On Board Cruise Report of KR06-12 Kairei Cruise

13-23/September/2006

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 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 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 at 18°N, and 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 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.

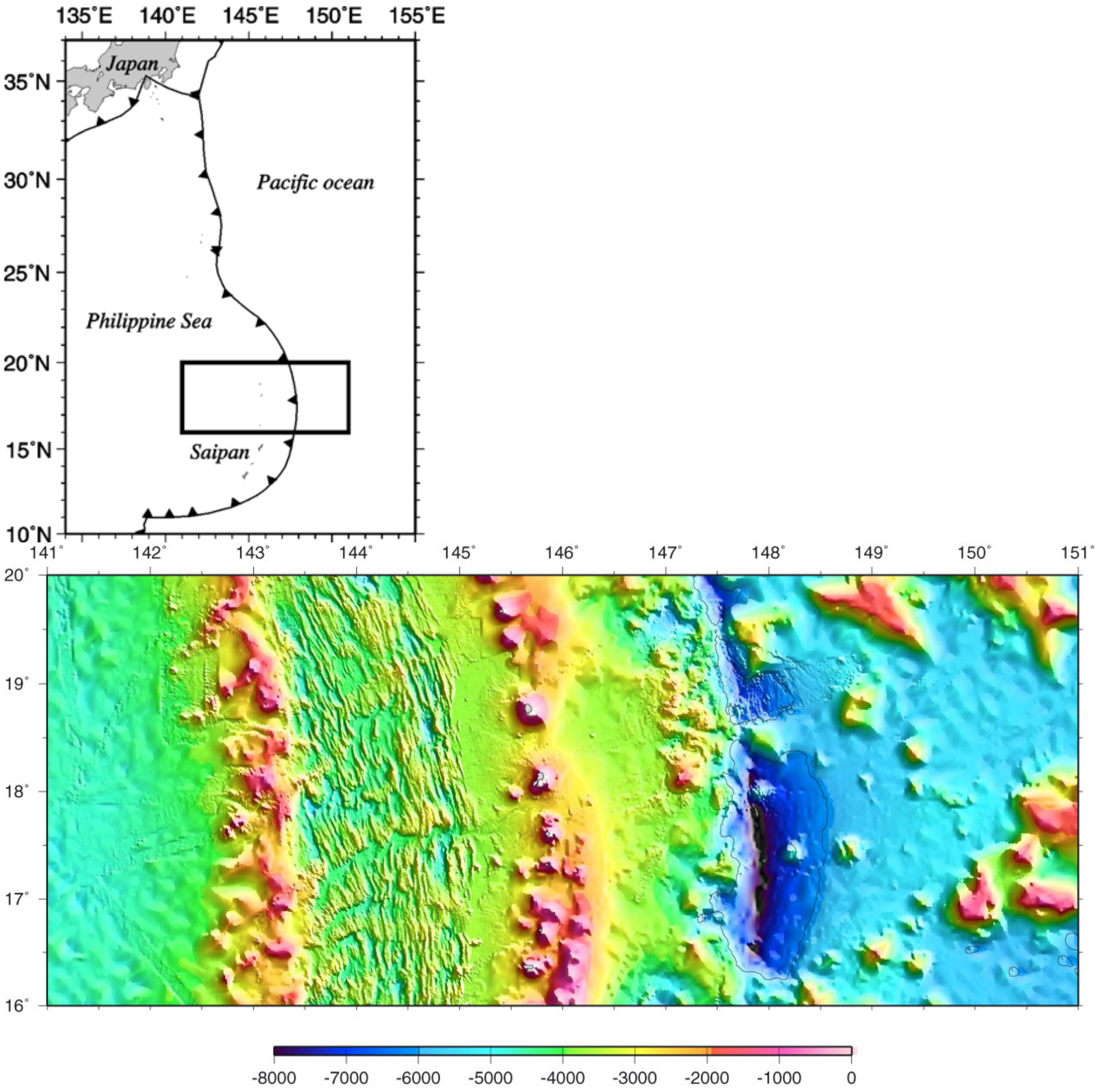

Figure 2-1. Location of the survey area (top). The bathymetry map within the survey area box is shown at the bottom.

2-2. Ship Log

Date	Time (UTC+10h)	Comment	Date(noon)/Weather/Ocean Wave/Sea Swell/Wind(direction/Force)
2006/9/13		Depart for Guam	12:00 (UTC+10h)
	9:00	Let go all shone line & Left Guam port	bc (fine But Cloudy)

	9:30-10:00	Onboard Education (Guidance for living condition and safety on board)	1 (Sea Calm)
	10:00-11:00	Research Meeting with R/V Kairei Ship Crew	2 (Low Swell-Long)
	11:00-12:00	Science Meeting	NE-2
	13:00-14:00	Setting Acoustic equipment	
	19:59-	MBES mapping survey started	
2006/9/14	3:58	Release XBT (17-44.0953N, 143-06.4385E)	12:00 (UTC+10h)
	-4:09	MBES mapping survey finished	bc (fine But Cloudy)
	4:33	Release command (Site1, USA)	3 (Sea Slight)
	6:18	OBEM on surface (Site1, USA, 17-43.9523N, 143-06.4012E)	2 (Low Swell-Long)
	6:39	OBEM on deck (Site1, USA)	NE-4
	7:40	Release command (Site2, Australia)	
	9:13	OBEM on surface (Site2, Australia, 17-45.2924N, 143-14.8954E)	
	9:24	OBEM on deck (Site2, Australia)	
	10:48	Release command (Site3, USA)	
	14:43	OBEM on surface (Site3, USA, 17-48.7934N, 143-32.6083E)	
	15:20	OBEM on deck (Site3, USA)	
	16:40	Release command (Site4, J_Kobe)	
	18:32	OBEM on surface (Site4, J_Kobe, 17-53.3438N, 143-45.0381E)	
	18:39	OBEM on deck (Site4, J_Kobe)	
	19:45	Ranging (Site5, USA)	
	20:59	Release command (Site6, J_ERI)	
	22:55	OBEM on surface (Site6, J_ERI, 17-59.7135N, 144-10.2978E)	
	23:09	OBEM on deck (Site6, J_ERI)	
2006/9/15	2:18	Release command (Site5, USA)	12:00 (UTC+10h)
	5:38	OBEM on surface (Site5, USA, 17-56.7635N, 143-57.3026E)	bc (fine But Cloudy)
	5:56	OBEM on deck (Site5, USA)	2 (Sea Smooth)
	7:57	Release command (Site7, USA)	2 (Low Swell-Long)
	8:05	Release command (Site7, Australia)	N-1
	9:56	OBM on surface (Site7, Australia, 18-04.6864N, 144-23.1818E)	
	10:04	OBM on deck (Site7, Australia)	
	10:05	OBE on surface (Site7, USA, 18-04.6298N, 144-23.2986E)	
	10:18	OBE on deck (Site7, USA)	
	11:08	Release command (Site9, Australia)	
	11:30	Release command (Site9, USA)	
	12:45	OBM on surface (Site9, Australia, 18-06.7020N, 144-30.1287E)	

	12:56	OBM on deck (Site9, Australia)	
	13:15	OBE on surface (Site9, USA, 18-06.7819N, 144-30.2215E)	
	13:22	OBE on deck (Site9, USA)	
	14:17	Release command (Site11, Australia)	
	15:31	Release command (Site12, USA)	
	16:59	OBEM on surface (site11, Australia, 18-09.4592N, 144-36.6162E)	
	17:23	OBEM on deck (Site11, Australia)	
	18:03	OBEM on surface (Site12, USA, 18-09.2622N, 144-39.0215E)	
	18:10	OBEM on deck (Site12, USA)	
	19:21	Release command (Site8, J_ERI) OBEM does NOT appear on surface	
	23:16	Release command (Site10, J_Jam)	
2006/9/16	0:58	OBEM on surface (Site10, J_Jam, 18-07.8728N, 144-33.5243E)	12:00 (UTC+10h)
	1:09	OBEM on deck (Site10, J_Jam)	bc (fine But Cloudy)
	2:23	Release command (Site16, J_Kobe)	2 (Sea Smooth)
	3:08	Release command (Site14, J_Kobe)	2 (Low Swell-Long)
	4:00	OBEM on surface (Site16, J_Kobe, 18-10.5869N, 144-44.5168E)	NNW-2
	4:09	OBEM on deck (Site16, J_Kobe)	
	4:32	OBEM on surface (Site14, J_Kobe, 18-09.7367N, 144-43.0019E)	
	4:48	OBEM on deck (Site14, J_Kobe)	
	5:08	Release command (Site13, Australia)	
	7:33	Release command (Site15, Australia)	
	8:11	OBEM on surface (Site13, Australia, 18-09.6667N, 144-41.8980E)	
	8:26	OBEM on deck (Site13, Australia)	
	8:53	Release command (Site15, USA)	
	9:31	OBM on surface (Site15, Australia, 18-10.3828N, 144-44.2044E)	
	9:39	OBM on deck (Site15, Australia)	
	10:50	OBE on surface (Site15, USA, 18-10.3371N, 144-44.0958E)	
	10:59	OBE on deck (Site15, USA)	
	11:28	Release command (Site17, USA)	
	12:19	Release command (Site17, Australia)	
	13:10	OBE on surface (Site17, USA, 18-11.0911N, 144-47.0168E)	
	13:22	OBE on deck (Site17, USA)	
	14:16	OBM on surface (Site17, Australia, 18-10.9585N, 144-47.3574E)	
	14:30	OBM on deck (Site17, Australia)	
	15:22	Release command (Site19, USA)	

	15:42	Release command (Site19, Australia)	
	17:04	OBE on surface (Site19, USA, 18-12.9592N, 144-52.8724E)	
	17:11	OBE on deck (Site19, USA)	
	17:31	OBM on surface (Site19, Australia, 18-12.9379N, 144-52.7876E)	
	17:40	OBM on deck (Site19, Australia)	
	17:58	Release command (Site18, J_Jam)	
	19:32	OBEM on surface (Site18, J_Jam, 18-12.0799N, 144-50.1215E)	
	19:43	OBEM on deck (Site18, J_Jam)	
	20:20	Release command (Site20, J_Jam)	
	22:11	OBEM on surface (Site20, J_Jam, 18-13.7740N, 144-56.3131E)	
	22:21	OBEM on deck (Site20, J_Jam)	
	23:24	Release command (Site22, J_ERI)	
2006/9/17	1:16	OBEM on surface (Site22, J_ERI, 18-15.1031N, 145-06.3018E)	12:00 (UTC+10h)
	1:33	OBEM on deck (Site22, J_ERI)	bc (fine But Cloudy)
	3:40	Release command (Site21, USA)	1 (Sea Calm)
	4:15	Release command (Site21, Australia)	2 (Low Swell-Long)
	5:30	OBE on surface (Site21, USA, 18-14.8870N, 144-59.2769E)	SW-3
	5:49	OBE on deck (Site21, USA)	
	6:03	OBM on surface (Site21, Australia, 18-14.8057N, 144-59.2676E)	
	6:12	OBM on deck (Site21, Australia)	
	7:44	Release command (Site23, USA) OBE does NOT appear on surface	
	8:23	Release command (Site23, Australia)	
	9:53	OBM on surface (Site23, Australia, 18-12.2385N, 145-20.9821E)	
	10:02	OBM on deck (Site23, Australia)	
	10:55	Release command (Site24, J_ERI)	
	12:19	OBEM on surface (Site24, J_ERI,18-10.6049N, 145-28.4061E)	
	12:36	OBEM on deck (Site24, J_ERI)	
	13:16	Release command (Site25, USA)	
	15:10	OBEM on surface (Site25, USA, 18-08.9799N, 145-35.3266E)	
	15:25	OBEM on deck (Site25, USA)	
	17:19	Release command (Site26, J_Jam)	
	18:48	OBEM on surface (Site26, J_Jam, 18-08.9165N, 146.00.0489E)	
	19:11	OBEM on deck (Site26, J_Jam)	
	20:31	Release command (Site27, Australia)	

	23:08	OBEM on surface (Site27, Australia, 18-12.4367N, 146-18.4127E)	
	23:28	OBEM on deck (Site27, Australia)	
2006/9/18	0:55	Release command (Site28, J_ERI)	12:00 (UTC+10h)
	2:50	OBEM on surface (Site28, J_ERI, 18-15.6563N, 146-36.8073E)	bc (fine But Cloudy)
	3:08	OBEM on deck (Site28, J_ERI)	2 (Sea Smooth)
	4:28	Release command (Site29, USA)	2 (Low Swell-Long)
	7:11	OBEM on surface (Site29, USA, 18-18.7874N, 146-55.2594E)	SSE-2
	7:28	OBEM on deck (Site29, USA)	
	8:53	Release command (Site30, Australia)	
	11:29	OBEM on surface (Site30, Australia, 18-21.8026N, 147-14.0349E)	
	11:39	OBEM on deck (Site30, Australia)	
	12:40	Release command (Site31, J_Kobe)	
	14:04	OBEM on surface (Site31, J_Kobe,18-24.5567N, 147-26.5571E)	
	14:12	OBEM on deck (Site31, J_Kobe)	
	15:35	Release command (Site32, J_ERI)	
	18:25	OBEM on surface (Site32, J_ERI, 18-29.2792N, 147-41.4394E)	
	18:42	OBEM on deck (Site32, J_ERI)	
	20:17	Release command (site34, J_ERI)	
	21:30	Release command (Site33, USA)	
	22:53	OBEM on surface (Site34, J_ERI, 18-30.5026N, 148-03.2062E)	
	23:07	OBEM on deck (Site34, J_ERI)	
2006/9/19	1:38	OBEM on surface (Site33, USA,18-28.1633N, 147-54.8266E)	12:00 (UTC+10h)
	1:56	OBEM on deck (Site33, USA)	bc (fine But Cloudy)
	3:33	Release command (Site35, Australia) OBEM does NOT appear on surface	2 (Sea Smooth)
	5:53	Release command (Site36, USA) OBEM does NOT appear on surface	4 (Moderate-Average)
	13:09	Release command (Site37, J_Kobe)	N-3
	15:22	OBEM on surface (Site37, J_Kobe, 18-39.9157N, 149-02.7722E)	
	15:31	OBEM on deck (Site37, J_Kobe)	
	17:11	Release command (Site38, Australia)	
	20:29-	MBES mapping survey started	
	21:17	OBEM on surface (Site38, Australia, 18-44.1437N, 149-23.2828E)	
	21:35	OBEM on deck (Site38, Australia)	
	21:45	Depart from voyage research sea area to YOKOSUKA	

2006/9/20		Voyaging toward YOKOSUKA Harbor	12:00 (UTC+9h)
	-2:10	MBES mapping survey finished	bc (fine But Cloudy)
	17:00-	MBES mapping survey started	3 (Sea Slight)
			4 (Moderate-Average)
			NE-4
2006/9/21		Voyaging toward YOKOSUKA Harbor	12:00 (UTC+9h)
			bc (fine But Cloudy)
			3 (Sea Slight)
			4 (Moderate-Average)
			E-4
2006/9/22		Voyaging toward YOKOSUKA Harbor	12:00 (UTC+9h)
	10:00-11:30	Seminar for ship Crew	c (Cloudy)
	17:08	MBES mapping survey finished	5 (Sea Rough)
			4 (Moderate-Average)
			ENE-6
2006/9/23	9:00	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 ; Violent storm ; 28.4-32.6m/sec		
12 ; Hurricane ; 32.7m/sec-		

3. Participants

3-1.Onboard Scientists

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3-2. Crew

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2nd Officer	Matsuo Imai
2nd Officer	Naoto Kimura
3rd Officer	Masato Chiba
Chief Enginer	Hiroyuki Shibata
1st Enginer	Tadashi Abe
2nd Enginer	Kazunori Noguchi
3rd Enginer	Wataru Kurose
Chief Electronics Operator	Hiroyasu Saitake
2nd Electronics Operator	Yohei Yamamoto
3rd Electronics Operator	Yosuke Komaki
Boat Swain	Kazuo Abe
Able Seaman	Sakae Sasaki
Able Seaman	Osamu Tokunaga
Able Seaman	Hatsuo Oda
Able Seaman	Shozo Fujii
Sailor	Yoshiaki Matsuo
Sailor	Myuta Yamazaki
No.1 Oiler	Masayuki Masunaga
Oiler	Masanori Siino
Oiler	Katsuyuki Miyazaki
Oiler	Yoshitomo Hiratsuka
Oiler	Shota Tatsuki
Chief Steward	Tomihisa Morita
Steward	Jihei Nakatsuka
Steward	Koji Kirita
Steward	Hideo Fukumura
Steward	Yuki Shimoosako

4. Observation

4.1 OBEM, OBE, and OBM Observation

Observations using OBEM, OBE, and OBM were made at 40 sites across the Mariana Trench and back-arc spreading center. Site positions are given in Table 4-1-1 and Figure 4-1-1, and description of the instruments used is in the following section. The observations were made from December 2005 up to the recovery in September 2006.

Site	Type	Latitude	Longitude	Depth (m)	Remarks
1	U	17 - 44.386 N	143 - 6.396 E	2463	
2	A	17 - 45.531 N	143 - 14.994 E	1590	
3	U	17 - 48.957 N	143 - 32.690 E	5150	
4	Jk	17 - 53.472 N	143 - 45.101 E	4618	
5	U	17 - 56.737 N	143 - 57.200 E	4473	
6	Je	17 - 59.795 N	144 - 10.416 E	3725	
7	Ca	18 - 4.655 N	144 - 23.276 E	4399	
	Cu	18 - 4.636 N	144 - 23.257 E	4366	
8	Je	18 - 5.688 N	144 - 27.003 E	4099	
9	Ca	18 - 6.799 N	144 - 30.385 E	3604	
	Cu	18 - 6.806 N	144 - 30.367 E	3574	
10	Jam	18 - 8.046 N	144 - 33.573 E	3280	
11	A	18 - 9.388 N	144 - 36.575 E	3229	
12	U	18 - 9.480 N	144 - 39.067 E	3395	
13	A	18 - 9.916 N	144 - 41.864 E	4027	
14	Jk	18 - 10.013 N	144 - 42.920 E	3757	
15	Ca	18 - 10.498 N	144 - 44.178 E	3913	
	Cu	18 - 10.495 N	144 - 44.127 E	3348	
16	Jk	18 - 10.671 N	144 - 44.598 E	3883	
17	Ca	18 - 11.168 N	144 - 47.190 E	3388	
	Cu	18 - 11.196 N	144 - 46.984 E	3520	
18	Jam	18 - 12.160 N	144 - 50.090 E	3357	
19	Ca	18 - 13.020 N	144 - 52.943 E	3463	
	Cu	18 - 12.988 N	144 - 52.957 E	3442	
20	Jam	18 - 13.857 N	144 - 56.210 E	3491	
21	Ca	18 - 14.947 N	144 - 59.480 E	3797	
	Cu	18 - 14.903 N	144 - 59.454 E	3768	
22	jeT	18 - 15.295 N	145 - 6.495 E	3757	not calibrated
23	Ca	18 - 12.305 N	145 - 20.906 E	3378	not calibrated
	Cu	18 - 12.238 N	145 - 20.847 E	3375	not calibrated
24	jeT	18 - 10.507 N	145 - 28.197 E	3047	not calibrated
25	U	18 - 9.016 N	145 - 35.035 E	2531	not calibrated
26	Jam	18 - 9.072 N	145 - 59.973 E	2704	
27	A	18 - 12.303 N	146 - 18.296 E	3385	not calibrated
28	jeT	18 - 15.502 N	146 - 36.530 E	3668	not calibrated
29	U	18 - 18.599 N	146 - 55.021 E	3616	not calibrated
30	A	18 - 22.000 N	147 - 14.039 E	3423	not calibrated
31	Jk	18 - 24.442 N	147 - 26.515 E	3297	
32	Je	18 - 29.124 N	147 - 41.598 E	6018	
33	U	18 - 28.107 N	147 - 54.506 E	4472	not calibrated
34	Je	18 - 30.463 N	148 - 3.181 E	5216	
35	A	18 - 31.829 N	148 - 14.925 E	5754	
36	U	18 - 34.610 N	148 - 29.135 E	5776	slant ranges instable
37	Jk	18 - 39.872 N	149 - 3.000 E	5529	
38	A	18 - 44.126 N	149 - 23.562 E	5512	

39	Jk	18 - 49.088 N	149 - 50.804 E	5432	
40	U	18 - 54.013 N	150 - 18.015 E	5464	not calibrated

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 4-1-1. Location of OBEM, OBM and OBE

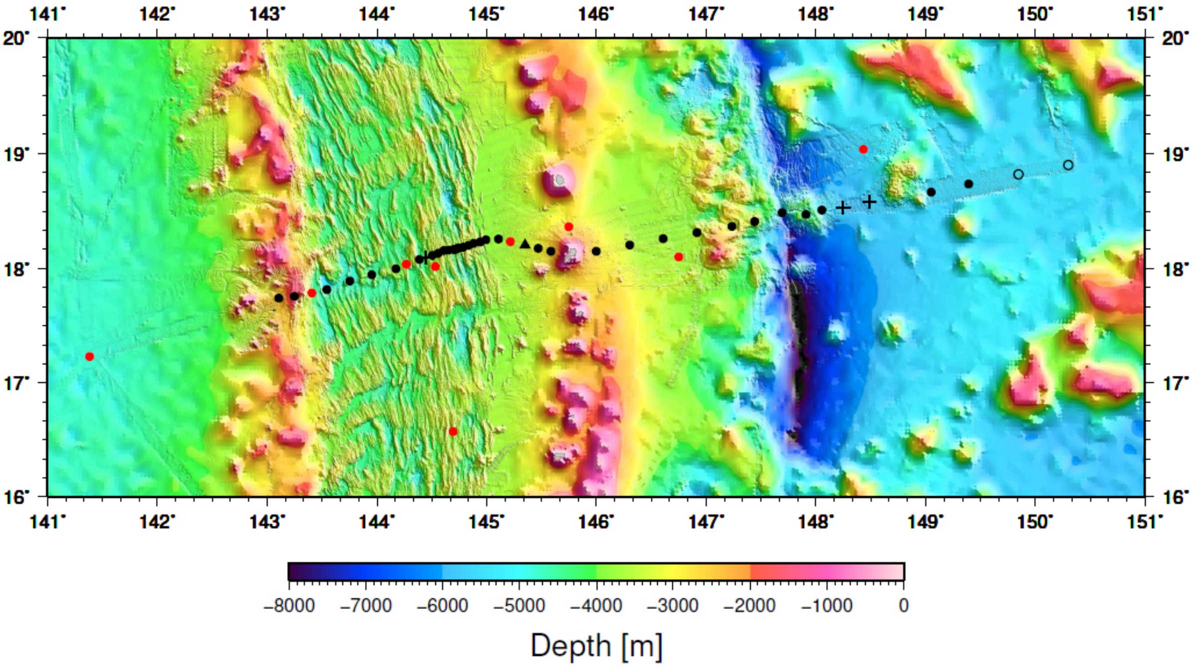


Figure 4-1-1a. A Location map of OBEMs, OBMs, and OBEs deployments through the Mariana subduction system. Black dots show the locations of OBEM or OBM & OBE recovered during KR06-12. The triangles show sites where only the OBM was recovered. Crosses denote sites where OBEM recovery failed. Open circles are sites at which OBEM remain deployed. Red circles are OBEM sites from previous studies for which data are already in hand.

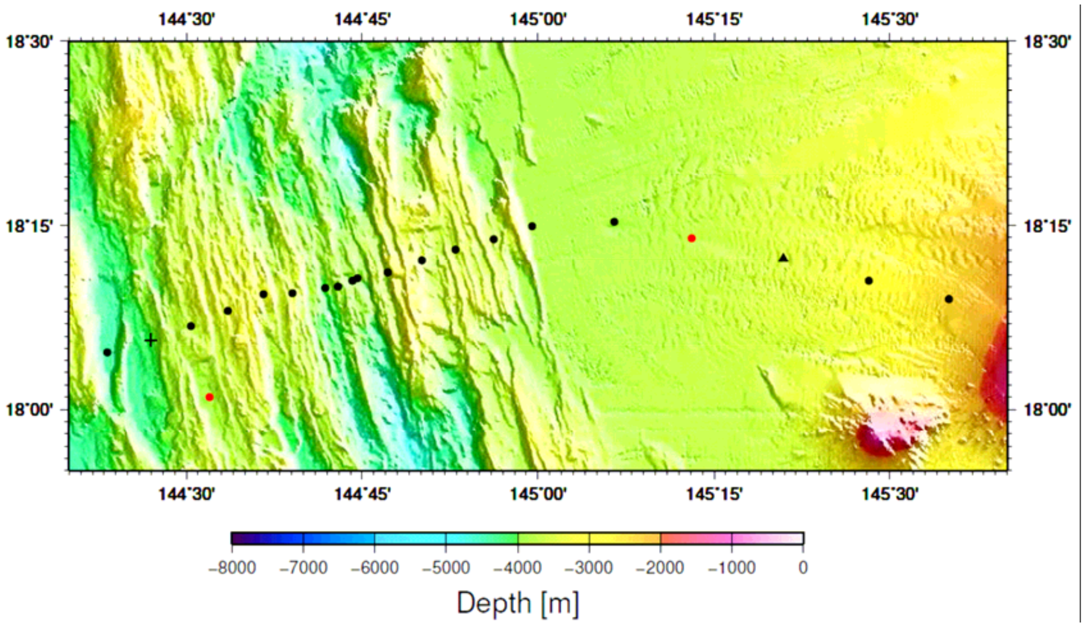


Figure 4-1-1b. Location map of OBEMs, OBMs, and OBEs near the spreading axis of Mariana Trough. The symbols are the same as Figure 4-1-1a.

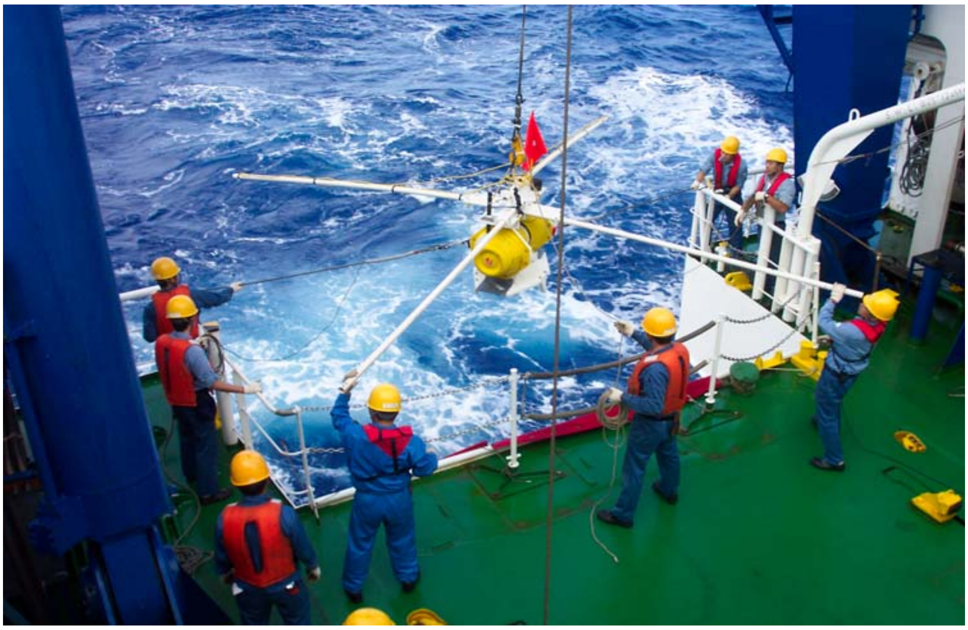
4-2. Australian instruments

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

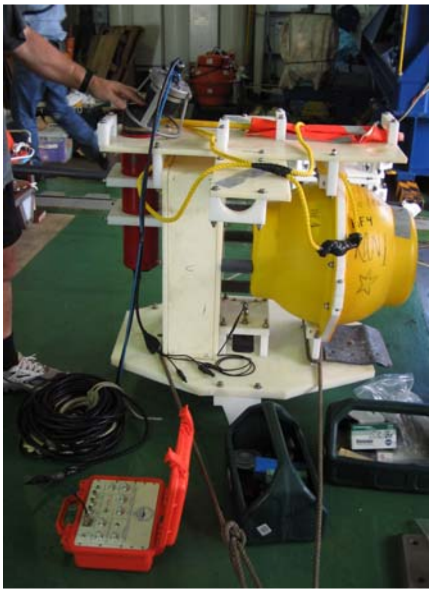
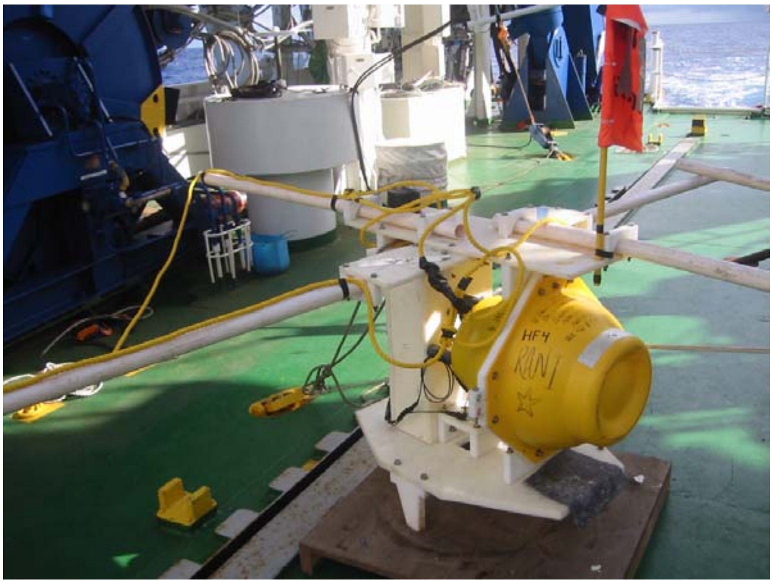
The full OBEM has a magnetometer in one of the glass spheres (inside the yellow hard hats), and an electrometer plus the acoustic electronics in the second glass sphere. Silver-silver chloride electrodes are fastened into the ends of the 3m white plastic pipes, giving a total span of 6m for the measurement 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, and 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.

4-3. 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. The resolutions are 0.01 nT for flux-gate magnetometer, 0.305 μV for voltmeter, 0.00026 degrees for tiltmeter, and 0.01°C for thermometer. 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 4-3-1).

Photo 4-3-1. 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 4-3-2). We have three type-1 OBEMs and four type-2 OBEMs. All the OBEMs mount Taiyo-Musen radio beacons and flashing lights.

Photo 4-3-2. ERI-OBEM (Type 2)

4-4. IFREE/JAMSTEC-OBEM

From IFREE/JAMSTEC, four OBEMs are contributed to this experiment; they are almost the same as ERI-OBEM type 2 (Photo 4-4-1). 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.

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

4-5. Kobe OBEM

The Kobe-OBEM 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 sensors are divided into two types. One is made by Tierra Tecnica Corp. (site 14) and the other sensors are made by Masashi Shimoizumi (Kyushu Polytechnic College) and Clover-tech Corp. (site 4, 16, 31, 37, 39). Data sampling was carried out once per one minute with Tierra Tecnica Corp.'s sensor and ten times (ten seconds) per one minute with M. S. and Clover-tech Corp.'s sensors. The OBEM also has radio beacon and flashing light for recovery.

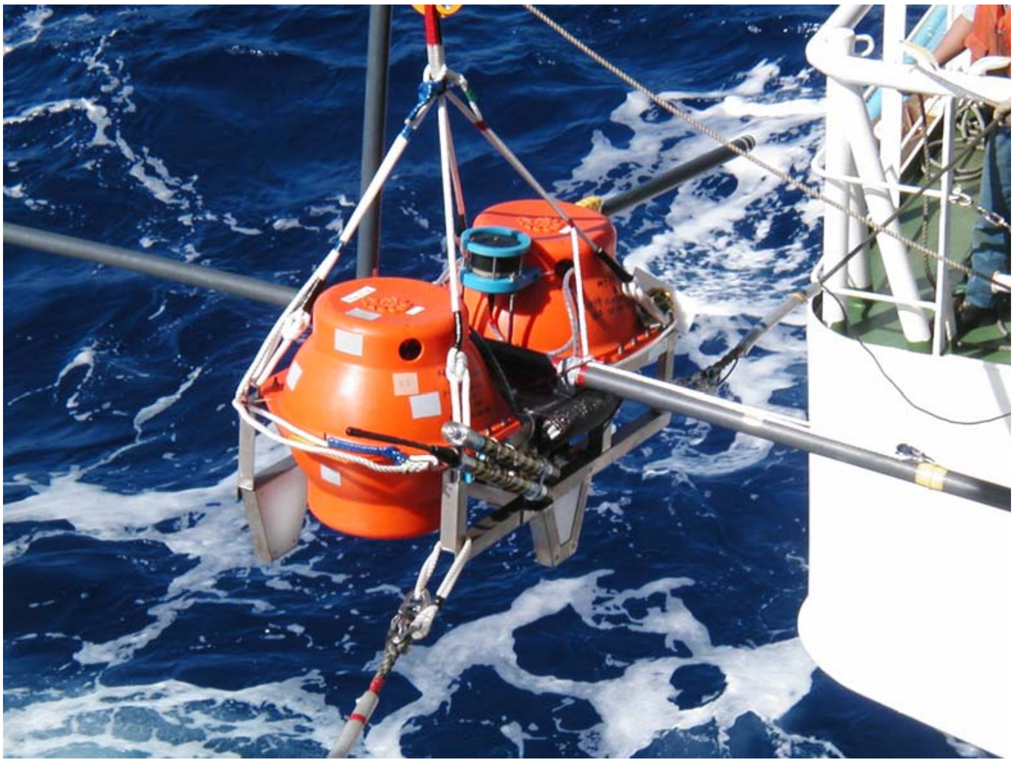


Photo 4-5-1. Kobe OBEM.

4-6. 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.

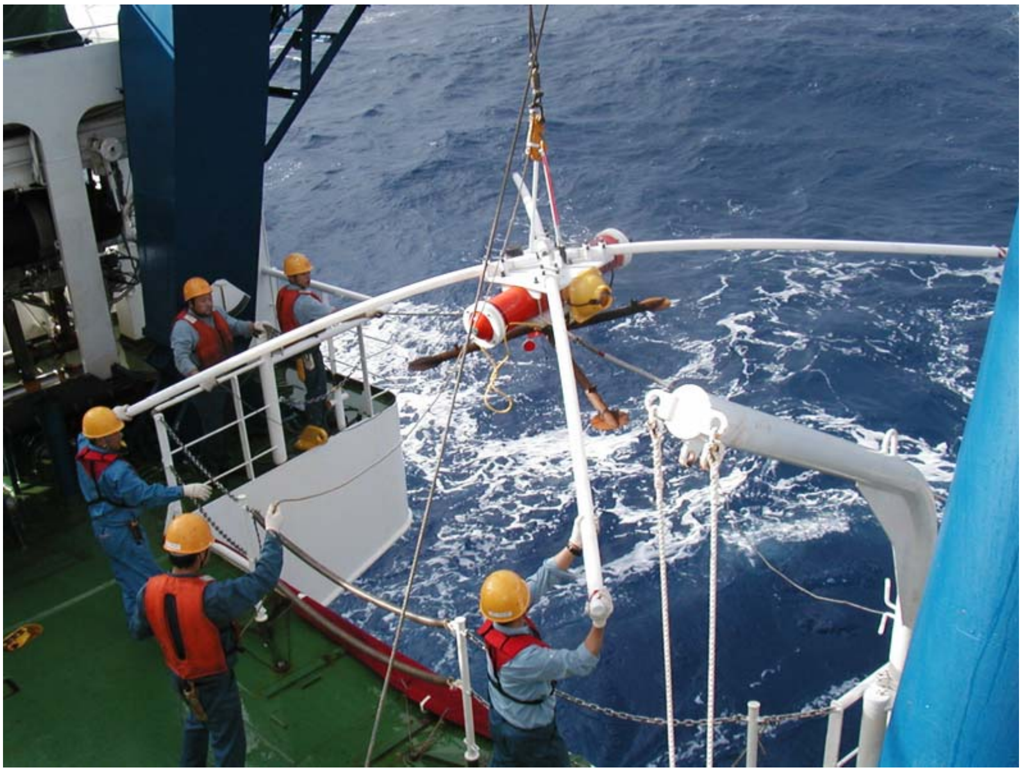


Photo 4-6-1. US OBEM.

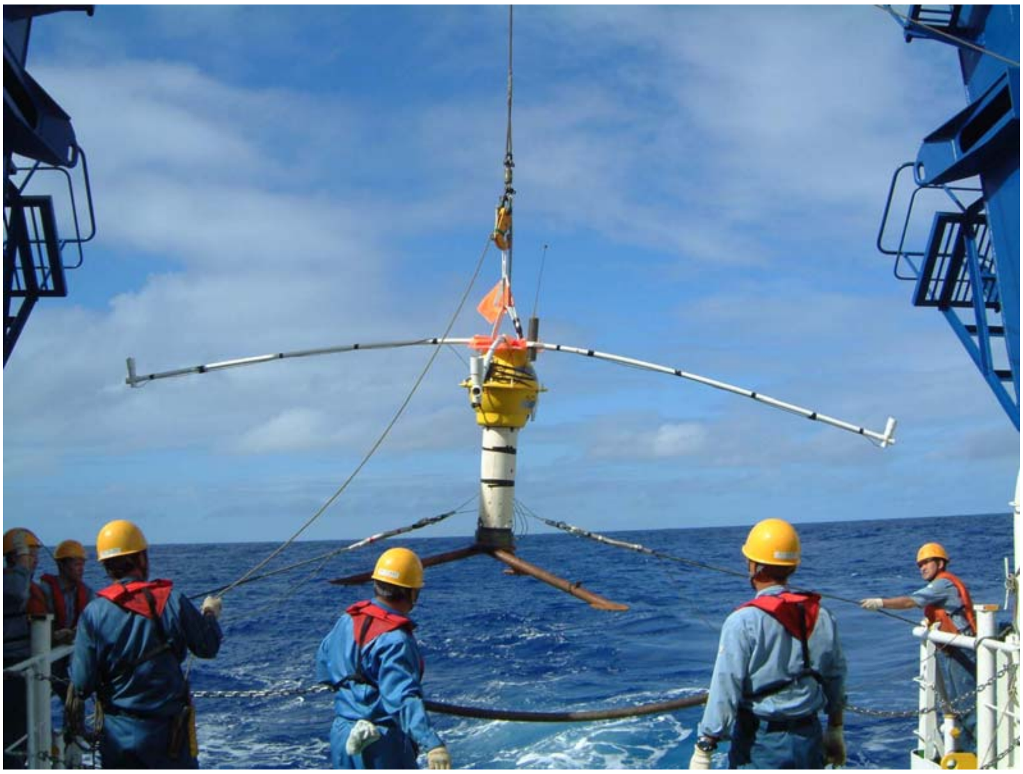


Photo 4-6-2. US OBE.

5. Preliminary Results

5-1. OBEM, OBM, and OBE recovery

Upon release, instruments were tracked to the surface using a variety of acoustic tracking tools. Some of the Japanese instruments utilized the inbuilt SSBL system on board the R/V Kairei to provide real-time x,y,z positions in the water column. Other groups 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.

Most instruments 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. Larger instruments were hooked in the same way but were passed around the stern and lifted on board using the a-frame and a capstan.

Australian instruments

Of the 14 Australian instruments 13 were recovered and one was abandoned because there was no response to the acoustic 'enable' or 'release' commands. In most cases acoustic contact was first established, and then a release command was sent; continuous ranging in the first 15 minutes established the time at which the burn wire corroded sufficiently for the ballast weight to drop and the instrument began to ascend. Periodic ranging allowed computation of a predicted surface time and location. In many cases, continuous ranging was also used to establish the exact time at which the instrument surfaced as the top transducer came out of the water. The bottom transducer was available for further tracking, but was not necessary because visual contact was rapidly established. All recoveries were through the hero platform on the starboard side of the ship, and were completed quickly and efficiently.

The only instrument lost was at site 35 where the OBEM did not respond to acoustic signals. Despite waiting and searching after the predicted surface arrival time (assuming receipt of the release commands), no sign of the instrument was observed and it was abandoned as lost.

ERI-OBEM

For type-1 OBEMs, the acoustic signal for releasing weight was sent by transducer hooked on the starboard side of R/V Kairei. For type-2 OBEMs, the hull transducer of R/V Kairei was available but for ones deployed on seafloor deeper than ~4000 m because of insufficient matching of the acoustic deck unit and the hull transducer. The OBEMs were tracked measuring slant ranges and ship's position. A buoy was released when the OBEM start ascending. At the surface, the OBEMs were easily caught on starboard side by crew taking the rope between the buoy and the OBEM, and then passed around the stern and lifted on deck using A-frame.

6 of 7 OBEMs were successfully recovered. The OBEM at site 8 acknowledged the acoustic enable command but ranging and the release commands that the reason is unknown and hence was left on seafloor.

IFREE/JAMSTEC-OBEM

Of the 4 MT stations deployed, all were recovered.

Kobe OBEM

Of the 6 MT stations deployed, 5 were recovered. One instrument remains deployed as the ship was forced to leave the survey area due to an oncoming typhoon.

US OBEM and OBE

Of the 9 MT stations deployed, 7 were recovered. One failed to respond to acoustic command and was lost. One instrument remains deployed as the ship was forced to leave the survey area due to an oncoming typhoon. Of the 7 HEF instruments deployed, all but one were recovered.

Site No.	Type	Water Depth (m)	Send release command		Lift off	Time for release (minute)	On Surface	On Deck	Time for recovery (minute)
1	u	2463	14/Sep/06	4:33	4:35	2	6:27	6:39	12
2	a	1590	14/Sep/06	7:40	7:58	18	9:13	9:24	11
3	u	5150	14/Sep/06	10:48	10:49	1	14:43	15:20	37
4	jk	4618	14/Sep/06	16:40	16:54	14	18:32	18:39	7
5	u	4473	15/Sep/06	2:18	2:18	0	5:38	5:56	18
6	je	3725	14/Sep/06	20:59	21:16	17	22:55	22:55	0
7	ca	4399	15/Sep/06	8:05	8:15	10	9:56	10:04	8
7	cu	4366	15/Sep/06	7:57	7:57	0	10:05	10:18	13
8	je	4099	15/Sep/06	19:21	Not released				
9	ca	3604	15/Sep/06	11:08	11:19	11	12:45	12:56	11
9	cu	3574	15/Sep/06	11:30	11:30	0	13:15	13:22	7
10	jam	3280	15/Sep/06	23:16	23:25	9	0:58	1:09	11
11	a	3229	15/Sep/06	14:17	14:29	12	16:59	17:23	24
12	u	3395	15/Sep/06	15:31	15:32	1	18:03	18:10	7
13	a	4027	16/Sep/06	5:08	5:18	10	8:11	8:26	15
14*	jk	3757	16/Sep/06	3:08	3:21	13	4:32	4:48	16
15*	ca	3913	16/Sep/06	7:33	7:45 ?	12	9:31	9:39	8
15	cu	3348	16/Sep/06	8:53	8:53	0	10:50	10:59	9
16	jk	3883	16/Sep/06	2:23	2:36	13	4:00	4:09	9
17	ca	3388	16/Sep/06	12:19	12:28	9	14:16	14:30	14
17	cu	3520	16/Sep/06	11:28	11:28	0	13:10	13:22	12
18	jam	3357	16/Sep/06	17:57	18:07	10	19:32	19:43	11
19	ca	3463	16/Sep/06	15:42	15:52	10	17:31	17:40	9
19	cu	3442	16/Sep/06	15:22	15:22	0	17:04	17:11	7
20	jam	3491	16/Sep/06	20:20	20:30	10	22:11	22:22	11
21	ca	3797	17/Sep/06	4:15	4:27	12	6:03	6:21	18

21	cu	3768	17/Sep/06	3:40	3:40	0	5:34	5:48	14
22	jeT	3757	16/Sep/06	23:24	23:31	7	1:16	1:33	17
23	ca	3378	17/Sep/06	8:23	8:32	9	9:53	10:02	9
23	cu	3375	17/Sep/06	7:44	No reply		Not found		
24	jeT	3047	17/Sep/06	10:55	11:02	7	12:19	12:36	17
25	u	2531	17/Sep/06	13:16	13:16	0	15:10	15:25	15
26	jam	2704	17/Sep/06	17:20	17:32	12	18:48	19:11	23
27	a	3385	17/Sep/06	20:31	20:44	13	23:08	23:28	20
28	jeT	3668	18/Sep/06	0:55	1:03	8	2:50	3:08	18
29	u	3616	18/Sep/06	4:28	4:28	0	7:12	7:28	16
30	a	3423	18/Sep/06	8:53	9:04	11	11:29	11:39	10
31	jk	3297	18/Sep/06	12:40	12:53	13	14:04	14:12	8
32	je	6018	18/Sep/06	15:35	15:42	7	18:25	18:42	17
33*	u	4472	18/Sep/06	21:30	21:30 ?	0	1:38	1:56	18
34	je	5216	18/Sep/06	20:17	20:23	6	22:53	23:07	14
35	a	5754	19/Sep/06	3:33	No reply		Not found		
36	u	5776	19/Sep/06	5:53	No reply		Not found		
37	jk	5529	19/Sep/06	13:09	13:23	14	15:22	15:31	9
38	a	5512	19/Sep/06	17:11	17:26	15	21:17	21:36	19
39	jk	5432	No time for recovery						
40	u	5464	No time for recovery						

Table 5-1-2. Timetable for instrument recovery at each site

Site	Type	Ascending Speed(m/min)	u	a	jk	ca	ca-I	cu	jam	je	jeT
1	u	22	22								
2	a	21		21							
3	u	22	22								
4	jk	47			47						
5	u	22	22								
6	je	38								38	
7	ca	44				44					
7	cu	34						34			
8	je										
9	ca	42				42					
9	cu	34						34			

10	jam	35							35		
11	a	22		22							
12	u	22	22								
13	a	23		23							
14*	jk	53			53						
15*	ca	37					37				
15	cu	29						29			
16	jk	46			46						
17	ca	31					31				
17	cu	35						35			
18	jam	39							39		
19	ca	35					35				
19	cu	34						34			
20	jam	35							35		
21	ca	40				40					
21	cu	33						33			
22	jeT	36									36
23	ca	42				42					
23	cu										
24	jeT	40									40
25	u	22	22								
26	jam	36							36		
27	a	24		24							
28	jeT	34									34
29	u	22	22								
30	a	24		24							
31	jk	46			46						
32	je	37								37	
33*	u	18	18								
34	je	35								35	
35	a										
36	u										
37	jk	46			46						
38	a	24		24							
39	jk										
40	u										
		AVERAGE	22	23	47	42	33	33	36	36	37

14* weight of the battery is lighter than the others
15*&33* lift off time is unknown

Table 5-1-3. Ascending speed of instrument

5-2. Surface Geophysical Survey

We conducted a surface geophysical survey during the transit to site 1 and after site 38 to collect multi-narrow beam bathymetry, gravity field, and magnetic field data. 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 14th September at site 1. The DGPS (differential global positioning system) was used to derive the best ship location. 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 a shipboard three component magnetometer (STCM: Isezaki, 1986), which can measure the vector of the geomagnetic field using deck-mounted fluxgate magnetometers and gyros.

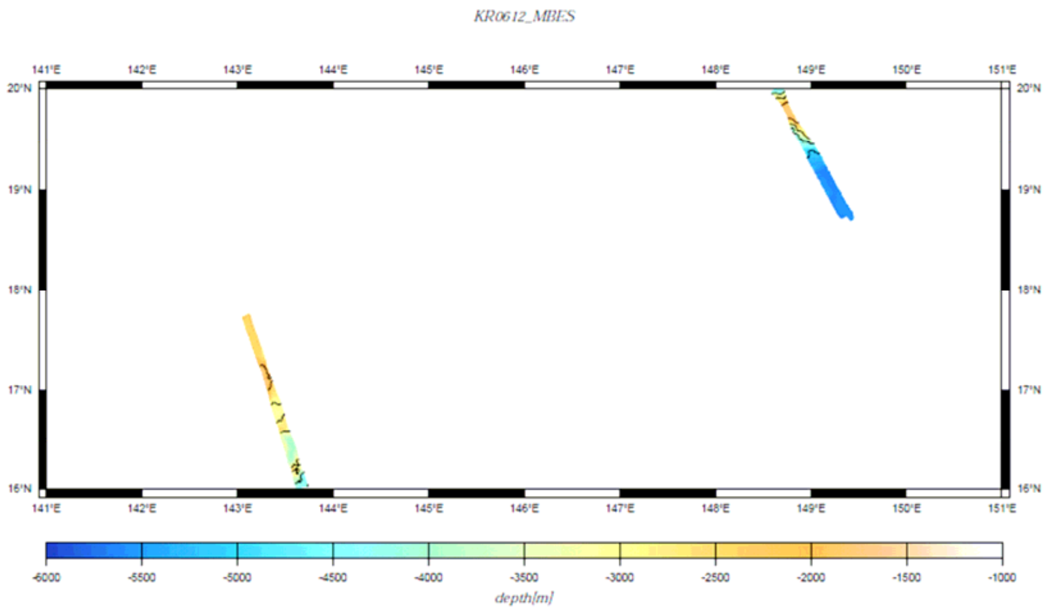


Figure 5-2-1. Topography map in the survey area

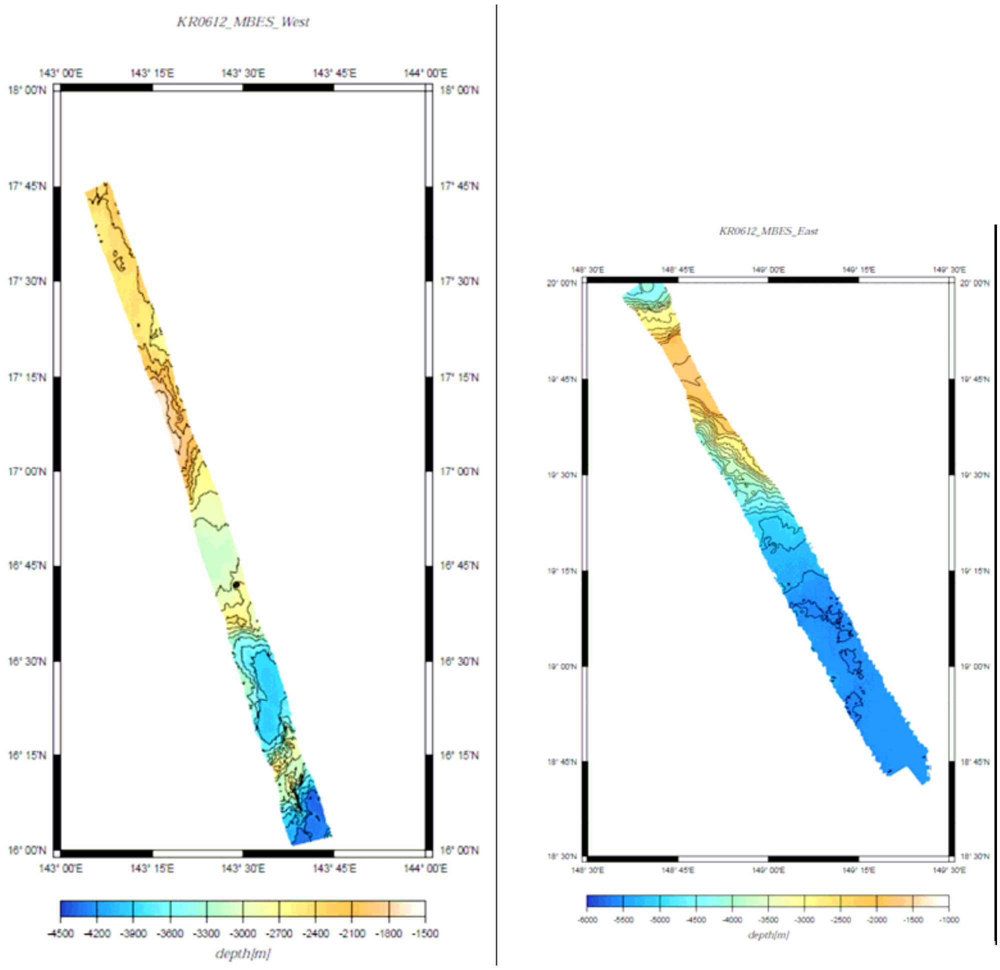


Figure 5-2-1. Topography map in the survey area (continue)

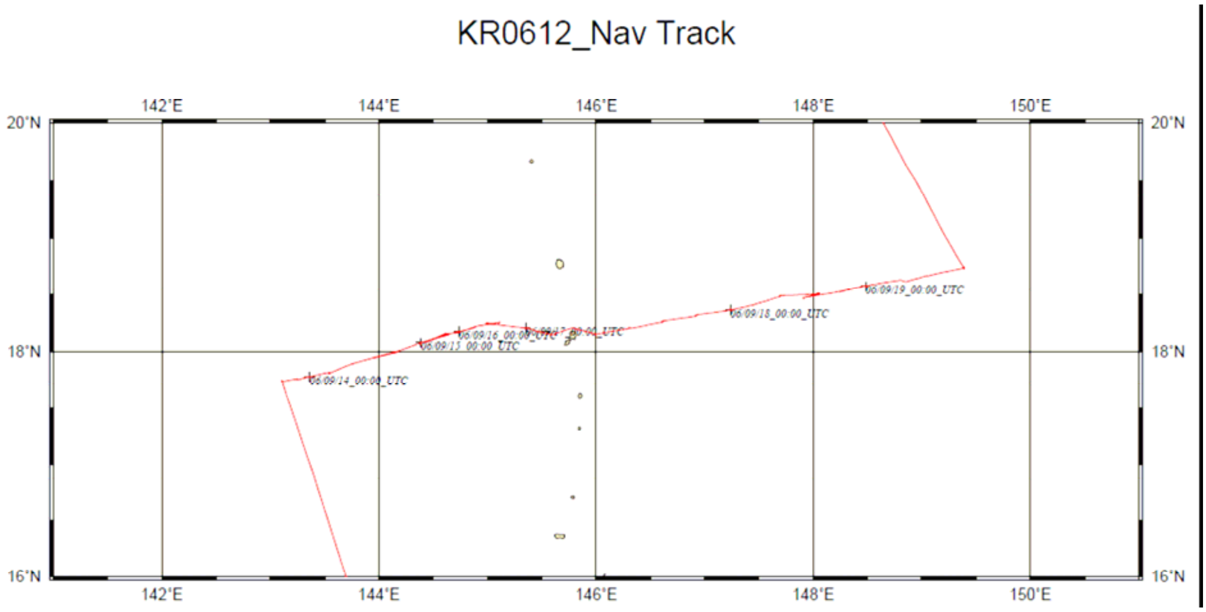


Figure 5-2-2. Ship track of the cruise in the survey area

6. Summary and Future Studies

We successfully recovered 28 OBEMs, 7 OBMs, and 6 OBEs at 35 sites. 3 OBEMs and and 1 OBE failed to respond to acoustic command and were not recovered. 2 OBEMs remains deployed as the ship was forced to leave the survey area due to an oncoming typhoon. The instruments measure geomagnetic and/or electric fields and 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. These results will provide a breakthrough for understanding mantle dynamics related to plate subduction.

Acknowledgement

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Appendix

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

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 (both of raw data and edited data)
   (The data are in DVD provided from the ship)