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Kairei Cruise Report

KR15-08

Geophysical research on large earthquake by 4D observation using seafloor and borehole observatories Kumano Nankai Trough

Jun.11.2015-Jun.18,2015

Japan Agency for Marine-Earth Science and Technology

(JAMSTEC)

Contents

1. Cruise Information

Cruise ID KR15-08

Name of vessel R/V Kairei

Title of the cruise

Geophysical research on large earthquake by 4D observation using seafloor and borehole observatories Kumano Nankai Trough

Title of proposal

Geological and Geophysical survey to elucidate mechanism of mega-thrust earthquake and tsunamis #6 4-D seismic survey using seafloor and subseafloor seismic observatories in the Nankai Trough test field

Cruise period 2015/6/11- 2015/6/18

Ports of departure: Yokosuka JAMSTEC pier / arrival: Yokosuka JAMSTEC pier

Research area Kumano Nankai Trough

Research Map

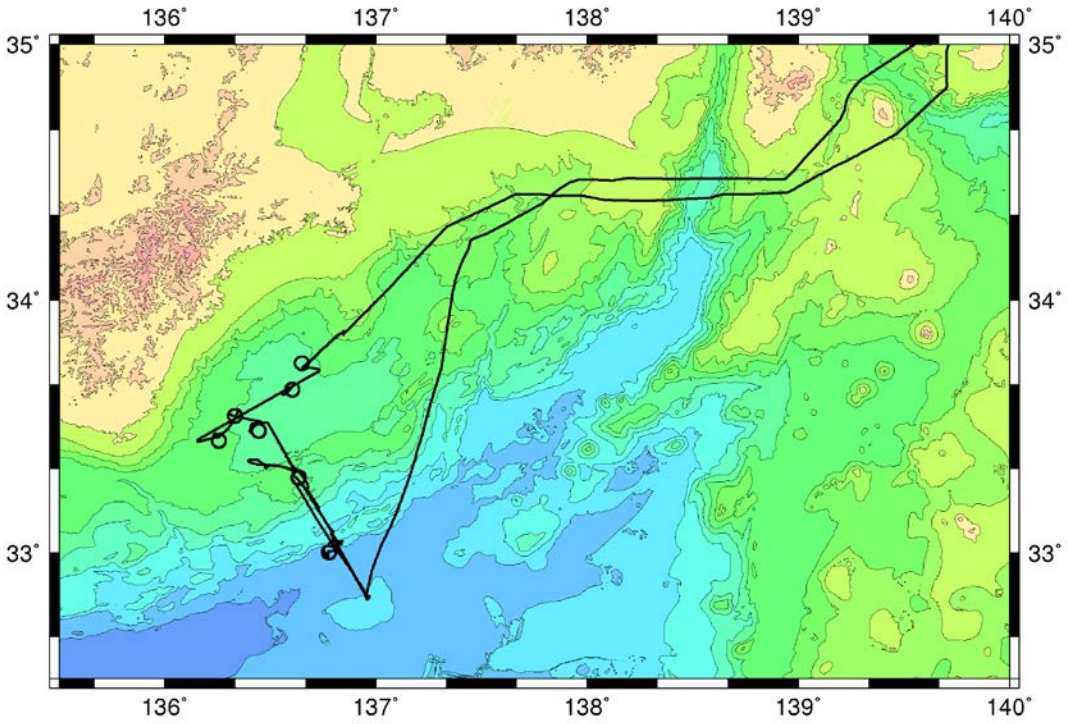

Figure 1. Ship track in KR15-08 cruise (solid black line)

2. Researchers

Chief scientist

Eiichiro Araki (JAMSTEC)

Representative of the science party

Shuichi Kodaira (JAMSTEC)

Shipboard science party

Shipboard Research Scientists

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Technicians

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Hikaru Iwamaru (NME)

Hideki Shibata (NME)

Akie Suzuki (NME)

Kaoru Takizawa (NME)

Naoto Noguchi (NME)

3. Observation

3.1. Background and Objectives

A cabled seismic observation system, named DONET (Dense Ocenfloor Network Systems for Earthquake and Tsunamis) have been in operation since 2011, which includes twenty three-components seismometers deployed on the seafloor in the Nankai Trough area. A borehole observatory IODP (Integrated Ocean Drilling Program) C0002G was also connected to the DONET since Jan. 2013. The borehole observatory has borehole seismometers, including three-component seismometers at the bottom of the borehole with depth of 900 mbsf. These observatories are distributed above the seismogenic plate boundary of the subducting Philippine Sea plate beneath Japan island arc, where large Tonankai earthquakes occur at 100-150 years intervals, and are mainly constructed for monitoring “passive” earthquake related phenomena, e. g. regional microearthquake, VLF events, seismic tremors, etc. In this area, the occurrence of the next Tonankai earthquake is anticipated in the near future, therefore it is important not only to monitor seismic events, but also to evaluate stress state of the seismogenic plate interface where the large earthquake may initiate, and the temporal evolution of the stress state. Stress state may be inferred in terms of seismic velocity structure of the media, by such as seismic anisotropy or the velocity itself of the media, which changes through deformation of micro-structure in different condition of the stress state.

In this cruise, we aim to use these observatories as seismic receivers for acquiring “active” seismic signal excited by air gun source to reveal the above mentioned properties in the subduction zone.

The detailed objectives of this cruise are as follows:

-Experimental study on new data acquisition and processing technique, air gun circle-shooting data observed by DONET and IODP C0002G three components seismometers, to obtain seismic velocity and anisotropy structure, which should be proxies of stress state beneath the subduction zone.

-Data acquisition for time-lapse survey to obtain time variation of subseafloor structure, including P- and S-wave velocity structure and velocity anisotropy for stress monitoring. This cruise is the third cruise to obtain time-lapse dataset by the air gun system and DONET and IODP C0002G observatories. The first cruise, KR13-17 with the same seismic source and receivers as this cruise, was conducted on Nov. 2013. The second cruise, KR-15-05 also used the same seismic source, was conducted in March. 2015.

3.2. Observation plan and results.

1) Seismic survey using DONET and C0002G seismometers and air gun array system

In this cruise, a tuned air gun array system was towed at 6 m depth and shot along circular and inline survey lines around DONET and C0002G observatories. Air gun signals were recorded by seismometers deployed on these observatories. 7 circular (KMC11-R3, C0002G-R3, KME17-R3, KME20-R3, KME19-R3, KMA03-R3, KMA02-R3) and 2 inline (NS1, EW1) survey lines were shot during this cruise (Fig. 3, Table 1).

For circular survey lines, the firing timing of air gun array was controlled by “distance mode” and the lay back parameter was set to zero. The trigger signal was therefore transmitted when R/V KAIREI passed just above each shot point. The positions of air gun array were measured by GPS attached to the gun array, and monitored by the shot point navigation system. To keep the positions of the air gun array being on circular lines, the ship crews and air gun operation team shared the shot point navigation system. Finally, precise ship control was achieved to maintain shot points. The air gun shootings at circular survey lines were started from North end of each survey lines, and were conducted with clockwise direction at every 2.0 degrees. The shooting intervals were 86.5 m. For inline survey lines (NS and EW lines), the shooting interval of 100m was maintained by using the distance mode. Test shooting observations were also conducted before and after the survey.

The seismic wave from the airgun array was received 20 seafloor observatories of DONET-1, and the long-term borehole monitoring system in IODP hole C0002G, and two additional ocean bottom seismographs (OBS1, OBS2) deployed during KR15-05 cruise, as well as land seismic stations. We recovered OBS1 and OBS2 after shooting KMC11-R3 and a part of NS1 line during this cruise.

To correct for the sound velocity structure in seismic and seafloor topography survey, we performed XBT seawater temperature profiling in three locations.

Observation of sea mammals was also performed by two observers to confirm status of implementation of the “Guidelines for Minimizing the Impact to Marine Mammals from Seismic Surveys”.

Fig. 4 shows C0002G borehole vertical seismic record for shots C0002G-R3, which exhibits effect of local topography in first motion travel time. Fig. 5 shows similar circular shot result for seafloor observatory, seafloor vertical seismic record at KME17 for shots KME17-R3. For the case of circular shots in 3 km distance for seafloor observatories, the first motion is acoustic phase in the seawater.

2) General geophysical observation
Seafloor topography, shipboard gravity, and sea current data were collected during the cruise.

3.3. Observation Instruments

1) Tuned air gun array system (APG)
A tuned air gun array of 7,800 cubic inch that has 4 sub-arrays (32 units) was used for this survey. The standard air pressure was 2,000 psi (about 14 MPa). During this survey, the air gun array was maintained at a depth of 6 m below the sea surface, which is the same as in the previous cruises KR13-17 and KR15-05. Top and side views of the air gun array are shown in Fig.2.

2) DONET and C0002G seismometers used as receivers
Seismometers deployed at DONET and C0002G observatories were used as receivers for the airgun shooting. DONET three component broadband seismometers, CMG3T manufactured by Guralp systems, were used as receivers with the sampling rate of 5 ms (200 Hz). C00002G borehole seismometers, three components broadband seismometer, CMG3TBD, and geophones, GS-11D, were also used as receivers with the sampling rates of 5 ms (200 Hz) and 8 ms (125 Hz), respectively. C0002G observatory also has seafloor seismometer, comprising three component geophone unit with sampling rates of 8 ms (125Hz). All acquired data were collected through DONET seafloor cable network, and data QC was conducted by land support scientists.

3) OBS (Ocean bottom seismometer)
We recovered two OBSs along the NS1 line which were deployed during KR-15-05 cruise. Location of the OBSs and time of deployment, recovery are as listed in Table 2. OBS1 was deployed at the midpoint between C0002G and KMD13 observatories, and OBS2 was deployed at southward of the KMD13 observatory with distance of 5km. The OBSs used 4.5 Hz type three component gimbal mounted geophones and 16 bit digital recording system with 100 Hz sampling rate. Long-term batter pack, for more than 3 months continuous recording, was used for the OBSs.

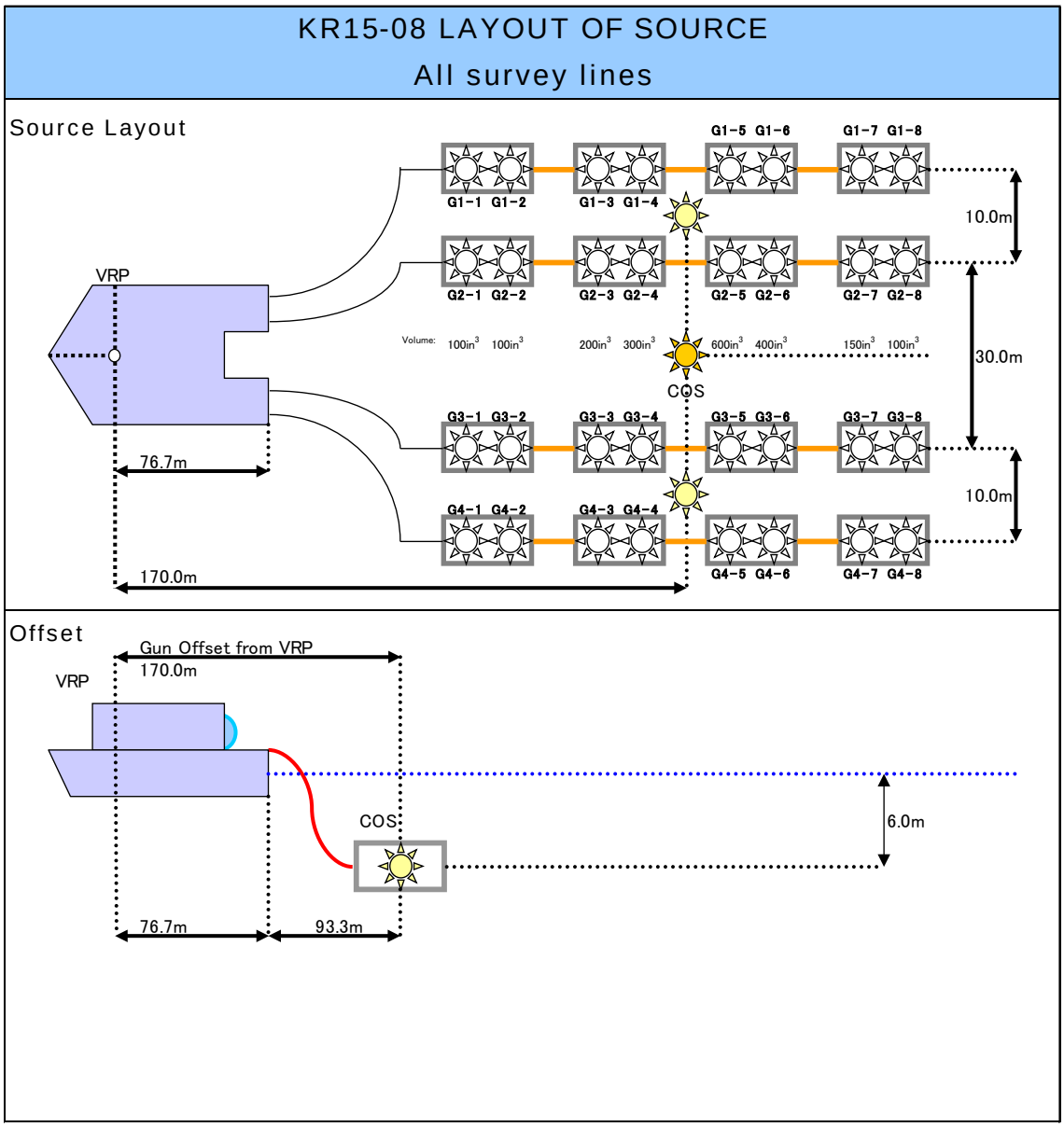

Figure 2. APG tuned airgun system layout.

3.4. Cruise Log

6/11/2015 (Time is JST)
0930 depart Yokosuka JAMSTEC HQ.

6/12
Seacurrent Survey (South of Node C: 2.3kn+ Near C0002 borehole 3.8kn Wind 13m/s)
Airgun deployment
Test shot
Airgun shooting
1550-2005 KMC11-R3(Circle)
2141-0043 NS1（North to South）
0133- NS1 (South to North）

6/13
Airgun shooting
-0600 NS1
Airgun recovery
OBS recovery (OBS1, OBS2)
Airgun Shooting
1756- C0002G-R3　(Current 4kn+)
XBT measurement (2 points)

6/14
Airgun shooting
-1132 C0002G-R3
1245-1612 NS1
1828 KME17-R3

6/15
Airgun shooting
KME17
Shooting interruptions due to sea mammals observation (three times)

6/16
Airgun shooting
-0759 KME17-R3 total of 16 round shootings.

1025-1239 KME20-R3
1500-1752 KME19-R3,
Part of KME19-R3 in Kuroshio current.
1939-0048 EW1
0123-0342 KMA03-R3

6/17
Airgun Shooting
0452-0746 EW1
0746-0955 KMA02-R3
Airgun Test shots (0955-1120)
Airgun recovery
XBT measurement
Leave survey area for Yokosuka

6/18
0900 Arrive at Yokosuka HQ

3.5. Research Information

1) Survey map

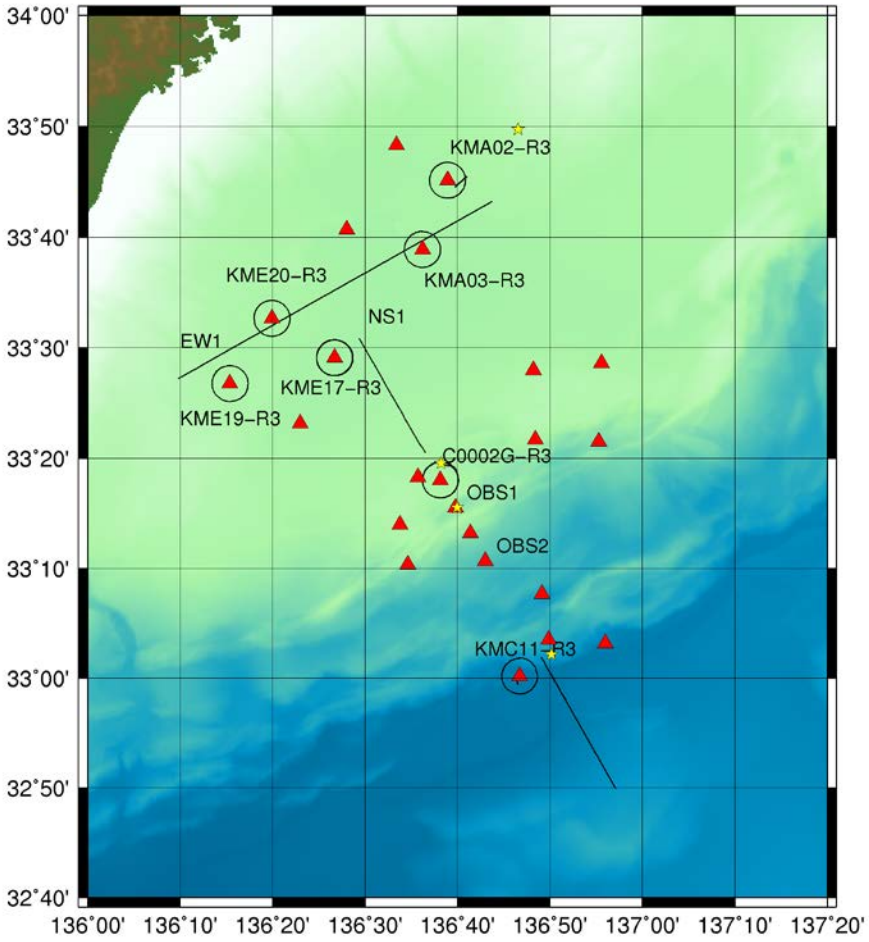

Figure 3. KR15-08 survey map. Red triangles: DONET-1 seafloor observatories and long-term borehole monitoring system. Black lines and circles: airgun shot positions. Yellow stas: location of XBT profile.

2) Survey line list (Table 1.)

NO.	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#	LENGTH FGSP - LGSP (km)	DIRECTION (°)	Mode (m)
1	150612_wave	12/06/2015	04:49:14	1001	32_59.94882'N	136_46.41511'E	4339	-	-	-	Cycle (30 sec)
		12/06/2015	04:49:14	1001	32_59.94882'N	136_46.41511'E	4339				
		12/06/2015	05:30:44	1084	32_59.40741'N	136_46.42938'E	4334				
		12/06/2015	05:30:44	1084	32_59.40741'N	136_46.42938'E	4334				
2	150617_wave	17/06/2015	01:29:58	1018	33_44.57954'N	136_39.85356'E	2009	-	-	-	Cycle (30 sec)
		17/06/2015	01:29:58	1018	33_44.57954'N	136_39.85356'E	2009				
		17/06/2015	02:20:28	1119	33_45.49405'N	136_41.11686'E	2002				
		17/06/2015	02:20:28	1119	33_45.49405'N	136_41.11686'E	2002				
3	C0002G-R3_0	13/06/2015	08:56:56	301001	33_19.62516'N	136_38.14466'E	2023	495	51.9	clockwise	Distance (2°)
		13/06/2015	08:58:02	301003	33_19.62070'N	136_38.28347'E	2030				
		14/06/2015	00:38:46	301497	33_18.07031'N	136_36.10739'E	1966				
		14/06/2015	00:38:46	301497	33_18.07031'N	136_36.10739'E	1966	(+1)			
4	C0002G-R3_1	14/06/2015	00:49:58	301501	33_18.30692'N	136_36.14222'E	1970	41	4.2	clockwise	Distance (2°)
		14/06/2015	00:52:39	301502	33_18.36433'N	136_36.16115'E	1972				
		14/06/2015	02:32:06	301542	33_19.61684'N	136_38.21662'E	2025				
		14/06/2015	02:32:06	301542	33_19.61684'N	136_38.21662'E	2025	(+1)			
5	EW1_0	16/06/2015	10:39:09	499998	33_27.26435'N	136_09.91944'E	1752	434	43.3	59.790	Distance (100.0m)
		16/06/2015	10:40:27	500000	33_27.31820'N	136_10.03145'E	1752				
		16/06/2015	15:48:03	500433	33_38.84402'N	136_34.39204'E	2065				
		16/06/2015	15:48:03	500433	33_38.84402'N	136_34.39204'E	2065	(+1)			
6	EW1_1	16/06/2015	19:52:19	500425	33_38.62119'N	136_33.95164'E	2064	169	16.8	59.790	Distance (100.0m)
		16/06/2015	19:57:40	500432	33_38.81065'N	136_34.34375'E	2065				
		16/06/2015	22:01:05	500600	33_43.25757'N	136_43.82550'E	1968				
		16/06/2015	22:01:05	500600	33_43.25757'N	136_43.82550'E	1968	(+1)			
7	KMA02-R3_0	16/06/2015	22:46:54	21075	33_43.77298'N	136_39.96415'E	2011	181	18.9	clockwise	Distance (2°)
		16/06/2015	22:48:17	21077	33_43.71524'N	136_39.84718'E	2012				
		17/06/2015	00:55:19	21257	33_43.71123'N	136_39.84649'E	2011				
		17/06/2015	00:55:19	21257	33_43.71123'N	136_39.84649'E	2011	(+1)			
8	KMA03-R3_0	16/06/2015	16:23:42	31001	33_40.52101'N	136_36.21376'E	2006	180	18.8	clockwise	Distance (2°)
		16/06/2015	16:26:06	31004	33_40.51561'N	136_36.41672'E	2005				
		16/06/2015	18:42:23	31183	33_40.51529'N	136_36.35149'E	2005				
		16/06/2015	18:42:23	31183	33_40.51529'N	136_36.35149'E	2005	(+1)			
9	KMC11-R3_0	12/06/2015	06:49:51	111001	33_01.83902'N	136_46.73936'E	3946	180	18.8	clockwise	Distance (2°)
		12/06/2015	06:51:11	111003	33_01.83063'N	136_46.87441'E	3943				
		12/06/2015	11:05:44	111182	33_01.80464'N	136_46.80870'E	3950				
		12/06/2015	11:05:44	111182	33_01.80464'N	136_46.80870'E	3950	(+1)			

Continued

NO.	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#	LENGTH FGSP - LGSP (km)	DIRECTION (°)	Mode (m)
10	KME17-R3_0	14/06/2015	09:28:35	171001	33_30.71709'N	136_26.70047'E	2052	1067	111.9	clockwise	Distance (2°)
		14/06/2015	09:29:57	171003	33_30.71084'N	136_26.83511'E	2055				
		14/06/2015	23:07:34	172069	33_30.57694'N	136_25.91252'E	2049				
		14/06/2015	23:07:34	172069	33_30.57694'N	136_25.91252'E	2049	(+1)			
11	KME17-R3_1	15/06/2015	00:32:33	172145	33_28.09639'N	136_28.24053'E	2066	11	1.1	clockwise	Distance (2°)
		15/06/2015	00:32:33	172145	33_28.09639'N	136_28.24053'E	2066				
		15/06/2015	00:40:19	172155	33_27.72978'N	136_27.73180'E	2063				
		15/06/2015	00:40:19	172155	33_27.72978'N	136_27.73180'E	2063	(+1)			
12	KME17-R3_2	15/06/2015	02:02:35	172253	33_30.66075'N	136_26.15831'E	2047	141	14.7	clockwise	Distance (2°)
		15/06/2015	02:02:35	172253	33_30.66075'N	136_26.15831'E	2047				
		15/06/2015	03:47:47	172393	33_28.92622'N	136_24.78026'E	2046				
		15/06/2015	03:47:47	172393	33_28.92622'N	136_24.78026'E	2046	(+1)			
13	KME17-R3_3	15/06/2015	05:08:33	172502	33_28.24153'N	136_28.35333'E	2062	1382	145.0	clockwise	Distance (2°)
		15/06/2015	05:08:33	172502	33_28.24153'N	136_28.35333'E	2062				
		15/06/2015	22:59:36	173883	33_30.70928'N	136_26.83467'E	2055				
		15/06/2015	22:59:36	173883	33_30.70928'N	136_26.83467'E	2055	(+1)			
14	KME19-R3_0	16/06/2015	06:00:13	191001	33_28.37140'N	136_15.38572'E	1919	180	18.8	clockwise	Distance (2°)
		16/06/2015	06:02:26	191004	33_28.36828'N	136_15.58863'E	1922				
		16/06/2015	08:52:20	191183	33_28.40789'N	136_15.52300'E	1921				
		16/06/2015	08:52:20	191183	33_28.40789'N	136_15.52300'E	1921	(+1)			
15	KME20-R3_0	16/06/2015	01:25:44	201001	33_34.28315'N	136_19.94516'E	1979	180	18.8	clockwise	Distance (2°)
		16/06/2015	01:27:17	201003	33_34.27934'N	136_20.08040'E	1981				
		16/06/2015	03:39:25	201182	33_34.28791'N	136_20.01262'E	1980				
		16/06/2015	03:39:25	201182	33_34.28791'N	136_20.01262'E	1980	(+1)			
16	NS1_0	12/06/2015	12:41:33	400255	33_01.83258'N	136_49.02672'E	3986	253	25.2	########	Distance (100.0m)
		12/06/2015	12:43:00	400253	33_01.73874'N	136_49.09031'E	4004				
		12/06/2015	15:43:31	400001	32_49.89909'N	136_57.10722'E	3962				
		12/06/2015	15:43:31	400001	32_49.89909'N	136_57.10722'E	3962	(-1)			
17	NS1_1	12/06/2015	16:33:41	400001	32_50.06833'N	136_57.02500'E	3975	224	22.3	########	Distance (100.0m)
		12/06/2015	16:35:28	400003	32_50.15728'N	136_56.95080'E	3985				
		12/06/2015	21:00:23	400226	33_00.64601'N	136_49.88186'E	4399				
		12/06/2015	21:00:23	400226	33_00.64601'N	136_49.88186'E	4399	(+1)			
18	NS1_2	14/06/2015	03:45:01	400649	33_20.54846'N	136_36.44105'E	1991	221	22.0	########	Distance (100.0m)
		14/06/2015	03:46:52	400650	33_20.59059'N	136_36.39856'E	1992				
		14/06/2015	07:12:25	400870	33_30.90842'N	136_29.32044'E	2064				
		14/06/2015	07:12:25	400870	33_30.90842'N	136_29.32044'E	2064	(+1)			
						Total		5339	552.4		

3) OBS position and observation period (Table 2).

Site	Cast	Release command	Calibrated Position at the deployment			Calibrated Position before recovery		
	Time UTC	Time UTC	Lat(N)	Lon(E)	Depth(m)	Lat(N)	Lon(E)	Depth(m)
OBS1	2015/03/21 22:23:53	2015/06/13 02:49:56	33_15.5229	136_39.8138	2346.2	33_15.5473	136_39.7850	2362.7
OBS2	2015/03/21 21:06:41	2015/06/13 00:54:17	33_10.6813	136_43.0289	3076.1	33_10.6903	136_43.0090	3172.3

4) Observed shot record

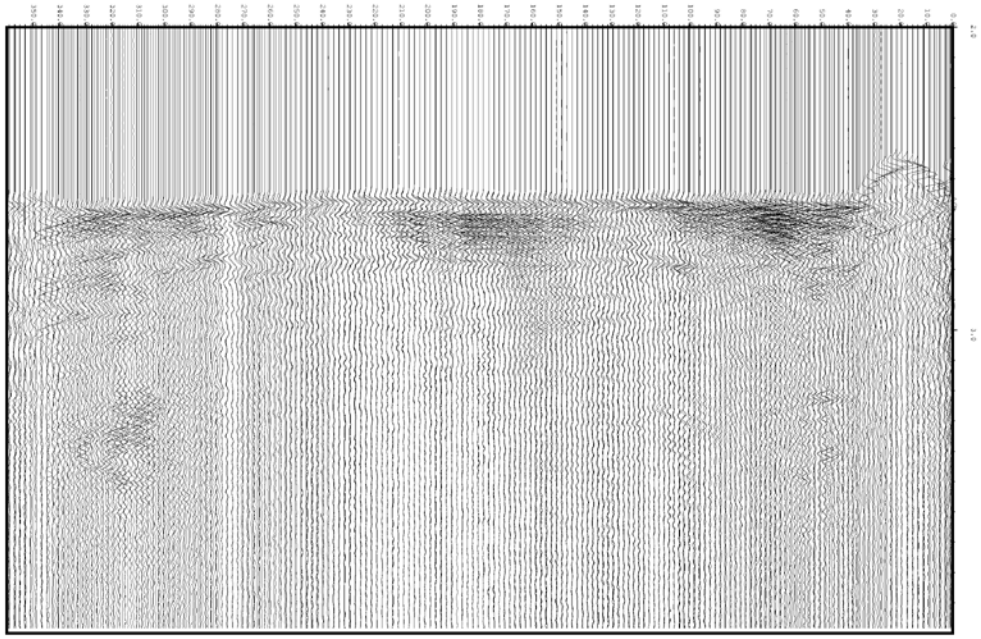

Figure 4. C0002G borehole vertical seismic record for Shots C0002G-R3

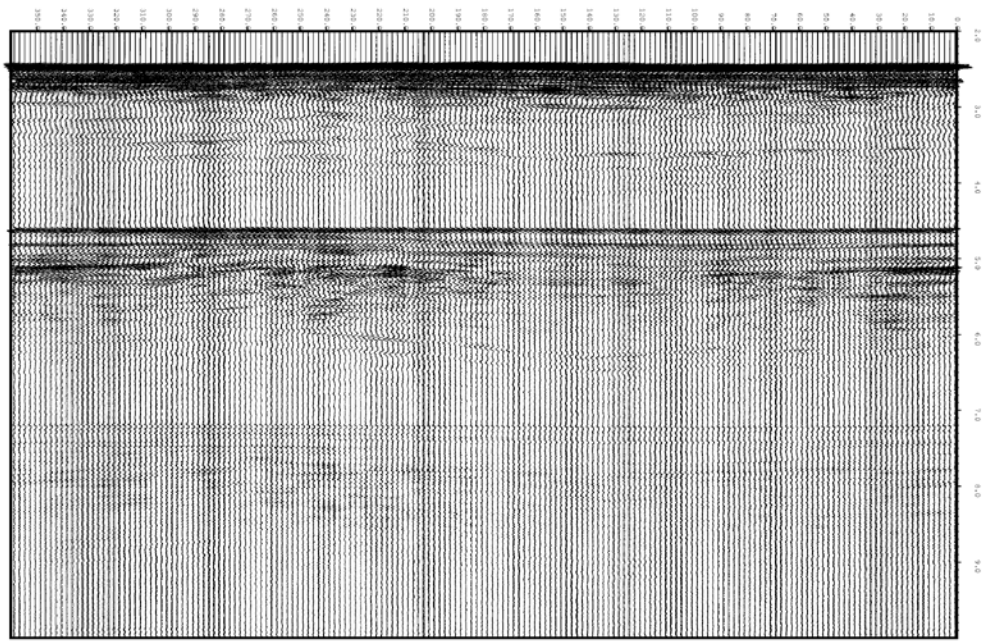

Figure 5. Seafloor vertical seismic record at KME17 for shots KME17-R3.

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 Scientist 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.