doi : 10.17596/0003591

Cruise Report of YK06-02

April 12 – April 21, 2006

(Yokosuka – Wakayama)

Preface

YK06-02 was held by R/V *Yokosuka* and the manned submersible *Shinkai 6500*. The mother vessel embarked on April 12, from JAMSTEC pier in Yokosuka and disembarked on April 21, 2006 at Wakayama harbor. This is the preliminary on board report of the cruise.

1. Background and purpose of project

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 that in Barbados and Nankai. However such methods can identify only large scale and micro or small-scale variation in mostly 2D. Although it is of prime importance to study the outcrop scale structures in order to understand detail tectonics development. The real geology by seeing the outcrops under the sea is used to be very difficult although it gives us very important 3D informations, but is only given by submersble observation.

On land, 3D geological survey is done along rivers where continuous exposures are obtained. Under the sea if dissected canyons are developed cutting the accretionary prism, they must provide the best places to visit. However only few examples of submersible study along the canyons have ever been done by submassive study have ever been tried by two of our team members, Anma et al. (2002, JAMSTEC Deep-Sea Res.) and Kawamura et al. (1999, JAMSTEC Deep-Sea Res.) to the Tenryu and Shionomisaki cyanions of the Nankai accretionary prism, respectively.

We will perform geologic structure survey cautiously along these canyons: we compare the geologic in between canyons, and will analyse the tectonic and mechanical history of accretionary prism in different parts; the former as of a typical type, wheareas thelatter is of the collapsed type by ridge subduction collision.

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

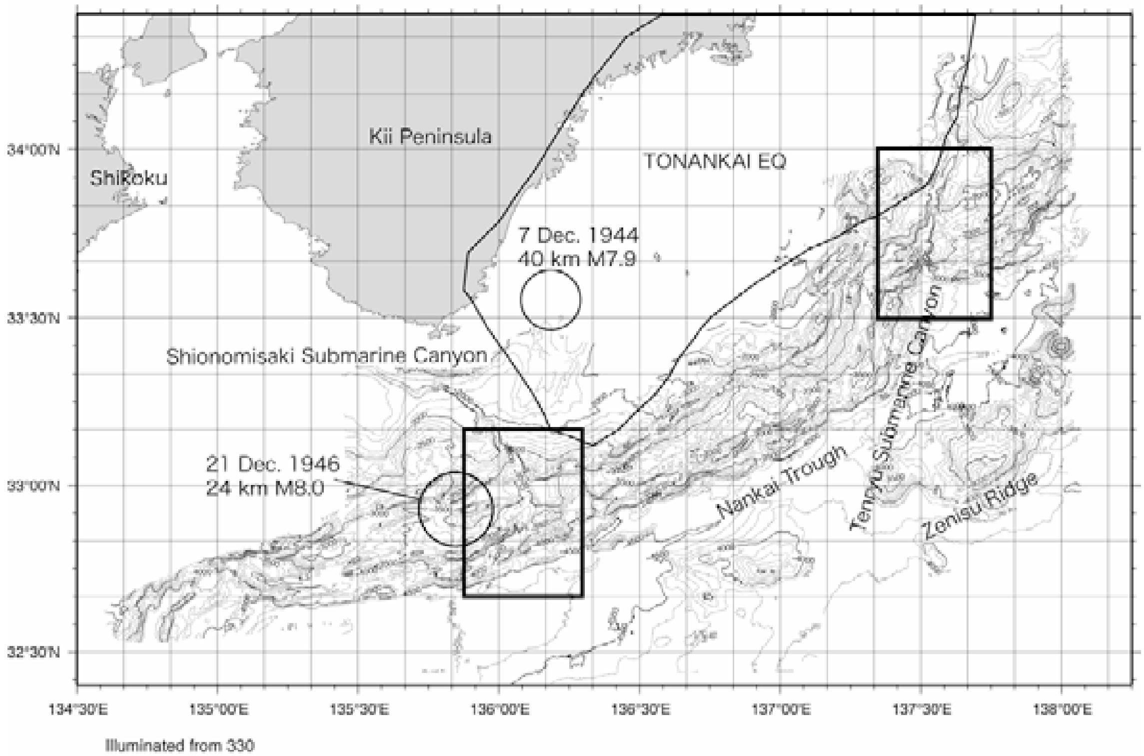


Figure: Study area

Shiono–Misaki Canyon Area

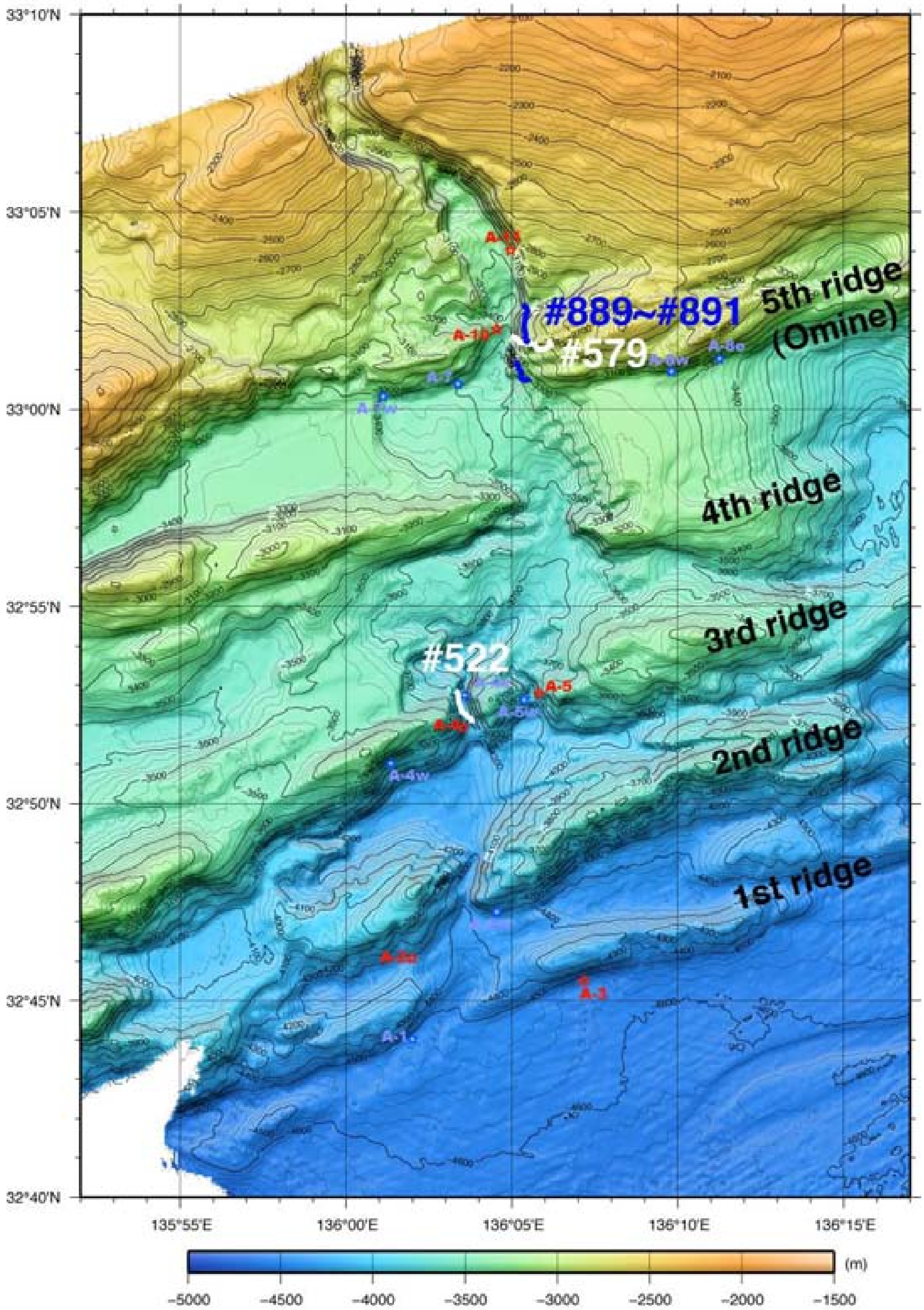


Figure: Planned dive sites of cruise YK06-02

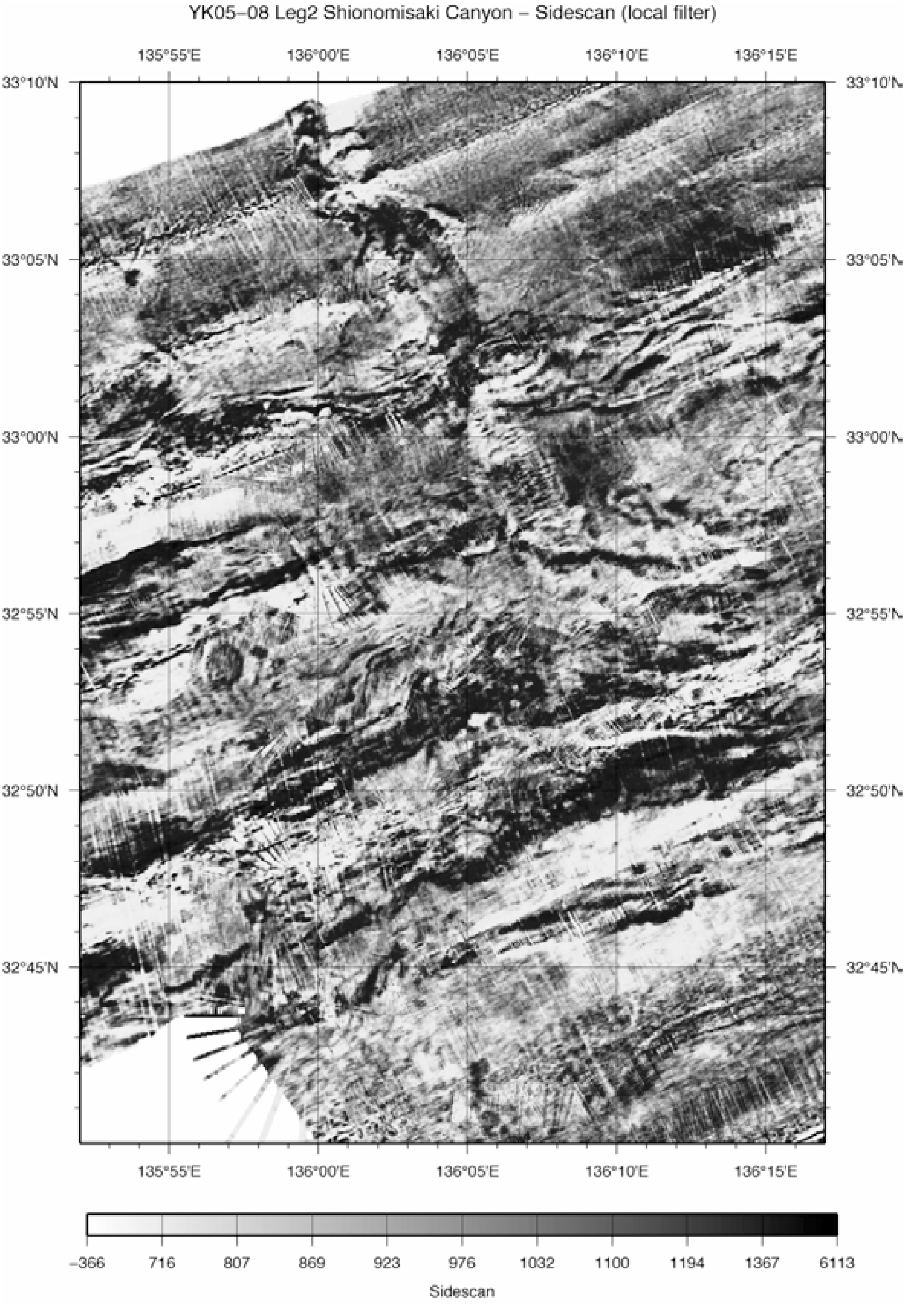


Figure: Sidescan image around the Shionomisaki Canyon

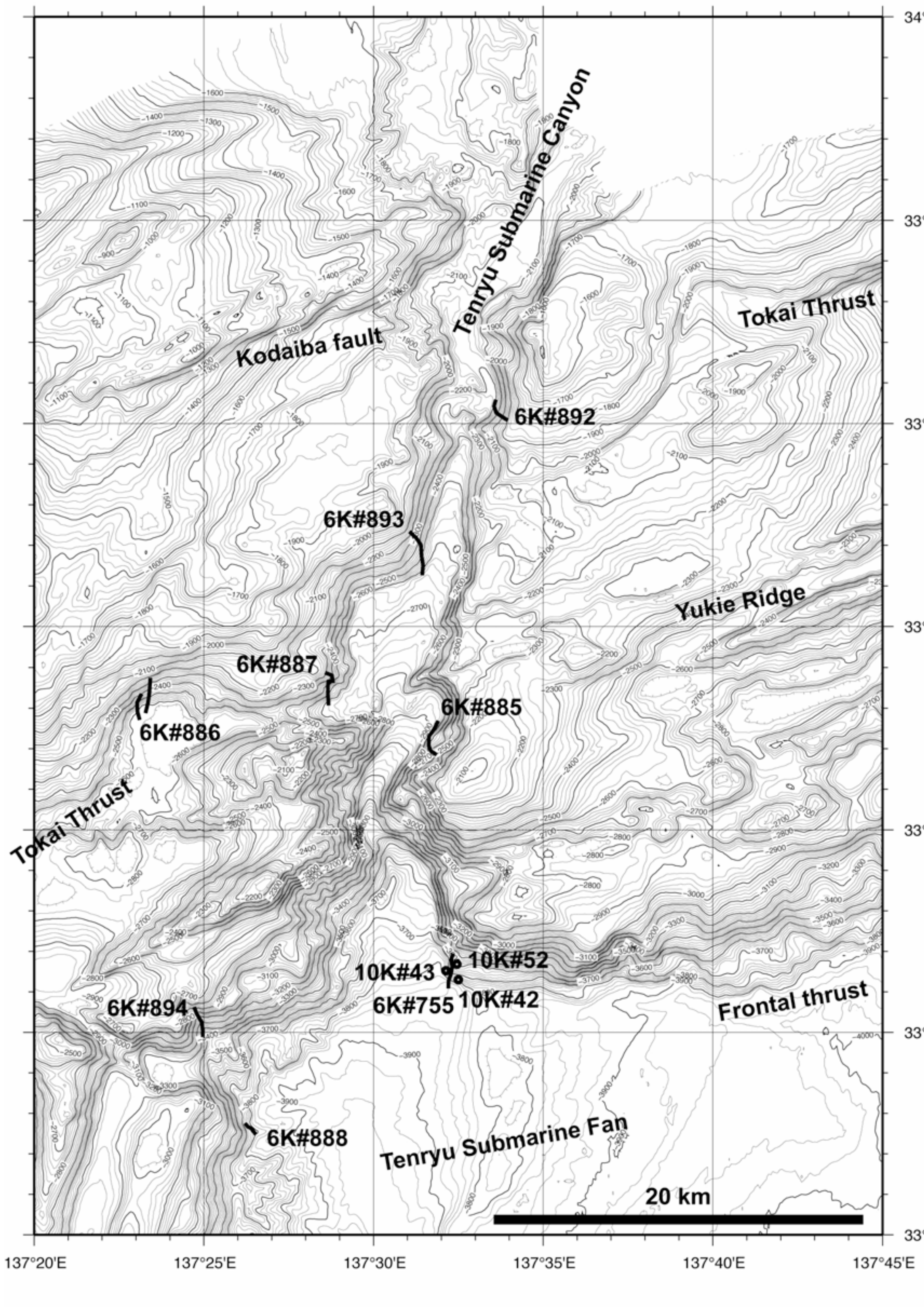


Figure: Previous dive sites around the Tenryu Canyon (6K#939 was operated nearby site 6K#888, toe of the prism)

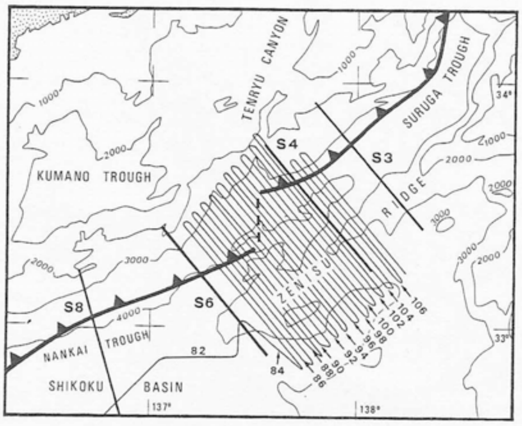


Fig. 2. Track chart. *S3–S8* are the seismic profiles of Aoki et al. [7]; *84–106* are the "Jean Charcot" profiles.

last ruptured in the 1944 Tonankai great earthquake. But the portion further to the east may not have been ruptured since 1854 [8] and now corresponds to a seismic gap of high potential seismic risk [9,10]. The seismic Wadati-Benioff zone is shallow, with an average 12° dip west of 137°E in its upper portion. East of 137°E, the Wadati-Benioff zone is curved in a complex fashion and the dip increases from 17° to 30°, to the west of Izu peninsula [11]. If large thrust-type typical subduction earthquakes characterize the seismicity along the Nankai Trough, the Izu-Bonin volcanic ridge to the east is affected by diffuse seismicity, dominantly of strike-slip type, which suggests internal diffuse shortening [3].

3. Magnetic and gravity anomalies: basement structure

Fig. 4 shows a composite free air gravity anomaly map, compiled by Tomoda [12], which includes the "Jean Charcot" gravity survey. This map is used to show our survey area in its general tectonic framework. Fig. 5 is the "Jean Charcot"

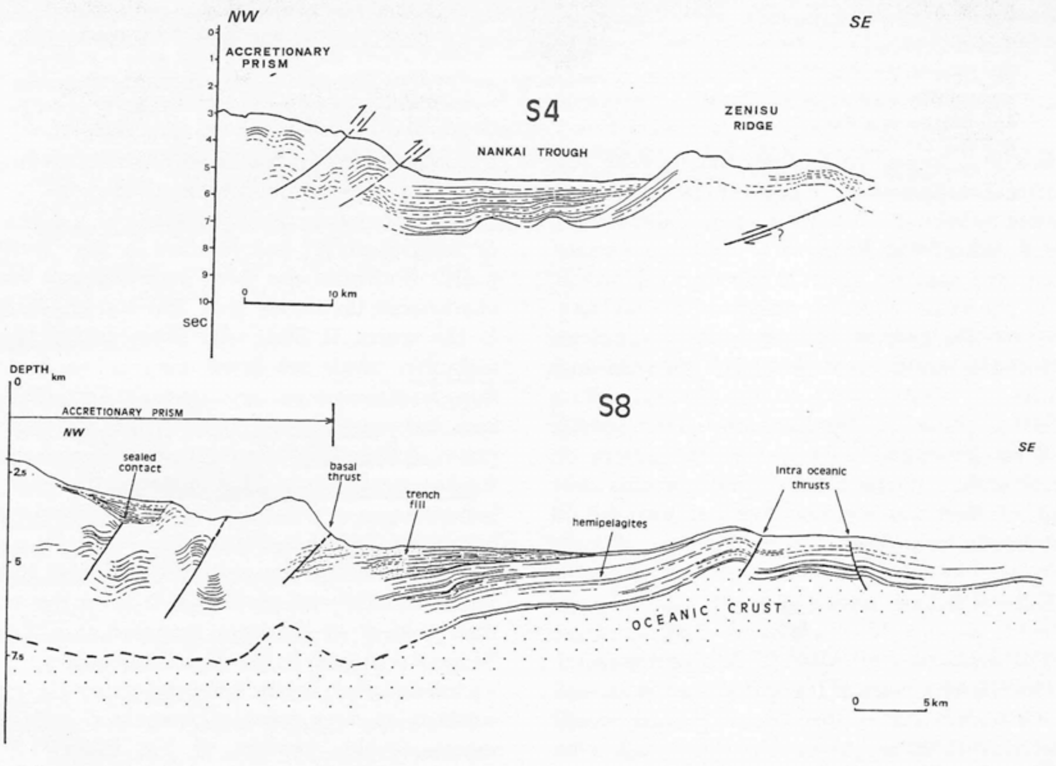


Fig. 3. Interpreted multichannel seismic profiles S4 and S8 across the Box 5 area showing thrusting south of the trench (after Aoki et al. [7]). See tracks in Fig. 2.

Figure: Seismic images along the Tenryu Canyon (Le Pichon, X., Iiyama, T., Boulegue, J., Chavet, J., Faure, M., Kano, K., Lallement, S., Okada, H., Rangin, C., Taira, A., Urabe, T. and Uyeda, S., 1987, Nankai Trough and Zenisu Ridge: a deep-sea submersible survey: Earth Planetary Science Letters, v. 83, p. 285-299.)

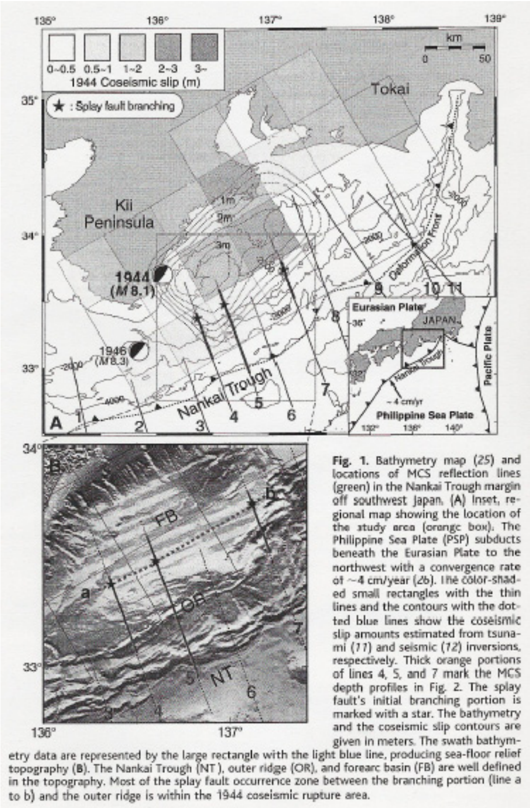


Fig. 1. Bathymetry map (*25*) and locations of MCS reflection lines (green) in the Nankai Trough margin off southwest Japan. (**A**) Inset, regional map showing the location of the study area (orange box). The Philippine Sea Plate (PSP) subducts beneath the Eurasian Plate to the northwest with a convergence rate of ~4 cm/year (*26*). The color-shaded small rectangles with the thin lines and the contours with the dotted blue lines show the coseismic slip amounts estimated from tsunami (*11*) and seismic (*12*) inversions, respectively. Thick orange portions of lines 4, 5, and 7 mark the MCS depth profiles in Fig. 2. The splay fault's initial branching portion is marked with a star. The bathymetry and the coseismic slip contours are given in meters. The swath bathymetry data are represented by the large rectangle with the light blue line, producing sea-floor relief topography (**B**). The Nankai Trough (NT), outer ridge (OR), and forearc basin (FB) are well defined in the topography. Most of the splay fault occurrence zone between the branching portion (line a to b) and the outer ridge is within the 1944 coseismic rupture area.

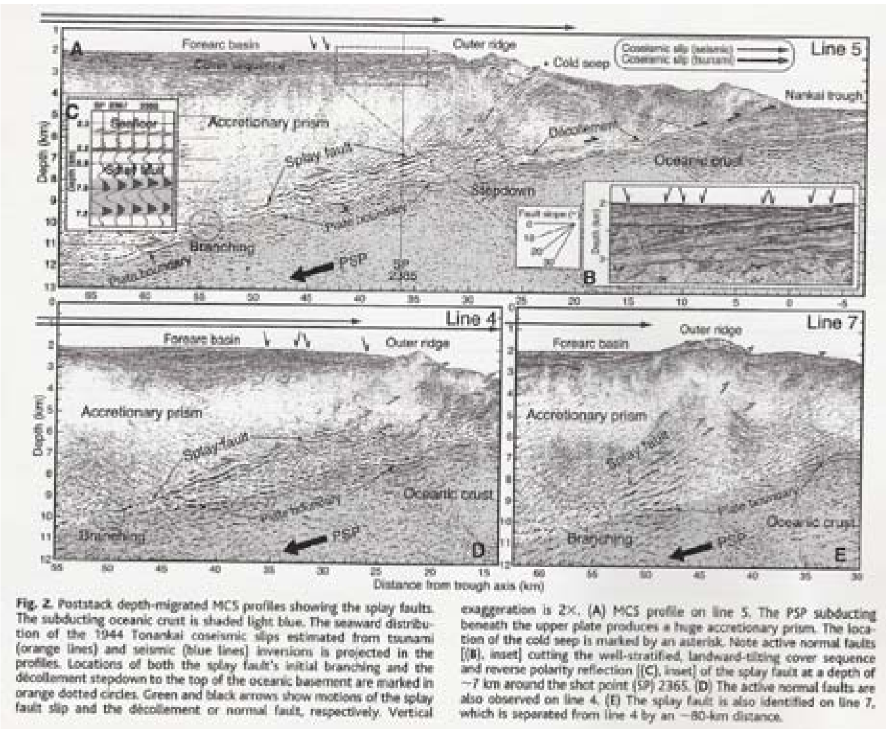


Fig. 2. Poststack depth-migrated MCS profiles showing the splay faults. The subducting oceanic crust is shaded light blue. The seaward distribution of the 1944 Tonankai coseismic slips estimated from tsunami (orange lines) and seismic (blue lines) inversions is projected in the profiles. Locations of both the splay fault's initial branching and the décollement stepdown to the top of the oceanic basement are marked in orange dotted circles. Green and black arrows show motions of the splay fault slip and the décollement or normal fault, respectively. Vertical exaggeration is 2×. (**A**) MCS profile on line 5. The PSP subducting beneath the upper plate produces a huge accretionary prism. The location of the cold seep is marked by an asterisk. Note active normal faults [(**B**), inset] cutting the well-stratified, landward-tilting cover sequence and reverse polarity reflection [(**C**), inset] of the splay fault at a depth of ~7 km around the shot point (SP) 2365. (**D**) The active normal faults are also observed on line 4. (**E**) The splay fault is also identified on line 7, which is separated from line 4 by an ~80-km distance.

Figure: Seismic images nearby the Shionomisaki Canyon (Park, J.O., Tsuru, T., Kodaira, S., Cummins, P. R., and Kaneda, Y., 2002, Splay Fault Branching Along the Nankai Subduction Zone: Science, v. 297, p.1157-1160.)

2. Equipments

2.1 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 deep freezer, incubator, and rock saw. In addition, YOKOSUKA has on-board video editing capability for DVCAM, S-VHS, VHS, system.

Yokosuka. At the JAMSTEC, Oppama, 12 April 2006

Research Vessel "*Yokoska*" The principal specifications

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
Accomodation: 15 reserchers' beds

2.2 SEA BEAM 2112 -Outline of system – (adopted fromYK03-03 cruise report)

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. Figure ### 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 hydrophne 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. The system synthesizes 2_2 degrees 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. ###. 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).

2.3 Sub bottom profiler

Sub bottom profiles were obtained by using the SEA BEAM 2112.004 Subbottom Profile

Subsystem, which is an additional option to the SEA BEAM 2112 Multibeam Bathymetry System. The capability of the system ranges from 50 m to 11,000 m. Depth penetration varies with bottom composition and may be as much as 75 m. The system uses an aray of 60 TR-109 projectors, operating at 4kHz to fprm a vertical beam of 45 degrees athwartship and 5 degrees fore/aft. The system startup, parameter setting, and real-time control is perfomed by Indy Work Station (SGI). The data is displayed on a terminal and EPC recorder, and stored on harddisk and a data logger.

2.4 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 SHINKAI6500; 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 SHINKAI6500 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 SHINKAI6500. In this case, SHINKAI6500 must be notified of her position by the mother vessel. However, coverage range is similar to that in LBL system.

Manned-submersible Shinkai 6500 vs on shore Shinkai 6500. At the JAMSTEC, Oppama, 12 April 2006

3. Participants

Shinkai 6500 Team Personnel

Yoshiji IMAI Operation Manager

Toshiaki SAKURAI Assistant Operation Manager

Yoshitaka SASAKI 1st Submersible staff

Tetsuji Maki 1st Submersible staff

Itaru Kawama 1st Submersible staff

Yoshio Ohno 1st Submersible staff

Tetsuya Komuku 2nd Submersible staff

Hirofumi Ueki 3rd Submersible staff

Yosuke chida 3rd Submersible staff

Fumiyo Saito 3rd Submersible staff

R/V *Yokosuka* Ship Crew

Masayoshi ISHIWATA Captain

Hiroaki MASUJIMA Chief Officer

Yasuo DEAI 2nd Officer

Yuuki HURUKAWA 3rd Officer

Hiroyuki SHIBATA Chief Engineer

Kazuhiko KANEDA 1st Engineer

Saburo SAKAEMURA 2nd Engineer

Daisuke GIBU 3rd Engineer

Fukuo SUDA Chief Radio Operator

Yusuke TAKEUCHI 2nd Radio Operator

Yoshio ODA Boat Swain

Able Seaman

Katsumi SHIMIZU Able Seaman

Seiji HOSOKAWA Able Seaman

Kiyoshi KANEDA Able Seaman

Shuichi YAMAMOTO Able Seaman

Shouzou FUJII Able Seaman

Toshiki OKUYAMA Sailor

Hiroyuki MURASE Sailor

Seiichi MATSUDA No.1 Oiler

Takeshi FUKUHARA Oiler

Tomoyuki HASHIMOTO Oiler

Sakou TANAKA Assistant Oiler

Yoshinori YAMAOKA Assistant Oiler

Takeshi MIYAUCHI Chief Steward

Shinsuke TANAKA Steward

Isao MATSUMOTO Steward

Kazunori NAGANO Steward

Tadayuki TAKATSU Steward

Shipboard Scientists

Kiichiro Kawamura (Fukada Geological Institute) (Chief scientist)

Yujiro Ogawa (University of Tsukuba) (Co-Chief scientist)

Ryo Anma (University of Tsukuba)

Akira Nakamura (University of Tsukuba)

Tomoyuki Sasaki (University of Tokyo)

Hidetoshi Hara (Geological Survey of Japan)

Hiroyuki Mizumoto (Fisheries Research Agency)

Driss Elouai (Kyoto University)

Yoko Michiguchi (University of Tsukuba)

Hisatoshi Sato (University of Tsukuba)

Ai Togami (University of Tsukuba)

Satoru Muraoka (University of Tsukuba)

Satoshi Okada (Nippon Marine Enterprise)

YK06-02 Shipboard Scientific Party

4. Preliminary results

4.1 Dive report of 6K#938 to the First Ridge of the Nankai Accretionary Prism

Yujiro Ogawa (University of Tsukuba)

The dive of 6K#938 was held at the southern slope of the First Ridge of the Nankai accretionary prism on the east of the mouth of the Shionomisaki Canyon, Nankai trough. The most frontal thrust was traversed first in the world upto the top of the first ridge, observing the internal structures and asking whether methane-bearing seepage occurs or not. As a result, no seepage was observed, instead, alternation of mudstone and sandstone, in some parts the sandstones were calcite cemented, was observed. No strong deformation by thrusts or minor folds, but one broad anticline, in parallel to the broad topographic profile was recognized. Mudstone, although not very highly indurated, is fractured by oblique cleavage to the bedding, is distributed.

Observation

12:53 landing at 4551 m. Current to 70, 3 cm/sec.

Cliff of 60 trend with 5 m height, the SW side down.

Mud floor with ripple marks.

Again, 90 trend cliff

No Calyptogena, nor any large biological signals, other than Koshioriebi and sea anemonea

13:22 Small cliff of 330 trend at 4532 m depth.

13:25 Small cliff of 330 trend at 4518 m depth.

Mudstone block, mudstone outcrops with gentle S dip.

13:27 Upslope with small cliff of mudstone outcrops at 4503 m depth.

13:41 Rock sampling R-001 at 4501 m depth. Soft mudstone with calcareous sand.

13:43 Rubbles of mudstone on the floor. Sporadic outcrops of layered mudstone with south dip at 4491 m depth.

13:4? Small plateau of "Kerama-Ruine" at 4476 m depth.

13:55 Layered mudstone with south dip at 4447 m depth.

14:00 Alternation of mudstone and sandstone with SW dip at 4417 m.

14:13 Umishida on mud floor at 4326 m.

14:33 Top of the ridge, a gentle slope with black sand floor with ripple marks. Two directions of flow (60, 330) due to bottom current.

14:40 Gastropod and its trail. Beyond the sand and mud floor, a huge cliff of large relief, at 4262 m. Diamond-dust like (actually by mica flakes) upwelling by submersible current is observed curiously.

14:51 Rock sampling R-002 at 4278 m. Calcareous sandstone with mudstone balls.

Large cliff with horizontal beds of alternation of mudstone and sandstone. Beautiful layers.

Mudstone is fractures with oblique cleavage to bedding.

Rock sampling R-003 at 4333 m. Mudstone with much mica flakes and plant frgment.

At 4300 m conjugate sets of normal faults and fractures with vertical compression.

15:22 Mud sample trial, but not successful at 4296 m.

15:25 Leaving the bottom. 4293 m.

17:05 Sea surface.

17:40 Retreaved.

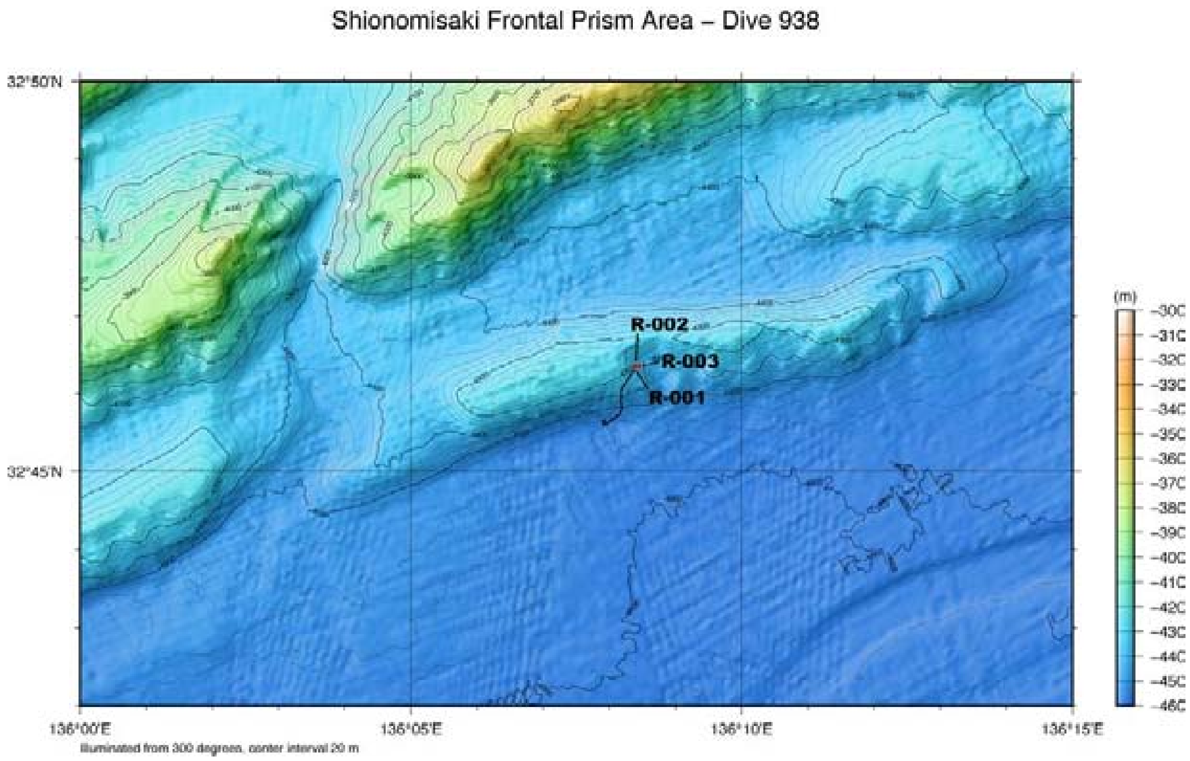


Figure: Dive route of 6K#938

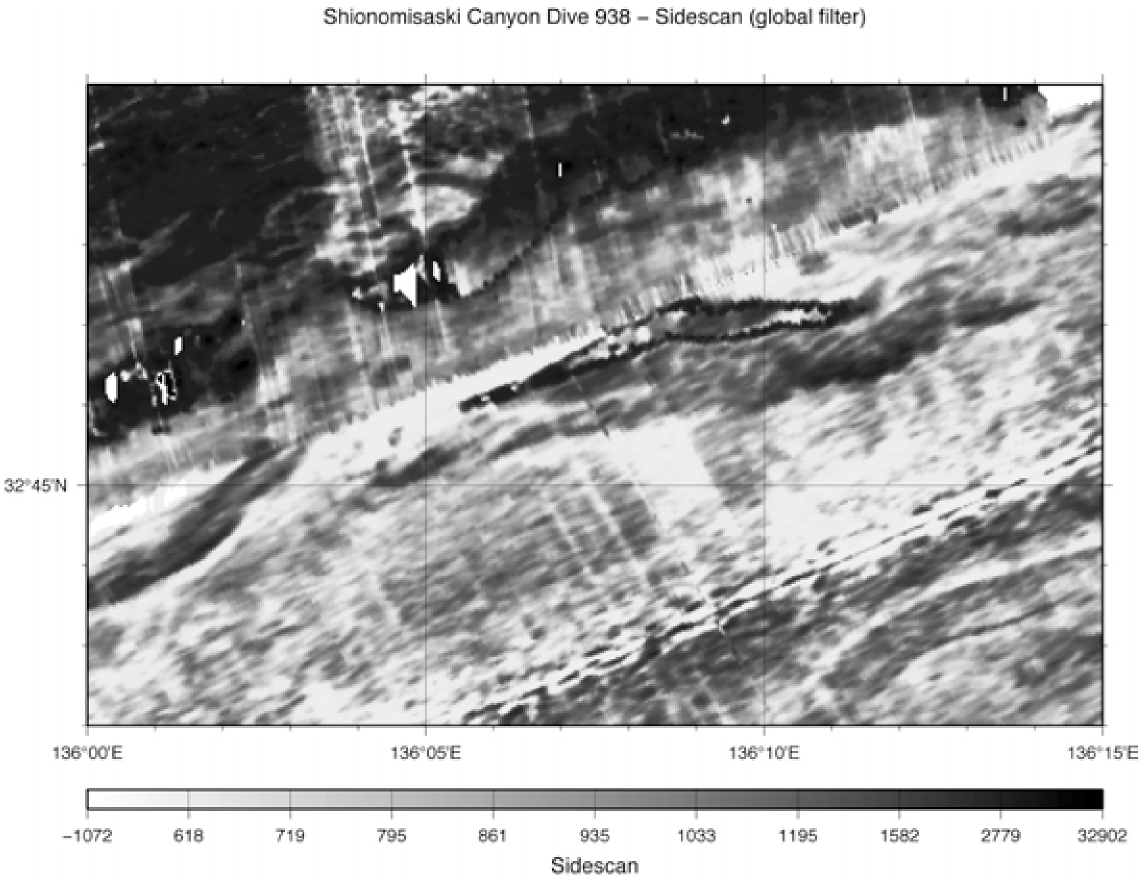


Figure: Sidescan image of the dive site 6K#938 (made by Tomoyuki Sasaki)

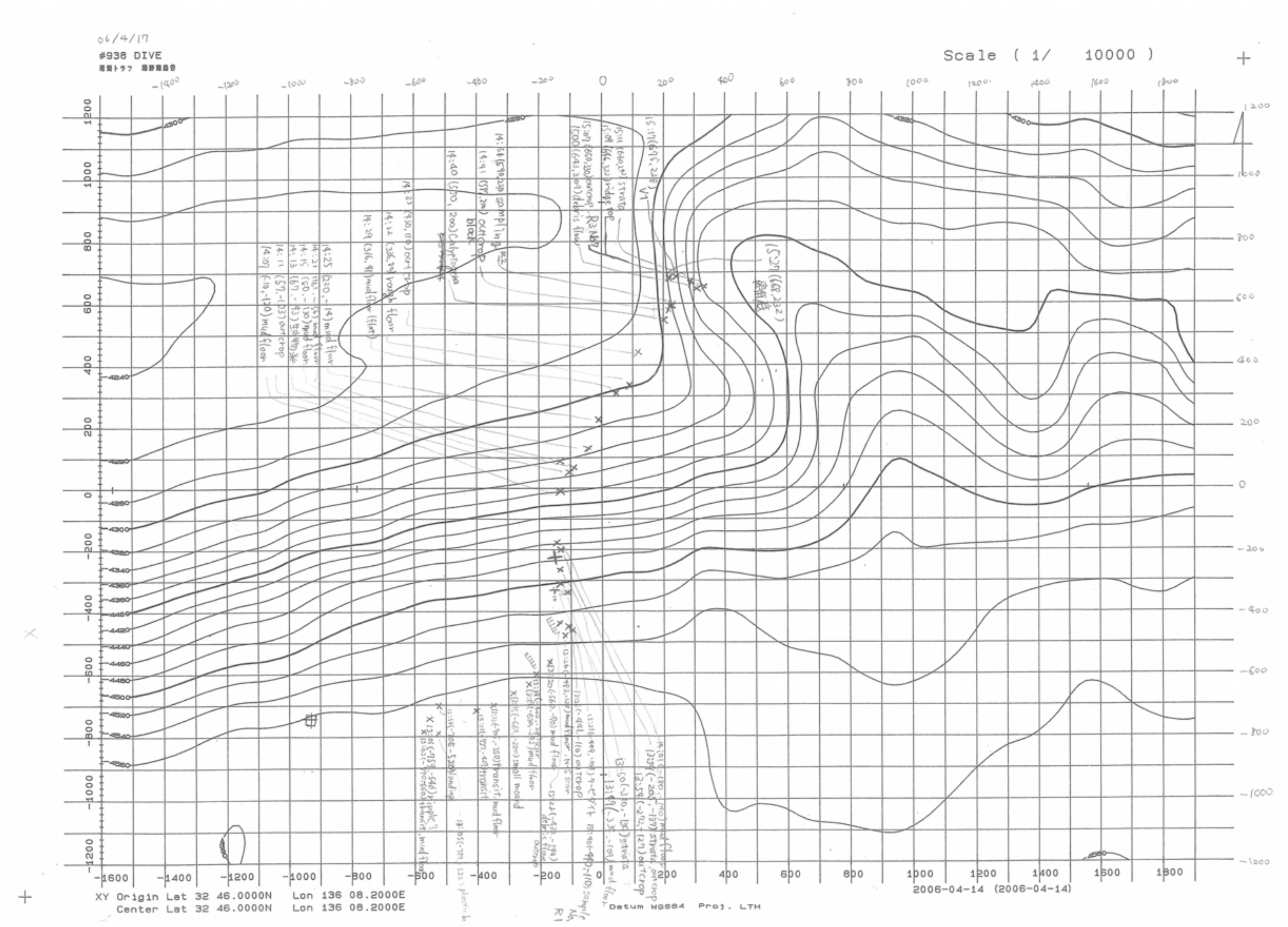


Figure: Detailed dive route of 6K#938

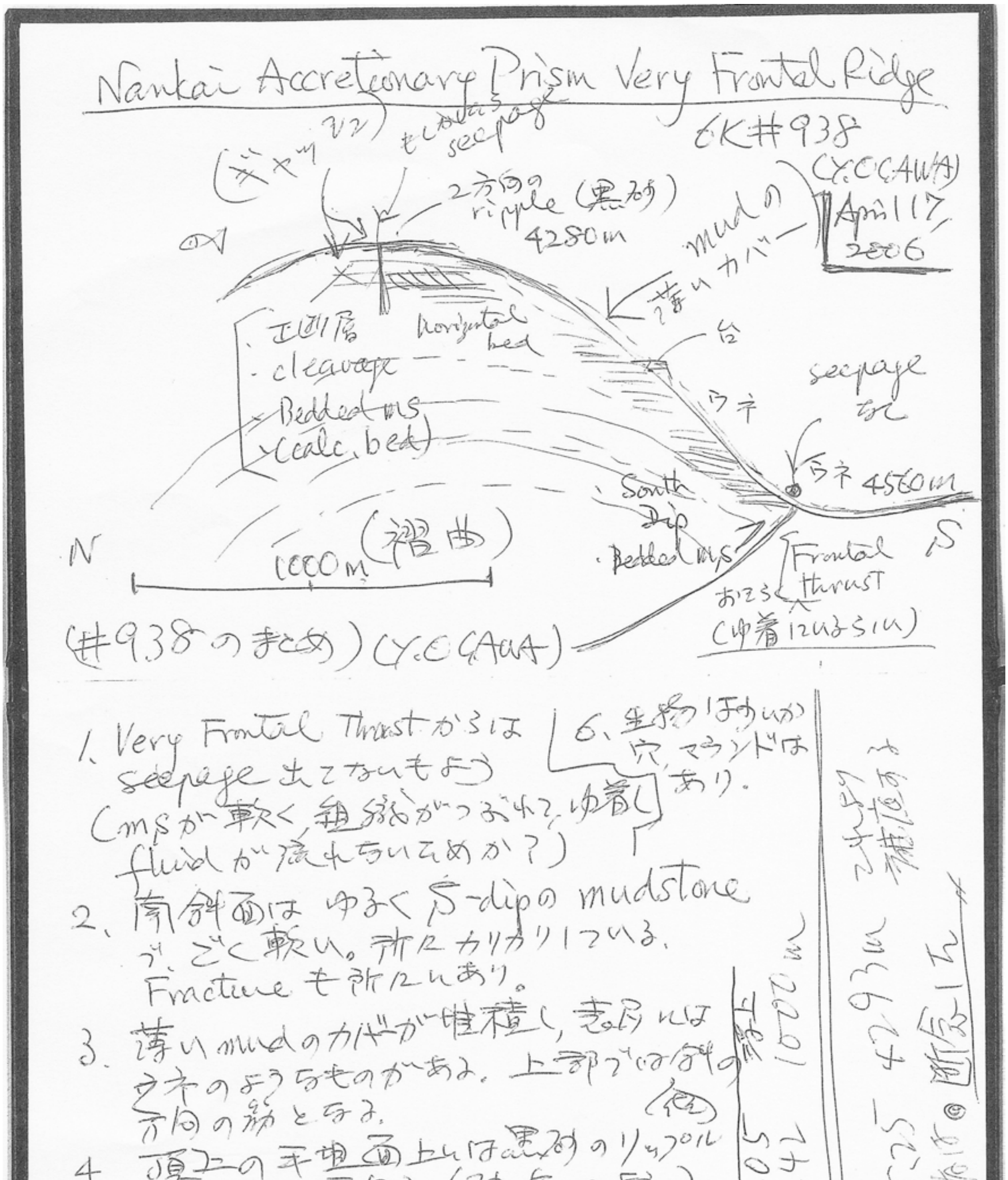


Figure: Sketch_map and dive summary of 6K#938

#938 DIVE 南海トラフ　小川　勇二郎　GPS(WGS-84)SSBL

*** EVENT MARK LIST ***　　2006-04-17 17:18:30

ORIGIN (XY<->LATLON CONVERT)　LAT 32°46.0000'N　LON 136°08.2000'E
XY ORIGIN ((X,Y)=(0,0))　LAT 32°46.0000'N　LON 136°08.2000'E

NO.	DAY	TIME	LAT	LON	X	Y
1	2006-04-14	10:00:00	32° 45.6000' N	136° 7.6000' E	-739.2	-936.9
	Landing Target					
2	2006-04-14	12:51:00	32° 45.6185' N	136° 7.8670' E	-705.0	-519.9
	Landing D=4551m					
3	2006-04-17	13:42:00	32° 45.7594' N	136° 8.1296' E	-444.6	-109.9
	Sampling Rock(1) D=4502m					
4	2006-04-17	14:51:00	32° 46.3207' N	136° 8.3405' E	592.7	219.3
	Sampling Rock(1) D=4269m					
5	2006-04-17	15:07:00	32° 46.3539' N	136° 8.4083' E	654.0	325.2
	Sampling Rock(1) D=4330m					
6	2006-04-17	15:26:00	32° 46.3647' N	136° 8.3537' E	674.0	240.0
	Left Bottom D=4293m					
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Figure: Event mark list of 6K#938

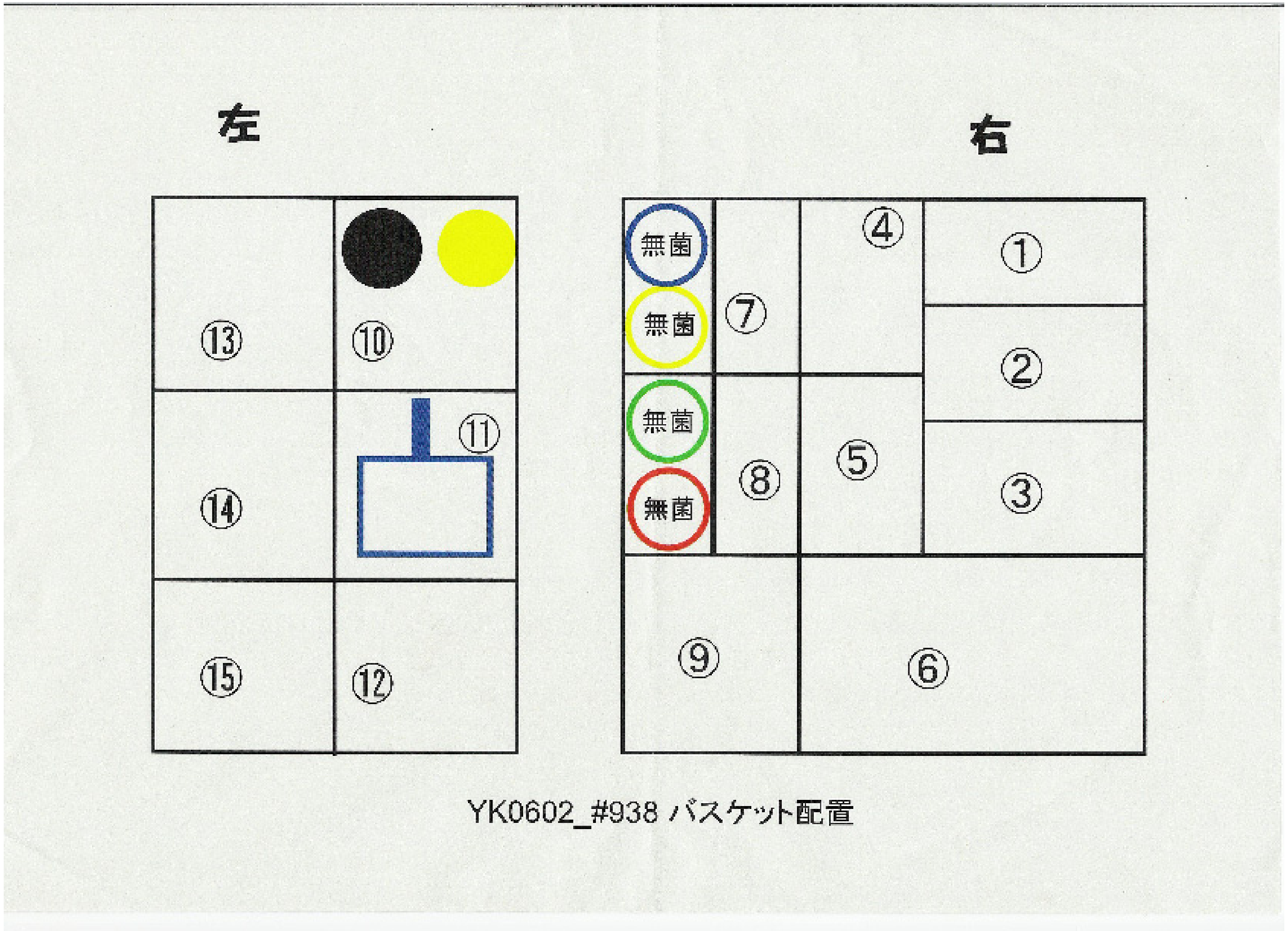


Figure: Payload of 6K#938

4.2 Dive report of 6K#939 to the toe of the Nankai Accretionary Prism

Kiichiro Kawamura (Fukada Geological Institute)

The dive of 6K#939 was held at the eastern slope of the toe of the Nankai accretionary prism on the west of the mouth of the Tenryu Canyon, Nankai trough. This site is nearby 6K#888 (Dive scienstist: Shunsuke UKE Kawakami) during cruise YK05-08. He found shells of *Calyptogena* and nice prism outcrop at there. However unfortunately he had to stop his dive emergency because of a bad weather. Hence, the distribution of the seepages and the geologic architectures of this site were not fully understood. As a result of the dive survey, seepages and *Calyptogena* colonies were observed along the thrust faults. The muddy turbidite layers were observed, and the dipping of the layers changed gradually from horizontal to steep dipping during climbing the eastern slope. Particularly, the horizonal turbidite layers are not so highly deformed without any fractures, whereas the dipping layers are observed many thrusts, normal faults and fractures.

Table: Dive log

6K#939:Tenryu Submarine Canyon:
33° 32. 70N 137° 26. 10E 3650r
Observer:Kiichiro Kawamura, Pilot:Sakurai, Co-pilot:Senda
Monday 19th,April 2006
origenal point 0=137 25.8 0=33 33.on

Hour	X-axis	Y-axis	Heading	Depth(m)	Altitude(m	Description
1130	-820	980	274	3740	6	landing, mudfoor
1131	-821	914	291	3739	7	biogenic mound
1134	-825	965	286	3739	7	C-001 sampling
1136	-815	958	281	3739	7	SC-001 sampling
1142	-820	960	333	3738	1	transit
1142	-810	960	1	3739	6	mud floor
1146	-770	990	168	3557	4	mud floor, transit
1147	-770	1000	168	3758	2	crab?
1151	-730	990	4	3770	4	mud floor
1154	-720	1000	347	3778	2	outcrop
1158	-700	1000	332	3778	1	Morinaga
1211	-700	1000	289	3777	1	R-001 sampling
1215	-700	1000	304	3774	2	transit
1217	-680	1000	305	3763	4	outcrop
1219	-650	950	280	3757	3	transit
1220	-670	920	269	3758	2	transit
1220	-660	800	270	3739	3	transit
1228	-670	730	313	3736	2	Cylptogena (dead)
1235	-660	720	261	3733	2	
1236	-600	700	264	3728	1	ebi
1239	-680	680	252	3713	2	outcrop
1240	-680	660	271	3703	3	strata
1241	-690	660	271	3705	1	
1246	-680	640	272	3704	2	outcrop
1248	-690	650	314	3704	2	R-002 sampling
1253	-660	660	292	3703	1	B-001,R-003 sampling
1300	-670	640	290	3692	3	outcrop
1305	-660	580	288	3671	2	tubeworm?
1308	-640	550	242	3668	2	Cylptogena
1313	-630	560	275	3667	1	
1314	-630	560	271	3667	1	SC-002 sampling
1322	-630	560	268	3667	1	
1327	-630	560	269	3667	1	C-002 sampling
1332	-630	560	248	3666	2	B-002 sampling
1337	-610	550	218	3666	2	SC-003 sampling
1339	-610	550	217	3666	1	C-003 sampling
1347	-560	500	304	3646	4	tubeworm?
1348	-570	470	306	3639	2	tubeworm?
1350	-550	430	304	3634	4	outcrop, umishida
1355	-520	390	305	3581	7	outcrop, tubeworm?
1356	-510	360	306	3586	21	transit
1400	-470	220	303	3600	8	outcrop
1404	-430	240	3	3565	5	outcrop
1407	-400	230	293	3562	7	outcrop, tubeworm?
1409	-380	200	285	3551	11	tubeworm?
1414	-360	140	241	3530	11	outcrop
1419	-380	120	184	3526	10	
1423	-380	110	184	3526	10	R-004 sampling
1427	-390	90	338	3515	10	mud mound

Dive 888 (Scale 1/50000)

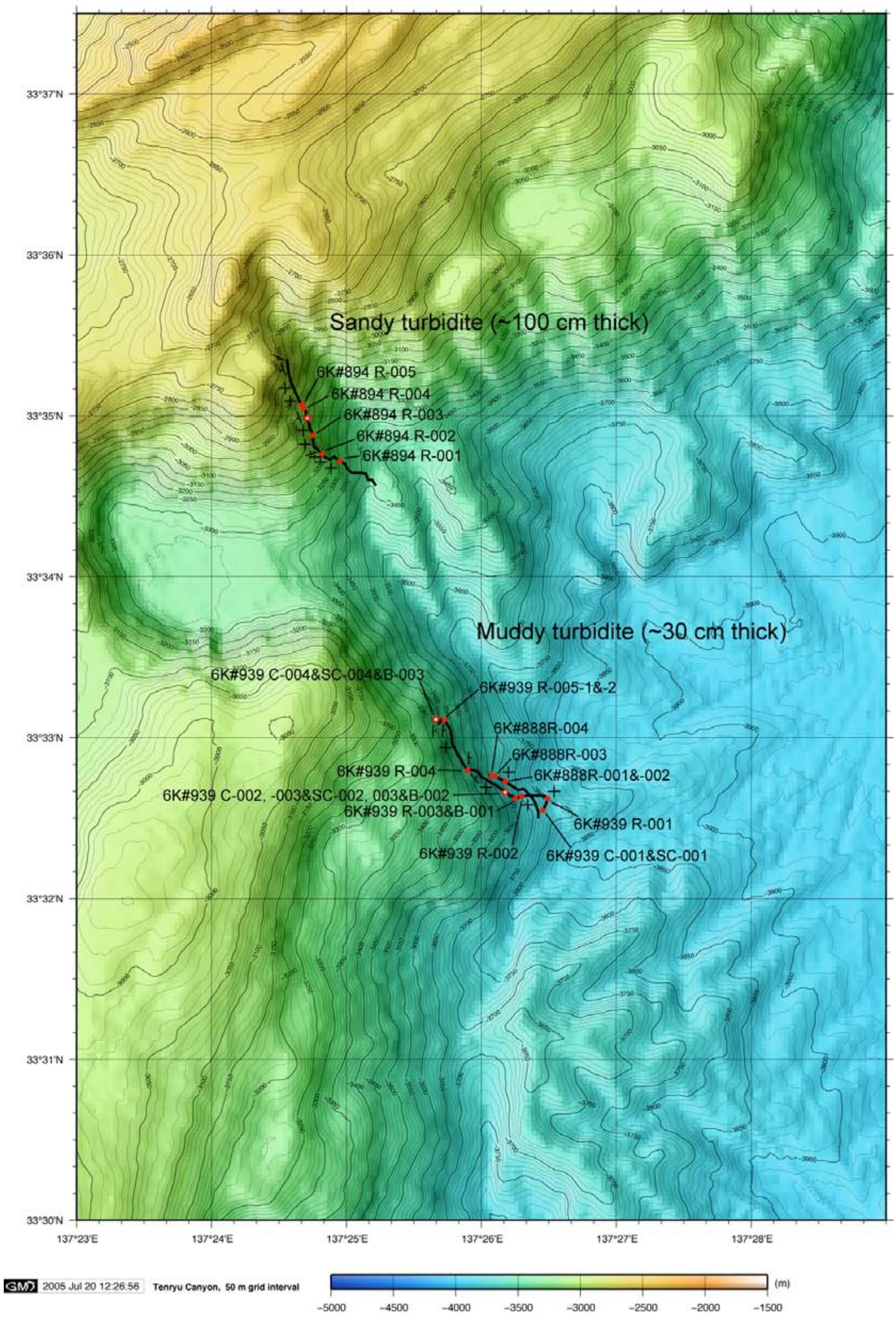


Figure: Dive route of 6K#939

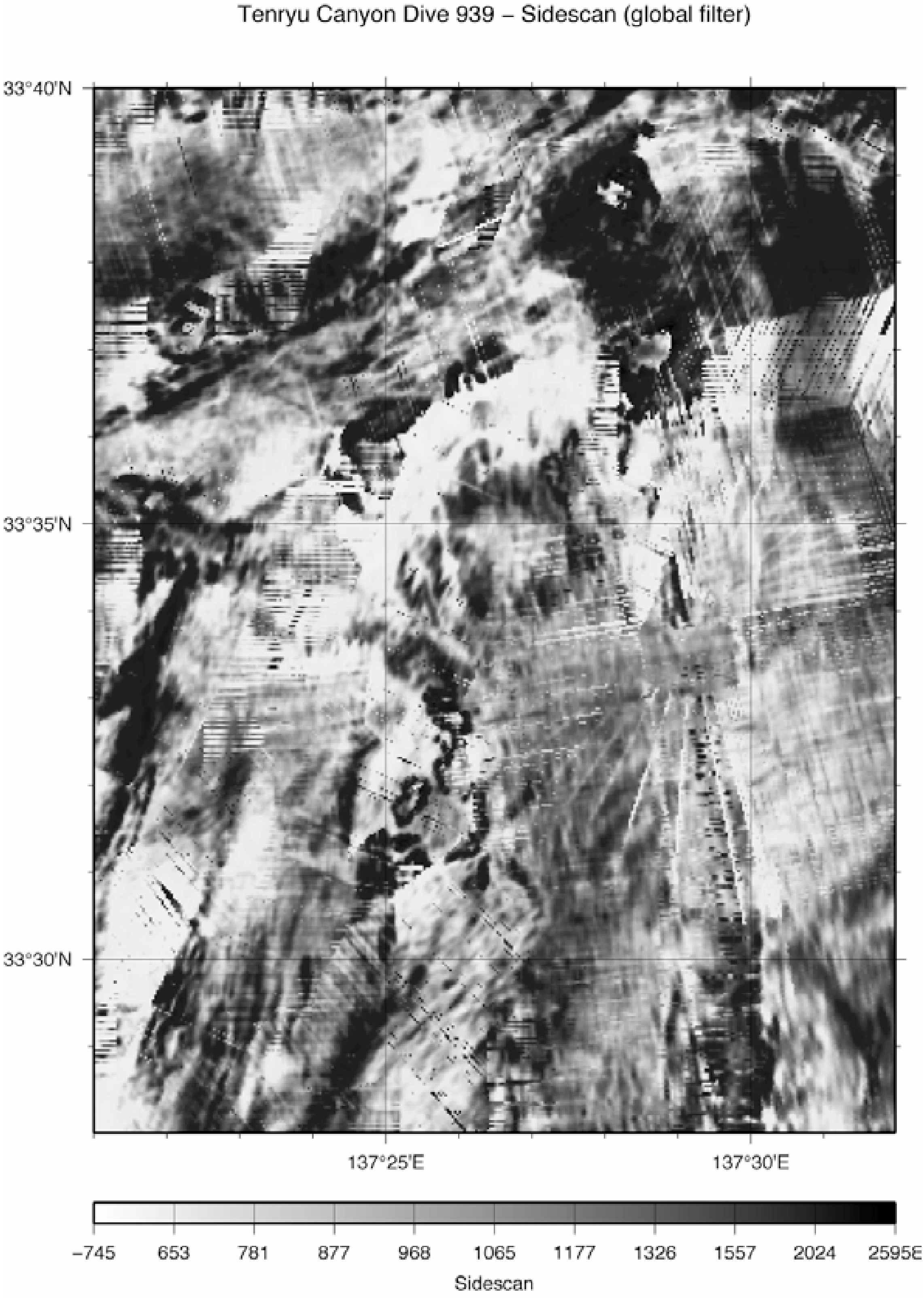


Figure: Sidescan image of the dive site 6K#939 (made by Tomoyuki Sasaki)

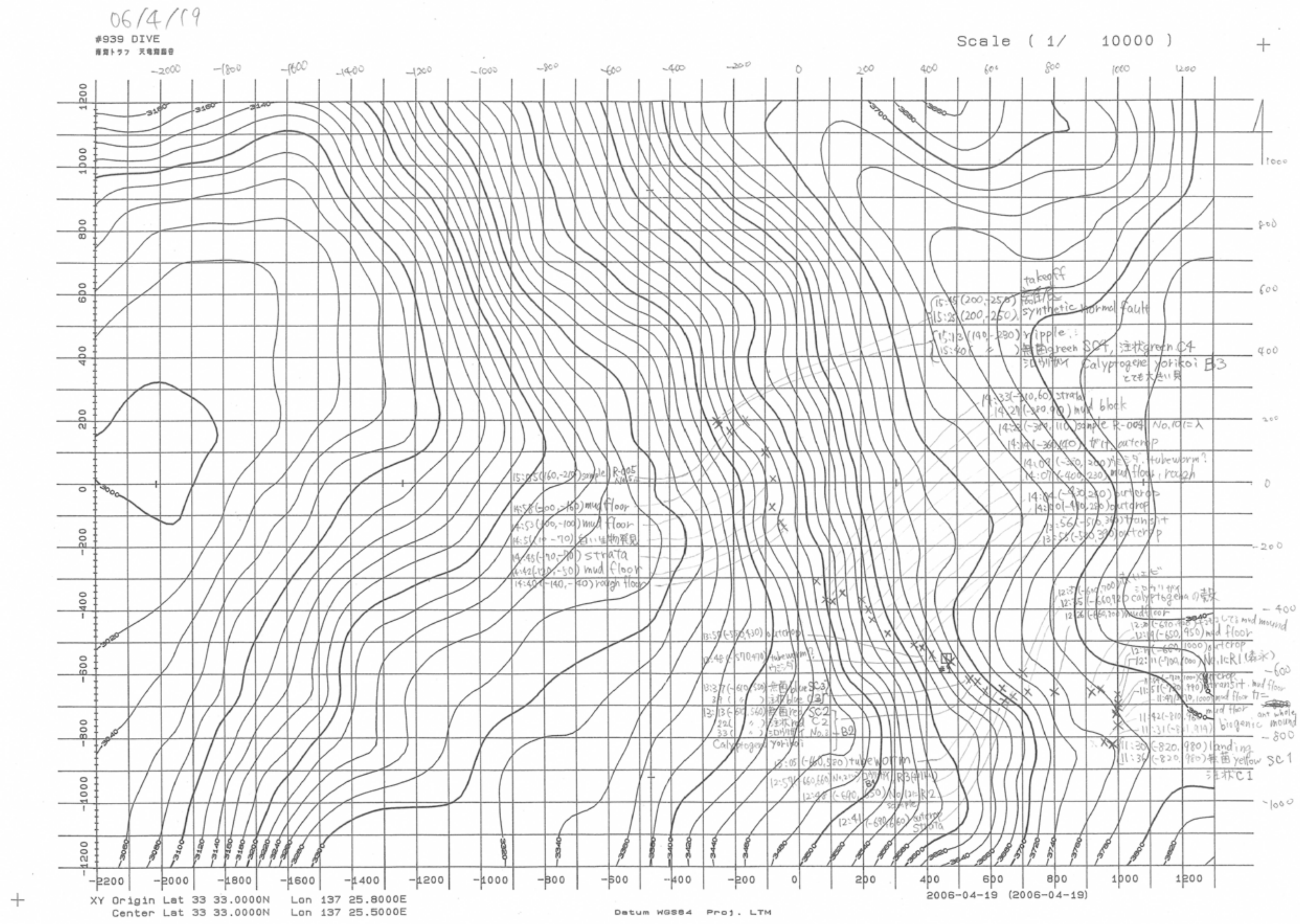


Figure: Detailed dive route of 6K#939

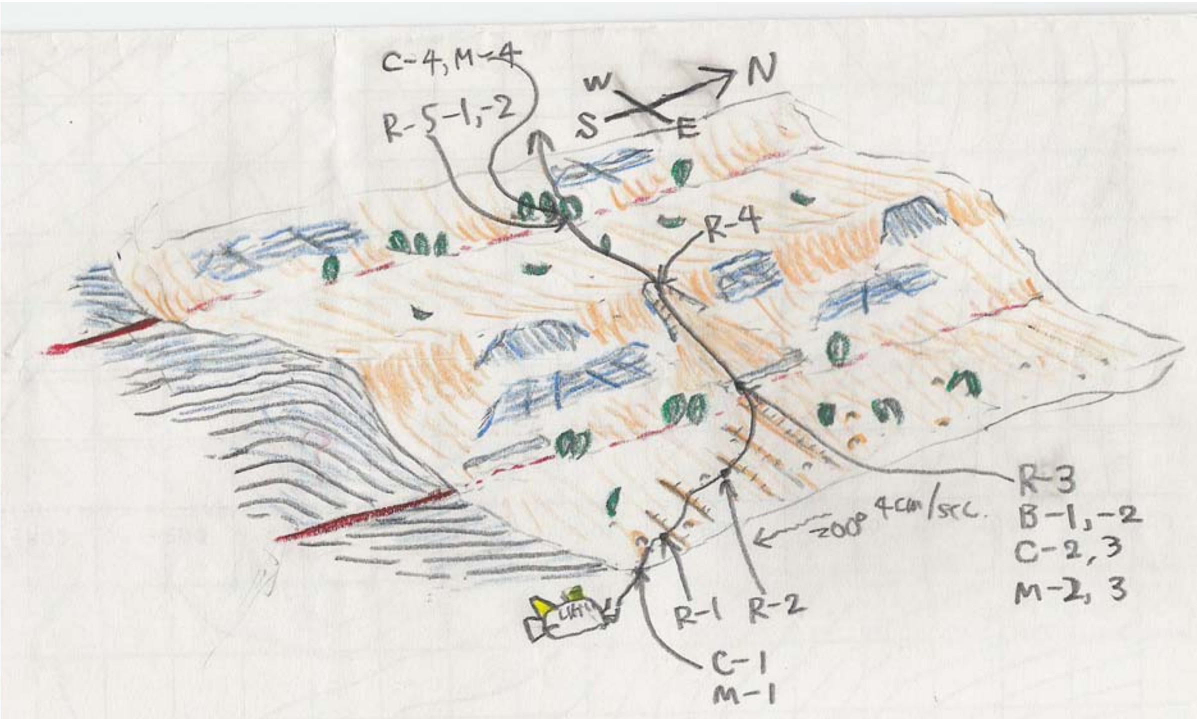


Figure: Sketch map and schematic model of the dive site

#939 DIVE 南海トラフ 川村 喜一郎 GPS(WGS-84)SSBL

*** EVENT MARK LIST *** 2006-04-19 15:46:56

ORIGIN (XY<->LATLON CONVERT) LAT 33°33.0000'N LON 137°25.8000'E
XY ORIGIN ((X,Y)=(0,0)) LAT 33°33.0000'N LON 137°25.8000'E

NO.	DAY	TIME	LAT	LON	X	Y
1	2006-04-19	10:00:00	33° 32.7000' N	137° 26.1000' E	-554.5	464.3
	Landing Target					
2	2006-04-19	11:29:00	33° 32.5574' N	137° 26.4302' E	-818.0	975.3
	Landing Samp. Core(ylw), Sterile core(ylw) D=3740m					
3	2006-04-19	12:10:00	33° 32.6209' N	137° 26.4478' E	-700.7	1002.5
	Sampling Mud stone D=3778m					
4	2006-04-19	12:34:00	33° 32.6451' N	137° 26.2635' E	-655.9	717.3
	Finding Shells of Caryptgena D=3736m					
5	2006-04-19	12:56:00	33° 32.6231' N	137° 26.2247' E	-696.6	657.3
	Sampling Rock(1), Mud stone, Calyptogena(1) D=2504m					
6	2006-04-19	13:40:00	33° 32.6610' N	137° 26.1592' E	-626.6	555.9
	Samp. Calypt(1),Core(red,blue),Strl(red,blue) D=3667m					
7	2006-04-19	14:23:00	33° 32.7919' N	137° 25.8745' E	-384.6	115.3
	Sampling Rock(1) D=3526m					
8	2006-04-19	15:04:00	33° 33.0913' N	137° 25.6630' E	168.7	-212.0
	Sampling Rocks(2) D=3416m					
9	2006-04-19	15:34:00	33° 33.1039' N	137° 25.6449' E	192.0	-240.0
	Samp. Calypt(3),Core(green),Strl(green) D=3402m					
10	2006-04-19	15:44:00	33° 33.1093' N	137° 25.6436' E	202.0	-242.0
	Left Bottom D=3390m					
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Figure: Event mark list

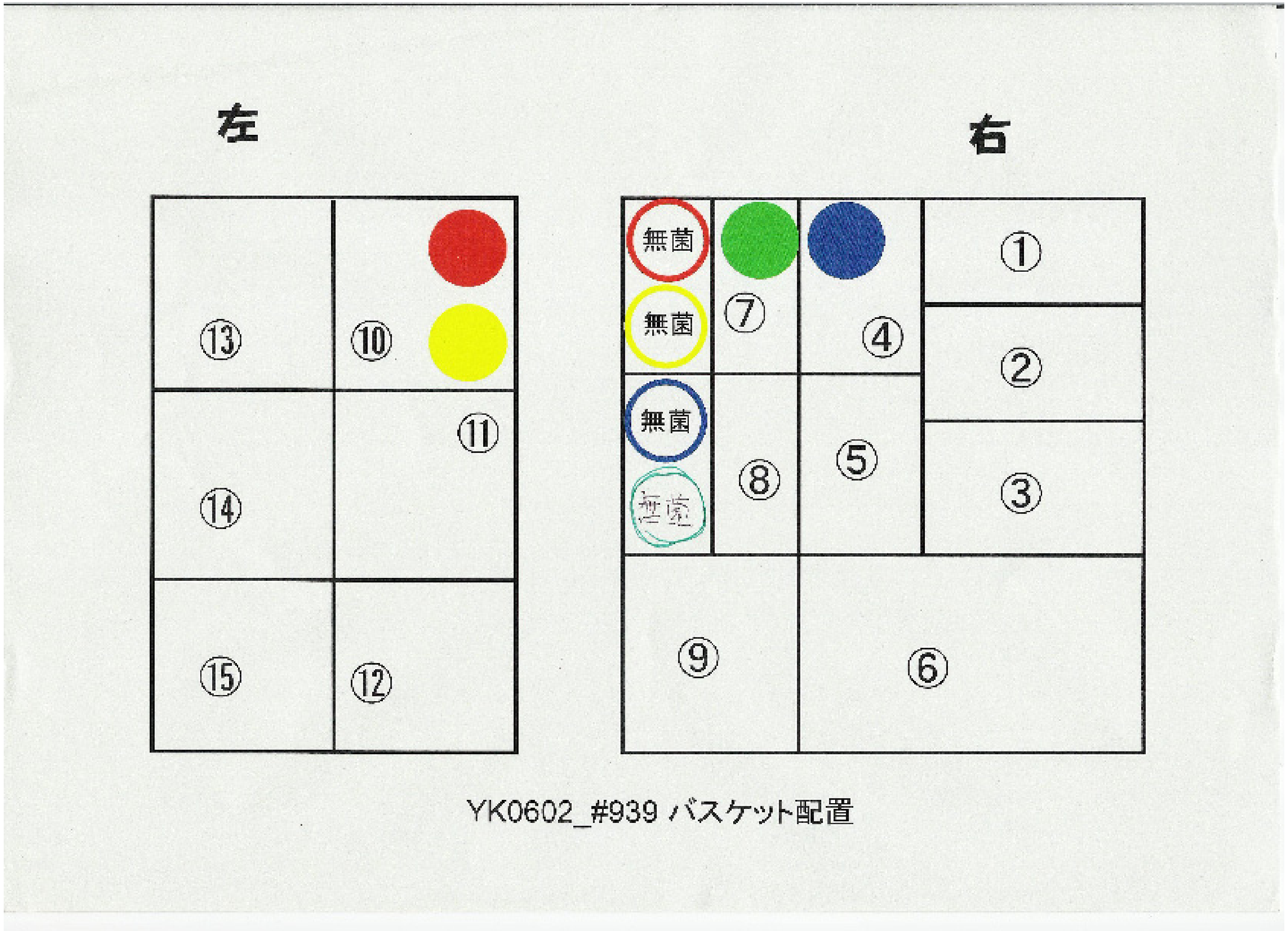


Figure: Payload of 6K#939

5. Sample description

5.1 Samples of 6K#938 (Dive scientist: Y. Ogawa)

6K#938 R-001 mudstone with sany part, sandstone is calcareous cemented
Sampling site: event mark No. 3

6K#938 R-002 Sandstone with mud balls, involved sandy part, which is calcareous cemented
Sampling site: event mark No. 4

6K#938 R-003 Mudstone with slight fractures
Sampling site: event mark No. 5

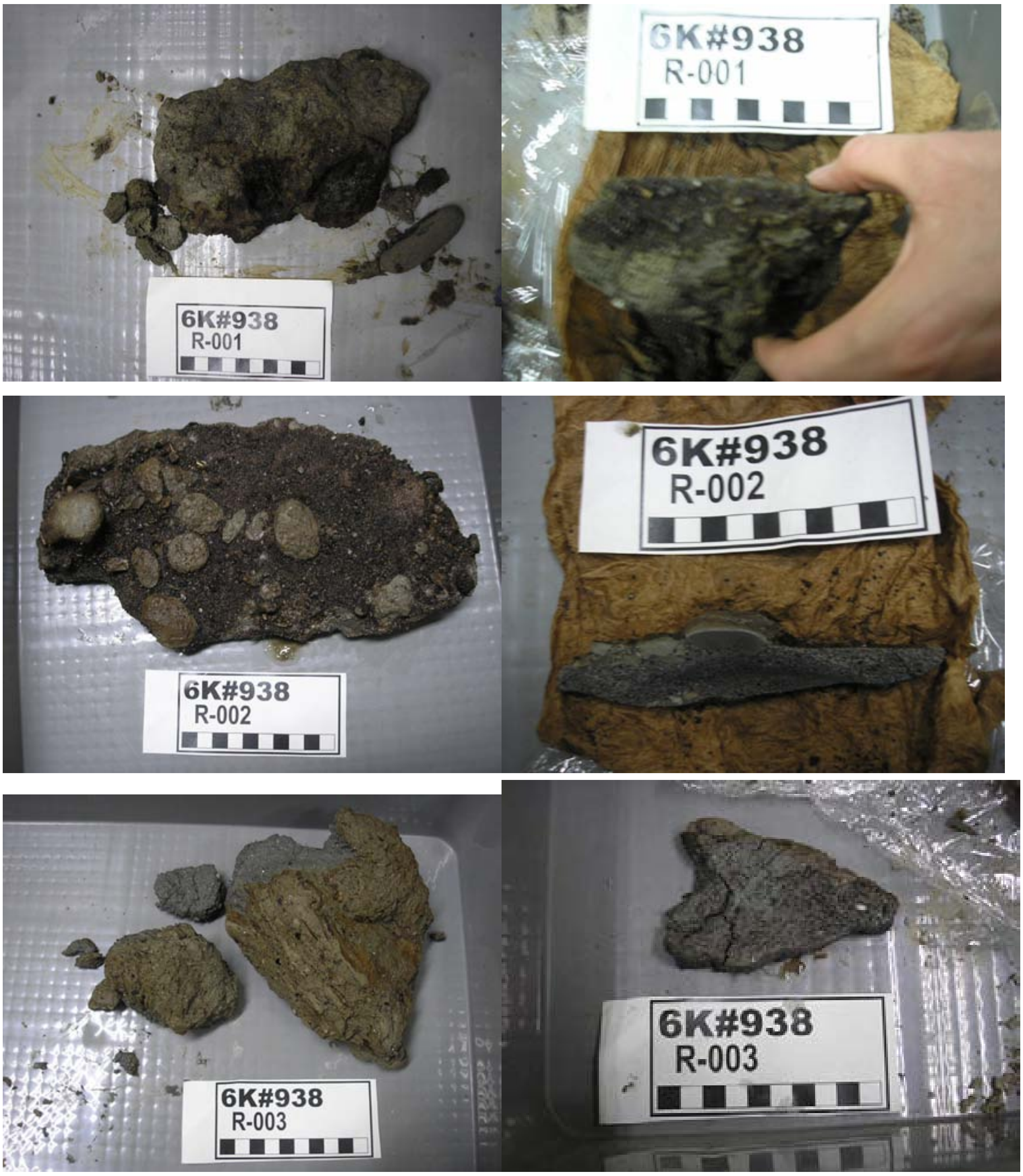


Photo: Sample photographs of 6K#938

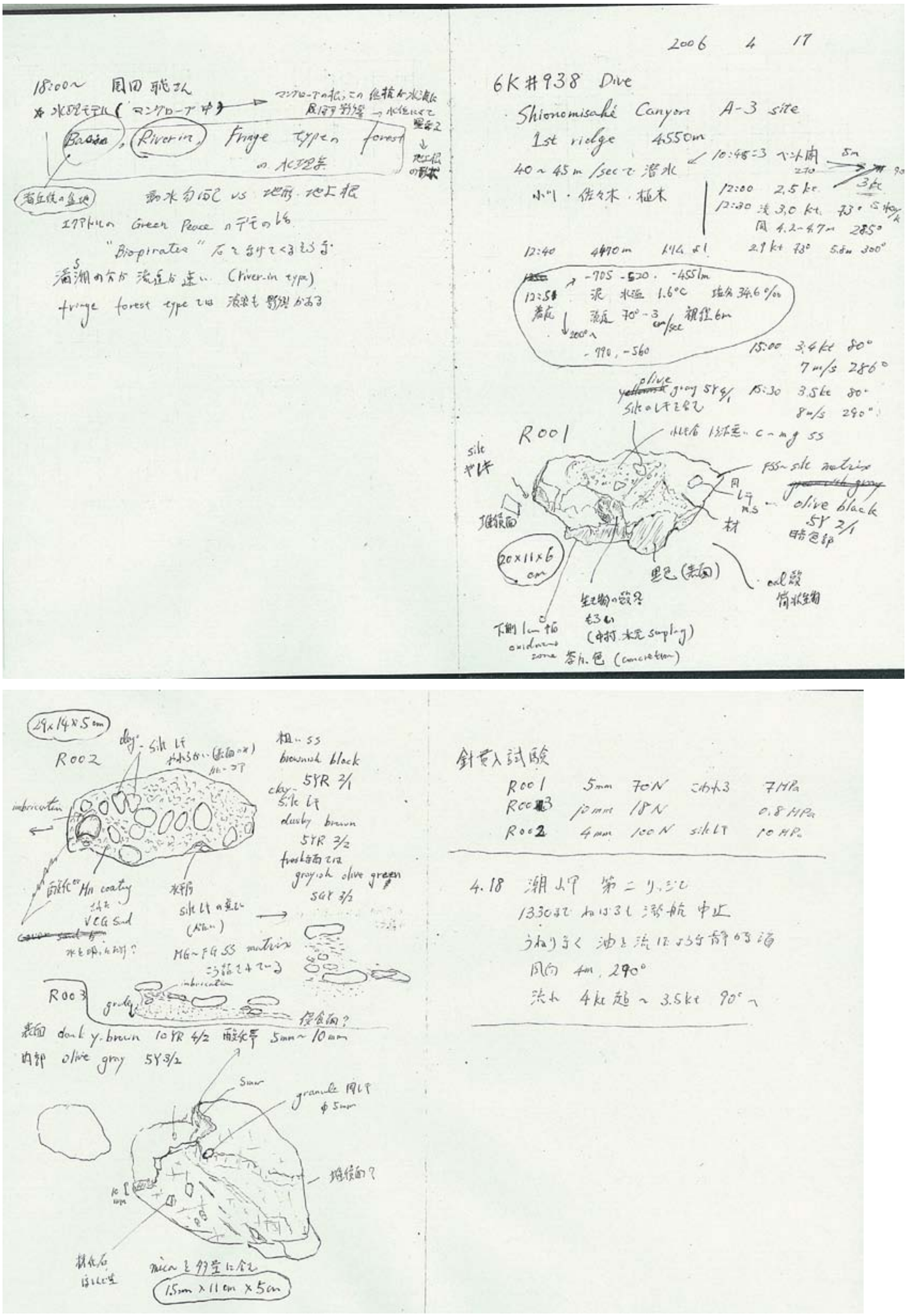


Figure: Sketch of samples of 6K#938

5.2 Samples of 6K#939 (Dive scientsti: K. Kawamura)

6K#939 R-001 Mudstone, collected from horizontal turbidite layer, muddy part: for sand analysis (Togami), radiolarian (Kawakami, AIST, onshore scientist), physical properties, fabric (Univ. Tsukuba, FGI) studies.
Sampling site: event mark No. 3

6K#939 R-002 Mudstone, collected from horizontal turbidite layer, muddy part: for sand analysis (Togami), radiolarian (Kawakami, AIST, onshore scientist), physical properties, fabric (Univ. Tsukuba, FGI) studies.
Sampling site: event mark No. 5

6K#939 R-003 Mudstone, collected from gentle east dipping turbidite layer, muddy part: for sand analysis (Togami), radiolarian (Kawakami, AIST, onshore scientist), physical properties, fabric (Univ. Tsukuba, FGI) studies.
Sampling site: event mark No. 5

6K#939 R-004 Mudstone, collected from vertical turbidite layer, muddy part: for sand analysis (Togami), radiolarian (Kawakami, AIST, onshore scientist), physical properties, fabric (Univ. Tsukuba, FGI) studies.
Sampling site: event mark No. 7

6K#939 R-005 Mudstone, collected from horizontal turbidite layer, muddy part: for sand analysis (Togami), radiolarian (Kawakami, AIST, onshore scientist), physical properties, fabric (Univ. Tsukuba, FGI) studies.
Sampling site: event mark No. 8

6K#939 B-001 Brownish muds and Calyptogena shells: muds for virus (Mizumoto) and geologic (Univ. Tsukuba) study, shells for isotope study (Univ. Tsukuba).
Sampling site: event mark No. 5

6K#939 B-002 Dark olive muds and Calyptogena clam: muds for virus (Mizumoto) and geologic (Univ. Tsukuba) study, shells for isotope study (Univ. Tsukuba), inside body of the Calyptogena for bacterial (JAMSTEC) study.
Sampling site: event mark No. 6

6K#939 B-003 Dark olive muds and three Calyptogena clams: muds for virus (Mizumoto) and geologic (Univ. Tsukuba) study, shells for isotope study (Univ. Tsukuba), inside body of the Calyptogena for bacterial (JAMSTEC) study.
Sampling site: event mark No. 9

6K#939 C-001 Grayish mud of ca. 10 cm long, collected from flat seabed, probably debris flow deposit: for geochemical study (Sato)
Sampling site: event mark No. 2

6K#939 C-002 Grayish mud of ca. 10 cm long, collected from inside of the seepage: for geochemical study (Sato)
Sampling site: event mark No. 6

6K#939 C-003 Grayish mud of ca. 10 cm long, collected from outside of the seepage: for geochemical study (Sato)
Sampling site: event mark No. 6

6K#939 C-004 Grayish mud of ca. 10 cm long, collected from inside of the seepage: for geochemical study (Sato)
Sampling site: event mark No. 9

6K#939 SC-001 Mud collected of ca. 50 cc, from flat seabed, probably debris flow deposit: for bacterial (Nakamura) and virus (Mizumoto) study
Sampling site: event mark No. 2

6K#939 SC-002 Mud of ca. 50 cc, collected from inside of the seepage: for bacterial (Nakamura) and virus (Mizumoto) study
Sampling site: event mark No. 6

6K#939 SC-003 Mud of ca. 50 cc, collected from outside of the seepage: for bacterial (Nakamura) and virus (Mizumoto) study
Sampling site: event mark No. 6

6K#939 SC-004 Mud of ca. 50 cc, collected from inside of the seepage: for bacterial (Nakamura) and virus (Mizumoto) study
Sampling site: event mark No. 9

Photo: Rock sample photographs of 6K#939

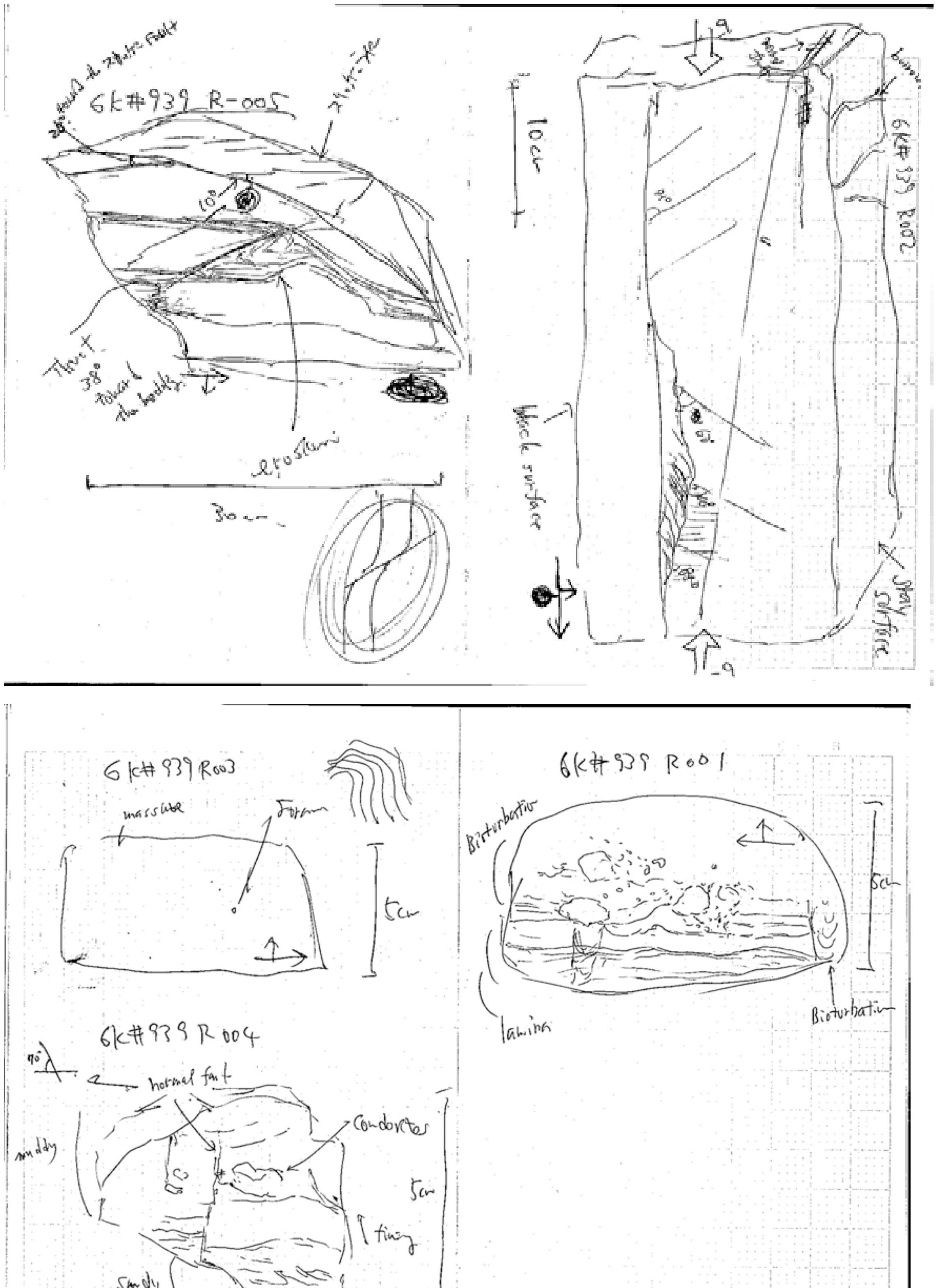


Figure: Sketch of rock samples of 6K#938

Figure: Bio sample photographs of 6K#939

Figure: Push core sample photographs of 6K#939 (C-001-C-004)

Figure: Sterile core sample photographs of 6K#939 (SC001-SC004)

5.3 Smear Slide Description

Kiichiro Kawamura (Fukada Geological Institute) and Ai Togami (University of Tsukuba)

We analyzed the grain size and mineral component of the rock samples by smear slide observation. The results are shown in table below. The rock samples are composed mainly of silisiclastic grains as quartz, feldsper and mica. Note that calcareous nannofossils are detected at 6K#939 R-001-005.

Table: Smear Slide Description

								Texture			Minerals															Biogenic								Rock		
Leg	R001 sand	H	Cor	T	Sc	Top (cm)	Lithology	Sand	Silt	Clay	Quartz	Feldspar	Biotite	Chlorite	Calcite	Dolomite	Amphibole	Epidote	Clay	Opaques	Fe Oxide	Glauconite	Volcanic glass	Zeolite	Zircon	Foraminifers	Diatoms	Radiolarians	Nannofossils	Sponge	Dinoflagellate	Pollen & Spores	Organic debris	Rock Fragments	Percentage	Remark
6k# 938	R001							5	40	55	+++	++	++				+		+++	+														+	0	silty clay
	R002							5	15	80	++	+	+		+++																				0	sand
	R003							3	47	50	++	+							+++	+															0	silty clay
6k# 939	R001 mud							5	60	35	60	5							30	4			1												100	clayey silt
	R001 sand							50	40	10	80						r		10				10												100	silty sand
	R002 mud							10	60	30	70	10							14				5							1					100	silty clay
	R002 sand							10	50	40	60	5							30				5												100	clayey silt
	R003 mud							5	30	55	50	5							40				5												100	silty clay
	R004 mud							5	50	45	65	4					r		30											1					100	clayey silt
	R004 sand							65	30	5	75	10					1		4				10												100	silty sand
	R005 mud							5	35	60	30	4							65											1					100	silty clay
	R005-1 sand							45	50	5	75	10							5				10												100	sandy silt
	R005-2 mud							5	35	60	80	10								1			8							1					100	silty clay
	R005-2 sand							10	60	30	80	10							2				7							1					100	clayey silt

6. Uniaxial compression strength of the rock samples

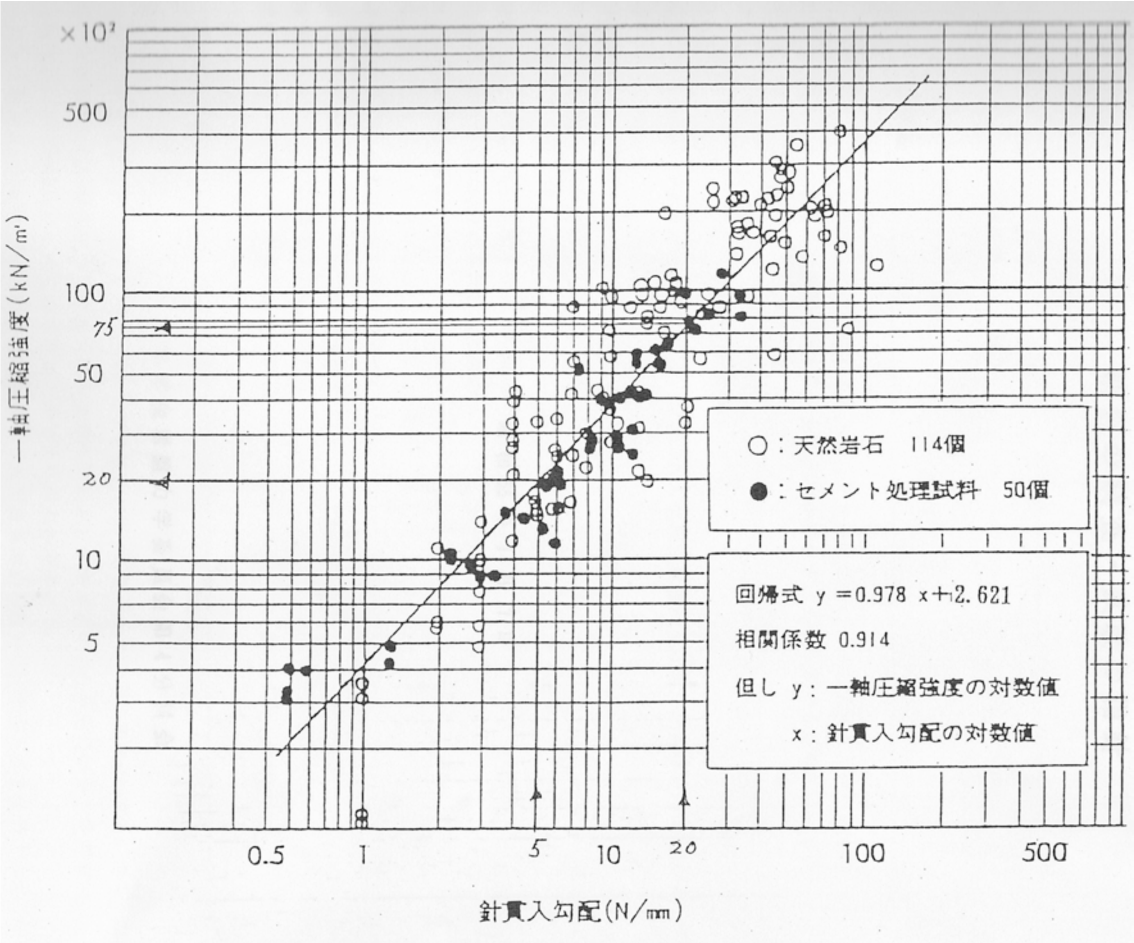
Kiichiro Kawamura (Fukada Geological Institute) and Ryo Anma (University of Tsukuba)

Uniaxial compression strength of the rock samples were tested by needle penetration test machine SH-01 of Seiken Co. Ltd., which is measured the needle penetration pressure and the needle penetration length. As the needle penetrates into the hard rock samples, the penetration pressure needs much more. The penetration length and the pressure depend on the rock hardness. Such the rock hardness is converted into the uniaxial compression strength as below calculations.

$y = 0.978\ x + 2.621$

y = logarithm of uniaxial compression strength (kgf / cm^2)
x = logarithm of (penetration pressure (N) / penetration length (mm))

Photo: Needle penetration tester



針貫入勾配と一軸圧縮強度の相関図

Figure: Conversion diagram

Results

Results are shown in Table below. The uniaxial compression strength of the rock samples are mostly 1-10 MPa.

Table: Uniaxial compression strength

Dive#	Sample#	Rock type	Needle penetration length (mm)	Penetration pressure (N)	Penetration gradient (N/mm)	>log (N/mm)	>	>	Uniaxial compressive strength (MPa)
#938	R-001	Mudstone	5	70	14	1	4	5520	5.52
	R-002	Sandstone	10	18	2	0	3	742	0.74
	R-003	Mudstone	4	100	25	1	4	9732	9.73
#939	R-001	Siltstone & Sandstone	10	10	1	0	3	418	0.42
	R-002	Mudstone & Siltstone	10	22	2	0	3	903	0.90
	R-003	Mudstone	10	16	2	0	3	662	0.66
	R-004	Siltstone & Sandstone	10	21	2	0	3	863	0.86
	R-005-1	Mudstone & Siltstone	10	21	2	0	3	863	0.86
	R-005-2	Mudstone & Siltstone	10	27	3	0	3	1104	1.10

7. Core sediment procedures

7.1 Geochemistry study (Hisatoshi Sato; University of Tsukuba)

Four push core samples were sliced in 2cm intervals. Sliced subsamples were immediately put in clean PE bottles and kept frozen at -40℃.

7.2 Virus study (Hiroyuki Mizumoto; Fisheries Research Agency)

プッシュコアラーによってサンプリングされた海底泥は、2cm 間隔でスライスした後、一部を滅菌した薬さじを用いて 50ml プラスチックチューブに入れ、-80℃で保存した．無菌採泥器によって得られた海底泥 500mg から、FastDNA SPIN Kit for Soil (Q-Bio gene)を用いて、ＤＮＡを抽出し、-80℃で保存した．シロウリガイとともにサンプリングされた海底泥は、滅菌した薬さじを用いてプラスチック製容器に約 50ｇずつ入れ、-80℃で保存した.

7.3 Bacterial study (Akira Nakamura; University of Tsukuba)

6K#939 DIVE の際に無菌採泥器で SC-001, 002, 003, 004 サンプルを取得した。

無菌採泥器より回収したチューブより 2 ml 分の泥質を遠心により集め、船内で Beads-Bead 法により DNA 抽出を行った。同様にシロウリガイ組織(B-003B)より 3 箇所(外套膜部、中間膜組織、内臓部)より、同様の手法で DNA を抽出した。残りのサンプルは 4℃で保存し、持ち帰ることとした。

8. Subbottom Profiler

Yoko Michiguchi (University of Tsukuba), Tomoyuki Sasaki (University of Tokyo) and Ai Togami (University of Tsukuba)

The subbottom profiler (hereafter SBP) was conducted three times; 1) 13 April 2006 to understand the sedimentary structures at the trench slope basin in the Tenryu Canyon, 2) 14 April 2006 to find the active faults along the Shionomisaki Canyon, 3) 19 April 2006 to detect the active faults and active folding in the Tenryu Submarine Fan. The SBP survey was operated in the ship speed of 6.0 knot. The data were output as specific binary files, so that we converted from these files to tiff image files during the cruise. The X axis of the SBP data shows a two-way travel time (ms: milli-second) between a shot point (bottom of the vessel) and a sea bed. The Y axis indicates a shot frequency (NOT distance!). It means that the Y axis depends on the ship speed.

Shionomisaki Canyon (060414)

In some places in Shionomisaki①, there is a black line where a certain constant interval is kept. They seem thrust plane. They are located after upheaval.

As the result of SBP, there are many folded black lines which are caused by diffracted wave. Probably it is influenced by geographical features or oceanic condition.

In regard to Shionomisaki④, it consider there is a cliff, because it could not catch reflected wave.

In addition, the deposit seems to have collected around shot number 1860 in Shionomisaki⑦. The place is located between a slope and another slope. Probably, the deposits are slump-sediments.

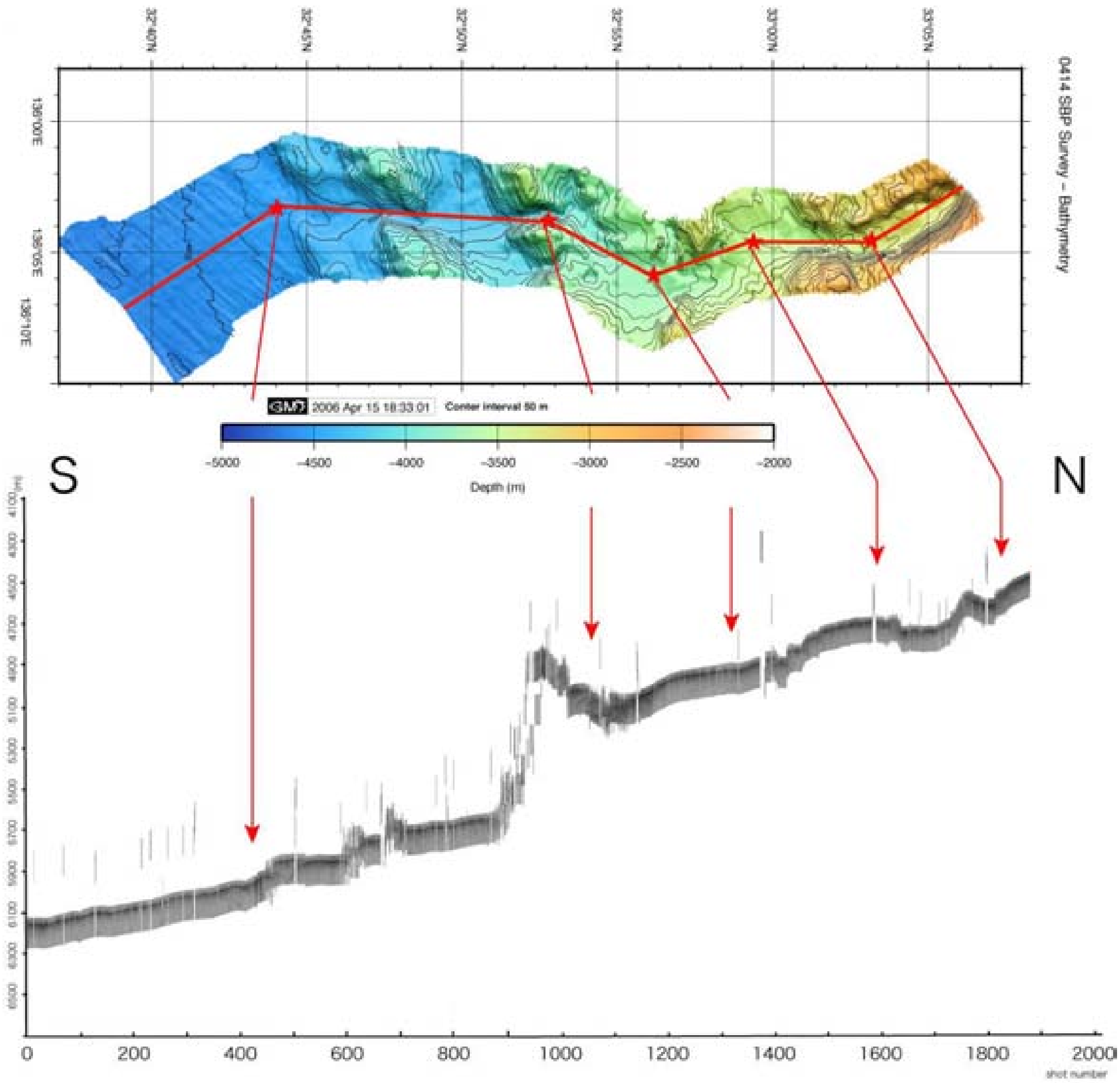


Figure: Subbottom profiler image along the Shionomisaki Canyon

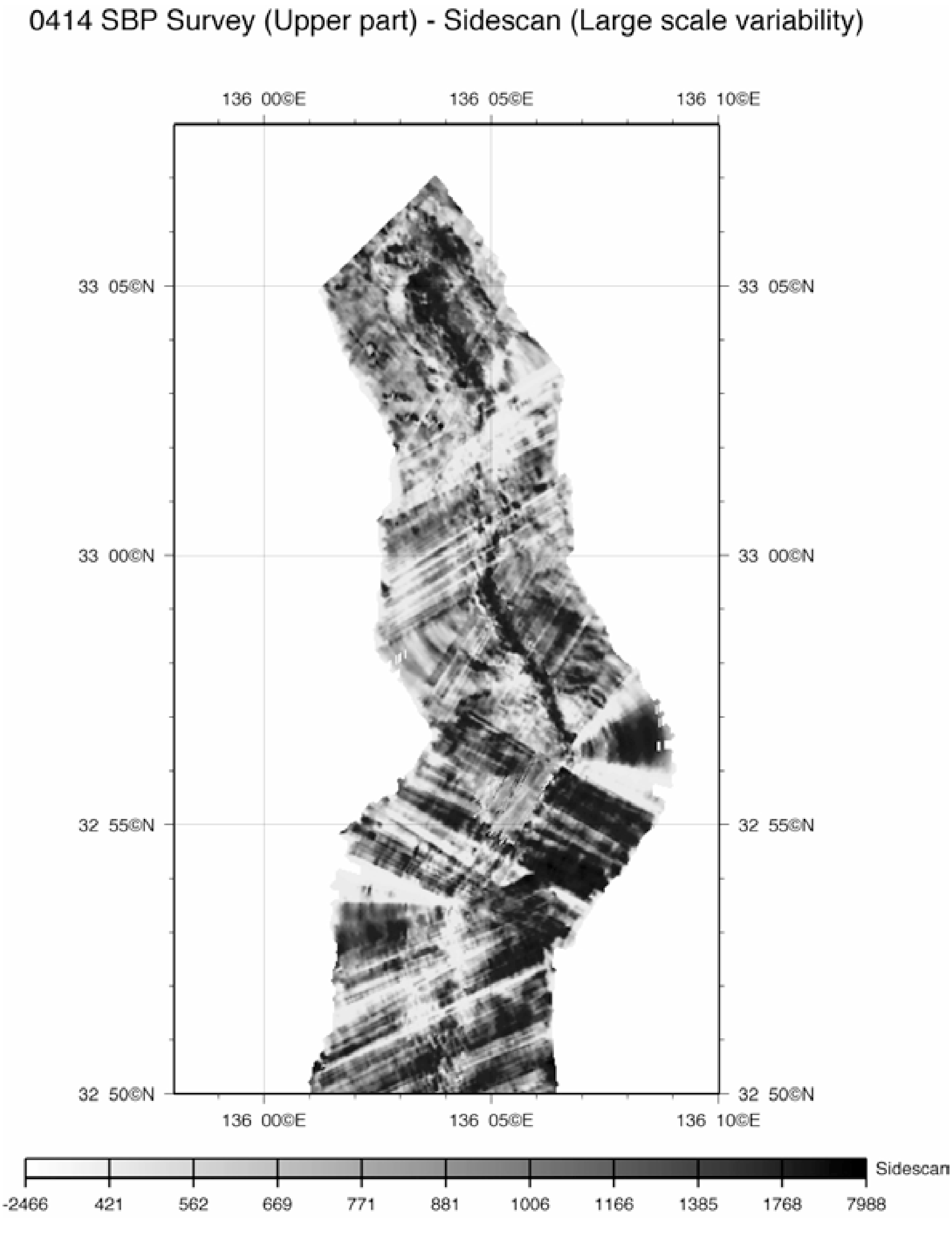


Figure: Sidescan image along SBP060414, Shionomisaki Canyon (north part)

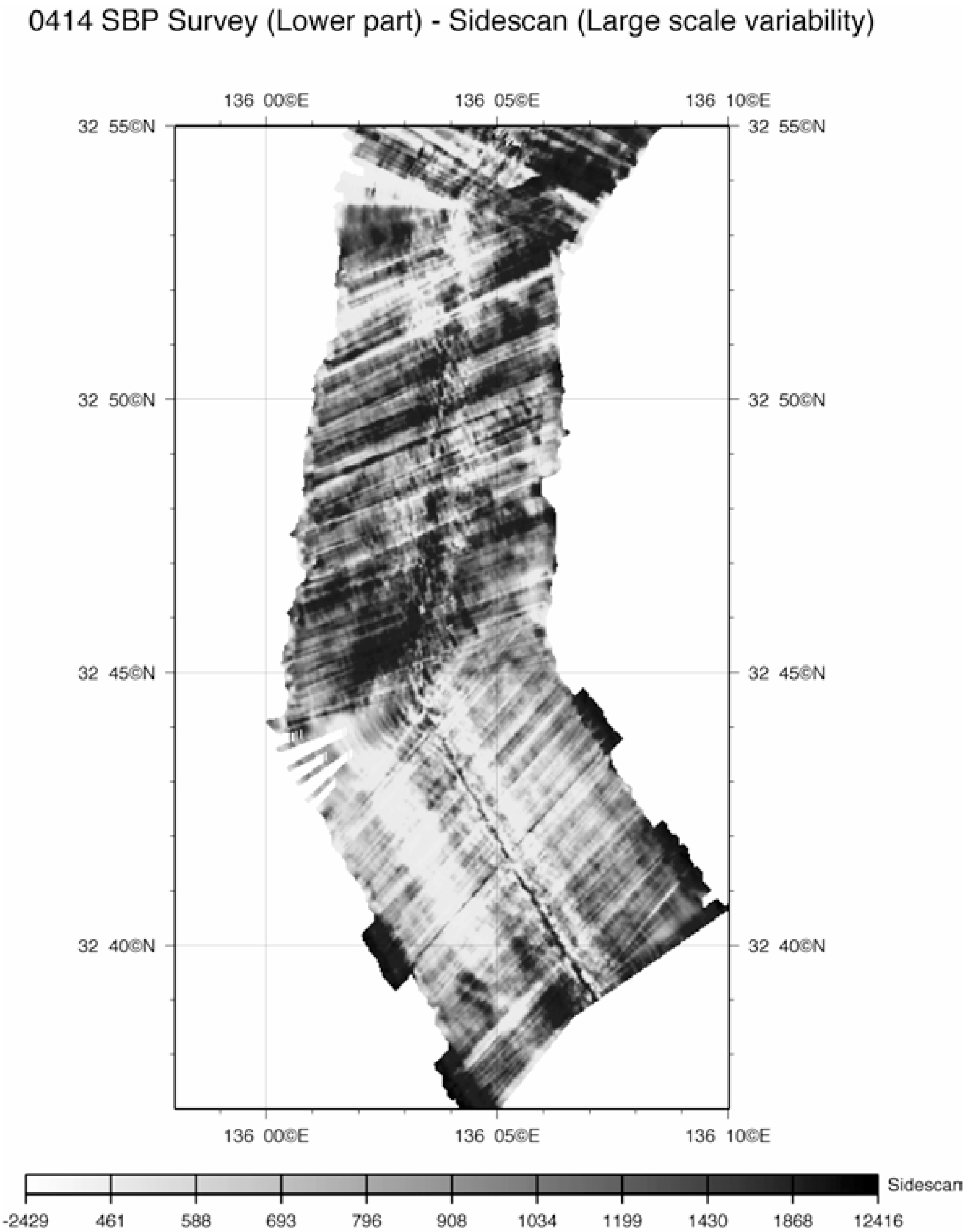


Figure: Sidescan image along SBP060414, Shionomisaki Canyon (south part)

Tenryu Canyon① (060413)

In some places, upheaval is observed.
The SBP Data shows striped pattern, in other words they are alternation of strata, black is sand and white is mud.
Between shot number 260 and 380, the deposit on the north side is relatively thicker than the south.
This observation implies that this place was slope.

Tenryu Canyon② (060419)

The bottom of the sea geographical features side is rough.
There are the black lines which seem thrusts.
There are folded mountains in Tenryu②.
In Tenryu④, the plane, south dipping, is observed on the slope of north side. Is this a normal fault??
Because alternation of strata is not distinct, it consider the deposits are mud.

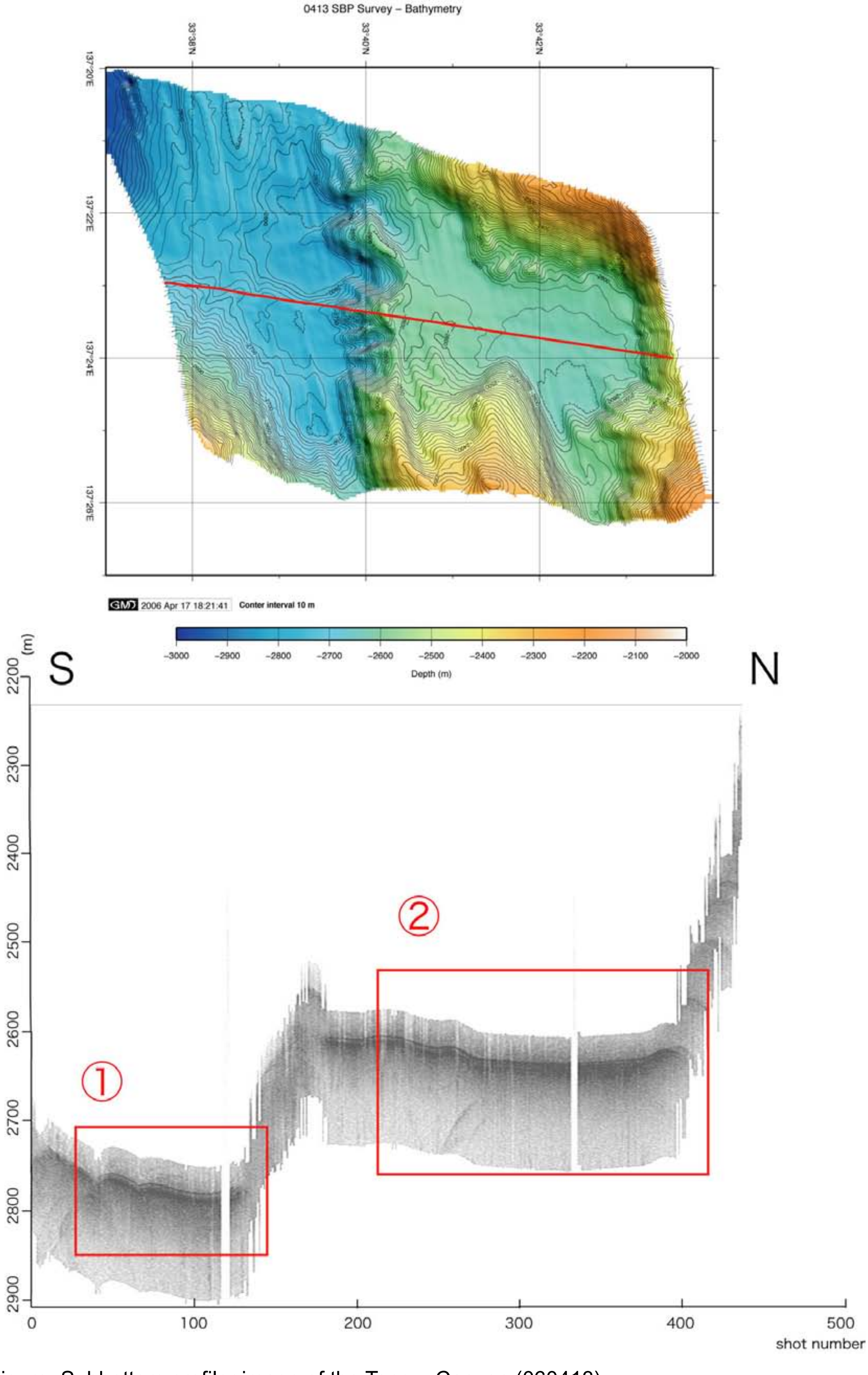


Figure: Subbottom profiler image of the Tenryu Canyon (060413)

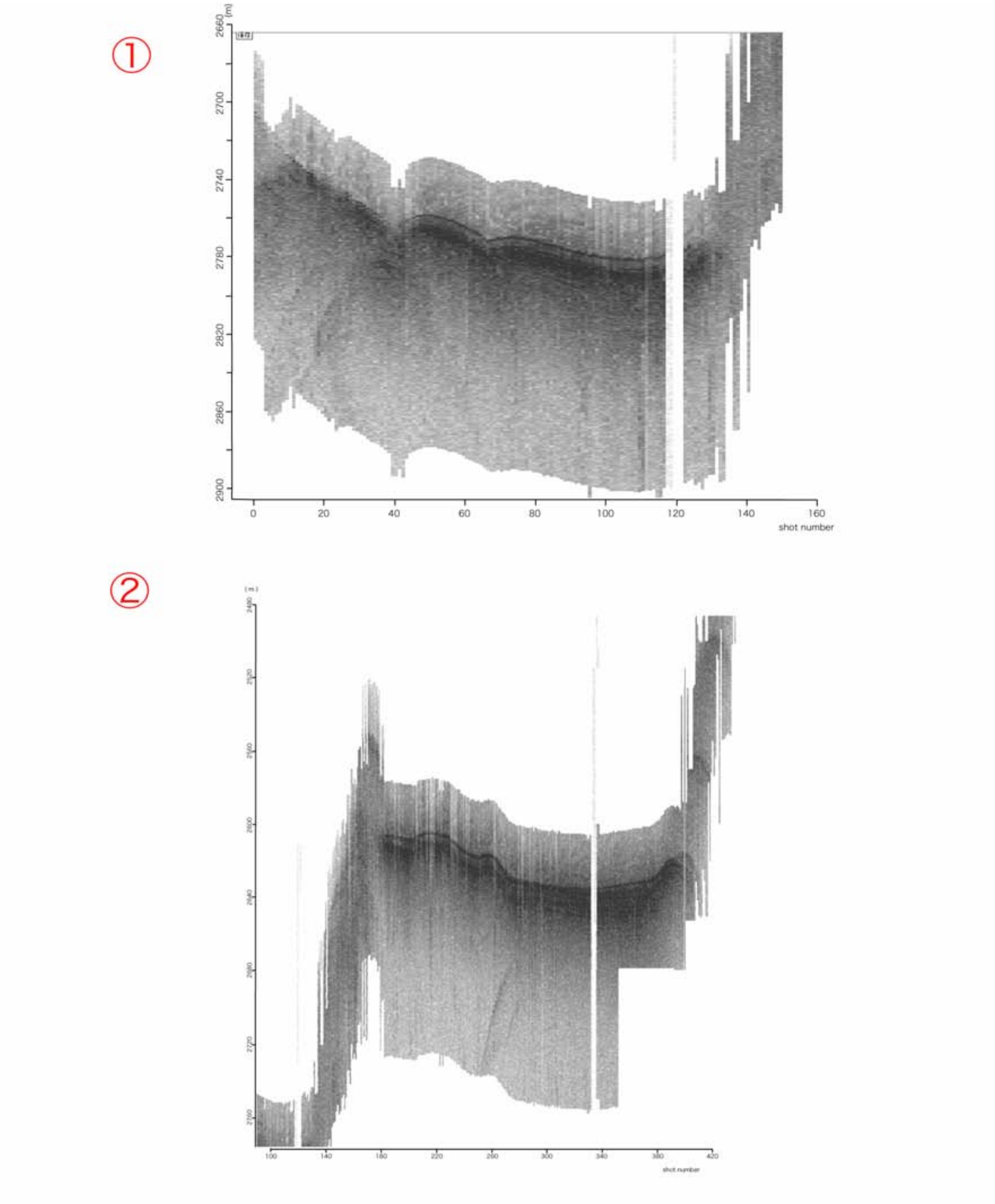


Figure: Subbottom profiler image of the Tenryu Canyon (060413)

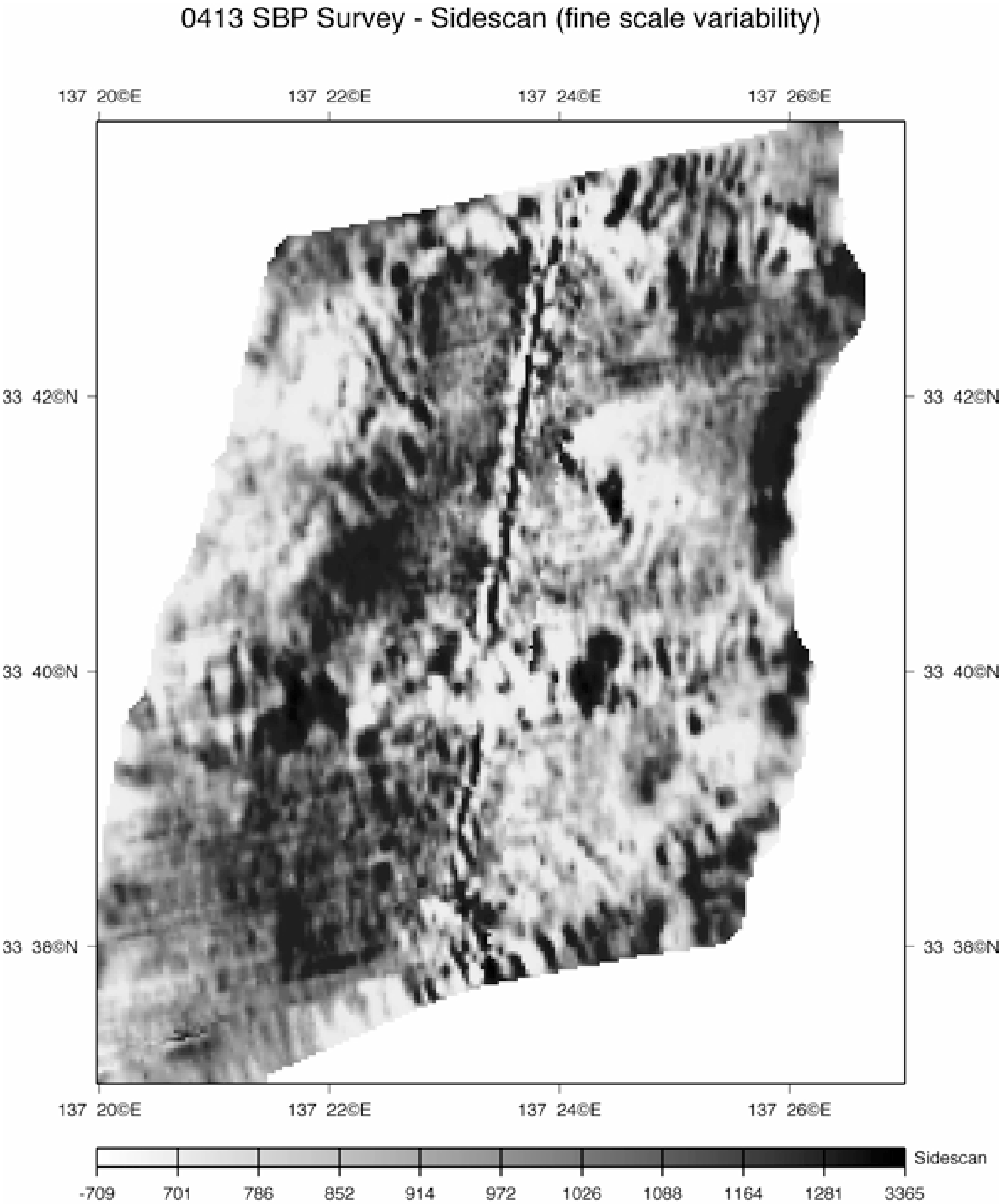


Figure: Sidescan image along SBP060413, Tenryu Canyon

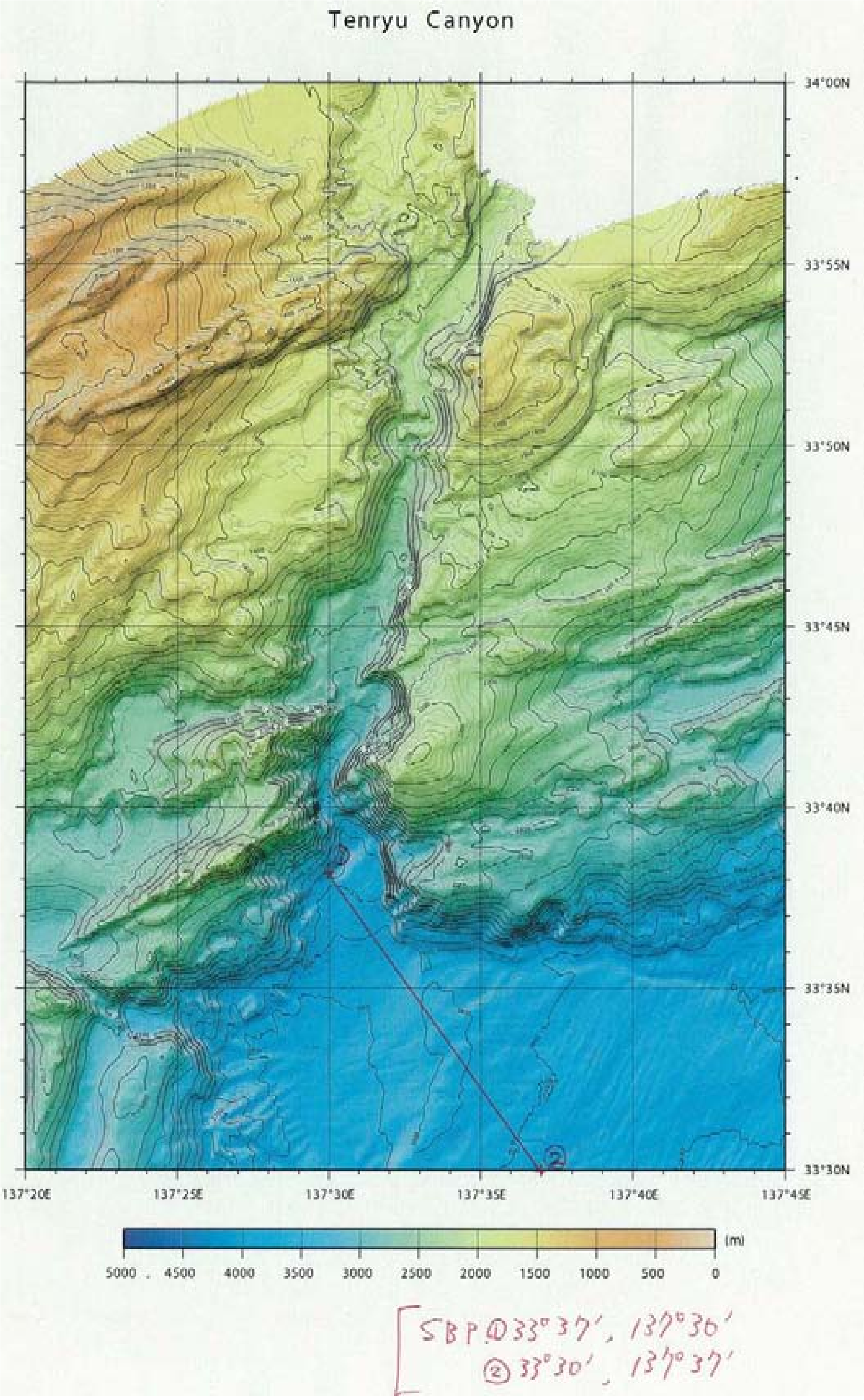


Figure: Subbottom profiler line of the Tenryu Canyon (060419)

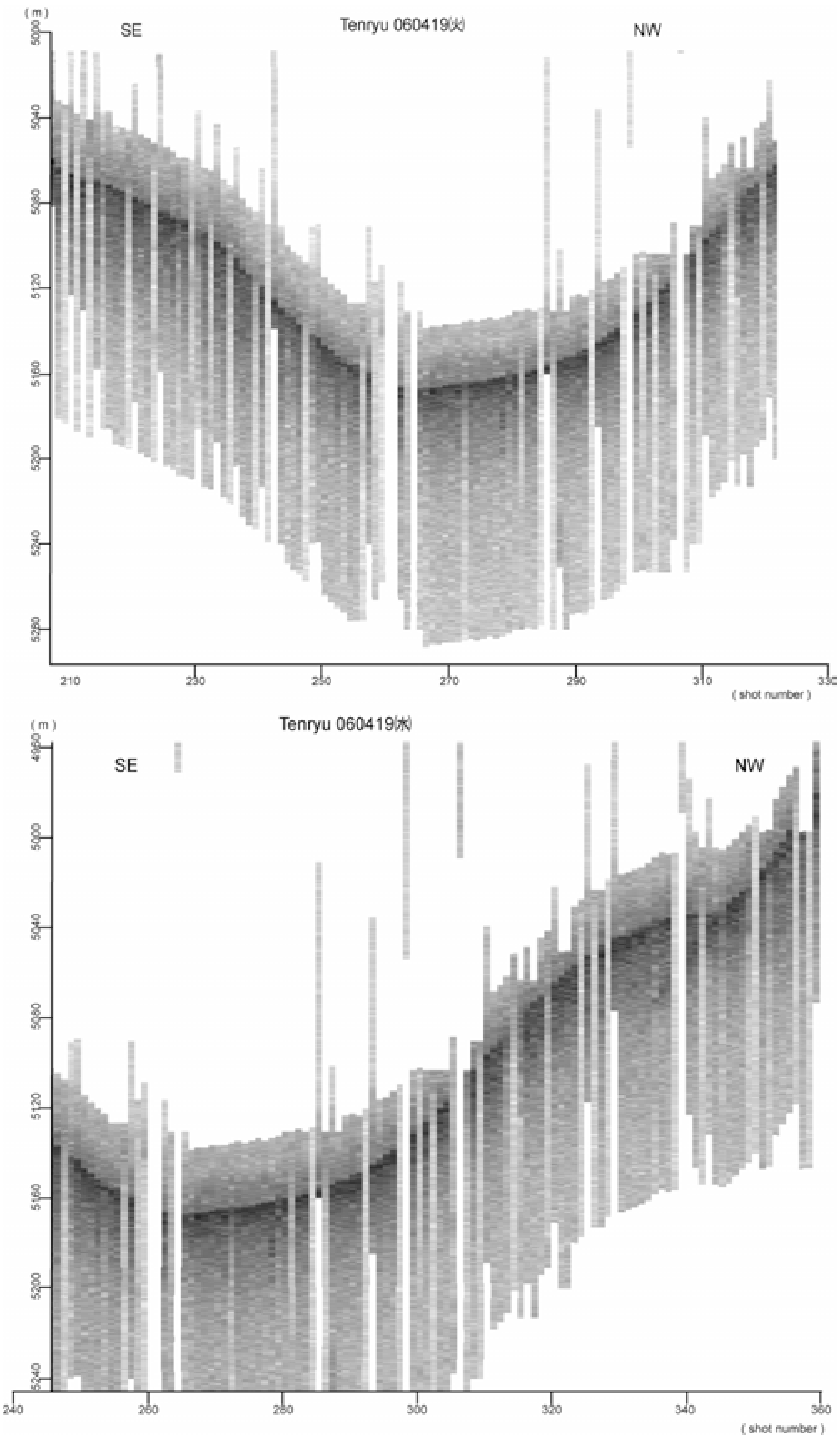


Figure: Subbottom profiler image of the Tenryu Canyon (060419)

Future study

川村喜一郎・小川勇二郎・安間了

岩石試料の物性，力学特性，磁化特性を明らかにするとともに，変形組織を観察し，岩石の変形履歴について，研究する．また，ダイブビデオを見返して，露頭から得られる地層の走向傾斜および断層，割れ目の方位について記載し，岩石試料と併せて，し，付加体の形成プロセスを明らかにする．

安間了

シロウリガイの貝殻の成長線の薄片観察を行い，成長縞などの組織に特徴的な周期が存在するかを検討する。成長縞ごとに詳細な地球化学的検討を行い，シロウリガイの成長を支配する因子を考察する。とくに、元素分布が冷湧水活動度の指標になるかを検討する。

中村顕

抽出 DNA については PCR-DGGE 及びクローン解析法により、バクテリア及び古細菌を中心とした微生物叢解析を行う。また、4℃保存のサンプルより各種微生物の分離を試みる。分離対象としては、好熱菌、窒素固定菌、共生菌、バイオフィルム形成菌を中心に幅広く検討する。

原　英俊

採取された泥岩中に含まれるイライトの結晶度を測定する。これにより泥岩の被熱温度が明らかにされ、泥岩の埋没履歴の復元が期待される。（また YK05－08 で採取された岩石も合わせて検討を行う。）

佐々木智之

YK06-02 Leg1 航海で取得したデータに関しては、サブボトムプロファイラ探査と同時に取得したマルチビーム測深データとサイドスキャンデータについて、潮岬海底谷と天竜海底谷沿い地点について、底質や地形と反射強度との関係についての考察を試みる。

加えて、昨年までの YK02-02 Leg2 航海、YK03-03 航海、YK05-08 Leg2 航海で取得されたマルチビーム測深データに関して、南海トラフ陸側斜面の崩壊地形に関しての解析と解釈を試みて来年のしんかいシンポジウムで発表をする。これらの結果をまとめて何らかの雑誌に投稿論文、あるいは短報としてまとめたい。雑誌は現在のところ未定。

水本裕之

深海底泥中に存在するウイルスについての研究事例は少数であり、ウイルスの遺伝子解析、および宿主生物の探索についてはほとんど研究事例がない．本航海中の天竜海底谷調査で得られた海底泥から、DNA および RNA を抽出し、ウイルス特異的遺伝子（DNA ポリメラーゼ、RNA

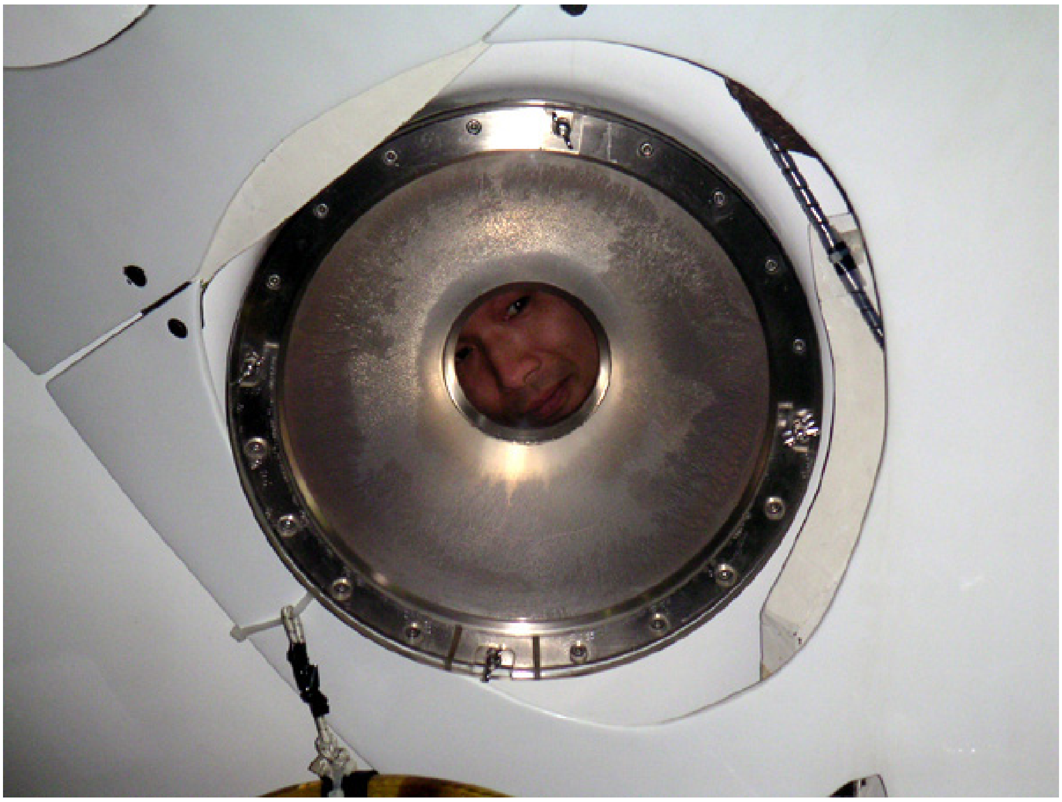
ポリメラーゼなど）を増幅する PCR を設計し、新奇ウイルス遺伝子の分離をおこなう．また、研究者所属機関（独立行政法人水産総合研究センター　瀬戸内海区水産研究所）で保持する多種のプランクトンに海底泥から抽出したウイルス粒子を接種し、宿主生物の探索を試みる．

佐藤寿年

These samples will be analyzed for metal concentrations and stable isotopes, and compare with other sediments which accumurated ruductive conditions. Cold seep areas are site-specific and very unique, therefore may have distinctively geochemical charactares.

村岡諭

房総半島南部の千倉層群が南海トラフ付加体と類似すると推察しているため、南海トラフの付加体と対比させ千倉層群の地質構造を明らかにする。



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