On Board Cruise Report of KR05-17 Kairei Cruise

10-26/December/2005

Contents

1. Purposes and Proposal

This project is a Japan, US, and Australia collaborative research effort. We will carry 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 Marina 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 upwellings 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 make 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 at 18°N so that the survey area extends from the Pacific Ocean to West Mariana Ridge. The deployment of the seafloor instruments and the surface geophysical surveys took place within the boxed are area shown in Figure 2-1. The area partly overlaps the exclusive economic zone (EEZ) of United States of America. We have permission to survey inside the US EEZ and territory.

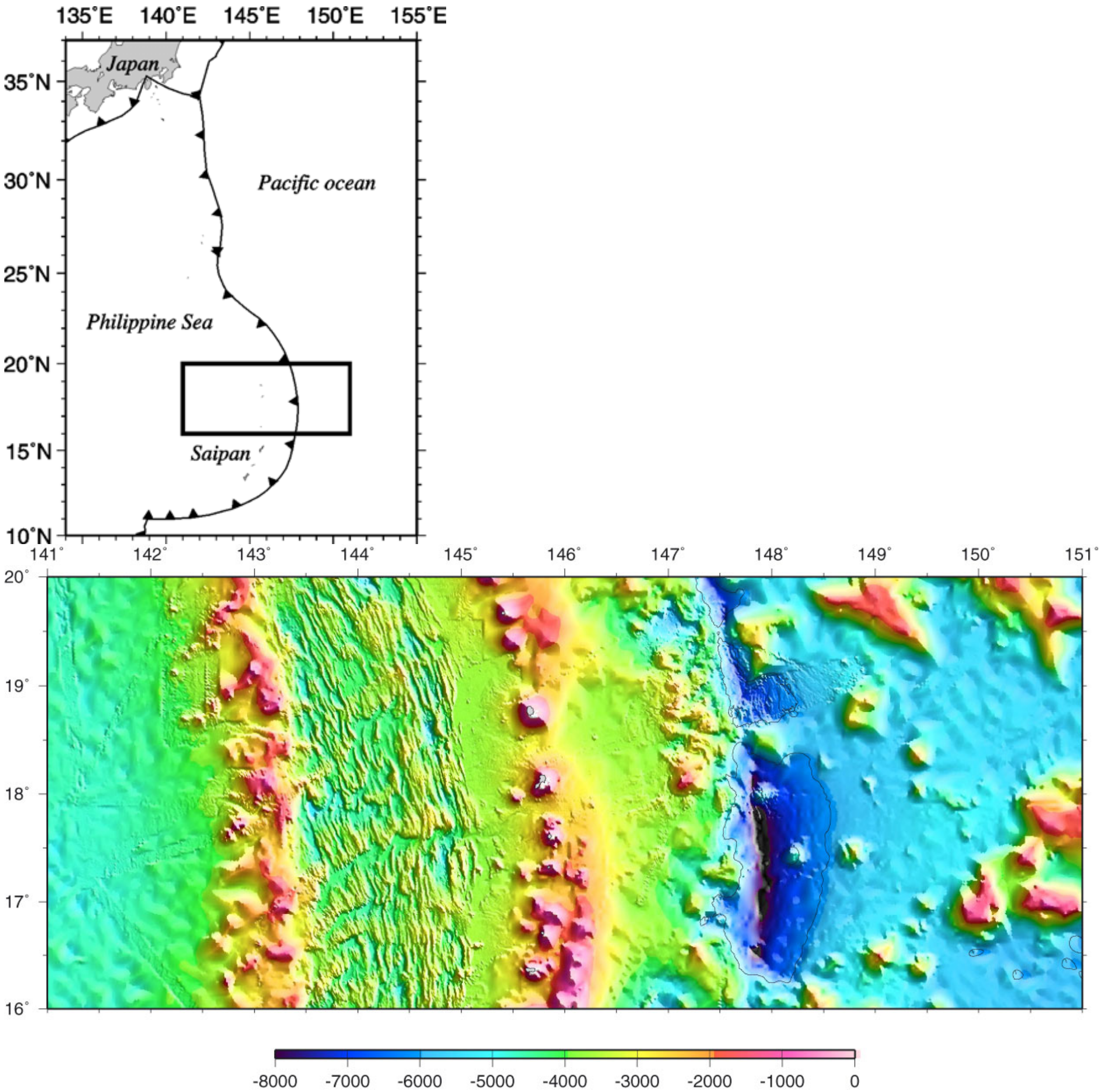

Figure 2-1. Location of the survey area (top). Bathymetry map in the box is shown at the bottom.

2-2. Ship Log

Date	Time (JST+9h)	Comment	Date (noon) / Weather / Ocean Wave / Sea Swell / Wind (direction･Force)
2005/12/9	11:00-12:00	Science Meeting in JAMSTEC	12:00 (JST = UTC+9h)
	13:00	Researcher boarding	bc (Fine But Cloudy)
			2 （Sea Smooth）

			SWE - 2
2005/12/10		Depart for Mariana research sea area	12:00 (JST = UTC+9h)
	08:15-09:00	Onboard Education（Guidance for living condition and safety on board）	bc (Fine But Cloudy)
	10:00	Let go all shone line & left YKOSUKA(JAMSTEC) port	4 （Sea Moderate）
	13:00-13:00	Reserch Meeting with R/V Kairei Ship Crew	2 (Low Swell-Long）
	16:40-17:00	"Konpira-san" on Bridge	W - 5
2005/12/11		Voyaging toward research sea area	12:00 (JST = UTC+9h)
	18:00-19:00	Science Meeting in Reseach Room	c (Cloudy)
			4 （Sea Moderate）
			2 (Low Swell-Long）
			SW - 5
2005/12/12		Voyaging toward research sea area	12:00 (JST = UTC+9h)
	13:00-14:00	Reserch Meeting with R/V Kairei Ship Crew	bc (Fine But Cloudy）
			3 （Sea Slight）
			2 (Low Swell-Long）
			NW - 3
2005/12/13	00:00-14:30	Voyaging toward research sea area	12:00 (JST = UTC+9h)
	14:30	Arived at reserch area and release XBT（19-05.4696'N, 150-14.9213'）	c (Cloudy）
	15:13-15:36	Carried out MNBES mapping survey	2 （Sea Smooth）
	16:08	Deployed OBEM（Site40, USA, 18-54.0125'N, 150-18.0153'E, D=5464m）	2 (Low Swell-Long）
	16:08-20:00	Acoustic Test (USA）	NNE - 4
	20:07-20:13	Deployed Proton magnetometer	
	20:13-	Carried out MNBES mapping survey	
2005/12/14	-05:23	Carried out MNBES mapping survey	
	07:04	Recovered Proton magnetometer	12:00 (JST = UTC+9h)
	07:36	Deployed OBEM（Site36, USA, 18-34.6096'N, 148-29.1346'E, D=5776m）	p (Passing Showers）
	10:31	Deployed OBEM（Site37, Kobe, 18-40.1084'N, 149-02.9964'E, D=5576m）	4 （Sea Moderate）
	13:08	Deployed OBEM（Site38, Australia, 18-44.0064'N, 149-24.0044'E, D=5526m）	2 (Low Swell-Long）
	13:57-14:01	Acoustic Test（Australia）	NE - 5
	16:19	Deployed OBEM（Site39, Kobe, 18-48.9842'N, 149-50.9986'E, D=5473m）	

	18:58-19:35	Carried out Calibration OBEM（Site39, Kobe）	
	21:57-	Carried out Calibration OBEM（Site38, Australia）	
2005/12/15	-00:46	Carried out Calibration OBEM（Site38, Australia）	
	01:00-02:27	Carried out MNBES mapping survey	12:00 (JST = UTC+9h)
	02:46-03:00	Carried out Calibration OBEM（Site37, Kobe）	bc (Fine But Cloudy）
	03:21-05:33	Carried out MNBES mapping survey	3 （Sea Slight）
	05:50-07:05	Carried out Calibration OBEM（Site36, USA）	3 (Moderate-Shot）
	07:20-08:05	Carried out MNBES mapping survey	NE - 4
	08:35	Deployed OBEM（Site35, Australia, 18-32.0105'N, 148-15.0090'E, D=5781m）	
	08:52-10:00	Carried out MNBES mapping survey	
	10:44	Deployed OBEM（Site34, ERI, 18-30.4708'N, 148-03.3209'E, D=5276m）	
	11:31-15:37	Carried out MNBES mapping survey	
	15:34	Deployed OBEM（Site32, ERI, 18-29.2290'N, 147-41.7895'E, D=6051m）	
	15:40-15:43	Tracking at OBEM（Site32, ERI）	
	16:08-17:04	Carried out MNBES mapping survey	
	18:09	Deployed OBEM（Site33, USA, 18-28.1065'N, 148-54.5064'E, D=4472m）	
	20:05-21:07	Carried out Calibration OBEM（Site35, Australia）	
	21:07-23:48	Carried out MNBES mapping survey	
	23:49-	Carried out Calibration OBEM（Site34, ERI）	
2005/12/16	-01:04	Carried out Calibration OBEM（Site34, ERI）	
	01:04-08:40	Carried out MNBES mapping survey	12:00 (JST = UTC+9h)
	04:31-05:17	Carried out Calibration OBEM（Site32, ERI）	bc (Fine But Cloudy）
	08:59	Deployed OBEM（Site31, Kobe, 18-24.5022'N, 147-26.5171'E, D=3284m）	4 （Sea Moderate）
	09:05-10:07	Carried out MNBES mapping survey	2 (Low Swell-Long）
	10:18	Deployed OBEM（Site30, Australia, 18-22.0002'N, 147-14.0391'E, D=3423m）	E - 5
	10:32-11:50	Carried out MNBES mapping survey	

	12:01	Deployed OBEM（Site29, USA, 18-18.5991'N, 146-55.0210'E, D=3616m）	
	12:09-13:23	Carried out MNBES mapping survey	
	13:34	Deployed OBEM（Site28, ERI, 18-15.5021'N, 146-36.5301'E, D=3668m）	
	13:44-14:56	Carried out MNBES mapping survey	
	15:07	Deployed OBEM（Site27, Australia, 18-12.3034'N, 146-18.2960'E, D=3385m）	
	15:21-20:46	Carried out MNBES mapping survey	
	20:46-21:14	Carried out Calibration OBEM（Site31, Kobe）	
	21:14-22:11	Carried out MNBES mapping survey	
	22:11-22:59	OBEM_Disable（Site30, Australia）	
	22:59-	Carried out MNBES mapping survey	
2005/12/17	-06:30	Carried out MNBES mapping survey	
	06:30-06:45	OBEM_Disable（Site27, Australia）	12:00 (JST = UTC+9h)
	06:45-08:05	Carried out MNBES mapping survey	
	08:25	Deployed OBEM（Site26, ERI, 18-09.0070'N, 145-00.0084'E, D=2695m）	bc (Fine But Cloudy)
	08:28-10:55	Carried out MNBES mapping survey	4 (Sea Moderate)
	11:01	Deployed OBEM（Site25, USA, 18-09.0156'N, 145-35.0352'E, D=2531m）	2 (Low Swell-Long)
	11:05-11:38	Carried out MNBES mapping survey	ENE - 5
	11:50	Deployed OBEM（Site24, ERI, 18-10.5072'N, 145-28.1970'E, D=3047m）	
	11:55-12:32	Carried out MNBES mapping survey	
	13:14	Deployed OBE（Site23, USA, 18-12.2375'N, 145-20.8474'E, D=3375m）	
	13:18	Deployed OBM（Site23, Australia, 18-12.3047'N, 145-20.9057'E, D=3378m）	
	13:28-14:31	Carried out MNBES mapping survey	
	14:48	Deployed OBEM（Site22, ERI, 18-15.2948'N, 145-06.4945'E, D=3757m）	
	14:52-15:26	Carried out MNBES mapping survey	
	15:44	Deployed OBE（Site21, USA, 18-14.9227'N, 144-59.3437'E, D=3783m）	
	15:47	Deployed OBM（Site21, Australia, 18-14.9725'E, 144-59.3869'E,	

		D=3783m）	
	16:00-21:50	Carried out MNBES mapping survey	
	21:50-23:00	Carried out Calibration OBEM（Site26, ERI）	
	23:00-	Carried out MNBES mapping survey	
2005/12/18	-06:43	Carried out MNBES mapping survey	
	07:03	Deployed OBEM（Site20, ERI, 18-13.8794'N, 144-56.0279'E, D=3538m)）	12:00 (JST = UTC+9h)
	07:49	Deployed OBM（Site19, Australia, 18-13.0110'N, 144-52.6773'E, D=3517m）	c (Cloudy）
	07:56	Deployed OBE（Site19, USA, 18-12.9439'N, 144-52.8112'E, D=3508m）	2 (Sea Smooth）
	08:58	Deployed OBE（Site17, USA, 18-11.1987'N, 144-46.8061'E, D=3590m）	1 (Low Swell-Short or Average）
	09:02	Deployed OBM（Site17, Australia, 18-11.2007'N, 144-46.8975'E, 3573m）	NE - 3
	09:45	Deployed OBE（Site15, USA, 18-10.4544'N, 144-43.7239'E, 3939m）	
	09:48	Deployed OBM（Site15, Australia, 18-10.4828'N, 144-43.8194'E, D=3983m）	
	10:55	Deployed OBEM（Site18, ERI, 18-12.1994'N, 144-49.8084'E, D=3324m）	
	12:25	Deployed OBEM（Site16, Kobe, 18-10.7064'N, 144-44.4168'N, D=3885m）	
	12:59	Deployed OBEM（Site14, Kobe, 18-09.9999'N, 144-42.8004'E, D=3814m）	
	13:28	Deployed OBEM（Site13, Australia, 18-09.8991'N, 144-41.7294'E, D=4001m）	
	13:30-13:40	Tracking at OBEM（Site13, Australia）	
	14:38	Deployed OBEM（Site12, USA, 18-09.5006'N, 144-38.9675'E, D=3369m）	
	15:24	Deployed OBEM（Site11, Australia, 18-09.3143'N, 144-36.5386'E, D=3227m）	
	15:25-15:35	Tracking at OBEM（Site11, Australia）	

	16:13	Deployed OBEM（Site10, ERI, 18-08.0008'N, 144-33.5907'E, D=3249m）	
	18:10-19:03	Carried out Calibration OBEM（Site13, Australia）	
	19:09-19:33	Carried out Calibration OBEM（Site14, Kobe）	
	19:38-20:40	Carried out Calibration OBE and OBM（Site15, USA, Australia）	
	20:44-21:09	Carried out Calibration OBEM（Site16, Kobe）	
	21:46-22:03	Carried out Calibration OBEM（Site18, ERI）	
	22:43-23:04	Carried out Calibration OBEM（Site20, ERI）	
	23:25-	Carried out Calibration OBE and OBM（Site21, USA, Australia）	
2005/12/19	-00:10	Carried out Calibration OBE and OBM（Site21, USA, Australia）	
	01:06-01:59	Carried out Calibration OBE and OBM（Site19, USA, Australia）	12:00 (JST = UTC+9h)
	02:42-03:37	Carried out Calibration OBE and OBM（Site17, USA, Australia）	r (Rain)
	04:20-05:05	Carried out Calibration OBEM（Site12, USA）	3 (Sea Slight)
	05:33-06:18	Carried out Calibration OBEM（Site11, Australia）	2 (Low Swell-Long)
	06:49-07:10	Carried out Calibration OBEM（Site10, ERI）	NE - 4
	08:11	Failed to deployment OBEM（Site8, ERI）	
	08:52	Recovered OBEM（Site8, ERI）	
	09:46	Deployed OBE（Site7, USA, 18-04.5431'N, 144-23.0407'E, D=4396m）	
	09:49	Deployed OBM（Site7, Australia, 18-04.5814'N, 144-23.0989'E, D=4398m）	
	10:55	Deployed OBE（Site9, USA, 18-06.6682'N, 144-30.1662'E, D=3561m）	
	10:58	Deployed OBM（Site9, Australia, 18-06.7101'N, 144-30.2206'E, D=3566m）	
	11:59	Deployed OBEM（Site8, ERI, 18-05.6045'N, 144-26.8106'E, D=4105m）	
	13:07-13:16	Acoustic Test（Australia）	

	13:53-15:11	Carried out Calibration OBE and OBM（Site9, USA, Australia）	
	15:35-17:06	Carried out Calibration OBEM（Site8, ERI）	
	17:28-18:19	Carried out Calibration OBE and OBM（Site7, USA, Australia）	
	18:27	Deployed Proton magnetometer	
	18:43-	Carried out MNBES mapping survey	
2005/12/20	-16:04	Carried out MNBES mapping survey	
	16:21	Recovered Proton magnetometer	12:00 (JST = UTC+9h)
	19:21-	Carried out MNBES mapping survey	r (Rain)
			5 （Sea Rough）
			4 (Moderate-Average)
			NE - 6
2005/12/21	-05:05	Carried out MNBES mapping survey	
	08:08	Deployed OBEM（Site1, USA, 17-44.4848'N, 143-06.4564'E, D=2508m）	12:00 (JST = UTC+9h)
	08:13-09:10	Carried out MNBES mapping survey	bc (Fine But Cloudy)
	09:26	Deployed OBEM（Site2, Australia, 17-45.5021'N, 143-15.0147'E, D=1579m）	4 （Sea Moderate）
	09:40-11:30	Carried out MNBES mapping survey	3 (Moderate-Shot)
	11:36	Deployed OBEM（Site3, USA, 17-49.0419'N, 143-32.5367'E, D=5201）	ENE - 5
	13:03	Deployed OBEM（Site4, Kobe, 17-53.5008'N, 143-45.0080'E, D=4640m）	
	14:18	Deployed OBEM（Site5, USA, 17-56.5191'N, 143-57.0364'E, D=4499m）	
	15:39	Deployed OBEM（Site6, ERI, 17-59.7110'N, 144-10.3216'E, D=3743m）	
	17:20-18:22	Carried out Calibration OBEM（Site6, ERI）	
	19:50-20:27	Carried out Calibration OBEM（Site5, USA）	
	21:27-21:57	Carried out Calibration OBEM（Site4, Kobe）	
	23:03-23:48	Carried out Calibration OBEM（Site3, USA）	
2005/12/22	01:09-02:05	Carried out Calibration OBEM（Site2, Australia）	12:00 (JST = UTC+9h)
	02:48-03:24	Carried out Calibration OBEM（Site1, USA）	bc (Fine But Cloudy)

	06:53	Deployed Proton magnetometer	2 （Sea Smooth）
	07:12-19:20	Carried out MNBES mapping survey	2 (Low Swell-Long）
	16:35	Recovered Proton magnetometer	S - 2
		Depart from voyage research sea area to YOKOSUKA	
2005/12/23		Voyaging toward YOKOSUKA Harbor	12:00 (JST = UTC+9h)
			bc (Fine But Cloudy）
			5 （Sea Rough）
			4 (Moderate-Average）
			N - 5
2005/12/24		Voyaging toward YOKOSUKA Harbor	12:00 (JST = UTC+9h)
	10:00-11:00	Meeting with R/V Kairei Ship Crew	bc (Fine But Cloudy）
			4 （Sea Moderate）
			3 (Moderate-Shot）
			WNW - 6
2005/12/25		Voyaging toward YOKOSUKA Harbor	12:00 (JST = UTC+9h)
			c (Cloudy）
			3 (Sea Slight）
			3 (Moderate-Shot）
			WNW - 4
2005/12/26	09:00	Arrived at YOKOSUKA 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；Vaiolent storm；28.4-32.6m/sec		
12；Hurricane；32.7m/sec-		

3. Participants

3-1.Onboard Scientists

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3-2. Crew

Captain	Shinya Ryono
Chief Officer	Satoshi Susami
2nd Officer	Akihisa Tsuji
Jr. 2nd Officer	Isao Maeda
3rd Officer	Hiroyuki Kato
Chief Engineer	Kiyonori Kajinishi
1st Engineer	Masahiro Kajihara
2nd Engineer	Yoshinobu Hiratsuka
3rd Engineer	Takafumi Tominaga
Chief Electronic Operator	Hiroyasu Saitake
2nd Electronic Operator	Katsutoshi Kitamura
Boat Swain	Makio Nakamura
Able Seamen	Kazuo Abe
Able Seamen	Kuniharu Kadoguchi
Able Seamen	Hideo Isobe
Able Seamen	Masanori Ohata
Able Seamen	Yutaka Sato
Able Seamen	Yoshiaki Matsuo
No.1 Oiler	Kazuaki Nakai
Oiler	Tsuneo Harimoto
Oiler	Junji Mori
Oiler	Hiroshi Yamamoto
Oiler	Sakoh Tanaka
Chief Steward	Takeshi Miyauchi
Steward	Koji Kirita
Steward	Hideo Fukumura
Steward	Hiroyuki Yoshizawa
Steward	Hiroaki Yaoita

4. Observation

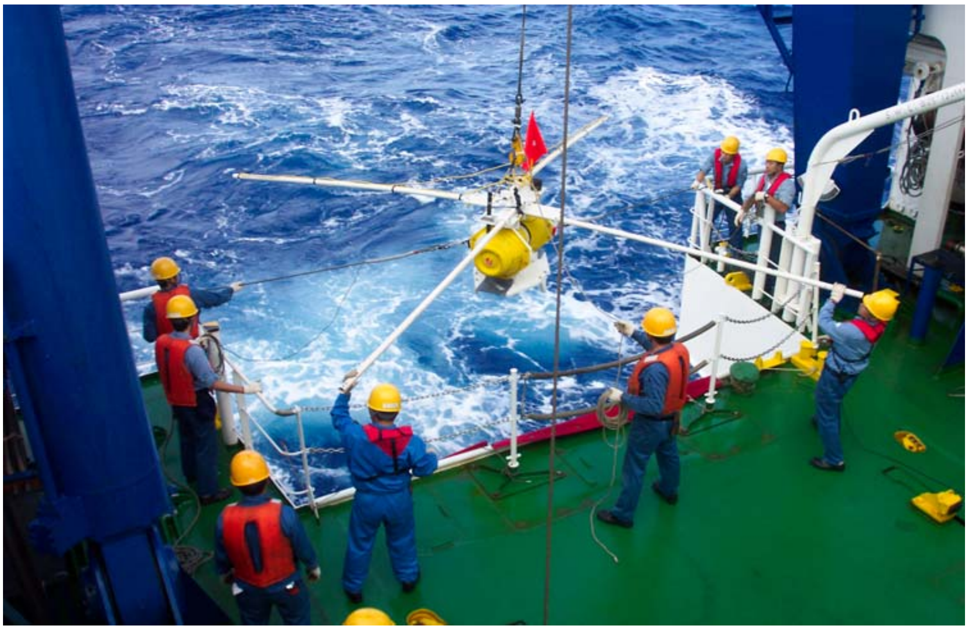
4-1. Australian instruments

The Australian instruments for the Mariana Trench project comprised;

- 7 full OBEM's (Ocean Bottom Magnetometer and Electrometer)
- 7 OBM's (Ocean Bottom Magnetometer)

OBEM

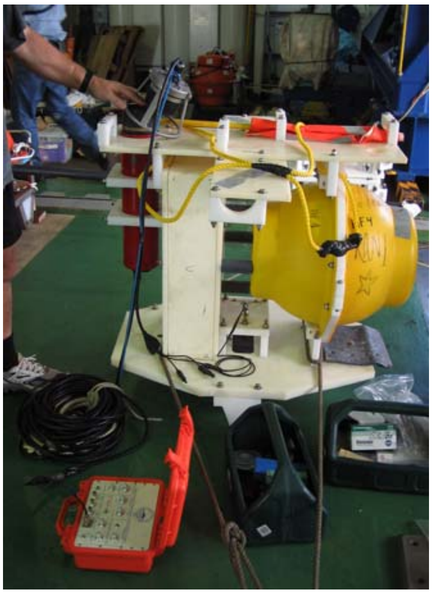
The full OBEM has a magnetometer in one of the glass spheres (inside the yellow hard hats), and an electrometer plus the acoustic electronics in the second glass sphere. Silver-silver chloride electrodes are fastened into the ends of the 3m. white plastic pipes, giving a total span of 6m. for the measurement of two horizontal components of the electric field gradient. Magnetic fields are sampled every minute at 0.1 nT resolution, and the electric field also every minute at approx 0.3 μV/m. There are 2 acoustic transponders, one on top of the instrument, the other near the bottom. Either can trigger the burn-wire to release the 25 kg lead ballast weight, allowing the instrument to float back to the surface for recovery. Using one or other of the transponders, the instrument may be tracked back to the surface.

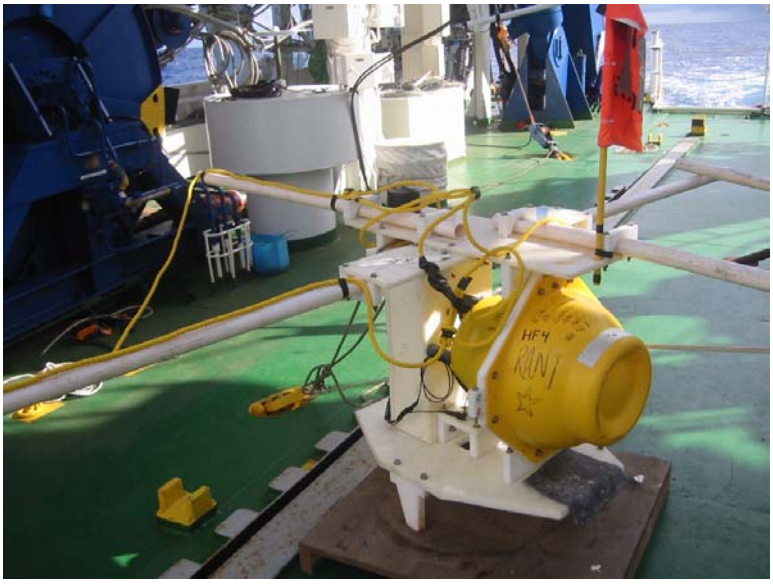


OBM

Four of the 7 OBM's were housed in Benthos recoverable transponders, giving a much smaller total package. An additional half of a hard hat and a couple of smaller (orange) floats provide a final structure where the release of the ballast weight allows the instrument to turn upside down with the transponder now at the bottom as it ascends. This ensures that the transponder remains in the water for tracking purposes when the instrument is at the surface.

Three of the OBM’s, again housed in a single sphere, had an instrument package much like the OBEM’s, except that the second sphere is replaced by a block of syntactic foam (white) and the acoustics are housed in a red aluminium tube. Although this instrument does not require plastic arms to house electrodes, short ones were in fact used, in order to allow a stray line to be fitted to the instrument.





4-2. ERI-OBEM

The ocean bottom electromagnetometers (OBEMs) are made by Tierra Tecnica, which can measure time variations of three components of magnetic field, horizontal electric field, the instrumental tilts, and temperature. There are two types of instrumental design. Type 1 equips three glass spheres housing Benthos acoustic transponder, the electromagnetometer, and a Lithium battery pack for the electromagnetometer, respectively (Photo 4-2-1).

Photo 4-2-1. ERI-OBEM (Type 1)

Type 2 is an improved version of type 1, which equips two glass spheres. A Nichiyu-Giken acoustic transponder and the battery pack are put together in one glass sphere (Photo 4-2-2). We have three type-1 OBEMs and four type-2 OBEMs. All the OBEMs mount Taiyo-Musen radio beacons and flashing lights. The acoustic frequencies and command codes, and radio frequencies are listed in section 5. For locations of the deployments, see section 5.

Photo 4-2-2. ERI-OBEM (Type 2)

4-3. IFREE/JAMSTEC-OBEM

From IFREE/JAMSTEC, four OBEMs are contributed to this experiment; they are almost the same as ERI-OBEM type 2 (Photo 4-3-1). The major differences from ERI-OBEMs are adoptions of Kaiyo-Denshi acoustic transponders for three of them and NOVATECH radio beacon and flashing light for all four OBEMs. The Kaiyo-Denshi transponder is used for positioning of the OBEMs with SSBL system. The acoustic frequencies and command codes, and radio frequencies are listed in section 5. For locations of the deployments, see section 5.

Photo 4-3-1. IFREE/JAMSTEC-OBEM

4-4. Kobe OBEM

Six Kobe-OBEMs measure 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 sensors are divided into two types. Five sensors are made by Masashi Shimoizumi (Kyushu Polytechnic College) and Clover-tech Corp. (site 4, 16, 31, 37, 39), and the other one is made by Tierra Tecnica Corp. (site 14). Data sampling will be carried out ten times (ten seconds) per one minute with M. S. and Clover-tech Corp.'s sensors, and once per one minute with Tierra Tecnica Corp.'s sensor. We will be able to get data for about ten months with the lithium battery pack. The clock of the OBEM was set to the GPS clock before the deployment, and starting time of measurement was set to 1:00 (UTC) at the next day after deployment. The OBEM's also have radio beacon and flashing light for recovery.

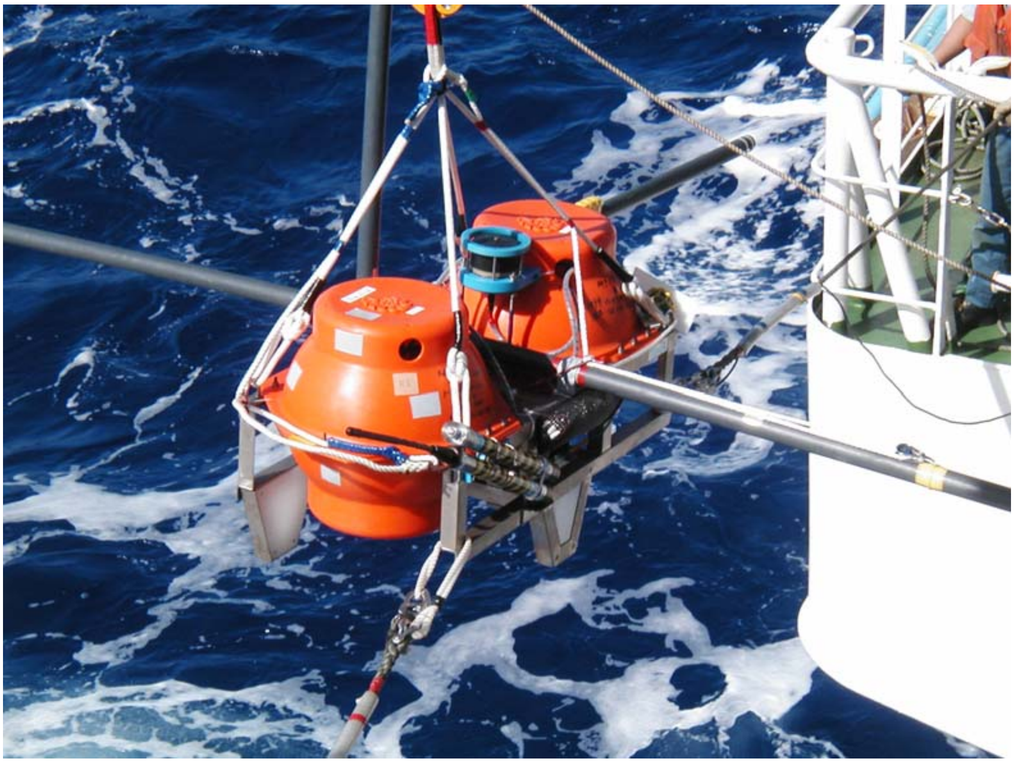


Photo 4-4-1. Kobe OBEM.

4-5. US OBEM and OBE

The US instruments come in two types: ocean bottom electric-magnetic field (OBEM) and ocean bottom electrometers (OBE). The electric field sections of the OBEMs and OBEs are nearly identical, measuring the voltage differences over 6 m (OBEM) or 5 m (OBE) 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 using optical feedback. The OBEMs also incorporate a two-component tilt sensor having 1 microradian resolution. All data are recorded internally on flash cards.

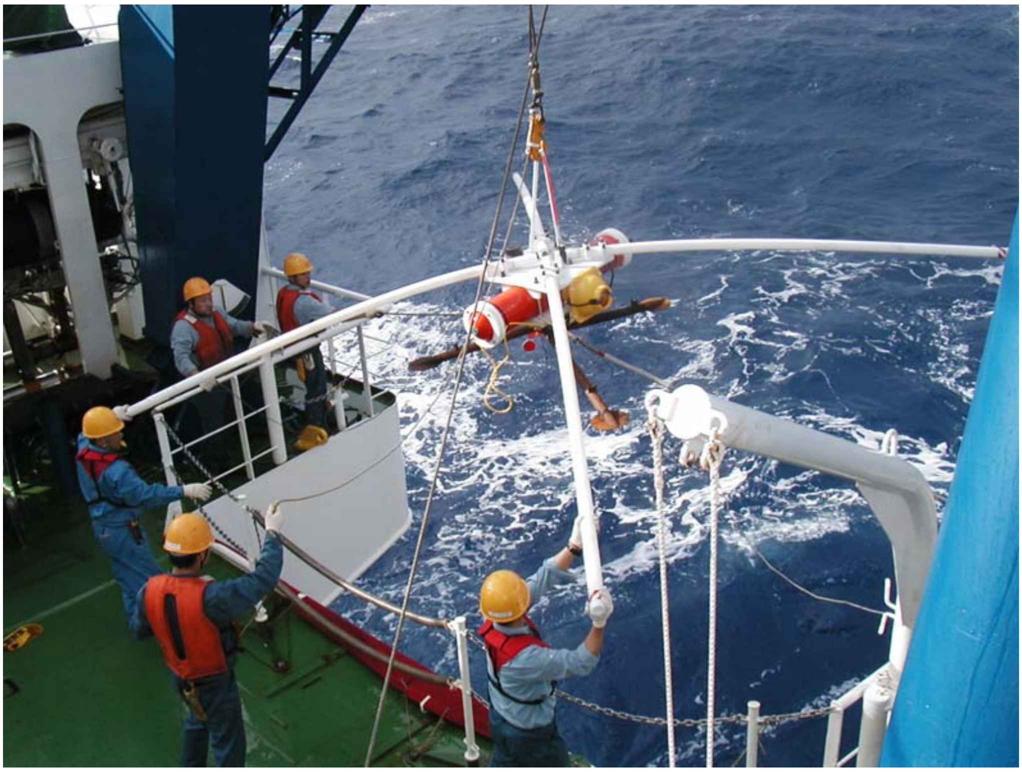


Photo 4-5-1. US OBEM.

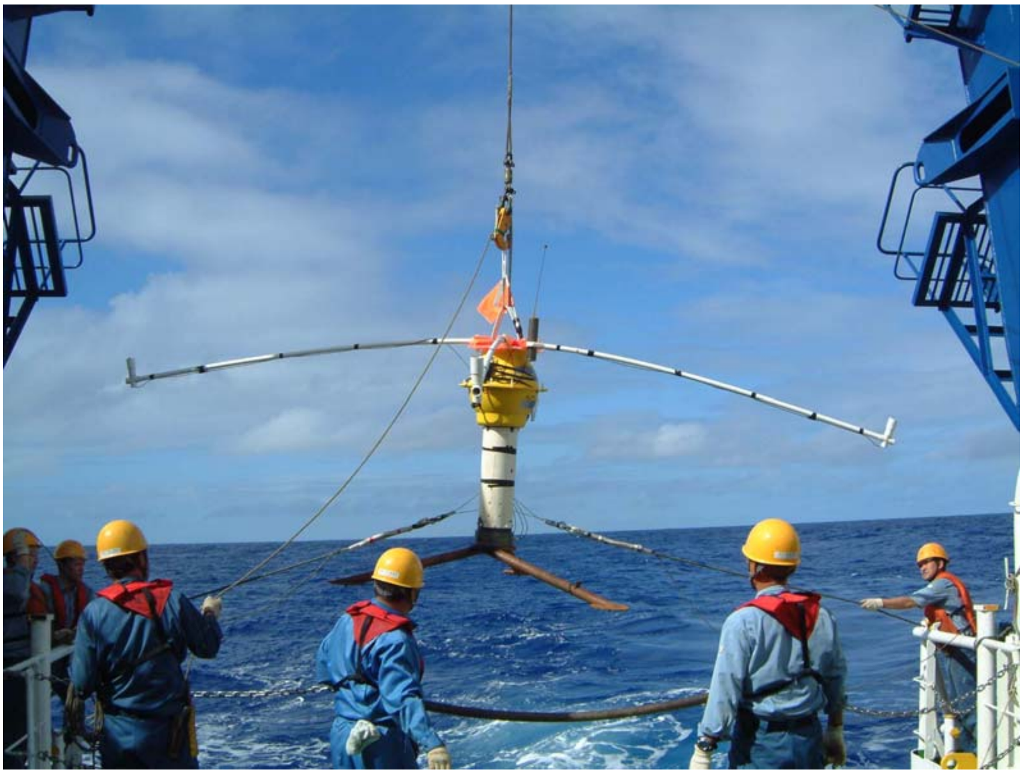


Photo 4-5-2. US OBE.

4-6. Specification of the Kobe STCM

The Kobe shipboard three component magnetometer (STCM: Isezaki, 1986) consists of five parts; magnetometer sensors, gyrocompass (provided by H. Fujimoto, Tohoku University), GPS, magnetometer control unit, and data logger. The magnetometer sensors are three flux gate magnetometers which are orthogonally aligned to each other. Dynamic range is ±100,000 nT with resolution of 1 nT and sampling rate is 8Hz. The magnetometer sensors were installed on the top deck (Photo 4-6-1). The gyrocompass comprises three ring laser gyros and three single axis accelerometers, giving angle resolution of 0.025 degrees, heading accuracy of 0.05 degrees rms with 0.01 degree/hour rms drift rate, and pitch and roll angle accuracy of < 0.1 degrees (Photo 4-6-2). The location and time data are supplied by GPS (global positioning system). The magnetometer control unit (Tiera technica SFG-1211) digitizes magnetometer values and compiles geomagnetic intensity, ship's attitude, location, and time data. These data are recorded by laptop PC via an RS-232C serial port. We can display geocentric coordinate three component geomagnetic intensity on the PC (Photo 4-6-3).

There are two STCM magnetometer sensors. One is the system which has been already installed on board the R/V Kairei on the top of tripod. The other was bought from Kobe University and is mounted in the mid-point of tripod. The GPS antenna is also installed on this deck.

Photo 4-6-1. STCM magnetometer sensors

Photo 4-6-2. Ring laser gyrocompass provided by H. Fujimoto, Tohoku University.

Photo 4-6-3. Magnetometer control unit and data logger.　Geocentric coordinate geomagnetic intensity can be seen on the PC display.

5. Preliminary Results
5-1. OBEM, OBM, and OBE deployment and positioning
Deployment

Deployments were made at 40 sites across the Mariana Trench and back arc spreading centre. Site positions are given in Table 5-1-1 and Figure 5-1-1, and the instrument information at each site is given in Table 5-1-2. The deployments were made starting from the east end of the transect, but the exact order of deployment was varied to fit in with SeaBeam surveys and positioning surveys during night time hours. Several instruments were tracked acoustically to the bottom (sites 36, 39, and 6) but, in general, the instruments were tracked only for a short time after deployment.

Site	Type	Launched			Settled		
		Latitude	Longitude	Depth (m)	Latitude	Longitude	Depth (m)
1	u	17 - 44.485 N	143 - 6.456 E	2508	17 - 44.386 N	143 - 6.396 E	2463
2	a	17 - 45.502 N	143 - 15.015 E	1579	17 - 45.531 N	143 - 14.994 E	1590
3	u	17 - 49.042 N	143 - 32.537 E	5201	17 - 48.957 N	143 - 32.690 E	5150
4	jk	17 - 53.501 N	143 - 45.008 E	4640	17 - 53.472 N	143 - 45.101 E	4618
5	u	17 - 56.519 N	143 - 57.036 E	4499	17 - 56.737 N	143 - 57.200 E	4473
6	je	17 - 59.711 N	144 - 10.322 E	3743	17 - 59.795 N	144 - 10.416 E	3725
7	ca	18 - 4.581 N	144 - 23.099 E	4398	18 - 4.655 N	144 - 23.276 E	4399
	cu	18 - 4.543 N	144 - 23.041 E	4396	18 - 4.636 N	144 - 23.257 E	4366
8	je	18 - 5.605 N	144 - 26.811 E	4105	18 - 5.688 N	144 - 27.003 E	4099
9	ca	18 - 6.710 N	144 - 30.221 E	3566	18 - 6.799 N	144 - 30.385 E	3604
	cu	18 - 6.668 N	144 - 30.166 E	3561	18 - 6.806 N	144 - 30.367 E	3574
10	jam	18 - 8.001 N	144 - 33.591 E	3249	18 - 8.046 N	144 - 33.573 E	3280
11	a	18 - 9.314 N	144 - 36.539 E	3227	18 - 9.388 N	144 - 36.575 E	3229
12	u	18 - 9.501 N	144 - 38.968 E	3369	18 - 9.480 N	144 - 39.067 E	3395
13	a	18 - 9.899 N	144 - 41.729 E	4001	18 - 9.916 N	144 - 41.864 E	4027
14	jk	18 - 10.000 N	144 - 42.800 E	3814.	18 - 10.013 N	144 - 42.920 E	3757
15	ca	18 - 10.483 N	144 - 43.819 E	3983	18 - 10.498 N	144 - 44.178 E	3913
	cu	18 - 10.454 N	144 - 43.724 E	3939	18 - 10.495 N	144 - 44.127 E	3348
16	jk	18 - 10.706 N	144 - 44.417 E	3885	18 - 10.671 N	144 - 44.598 E	3883
17	ca	18 - 11.201 N	144 - 46.898 E	3573	18 - 11.168 N	144 - 47.190 E	3388
	cu	18 - 11.199 N	144 - 46.806 E	3590	18 - 11.196 N	144 - 46.984 E	3520
18	jam	18 - 12.199 N	144 - 49.808 E	3324	18 - 12.160 N	144 - 50.090 E	3357
19	ca	18 - 13.011 N	144 - 52.677 E	3517	18 - 13.020 N	144 - 52.943 E	3463
	cu	18 - 12.944 N	144 - 52.811 E	3508	18 - 12.988 N	144 - 52.957 E	3442
20	jam	18 - 13.879 N	144 - 56.028 E	3538	18 - 13.857 N	144 - 56.210 E	3491
21	ca	18 - 14.973 N	144 - 59.387 E	3783	18 - 14.947 N	144 - 59.480 E	3797
	cu	18 - 14.993 N	144 - 59.344 E	3783	18 - 14.903 N	144 - 59.454 E	3768
22	jeT	18 - 15.295 N	145 - 6.495 E	3757			
23	ca	18 - 12.305 N	145 - 20.906 E	3378			
	cu	18 - 12.238 N	145 - 20.847 E	3375			
24	jeT	18 - 10.507 N	145 - 28.197 E	3047			
25	u	18 - 9.016 N	145 - 35.035 E	2531			

26	jam	18 - 9.007 N	146 - 0.008 E	2695	18 - 9.072 N	145 - 59.973 E	2704
27	a	18 - 12.303 N	146 - 18.296 E	3385			
28	jeT	18 - 15.502 N	146 - 36.530 E	3668			
29	u	18 - 18.599 N	146 - 55.021 E	3616			
30	a	18 - 22.000 N	147 - 14.039 E	3423			
31	jk	18 - 24.502 N	147 - 26.517 E	3284	18 - 24.442 N	147 - 26.515 E	3297
32	je	18 - 29.229 N	147 - 41.790 E	6051	18 - 29.124 N	147 - 41.598 E	6018
33	u	18 - 28.107 N	148 - 54.506 E	4472			
34	je	18 - 30.471 N	148 - 3.321 E	5276	18 - 30.463 N	148 - 3.181 E	5216
35	a	18 - 32.011 N	148 - 15.009 E	5781	18 - 31.829 N	148 - 14.925 E	5754
36	u	18 - 34.610 N	148 - 29.135 E	5776			
37	jk	18 - 40.108 N	149 - 2.996 E	5576	18 - 39.872 N	149 - 3.000 E	5529
38	a	18 - 44.006 N	149 - 24.004 E	5526	18 - 44.126 N	149 - 23.562 E	5512
39	jk	18 - 48.984 N	149 - 50.999 E	5473	18 - 49.088 N	149 - 50.804 E	5432
40	u	18 - 54.013 N	150 - 18.015 E	5464		-	

Table 5-1-1. Launched and settled positions of OBEM, OBM and OBE

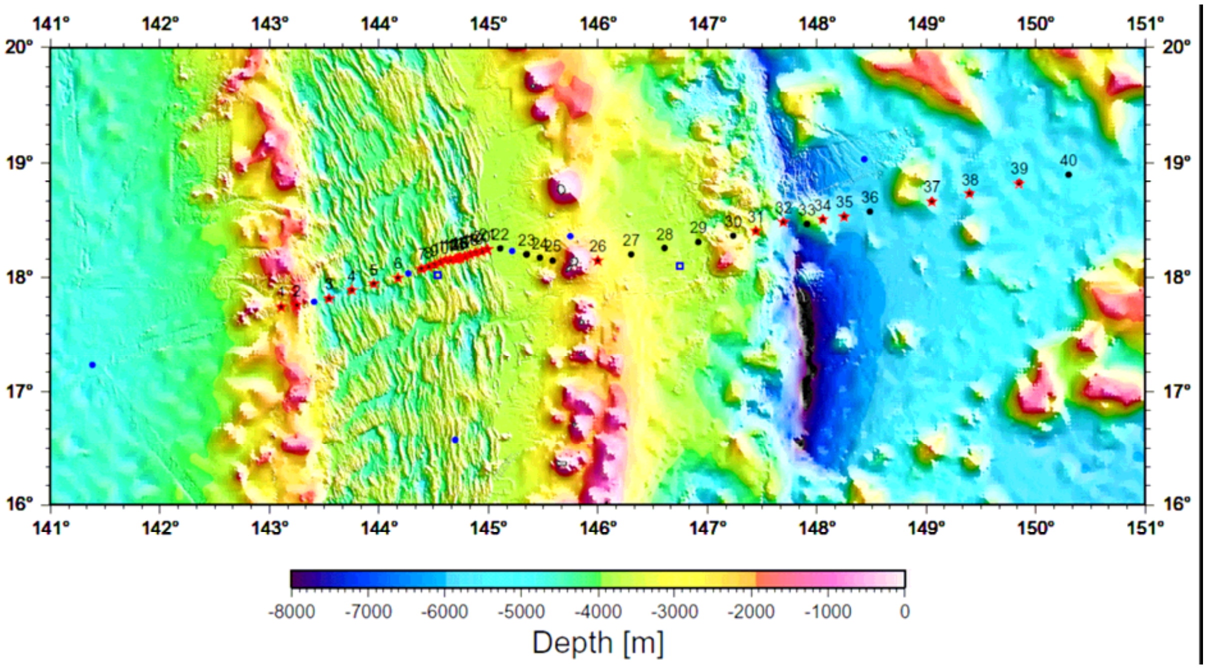


Figure 5-1-1a. Location map of OBEM,OBM and OBE. Black circles, red stars, blue symbols show launched positions, show settled positions, and OBEM positions from previous studies, respectively.

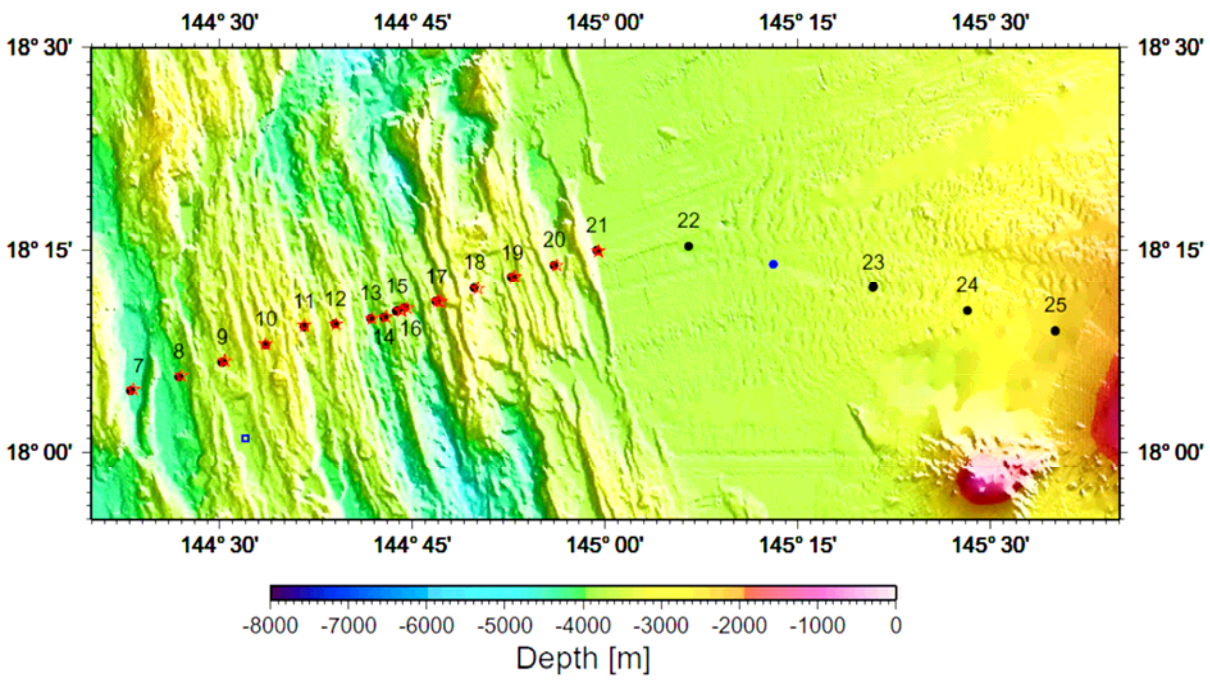


Figure 5-1-1b. Location map of OBEM,OBM and OBE near the spreading axis of Mariana Trough. The symbols are the same as Figure 5-1-1a.

Site	Type	ID	Release Com.	Transmit Freq.	Response Freq.	Radio Beacon Freq.	Light	positioning
1	u	13		Code 4245	12.0kHz	161.950/161.975	Y	Y
2	a	Charlie	10, 13	13.5kHz	12.0kHz	161.800/161.900	N	Y
3	u	11		Code 4125	12.0kHz	161.875/161.900	Y	Y
4	jk	unit11	2B-2	14.286kHz	14.000KHz	43.528	Y	Y
5	u	1		Code 5285	12.0kHz	161.825/161.875	Y	Y
6	je	TT8	3F			43.528	Y	Y
7	ca	Ted2	Benthos B	10.0kHz	12.0kHz	None	Y	Y
	cu	4		Code 4241	12.0kHz	161.850/161.925	N	Y
8	je	TT6	3D			43.528	Y	Y
9	ca	Ted3	Benthos B	11.0kHz	12.0kHz	None	Y	Y
	cu	8		Code 4225	12.0kHz	161.875/161.975	N	Y
10	jam	JM2	1C-1	11.029kHz	13.500kHz	43.528	Y	Y
11	a	Gonzo	10, 15	13.0kHz	12.0kHz	None	N	Y
12	u	9		Code 4151	12.0kHz	161.800/161.875	Y	Y
13	a	Igor	9, 7	11.0kHz	12.0kHz	None	N	Y
14	jk	unit5	5A-2	15.385kHz	14.000kHz	43.528	Y	Y
15	ca	HF4	10, 7	10.0kHz	12.0kHz	None	N	Y
	cu	7		Code 8381	12.0kHz	161.925/161.950	N	Y
16	jk	unit7	7A-1	11.834kHz	15.000kHz	43.528	Y	Y
17	ca	HF3	10, 7	10.5kHz	12.0kHz	None	N	Y
	cu	1		Code 8315	12.0kHz	161.800/161.925	N	Y
18	jam	JM7	3C-1	10.000kHz	13.500kHz	43.528	Y	Y
19	ca	HF1	10, 7	11.5kHz	12.0kHz	None	N	Y
	cu	5		Code 8325	12.0kHz	161.800/161.925	N	Y
20	jam	JM4	1A-1	11.029kHz	13.500kHz	43.528	Y	Y

21	ca	Ted4	Benthos B	10.5kHz	12.0kHz	None	Y	Y
	cu	2		Code 9331	12.0kHz	161.800/161.825	N	Y
22	jeT	TT1	Benthos A	11.0kHz	10.0 kHz	43.528	Y	N
23	ca	Ted1	Benthos B	11.5kHz	12.0kHz	None	Y	N
	cu	3		Code 4215	12.0kHz	161.825/161.950	N	N
24	jeT	TT4	Benthos C	10.0kHz	11.0 kHz	43.528	Y	N
25	u	10		Code 4155	12.0kHz	161.825/161.925	Y	N
26	jam	JM1	3H			43.528	Y	Y
27	a	Ernie	9, 15	13.5kHz	12.0kHz	None	Y	N
28	jeT	TT3	Benthos F	9.0kHz	12.0 kHz	43.528	Y	N
29	u	14		Code 8345	12.0kHz	161.875/161.925	Y	N
30	a	Jonah	9, 11	11.5kHz	12.0kHz	None	Y	N
31	jk	unit9	9A-3	12.500kHz	14.500kHz	43.528	Y	Y
32	je	TT5	3C			43.528	Y	Y
33	u	12		Code 4285	12.0kHz	161.850/161.875	Y	N
34	je	TT7	3E			43.528	Y	Y
35	a	Fuzzy	9, 11	11.0kHz	12.0kHz	None	Y	Y
36	u	3		Code 4285	12.0kHz	161.900/161.975	Y	N
37	jk	unit6	6A-3	12.738kHz	14.500kHz	43.528	Y	Y
38	a	DoDo	9, 13	11.0kHz	12.0kHz	None	Y	Y
39	jk	unit8	8A-2	12.121kHz	14.000kHz	43.528	Y	Y
40	u	2		Code 4261	12.0kHz	161.850/161.975	Y	N

a: AUS OBEM
ca: AUS OBM
cu: US OBE
jam: JAMSTEC OBEM
je: ERI OBEM
jeT: ERI OBEM (3 spheres)
jk: Kobe OBEM
u: US OBEM

Table 5-1-2. Instrument information at each site

All deployments were made using the A-frame, except for 4 Australian OBM's which were small enough to be released from a small davit. All deployments were successful except for a single case where an anchor ballast weight was dislodged from an OBEM (site 6). This instrument had to be recovered from the sea surface. It was re-deployed successfully after a new anchor weight was fabricated and fitted to the instrument.

East of the Trench sites spacing was approximately 40 km, but to the west the spacing was closer, particularly in the vicinity of the back arc spreading centre, where the sites were only a few km apart.

Positioning

Positioning of the instruments on the ocean floor at 29 sites was performed during night time hours; the final positions are also given in Table 5-1-1 and full details of the positioning data are given in Appendix (CD version). At most sites a single OBEM (Ocean Bottom

Magnetometer and Electrometer) was deployed, but at 7 sites an OBM (Ocean Bottom Magnetometer) from the Australian group was deployed with an OBE (Ocean Bottom Electrometer) from the US group to make a combined site. In these cases both instruments were positioned independently. “Kairei” SSBL (Super Short Base Line) positioning system was used for all the Kobe OBEM’s and some of the JAMSTEC OBEM’s. A ping every 16 seconds was transmitted from the acoustic on board unit, and the response from the transponder of the OBEM was received by “Kairei” SSBL (Super Short Base Line). The final position of all instruments at 29 sites were determined by using slant ranges between ship and transponder.

Photo 4-4-2. Main unit of “Kairei” SSBL (left), and acoustic on board units of JAMSTEC (middle) and of Kobe Univ. (right).

5-2. Surface Geophysical Survey

We conducted a surface geophysical survey mainly during night time hours to collect multi-narrow beam bathymetry, gravity field, and magnetic field data. Some of the area had detailed SeaBeam bathymetry available, but other areas along the transect had to be surveyed before exact instrument deployment sites could be decided. A map of the transect area is shown in Figures 5-2-1, and the ship tracks are shown in Figure 5-2-2. Multi-narrow beam bathymetric feature was obtained by SeaBeam 2112, which also provides a backscatter image, which will be processed after the cruise. An XBT was done on 13th December. The DGPS (differential global positioning system) was used to derive the best ship location.

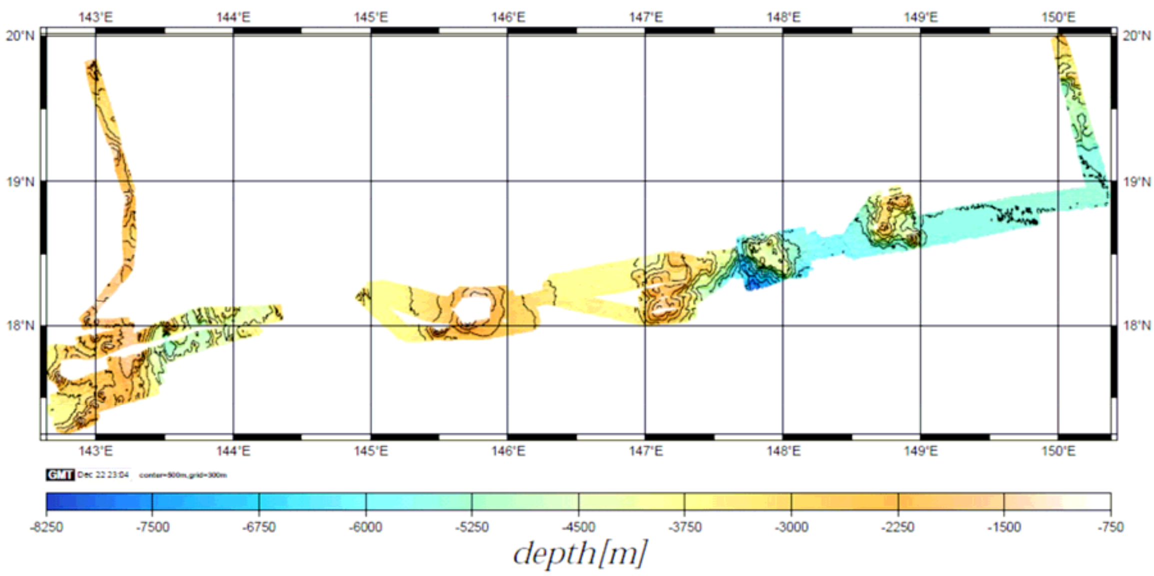


Figure 5-2-1. Topography map in the survey area

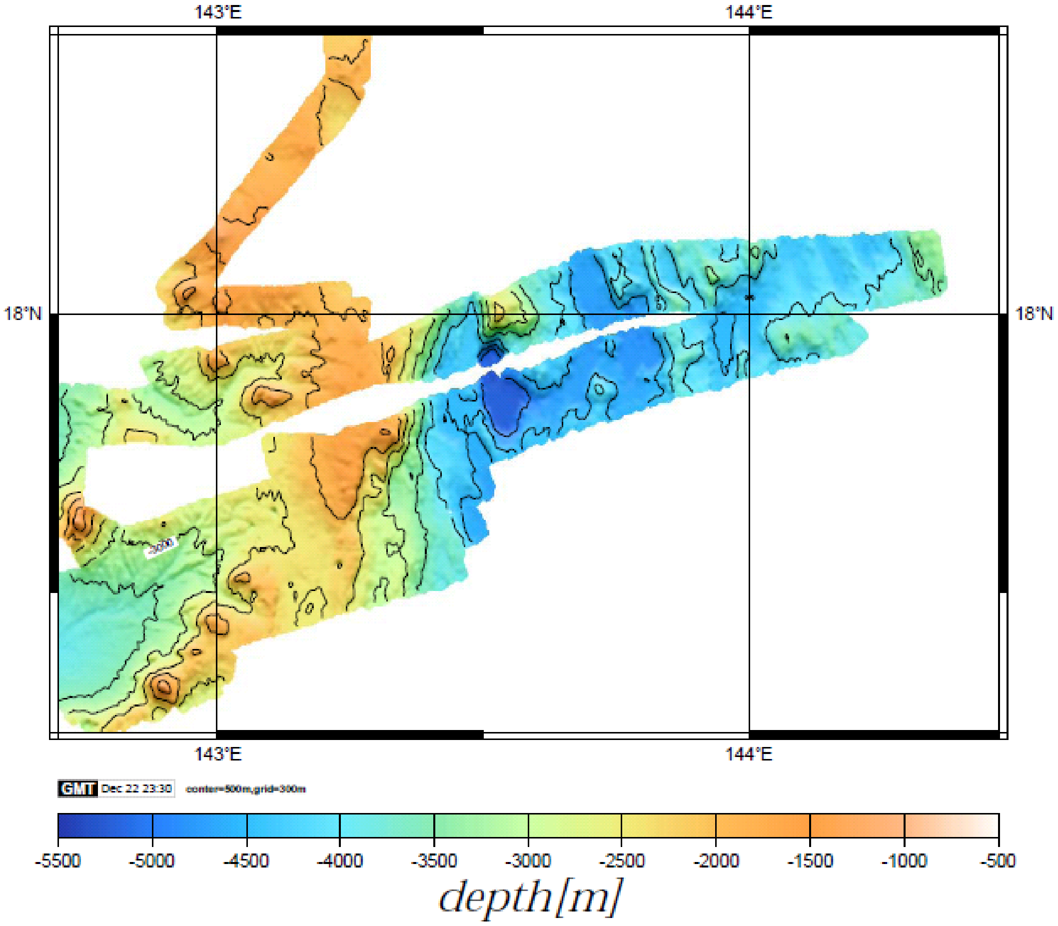


Figure 5-2-1. Topography map in the survey area (continue)

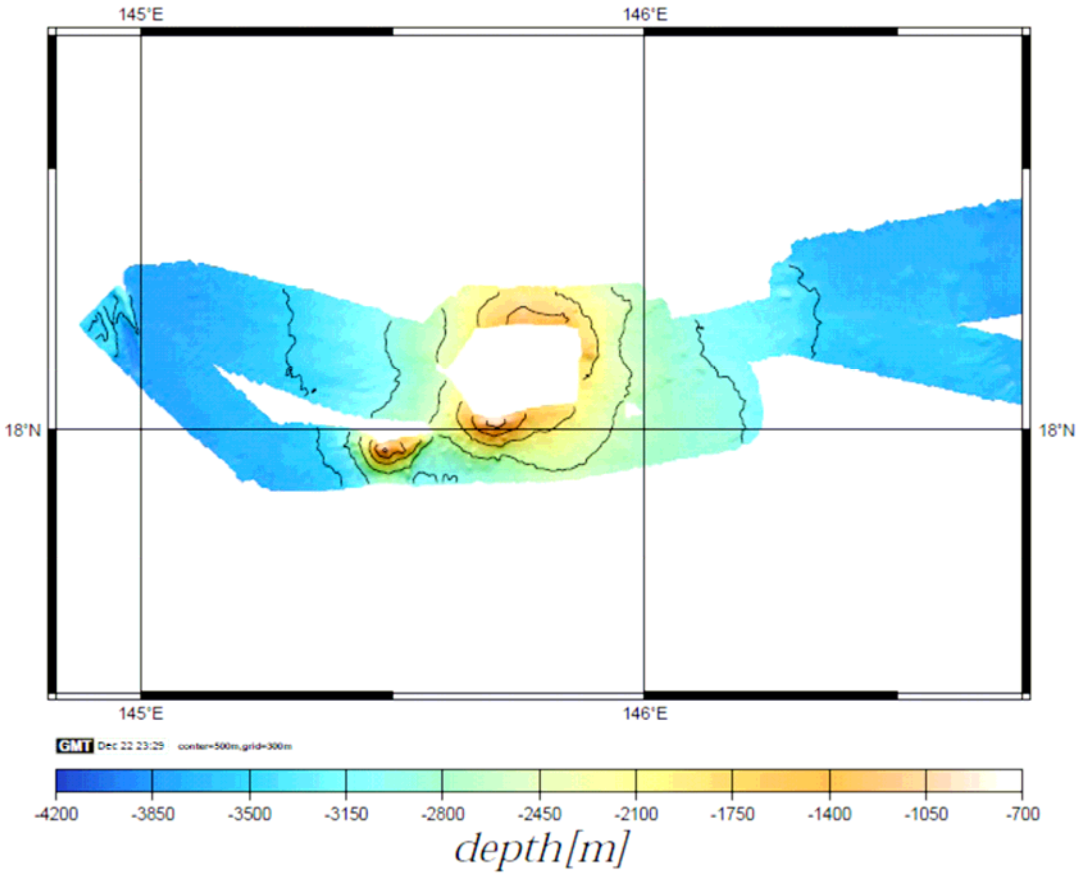


Figure 5-2-1. Topography map in the survey area (continue)

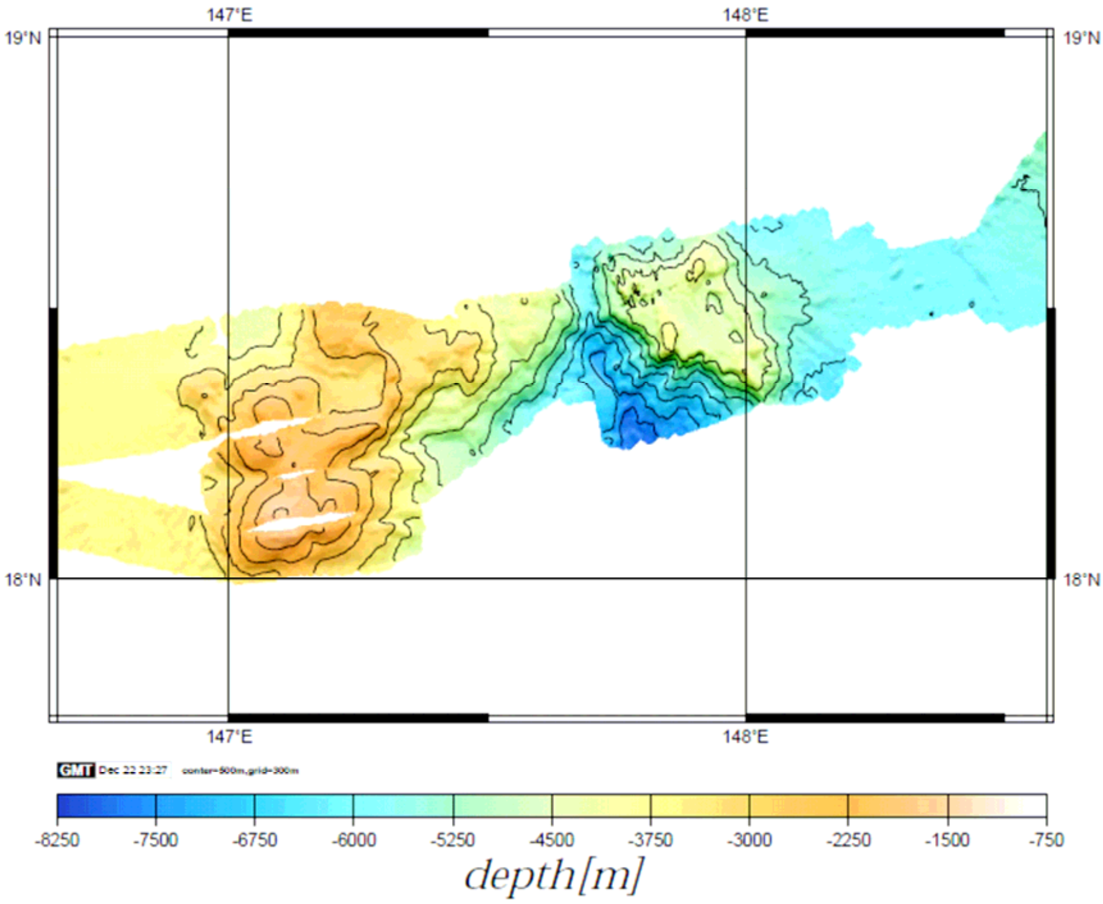


Figure 5-2-1. Topography map in the survey area (continue)

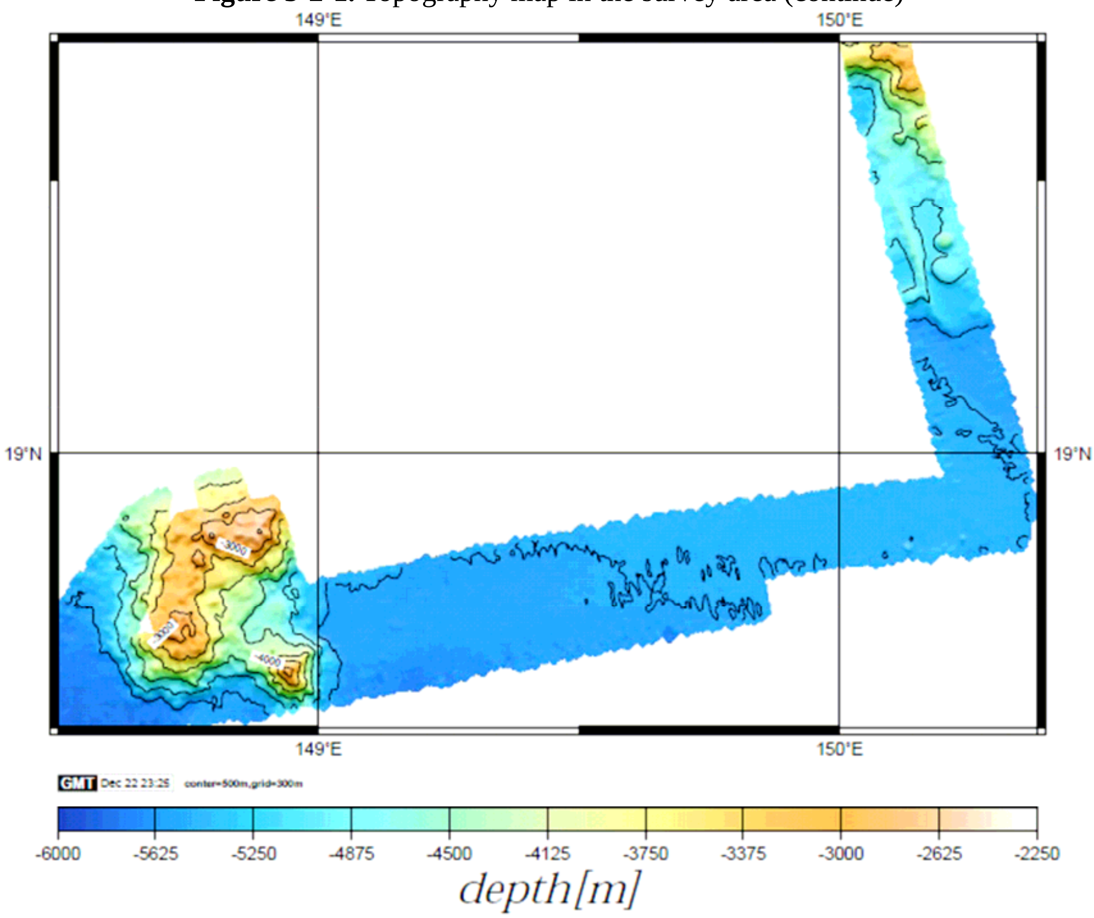


Figure 5-2-1. Topography map in the survey area (continue)

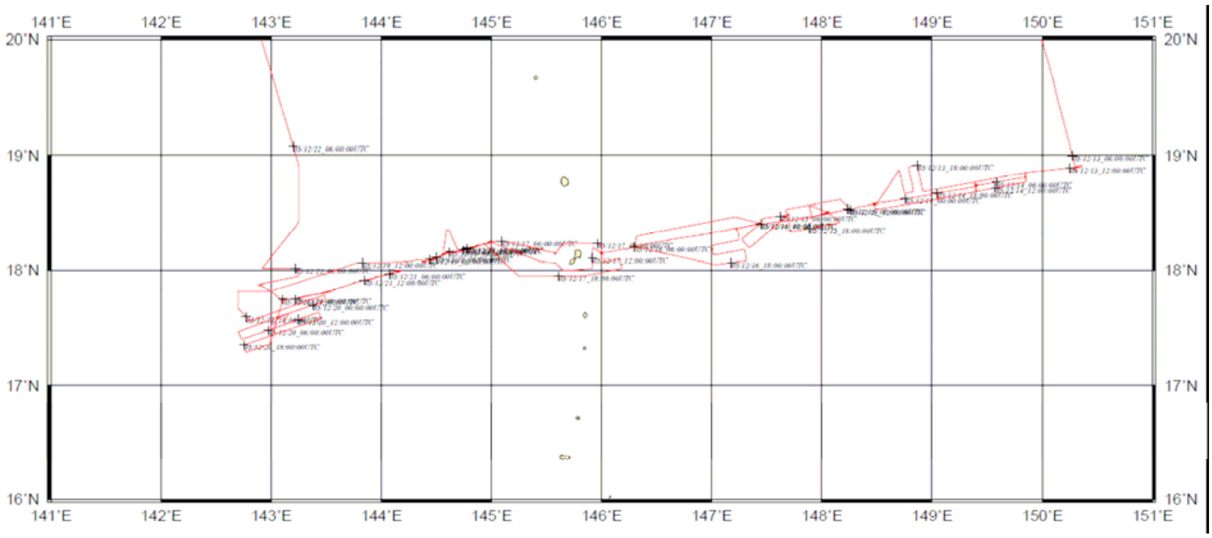


Figure 5-2-2. Ship track of the cruise in the survey area

Gravity field data were obtained from a shipboard gravimeter (KSS-31, Bodenseewerk Perkin-Elmer GmbH). The gravity field data at Yokosuka port measured by a gravimeter (CG-3M, Scintrex) will be used to correct the data drift.

Magnetic field data were collected by three instruments; two shipboard three component magnetometers (STCM: Isezaki, 1986), which can measure the vector of the geomagnetic field using deck-mounted fluxgate magnetometers and gyros, and a ship-towed proton precession magnetometer which can measure the intensity of the geomagnetic field. One STCM was brought from Kobe University. The other STCM is the system which has been already installed on board the R/V Kairei and its performance is as follows: Magnetometer sensors can measure within the range of ±100,000 nT with a resolution of 1 nT. The horizontal attitude sensor comprises of fiver gyros and accelerometers, giving pitch and roll angle resolution of 0.0055 degrees and an accuracy of ±0.2 degrees (< 30 degrees). The sampling rate is 8Hz. Since the Mariana region is near the geomagnetic equator, the vector geomagnetic anomaly field is especially useful to understand its tectonics. This is because total intensity anomaly amplitudes are often much reduced depending on the orientation of the ambient geomagnetic field and magnetic lineation while these have no effect on vector anomalies (Isezaki, 1986). The STCM data contain the effects of ship's magnetic field, which is required to 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 the data from "Figure 8 turns" . "Figure 8 turns" are made by steering the ship in a tight circle, both clockwise and counter clockwise. During the cruise, "Figure 8 turns" were conducted four times and these are listed in Table 5-2-1.

No.	Date	Time(UT)	Latitude	Longitude
1	11 Dec.	07:00-07:17	28°49.051'N	142°50.996'E
2	11 Dec.	23:30-23:48	25°24.740'N	145°16.453'E
3	21 Dec.	09:33-09:51	17°59.680'N	144°08.753'E
4	22 Dec.	05:59-06:11	19°04.276'N	143°12.105'E

Table 5-2-1. List of "Figure 8 turns"

6. Summary and Future Studies

We successfully deployed 33 OBEMs, 7 OBMs, and 7 OBEs at 40 sites. Positioning of the instruments on the ocean floor at 29 sites was performed, which allows us to determine the positions precisely. All the instruments measure geomagnetic and/or electric fields continuously until we will recover them in September, 2006. After the recovery, these data will provide 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 electro-magnetic data and provide additional information for an interpretation of electrical conductivity structure. These results will make a breakthrough for understanding mantle dynamics related to plate subduction.

Acknowledgement

We gratefully recognize the efforts of the officers and crew (Shinya Ryono, captain) of the R/V Kairei during the cruise. We thank all the support staffs in JAMSTEC. We also thank H. Fujomoto for providing us a ring laser gyrocompass, which was used for our STCM measurement. This research was supported by Grant-In-Aid for Scientific Research (B)(1)(No. 15340149), Japan Society for the Promotion of Science, “The 21st Century COE Program of Origin and Evolution of Planetary Systems” and “Stagnant Slab Project (No. 17037003)” in Ministry of Education, Culture, Sports, Science, and Technology, Flinders University, and U.S. National Science Foundation.

Appendix

A-1. Data List (Nobukazu Seama is in charge of these data)

1. Positioning data (Excel files) and the result of the positioning (Postscript files)
   (The data are in Appendix - CD version)
2. SOJ data (ship log, gravity, and magnetic data) and the data format
   (The data are in DVD provided from the ship)
3. SOQ data (SSBL data) and the data format
   (The data are in DVD provided from the ship)
4. STCM magnetic data
   (The data are in DVD provided from the ship)
5. SeaBeam bathymetry data (both of raw data and edited data)
   (The data are in DVD provided from the ship)
6. Kobe STCM data and the data format
   (The data are in Appendix - CD version)
7. Check sheet for OBEM (pdf files)
   (The data are in Appendix - CD version)