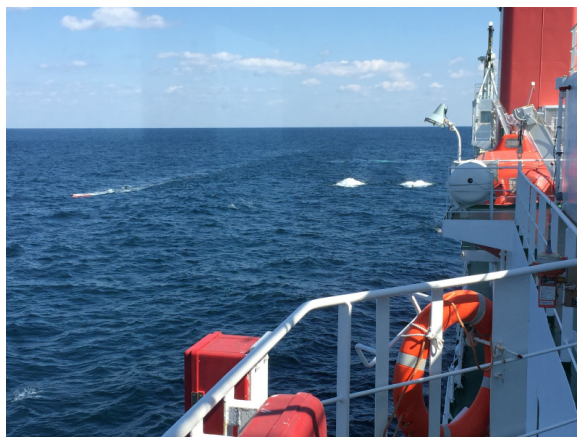




R/V KAIREI Cruise Report KR15-05



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

Kumano nada

Mar.21,2015-Mar.31,2015

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

Contents

1. Cruise Information

2. Researchers

3. Observations

3.1. Background and Objectives

3.2. List of Observations

3.3. List of Observation Instruments

3.4. Cruise Log

3.5. Research Information

4. Notice on using

5. Acknowledgement

Appendix

1. Cruise Information

Cruise ID: KR15-05
Name of vessel: R/V KAIREI
Title of the cruise:

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

Title of proposal:

same as title of the cruise

Cruise period:

March 21, 2015 to March 31, 2015

Ports of call:

Yokosuka (JAMSTEC Headquarter) to Kobe port

Research area:

Kumano basin

Research map:

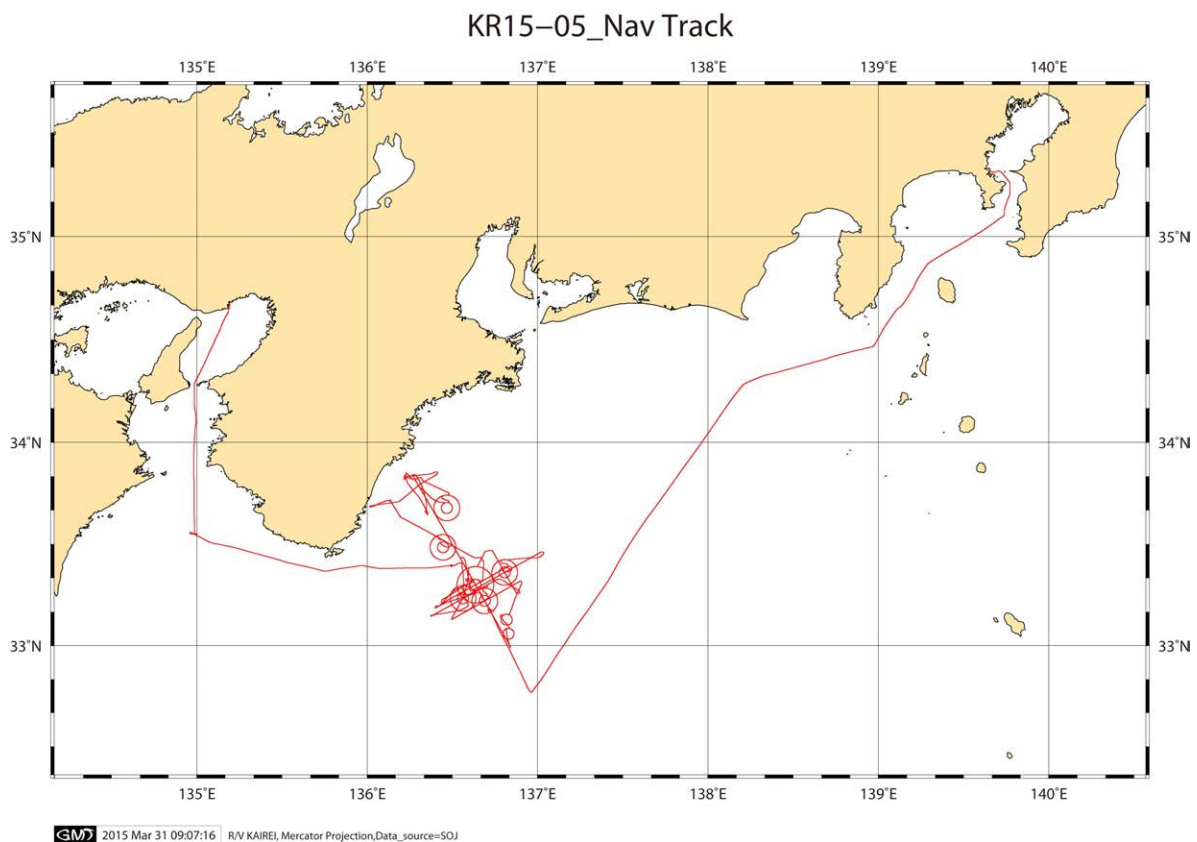


Fig. 1 Vessel track of KR15-05. Red lines show the vessel track of KR15-05

2. Researchers

- Chief scientist Toshinori Kimura [JAMSTEC]
- Representative of the science party: Shuichi Kodaira [JAMSTEC]
- Science party (list):

Narumi Takahashi [JAMSTEC]
Seiichi Miura [JAMSTEC]
Ayako Nakanishi [JAMSTEC]
Eiichiro Araki [JAMSTEC]
Kazuya Kitada [JAMSTEC]
Masaru Nakano [JAMSTEC]
Takeshi Nakamura [JAMSTEC]

- Observatory Operation Team [Nippon Marine Enterprises, LTD.]

Party chief Hidenori Shibata
Yuta Watarai
Kyoko Tanaka
Haruhiro Shibata
Ikumasa Teradea
Toshinori Saijo
Kiyoshi Shiono
Hiromichi Soejima

- R/V KAIREI Crew [Nippon Marine Enterprises, LTD.]

Captain	Takafumi Aoki
Chief Officer	Akihisa Tsuji
2nd Officer	Kazuki Miyake
3rd Officer	Yusuke Ishii
Jr.3rd Officer	Shunsuke Fujii
Chief Engineer	Takashi Ohta
1st Engineer	Wataru Kurose
2nd Engineer	Saburo Sakaemura
3rd Engineer	Kota Kataoka
Chief Electronics Operator	Hiroyasu Saitake
2nd Electronics Operator	Shunsuke Fukagawa
3rd Electronics Operator	Toshihiko Yuasa
Boat Swain	Masanori Ohata
Able Seaman	Yasuo Konno
Able Seaman	Saikan Hirai
Sailor	Hiroataka Shigeta
Sailor	Kosei Kawamura
Sailor	Sho Suzuki
Sailor	Hideaki Nakata
No.1 Oiler	Toshikazu Ikeda
Oiler	Masanori Ueda
Oiler	Ryo Sato
Oiler	Makoto Kozaki
Assistant Oiler	Aoi Takamiya

Chief Steward	Yukio Tachiki
Steward	Tatsunari Onoue
Steward	Kanji Mae
Steward	Toru Wada
Steward	Jun Sato

3. Observation

3.1. Background and Objectives

We are operating cabled seismic observation system, named DONET (Dense Oceanfloor Network Systems for Earthquake and Tsunamis), which includes twenty three-components seismometers deployed on the seafloor in the Nankai Trough area. We also have a borehole observatory IODP (Integrated Ocean Drilling Program) C0002G, which have borehole seismometers, including three-components 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 second 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.

3.2. List of Observations

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 was fired along circular and inline survey lines around DONET and C0002G observatories. Then the air gun signals were acquired by seismometers deployed on these observatories. Fourteen circular and six inline survey lines were completed during this cruise (Fig. 4). 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 0.5, 1.0 and 2.0 degree for R10 (radius: 10km), R7 (radius: 7km) and R3 (radius: 3km) survey lines, respectively (The shooting intervals were then 105m, 121.5m and 86.5 m, respectively). 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. Fig.2 shows examples of observed test shot records. Fig. 5 shows an example of shot records observed by C0002G borehole seismometer.

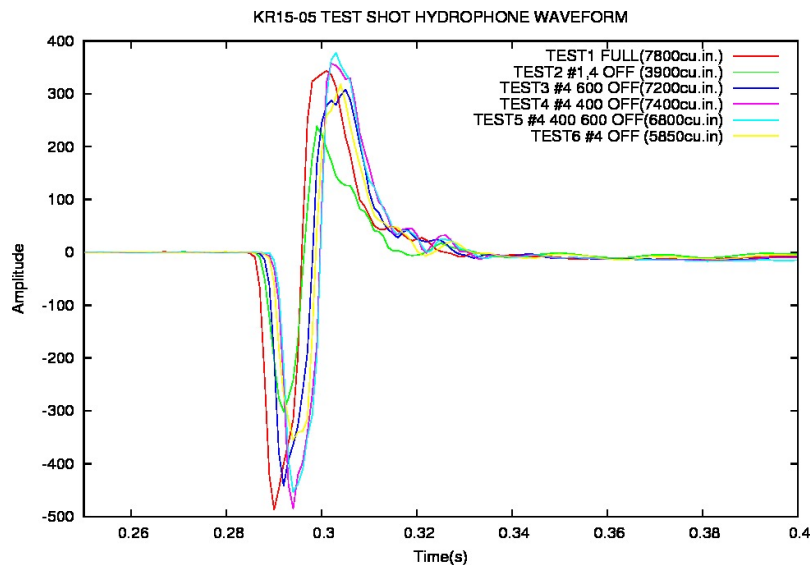


Fig. 2 Comparison of observed test shot records.

2) Bathymetry, Geomagnetic, Gravity measurements

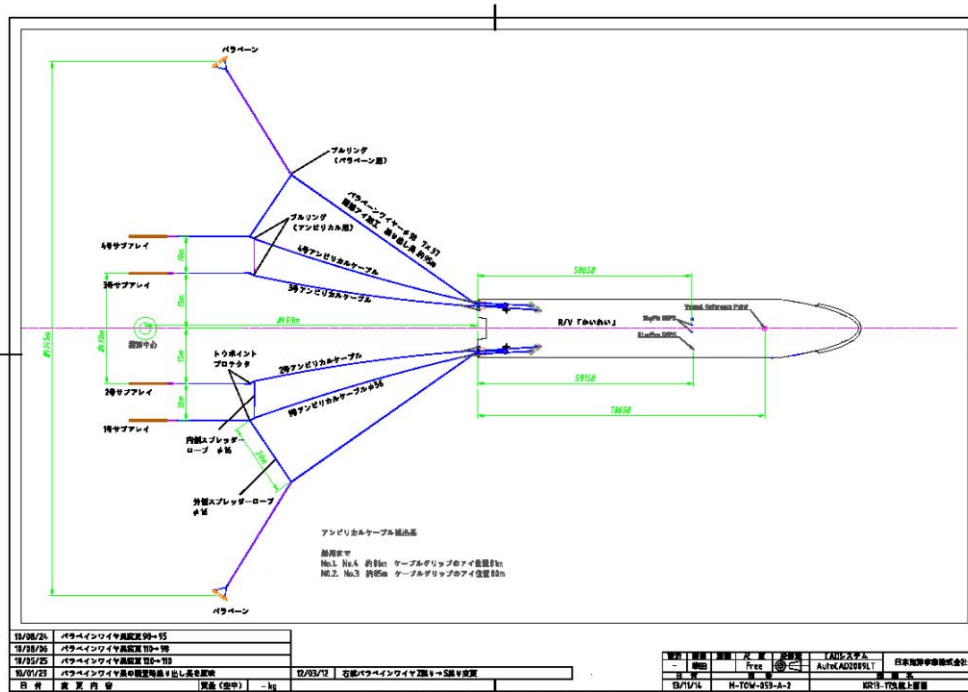
Bathymetry, geomagnetic and gravity data were recorded during the cruise.

3.3. List of Observation Instruments

1) Tuned air gun array system

A tuned air gun array of 7,800 cubic inch that has 4 sub-arrays 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. Top and side views of the air gun array are shown in Fig.3.

Top view



Side view

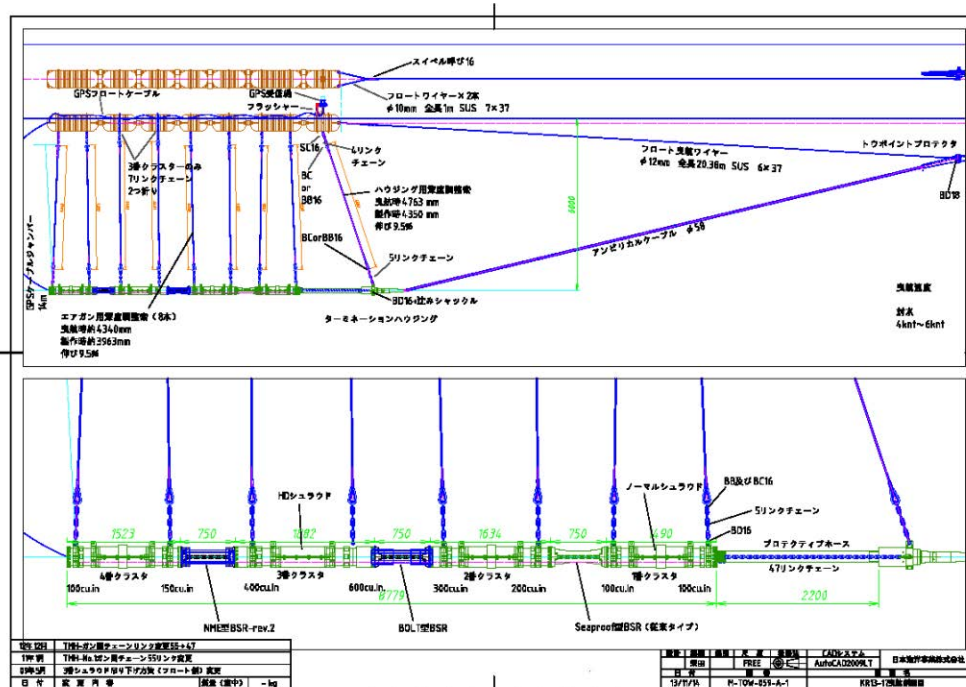


Fig. 3 Top and side views of the tuned air gun array system

2) DONET and C0002G seismometers used as receivers

Seismometers deployed at DONET and C0002G observatories were used as receivers for the air gun shooting. DONET three component broadband seismometers, CMG3T manufactured by Guralp systems, were used as receivers with the sampling rate of 5 ms (200 Hz). C0002G 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 has also 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 deployed two OBSs along the NS1 line. 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.

3.4. Cruise Log

[2015-03-21]

9:00	Departure from Yokosuka, port of JAMSTEC
13:00	Safety training
14:00	Operational meeting

[2015-03-22]

05:27	Deployed XBT
06:06-07:24	Deployed two OBSs(OBS1,OBS2)
08:50-11:40	Deployed paravane and air gun array
12:00-12:43	Deployed V-fin, Soft-start
13:15-15:09	[Wave form observation] air gun shooting around KMD16
15:14-15:22	Recovered V-fin Hydrophone
16:02-23:38	[C0002G-R3_0] air gun shooting (clockwise) Trouble on steering system of Kairei
00:00-02:30	Recovered air gun array and paravane, Drifted to off the Shingu port.

[2015-03-23]

08:00-	Anchored at off the Shingu port
13:00-15:00	Trouble shooting by an engineer boarded by a traffic boat
15:00-	Trouble shooting was completed, and the engineer left Kairei by a traffic boat
16:00-	Weighed anchor, and drifted to survey area

[2015-03-24]

06:05	Deployed paravane and air gun array. Test shooting.
09:41-10:41	[NS1_0] air gun shooting (northern point to southward) Trouble on C0002G seismometer, moved to KMA04-R3
13:11-15:30	[KMA04-R3_0] air gun shooting (clockwise)
16:34-21:51	[KMA04-R7_0] air gun shooting (clockwise)

[2015-03-25]
00:57-06:03 [NS1_1] air gun shooting (north to south)
07:15-9:31 [KME17-R3_0] air gun shooting (clockwise)rt
10:36-15:51 [KME17-R7_0] air gun shooting (clockwise)
16:08-20:01 [NS1_2] air gun shooting (north to south)
20:30-23:41 [KMD13-R3] air gun shooting (clockwise)

[2015-03-26]
00:32-06:39 [KMD13-R7_0] air gun shooting (clockwise)
09:26-12:15 [KMD15-R3_0] air gun shooting (clockwise)
13:02-19:45 [KMD15-R7_0] air gun shooting (clockwise)
No fire occurred on #3-3 gun (200 cu.). Firing was stopped at 14:43
19:57-20:10 Conducted test shooting of #3 gun array and make sure the array was working.
22:46- [C0002G-EW_0] air gun shooting (west to east)

[2015-03-27]
-03:28 [C0002G-EW_0] air gun shooting (west to east)
Communication error on #2-3~#2-8 airgun array occurred. Firing was stopped at 01:31.
04:52-07:08 [KMB07-R3_0] air gun shooting (clockwise)
08:11-13:29 [KMB07-R7_0] air gun shooting (clockwise)
13:30- Recovered #2 air gun array, repaired and redeployed.
19:08-22:15 [KMB07-EW_0] air gun shooting (east to west)

[2015-03-28]
00:39-06:58 [NS1_3] air gun shooting (north to south)
10:40-15:58 [KMC09-R3_0] air gun shooting (clockwise)
18:12-22:13 [KMC12-R3_0] air gun shooting (clockwise)

[2015-03-29]
00:32-06:17 [KMD13-EW_0] air gun shooting (east to west)
10:09-18:13 [C0002G-R10_0] air gun shooting (clockwise)
19:48-22:42 [KMB07-NS_0] air gun shooting (north to south)

[2015-03-30]
01:19-08:45 [KMD15-EW_0] air gun shooting (east to west)
09:03- Deployed V-fin Hydrophone
09:03-11:40 [Wave form observation]
11:50 Recovered V-fin Hydrophone
-15:19 Recovered Air gun and Paravane
16:15 Transit to Kobe-port

[2015-03-31]
09:00 Arrived at Kobe-port
KR15-05 Research cruise was successfully completed !!

3.5. Research Information

1) Index map of survey line

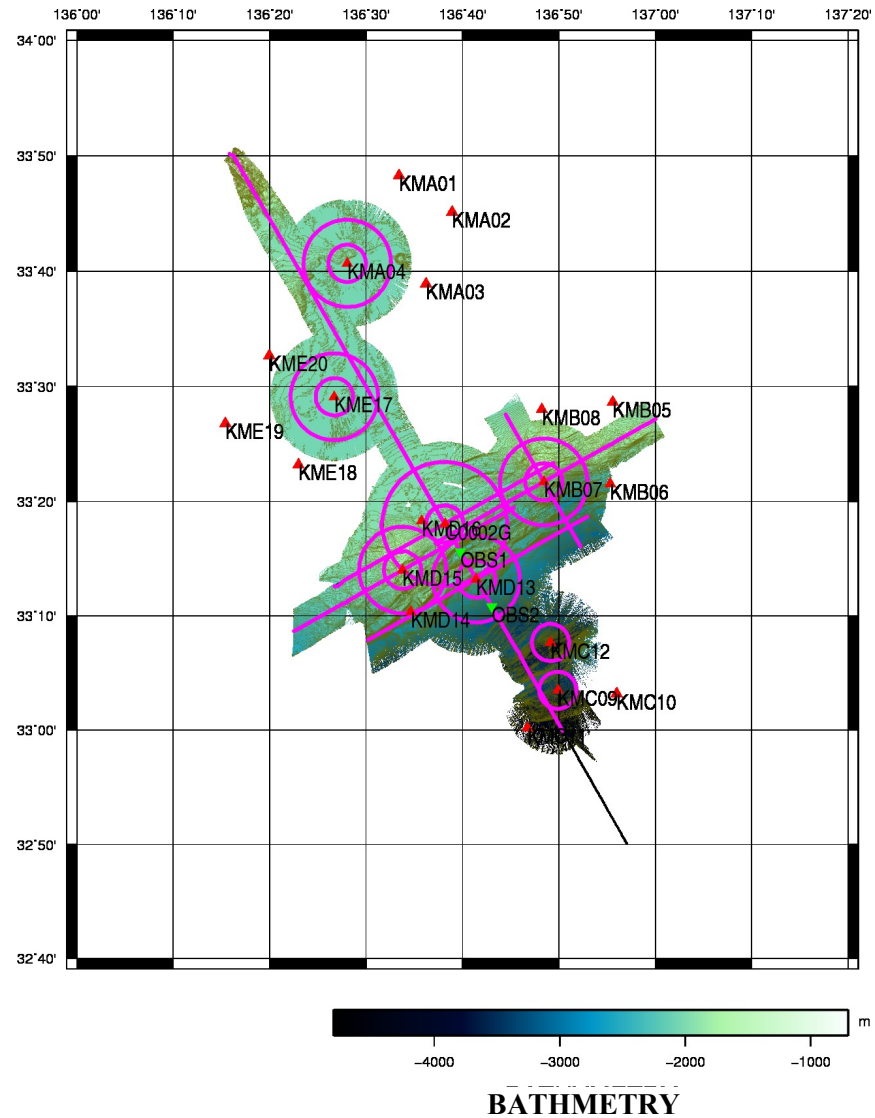


Fig.4 Survey map of KR15-05 cruise. Magenta lines show the air gun shooting lines. Red triangles show the DONET and IODP C0002G observatories. Green triangles show the location of deployed OBS.

2) Survey line list

NO.	LINE NAME	DIRECTION	DATE (JST)	TIME (JST)	Lat.	Lon.
	Test shot	-	22/03/2015	13:15:02	33 19.13644°N	136 37.46941°E
			22/03/2015	15:11:02	33 19.81128°N	136 35.11028°E
1	C0002G-R3_0	CW	22/03/2015	16:02:56	33 19.62744°N	136 38.14981°E
			22/03/2015	23:38:01	33 19.33285°N	136 39.38186°E
2	NS1_0	CW	24/03/2015	09:41:30	33 50.08798°N	136 15.91011°E
			24/03/2015	10:41:17	33 46.94211°N	136 18.32735°E
3	KMA04-R3_0	CW	24/03/2015	13:11:29	33 42.30180°N	136 28.04288°E
			24/03/2015	15:30:08	33 42.29640°N	136 28.24600°E
4	KMA04-R7_0	CW	24/03/2015	16:34:50	33 44.46687°N	136 28.04294°E
			24/03/2015	21:51:12	33 44.46864°N	136 28.20140°E
5	NS1_1	N->S	25/03/2015	00:57:50	33 48.21751°N	136 17.47397°E
			25/03/2015	06:03:47	33 30.57399°N	136 29.58460°E
6	KME17-R3_0	CW	25/03/2015	07:15:03	33 30.71906°N	136 26.70300°E
			25/03/2015	09:31:46	33 30.71461°N	136 26.83789°E
7	KME17-R7_0	CW	25/03/2015	10:36:02	33 32.87106°N	136 26.70295°E
			25/03/2015	15:51:23	33 32.87743°N	136 26.94000°E
8	NS1_2	N->S	25/03/2015	16:08:15	33 32.31200°N	136 28.39851°E
			25/03/2015	20:01:12	33 16.44139°N	136 39.23161°E
9	KMD13-R3_0	CW	25/03/2015	20:30:31	33 14.85103°N	136 41.42043°E
			25/03/2015	23:41:33	33 14.85565°N	136 41.55665°E
10	KMD13-R7_0	CW	26/03/2015	00:32:59	33 17.00000°N	136 41.48450°E
			26/03/2015	06:39:39	33 17.10660°N	136 41.58090°E
11	KMD15-R3_0	CW	26/03/2015	09:26:00	33 15.63009°N	136 33.78358°E
			26/03/2015	12:15:41	33 15.61293°N	136 33.91818°E
12	KMD15-R7_0	CW	26/03/2015	13:02:11	33 17.77533°N	136 33.78314°E
			26/03/2015	19:38:00	33 17.78331°N	136 33.94074°E
13	C0002G-EW_0	W->E	26/03/2015	22:46:41	33 12.59476°N	136 26.80759°E
			27/03/2015	03:28:11	33 23.37925°N	136 49.52240°E
14	KMB07-R3_0	CW	27/03/2015	04:52:15	33 23.29882°N	136 48.56781°E
			27/03/2015	07:08:17	33 23.26991°N	136 48.70025°E
15	KMB07-R7_0	CW	27/03/2015	08:11:42	33 25.45070°N	136 48.43293°E
			27/03/2015	13:29:14	33 25.45491°N	136 48.59025°E
16	KMB07-EW_0	E->W	27/03/2015	17:08:29	33 27.08713°N	136 59.90239°E
			27/03/2015	22:15:18	33 16.33768°N	136 37.07599°E
17	NS1_3	N->S	28/03/2015	00:40:24	33 25.26669°N	136 33.20585°E
			28/03/2015	06:58:11	32 59.84995°N	136 50.34490°E
18	KMC09-R3_0	CW	28/03/2015	10:40:16	33 05.15466°N	136 49.87968°E
			28/03/2015	15:58:28	33 05.12675°N	136 50.15025°E
19	KMC12-R3_0	CW	28/03/2015	18:12:18	33 09.29678°N	136 49.12914°E
			28/03/2015	22:13:19	33 09.29972°N	136 49.26403°E
20	KMD13-EW_0	E->W	29/03/2015	00:32:00	33 18.61023°N	136 52.87241°E
			29/03/2015	06:17:04	33 07.87263°N	136 30.07325°E
21	C0002G-R10_0	CW	29/03/2015	10:09:28	33 23.42431°N	136 38.14998°E
			29/03/2015	18:13:48	33 23.39989°N	136 38.26197°E
22	KMB07-NS_0	N->S	29/03/2015	19:47:55	33 27.48773°N	136 44.50798°E
			29/03/2015	22:42:36	33 15.95607°N	136 52.29557°E
23	KMD15-EW_0	E->W	30/03/2015	01:21:03	33 19.39478°N	136 45.23732°E
			30/03/2015	08:45:55	33 08.67074°N	136 22.42450°E
	Test shot	-	30/03/2015	09:22:13	33 09.38750°N	136 25.24937°E
			30/03/2015	11:35:43	33 11.40044°N	136 34.88085°E

3) OBS position list

Site	Calibration position					Remarks
	S/R(m)	HR(m)	Lat(N)	Lon(E)	Depth(m)	
OBS1	2367.0	313.1	33_15.5229	136_39.8138	2346.2	
OBS2	3094.0	332.1	33_10.6813	136_43.0289	3076.1	

4) Observed shot records

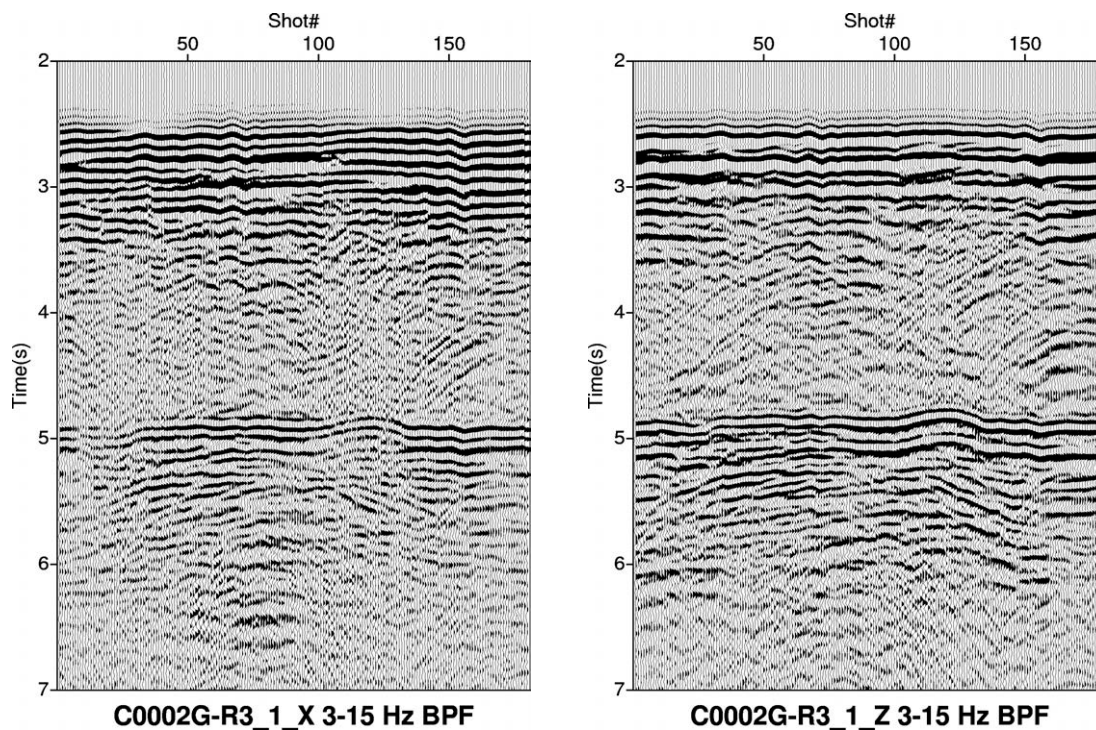


Fig. 5 Shot records of C2G-R3_1 line observed by C0002G borehole geophone (X and Z components)

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.

5. Acknowledgement

We would like to thank the captain Takafumi Aoki and his crew of the R/V KAIREI, and Hidenori Shibata and the marine technician team (Nippon Marine Enterprises, Ltd.) for their safe operation and great support during the cruise. We are grateful to member of CEAT (Research and Development (R&D) Center for Earthquake and Tsunami), and MARITEC (Marine Technology Center) in JAMSTEC for their help on this cruise. Figures are produced with “The Generic Mapping Tools” (Wessel and Smith, 1991).

Appendix

Shot points of each survey line. Magenta dots show the shot points of KR15-05. Gray dots show the shot points of KR13-17. Solid black lines show the planned shot lines.

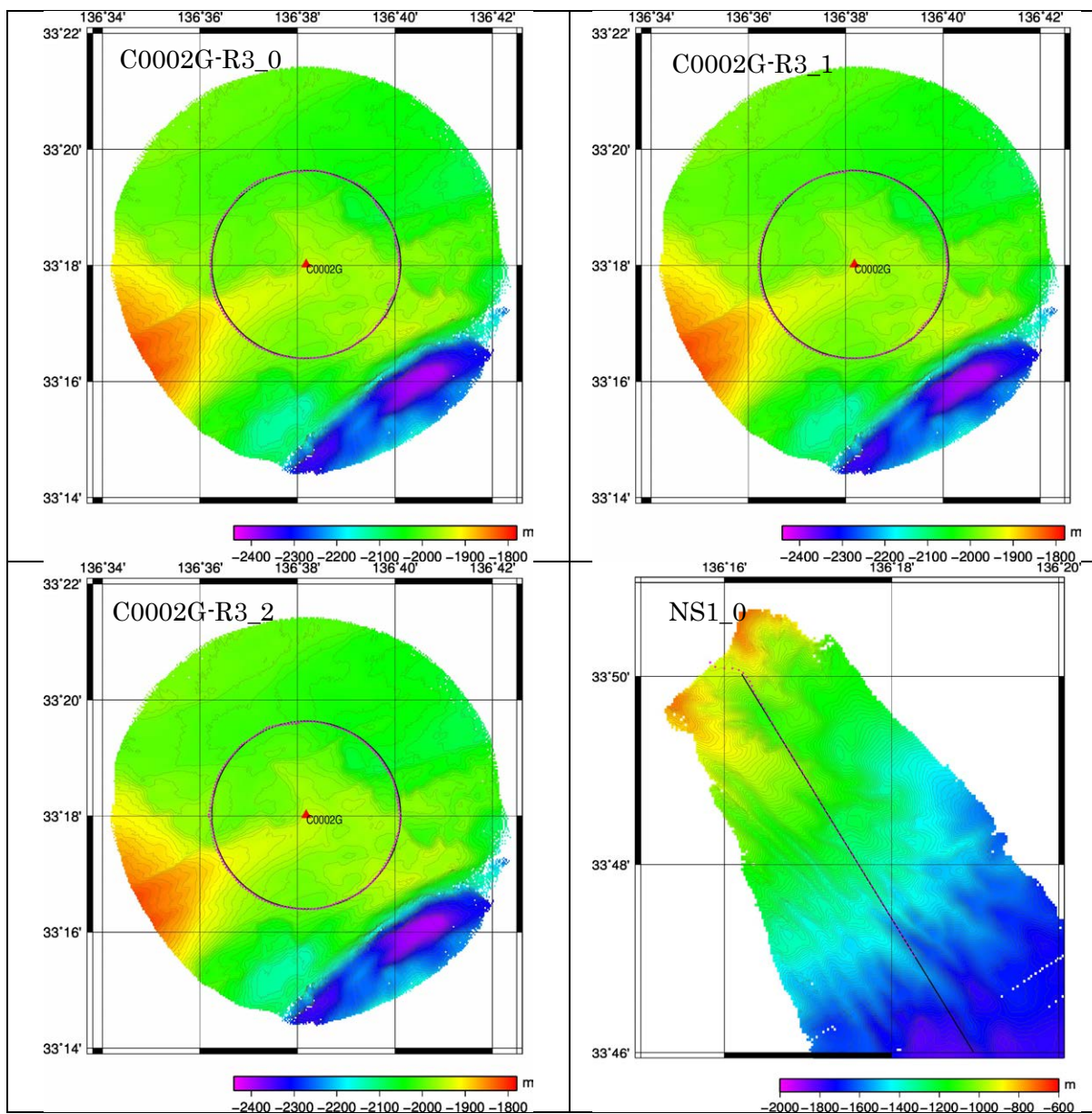


Fig. A1 Shot points of C0002G-R3_0, C0002G-R3_1, C0002G-R3_2, and NS1_0.

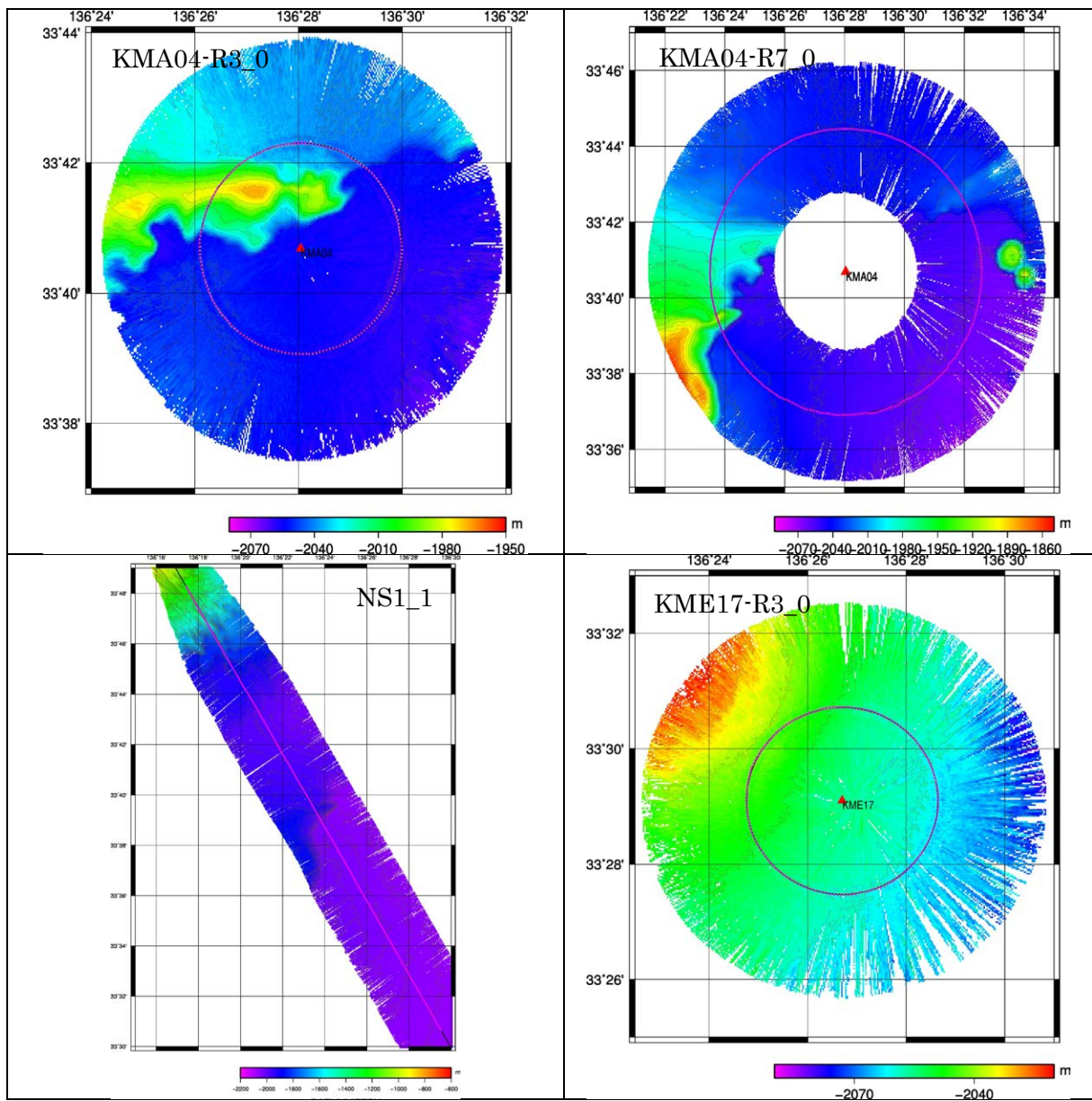


Fig. A2 Shot points of KMA04-R3_0, KMA04-R7_0, NS1_1, and KME17-R3_0

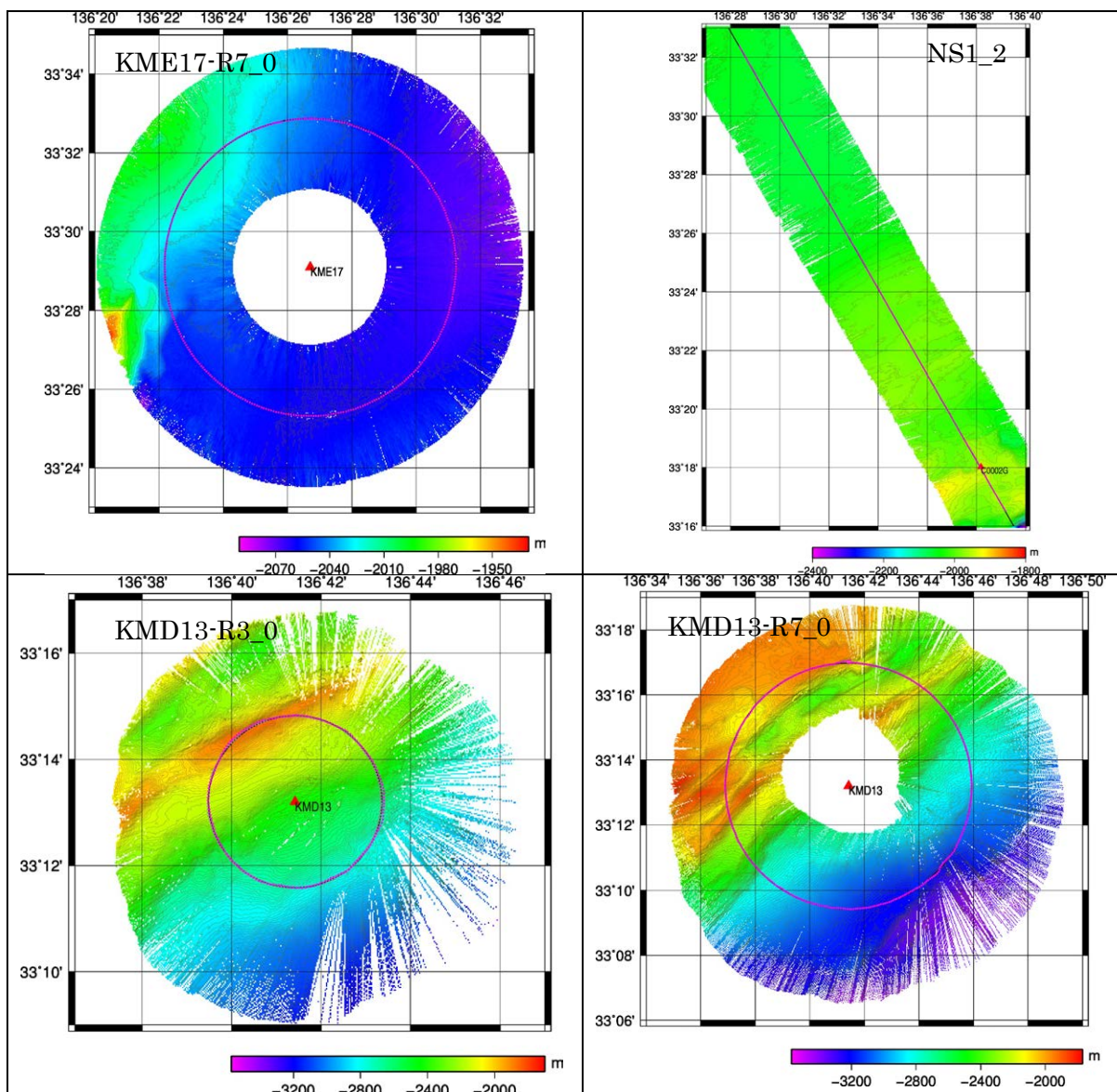


Fig. A3 Shot points of KME17-R7_0, NS1_2, KMD13-R3_0, and KMD13-R7_0 survey lines.

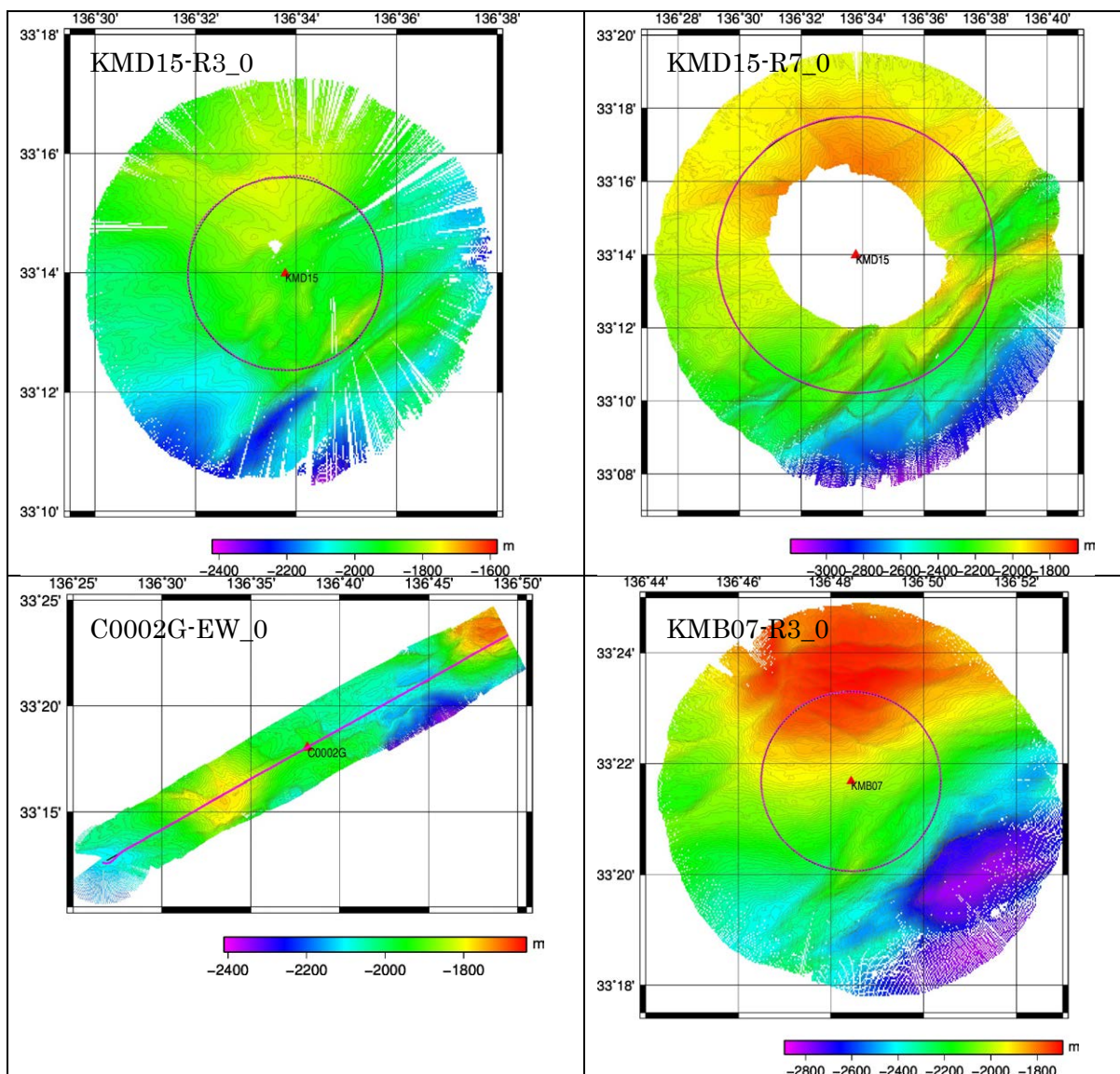


Fig. A4 Shot points of KME17-R3_0, NS1_3, KMC12-NS_0, and KMB07-R3_0 survey lines.

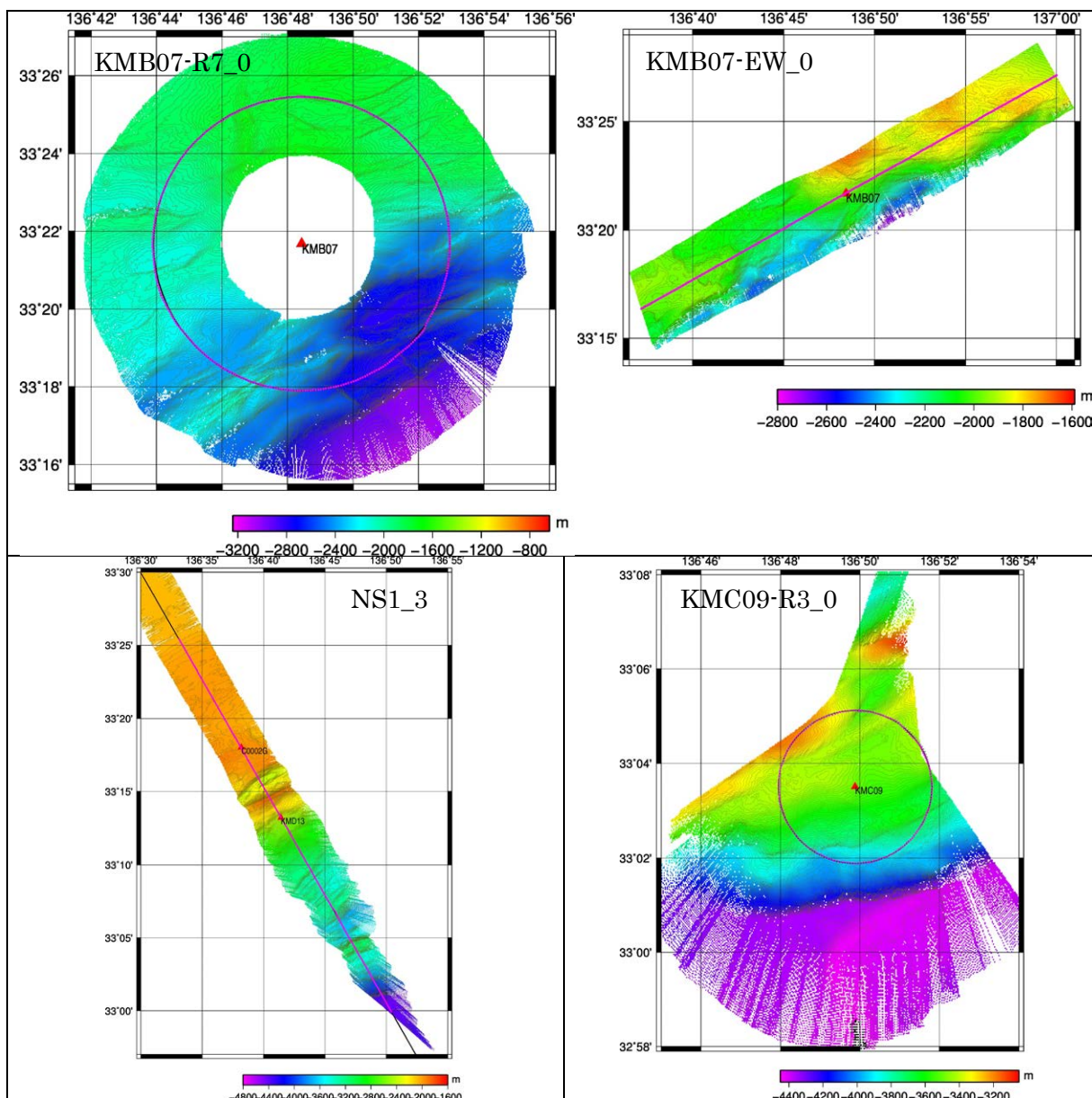


Fig. A5 Shot points of KMB07-R7_0, KMB07-EW_0, NS1_3, and KMC09-R3_0 survey lines.

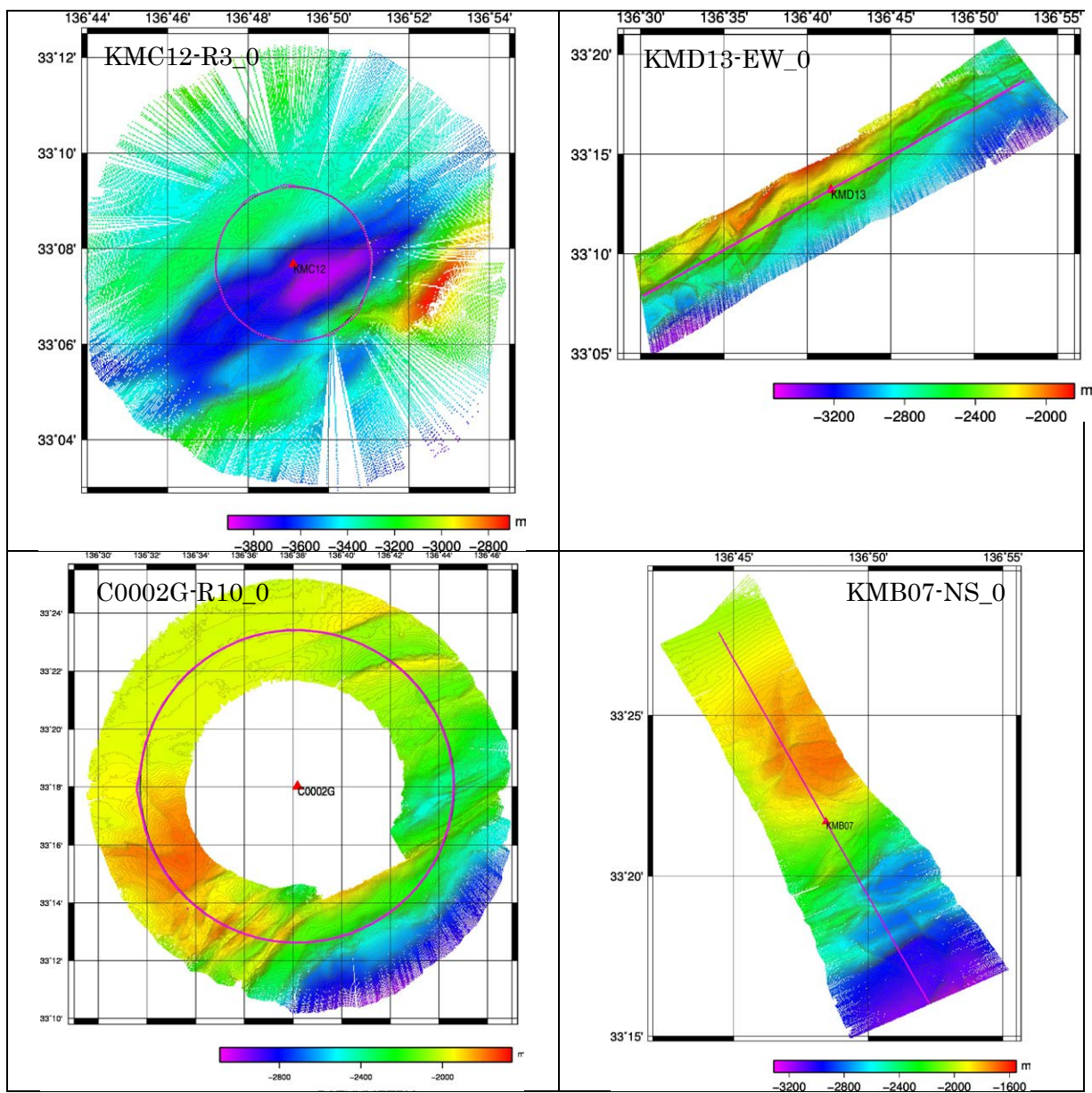


Fig. A6 Shot points of KMC12-R3_0, KMD13-EW_0, C0002G-R10_0, and KMB07-NS_0 survey lines.

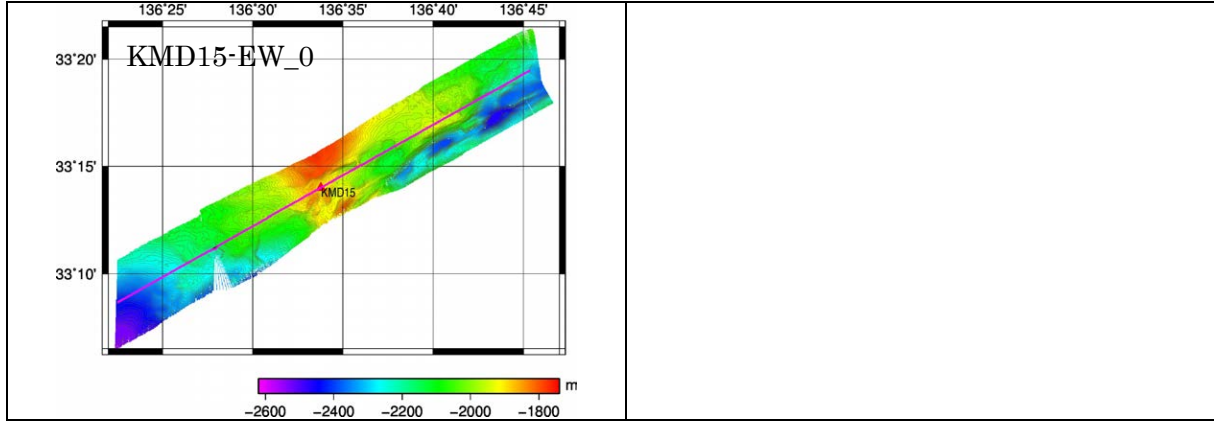


Fig. A7 Shot points of KMD15-EW_0 survey line.