On Board Cruise Report of KR07-16 Kairei Cruise

26/November-2/December/2007

Contents

1. Purpose and Proposal

This project is a Japanese, US, and Australian collaborative research effort. We carried out a marine magnetotelluric transect across the central Mariana subduction system using ocean bottom electro-magnetometers (OBEMs), ocean bottom electrometers (OBEs), and ocean bottom magnetometers (OBMs) to provide a comprehensive image of the electrical conductivity structure of the Mariana island-arc system extending from the Pacific ocean to the West Mariana Ridge (remnant arc) through the Mariana Trough. Subduction zones are fundamental to Earth recycling, controlling the return of crustal materials into the mantle and the partitioning of some fraction back to the surface. The Mariana subduction system is the classic example of an intra-oceanic arc, trench, and back-arc system. Our transect across the central Mariana subduction system, which includes three instances of upwelling of serpentine diapirs, arc volcanism, and back-arc spreading, will address issues of hydration of the mantle wedge resulting from subduction and the nature and distribution of subsequent melting through estimation of the electrical conductivity structure. This will provide a breakthrough for understanding mantle dynamics related to plate subduction.

2. Cruise Log

2-1. Survey area

The target of the experiment is the Mariana subduction system across 18°N, and the survey area extends from the Pacific plate to West Mariana Ridge. The OBEM observations and the surface geophysical surveys took place within the boxed area shown in Figure 2-1. The area partly overlaps the exclusive economic zone (EEZ) of the United States of America. We have permission to survey inside the US EEZ.

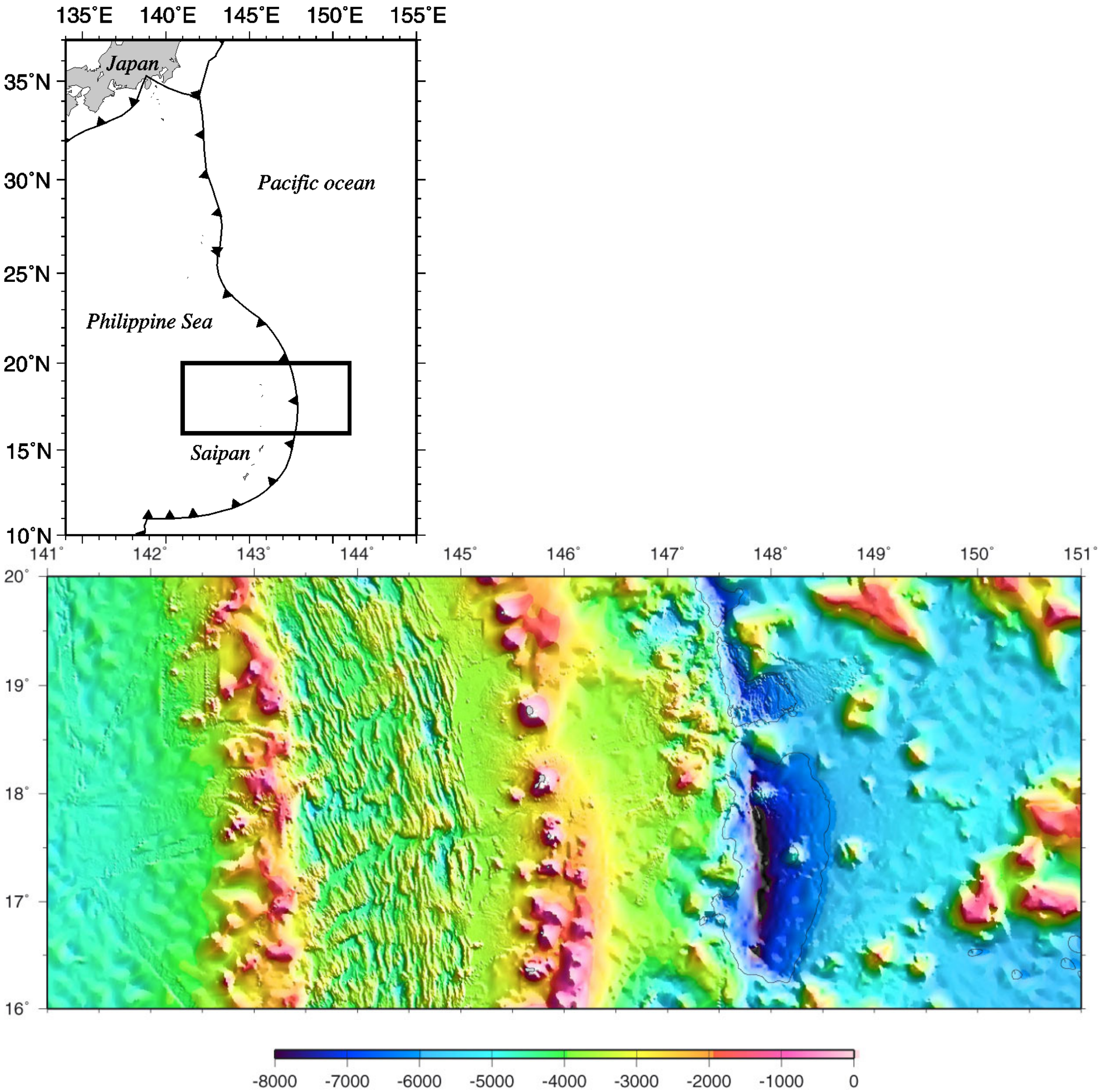

Figure 2-1. Location of the survey area (top). The bathymetry map within the survey area box is shown at the bottom.

2-2. Ship Log

Date	Time	Comment	Date(noon)/Weather /Ocean Wave/Sea Swell /Wind(direction/Force)
2007/11/26		Depart from YOKOHAMA	14:00(UTC+9h)
	14:00	Let go all shone line & Left Yokohama Port	

	14:30-15:00	Onboard Education (Guidance for living condition and safety on board)	
	16:40-17:00	Ceremony of the prayer to KONPIRA-Shrine for a safe voyage	
2007/11/27		Voyaging toward research area	12:00 (UTC+9h)
			bc (fine But Cloudy)
			3 (Sea Slight)
			2 (Low Swell-Long)
			NW-4
2007/11/28		Voyaging toward research area	12:00 (UTC+9h)
			bc (fine But Cloudy)
			2 (Sea Smooth)
			2 (Low Swell-Long)
			SSE-4
2007/11/29	14:32-14:47	Deployment Lander-A	12:00 (UTC+9h)
		(18_49.2002'N,149_50.5741'E,d=5474)	bc (fine But Cloudy)
	14:55-15:06	Deployment Lander-B	4 (Sea Moderate)
		(18_49.0611'N,149_51.0136'E,d=5475)	3 (Moderate-Short)
	15:48	Started MBES Mapping Survey	SE-5
2007/11/30	3:39	Finished MBES Mapping Survey	12:00 (UTC+9h)
	3:58	Release command (Site40, USA)	bc (fine But Cloudy)
	8:20	OBEM on surface (Site40, USA)	3 (Sea Slight)
	8:42	OBEM on deck (Site40, USA)	2 (Low Swell-Long)
	11:00	Release command (Site39, J_Kobe)	ESE-3
	11:20	Release command (Lander-A)	
	12:00	Release command (Lander-B)	
	13:30	OBEM on surface (Site39, J_Kobe)	
	13:36	OBEM on deck (Site39, J_Kobe)	
	14:24	Recovery Lander-A	
	15:20	Lander-A on Deck	
	16:02	Recovery Lander-B	
	16:33	Lander-B on Deck	
	16:39	Started MBES Mapping survey	
2007/12/1	M.N.	Adjusted time 1hour ahead(UTC+10h)	12:00 (UTC+10h)
	22:02	Finished MBES Mapping Survey	bc (fine But Cloudy)
		Voyaging toward Guam Harbor	4 (Sea Moderate)
			3 (Moderate-Short)
			ENE-4
2007/12/2	16:00	Arrived at Guam Harbor	

Scale

Wind Force	Ocean Wave	Sea Swell
0 ; Clam ; 0-0.2m/sec	0 ; Calm (Glassy)	0 ; No Swell
1 ; Light air ; 0.3-1.5m/sec	1 ; Calm (Rippled)	1 ; Low Swell-Short or Average
2 ; Light breeze ; 1.6-3.3m/sec	2 ; Smooth (Wavelets)	2 ; Low Swell-Long

3 ; Gentle breeze ; 3.4-5.4m/sec	3 ; Slight	3 ; Moderate-Shot ;
4 ; Moderate breeze ; 5.5-7.9m/sec	4 ; Moderate	4 ; Moderate-Average ;
5 ; Fresh breeze ; 8.0-10.7m/sec	5 ; Rough	5 ; Moderate-Long ;
6 ; Strong breeze ; 10.8-13.8m/sec	6 ; Very rough	6 ; Heavy Swell-Short ;
7 ; Near gale ; 13.9-17.1m/sec	7 ; Hight	7 ; Heavy Swell-Average ;
8 ; Gale ; 17.2-20.7m/sec	8 ; Very high	8 ; Heavy Swell-Long ;
9 ; Strong gale ; 20.8-24.4m/sec	9 ; Phenomenal	9 ; Confused Swell
10 ; Storm ; 24.5-28.4m/sec		
11 ; Violent storm ; 28.4-32.6m/sec		
12 ; Hurricane ; 32.7m/sec-		

3. Participants

3-1.Onboard Scientists

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Chief Officer	Satoshi SUSAMI
2nd Officer	Naoto KIMURA
3rd Officer	Yuki FURUKAWA
Chief Engineer	Hiroyuki SHIBATA
1st Engineer	Asahiro KAJIHARA
2nd Engineer	Azunori NOGUCHI
3rd Engineer	Wataru KUROSE
Chief Electronics Operator	Hideyuki AKAMA
2nd Electronics Operator	Yoichi INOUE
3rd Electronics Operator	Ken YAMAGUCHI
Boatswain	Yasuyoshi KYUKI
Able Seaman	Kiyoshi KANEDA
Able Seaman	Tadahiko TOGUCHI
Able Seaman	Hatsuo ODA
Able Seaman	Yuki YOSHINO
Sailor	Yoshiaki MATSUO

Sailor	Nao ISHIZUKA
No.1 Oiler	Masayuki MASUNAGA
Oiler	Masaki SHIINO
Oiler	Keita FUNAWATARI
Oiler	Yuji HIGASHIKAWA
Oiler	Shota WATANABE
Chief Steward	Teruyuki YOSHIKAWA
Steward	Shinsuke TANAKA
Steward	Koji KIRITA
Steward	Hideo FUKUMURA
Steward	Akira KANAYA

4. Preliminary Results

4-1. OBEM recovery

We recovered two ocean bottom electric-magnetometers (OBEMs) that had remained deployed, as the ship was forced to leave the survey area due to an oncoming typhoon during the previous recovery KR06-12 cruise. One is Kobe OBEM at site 39 and the other is US OBEM at site 40. Site positions are given in Figure 4-1-1 and Table 4-1-1. Upon release, instruments were tracked to the surface using a variety of acoustic tracking tools. Kobe OBEM utilized the inbuilt SSBL system on board the R/V Kairei to provide real-time x,y,z positions in the water column. US OBEM used a combination of slant ranges and the ship position along with the starting position and measured ascent rates to calculate the position. By tracking the instruments closely we were able to accurately predict their surface times and positions and quickly find them with the ship. The OBEMs were recovered using a platform on the starboard side of the ship. The instruments were hooked by the crew and lifted by a chain hoist and crane onto the platform where the instrument was broken down and moved inboard. This operation was quick and took at most 30 minutes to complete.

The Kobe-OBEM (Photo 4-1-1) measures three components of magnetic field variation, three components of electric field variation, two components of instrument tilt, and temperature. Each OBEM has two pressure-resistant glass spheres; one contains fluxgate type magnetometers, voltmeters, and tilt meters, and the other contains lithium battery packs and the transponder unit. They have pipes for attaching five Filloux-type silver-silver chloride electrodes (Filloux, 1987). The OBEM sensor is made by Masashi Shimoizumi (Kyushu Polytechnic College) and Clover-tech Corp. Data sampling was carried out ten times (ten seconds) per one minute. The OBEM also has a radio beacon and flashing light for recovery.

The electric field section of the US OBEM (Photo 4-1-2) measures the voltage differences over 6 m using Ag-AgCl electrodes with a gain-ranging data logger having 20 bit resolution. The magnetic field sensors record three components of the time-varying magnetic field with 0.1 nT resolution using suspended magnet sensors with optical feedback. The OBEM also incorporates a two-component tilt sensor having 1 microradian resolution. All data are recorded internally on flash cards.

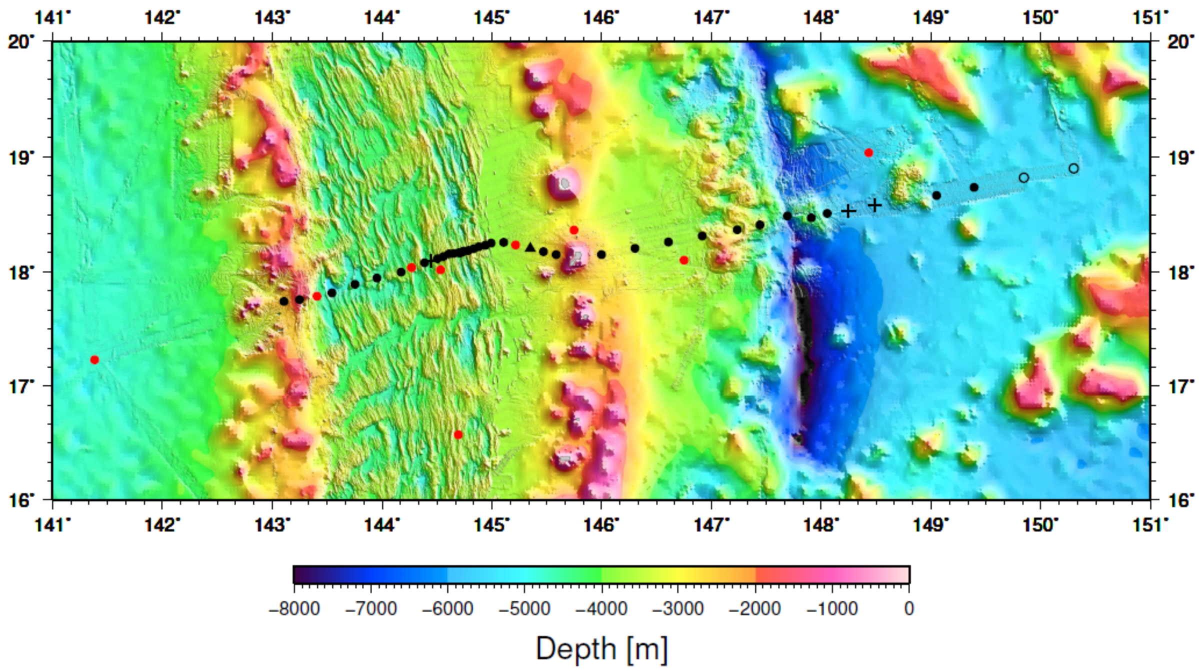

Figure 4-1-1. A Location map of OBEMs, OBMs, and OBEs deployments through the Mariana

subduction system. Open circles show the locations of OBEM recovered during KR07-16 cruise. Black dots show the locations of OBEM or OBM & OBE recovered during KR06-12 cruise. The triangles show sites where only the OBM was recovered. Crosses denote sites where OBEM recovery failed. Red circles are OBEM sites from previous studies for which data are already in hand.

Site	Type	Latitude	Longitude	Depth (m)	Remarks
39	Jk	18 - 49.088 N	149 - 50.804 E	5432	
40	U	18 - 54.013 N	150 - 18.015 E	5464	not calibrated

jk: Kobe OBEM
u: US OBEM

Table 4-1-1. Location of OBEM

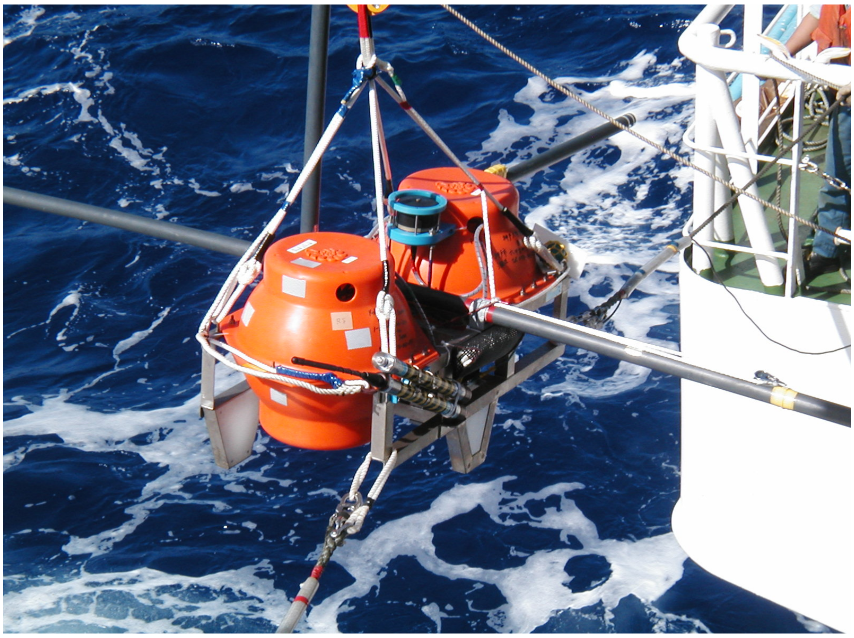

Photo 4-1-1. Kobe OBEM.

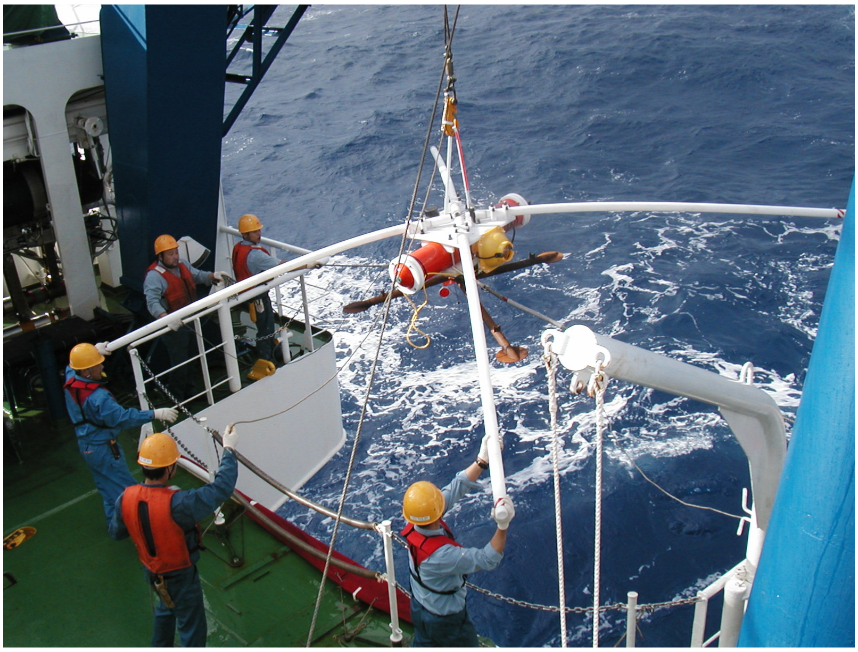

Photo 4-1-2. US OBEM.

4-2. Surface Geophysical Survey

We conducted a surface geophysical survey to collect multi-narrow beam bathymetry, magnetic field, and gravity field data. The ship tracks and the bathymetry map are shown in Figures 5-2-1 and Figure 5-2-2, respectively. Multi-narrow beam bathymetric data were obtained using a SeaBeam 2112, which also provides a backscatter image that will be processed after the cruise. An XBT was done on 29 November at site 39. The DGPS (differential global positioning system) was used to derive the ship's location. Magnetic field data were collected with two instruments: a shipboard three component magnetometer (STCM: Isezaki, 1986) that can measure the vector geomagnetic field using deck-mounted fluxgate magnetometers and gyros, and a ship-towed proton precession magnetometer that can measure the intensity of the geomagnetic field. The STCM data contain the effects of the ship's magnetic field that must be corrected in order to derive the real geomagnetic field. Twelve constants (B(1,1)-B(3,4)) related to the ship's permanent and induced magnetic field are estimated using data from "Figure 8 turns". "Figure 8 turns" is made by steering the ship in a tight circle, both clockwise and counter clockwise. During the cruise, "Figure 8 turns" were conducted two times and these are listed in Table 4-2-1 and the ship tracks are shown in Figure 4-2-3. Gravity field data were obtained from a shipboard gravimeter (KSS-31, Bodenseewerk Perkin-Elmer GmbH). However, the shipboard gravimeter stopped measuring the gravity field at times, and had to be restarted. The gravity field data at Yokohama and Guam ports measured with a gravimeter (CG-3M, Scintrex) will be used to correct the instrument drift.

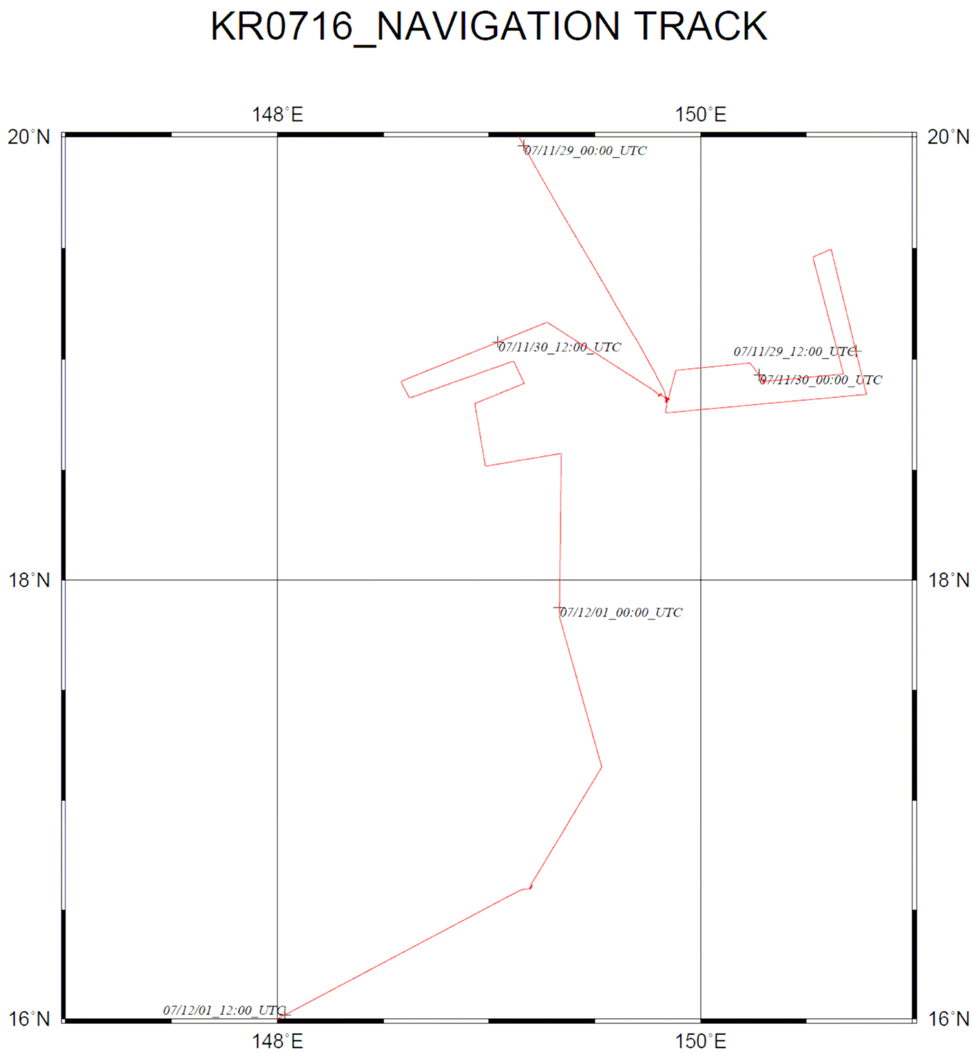

Figure 4-2-1. Ship track of the cruise in the survey area

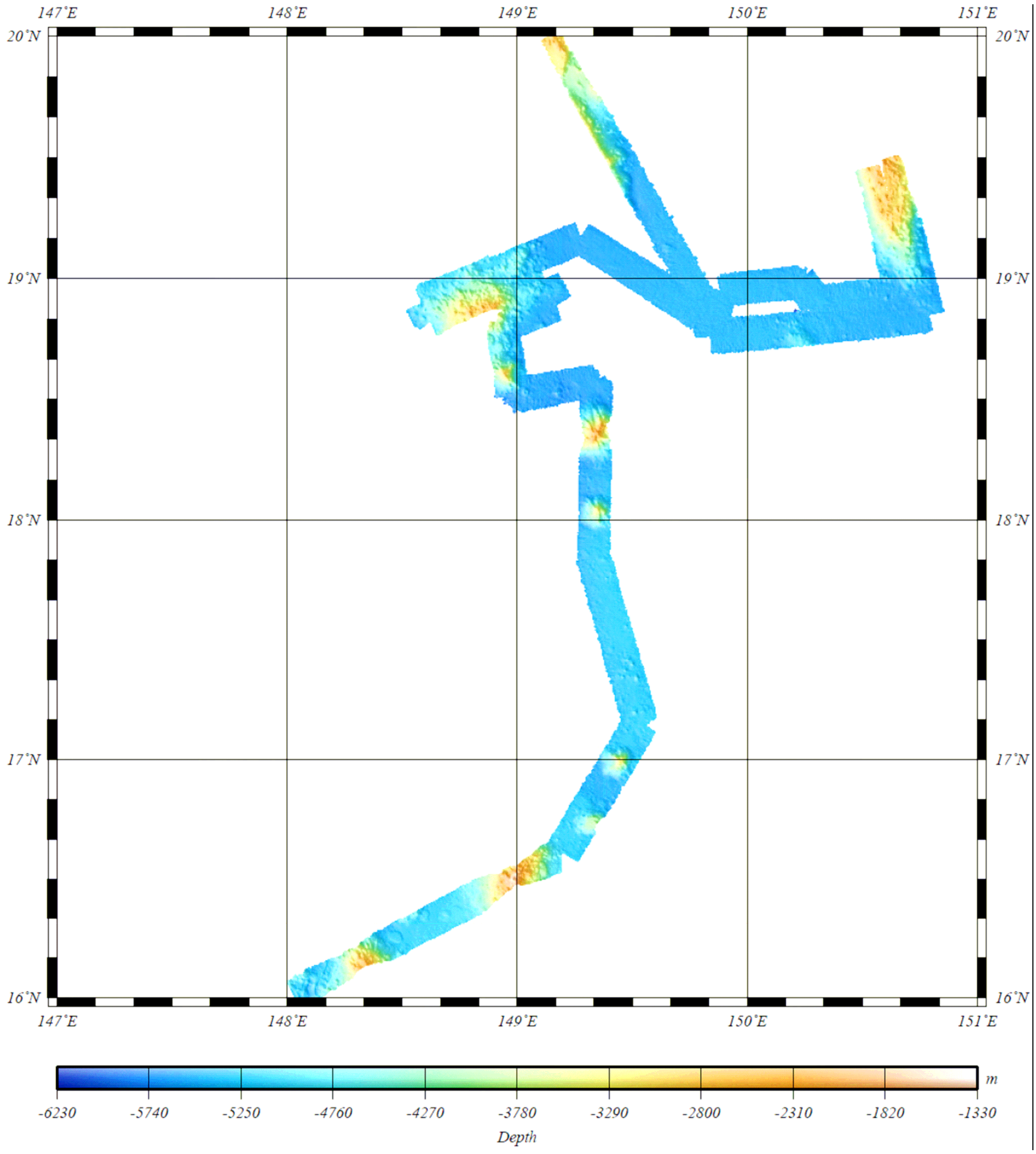

Figure 4-2-2. Bathymetry map in the survey area

No.	Date	Time(UT)	Latitude	Longitude
1	30/Nov.	08:01-08:20	18°50.4'N	149°48.5'E
2	1/Dec.	06:01-06:18	16°36.3'N	149°11.9'E

Table 4-2-1. List of "Figure 8 turns"

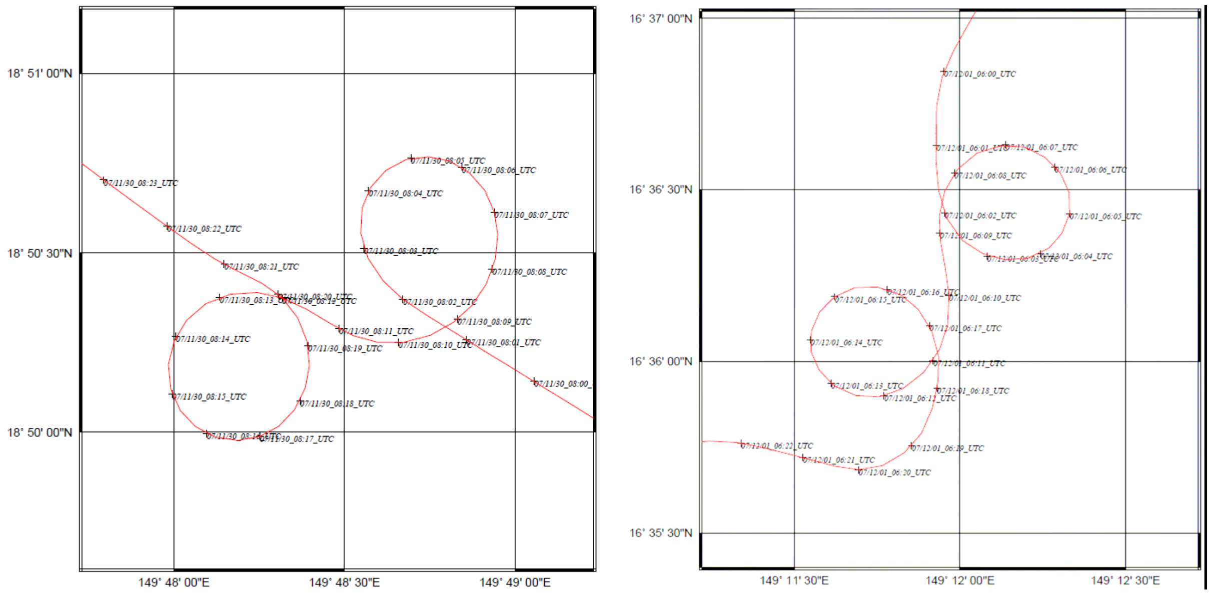

Figure 4-2-1. Ship tracks of two "Figure 8 turns".

4-3. Deep-sea scavenging fauna at 5400m in the Mariana Region, NW Pacific Ocean

The hadal-zone (6000-11000m) is inhabited by a distinctive and poorly understood faunal community compared to that of the neighboring abyssal-zone. Expeditions over 50 years ago found some unique hadal-populations with high degrees of endemism, while others were completely lacking. Species have evolved special physiological adaptations to survive at pressures of up to 1 ton.cm^{-2}, a very important and still underrepresented area of deep-sea biology. Given the adverse effects of retrieving specimens from these depths, all observations and experimentation are performed *in situ*. Theoretically, scavenging on carrion falls should be an important ecological process at these depths given its remoteness from surface-derived particulate organic matter. On this RV *Kairei* cruise as part of the HADEEP project (funded by Nippon Foundation, Japan and NERC, UK), a simulated carrion-fall was deployed on two free-fall landers (one video, one still photography) to ~5400m in the Marianas region, NW Pacific Ocean, as the abyssal component to the abyssal-hadal biological transition zone.

The landers were deployed at 5575m (18º 49.187N 149º 50.583E; Video and 18º 49.060N 149º 51.021E; Stills). The video lander was pre-programmed to record 1 minute of footage every five minutes and did so for the required 10 hours on the sea floor. The still lander took 1 image every one-minute (totalling 1540 images). The temperature and pressure were recorded every 30 seconds throughout (mean=1.5ºC). The scavenging community observed comprises primarily macrourid fishes (*Coryphaenoides yaquinae*), although larger cusk eels and the occasional natantian decapod were also observed. The baited funnel traps attached to the video lander also collected approximately 500 individual amphipods for part of an ongoing population genetics project.

Figure 4-3-1. The deep-sea macrourid *Coryphaenoides yaquinae* at 5574m in the Marianas region.

5. Summary and Future Studies

We successfully recovered 2 OBEMs at 2 sites. The instruments measure geomagnetic and/or electric fields, and these data will contribute to a comprehensive image of the electrical conductivity structure for the Mariana island-arc system extending from the Pacific Ocean to the West Mariana Ridge (remnant arc) through the Marina Trough. Further, the surface geophysical survey data will be used for the topographic correction of electromagnetic data and provide additional information for an interpretation of electrical conductivity structure. These results will provide a breakthrough for understanding mantle dynamics related to plate subduction. Moreover, two free-fall landers were successfully deployed and recovered. The scavenging community observed comprises primarily macrourid fishes (*Coryphaenoides yaquinae*) although larger cusk eels and the occasional natantian decapod were also observed.

Acknowledgement

We gratefully recognize the efforts of the officers and crew (Hitoshi Tanaka, captain) of the R/V Kairei during the cruise. We thank all the support staffs in JAMSTEC. This research was supported by Japan Society for the Promotion of Science (Grant-In-Aid for Scientific Research (B)(1)(No. 15340149), Japan-US Integrated Action Program, and "The 21st Century COE Program of Origin and Evolution of Planetary Systems"), "Stagnant Slab Project (No. 17037003)" in Ministry of Education, Culture, Sports, Science, and Technology, Flinders University, the U.S. National Science Foundation MARGINS program, Nippon Foundation, Japan, and NERC, UK.

Appendix

A-1. Data List

(Nobukazu Seama is in charge of these data, and Toyonobu Fujii is in charge of picture and video files)

1. SOJ data (ship log, gravity, and magnetic data) and the data format
   (The data are in DVD provided from the ship)
2. SOQ data (SSBL data) and the data format
   (The data are in DVD provided from the ship)
3. SeaBeam bathymetry data (edited data)
   (The data are in DVD provided from the ship)
4. STCM magnetic field data
   (The data are in DVD provided from the ship)
5. Picture and Video files from landers