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R/V Kairei Cruise Report
KR16-08

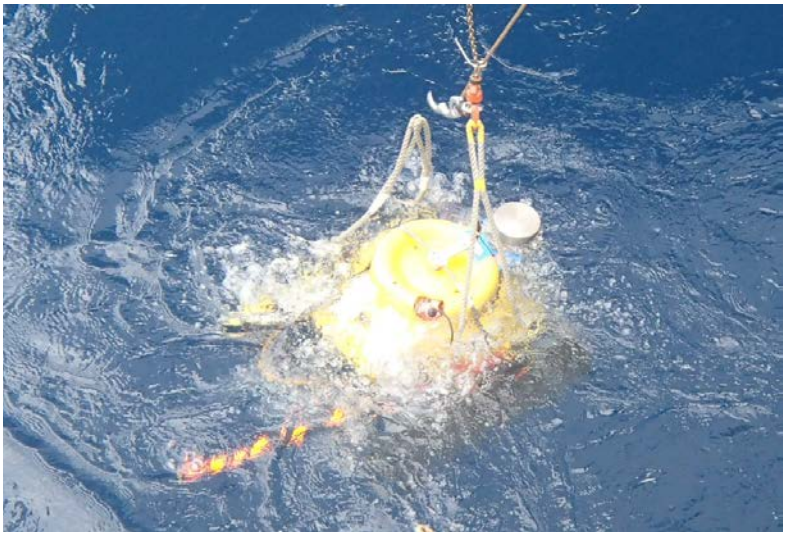
2016FY "Integrated Research Project on Seismic and Tsunami Hazards Around the Sea of Japan"

Japan Sea

Jul. 26, 2016 – Aug. 13, 2016

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Contents:



1. Cruise Information:

(1) Cruise ID, Ship name: KR16-08, R/V *KAIREI*

(2) Title of the cruise: 2016FY "Integrated Research Project on Seismic and Tsunami Hazards Around the Sea of Japan"

(3) Title of proposal: Integrated Research Project on Seismic and Tsunami Hazards Around the Sea of Japan

(4) Cruise period, Port call: 2016/7/26 – 2016/8/13, Yokosuka (JAMSTEC) to Yokosuka (Sumitomo Heavy Industry East dock)

(5) Research Area: Japan Sea

(6) Research Map: Fig. 1

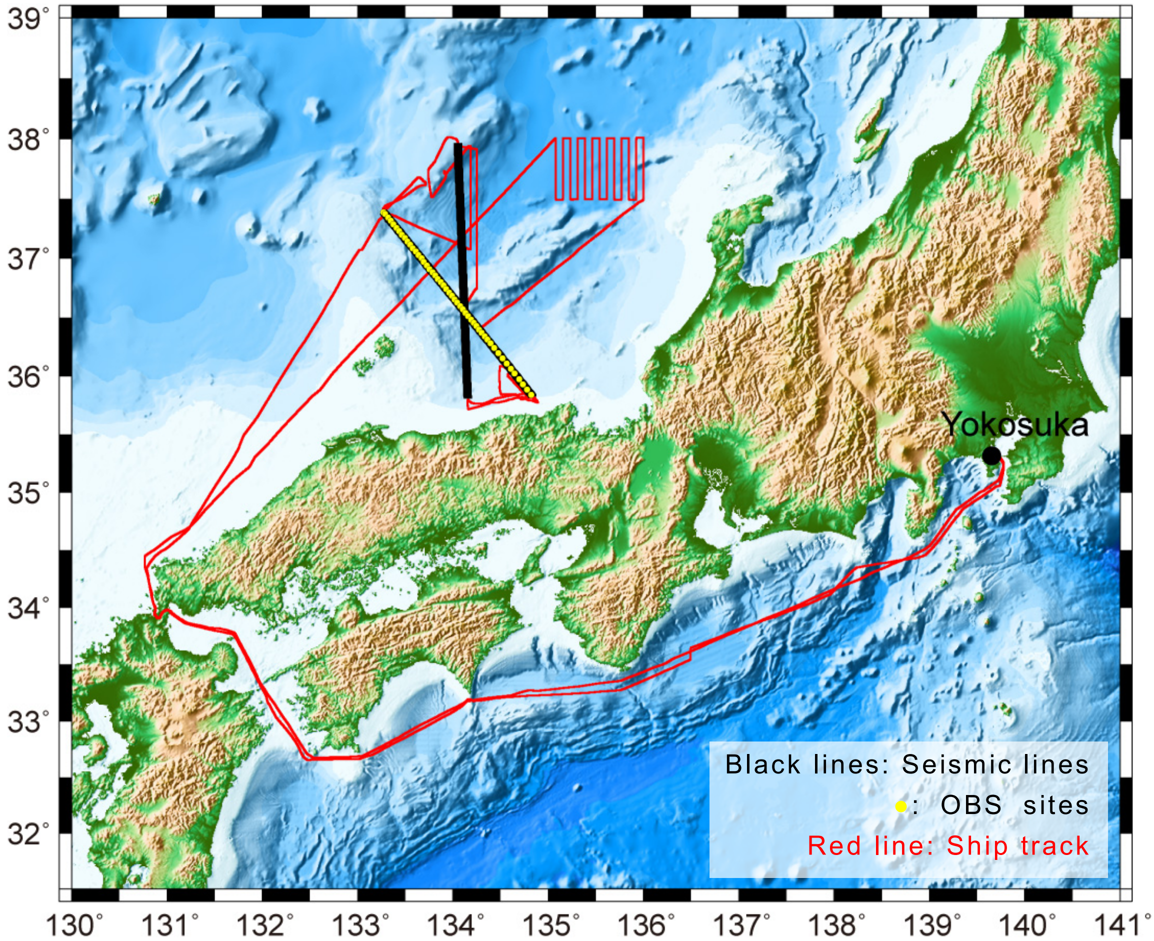


Fig. 1: Ship track during KR16-08 cruise.

2. Researchers and Crews:

(1) Chief Scientists [Affiliation]:
Takeshi SATO [JAMSTEC]

(2) Representative of Science Party [Affiliation]:
Shuichi KODAIRA [JAMSTEC]

(3) KR15-11 Shipboard Science Party:
Takeshi SATO [JAMSTEC]: Chief Scientist
Tetsuo NO [JAMSTEC]: Vice-chief Scientist
Seiichi MORI [Nippon Marine Enterprises, Ltd. (NME)]: Chief marine technician
Kaoru TSUKUDA [NME]: Marine technician
Yuta WATARAI [NME]: Marine technician
Kyoko TANAKA [NME]: Marine technician
Keita SUZUKI [NME]: Marine technician
Akie SUZUKI [NME]: Marine technician
Ryo MIURA [NME]: Marine technician
Kimiko SERIZAWA [NME]: Marine technician
Eri SAKAMOTO [NME]: Marine technician
Toshinori SAIJO [NME]: Marine technician
Tatsuya SUGIYAMA [NME]: Marine technician

(4) R/V *KAIREI* Crews:
Captain: Yoshiyuki NAKAMURA
Chief Officer: Hiroyuki KATO
1st Officer: Yasuhiko SAMMORI
2nd Officer: Yuki FURUKAWA
3rd Officer: Yoshihiro OGAWA
Jr.3rd Officer: Akihiro NUNOME
Chief Engineer: Eiji SAKAGUCHI
1st Engineer: Wataru KUROSE
2nd Engineer: Katsuto YAMAGUCHI
3rd Engineer: Yoichi YASUE
Chief Electronics Operator: Masamoto TAKAHASHI
2nd Electronics Operator: Takayuki MABARA
3rd Electronics Operator: Emi SAWAYANAGI
Jr.3rd Electronics Operator: Ryosuke MATSUI
Boat Swain: Tadahiko TOGUCHI
Able Seaman: Nobuyuki ICHIKAWA
Able Seaman: Norihiko NAKAMURA
Able Seaman: Naoki IWASAKI
Able Seaman: Yoshiaki MATSUO
Able Seaman: Jun SHINODA
Sailor: Yuta MOTOOKA
Sailor: Takumi MIURA

No.1 Oiler: Kozo MIURA
Oiler: Masayuki FUJIWARA
Oiler: Masaki TANAKA
Oiler: Daiki SATO
Assistant Oiler: Atsumu HARA
Assistant Oiler: Koshi NAKAJIMA
Chief Steward: Tatsunari ONOUE
Steward: Toru MURAKAMI
Steward: Jun SATO
Steward: Koichiro KASHIWAGI
Steward: Reon SUTO

3. Overview of Observation:

(1) Objective:

The relationship between crustal structures and earthquakes that occurred along the eastern margin of the Japan Sea has been revealed recently by seismic survey as part of the research project "Multidisciplinary research project for construction of fault model in the high strain rate zone" (Sato et al., 2014; No et al., 2014). However, because other areas in the Japan Sea have not yet been conducted to seismic survey for study of the crustal structure, we do not have information about this relationship. Therefore, we have participated in "Integrated Research Project on Seismic and Tsunami Hazards Around the Sea of Japan" conducted by the MEXT of Japan. In particular, we have performed seismic surveys from the R/V *KAIREI* in the Japan Sea since 2014.

From July to August 2016, we conducted a marine seismic survey using multi-channel seismic reflection (MCS) system and ocean bottom seismographs (OBSs) to study the crustal structure around the area from off Kyoto to off Tottori. The survey covered the areas from the continental shelf to the Oki Bank, the Yamato Basin. Using an improved seismic acquisition technology for deep seismic imaging, we are able to obtain data so as to clarify the detail crustal structure such as those presented by No et al. (2014) and Sato et al. (2014) for the eastern Japan Sea. Therefore, we will clarify more detail crustal structure than that reported previously by Ludwig et al. (1975), Katao (1988), and Hirata et al. (1989) in this area. This obtained data is important for studies of seismotectonics in the survey area and for understanding of the formation process of the Japan Sea.

(2) **List of observation instruments:**

1) Multichannel seismic reflection (MCS) survey

We used a multichannel seismic reflection (MCS) system of the R/V *KAIREI* (Miura, 2009) (Fig. 2). MCS data were acquired along 2 lines (SJ16HY and SJ16TR lines) with a total length of approximately 440 km. Some seismic lines were crooked to avoid the fishing operations and equipment in the survey area.

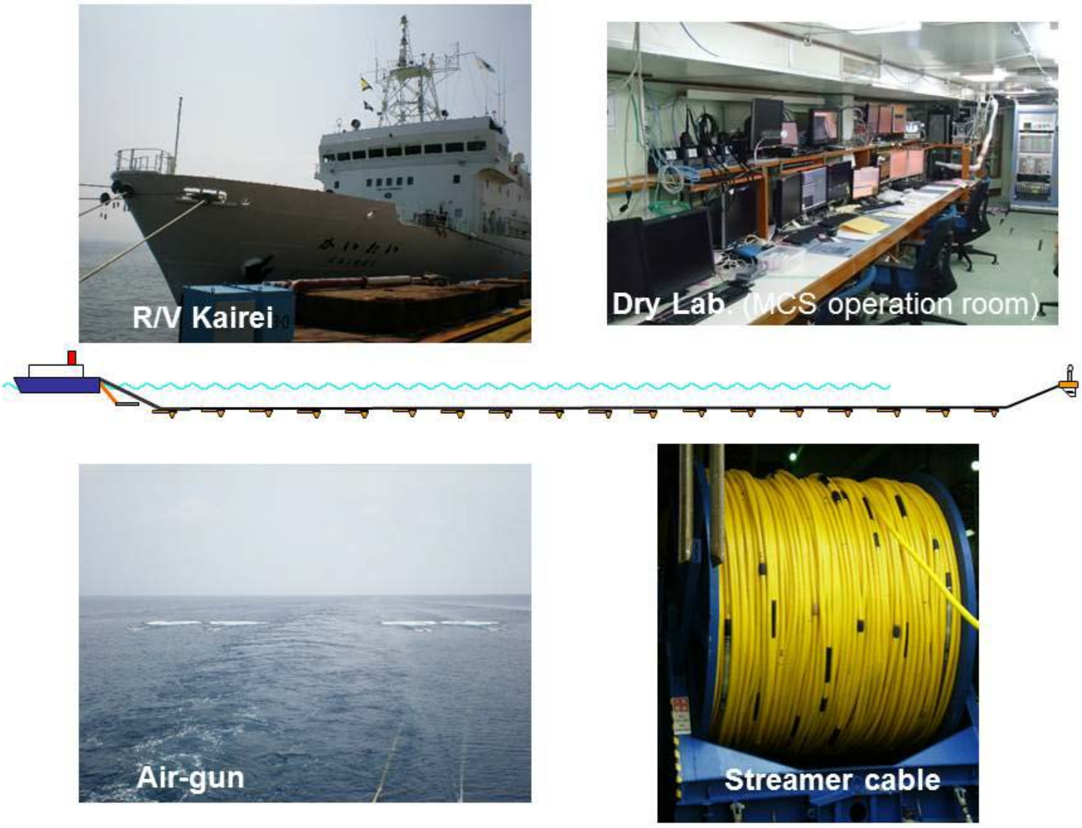


Fig. 2: MCS system on R/V *KAIREI*.

a) Source:

To obtain high-quality MCS data, we shot an air gun array at a spacing of 50 m, which corresponds to a spacing of 20 to 30 s depending on the vessel speed (average of 4.5 knot). The tuned airgun array has a maximum total capacity of 7,800 cubic inches (about 130 liters), and consists of 32 Bolt Annular Port airguns. The standard air pressure was 2,000 psi (about 14 MPa). During the MCS survey, the depth of the airgun array was kept at 10 m below the sea surface. Fig. 3 shows four strings of sub-arrays deployed at the port and starboard sides of the vessel. Their width was expanded to 45 m by a paravane system, and the central position of the array was set 203 m behind that of the ship's antenna.

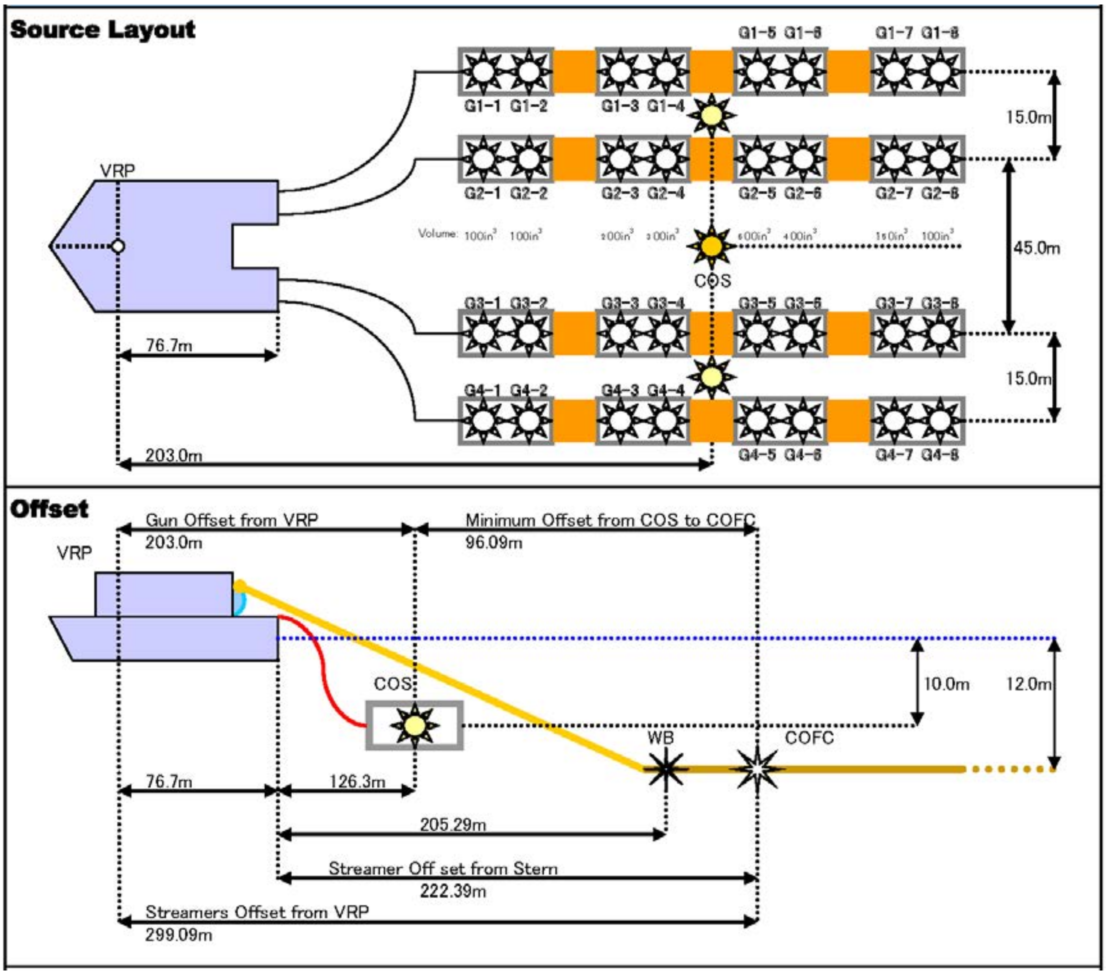


Fig. 3: Vessel towing geometry during the MCS survey. Top figure shows the source (airgun system) layout, bottom figure represents source–receiver depth and position, and navigation offsets.

b) Receiver:

During airgun shooting, we towed a 444-channel hydrophone streamer cable with a group interval of 12.5 m (Sentinel Digital Streamer System, Sercel Inc.) (Fig. 4). Hydrophone sensors (Benthos Reduced Diameter Array hydrophone) with a sensitivity of 19.7 V/Bar were used. The signals from eight sensors in the same group (channel) were stacked before A/D conversion. The interval of each group is 12.5 m. The length of the cable was about 6 km. The towing depth of the streamer cable was kept at 12 m below the sea surface by the depth controller called Bird (I/O DigiCOURSE streamer depth controllers).

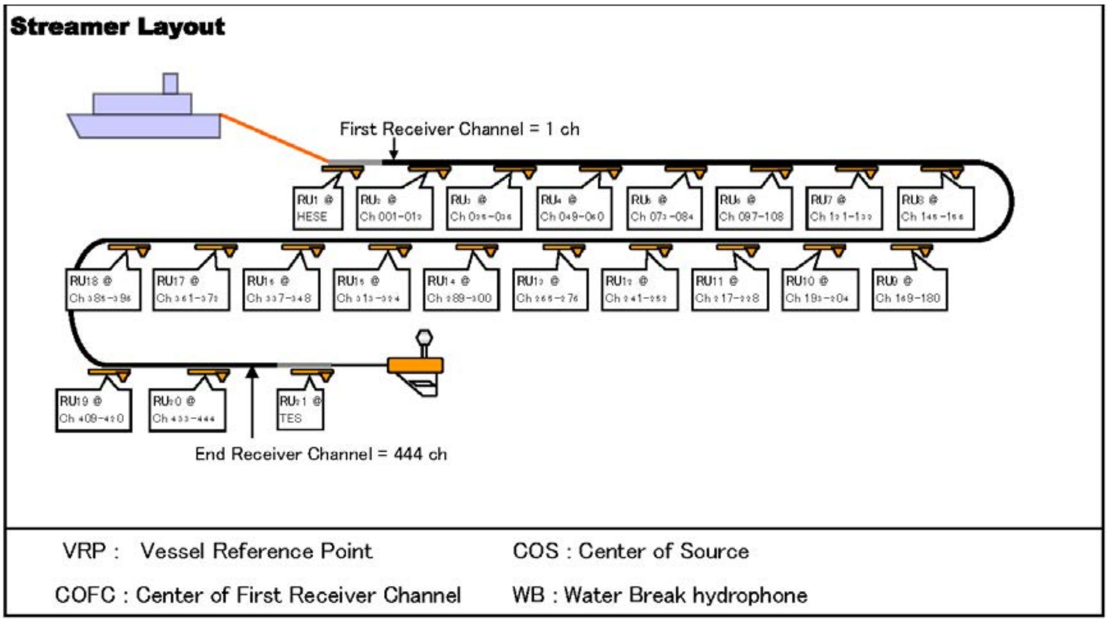


Fig. 4: Streamer cable configuration during the MCS survey.

c) Recording and navigation systems

A Sercel Seal System Ver.5.2 recording system, made by Sercel Inc., was used in the survey; this collected seismic data on LTO tape in the SEG-D 8058 Rev.1 format. The system delay was set to 200 ms, the sampling rate was 2 ms, and the recording length was 16 s.

The Differential Global Positioning System (DGPS) was used for positioning. We adopted NAVCOM's StarFire as the main positioning system, and used Fugro's StarFix as the backup. The accuracy was reported to be about 0.4 m in StarFire and 0.2 m in StarFix. We used SPECTRA 2D (Concept Systems Ltd.) as our navigation software for the seismic data acquisition. Positioning data collected from both StarFire and StarFix were sent to the Power Real Time Navigation Unit (PowerRTNU) (Concept Systems Ltd.) via a terminal server connected to a LAN in the vessel. Shot times and shot points (SPs) were set on SPECTRA, and then a trigger signal was sent to the recording system and the gun controller (ION DigiSHOT Ver.3.1). The main navigation parameters were as follows: survey datum was WGS84; map projection was UTM; UTM zone parameter was 53N.

d) Onboard processing of MCS data:

Raw MCS reflection data were processed on board for the purpose of quality control in the study areas. Onboard data processing was conducted in the conventional processing sequence, which includes trace header edit, trace edit, common midpoint (CMP) binning with an interval of 6.25 m, a bandpass filter, datum correction, amplitude compensation, predictive deconvolution, velocity analysis, normal moveout correction, multiple suppression, mute, CMP stack, F-K migration, and a bandpass filter (Figs. 5 and 6).

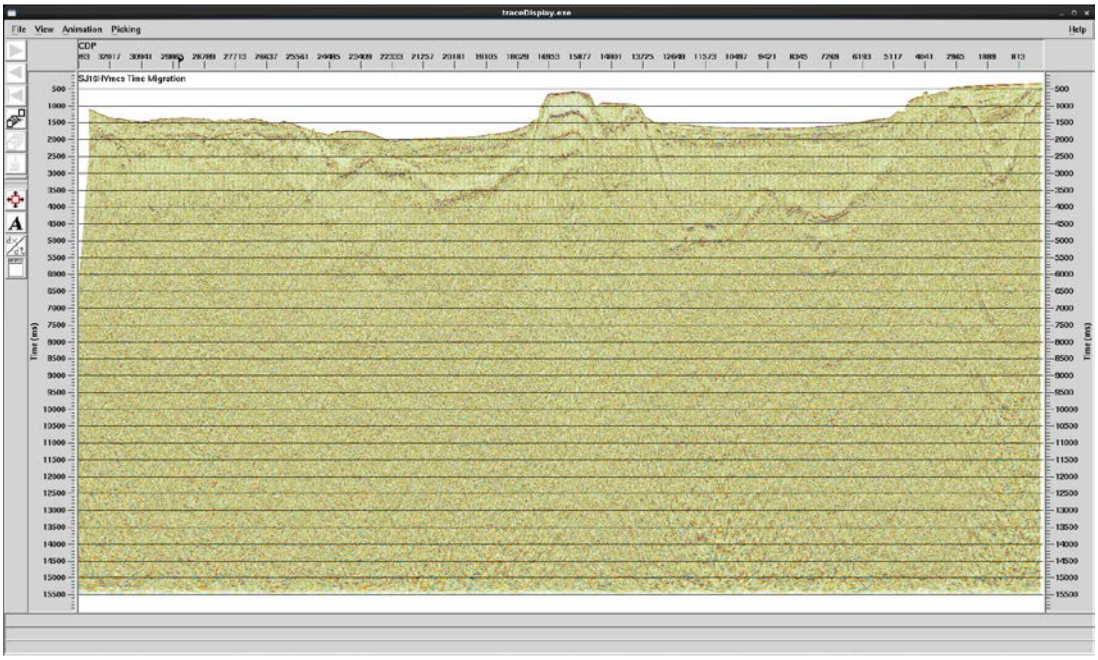


Fig. 5: Example of MCS profile with onboard processing (SJ16HY line).

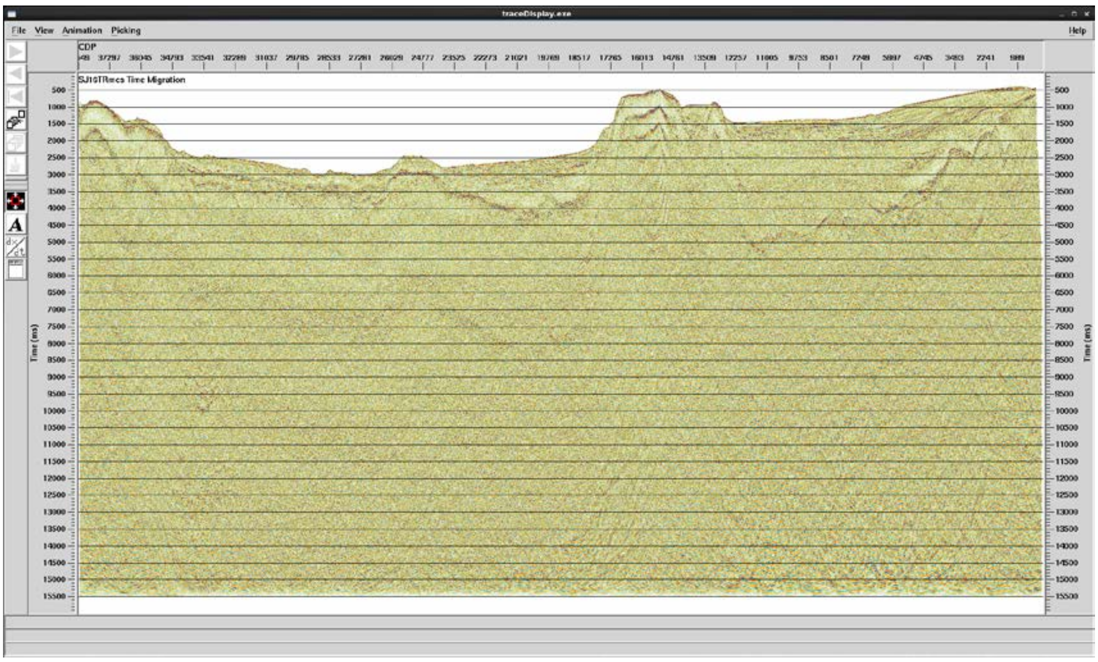


Fig. 6: Example of MCS profile with onboard processing (SJ16TR line).

2) Seismic refraction survey using OBSs

We deployed 50 OBSs along the SJ16HY line. The seismic refraction survey was performed on the SJ16HY line using OBSs and an airgun array with a shot spacing of 200 m. The airgun array in the seismic refraction survey was placed in almost the same configuration as that in the MCS survey, although the width was expanded to 45.0 m by a paravane system, and the central position of the array was set 203 m behind the ship's antenna (Fig. 7). Each OBS was equipped with three-component geophones with gimbal-leveling mechanisms, a natural frequency of 4.5 Hz, and a hydrophone sensor (Kaneda et al., 2005) (Table 1). The airgun signals were recorded by the OBSs with a sampling rate of 200 Hz.

For 50 OBSs deployed, 42 OBSs (Site1-42) were retrieved by *KAIREI*. Other 8 OBSs (Site43-50) were retrieved by other vessel (*R/V KAIYO MARU NO.1)* and ROV (*ROV KAIYO 3000*). The position at the sea bottom of each OBS was determined using the super short baseline acoustic positioning system (SSBL) of the R/V *KAIREI*. On the other hand, the position of 8 OBS (Site43-50) was determined through acoustic measurement of distances between the OBS and vessel from 3 points. Moreover, calibration of the OBS clock to GPS time was performed using the time difference between the OBS clock and GPS time, which was measured just before OBS deployment and just after OBS retrieval. Fig. 8 shows examples of the record section for OBSs (Site21 and 38).

Type	TOBS-24N, TOKYO SOKUSHIN CO., LTD.
Maximum Depth	6,700 m
Sensor	Three-component Geophone & Hydrophone [One vertical and two horizontal components, Natural frequency: 4.5Hz, Sensitivity:0.41V/cm/s (OPEN)]
Recording System	Sampling continuously (Timer control is possible for start time). Pre Amplifier Gain(40/40/40/20 dB)
Recording Media	Hard disk
Sampling Rate	24 bit, 200Hz
Power	Lithium battery
Acoustic Communication & Release System	Electric corrosion method
Attached Parts	Weight, Flush light, Radio beacon
Pressure Resistant Container	17 inch glass sphere

Table 1: OBS specifications of seismic refraction survey.

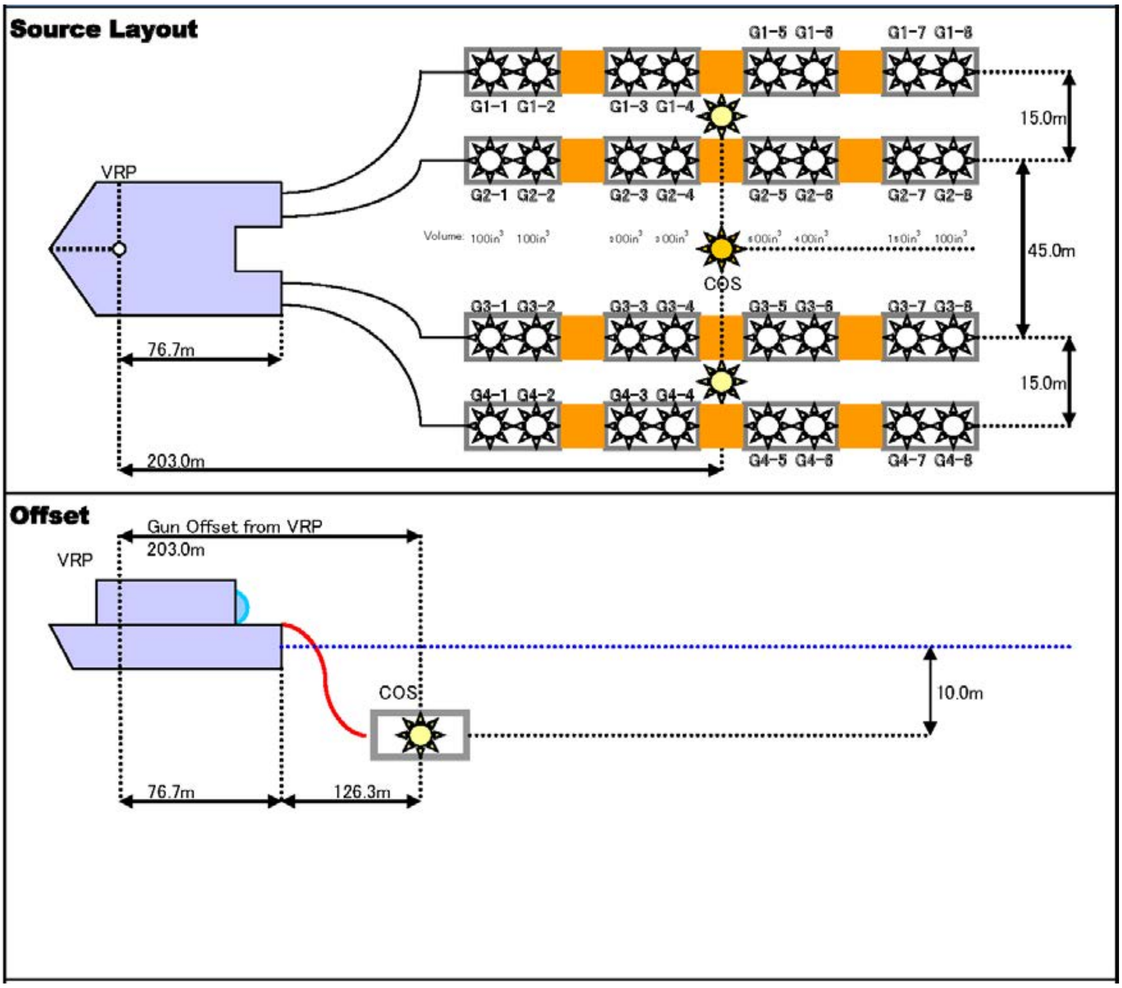
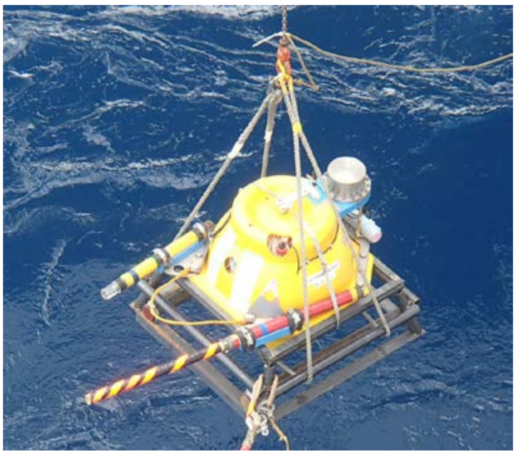
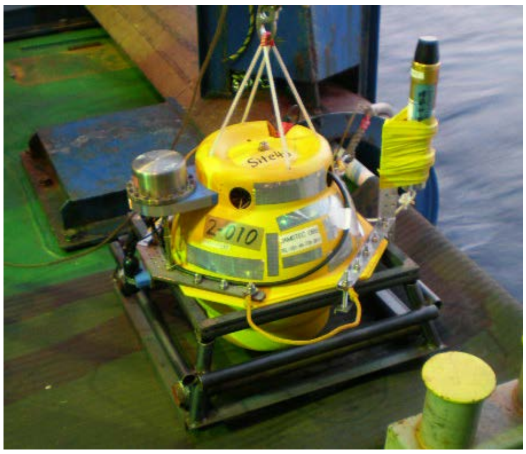
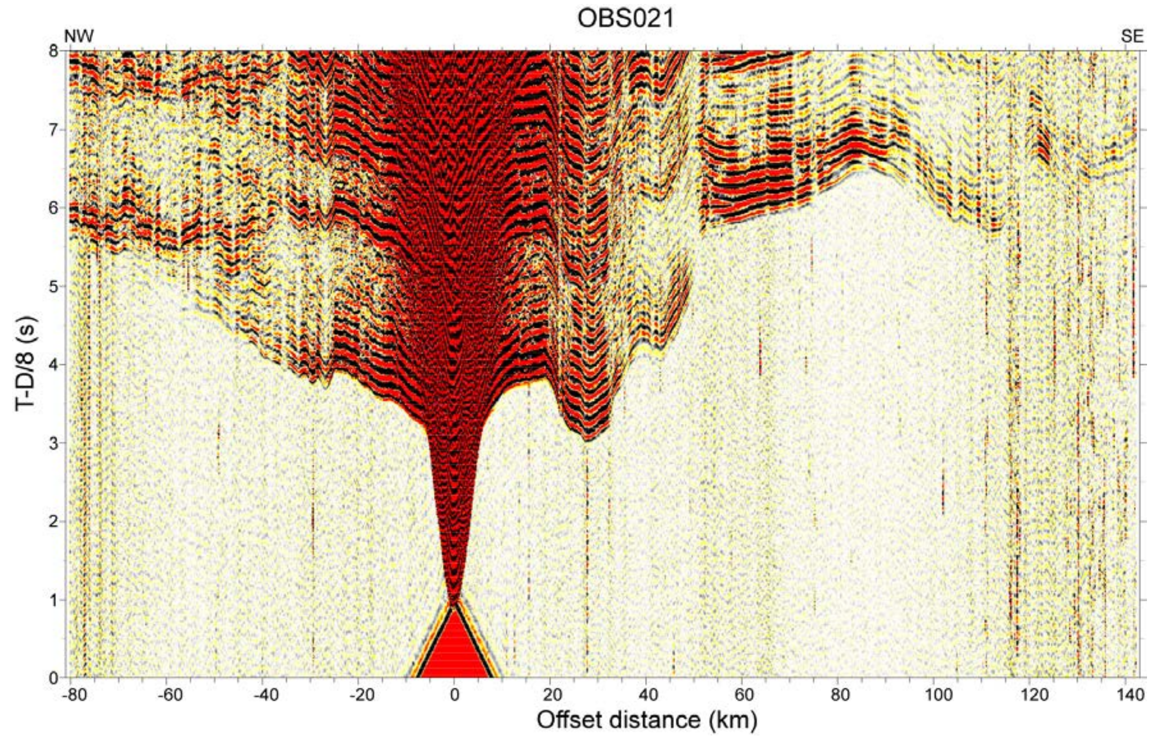


Fig. 7: Vessel towing geometry during the seismic refraction survey on the SJ16HY line. Top figure shows the source (airgun system) layout, bottom figure represents source depth and position, and navigation offsets.







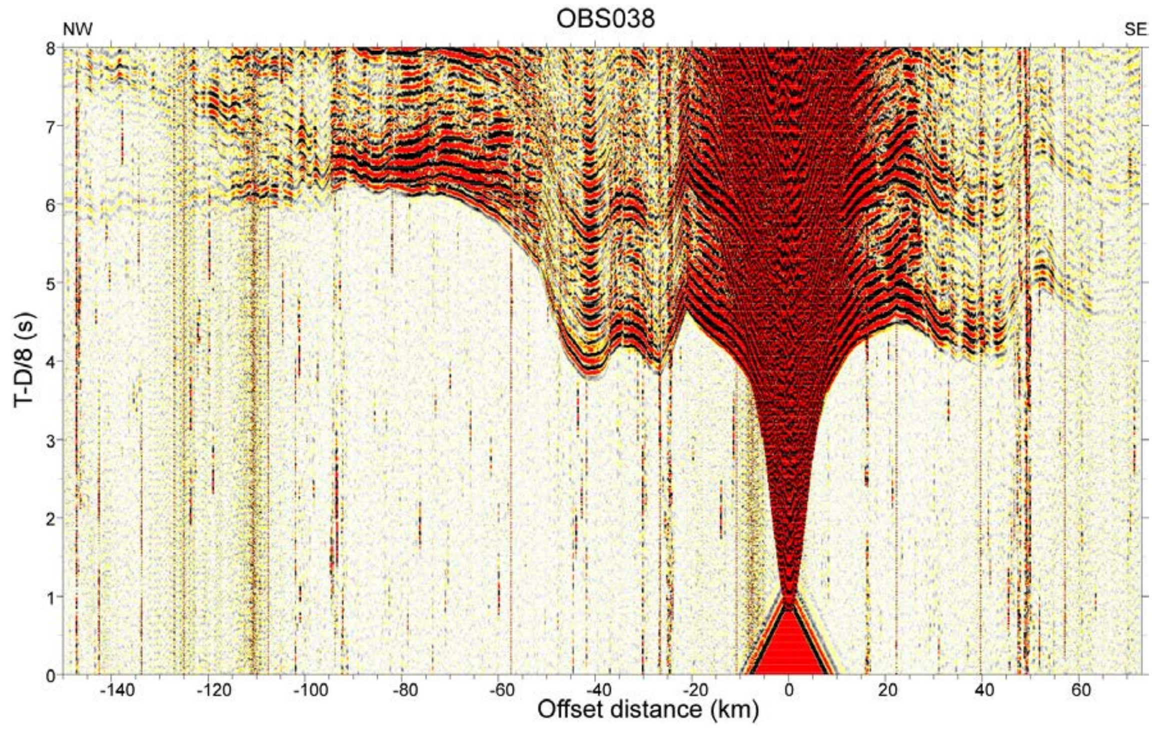


Fig. 8 Examples of record sections for OBSs (Site21 and 38).

3) Bathymetry, geomagnetic, and gravity observations:

Bathymetry, geomagnetic, and gravity data were recorded continuously during the survey. The bathymetry survey on the R/V *KAIREI* used a multi-narrow beam echo sounder (Sea Beam 3012, SeaBeam Instruments) (Fig. 9). Gravity data was obtained by a shipboard gravimeter (Marine Gravity System 6 (MGS-6), Micro-g LaCoste). The geomagnetic survey used a three-component magnetometer (SFG-1214, Tierra Tecnica Corporation).

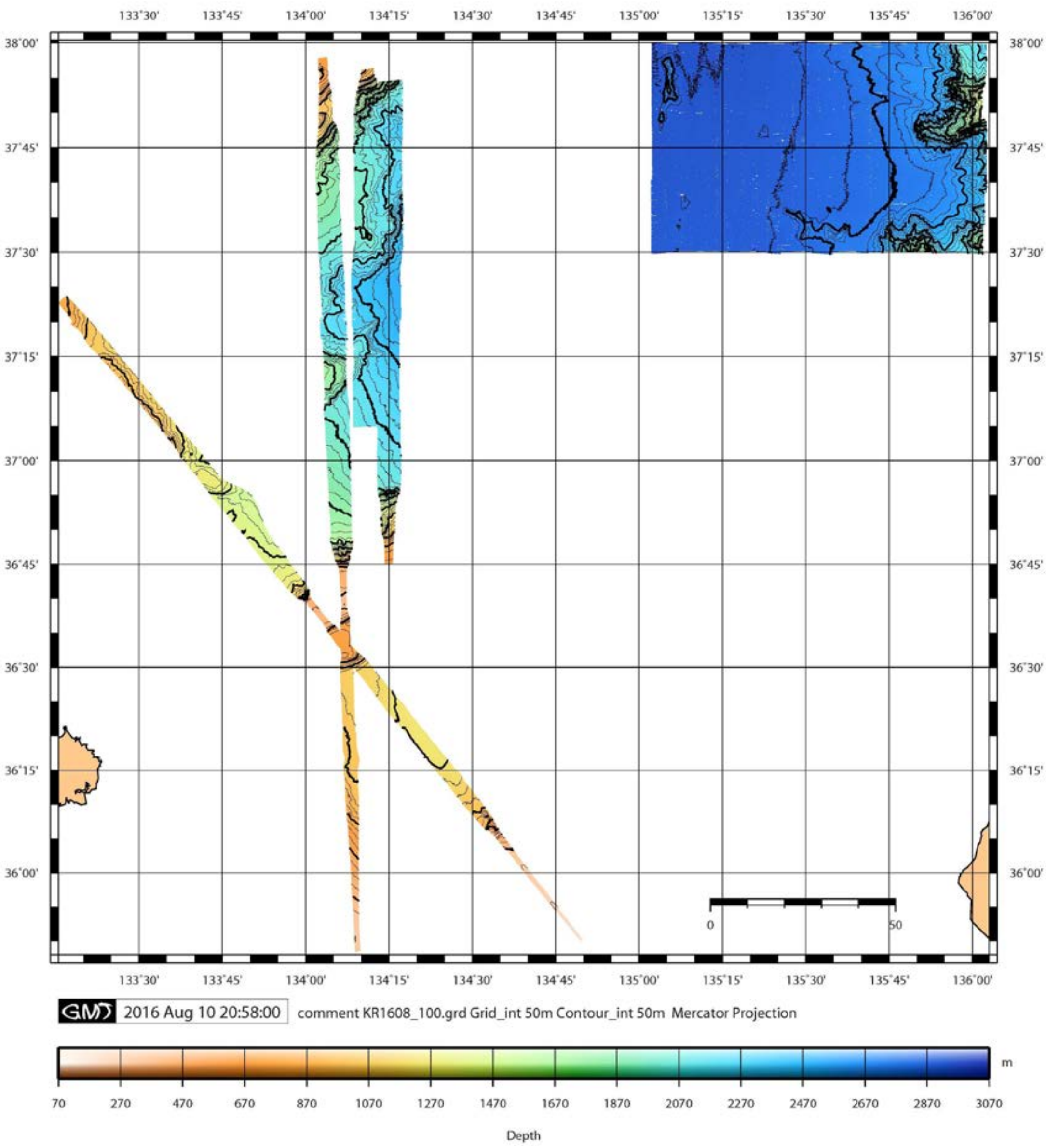


Fig. 9: Result of the bathymetry survey.

(3) Cruise log: Table 2

Date		Remarks
2016/7/26	Tue	Departure from JAMSTEC (Yokosuka), and transit to the survey area
2016/7/27	Wed	Transit to the survey area and evacuation drill
2016/7/28	Thu	Transit to the survey area and OBS deployment
2016/7/29	Fri	OBS deployment
2016/7/30	Sat	OBS deployment, check survey about tackle, and bathymetry survey
2016/7/31	Sun	Bathymetry survey and check survey about tackle,
2016/8/1	Mon	Seismic refraction survey (SJ16HY, 200 m shot interval)
2016/8/2	Tue	Seismic refraction survey (SJ16HY, 200 m shot interval) and MCS survey (SJ16HY, 50 m shot interval)
2016/8/3	Wed	MCS survey (SJ16HY, 50 m shot interval)
2016/8/4	Thu	MCS survey (SJ16TR, 50 m shot interval)
2016/8/5	Fri	MCS survey (SJ16TR, 50 m shot interval) and bathymetry survey
2016/8/6	Sat	Bathymetry survey and OBS retrieval
2016/8/7	Sun	OBS retrieval
2016/8/8	Mon	Bathymetry survey
2016/8/9	Tue	Bathymetry survey
2016/8/10	Wed	Bathymetry survey and transit to Yokosuka
2016/8/11	Thu	Transit to Yokosuka
2016/8/12	Fri	Transit to Yokosuka
2016/8/13	Sat	Arrival at Sumitomo Heavy Industry East dock (Yokosuka)

Table 2: Cruise log.

(4) Seismic lines : Fig. 10

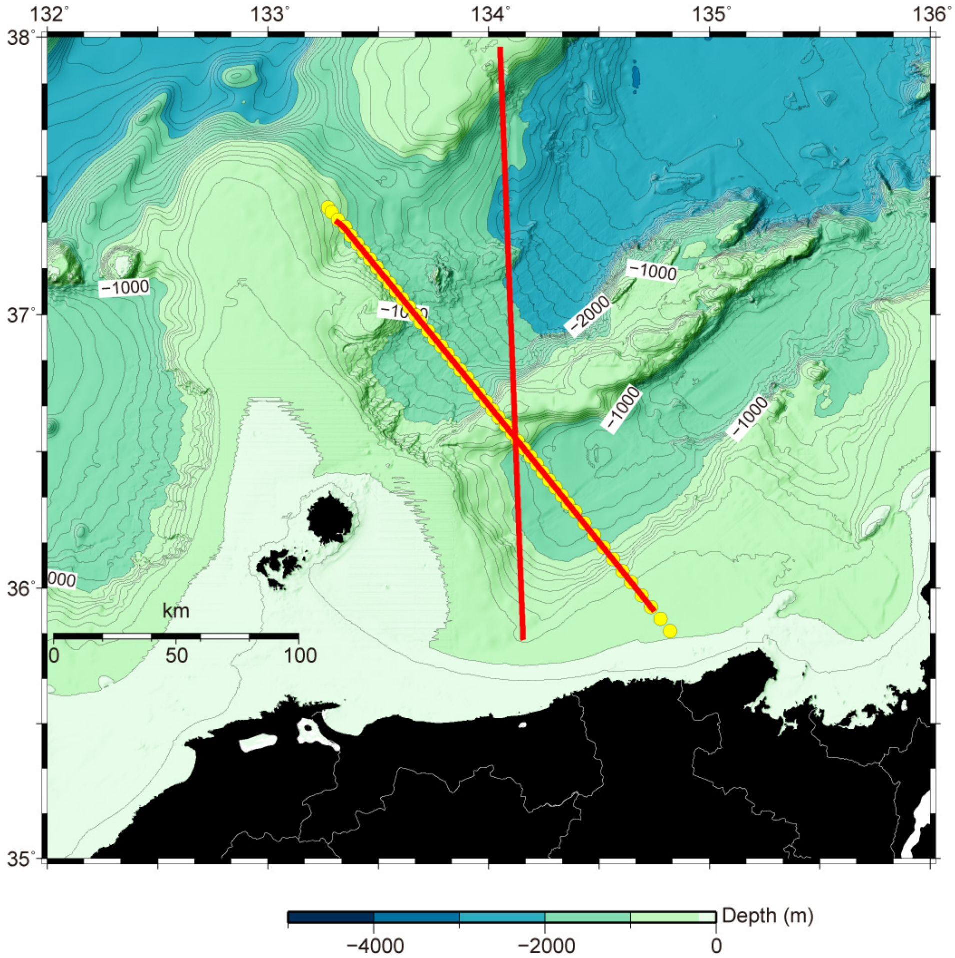


Fig. 10: Map of the bathymetry around the survey area and seismic survey lines in this cruise. Red lines and yellow circles show the MCS lines and positions of deployed OBSs, respectively.

(5) **Seismic line list:** Table 3

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)	LENGTH FGSP - LGSP (km)	DIRECTION (°)	Mode (m)
SJ16HY mcs_0	02/08/2016	08:04:21	5650	37_20.41190'N	133_18.33943'E	834	200.4	141.585	Distance (50.0m)
	02/08/2016	08:36:00	5574	37_19.13031'N	133_20.43887'E	988			
	03/08/2016	07:00:10	1566	35_54.89720'N	134_45.05550'E	242			
	03/08/2016	07:00:10	1566	35_54.89720'N	134_45.05550'E	242			
SJ16HY obs_0	31/07/2016	15:57:41	1317	35_49.71561'N	134_49.91146'E	206	222.2	321.585	Distance (200.0m)
	31/07/2016	15:59:51	1321	35_49.84060'N	134_49.89084'E	207			
	01/08/2016	17:50:33	5765	37_23.30634'N	133_16.18374'E	766			
	01/08/2016	17:50:33	5765	37_23.30634'N	133_16.18374'E	766			
SJ16TR mcs_0	03/08/2016	16:56:56	1195	35_48.58061'N	134_09.37891'E	330	234.7	358.303	Distance (50.0m)
	03/08/2016	17:28:39	1286	35_51.04019'N	134_09.26542'E	302			
	04/08/2016	21:57:24	5980	37_57.87657'N	134_03.09499'E	668			
	04/08/2016	21:57:24	5980	37_57.87657'N	134_03.09499'E	668			
					Total		657.3		

Table 3: List of seismic survey (refraction and MCS) lines in this cruise.

(6) OBS position list: Tables 4.

Site	Lat. [N]	Lon.[E]	Depth [m]	Site	Lat. [N]	Lon.[E]	Depth [m]
1	37_23.1942	133_16.3477	796	**26**	36_40.9939	133_59.2941	1046
2	37_22.2768	133_17.2797	811	**27**	36_39.2178	134_01.0016	462
3	37_20.5744	133_19.0375	894	**28**	36_37.5925	134_02.7155	426
4	37_19.0423	133_20.9912	1006	**29**	36_35.7822	134_04.5822	547
5	37_17.1156	133_22.5559	1072	**30**	36_34.0389	134_06.3080	649
6	37_15.3861	133_24.3274	1047	**31**	36_32.3218	134_07.9404	644
7	37_13.6848	133_26.0870	1007	**32**	36_30.6381	134_09.6222	968
8	37_11.9616	133_27.8146	1036	**33**	36_28.9350	134_11.3654	1110
9	37_10.2262	133_29.6082	1028	**34**	36_27.2427	134_13.0811	1163
10	37_08.5034	133_31.3174	1064	**35**	36_25.4984	134_14.7849	1182
11	37_06.8127	133_33.1064	1033	**36**	36_23.7959	134_16.4603	1200
12	37_05.1228	133_34.8047	1096	**37**	36_22.1375	134_18.1668	1175
13	37_03.4058	133_36.5881	1107	**38**	36_20.3854	134_19.9173	1271
14	37_01.6880	133_38.3661	1218	**39**	36_18.6177	134_21.6769	1252
15	36_59.9192	133_40.0909	1322	**40**	36_16.8610	134_23.6179	1258
16	36_58.2491	133_41.5018	1271	**41**	36_14.3264	134_26.0129	1188
17	36_56.4626	133_43.5654	1273	**42**	36_11.6641	134_28.5965	1101
18	36_54.6144	133_45.3067	1445	**43**	36_09.0278	134_31.2030	999
19	36_53.0235	133_47.1140	1361	**44**	36_06.3851	134_33.8113	528
20	36_51.3455	133_48.8892	1417	**45**	36_03.7376	134_36.3867	445
21	36_49.5607	133_50.5472	1400	**46**	36_01.3234	134_38.7671	297
22	36_47.8851	133_52.3224	1415	**47**	35_58.4667	134_41.5668	266
23	36_46.2190	133_54.1589	1400	**48**	35_55.8295	134_44.1440	246
24	36_44.4390	133_55.7126	1354	**49**	35_53.1642	134_46.6983	231
25	36_42.6972	133_57.5400	1202	**50**	35_50.5396	134_49.3259	213

Table 4: List of OBS deployed positions on the SJ16HY line.

The position of Site43-50 is determined through acoustic measurement of distances between the OBS and vessel from 3 points. The position of other OBSs is determined using SSBL.

4. Notice on using:

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

This report may not be corrected even if changes on contents (i.e. taxonomic classifications) may be found after its publication. This report may also be changed without notice. Data on this cruise report may be raw or unprocessed. If you are going to use or refer to the data written on this report, please ask the Chief Scientists for latest information.

Users of data or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.

Acknowledgement:

We thank the captain, Mr. Yoshiyuki Nakamura, and the crew of R/V *KAIREI*, and the marine technician team (Nippon Marine Enterprises, Ltd.) for their efforts in obtaining the MCS data, OBS data, and other geophysical data. We are grateful to participants of CEAT (Research and Development center for Earthquake and Tsunami) and MARITEC (Marine Technology Center) in JAMSTEC for their great support in this cruise. This cruise is funded by programs called "Integrated Research Project on Seismic and Tsunami Hazards Around the Sea of Japan," which is part of the Special Coordination Funds for Promoting Science and Technology of the Ministry of Education, Culture, Sports, Science, and Technology. We used "The Generic Mapping Tools" by Wessel and Smith (1998) to construct the figures.

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