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Preliminary Report
of
the *R/V KAIMEI* Cruise KM17-05

May 22 – June 20, 2017

Training cruise for 2 Dimensional Multi-Channel Seismic Survey

in the Japan Trench

JAMSTEC - Off Sendai - Otaru port

Marine Technology and Engineering Center (MARITEC)
R&D Center for Earthquake and Tsunami (CEAT)

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

CONTENTS

PREFACE

In May to June, 2017, the KM17-05 cruise using *R/V KAIMEI* of JAMSTEC (Japan Agency for Marine-Earth Science and Technology) was successfully carried out in the Japan Trench, Off Tohoku, Japan. The cruise was divided into two Legs according to participants' schedule.

The purpose of this cruise is training for the newly acquired seismic reflection survey system onboard the *R/V KAIMEI*. To understand and practice the launch and recovery procedure for seismic streamer cable, paravane, air gun arrays was safely conducted during cruise. Towing layout was adjusted depends on the ship's speed and was finally confirmed.

The system was put into operation on several sea trials of the *R/V KAIMEI* in 2015, 2016, and 2017. After some modification of the system based on the experience on these trials, KM17-05 cruise marked its first scientific operation.

1. Participants aboard the *R/V KAIMEI* cruise

Leg1 (2017/05/22 ～ 06/11)

YAMAMOTO Fujio*	JAMSTEC/MARITEC
NO Tetsuo	JAMSTEC/CEAT
OHIRA Akane	JAMSTEC/CEAT
KIKUCHI Hidekuni	JGI, Inc
KONNO Megumi	JGI, Inc

*Chief of the cruise

Leg2 (2017/06/11～ 06/20)

AMITANI Yasutaka *	JAMSTEC/MARITEC
NO Tetsuo	JAMSTEC/CEAT
FUJIE Gou	JAMSTEC/CEAT
KIDO Motoyuki	Tohoku Univ.
KIKUCHI Hidekuni	JGI, Inc
KONNO Megumi	JGI, Inc

*Chief of the cruise

Marine technician

ITO Makoto [Nippon Marine Enterprises, Ltd. (NME)]: Chief marine technician
OHWATARI Yuki [NME]
WATARAI Yuta [NME]
SUZUKI Keita [NME]
SUZUKI Akie [NME]
NOGUCHI Naoto [NME]
TERADA Ikumasa [NME]
SAKAMOTO Eri [NME]
HORIUCHI Yoshiki [NME]
KOMATSU Waka [NME] (Leg1)
SERIZAWA Kimiko [NME] (Leg1)
RICARD Barbachavira [Sound Oceanics] (Leg1)
JACOB Green [Sound Oceanics] (Leg1)
RAYMOND Axibal [Seamap] (Leg1)
TSUKUDA Kaoru [NME] (Leg2)
IWAMARU Hikaru [NME] (Leg2)
SHIMOMURA Norio [NME] (Leg2)
SAIJO Toshinori [NME] (Leg 2)

2. Observation

2-1. Background and objectives

In trench-outer rise regions, the normal faults develop due to the bending of the oceanic plate, and numerous normal-faulting earthquakes occur beneath the outer trench slope. To understand the structural variation and systematic changes of the oceanic plate (i.e., incoming sediments, horst-and-graben structure, the reflection character of the oceanic Moho, Vp and Vs structure), we conducted a seismic reflection and refraction survey along the survey lines approximately perpendicular to the trench axis. We used 40 Ocean Bottom Seismographs (OBS) and multi-channel seismic (MCS) system of *R/V KAIMEI*. In addition to the seismic survey, we tested GPS/A seafloor positioning system at selected seafloor transponder's sites using a hull-mount transducer and GPS antenna array equipped on *R/V KAIMEI*.

2-2. List of observation

(1) MCS survey

A 3840-channel seismic streamer with 3.125 m length per channel is towed at 12 m depth and receives the returned seismic signal. The streamer is equipped with depth controllers attached every 300 m which can be remotely monitored and controlled. The real time digital data are fed into the data acquisition system (NTRS) and the data are eventually stored onto hard disk drive as SEG-D format.

Total 4 air gun arrays are towed at 10 m depth and are fired every 50 m. The ship speed is kept ~3.5-4.5 knots during the shooting. Compressed air is supplied by three compressor systems permanently installed on the vessel.

Though the system still requires further modifications for stable operations, it has proven to produce good quality, high resolution and deep penetration image of the crust beneath oceans.

Specifications for the streamer cable and air gun array system are as follows.

・Streamer cable

Manufacturer:	Hydroscience Technology, Inc
Number of channel:	3,840 channel streamer cable, maximum offset ~12 km
Group interval:	3.125 m
Cable depth:	12 m

・Air gun array system

Manufacturer:	Bolt Technology
Type of airgun:	1500LL and 1900LL Cluster
Total volume:	10,600 cu in
Air pressure:	2,000 psi
Source depth:	10 m

(2) OBS observation

During Leg1, 40 OBSs were deployed along the survey line A4 to record the seismic waves generated by air guns. Each OBS location was determined by SSBL system after deployment. Airgun shooting with a shot spacing of 100 m was conducted during Leg 2. Finally, all OBSs were retrieved by acoustic release and self-popup system during cruise. Specification for 2 types of OBSs are shown in following tables and figures.

Table 2-2 Katsushima type OBS

Type	POBS-150, Katsujima Co., LTD.
Maximum Depth	6,000 m
Dimension (w/ anchor)	120 * 100 * 52 cm
Weight (w/ anchor)	98 kg in air, 43 kg in water
Sensor	Three-component Geophone [One vertical and two horizontal components, Natural frequency: 4.5Hz, Sensitivity:0.8V/inch/s (OPEN)] & Hydrophone
Recorder	SPM II, Nippon Marine Enterprises Ltd.
Recording System	Sampling continuously (Timer control is possible for start time)
Sampling Rate	24 bit, 250Hz
Power	Lithium Ion Rechargeable Battery
Acoustic Communication & Release System	Electric corrosion method
Attached Parts	Weight, Flush light, Radio beacon
Pressure Resistant Container	17 inch glass sphere

Figure 2-2 Katsujima type OBS

Table 2-3 OBS2G-UD type OBS

Type	OBS2G-UD, Nippon Marine Enterprises Ltd.
Maximum Depth	11,000 m
Dimension (w/ anchor)	120 * 100 * 65 cm
Weight (w/ anchor)	105 kg in air, 50 kg in water
Sensor	Three-component Geophone [One vertical and two horizontal components, Natural frequency: 4.5Hz, Sensitivity:0.8V/inch/s (OPEN)] & Hydrophone
Recorder	SPM II, Nippon Marine Enterprises Ltd.
Recording System	Sampling continuously (Timer control is possible for start time)
Sampling Rate	24 bit, 250Hz
Power	Lithium Ion Rechargeable Battery
Acoustic Communication & Release System	Electric corrosion method
Attached Parts	Weight, Flush light, Radio beacon
Pressure Resistant Container	445mm ceramic sphere

Fig. 2-3 OBS2G-UD

(3) XCTD and XBT measurements

We conducted XCTD and XBT casts at the north and south of the survey area to obtain the acoustic velocity profile in the water column.

(4) Bathymetry, gravity, magnetic surveys

Bathymetry data were collected by vessel mounted multi beam echo sounder (Kongsberg EM122) during the survey. Gravity and magnetic data were also collected.

(5) GPS-Acoustic survey

Hull mounted transducer for the GPS/acoustic seafloor geodetic observation was tested and was used to measure positions of 4 bottom mounted transponders.

Spesifications

Hull-mount transducer on R/V Kaimei	: ITC-3482 (TRBS812-15)
Hull-mount GNSS antenna array on R/V Kaimei	: Zephyr Geodetic 2 (main), Zephyr 2 (sub)
Fiber Optic Gyro equipped on R/V Kaimei	: PHINS (20Hz)
GNSS Receiver 1	: JAVAD Delta (2Hz, GPS/GLONASS, auxiliary antenna baselines)
GNSS Receiver 2	: Septentrio PolaRx2@ (2Hz, GPS, auxiliary antenna baselines)
GPS-Acoustic control UNIT	: Kaiyo-denshi MOTB-001 (100kHz, 16bit, 10sec for each ping)

2-3. Survey area

Fig. 1 shows planned MCS lines for this cruise. Planned OBSs positons are also shown in this figure.

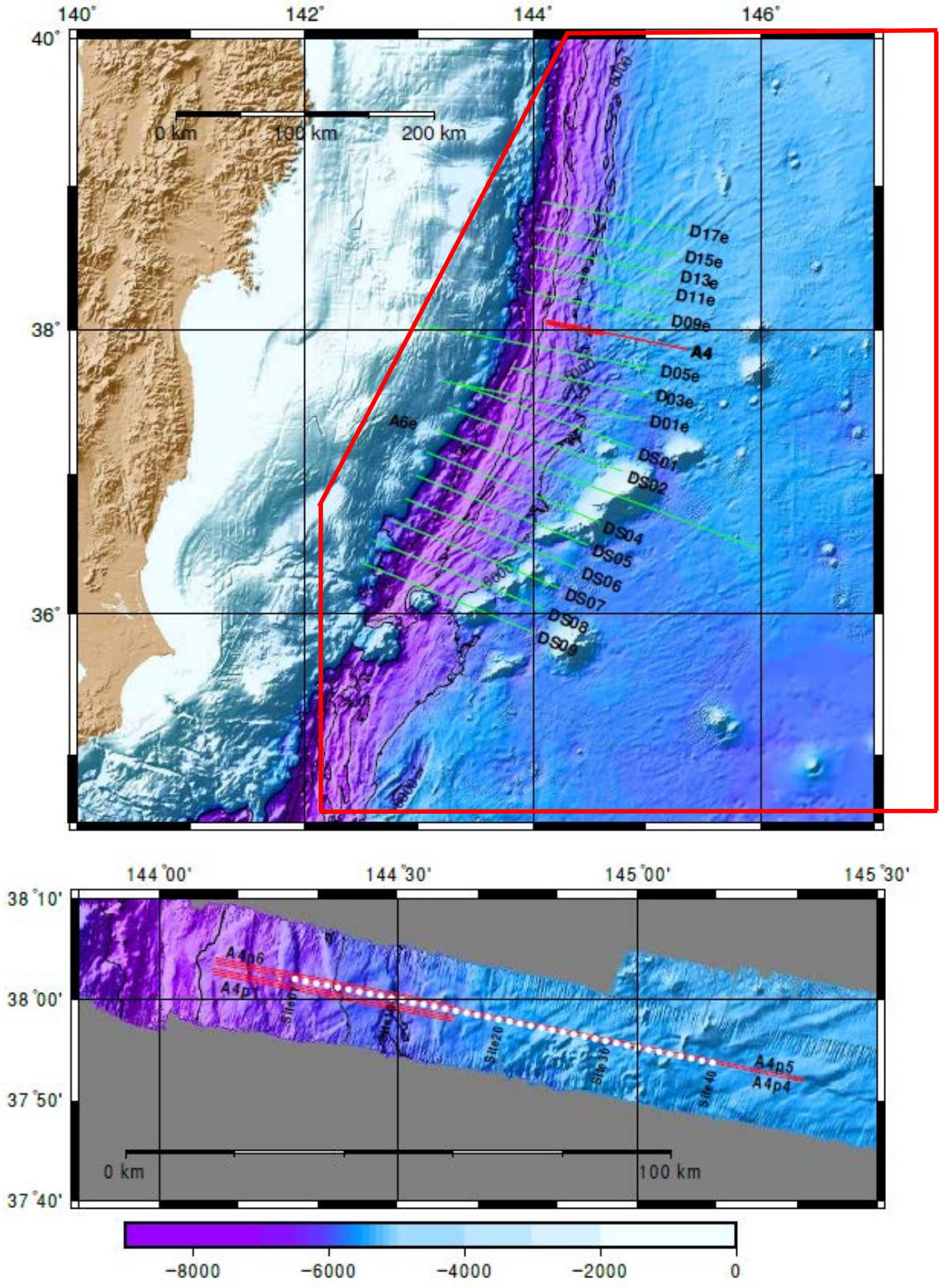

Fig. 2-1 Panned MCS lines (○ : OBS position)

3. Cruise track

KM17-05 cruise was started from JAMSTEC pier on May 22 and then, the vessel went to the survey area. Before we arrived at survey area, one OBS deployed by *R/V KAIREI* in this February was retrieved. After that, MCS/OBS survey and bathymetric survey were conducted in the Japan Trench. Finally, the vessel arrived at Otaru Port on June 20 and we ended KM17-05 cruise.

Fig. 3-1 shows ship's tracks for the entire cruise and table 3-1 shows activity log during the cruise.

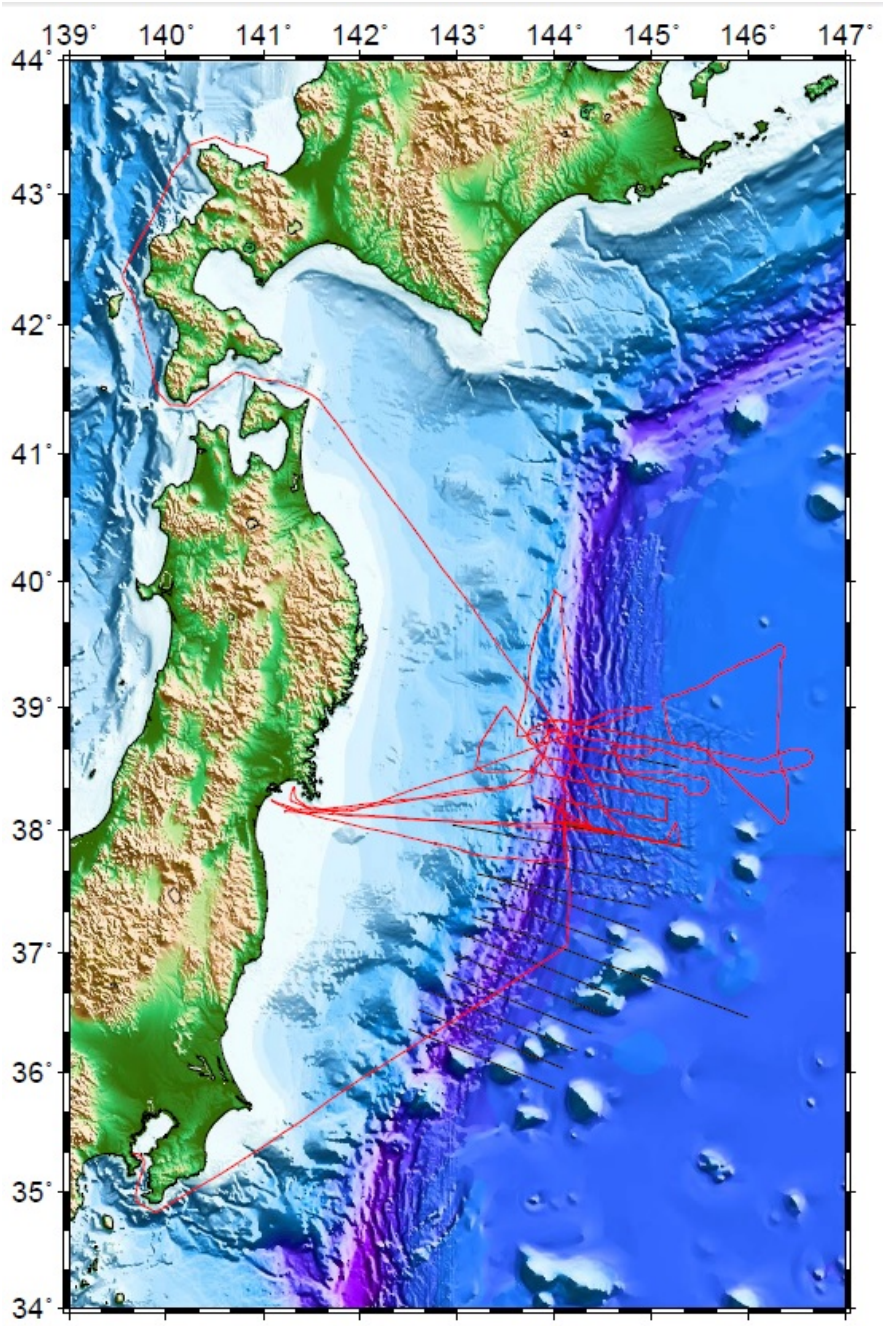

Fig. 3-1 Ship's tracks for the entire KM17-05 cruise

Table 3-1 Cruise log

Leg	Date		Remarks
1	2017/5/22	Mon	Departure from JAMSTEC port and transit to the survey area
	2017/5/23	Tue	OBS2G retrieval and transit to the survey line (D17e)
	2017/5/24	Wed	MCS system deployment and maintenance
	2017/5/25	Thu	MCS system deployment and maintenance
	2017/5/26	Fri	MCS system deployment and maintenance
	2017/5/27	Sat	MCS system deployment and maintenance
	2017/5/28	Sun	MCS system deployment and maintenance
	2017/5/29	Mon	MCS system deployment and maintenance
	2017/5/30	Tue	MCS system deployment and maintenance
	2017/5/31	Wed	MCS survey (D17e)
	2017/6/1	Thu	MCS survey (D17e) and retrieve all equipments
	2017/6/2	Fri	Wait on weather in Ishinomaki Bay
	2017/6/3	Sat	Wait on weather in Ishinomaki Bay and transit to a survey line (D15e)
	2017/6/4	Sun	MCS system deployment
	2017/6/5	Mon	MCS survey (D15e)
	2017/6/6	Tue	MCS survey (D13e)
	2017/6/7	Wed	MCS survey (D13e)
	2017/6/8	Thu	Wait on weather in Sendai Bay
	2017/6/9	Fri	OBS deployment
	2017/6/10	Sat	OBS deployment and transit to Sendai
2	2017/6/11	Sun	Change of some scientists and marine technicians off Sendai, and transit to G11. Test of seafloor geodetic observation system (G14).
	2017/6/12	Mon	Airgun shooting (A4p4, 100 m shot interval).
	2017/6/13	Tue	Airgun shooting (A4p4, 100 m shot interval), OBS retrieval.
	2017/6/14	Wed	OBS retrieval. Test of seafloor geodetic observation system (G11).
	2017/6/15	Thu	OBS retrieval, and MCS system deployment.
	2017/6/16	Fri	MCS survey (D11e)
	2017/6/17	Sat	MCS survey (D09e, A4p4)
	2017/6/18	Sun	MCS survey (A4p4) and retrieve all equipments. Operation test of seafloor geodetic observation system (G07).
	2017/6/19	Mon	Transit to Otaru port.
	2017/6/20	Tue	Arrival at Otaru port.

4. Preliminary results

Fig. 4 shows the results of KM17-05 cruise. Seafloor geodetic observations were conducted at site G11 and G14.

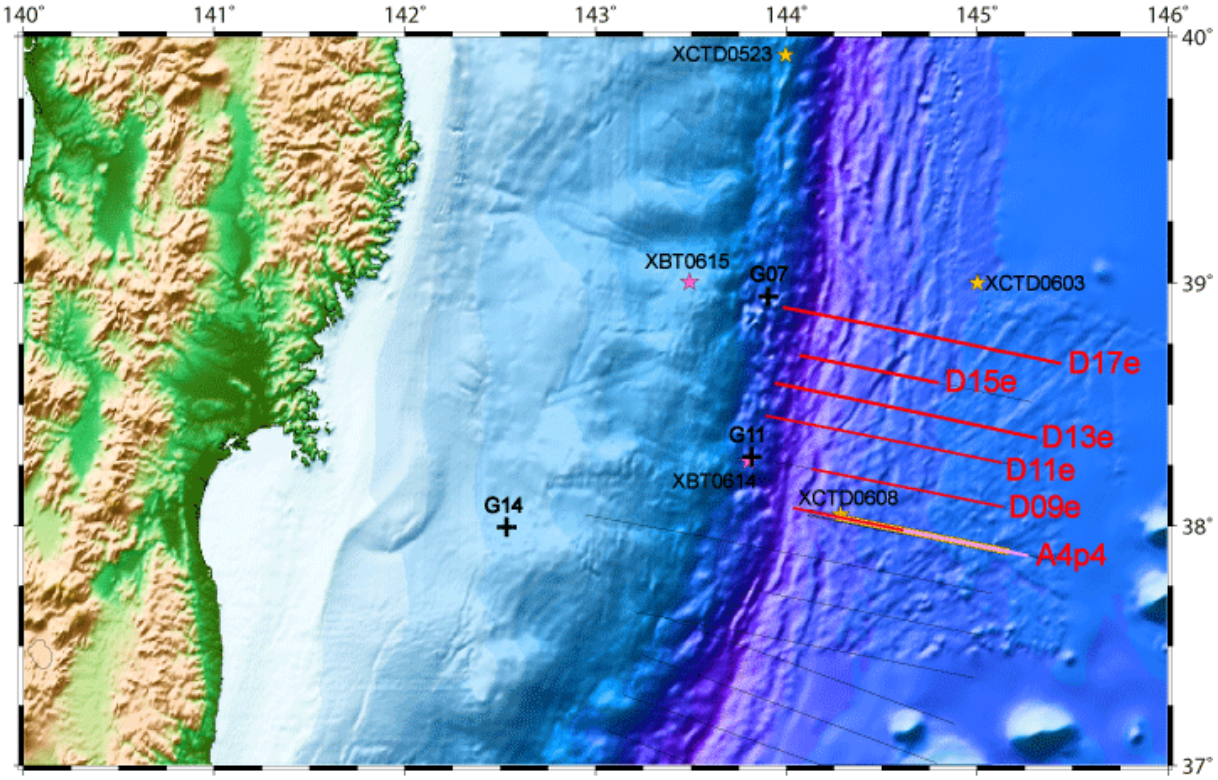

Fig. 4 Results of KM17-05 cruise

(KM17-05 survey points are shown in this figure)

4-1. Bathymetric survey

A bathymetric survey by using Kongsberg EM122 (12kHz) was conducted in the survey area. The results of bathymetric survey is shown in Fig. 4-1.

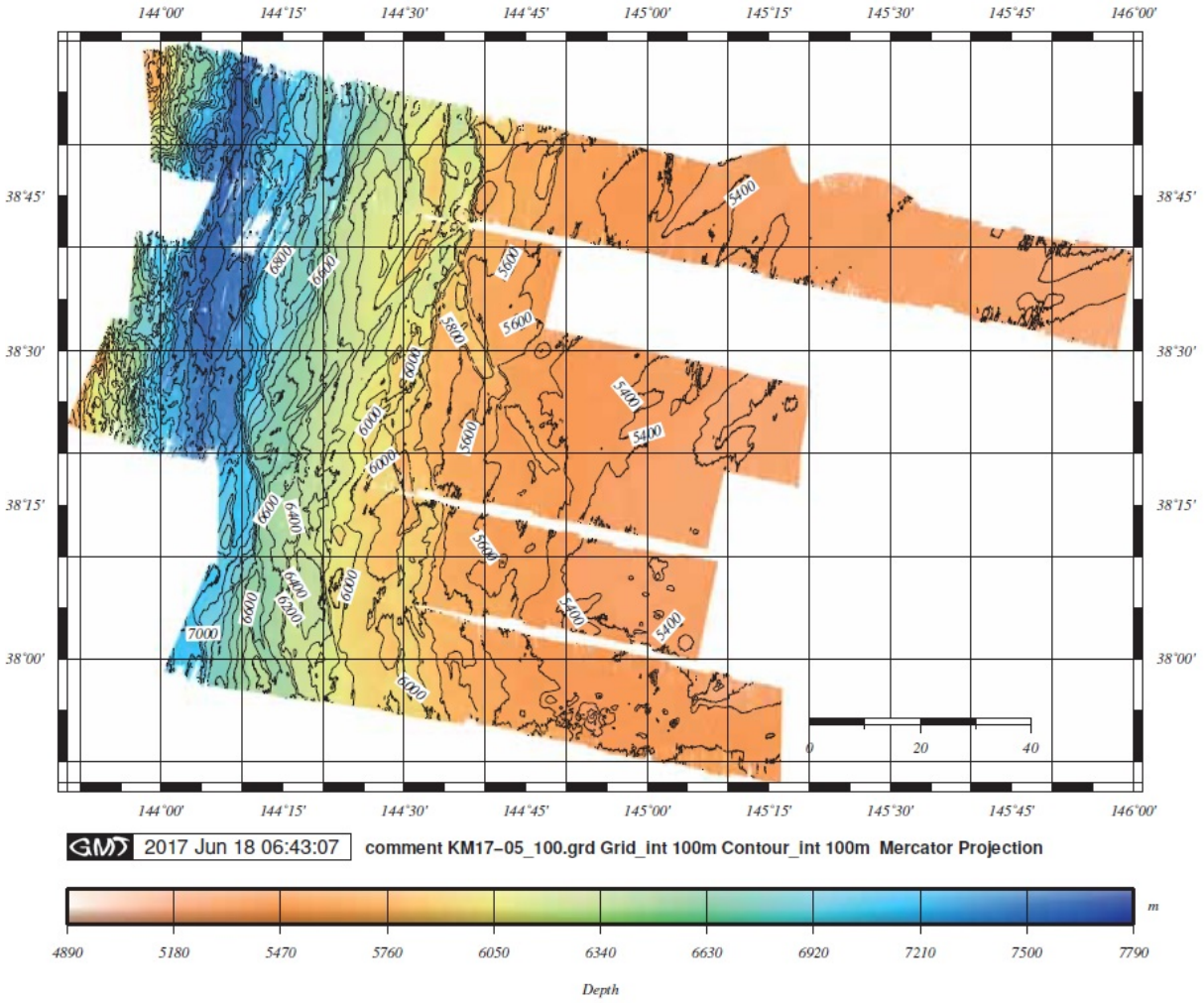

Fig. 4-1 Bathymetric chart

4-2. Seismic survey

A total of 662 km of MCS data was collected in the survey area. Table 4-2 shows results of the MCS survey. Differential Global Positioning System (DGPS) of WGS84 was used for the positioning. Raw MCS reflection data was processed for the purpose of quality control during the cruise.

Table 4-2 MCS log

LINE NAME	DATE (UTC)	TIME (UTC)	F.S.P. F.G.S.P. L.G.S.P. L.S.P.	VESSEL POSITION Lat.	VESSEL POSITION Lon.	Depth (m)	NUMBER OF SHOT FGSP - LGSP (SP# Increment)	LENGTH FGSP - LGSP (km)	DIRECTION (°)	Mode (m)
A4p4 (MCS)	17/06/2017	09:44:56	881	33_04.14990'N	144_03.07332'E	7203	1021	51.0	102.8	Distance (50m)
	17/06/2017	09:44:56	881	33_04.14990'N	144_03.07332'E	7203				
	17/06/2017	17:17:54	1901	37_58.83936'N	144_37.26918'E	5692				
	17/06/2017	17:17:54	1901	37_58.83936'N	144_37.26918'E	5692	(+1)			
A4p4 (OBS)	12/06/2017	04:35:37	1101	38_03.01350'N	144_10.45464'E	6537	983	98.2	102.8	Distance (100m)
	12/06/2017	04:35:37	1101	38_03.01350'N	144_10.45464'E	6537				
	12/06/2017	17:44:23	3065	37_52.56552'N	145_16.19430'E	5488				
	12/06/2017	17:44:23	3065	37_52.56552'N	145_16.19430'E	5488	(+2)			
D09e	16/06/2017	17:30:38	3127	38_04.75866'N	145_07.26960'E	5361	1758	87.9	279.1	Distance (50m)
	16/06/2017	17:43:10	3099	38_04.90662'N	145_06.33066'E	5380				
	17/06/2017	05:48:23	1342	38_14.20998'N	144_07.35618'E	7065				
	-	-	1341	-	-	-	(-1)			
D11e	16/06/2017	01:12:18	881	38_27.11970'N	143_54.70848'E	6191	2187	109.3	99.1	Distance (50m)
	16/06/2017	01:12:18	881	38_27.11970'N	143_54.70848'E	6191				
	16/06/2017	14:18:21	3067	38_15.59400'N	145_08.29776'E	5330				
	16/06/2017	14:18:21	3067	38_15.59400'N	145_08.29776'E	5330	(+1)			
D13e	06/06/2017	11:59:55	3328	38_21.77376'N	145_18.74232'E	5320	2448	122.4	279.6	Distance (50m)
	06/06/2017	11:59:55	3328	38_21.77376'N	145_18.74232'E	5320				
	07/06/2017	02:17:14	881	38_35.34492'N	143_56.40408'E	6509				
	07/06/2017	02:17:14	881	38_35.34492'N	143_56.40408'E	6509	(-1)			
D15e	04/06/2017	22:12:18	1051	38_42.16632'N	144_04.37388'E	7282	1287	64.3	99.1	Distance (50m)
	04/06/2017	22:12:18	1051	38_42.16632'N	144_04.37388'E	7282				
	05/06/2017	06:52:56	2337	38_35.39742'N	144_47.84472'E	5526				
	-	-	2338	-	-	-	(+1)			
D17e	31/05/2017	02:32:49	3400	38_40.22562'N	136_26.22168'E	5559	2580	129.0	279.0	Distance (50m)
	31/05/2017	02:32:49	3400	38_40.22562'N	136_26.22168'E	5559				
	31/05/2017	17:41:47	821	38_53.96652'N	143_58.92828'E	5825				
	31/05/2017	17:41:47	821	38_53.96652'N	143_58.92828'E	5825	(-1)			
					Total		12264	662.0		

Onboard data processing flow is shown in Fig. 4-2.

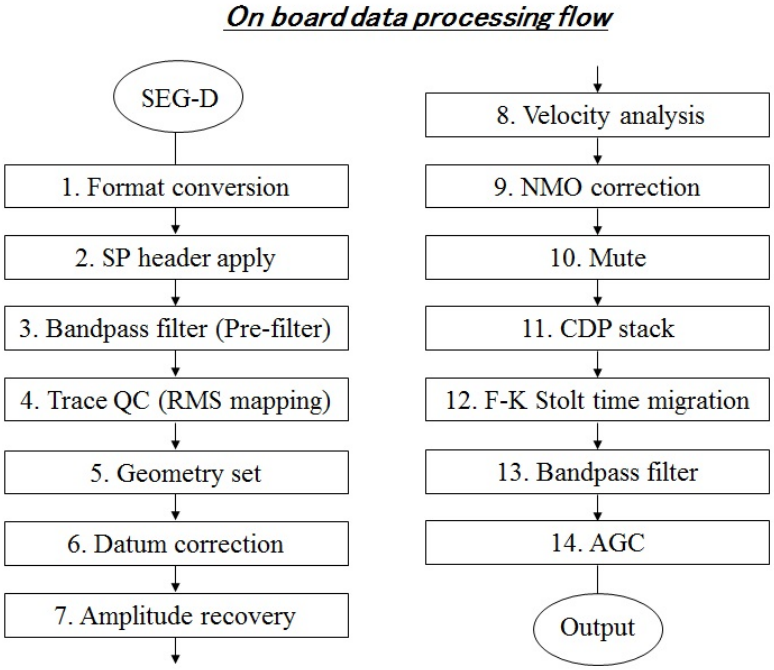

Fig. 4-2 Bathymetric chart

We imported the raw data (SEG-D) and navigation data (UKOOA) to SeisSpace, then applied a conventional data processing flow to the seismic reflection data. We checked the data quality using RMS mapping of traces, and applied datum correction, amplitude recovery, velocity analysis, normal moveout correction, muting, common depth point stacking, time migration, band-pass filter, and automatic gain control.

(2)Seismic profile

Fig. 4-3 shows one of the results of the onboard data processing. Interpretation will be performed afterwards.

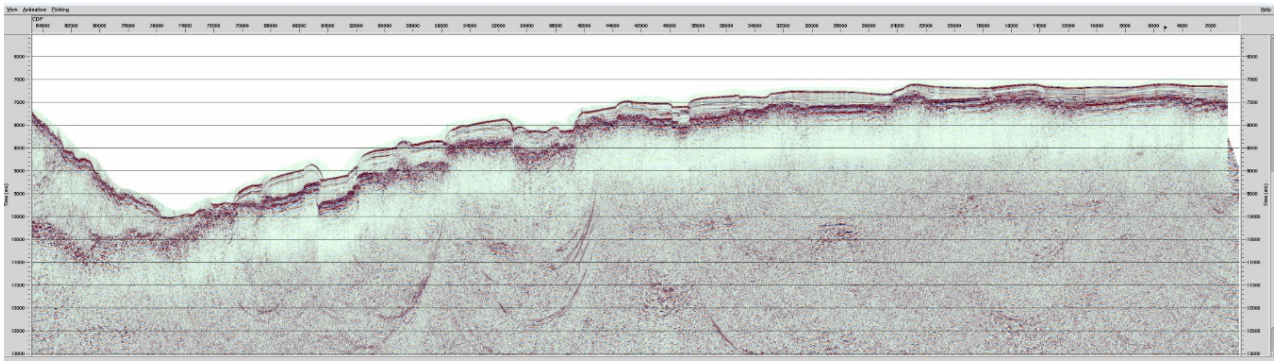

Fig. 4-3 Line D17e MCS

4-3. OBS observation

Table 4-3 shows lositions of OBS deployment. Each OBS location was determined by SSBL system after deployment during leg1. Air gun shooting with a shot spacing of 100 m was conducted during Leg 2 and finally all OBSs were retrieved.

Table 4-3 OBS lositions

Type	Site	Lat(S)	Lon(E)	Depth(m)	Type	Site	Lat(S)	Lon(E)	Depth(m)
2G-UD	1	38_02.2445	144_17.1192	6283	K	21	37_57.7595	144_43.9392	5571
2G-UD	2	38_01.9850	144_18.5876	6244	K	22	37_57.5406	144_45.2592	5516
2G-UD	3	38_01.8272	144_19.7722	6256	K	23	37_57.3029	144_46.5730	5505
2G-UD	4	38_01.5617	144_21.0606	6159	K	24	37_57.0909	144_47.9412	5538
K	5	38_01.3713	144_22.3933	5990	K	25	37_56.8907	144_49.1800	5503
K	6	38_01.1010	144_23.7586	5984	K	26	37_56.6445	144_50.6653	5460
K	7	38_00.8824	144_25.0323	5967	K	27	37_56.3832	144_51.9677	5469
K	8	38_00.7290	144_26.3593	5928	K	28	37_56.1811	144_53.3336	5456
K	9	38_00.4186	144_27.7349	5867	K	29	37_55.9358	144_54.6751	5461
K	10	38_00.2459	144_29.1122	5867	K	30	37_55.7383	144_55.9872	5440
K	11	38_00.0265	144_30.4967	5969	K	31	37_55.4945	144_57.3047	5505
K	12	37_59.8740	144_32.0225	5891	K	32	37_55.3671	144_58.6554	5491
K	13	37_59.5731	144_33.1601	5832	K	33	37_55.1336	144_59.9920	5414
K	14	37_59.4423	144_34.8287	5723	K	34	37_54.5430	145_01.5400	5436
K	15	37_59.1790	144_35.9207	5709	K	35	37_54.6499	145_02.6817	5402
K	16	37_58.9654	144_37.2419	5715	K	36	37_54.4891	145_04.0685	5446
K	17	37_58.6965	144_38.5805	5663	K	37	37_54.2740	145_05.3410	5435
K	18	37_58.3491	144_40.0950	5632	K	38	37_54.0538	145_06.6989	5427
K	19	37_58.1765	144_41.2761	5645	K	39	37_53.8100	145_08.0040	5438
K	20	37_57.9719	144_42.5801	5599	K	40	37_53.6172	145_09.3563	5443
					K:Katsujima				

4-4. GPS-Acoustic survey

Throughout the cruise, GNSS data of the main antenna and baselines to the three sub antennas were recorded at 2Hz with two GPS receivers, as well as vessel attitude (heading, roll, pitch, heave) were obtained at 20Hz through both the LAN connection and direct serial output. In addition, high-resolution GNSS NMEA output from Fugro's StarPack system at 1Hz were also recorded during 2017-06-18 15:34:50-17:13:43 (JST) for comparison. Preliminary results are as follows.

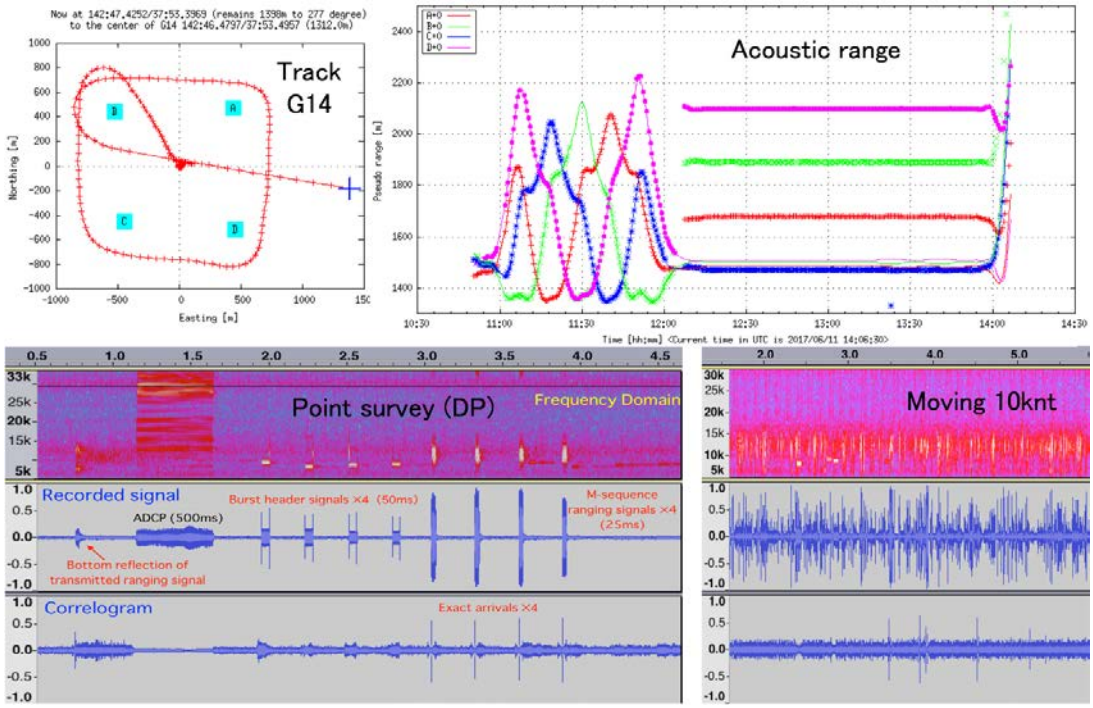

Fig. 4-4 Ship track, acoustic ranges to seafloor transponders, and raw/correlogram waveforms to assess the S/N level during the GPS-A survey at G14.

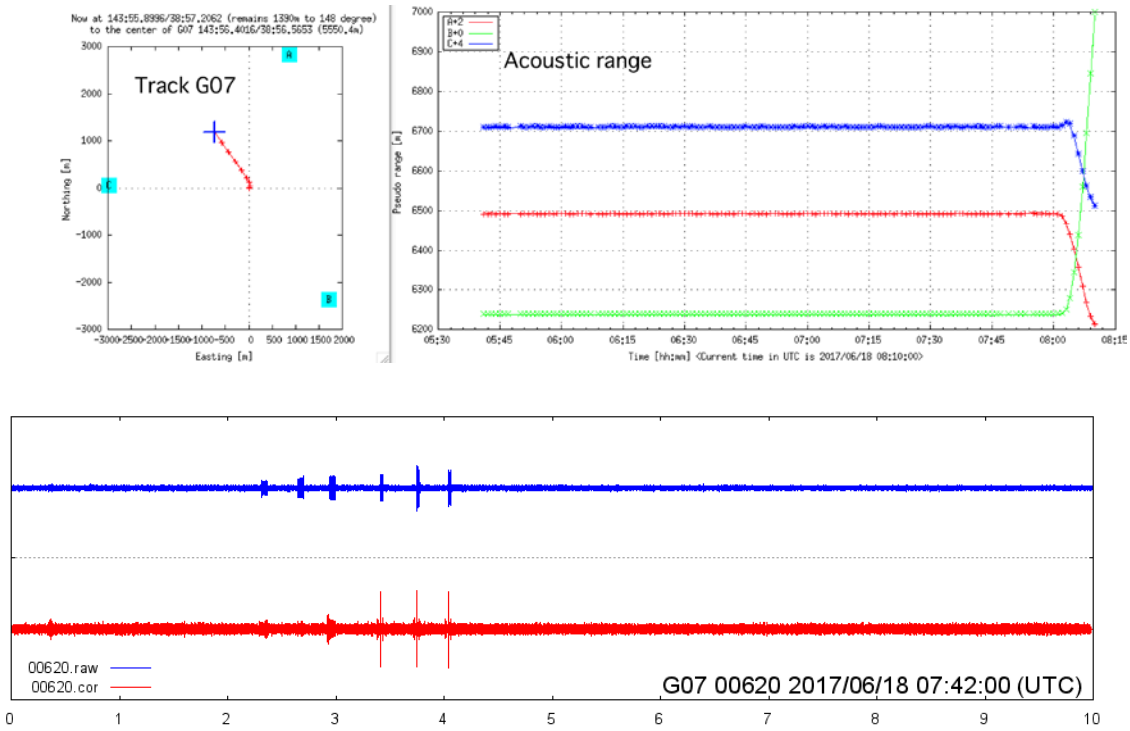

Fig. 4-6 Ship track, acoustic ranges to seafloor transponders, and raw/correlogram waveforms to assess the operation software demonstration during the GPS-A survey at G11.

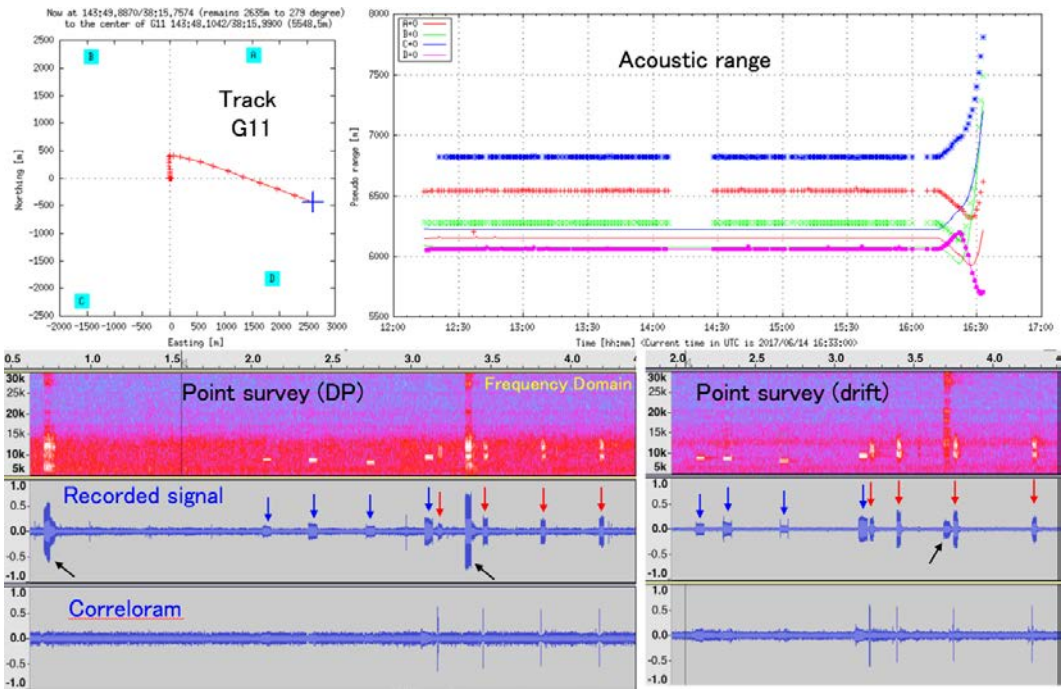

Fig. 4-5 Ship track, acoustic ranges to seafloor transponders, and raw/correlogram waveforms to assess the S/N level during the GPS-A survey at G11.

5. Acknowledgement

We thank Captain YOSHIDA Rikita, crew and technical staffs of our experiments conducted during the KM17-05 cruise, for their kind and thoughtful supports during the cruise.

※ Notice on using

This cruise report is a preliminary documentation as of the end of the cruise.

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Users of data or results on this cruise report are requested to submit their results to the Data Integration and Analysis Group (DIAG) of JAMSTEC.