652m	Landing
11:48	33° 46.2981'N 137° 31.5386'E	2643m	Sample #R-001
12:06	33° 46.3591'N 137° 31.5131'E	2619m	Sample #R-002
13:06	33° 46.5791'N 137° 31.4786'E	2538m	Sample #R-003 (mud) Core #C-001 (MBARI;black) Core #C-002 (push; red)
14:23	33° 47.0912'N 137° 31.4332'E	2434m	Sample #R-004
15:36	33° 47.1392'N 137° 31.4025'E	2401m	Sample #R-005 Sample #B-001 (Tube worm)
15:56	33° 47.1908'N 137° 31.3766'E	2379m	Core #C-003 (MBARI; red) Core #C-002 (push; yellow)
16:10	33° 47.3102'N 137° 31.3140'E	2326m	Left Bottom

Video Digests:

11:23 Central axis of the Tenryu submarine canyon at the landing point. NNE-SSW trending ripples were commonly developed on the bottom of the canyon.

11:35 Outcrop with consolidated blocks encased in highly sheared silt. R-001 samples of hard blocks were collected here. Shear planes develop in almost horizontal layer and dip gently (~10°) to NE.

11:56 NW trending ridge of sandstone. R-002 was sampled.

12:08 NE-ward dipping strata.

12:29 Vestimentiferan

- 12:37 Highly sheared silt. Scaly fabrics seem to develop (dip  $\sim 10^\circ$  to east). R-003 was collected.
- 12:53 Push core (red: C-002) and MBARI core (black: C-001) samples were obtained in the same outcrop where Vestimentiferans were observed at 12:29.
- 13:18 Biomat (?). Move 500 m to north.
- 13:49 R-004 outcrop. Bedding plane dips gently ( $\sim 30^\circ$ ) to east.
- 14:29 Silty laminated sediments dipping gently ( $\sim 10^\circ$ ) to north.
- 14:37 We observed Vestimentiferan in several localities around this position.
- 14:58 Sandstones (?) dipping moderately to east.
- 15:12 R-005 outcrop. Fine laminae were observed on the surface of broken outcrop. The laminae seem to dip steeply to south.
- 15:43 Bacteria mat. MBARI core (red; C-003) and push core (yellow; C-004) samples were obtained here.

#### Description of samples:

- R-001: Breccia in shear zone. Alternation of olive-gray siltstone and fine-grained gray sandstones. Sandstone is rich in graphite. Silty part flows into sandy part and they are mixed along the boundaries. Restored direction of boundary plane seems steeply dipping implying that the sample is of rotated breccia.
- R-002: Firmly consolidated, sheared block that composed of alternation of calcareous silt (gray) and medium-grained sandstone. Black seams with web-like patterns were developed. Calcite mineralization was observed. Both bedding plane and black seams are sub-horizontal.
- R-003: Mud.
- R-004: Highly consolidated and massive, fine- medium-grained sandstone. Graphite-rich. Contains C-rich clot of shale. Light-gray in color. Liquefied medium-grained sand intruded into host fine-grained sandstone. Burrows are observed.
- R-005: Fine- Medium-grained sandstone. Highly jointed.

C-001: MBARI (black); see appendix

C-002: push core (red); see appendix

C-003: MBARI (red); see appendix

C-004: push core (yellow); see appendix

B-001: *Vestimentiferan sp.*; see appendix

#### Future studies

Rock samples will be used for laboratory studies at U. Tsukuba. Those include measurement of natural remanent magnetization to orientate samples, thin section observation and AMS for fabric analysis to understand rock deformation history, test for rock strength to estimate maximum burial. Radiolarian fossils will be studied by S. Kawakami to determine age of sedimentation. Sediments from the corers are used for isotope and metal concentration study by K. Hayashi. Pore fluid will be analyzed by T. Toki. *Vestimentiferan* (B-001) will be provided to C. Kato for analyses.

## Dive #894 report

Yujiro Ogawa (University of Tsukuba)

Date: July 7, 2005

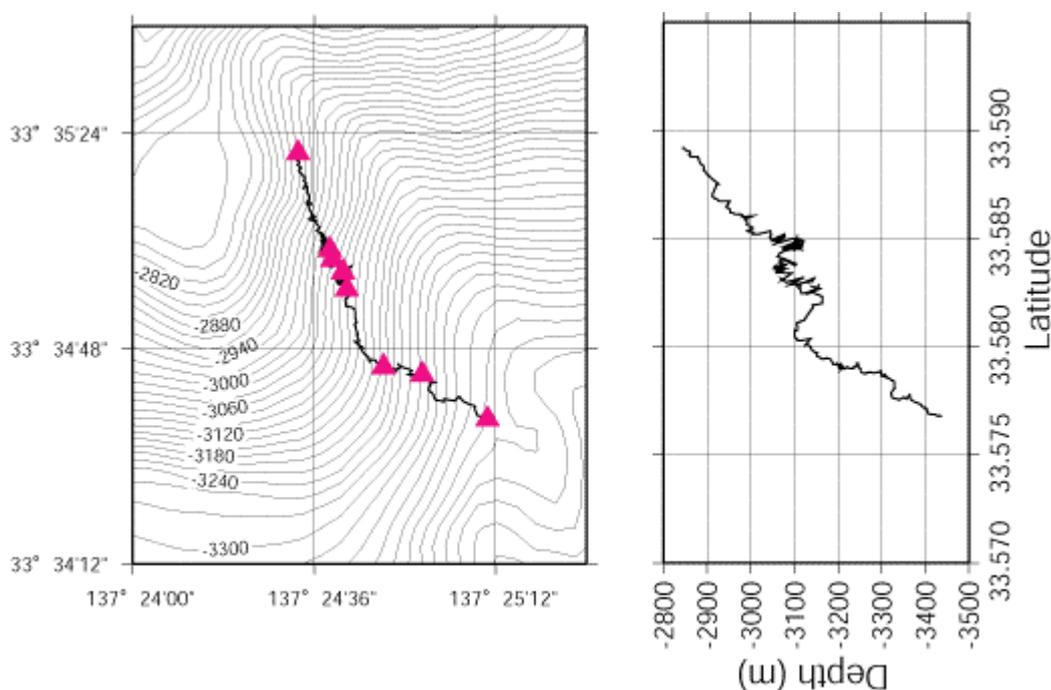
Site Name: Steep slope of west mouth of the Tenryu Canyon (B-1 area)

Landing: 33° 34.6034' N, 137° 25.1740' E, 11:29, 3433 m

Leaving: 33° 35.3457' N, 137° 24.5470' E, 15:57, 2839 m

Observer: Yujiro Ogawa (University of Tsukuba)

Pilot: Sakurai, T., Co-Pilot: Ueki, H.



GMD 2005 Jul 07 20:06:26 Data=:/YK0508grd\_data/previous\_cruises\_data\_100m.grd,Grd\_int=50m/50m,Scale=1:35000,Cont\_int=20m,Anot\_int=60m

### Objectives:

The objectives of this dive are to observe strata distribution, structures, deformation styles, hydrogeological features around the toe area of the Tenryu Canyon mouth. To sample rocks and sediments; the MBARI and push core samples for metal and fluid chemistry at cold seep sites. Also to sample chemosynthetic clams and/or tube worms for geochemical and/or biological research. Gamma Ray Monitoring System (GRAMS) at cold seep sites.

## Dive Summary:

Dive 894 route map is shown in Fig. 894-1. I dived the western side of the Tenryu Canyon mouth area, particularly its very steep slope, the top of which is tentatively called the "Ishida ridge" after the Captain Sadao Ishida of the mother vessel Yokosuka of this cruise. This part of the slope may correspond to the very toe area, the dive 6K#888 (Kawakami), or the previous dive of 6K#722 (Kawamura). Rocks are almost continuously exposed throughout the route from 3300 m to 2900 m depth. Most of the rocks are the same sedimentary sequence of alternation of sandstone-mudstone, turbidite, and they are unexceptionally fractured into fracture cleavage with high angle or moderate angle to the bedding. Beds are dipping westward or easterward, forming gentle undulation, the former dipping is common. Faults are also common as well as web structure in sandstone, and such deformational features are similar to the Emi and Miura Groups of Boso-Miura Peninsulas. Although in the onland examples fracture (or fracture cleavage) is not common. At least two thrust faults of low angle were confirmed by the occurrence of *Calyptogena* colonies and white deposition (probably calicet) on the surface. In the latter case, sand or sandstone beds are suffered by white material precipitation with some vein fillings in joints or faults. They are also common in Boso-Miura. In the upper section, faults and folds become common, and all the kinds of faults; thrusts (in some places conjugate) and normal faults occur. Drag of strata is seen, particularly in the normal fault case. Metre-order kinks of beds of drag in origin are observed in the latter course. High angle fractures or faults are also common. As a result, this slope represents the most spectacular geological features ever.

I sampled three cores, one ordinary push type, two MBARI type around the *Calyptogena* colony in the middle slope. Rock samples were collected at five sites, and among them some has cross bedding in laminated sandstone. All the samples have fracture cleavage as a strong deformation feature.

Geologic cross section is thought to be an imbricate thrust zone with repetition of the single lithology (turbidite) with sporadic ash layers. Important is that even very soft, fragile, all the sedimentary rocks have

fracture cleavage. We would compare with the results of Dive 6K#885 (Kawamura) and 887 (Dilek).

We may make a continuous section combining all the dives in the Tenryu Canyon area.

Keywords:

Frontal thrust zone, cold seep, fractures, imbricate thrust, fault, fold.

Payloads:

Ordinary type core sampler (short) x2

MBARI core sampler (long) x2

Push cores x2

Sample basket x2 (one black box, two green cloth bags inside)

Net scoop

Location of Events:

((NOT YET COMPLETE; BUT As BELOW))

Time	Position	Depth	Event
11:29	33° 34.6034' N, 137° 25.1740' E,	3433 m	Landing
15:57	33° 35.3457' N, 137° 24.5470' E,	2839 m	Leaving

Video Digest:

12:13, 3287 m, R-001, 33 34.7275, 137 24.9569

12:41, 3202 m, R-002, 33 34.7488, 137 24.8382

13:20, 3131 m, R-003, 33 34.9652, 137 24.7078

14:08, 3058 m, C-001, 002, 003, 33 35.0135, 137 24.6949

14:21, 3065 m, R-004, 33 35.0485, 137 24.6608

14:53, 3074 m, R-005, 33 35.0759, 137 24.6526

15:30-57, Climbing steep slopes or cliffs.

15:57, Left bottom.

#### Future studies

Dive 6K#894 may provide various types of studies. One is biological of Calyptogena samples; both hard shell for isotope study, another is the soft tissue for DNA analysis. The former would be studied by R. Anma, and the latter by T. Sato and C. Kato. Rock samples are interesting from view point of structural geology. Turbidite of younging direction may give the structural information of direction. If the samples are oriented by magnetic direction, the fabrics of cleavage, fractures, joints must give us the deformation history. Even soft, all the mudstones samples are foliated, some weak, some strong. They may show several stages of deformation. Thin section and SEM analysis will be done by Tsukuba people, R. Anma, T. Ota, R. Endo and Y. Ogawa in addition to K. Kawamura and Yildirim Dilek. Sedimentation age by various fossils, particularly radiolarian by S. Kawakami is important. Sediments from the corers are used for isotope and metal concentration study by K. Hayashi. Pore fluid squeezed is analyzed by T. Toki. Hopefully all the structural geologists may make several papers from each site of the Tenryu Canyon area, and may integrate into an interesting fashion.

## 8. Radiolarian Biostratigraphy

Shunsuke KAWAKAMI (AIST, GSJ)

The depositional age of the collected rocks were examined by a radiolarian biostratigraphy as a preliminary report. Summaries of results are shown in a figure.

Rock samples were disaggregated by the following method as a shipboard examination. 1) Break about 5 gram of a sample into 0.5 cm pieces and places in a beaker. 2) Rinse and cover with 15% hydrogen peroxide solution and boil up a sample on a heated plate until a reaction over. 3) Rinse thoroughly and sieve a residue through a 63  $\mu\text{m}$  sieve screen. 4) Repeat second and third steps 2-3 times, and mount residues with Canada Balsam for a light microscope observation. The radioarian biostratigraphic zonation is afer the Northwest Pacific zonation in Motoyama and Maruyama (1998).

This is just a preliminary, and then the detail will be examined as onland studies.

### Reference:

Motoyama, I. and Maruyama. T., 1998. Neogene diatom and radiolarian biochronology for the middle-to-high latitudes of the Northwest Pacific region: Calibration to the Cande and Kent's geomagnetic polarity time scales (CK92 and CK95), Jour. Geol. Soc. Japan, 104, 171-183.

YK05-08 6K#885

R-001

Age: ?

Radiolarians: very rare, moderate preservation

Too hard to disaggregate, but onland studies will elucidate.

Fossils: radiolarian, diatom

R-002

Age: ?

Radiolarians: very rare, moderate preservation

Too hard to disaggregate, but onland studies will elucidate.

Fossil: radiolarian

R-003

Age: ?

Radiolarians: very rare, moderate preservation

Too hard to disaggregate, but onland studies will elucidate.

Fossil: radiolarian

R-004

Age: ?

Radiolarians: very rare, moderate preservation

Too hard to disaggregate, but onland studies will elucidate.

Fossil: radiolarian

YK05-08 6K#886

R-001

Age: Upper Pleistocene

Botryostrobus aquilonaris Zone

Radiolarians: common-abundant, moderate preservation

Haeckeliella inconstans, Amphirhopalum ypsilon, Didymocyrtis tetrathalamus,

Spongaster tetras irregularis, Cycladophora davisiana davisiana, Lamprocyrtis nigriniaie,

Theocorythium trachelium trachelium

Fossils: radiolarian, diatom, foraminifer

Remarks: Some reworked skeletons were got mixed in this assemblage, e.g. Haeckeliella inconstans.

R-002

Age: Middle Pleistocene

Axoprunum angelinum Zone

Radiolarians: common-abundant, moderate preservation

Thecosphaera dedoensis, Axoprunum angelinum, Didymocyrtis tetrathalamus, Spongaster tetras tetras, Cycladophora davisiana davisiana, Cycladophora sp. aff. sakaii,

Lamprocyrtis neoheteroporos, Theocorythium trachelium trachelium

Fossils: radiolarian, diatom, foraminifer

YK05-08 6K#887

R-001

Age: Pliocene-Pleistocene

Radiolarians: very rare, moderate preservation

Amphirhopalum ypsilon

Too hard to disaggregate, but onland studies will elucidate.

Fossils: radiolarian, diatom

Remarks: The first occurrence of the Amphirhopalum ypsilon nearly corresponds the bottom of Pliocene in the Tropical and Northwest Pacific.

R-002

Age: ?

Radiolarians: very rare, moderate preservation

Too hard to disaggregate, but onland studies will elucidate.

Fossils: radiolarian, diatom

R-003

Age: ?

Radiolarians: very rare, moderate preservation

Too hard to disaggregate, but onland studies will elucidate.

Fossils: radiolarian, diatom

YK05-08 6K#888

R-001

Age: ?

Radiolarians: very rare, moderate preservation

Fossils: radiolarian, foraminifer, diatom

R-002

Age: ?

Radiolarians: very rare, moderate preservation

Fossils: radiolarian, foraminifer, diatom

R-003

Age: ?

Radiolarians: very rare, moderate preservation

Fossils: radiolarian, foraminifer, diatom

R-004

Age: Upper Pliocene

Uppermost part of *Cycladophora sakaii* Zone

Radiolarians: rare, moderate preservation

*Porodiscus macroporos*, *Cycladophora davisiana davisiana*, *Cycladophora sakaii*,

*Botryostrobus aquilonaris*

Remarks: The age was determined by the co-occurrence of *Cycladophora davisiana davisiana* and *Cycladophora sakaii*, and the absence of *Lamprocyrtis heteroporos* and *Lamprocyrtis neoheteroporos*.

YK05-08 6K#889

R-001

Age: ?

Radiolarians: very rare, moderate preservation

Fossils: radiolarian, diatom

R-002

Age: ?

Radiolarians: very rare, moderate preservation

Fossil: radiolarian

R-003

Age: ?

Radiolarians: very rare, moderate preservation

Fossil: radiolarian

R-007

Age: ?

Radiolarians: very rare, moderate preservation

Fossils: foraminifer, radiolarian, diatom

YK05-08 6K#890

R-001

Age: ?

Radiolarians: very rare, moderate-bad preservation

Too hard to disaggregate, but onland studies will elucidate.

Fossil: radiolarian

R-002

Age: ?

Fossil: some siliceous fragments

R-005

Age: Upper Pleistocene

Botryostrobus aquilonaris Zone

Radiolarians: common, moderate preservation

Amphirhopalum ypsilon, Didymocyrtis tetrathalamus, Cycladophora davisiana davisiana, Lamprocyrtis nigrinae, Theocorythium trachelium trachelium, Botryostrobus aquilonaris

Fossils: radiolarian, foraminifer, diatom

Remarks: The Axoprunum angelinum is absent in the observed assemblage, and so, it assume almost recent sediment.

YK05-08 6K#891

R-001

Age: Upper Pliocene

Bottom of the Eucyrtidium matuyamai Zone (Northwest Pacific) or Pterocanium prismatium Zone (Tropical Pacific)

Radiolarians: common-abundant, moderate preservation

Haeckeliella inconstans, Thecosphaera dedoensis, Thecosphaera sp. aff. miocenica, Sphaeropyle langii, Axoprunum angelinum, Didymocyrtis tetrathalamus, Spongaster sp. aff. pentas, Spongaster tetras tetras, Spmellaria genn. et. spp., Lamprocyrtis heteroporos, Theocorythium vetulum, Phormostichoartus doliolum

Fossils: radiolarian, diatom

Remarks:

1) This assemblage is corresponded in somewhere the above two zones by the characteristic co-occurrence of the above species, but there is no zonal definitive species such as Eucyrtidium matuyamai and Pterocanium prismatium. This implies the mixing of fauna, and the restricted distributions of the zonal definitive species.

2) The depositional age of this is older than the previous examined 6K#579 R-002. These assemblages resemble, but the assemblage of the 6K#891 R-001 is distinguished from other by the occurrence of the *Lamprocyrtis heteroporos*, *Theocorythium vetulum*, and *Phormostichoartus doliolum*. Each of three species have phylogenetic relationships for *Lamprocyrtis neoheteroporos*, *Theocorythium trachelium trachelium*, and *Phormostichoartus corbula* from the 6K#579 R-002. In consequence, the depositional ages of them are nearly consecutive relation.

3) The radiolarian assemblage of the 6K#891 R-001 resembles the assemblage of the Nobori Formation, Tounohama Group in the southeast Shikoku Island.

R-002

Age: ?

Radiolarians: rare, moderate preservation

*Axoprunum angelinum*, *Eucyrtidium calvertense*

Fossils: radiolarian, diatom

R-004

Age: ?

Radiolarians: very rare, moderate preservation

Fossils: radiolarian, diatom

R-005

Age: Upper Pliocene

*Cycladophora sakaii* Zone

Radiolarians: rare, moderate preservation

*Thecosphaera dedoensis*, *Axoprunum angelinum*, *Cycladophora sakaii*, *Lithopera bacca*

Fossils: radiolarian, diatom, foraminifer

Remarks: This assemblage includes the *Cycladophora sakaii* which define the *Cycladophora sakaii* zone, and so, this assemblage implies an older depositional age than the 6K#891 R-001.

R-006

Age: ?

Radiolarians: rare, moderate preservation

*Thecosphaera dedoensis*, *Eucyrtidium calvertense*, *Botryostrobus aquilonaris*

Fossils: radiolarian, diatom

R-007

Age: ?

Radiolarians: rare, moderate preservation

*Thecosphaera dedoensis*, *Axoprunum angelinum*, *Eucyrtidium calvertense*

Fossils: radiolarian, diatom

R-008

Age: ?

Radiolarians: very rare, moderate preservation

Fossils: radiolarian, diatom

YK05-08 6K#892

R-002

Age: ?

Fossils: diatom

R-003

Age: ?

Too hard to disaggregate by hydrogen proxide solution.

R-004

Age: ?

R-005

Age: Middle Pleistocene

Axoprunum angelinum Zone

Radiolarians: abundant, moderate preservation

Haeckeliella inconstans, Haeckeliella sp. aff. inconstans, Sphaeropyle langii, Axoprunum angelinum, Amphirhopalum ypsilon, Didymocyrtis tetrathalamus, Spongaster tetras tetras, Spongaster tetras irregularis, Cycladophora davisiana davisiana, Theocorythium trachelium trachelium, Botryostrobus aquilonaris

Fossils: radiolarian, foraminifer, diatom

Remarks:

- 1) All of the Haeckeliella inconstans were broken skeleton, and so, these typical Pliocene radiolarian was assumed reworkings. Haeckeliella sp. aff. inconstans has fewer spine blades than the typical H. inconstans. Both of them may have a phylogenetic relationship.
- 2) Bifurcation patterns of the Amphirhopalum ypsilon might show stratigraphic changings. In early Pliocene, their forked shapes was unclear, but Pleistocene type had a clear bifurcation, and recent type shows decorated bifurcation.

R-006

Age: ?

YK05-08 6K#893

R-001

Age: Upper Pleistocene

Botryostrobus aquilonaris Zone

Radiolarians: abundant, moderate preservation

Didymocyrtis tetrathalamus, Spongaster tetras tetras, Cycladophora davisiana davisiana, Eucyrtidium calvertense, Lamprocyrtis nigriniae, Theocorythium trachelium trachelium, Botryostrobus aquilonaris, Phormostichoartus corbula

Fossils: radiolarian, foraminifer, diatom

R-002

Age: ?

Too hard to disaggrigated, but onland studies will elucidate.

R-003

Age: Upper Pleistocene

Botryostrobus aquilonaris Zone

Radiolarians: common, moderate preservation

Didymocyrtis tetrathalamus, Spongaster tetras tetras, Eucyrtidium calvertense, Botryostrobus aquilonaris

Fossils: radiolarian, foraminifer, diatom

R-004

Age: ?

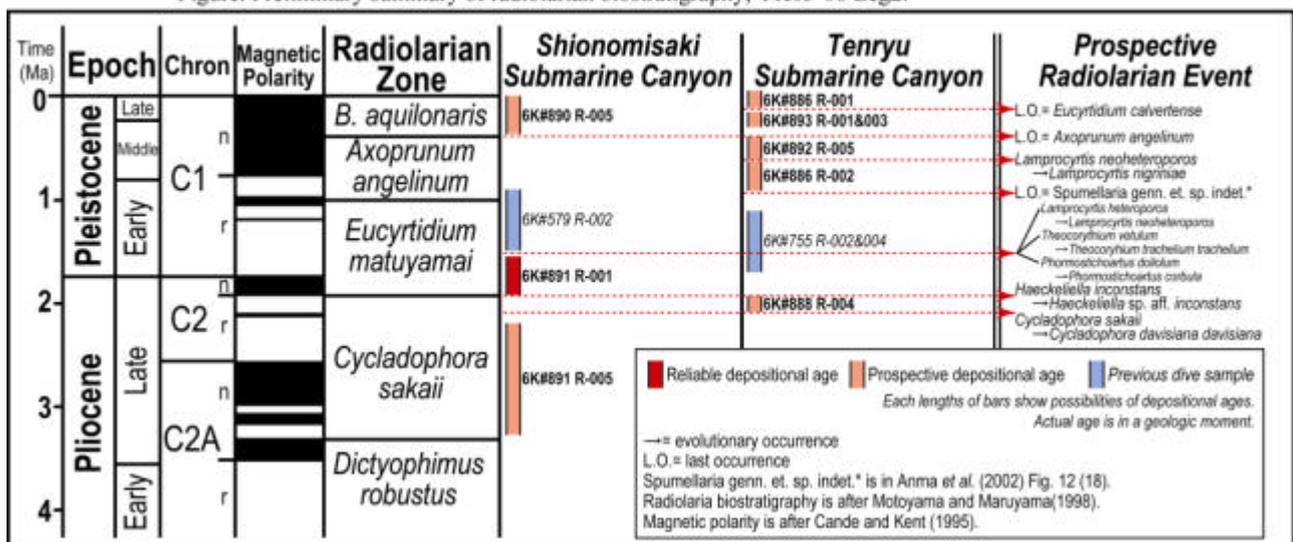
Too hard to disaggrigated, but onland studies will elucidate.

Fossils: radiolarian, foraminifer

YK05-08 6K#894

Work in progress...

Figure. Preliminary summary of radiolarian biostratigraphy, YK05-08 Leg2.



## **9. Geochemistry**

### **Chemical and isotopic compositions of pore water**

T. Toki, T.Gamo (ORI), U. Tsunogai (Hokkaido Univ.)

#### **Introduction**

In the Nankai Trough, numerous deep benthic faunal assemblages, depending on emissions of chemically reduced fluids, have been found along the accretionary prism (e.g., see reviews by Kojima, 2002). Pore fluid from surface sediment beneath the chemosynthetic organisms has been reported to be rich in methane (Suess et al., 1985). On the other hand, methane has been known to be poor in surface sediment but rich at great depths below normal seafloor. It indicates that fluid bearing methane comes up from depth to the seafloor beneath the benthic organisms, and methane concentration in pore fluid from the sediment depends on the activity of upcoming fluid. Stable carbon isotopic composition of methane is closely related to the origin of methane (Schoell, 1983). Using the isotopic composition of methane as geochemical tracers, the migration and the origin of upcoming fluid can be defined clearly. The migration and origin of the expelled fluids offers useful information for the mechanism of earthquakes, the distribution of resources, and the assessment of activities of subsurface biosphere.

During the YK05-08 cruise, we took interstitial waters extracted from surface sediment in and around dense biological communities on the seafloor at the Tenryu Canyon and the Shionomisaki Canyon in the Nankai accretionary prism. We will measure chemical and isotopic compositions for the interstitial fluid samples retrieved from the surface sediment using the MBARI corer and seawater overlying the sediment in the corer within chemosynthetic organisms on the seafloor in the Nankai accretionary prism. We will elucidate the distribution and the origin of methane, discuss the plumbing system of the Nankai accretionary wedge, and assess the activities of subsurface biosphere.

#### **Sampling**

Sample names are listed together with descriptions of each sampling site in Table 1.

### *Equipments*

The sediment core samples were collected with an MBARI-type corer by the manned submersible “*Shinkai 6500*” belonging to the Japan Marine Science and Technology Center (JAMSTEC). The MBARI-type core sampler is a tool to take surface sediment from the seafloor (up to 35 cm) by using submersible. Especially, this tool is designed to collect interstitial water from the sampled sediment core in an on-board laboratory as quickly as possible without evaporation, degassing and contamination. The sampler has six holes on the side of an acrylic inner tube in the interval of 5-cm. The holes are closed by seal before a dive, and after recovery, we open the seal on the holes and put a 50-cm<sup>3</sup> syringe into the each hole for retrieval of interstitial water from sediment sample.

#### Description

Length	350 mm
Diameter	70 mm

*MBARI-type core  
sampler*



### *Sample treatment*

The pore waters were immediately extracted from sediment core samples in the onboard laboratory of the tender ship *Yokosuka* using a following procedure described in Manheim (1974). As quickly as possible after the corer’s recovery, subsampled sediments for chemical analysis were taken with an effort to avoid degassing and contamination using following procedures: First, a cut off 50-cm<sup>3</sup> plastic syringe barrel was inserted into the sediment in the corer through the holes at the side of the corer, and then the sediment in the barrel was transferred into a plastic syringe with filter. A plunger was held fixed in the syringe barrel filled by the sediment sample with a piston. A nozzle of the syringe was connected to 10-cm<sup>3</sup> plastic syringe without headspace. The pore water was transferred to a 10-cm<sup>3</sup> plastic container by compressing the sediment sample using Manheim’s (1974) vice in the refrigerator.

The pore water was distributed to sample bottles. About 2 cm<sup>3</sup> of the retrieved pore water was immediately transferred to a 3-cm<sup>3</sup> vial, added with amidosulfuric acid and HgCl<sub>2</sub>, and capped with a butyl rubber septum as a preservative for subsequent shore-based analysis of concentrations and stable isotopic compositions of dissolved CH<sub>4</sub> and ΣCO<sub>2</sub> for reference of gas samples. The remaining fluid was preserved in a polypropylene bottle for measurements of major cation and anion as well as analyses of <sup>18</sup>O and deuterium of pore water. The samples were refrigerated in the dark and kept at 4°C until analysis.

### **Analysis**

Immediately after reception of the corer on board, the pore water samples in the polypropylene bottles were analyzed aboard ship for pH, silica, ammonium, and alkalinity determination. In order to obtain the value of silica, the samples were diluted 5-fold and analyzed by the silicomolybdate colorimetric method. Ammonium was determined by spectrophotometry of phenol blue. Alkalinity measurements were carried out by potentiometric titration with HCl.

### **Results and discussion**

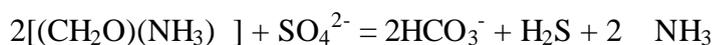
A list of analytical results, pH and salinity, is shown in Table 1.

Pore waters from sediments of the Tenryu Canyon and the Shionomisaki Canyon show patterns of dissolved constituents characteristic of an early diagenetic process (Fig.1). This is expected in hemipelagic environments, but particularly at D892-C2 and D893-C3 sites the interstitial nutrient patterns are anomalously increased in alkalinity. The anomalies are attributed to the oxidation of CH<sub>4</sub> as a carbon substrate, because the utilization of CH<sub>4</sub> by microbes generates no dissolved NH<sub>4</sub><sup>+</sup> at all. The different alkalinity and NH<sub>4</sub><sup>+</sup> regeneration ratios are evident from the following comparison:

Methane anaerobic oxidation:



Sedimentary organic matter oxidation:



Hereby denotes the inverse of the carbon-to-nitrogen regeneration ratio according to the Redfield stoichiometry; i.e.  $C/N = 106/16$ . Therefore, the alkalinity anomalies in pore fluids from the localities may reflect the combined contributions of each of the two substrates, particulate organic carbon and  $CH_4$ . It is suggested that the upward migration of methane plays an important role as a carbon source in addition to the sedimentary organic matter derived from the water column above.

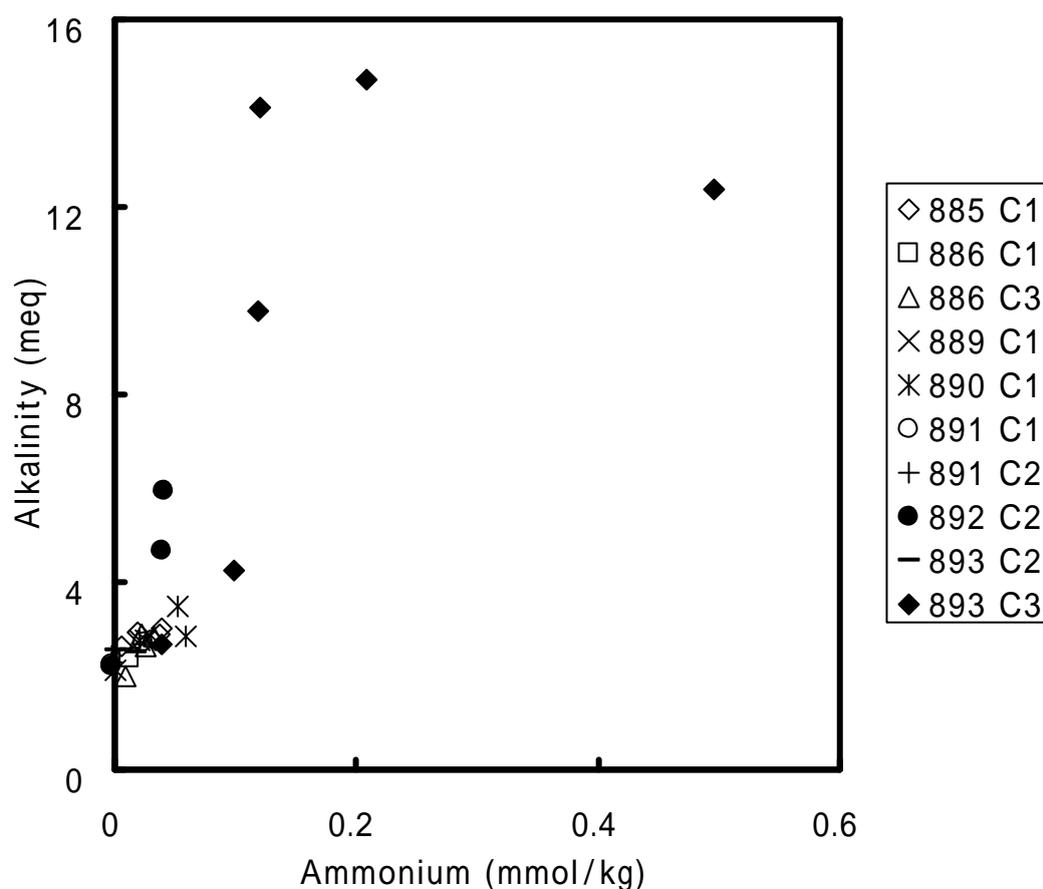


Fig. 1 Correlation of ammonium with alkalinity for all pore water samples

### Future study

In this study, we will analyze chemical and isotopic compositions of  $CH_4$ ,  $CO_2$  and  $H_2O$ , and concentrations of major components ( $Cl$  and  $SO_4^{2-}$ ) in the water and gas samples and discuss the interpretation of the chemical and isotopic compositions of the samples in order to delineate the origin of methane and that of fluid.

## **References**

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Dive#	Sample#	Rock type	Uniaxial compressive strength (kN/m <sup>2</sup> )										
#885	R-001	Mudstone	56	<table border="1"> <tr> <td>Sediment</td> <td>&lt; 1</td> </tr> <tr> <td>Soft</td> <td>1-10</td> </tr> <tr> <td>Moderate</td> <td>10-100</td> </tr> <tr> <td>Hard</td> <td>&gt;100</td> </tr> </table>	Sediment	< 1	Soft	1-10	Moderate	10-100	Hard	>100	
	Sediment	< 1											
	Soft	1-10											
	Moderate	10-100											
	Hard	>100											
	R-002	Mudstone	56										
R-003	Mudstone	12											
R-003	Sandstone	8											
R-004	Mudstone	36											
R-004	Sandstone	56											
#886	R-001	Mudstone	<1										
	R-002	Mudstone	<1										
#887	R-001	Mudstone	12										
	R-002	Mudstone	5										
	R-003	Mudstone	15										
	R-004	Mudstone	11										
	R-005	Mudstone	12										
	R-006	Mudstone	11										
#888	R-001	Mudstone	no data										
	R-002	Mudstone	9										
	R-002	Mudstone	8										
	R-003	Mudstone	5										
	R-003	Mudstone	11										
	R-003	Mudstone	8										
	R-004	Mudstone	8										
	R-004	Mudstone	8										
#889	R-001	Mudstone	20										
	R-002	Mudstone	<1										
	R-003	Mudstone	12										
	R-003	Mudstone	5										
	R-004	Sandstone	129										
	R-004	Sandstone	192										
	R-006	Mudstone	5										
	R-007	Mudstone	20										
R-007	Sandstone	6											
#890	R-001	Mudstone	<1										
	R-002	Chert	192										
	R-003	Sandstone	192										
	R-004	Sandstone	378										
	R-005	Mudstone	<1										
#891	R-001	Mudstone	no data										
	R-002	Siltstone	12										
	R-003	Mudstone	<1										
	R-004	Mudstone	5										
	R-005	Mudstone	6										
	R-006	Mudstone	6										
	R-007	Mudstone	no data										
	R-008	Sandstone	28										
#892	R-002	Mudstone	no data										
	R-003	Siltstone	49										
	R-004	Mudstone	8										
	R-005	Mudstone	<1										
	R-006	Mud	<1										
#893	R-001	Sandstone	23										
	R-002	Sandstone	192										
	R-003	Mud	<1										
	R-004	Mudstone	192										
	R-004	Sandstone	378										

Fig. 1

## 11. Future study

We obtained many data and samples during YK05-08 Leg 2 cruise, including dive videos, rocks, sediments and biological samples, in addition to topographic and geophysical data. We will do, and already did, various kinds of treatment. Followings are the research proposals which we together discussed during the cruise. Each researcher will do and is obliged to present talk or poster at international conferences and JAMSTEC Shinkai symposium in 2004-2005, and to publisize the results to international journals.

Research proposal YK05-08 Leg 2 (arranged by Yujiro Ogawa) (June 29, 2005) v.1

### Contents

Topography

Age of sediments and sedimentary rocks; biostratigraphy

Sedimentation, stratigraphy, paleogeography, paleoceanography etc.

Structural geology (deformation analysis)

Physical properties and mechanical behavior

Geochemistry

Tectonics, Geophysics, Seismology, Synthesis

(First summary of tentative proposals from individual scientist, and these are fully tentative, and need mutual discussion and rearrangement. Please collaborate together.

Y. Ogawa)

(Followings are categorized from basic to applicable or to synthetic for each person or group)

### 1. Topography

#### 1.1. T. Sasaki

Title: Topographical mapping of the landward slope of the Nankai Trough by SeaBeam:

Comparative study of subduction zone topography and tectonics

(Various datasets are used) With all other shipboard scientists

(for AGU Fall meeting, 2005, San Francisco, or JAMSTEC symposium, Feb. 15 or so, 2006 at Yokohama; poster)

#### 1.2. S. Yokoyama

Title: Description of topographic feature of the westward slope of the Tenryu Canyon in relation between topography and tectonics of the eastern Nankai accretionary prism  
(Method) Distribution of slope movement landforms (almost collapse scarp).  
Distribution of lineament and linear depression (probably tectonic landforms)  
Inference of active faults. History of development of the slope (relation to the faulting and slope movement).

## 2. Age of sediments and sedimentary rocks; or biostratigraphy

### 2.1. S. Kawakami

Title: Chronostratigraphy Around the Eastern Part of Nankai Accretionary Prism

Author: Kawakami (Rads), Mohiuddin (Foram), Romero (Diatom), Kameo (Nano)

(Correspondent: S. Kawakami)

Purpose: Elucidate the ages and stratigraphy around the eastern part of Nankai accretionary prism. In this study, I will summarize the my whole undisclosed data, which include previous dives.

Deadline: By the end of fiscal year, or before I quit (change) a job.

I need the rock samples of a half fist size for the radiolarian & other microfossil biostratigraphic studies, wherever possible, I want to examine all of the rock samples for clear-up of the surveyed area chronostratigraphy.

## 3. Sedimentation, stratigraphy, paleogeography, paleoceanography etc.

### 3.1. Greg Moore, Mike Underwood

Title: Provenance of Sandstones and Mineralogy of Clays of the Eastern Nankai Accretionary Prism (G. Moore -- shipboard participant; M. Underwood -- shorebased participant)

We would like to provide analyses of the sedimentary rocks collected from Shionomisaki and Tenryu Canyon areas in order to understand the provenance of the sands and to quantify the mineralogy of the clays.

(Sand and sandstone samples: representative two or three slices, perpendicular to the bedding plane from each sampling site, each dive if there are.)

### 3.2. S. Yokoyama, S. Kawakami etc.

Title: Recent Debris Flow on the Accretionary Prism in the landward slope of Nankai Trough

Author: Yokoyama (Applied Geology), Kawakami (Rads+Sedimentology), Mohiuddin (Form)

Asumption: It is a given fact that the age and environment by the various microfossil analysis are significant.

Purpose: The almost recent rock sample 6K#886 R-001 commonly occurs well preserved calcareous fossils, on the other hand, the surface deposits few calcareous fossils. The R-002 (meddle Pleistocene) also often occurs well preserved calcareous fossils. This fact implies history of the pattern of debris flow. We try to elucidate how a debris flow development by the analysis of topography, age, and benthic foraminifer. I, Kawakami, already discussed with Prof. Yokoyama. First and foremost, this study has asumption.

Deadline: By the end of fiscal year, or before I quit (change) a job.

### 3.3. K. Hayashi

Title: Behavior of elements in deep sea sediments: comparative study on redox sensitive elements under oxic and anoxic environments.

Samples used: core catcher mud (2-4 cores) from each corer sample.

Cooperation: fossil age will be important(?) to calculate sedimentation rate.

## 4. Structural geology (deformation analysis)

### 4.1. A. Yamaguchi, S. Hirano, Y. Dilek

Title: The origin and implication of a young mineral vein collected from the toe of Nankai accretional prism

(Same to Dilek: See Dilek's proposal. Origin and implication of a young mineral vein collected from the Nankai Trough accretionary prism.)

Authors: Asuka Yamaguchi, Yildirim Dilek, Satoshi Hirano (JAMSTEC, carbonate geochemist), and Shipboard scientific party of YK05-08 Leg2

Purpose: To draw the formation history of young mineral vein, and discuss about the on-going deformation and fluid flow processes in the young accretionary prism.

Analysis methods: thin sections (microtextures), XRD (mineral assemblage), XRF (bulk chemical composition of host rock), SEM (microfabrics of deformation structure), EPMA (small-scale compositional changes), Carbon & Oxygen isotope analysis (origin of vein minerals). and, if possible, fluid inclusion (determination of vein-formed P-T), radiometric dating (using U-Th series, with Nakai Lab., ERI, Univ. Tokyo), and permeability test are very attractive analytical methods.

### 4.2. Y. Dilek

A. Sampling Request:

I would like to request a thin-section of each representative rock sample recovered during Dives 885, 887 and 888 from the Tenryu Canyon and during the anticipated Dives in the Shiono-Misaki Canyon and its vicinity for petrographic analysis at Miami University. This proposed analysis will include a careful documentation of depositional and tectonic fabric elements, sedimentological features, and their variations in space and time within the current accretionary prism architecture. Because most of these samples are highly fragile and subject to dry up quickly and because special handling and processing techniques and methods must be employed during thin sectioning (i.e. both alcohol and epoxy treatment), I am requesting thin-sections only (to be made under the guidance of Professor Ogawa at the University of Tsukuba) rather than rock samples. I hope that more rock samples would be spared this way for other shipboard scientists to do some other exciting work with them.

B. Title of Paper: (done by structural geologist party with Yamaguchi, Anma, Ota, Ogawa or else if needed or wanted....Ogawa's opinion)

C. The followings may be better merge to the synthetic paper 7.1. (Ogawa's opinion) or else.

D. Tentative Titles for Papers:

1. Structure and tectonics of the Nankai Trough accretionary prism exposed along the Tenryu Canyon, Japan.

Authors: Dilek, Ogawa, Kawamura, Anma, Sasaki, Kawakami, (All Shipboard Scientific Party...)

4.3. T. Ota and R. Anma

Title: Deformation structures in the accretionary prism section by oriented samples from submersible

Method: To measure AMS (anisotropy of magnetic susceptibility) from all available samples to know the fabrics (sedimentary or deformational or else or all?). In addition, various other physical properties of those samples as many as possible; e.g. porosity, density, permeability etc. to discuss the deformation and related structural history. Also Structural analysis of deformation styles, using thin sections made by embedded method, is to be added. (This work is the graduation thesis of T. Ota in University of Tsukuba, under the guidance of Dr Ryo Anma.)

4.4 Kiichiro Kawamura, Yujiro Ogawa et al. (Anybody is invited, but this is the general

report with new findings)

(AGU Fall meeting Dec. 2005, to Nantro SEIZE session; poster?)

Title: Sedimentation and deformation in the Nankai accretionary prism: Deformation styles and facies from the toe parts along the two canyons

## 5. Physical properties and mechanical behavior

### 5.1. S. Kawamura and O. Aydan

Title: Measurements of rock mass strengths of the Nankai accretionary prisms using Geological Strength Index

Kiichiro Kawamura (Fukada Geological Institute) and Omel Aydan (Tokai University)

Purpose: Geological Strength Index (GSI) is used to be measured an internal friction angle and a cohesion strength of rock mass using outcrop images and strengths of intact rocks. The GSI has been used mainly for a tunnel and/or a dam construction. I will apply such the GSI method to disclose the strength of the rock mass including fractures, faults, and weathering degree in the Nankai accretionary prisms.

Request materials: 1. Dive video data set. 2. Needle penetration test data set

### 5.2. K. Kawamura, S. Kawakami, R. Anma, Y. Ogawa

Title: Physical properties, mechanical properties and deformation microtextures of the Nankai accretionary prisms

Kiichiro Kawamura (Fukada Geological Institute), Shunsuke Kawakami (GSJ), Ryo Anma and Yujiro Ogawa (Tsukuba Univ.)

Purpose: Rock samples collected by the Shinkai manipulator could not describe any original orientation directions, because these rock samples are mostly tumbled and disrupted in the basket of the Shinkai. Therefore, the deformation textures in the rock samples could not be discussed detailedly and accurately. In this cruise, I reconstruct the original orientations of the rock samples using video data and paleomagnetic data. Rough orientation directions can be reconstructed by the video data (but the reconstruction was already done onboard), and detailed orientation direction can be measured by the onshore paleomagnetic data. After the orientation reconstruction by the onshore paleomagnetic measurements, SEM samples and thin section samples for deformation microstructure observations are made by three directions along horizontal, N-S and E-W directions using freeze-drying and embedded methods. Furthermore, physical properties and consolidation tests will be conducted to estimate an experienced maximum burial depths of the rock samples. Based on these results with the age data from Kawakami, I will discuss about deformation regime and history of the rock

samples.

Request materials: 1. One or more rock samples of all the sites. Sizes are required more than 10 x 10 x 10 cm. 2. Needle penetration data set

5.3. K. Tanaka, Y. Ogawa, R. Anma (all at University of Tsukuba)

Title: Consolidation and triaxial tests of sediments and sedimentary rocks from Nankai accretionary prism

(Method) Do above works using two machines at University of Tsukuba and Geological Survey of Japan (AIST), Tsukuba. Consolidation machine upto 10 MPa will be done at University of Tsukuba, and upto 100 MPa at GSJ.

(Sample) As large as possible for coring 3 (diameter) x 6 (height) cm cylindrical specimens at least three or five from each sample. Samples should be kept wet, not frozen, nor dried up.

(Rem) Associated collaboration by anybody is highly welcome. But, this would be part of PhD work of Katsunori Tanaka (Noritan)

6. Geochemistry

6.1. T. Toki

Title: Geochemical study of pore water from Nankai accretionary prism.

(Method and scope)

The pore water samples were retrieved from surface sediment and measured pH, alkalinity, Si, and  $\text{NH}_4^+$  in onboard laboratory. In Ocean Research Institute,  $^3\text{He}/^4\text{He}$  ratio and  $\delta\text{D}_{\text{H}_2}$  in the pore waters will be measured. In Hokkaido University, the pore waters will be analyzed for  $\text{CH}_4$ ,  $\text{C}_2\text{H}_6$ ,  $\text{H}_2$ ,  $\delta\text{CO}_2$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\delta^{13}\text{C}_{\text{CH}_4}$ ,  $\delta^{13}\text{C}_{\text{C}_2\text{H}_6}$ ,  $\delta^{13}\text{C}_{\text{CO}_2}$ ,  $\delta\text{D}_{\text{H}_2\text{O}}$  and  $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ . In Toyama University,  $\delta^{37}\text{Cl}$  and  $\delta^{34}\text{S}_{\text{SO}_4}$  in the samples will be analyzed. Based on the chemical and isotopic compositions of the pore fluids, we will discuss on the origin of the pore fluid.

6.2. R. Anma and Y. Yokoo

Title: Isotopic study of Calyptogena and other carbonate shells from Nankai accretionary prism

Method: Strontium analysis of each layer of Calyptogena shells to know the secular variation and its implication

Sample request: Calyptogena and other shells as many as possible; dead and alive.

6.3 See Yamaguchi et al. at 4.1.

## 7. Tectonics, Geophysics, Seismology, Synthesis

### 7.1. Y. Ogawa et al. : Shipboard Scientific Party

Title: Tectonics of eastern and central Nankai accretionary prism: comparative study along two canyons by submersible

(Proposing to expose in AGU Fall Meeting, Dec. 2005, San Francisco; talk in NanTroSEIZE session)

### 7.2. Y. Dilek et al. "Synthetic paper" See 7.1. Ogawa et al.

Title: Development of structural fabric in accretionary prism sediments in the Nankai Trough, Japan.

[I envision this paper to include some data and observations derived in part from magnetic studies and uniaxial-triaxial stress experiments]

Authors: Dilek, Anma, Kawamura, Norita, Ogawa, Yokoyama, ?

(to all participants: Dilek-san sent me (Ogawa) a proposal letter.

### 7.3. Y. Yagi and T. Nishimura

Titel: Stress state near Nankai Trough

In general, the stress field near seismic source area suddenly changes after large earthquake. If some geological researchers' estimate stress field, P- and T-axis, or stress state, I would like to support them using computer simulation.

### 7.4. T. Sasaki, Y. Ogawa et al.

Title: Comparative subductology: Topographic, geologic, and tectonic consideration from new SeaBeam data from Nankai, Japan and Kurile trenches

Methods: SeaBeam data analysis

(Output) To some international journal

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(List of Shipboard Scientific Party of YK05-08 Leg 2 with onshore collaborative scientists)

1. Yujiro Ogawa (chief scientist; tectonics)
2. Kiichiro Kawamura (vice chief scientist; sedimentology, physical properties)
3. Ryo Anma (substitute for chief; tectonics, structural geology)

4. Ken-ichiro Hayashi (geochemistry; metals)
5. Gregory Frank Moore (tectonics, seismic profiling)
6. Shunji Yokoyama (applied geology, land sliding)
7. Yildirim Dilek (tectonics, structural geology)
8. Shunsuke Kawakami (sedimentologist, rads man)
9. Tomoyuki Sasaki (geomorphology, SeaBeam)
10. Tomohiro Toki (geochemistry, fluid chemistry)
11. Ryota Endo (structural geology, physical properties)
12. Asuka Yamaguchi (structural geology, isotope geochemistry)
13. Yuji Yagi (seismology)
14. Teppei Ota (structural geology)
15. Mamoru Sano (JME)
- (onshore scientist)
17. Yoriko Yokoo (isotope geochemistry) (Doshisha University)
18. Satoshi Hirano (geochemistry) (JAMSTEC at Yokosuka;
19. T. Nishimura (seismology) (Univ. Tsukuba)
20. Katsunori Tanaka (Noritan) (Triaxial structural geology)

## 12. Summary

As described above, we have performed ten dives to the canyons of the Nankai trough by submersible with associated mapping in and around. Our dive results range various parts of science, and were summarized below.

1. Seven dives were done in the Tenryu canyon area, and we elucidated the rather full extent of the inside structure of the Nankai accretionary prism in the eastern part from the toe to the Tokai thrust, the latter may correspond to the out-of-sequence thrust.
2. Three dives were done in the Shionomisaki canyon area, only at the outer ridge (western extension of the Kumano ridge), which corresponds to the out-of-sequence thrust. We verified the full cross section of the splay fault system.
3. In both areas, sedimentary sequences are very much deformed into shear fractures, faults and folds. Rock samples attain sufficient for the structural study, and the in situ orientation are being marked by magnetometric method.
4. Beds are in places mostly mudstone, but in other places mostly sandstone; and in general they are of turbidites. Considering the oldest age of the sedimentary rocks at each site (down to late Pliocene, around 3 MaBP), most of the sedimentary rocks were deposited as in the Shikoku basin sequence, and were accreted by offscraping or underplating, and deformed by those processes and additional ridge subduction, particularly in the Tenryu canon area.
5. Beds are more or less inclined, although considerable areas are occupied by subhorizontal beds. They show faults (normal and reverse faults) and folds (open and close or tight). Such deformation styles must be in close relationship to the minor elements of deformation, and will be studied onshore.
6. Seepage zones are rather many in most of the dive sites, and methane-bearing fluid supported biocommunities were recognized and sampled. Also the surrounding superficial sediments were sampled. They are being studied by geochemical methods.
7. Radiolarian biostratigraphy was successful to know the ages of sedimentary rocks, ranging from upper Pliocene to upper Pleistocene.
8. Some clams collected are important for future study.
9. Future studies in various aspects must verify much more interesting features of development of the prism, and will soon be published.

(The End of Text)

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# Appendices

# A-1. Inventory Sheet

インベントリ基本情報記入シート(1)

インベントリ		プロポーザル		実施要領書	
使用船舶		「よこすか」		「よこすか」	
使用機器		「しんかい16500」		「しんかい16500」	
航海番号		YK05-08		YK05-08 LEG2	
プロポーザル受付番号		S 0 5 - 14			
研究分野		生物圏			
課題名		南海付加体トランセクト-天竜・潮岬海底谷ダイブ計画：構造観察と物性測定のための連続サンプリング			
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	所属機関	筑波大学			
	所属部署	大学院生命環境科学研究科			
	職名	教授			
	住所				
	電話番号				
	ファックス				
	E-mail				
調査海域		南海トラフ		南海トラフ	
緯度、経度		32° 40.0N - 33° 20.0N 135° 45.0E - 136° 15.0E		32° 00N-34° 20.0N-32° 00N-33° 15N-34° 20N 135° 00E-137° 30E-138° 00E-135° 00E-138° 00E	
水深		1300-4600m		1300-4600m	
EEZ申請の有無		無		無	
EEZ関連の条件		無		無	
出港年月日		2005/6/20		2005/6/20	
出港地		和歌山港		和歌山港	
入港年月日		2005/7/8		2005/7/8	
入港地		JAMSTEC		JAMSTEC	
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	18.position/氏名 所属				
	19.position/氏名 所属				
	20.position/氏名 所属				

印：プロポーザル段階での乗船予定者

研究者グループ名簿

プロポーザル受付番号	S05-14	
研究分野	生物圏	
課題名	南海付加体トランセクト天竜・潮岬海底谷ダイブ計画 構造観察と物性測定のための連続サンプリング	
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## A-2. Miscellaneous

Sample list of Dive #885

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#885 R-001	Rock	33°42.6059	137°31.9790	2,778
#885 R-002	Rock	33°42.3985	137°31.7658	2,742
#885 R-003	Rock	33°42.1904	137°31.5932	2,707
#885 R-004	Rock	33°41.1630	137°31.6277	2,660
#885 C-001	MBARI core	33°41.7443	137°31.8594	2,552
#885 C-002	CC core	33°41.7443	137°31.8594	2,552



## 6K#885 R-001

Dark greenish gray (5G 4/1) fine sandstone (from crust to core, color dusky red (5R 3/4) to light brown (5YR 5/0))



## 6K#885 R-002

Light olive gray (5Y 5/2) fine sandstone  
Surface is covered with reddish brown crust of probably manganese oxides.

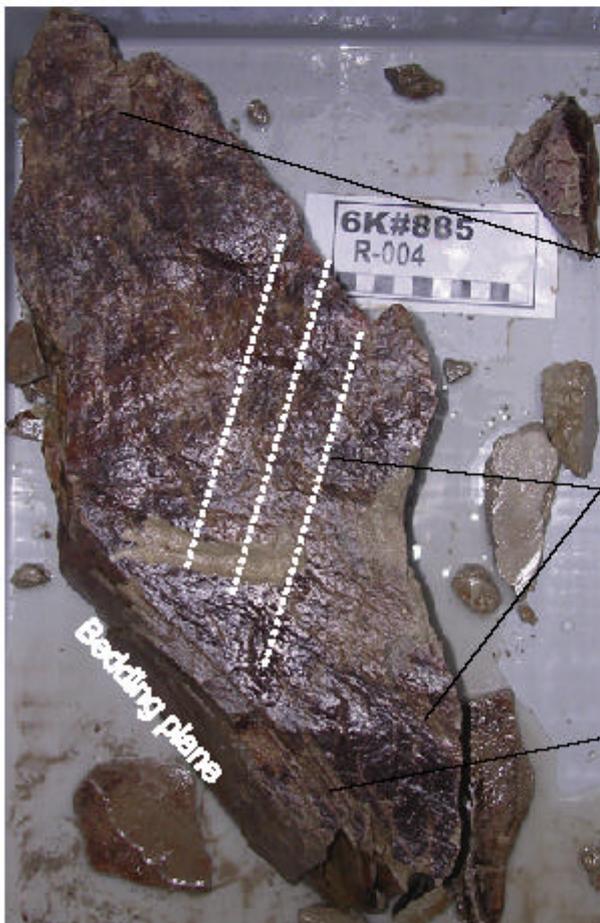
Medium bluish gray mudstone

Graysh brown (5YR 3/2) slightly fissile mudstone



## 6K#885 R-003

Light olive gray (5Y 5/2) mudstone with conjugate joints of closely spaced "sheeting" like planes



## 6K#885 R-004

Light olive grey (5Y 5/2) fine sandstone and mudstone

Spaced fractures crosses to bedding plane

"Sheeting"-like joints parallel to bedding plane

# 6K#885 C-001



## 6K#885 C-001 MBARI Core

June 23, 2005  
33,41.7443' N  
137,31.8594' E  
2525 m

cm	Sub no.	Color	Texture	Description
0	1	dark brown	loose	silty to clayey
	2			
	3			
5	4	dark grey	contains pebble breccia	
	5			
	6			
	7			
10	8			
	9			
	10			
15	11			
	12			
20				

### Sample list of Dive #886

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#886 R-001	Rock	33 ° 43.0652	137 ° 23.1066	2,584
#886 R-002	Rock	33 ° 43.0958	137 ° 23.1014	2,566
#886 C-001	MBARI core	33 ° 42.6511	137 ° 22.6863	2,531
#886 C-002	CC core	33 ° 42.6511	137 ° 22.6863	2,531
#886 C-003	MBARI core	33 ° 43.4168	137 ° 23.2218	2,379
#886 C-004	CC core	33 ° 43.4168	137 ° 23.2218	2,379



## 6K#886 R-001

Graysh mudstone with no bedding structure.



## 6K#886 R-002

Olive mudstone with massive structure.



6K#886 C-001



6K#886 C-003

# 6K#886 C-002

June 24, 2005  
33;42.6511' N  
137;22.6863' E  
2531 m

cm	Sub no.	Color	Texture	Description
0	1	dark brown	loose	silty to clayey
	2			
5	3	dark gray		
	4			
	5		compact	
10	6			
	7			
	8			
15				



no. 1  
0.0-2.0 cm



no. 2  
2.0-4.0 cm



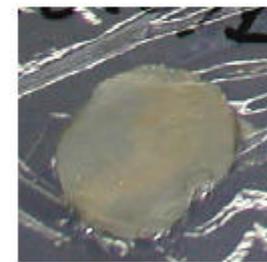
no. 3  
4.0-6.0 cm



no. 4  
6.0-8.0 cm



no. 5  
8.0-10.0 cm



no. 6  
10.0-11.0 cm



no. 7 & 8  
11.0-15.0 cm

# 6K#886 C-004

June 24, 2005  
 33j43.4168' N  
 137j23.2218' E  
 2379 m

cm	Sub no.	Color	Texture	Description
0	1	dark brown	loose	silty to clayey
	2			
5	3	dark gray	compact	
	4			
	5			
10	6			
	7			
	8			
	9			
	10			
20	11			
	12			

25 —



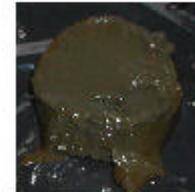
no. 1  
0.0-2.0 cm



no. 2  
2.0-4.0 cm



no. 3  
4.0-6.0 cm



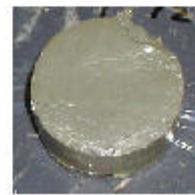
no. 4  
6.0-8.0 cm



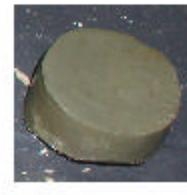
no. 5  
8.0-10.0 cm



no. 6  
10.0-12.0 cm



no. 7  
12.0-14.0 cm



no. 8  
14.0-16.0 cm



no. 9  
16.0-17.5 cm



no. 10  
17.5-19.5 cm



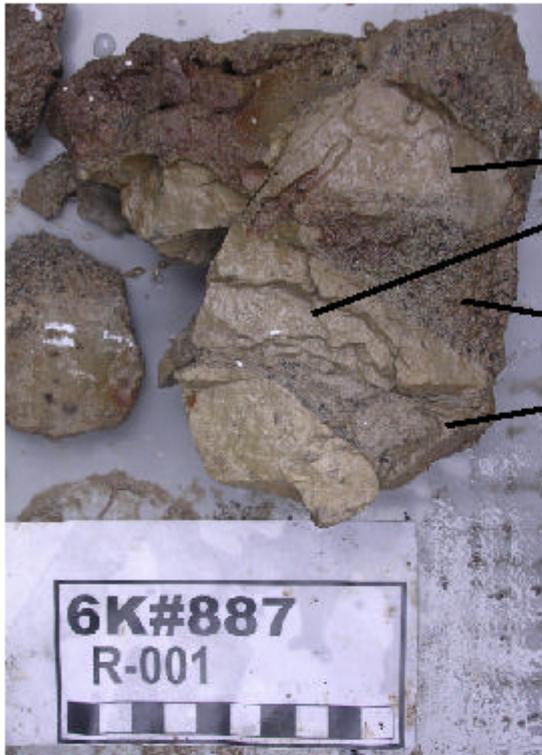
no. 11  
19.5-21.5 cm



no. 12  
21.5-23.5 cm

### Sample list of Dive #887

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#887 R-001	Rock	33 ° 43.0342	137 ° 28.6258	2,696
#887 R-002	Rock	33 ° 43.1352	137 ° 28.6275	2,700
#887 R-003	Rock	33 ° 43.1965	137 ° 28.6444	2,690
#887 R-004	Rock	33 ° 43.4479	137 ° 28.6737	2,560
#887 R-005	Rock	33 ° 43.6008	137 ° 28.6793	2,454
#887 R-006	Rock	33 ° 43.7306	137 ° 28.7315	2,394
#887 C-001	CCcore	33 ° 43.1352	137 ° 28.6275	2,700
#887 C-002	MBARI core	33 ° 43.4645	137 ° 28.5796	2,486
#887 C-003	CC core	33 ° 43.4645	137 ° 28.5796	2,486



## 6K#887 R-001

Yellowish gray (5y7/2)  
mudstone

Graysh olive (10Y 4/2) coarse  
sandstone



## 6K#887 R-002

Light olive gray (5Y 5/2)  
mudstone

Graysh black (N2)  
manganese crust

Reddish brown part (10R 4/6)  
goethite?

## 6K#887 R-003



Light olive brown (5Y 5/6) mudstone with thin sandstone laminae and/or bed

Light olive gray (5Y 5/2) mudstone

Light olive gray (5Y 5/2) mudstone with sandstone laminae

## 6K#887 R-004



Bluish gray (5BG 3/2)  
fine-medium grained sandstone



## 6K#887 R-005

Olive gray (5Y 4/1) fine to medium grained sandstone



## 6K#887 R-006

Light olive brown (5Y 5/6) mudstone with sandstone bed



Fresh surface after diamond cutter section

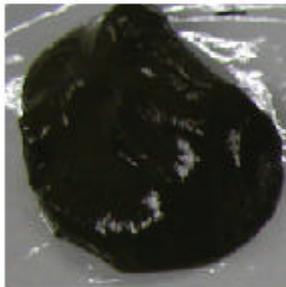
Finely laminated medium to fine grained sandstone

Graysh olive (10Y 4/2) mudstone

# 6K#887 C-001

June 25, 2005  
33j43.1352' N  
137j28.6275' E  
2700 m

cm	Sub no.	Color	Texture	Description
0	1	dark brown	loose	silty to clayey
	2	brownish gray	compact	
	3			
5	4			
	5			
	6			
10	7			
	8			
15				



no. 1  
0.0-2.0 cm



no. 2  
2.0-4.0 cm



no. 3  
4.0-6.0 cm



no. 4  
6.0-8.0 cm



no. 5  
8.0-9.5 cm



no. 6  
9.5-11.5 cm



no. 7  
11.5-13.5 cm



no. 8  
13.5-14.5 cm



**6K#887 C-002**

# 6K#887 C-003

June 25, 2005  
33°43.4645' N  
137°28.5796' E  
2486 m

cm	Sub no.	Color	Texture	Description
0	1	dark brown	loose	silty to clayey
	2			
5	3	dark gray	compact	
	4			
	5			
10	6			fine sandstone
	7			
	8			
15				



no. 1  
0.0-2.0 cm



no. 2  
2.0-4.0 cm



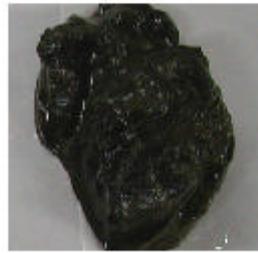
no. 3  
4.0-6.0 cm



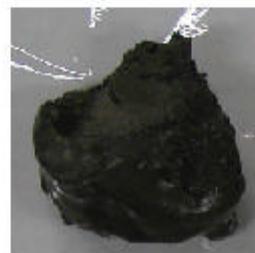
no. 4  
6.0-8.0 cm



no. 5  
8.0-9.5 cm



no. 6  
9.5-11.5 cm



no. 7  
11.5-13.5 cm



no. 8  
13.5-14.5 cm

Sample list of Dive #888

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#888 R-001	Rock	33°32.6491	137°26.2109	3,691
#888 R-002	Rock	33°32.6498	137°26.2066	3,690
#888 R-003	Rock	33°43.1965	137°28.6444	3,690
#888 R-004	Rock	33°32.7234	137°26.0636	3,611



## 6K#888 R-001

Light brown (5YR 5/6) sandstone

Graysh olive (10Y 4/2)  
fine sandy mudstone  
Shiny fragments are included



## 6K#888 R-002

Dark greenish gray (5G 4/1)  
sandstone

Light olive gray (5Y 5/2)  
sandstone

## 6K#888 R-003



Moderate yellowish brown (10YR 5/4);  
finely laminated sandstone

Black (N1) manganese coating

Light olive gray (5Y 5/2) sandstone

## 6K#888 R-004



Pale yellowish brown (10YR 4/2)  
mudstone

Medium dark gray (N4) mudstone

Sample list of Dive #889

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#889 R-001	Rock	33°01.8164	136°04.7172	3,443
#889 R-002	Rock	33°01.7666	136°04.9579	3,379
#889 R-003	Rock	33°01.6801	136°04.9189	3,394
#889 R-004	Rock	33°01.4976	136°04.9236	3,387
#889 R-006	Rock	33°01.4568	136°04.9236	3,387
#889 R-007	Rock	33°01.3536	136°04.9429	3,370
#889 B-001	Organism	33°01.5496	136°04.9112	3,400
#889 B-002	Organism	33°01.4976	136°04.9189	3,470
#889 C-001	MBARI core	33°01.5496	136°04.9112	3,400
#889 C-002	CC core	33°01.5496	136°04.9112	3,400

## 6K#889 R-001



Dark yellowish green (5GY 5/2)  
siltstone

## 6K#889 R-002



Moderate olive berry (5Y 4/4)  
siltstone

Manganese coating



## 6K#889 R-003

Greenish yellow (5G 6/1) mudstone

Moderate yellowish brown (10YR 5/4) mudstone  
Weakly laminated

Brownish black (5YR 2/1) thin manganese coating



## 6K#889 R-004

Dark yellowish orange (10YR 6/0) oxidized part

Medium gray (N5) sandstone



## 6K#889 R-006



Light olive brown (5Y 5/0) medium to coarse quartzose sandstone

Manganese coating

## 6K#889 R-007

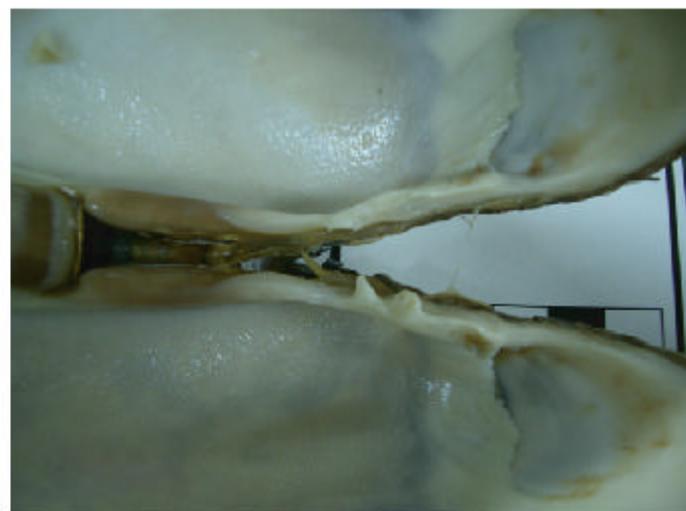


Graysh green (5G 5/2)  
fine sandstone



Moderate olive brown (5Y 4/4)  
coarse to medium sandstone

## 6K#889 biological samples



*Calyptogena nautiliei*

Sample locality: Shiono-misaki submarine canyon

Longitude, latitude: 136: 04.92E, 33: 01.50N

Depth: 3,407 m

Size: 15 cm (length) x 8.5 cm (width) x 7 cm (breadth)  
with prominent teeth (in right)



Vestimentiferan (dead shell)

Sample locality: Shiono-misaki submarine canyon

Longitude, latitude: 136: 04.92E, 33: 01.50N

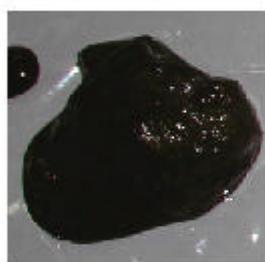
Depth: 3,407 m

Size: 14.5cm (length) x 0.7 - 0.5 cm (diameter)

# 6K#889 C-002

June 29, 2005  
 33°1.5946' N  
 136°4.9112' E  
 3400 m

cm	Sub no.	Color	Texture	Description
0	1	brown	loose	silty to clayey
	2			
5	3	brownish gray	compact	
	4			
10	5	gray		
	6			
	7			
	8			
15	9			



no. 1  
0.0-2.0 cm



no. 2  
2.0-4.0 cm



no. 3  
4.0-6.0 cm



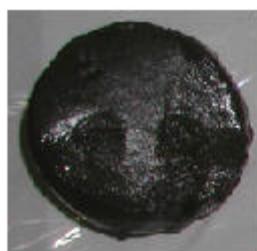
no. 4  
6.0-8.0 cm



no. 5  
8.0-10.0 cm



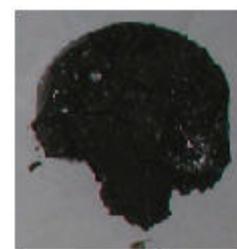
no. 6  
10.0-11.5 cm



no. 7  
11.5-13.5 cm



no. 8  
13.5-15.5 cm



no. 9  
15.5-16.5 cm

## Sample list of Dive #890

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#890 R-001	Rock	33 ° 01.3226	136 ° 04.9446	3,396
#890 R-002	Rock	33 ° 01.2140	136 ° 04.9639	3,380
#890 R-003	Rock	33 ° 01.0654	136 ° 04.9823	3,361
#890 R-004	Rock	33 ° 0.8955	136 ° 04.9930	3,362
#890 R-005	Rock	33 ° 0.7989	136 ° 5.0953	3,391
#890 B-001	Organism	33 ° 0.8551	136 ° 5.0204	3,409
#890 B-002	Organism	33 ° 0.8220	136 ° 5.0409	3,421
#890 C-001	MBARI core	33 ° 0.8552	136 ° 5.0205	3,410
#890 C-002	MBARI core	33 ° 0.8221	136 ° 5.0410	3,422

## 6K#890 R001



Moderate brown (5Y 4/4) scaly cleaved mudstone or claystone

Graysh green (10GY 5/2) rounded quartzose coarse sandstone

## 6K#890 R-002



Graysh green (10GY 5/2) siliceous mudstone or fine sandstone

## 6K#890 R-003



Weathered surface  
Yellowish gray (5Y 7/2)

Fresh surface  
Pale blue (5B 6/2) medium to coarse sandstone  
(with calcite cementation?)

## 6K#890 R-004



Weathered surface  
Graysh brown (5YR 3/2)

Fresh surface  
Pale blue (5B 6/2) sandstone

# 6K#890 R-005



Yellowish gray (5Y 7/2)  
mudstone  
Bioturbated and graded

Many small holes

# 6K#890 biological samples

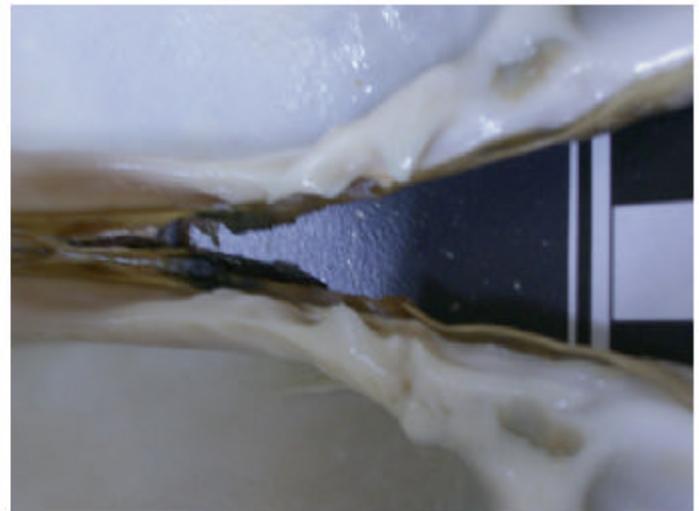
*Calyptogena nautiliei*



Sample name: 6K#890 B-001

Longitude, latitude: 136: 05.02E, 33: 00.86N

Size: 14.6 cm (length) x 7.9 cm (width) x 6.4 cm (breadth) with prominent teeth (in right)



Sample locality: Shiono-misaki submarine canyon

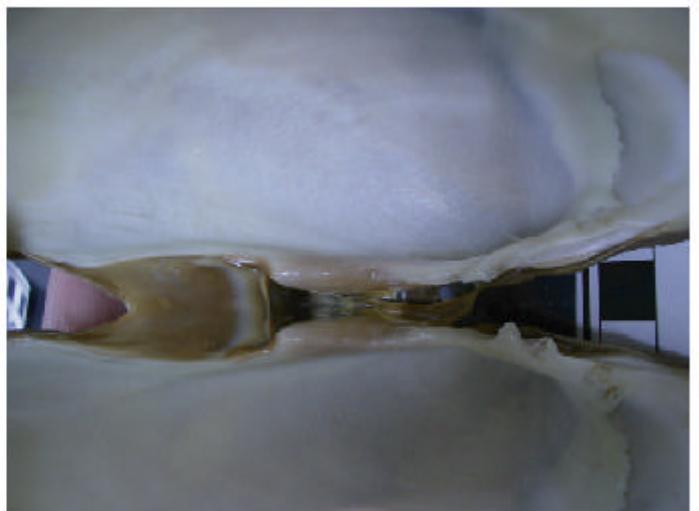
Depth: 3,409 m



Sample name: 6K#890 B-002

Longitude, latitude: 136: 05.02E, 33: 00.86N

Size: 13.8 cm (length) x 7.8 cm (width) x 6.3 cm (breadth) with prominent teeth (in right)



Sample locality: Shiono-misaki submarine canyon

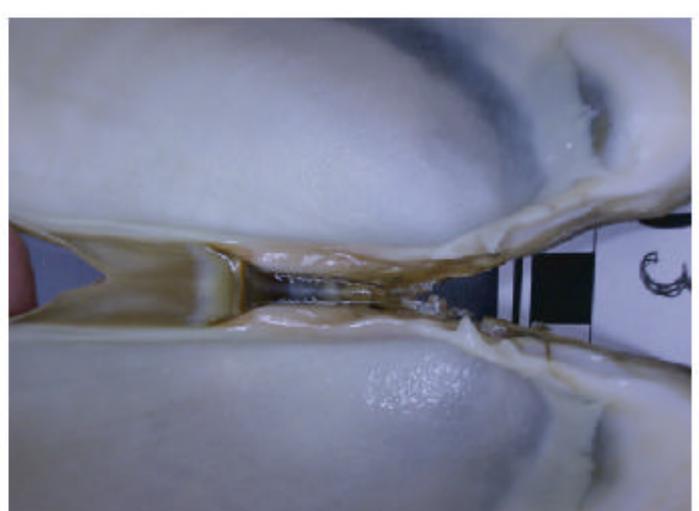
Depth: 3,409 m



Sample name: 6K#890 B-003

Longitude, latitude: 136: 05.04E, 33: 00.82N

Size: 12.6 cm (length) x 7.0 cm (width) x 4.8 cm (breadth) with prominent teeth (in right)



Sample locality: Shiono-misaki submarine canyon

Depth: 3,421 m

## Sample list of Dive #891

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#891 R-001	Rock	33 ° 02.6507	136 ° 05.1810	3,349
#891 R-002	Rock	33 ° 02.5544	136 ° 05.2058	3,338
#891 R-004	Rock	33 ° 02.5526	136 ° 05.2084	3,336
#891 R-005	Rock	33 ° 02.3376	136 ° 05.1561	3,220
#891 R-006	Rock	33 ° 02.1800	136 ° 05.1840	3,190
#891 R-007	Rock	33 ° 01.8323	136 ° 05.1857	3,120
#891 R-008	Rock	33 ° 01.7728	136 ° 05.2353	3,129
#891 B-001	Organism	33 ° 02.6536	136 ° 05.1600	3,367
#891 B-002	Organism	33 ° 02.6536	136 ° 05.1600	3,367
#891 C-001	MBARI core	33 ° 02.6536	136 ° 05.1600	3,367
#891 C-002	CC core	33 ° 02.6536	136 ° 05.1600	3,367
#891 C-003	CC core	33 ° 01.7299	136 ° 05.2906	3,129

## 6K#891 R-001



Greenish gray sandy mudstone  
with burrows by organisms

## 6K#891 R-002



Fissile mudstone

Thin manganese coating

Lithic coarse to medium  
sandstone



## 6K#891 R-004



Pale olive (10Y 6/2) mudstone

Hole of burrow

## 6K#891 R-005



Graysh green (10GY 5/2) sandstone

Color of weathered surface changes to dusky yellow (5Y 6/4)

## 6K#891 R-006



Pale olive (10Y 6/2) mudstone

Manganese coating

Sand inside burrow

## 6K#891 R-007



Light olive gray (5Y 5/2)  
mudstone

## 6K#891 R-008



Laminated fine sandstone

Light olive brown (5Y 5/6) sandstone

Weathered surface (moderate reddish brown, 10R 4/6)

6K#891 C-001



# 6K#891 C-002

July 1, 2005  
33;2.6536' N  
136;5.1600' E  
3367 m

cm	Sub no.	Color	Texture	Description
0	<b>1</b>	brown	loose	silty to clayey
	<b>2</b>	dark brown	compact	
	<b>3</b>	dark gray		
5	<b>4</b>			
10				



no. 1  
0.0-2.0 cm



no. 2  
2.0-4.0 cm



no. 3  
4.0-6.0 cm



no. 4  
6.0-8.0 cm

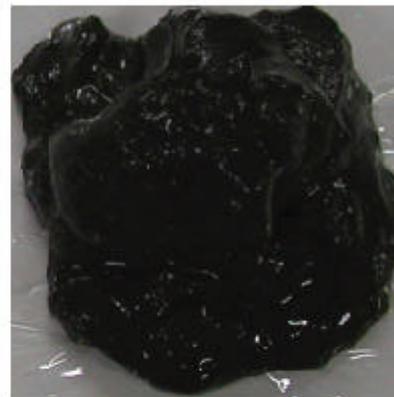
# 6K#891 C-003

July 1, 2005  
33j1.7299' N  
136j5.2906' E  
3129 m

cm	Sub no.	Color	Texture	Description
0	1	dark gray	loose	silty to clayey
	2		compact	
5				

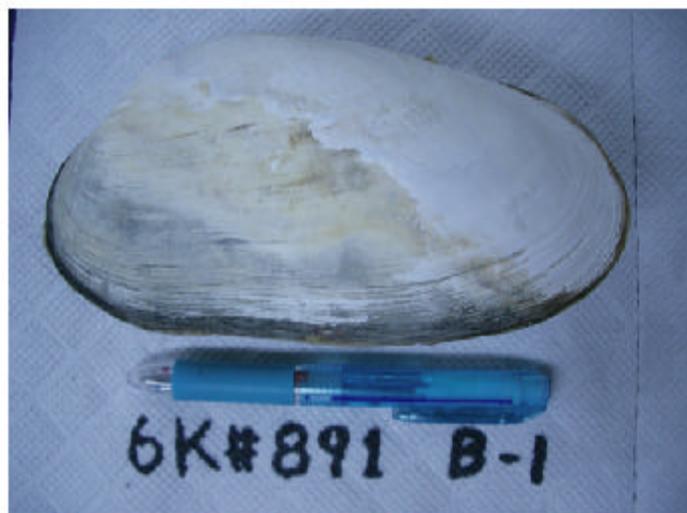


no. 1  
0.0-2.0 cm



no. 2  
2.0-4.0 cm

# 6K#891 biological samples *Calyptogena nautiliei*



Sample name: 6K#891 B-001 (1)

Longitude, latitude: 136: 05.16E, 33: 02.65N

Size: 15.5 cm (length) x 7.7 cm (width) x 6.4 cm (breidth)

Sample locality: Shiono-misaki submarine canyon

Depth: 3,367 m

# 6K#891 biological samples

*Calyptogena nautiliei*



Sample name: 6K#891 B-001 (2)  
Longitude, latitude: 136: 05.16E, 33: 02.65N  
Size: 13.8 cm (length) x 7.3 cm (width) x 5.2 cm (breidth)

Sample locality: Shiono-misaki submarine canyon  
Depth: 3,367 m



Sample name: 6K#891 B-001 (3) dead shell  
Longitude, latitude: 136: 05.16E, 33: 02.65N  
Size: 13.0 cm (length) x 8.6 cm (width) x 7.0 cm (breidth)



Sample locality: Shiono-misaki submarine canyon  
Depth: 3,367 m

## Sample list of Dive #892

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#892 R-001	Rock	33 ° 50.8677	137 ° 33.6037	2,194
#892 R-002	Rock	33 ° 50.5828	137 ° 33.6858	2,149
#892 R-003	Rock	33 ° 50.4194	137 ° 33.8669	2,001
#892 R-004	Rock	33 ° 50.3664	137 ° 34.0864	1,852
#892 R-005	Rock	33 ° 50.4083	137 ° 33.5406	2,194
#892 B-001	Organism	33 ° 50.8677	137 ° 33.6037	2,194
#892 C-001	MBARI core	33 ° 50.8677	137 ° 33.6037	2,194
#892 C-002	CC core	33 ° 50.8677	137 ° 33.6037	2,194

**6K#892 R-002**



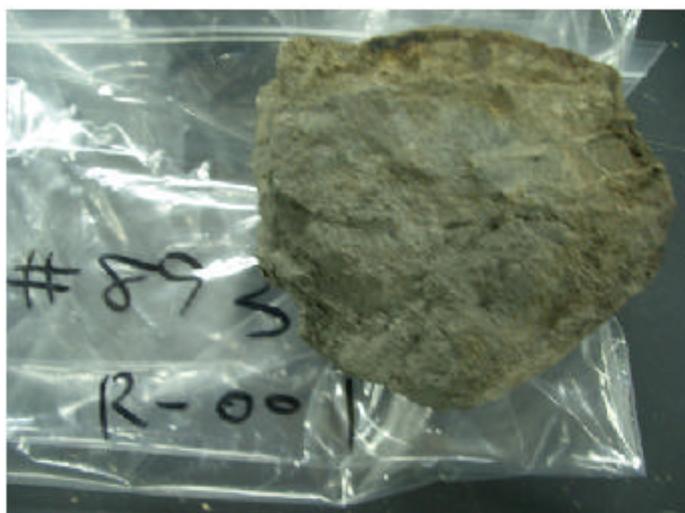
**6K#892 R-003**



Sample list of Dive #893

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#893 R-001	Rock	33-46.2981	137-31.5386	2,643
#893 R-002	Rock	33-46.3591	137-31.5131	2,619
#893 R-003	Mud	33-47.0912	137-31.4332	2,434
#893 R-004	Rock	33-47.1392	137-31.4025	2,401
#893 R-005	Rock	33-46.5791	137-31.4786	2,538
#893 B-001	Tube warm	33-47.1392	137-31.4025	2,401
#893 C-001	MBARI core	33-46.5791	137-31.4786	2,538
#893 C-002	CC core	33-46.5791	137-31.4786	2,538
#893 C-003	MBARI core	33-47.1908	137-31.3766	2,379

# #893 R-001



# #893 R-002

# #893 R-004



# #893 R-005

**6K#893 biological sample**

Vestimentiferan



Sample locality: Tenryu submarine canyon

Longitude, latitude: 137: 31.40E, 33: 47.14N

Depth: 2,401 m

Size: 38cm (length) x 1.2 cm (diameter)

# 6K#893 C-001

July 5, 2005  
33°46.5791' N  
137°31.4786' E  
2538 m

cm	Sub no.	Color	Texture	Description
0	1	brownish grey	loose	silty to clayey
	2			
5	3	grey	compact	
	4			
	5			
10	6			



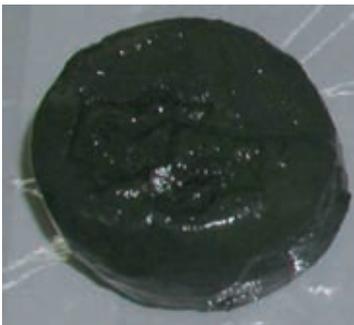
no. 1  
0.0-2.0 cm



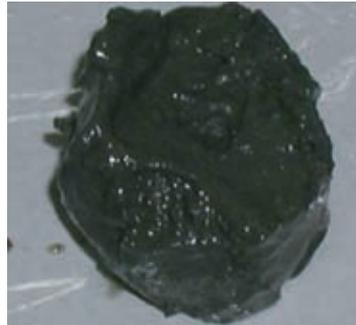
no. 2  
2.0-4.0 cm



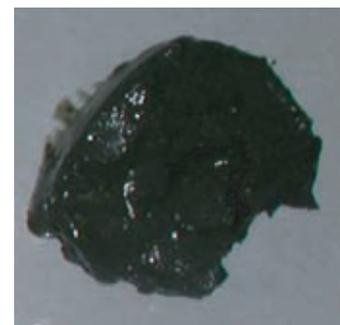
no. 3  
4.0-6.0 cm



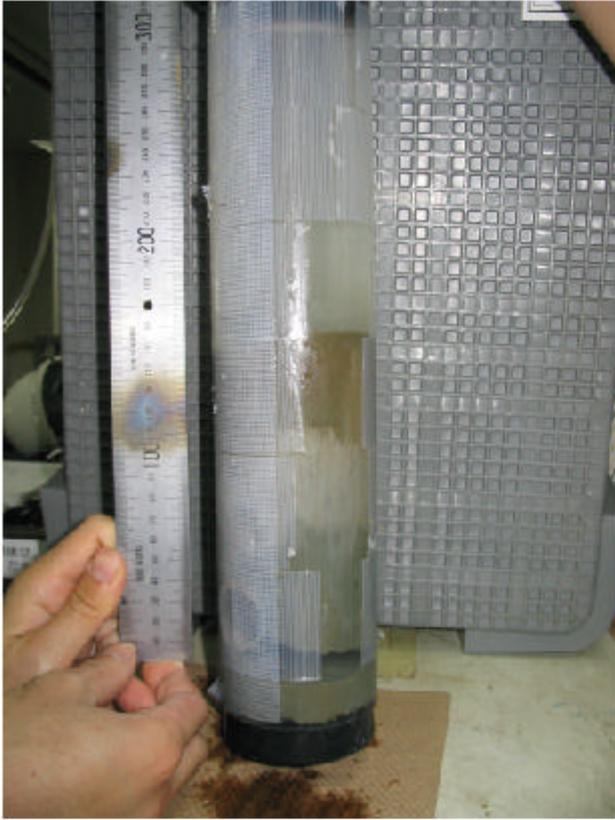
no. 4  
6.0-8.0 cm



no. 5  
8.0-10.0 cm



no. 6  
10.0-11.0 cm



#893 C-002



#893 C-003

# 6K#893 C-004

July 5, 2005  
33°47.1908' N  
137°31.3766' E  
2379 m

cm	Sub no.	Color	Texture	Description
0	1	brownish grey	loose	silty to clayey
	2		compact	
5	3	grey		containing pebble

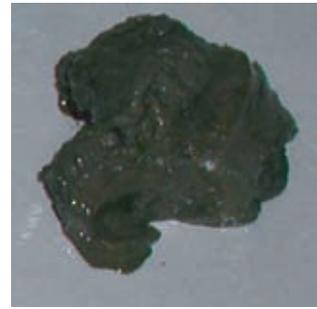
10 —



no. 1  
0.0-2.0 cm



no. 2  
2.0-4.0 cm



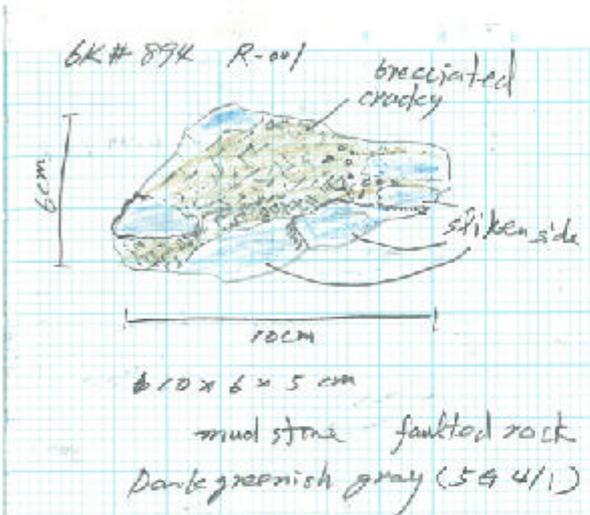
no. 3  
4.0-6.0 cm

### Sample list of Dive #894

Sample No.	Sample type	Latitude (N)	Longitude (E)	Depth (m)
#894 R-001	Rock	33-34.7275	137-24.9569	3,287
#894 R-002	Rock	33-34.7488	137-24.8302	3,202
#894 R-003	Rock	33-34.9652	137-24.7078	3,131
#894 R-004	Rock	33-35.0485	137-24.6608	3065
#894 R-005	Rock	33-35.0759	137-24.6526	3074
#894 B-001	Calypt	33-35.0135	137-24.6949	3,058
#894 C-001	MBARI core	33-35.0135	137-24.6949	3,058
#894 C-002	MBARI core	33-35.0135	137-24.6949	3,058
#894 C-003	CC core	33-35.0135	137-24.6949	3,058



#894 R-002



#894 R-001



#894 R-003



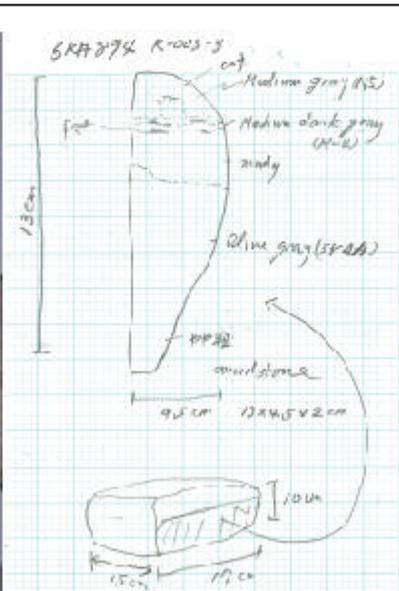
#894 R-004-1



#894 R-004-2



#894 R-005-1



#894 R-005-3



#894 R-005-2

# 6K#894 biological samples *Calyplogena* & *Vesicomomyidae*



Sample name: 6K#894 B-001 (2 alive, 3 dead shells)  
Longitude, latitude: 137: 24.69E, 33: 35.01N

Sample locality: Tenryu submarine canyon  
Depth: 3,058 m

Top left: *Calyplogena nautiliei* (alive); Size: 9.0 cm (length) x 5.1 cm (width) x 3.7 cm (breadth)

Top right: *Vesicomomya* sp. (alive); Size: 5.2 cm (length) x 3.3 cm (width) x 2.4 cm (breadth)

Left middle: dead *Vesicomomya* sp. shells no. 3 to no. 5 from the left:

3. Size: 5.3 cm (length) x 3.5 cm (width) x 2.4 cm (breadth) with prominent teeth (bottom right)

4. Size: 4.8 cm (length) x 3.1 cm (width) x 2.1 cm (breadth)

5. Size: 4.1 cm (length) x 2.5 cm (width) x 1.8 cm (breadth)

Bottom left: host muddy sediments in site 6K#894 B-001



#894 C003