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KAIREI Cruise Report

KR15-03

Monitoring of tsunamis by long-term seafloor EM observation

West Philippine Basin and near the Nishino-shima

20 February – 1 March, 2015

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

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KR15-03

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KAIREI

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Monitoring of tsunamis by long-term seafloor EM observation

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Monitoring of tsunamis by long-term seafloor EM observation

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20 February – 1 March, 2015

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JAMSTEC, Yokosuka – Port of Kochi

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West Philippine Basin and near the Nishino-shima

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2. Researchers

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2.2. Representatives of Science Party

Hiroaki Toh [Graduate School of Science, Kyoto University]

2.3. Science party

Researchers

Chief Scientist

Hiroaki Toh [Graduate School of Science, Kyoto University]

Representatives of Science Party

Hiroaki Toh [Graduate School of Science, Kyoto University]

Science party

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Kazuyoshi Hirata [MARITEC, JAMSTEC, support]

2.4. Captain, crew and KAIKO operation team

2.4.1 Captain and crew of the R.V. KAIREI

Captain	EIKO UKEKURA
Chief Officer	AKIHISA TSUJI
Jr. Chief Officer	TAKAFUMI AOKI
2nd Officer	KAZUKI MIYAKE
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	HIROTAKA SHIGETA
Sailor	KOSEI KAWAMURA
Sailor	HIDEAKI NAKATA
Sailor	YUSAKU KANADA
No.1 Oiler	TOSHIKAZU IKEDA
Oiler	KEIYA TANIGUCHI
Oiler	RYO SATO
Assistant Oiler	RYO MATSUUCHI
Assistant Oiler	AOI TAKAMIYA
Chief Steward	YUKIO TACHIKI
Steward	KANJI MAE
Steward	TORU WADA
Steward	TORU MURAKAMI
Steward	JUN SATO

2.4.2 KAIKO operation team

Operation Manager	ATSUMORI MIURA
1st ROV Operator	HOMARE WAKAMATSU
2nd ROV Operator	KIYOSHI TAKISHITA
2nd ROV Operator	SEIJI SHIGETAKE
2nd ROV Operator	JUNYA NIIKURA
2nd ROV Operator	YUDAI SAKAKIBARA
2nd ROV Operator	SHOTA IHARA
3rd ROV Operator	TAKUMA GOTO
3rd ROV Operator	YOICHI YASUE

2.5 Marine Technician

Satomi Minamizawa	Nippon Marine Enterprises, LTD.

3. Observation

3.1. Observation

3.1.1. Purpose and the background

Electric and magnetic (EM) fields are generated within ocean currents moving through the earth's magnetic field, and tsunami flows are also considered to generate EM fields in the ocean, what so called tsunami dynamo effect. A long-term Sea Floor EM Station (SFEMS) in the northwestern pacific (NWP) co-developed and co-operated by Kyoto University and JAMSTEC successfully enabled to measure the EM perturbations by the tsunami associated with the 2006 Kurile earthquake on 15 November in 2006 for the first time due to recent advances in high precision measurements of EM fields (Toh et al., 2011). Moreover, we have equipped a differential pressure gauge (DPG) with the SFEMS to simultaneously observe not only the EM perturbation but also the sea level change by tsunami since February of 2011, which is more enhanced performance than general tsunami measurement in that the observed data extracted tsunami characteristic including the direction and velocity of tsunami propagation as well as sea level change. We actually verified the effectiveness by the EM data detected from the 2011 Tohoku-oki earthquake tsunami. In this cruise we start the observation at the SFEMS for the tsunami associated with the collapse event by volcanic activities near the Nishino-shima volcano.

The Nishino-shima volcano of the Bonin Islands has been continued eruptive activity since 20 November in 2013. The purpose of this research cruise is to make scientific observation for the activity of the volcano and the tsunami associated with the collapse of a part of the volcano. We install Long-Term Ocean Bottom Seismometers (LTOBSs) developed by Earthquake Research Institute, University of Tokyo around the Nishino-shima, and collect infrasonic and visual data during the cruise. In addition, we make some preliminary experiments for development of a new monitoring system for the island volcano and/or the submarine volcano using an unmanned automated sea vehicle (Wave Glider developed by Liquid Robotics Inc.).

3.1.2. Observations

We retrieved the SFEMS#3 deployed at the western Philippine basin (WPB) on 15 November in 2012. The retrieved operation was done by KAIKO Mk-IV (Dive #648), which is the celebratory first dive of the Mk-IV. The SFEMS was found to have successfully recorded continuous electromagnetic time-series in addition to associated attitude data for about 2 years (from 15 November 2012 to 6 November 2014) with an interval of two minutes. The DPG attached to SFEMS recorded variations of ocean bottom pressure for 2 years and 2 months (from 14 November 2012 to 23 January 2015) by 100 Hz sampling.

We deployed the SFEMS#4 at around 10-km east to the Nishino-shima (Figure 2). The location was determined by the acoustic range measurement at three points via the ship bottom transducer using the acoustic communication system by Nichiyu Giken Ltd. (Code: 3F) equipped with the SFEMS#4. In addition, an ROV homer (ID: 21) was equipped with SFEMS in order to guarantee quick spotting. We confirmed the condition of the SFEMS in the observation by KAIKO Mk-IV (Dive #649). We also sampled several volcanic rocks around the station by KAIKO Mk-IV. We installed five LTOBSs around the Nishino-shima volcano, which are going to store data for 6 to 10 months (Figure 2). The locations were confirmed by the acoustic range measurements (Table 1). We mapped the bathymetry and the subsurface structure by onboard Multi-Beam Echo Sounding (MBES) and the sub-bottom profiler, respectively. Surface tow of a proton precession magnetometer was also conducted around the Nishino-shima whenever it was possible (Figure 3).

Four infrasonic microphones were set at the funnel deck of the KAIREI. The best installation to reduce wind and electric noises was explored and finally the infrasonic measurement for Nishino-shima volcano was done with three microphones. While KAIREI were close to Nishino-shima, the volcanic activity was taken by a video camera to be compared with the infrasonic data. As the experiments for the development of the Wave Glider observation system, which has been co-developing by Earthquake Research Institute, University of Tokyo and JAMSTEC, we tried data transfer via 'Thuraya' satellite phone, and conducted tests of two types of hydrophone.

3.1.3. Methods and Instruments

SFEMS is an electro-magnetometer on seafloor with high resolution of 0.1 nT and 50 nV/m in magnetic and electric fields, respectively. In this cruise, we deployed one SFEMS at depth of about 2200 m near the Nishino-shima, where is estimated 41480 nT and 25144 nT of total and vertical Earth's magnetic fields, respectively. Based on the ocean dynamo theory (e.g. Sugioka, Hamano et al. 2014), the SFEMS could detect tsunami with amplitude of 1-cm-order associated with volcanic activities.

DPG is very sensitive pressure sensor suitable for acoustic phenol in frequencies in 10 mHz to 10 Hz. It, however, could be compensated by a frequency response to be measurable in up to tidal bands, which is estimated by an experiment in laboratory (Araki and Sugioka, 2009).

LTOBS was developed by ERI of University of Tokyo. A three-component sensor (LE-3Dlite by Lennartz co ltd.) is installed in the LTOBS, which can sense in higher frequencies than 1 Hz to detect tremors associated with volcanic activities from Nishino-shima.

3.1.4. Research results

(1) We retrieved the SFEMS with DPG deployed at the western Philippine basin (WPB) on 15 November in 2012 to recover the data from 15 November 2012 to 6 November 2014 and from 14 November 2012 to 23 January 2015 recorded on the electromagnetometers and the DPG, respectively.

(2) We deployed one SFEMS and one LTOBS at around 10-km east to the Nishino-shima volcano and four LTOBSs at around 6-km area surrounding the volcano (Figure 3). The locations were determined by the acoustic range measurement at three points as shown in Table 1.

(3) We surveyed the sea bottom topography outside around 6-km area by the MBES (Figure 3).

(4) We conducted the infrasonic measurement for the Nishino-shima volcano by three microphones set at the funnel deck of the KAIREI. While KAIREI were close to the Nishino-shima, we took sequentially movies of the volcanic activity by video camera to be compared with the infrasonic data (Figure 4).

(5) We sampled the rocks around the Nishino-shima volcano by KAIKO Mk-IV (cf. Figure 5 and Table 2), which was associated with the former eruption. We will analyze the chemical components to understand the magmatic processes.
(6) We sampled some fresh volcanic ashes at the funnel deck of the KAIREI. We will analyze the structure of crystals and the chemical components.

3.2. Cruise log

2015/2/20 Sail out, proceeding to the research area.

Weather: Fine but cloudy / Wind direction: NE / Wind force: 4/ Wave scale: 3 /
Swell scale: 2 / Visibility: 7 miles/ (34-47.0N, 139-07.0E) 12:00JST

07:30	Onboard
08:30	Let go all shore line, left YOKOSUKA for research area
10:00-11:00	Carried out shipboard education & training for scientists
15:00-15:20	Briefing on KAIKO Mk-IV operation
16:40-17:00	KONPIRA Ceremony

2015/2/21 Proceeding to the research area

Weather: Cloudy/ Wind direction: SE / Wind force: 3 / Wave scale: 2 /
Swell scale: 2 / Visibility: 7 miles / (30-20.0N, 135-47.0E) 12:00 JST

09:00	Boat, fire, and collision station drill.

2015/2/22 Proceeding to the research area

Weather: Fine but cloudy / Wind direction: East / Wind force: 4 / Wave scale: 3 /
Swell scale: 2 / Visibility: 7 miles / （25-03.0N,135-28.0E） 12:00 JST

09:00-10:00	Onboard seminar.

2015/2/23 Arrive to research area (West Philippine Basin)

Weather: Fine but cloudy / Wind direction: East / Wind force: 5 / Wave scale: 3 /
Swell scale: 2 / Visibility: 7 miles / （19-28.0N,135-07.0E） 12:00 JST

12:45	Arrived at research area (West Philippine Basin).
12:52	Released XBT @ 19-20.3651N, 135-07.3473E

12:59-14:31	Carried out communication test of SFEMS3.
14:54-16:00	Carried out communication test of THURAYA XT.
16:09-16:20	Carried out figure eight running.

2015/2/24 ROV KAIKO Mk-IV Dive#648

Weather: Fine but cloudy / Wind direction: East / Wind force: 4 / Wave scale: 3 / Swell scale: 2 / Visibility: 7 miles /（19-19.5N,135-06.6E）12:00 JST

07:38	Hoisted up KAIKO Mk-IV
07:45	Launched KAIKO Mk-IV, and started 7K#648 dive operation.
10:40	KAIKO Mk-IV landed at sea bottom; depth= 5681m
11:36	KAIKO Mk-IV left bottom; depth= 5681m
14:35	Refloated KAIKO Mk-IV
14:59	Recovered KAIKO Mk-IV
15:46	Recovered SFEMS3
16:00	Left West Philippine Basin for next research area.

2015/2/25 Proceeding to research area

Weather: Fine but cloudy / Wind direction: North / Wind force: 2 / Wave scale: 2 / Swell scale: 1 / Visibility: 7 miles /（23-12.0N,137-56.0E）12:00 JST

Proceeded to research area.

2015/2/26 Arrive at research area (Nishino-shima)

Weather: Overcast / Wind direction: SSE / Wind force: 4 / Wave scale: 2 / Swell scale: 1 / Visibility: 7 miles /（27-12.0N,141-00.0E）12:00 JST

05:00	Arrived at research area (Nishino-shima).
05:30	Released XBT @ 27-08.6848N, 140-56.0619E
06:00-07:00	Carried out geophysical survey (MBES, SBP, and towing Proton magnetometer).
08:27	Deployed OBS-1 @ 27-12.029N, 141-00.5121E
08:43	Deployed SFEMS4 @ 27-11.9819N, 141-00.3554E
09:11-10:38	Carried out calibration OBS-1, SFEMS4.
11:32	Hoisted up KAIKO Mk-IV

11:38	Launched KAIKO Mk-IV, and started 7K#649 dive operation
13:27	KAIKO Mk-IV landed at sea bottom depth= 2131m
15:35	KAIKO Mk-IV left bottom depth= 2128m
17:14	Refloated KAIKO Mk-IV
17:21	Recovered KAIKO Mk-IV
18:26	Proceeded to geophysical survey (MBES, SBP and towing Proton magnetometer).

2015/2/27 Deploy OBS, and leave research area

Weather: Cloudy / Wind direction: SW / Wind force: 4 / Wave scale: 3 /
Swell scale: 2 / Visibility: 7 miles / （27-12.0N,140-50.0E） 12:00 JST

07:30	Finished geophysical survey.
07:46-07:58	Carried out figure eight running.
08:23	Deployed OBS-4 @ 27-17.3826N, 140-49.2071E.
08:38-09:02	Carried out calibration OBS-4.
09:31	Deployed OBS-3@ 27-18.2438N, 140-54.3710E.
09:45-10:09	Carried out calibration OBS-3.
10:40	Deployed OBS-2 @ 27-13.3316N, 140-56.2835E.
10:55-11:15	Carried out calibration OBS-2.
11:49	Deployed OBS-5 @ 27-11.8927N, 140-49.8781E.
12:06-12:30	Carried out calibration OBS-5.
13:13-14:40	Carried out hydrophone test and communication test of THURAYA XT.
15:09-15:32	Carried out MBES mapping and SBP survey.
16:00	Left research area for Kochi.

2015/2/28 Proceeding to Port of Kochi

Weather: Fine but cloudy / Wind direction: NNE / Wind force: 5 / Wave scale: 4 /
Swell scale: 3 / Visibility: 7 miles / （30-50.0N,136-42.0E） 12:00 JST

23:29-23:38	Carried out figure eight running.

2015/3/1 Arrive at Port of Kochi

09:00	Arrived at Port of Kochi.
11:00	Disembarked KAIREI
	Finished KR15-03 cruise.

4. Acknowledgements

We are indebted to the skillful help of the captain and crew members of R/V KAIREI and the operation team of ROV KAIKO Mk-IV. The shipboard party expresses its sincere thanks to the cordial land support given by JAMSTEC, Graduate School of Science, Kyoto Univ. and ERI, Univ. Tokyo.

5. Notice on use

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.

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[1] Toh, H., Satake, K., Hamano, Y., Fujii, Y., and Goto, T., Tsunami signals from the 2006 and 2007 Kuril earthquakes detected at a seafloor geomagnetic observatory, *J. Geophys. Res.*, 116, 2011.

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[3] Sugioka, H., Hamano, Y., Baba, K., Kasaya, T., Tada, N., and Suetsugu, D., Tsunami: Ocean dynamo generator, *Scientific Reports*, 2014.

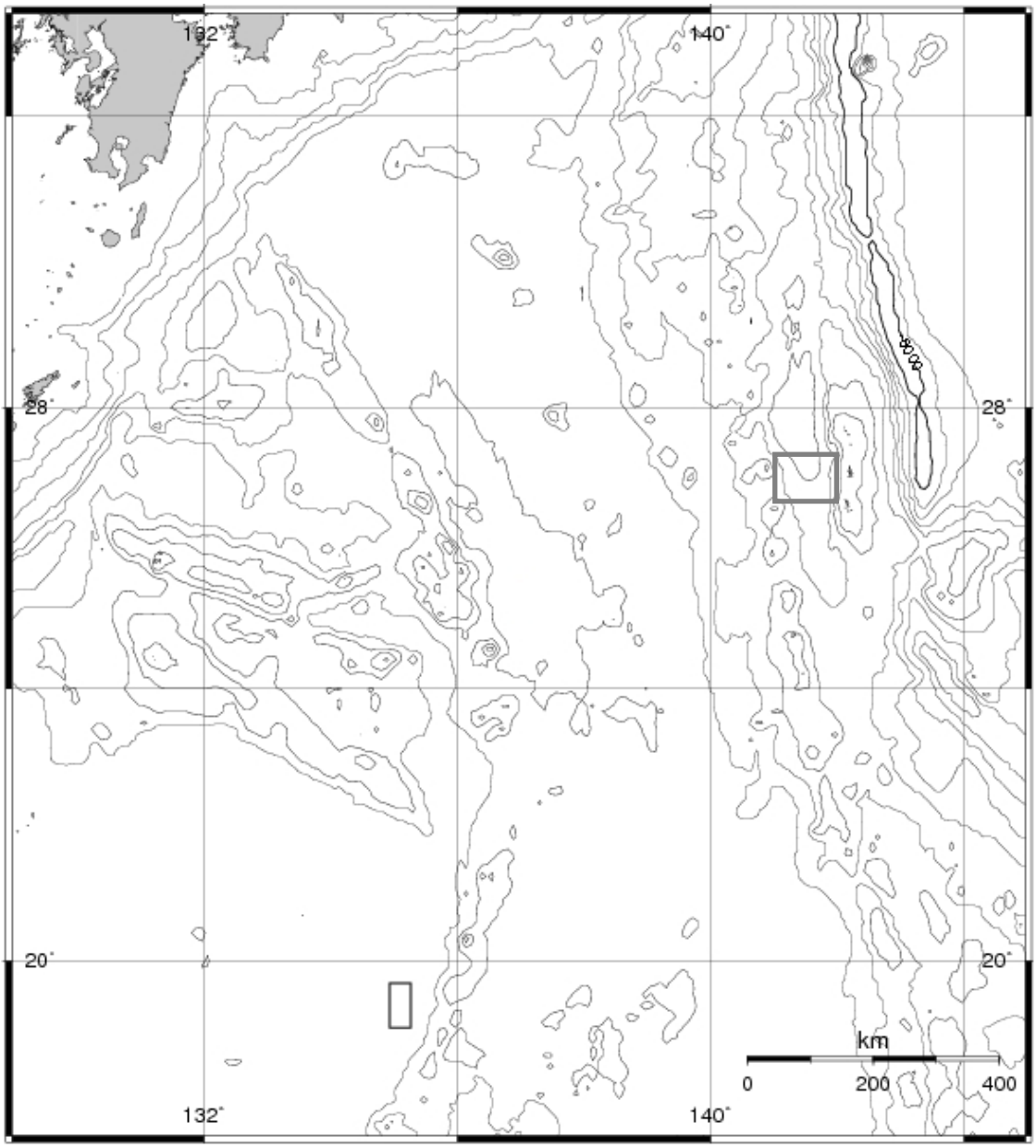

Figure 1: Location map of the surveyed sites. The sites of WPB and near the Nishino-shima are within the small rectangular area in the lower left and in the upper right, respectively.

Figure 2: Photographs of the SFEMS using A-frame crane (left) and the LTOBS using davit crane (right) launching on the deck.

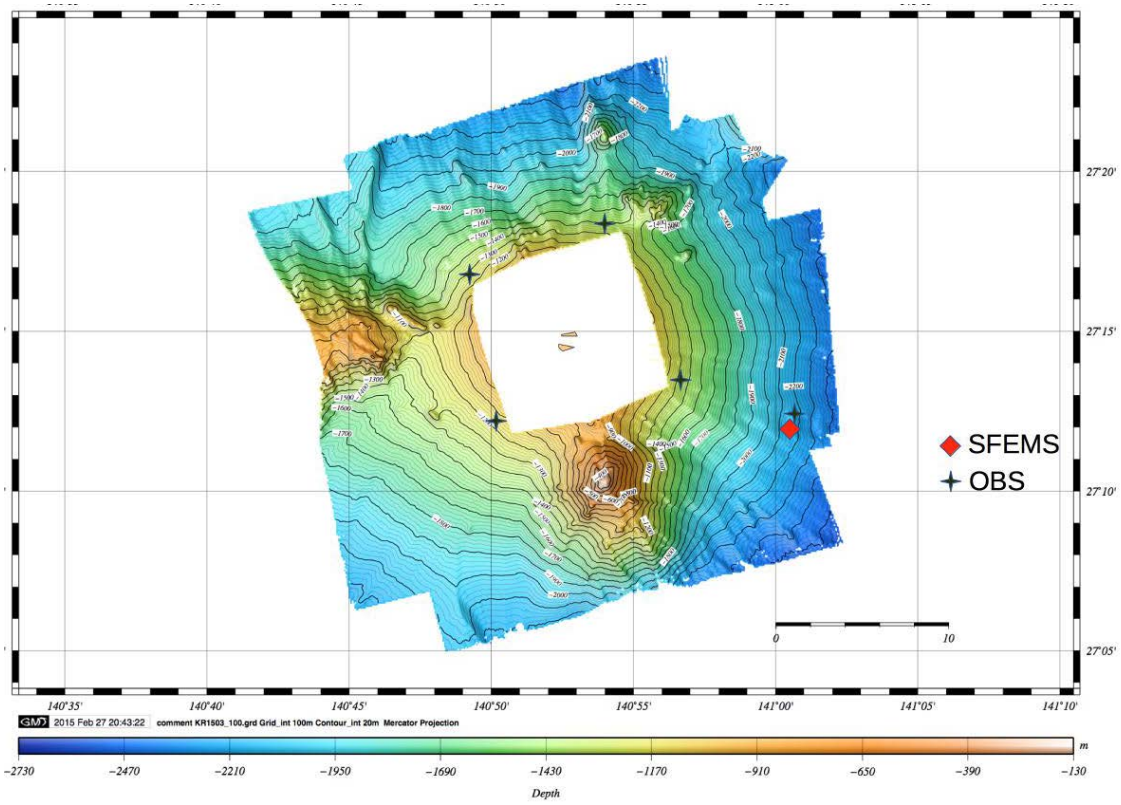

Figure 3: Sea topography map around the Nishino-shima volcano surveyed by the MBES and the deployed locations of one SFEMS and four LTOBSs indicated by red diamond black and black crosses, respectively.

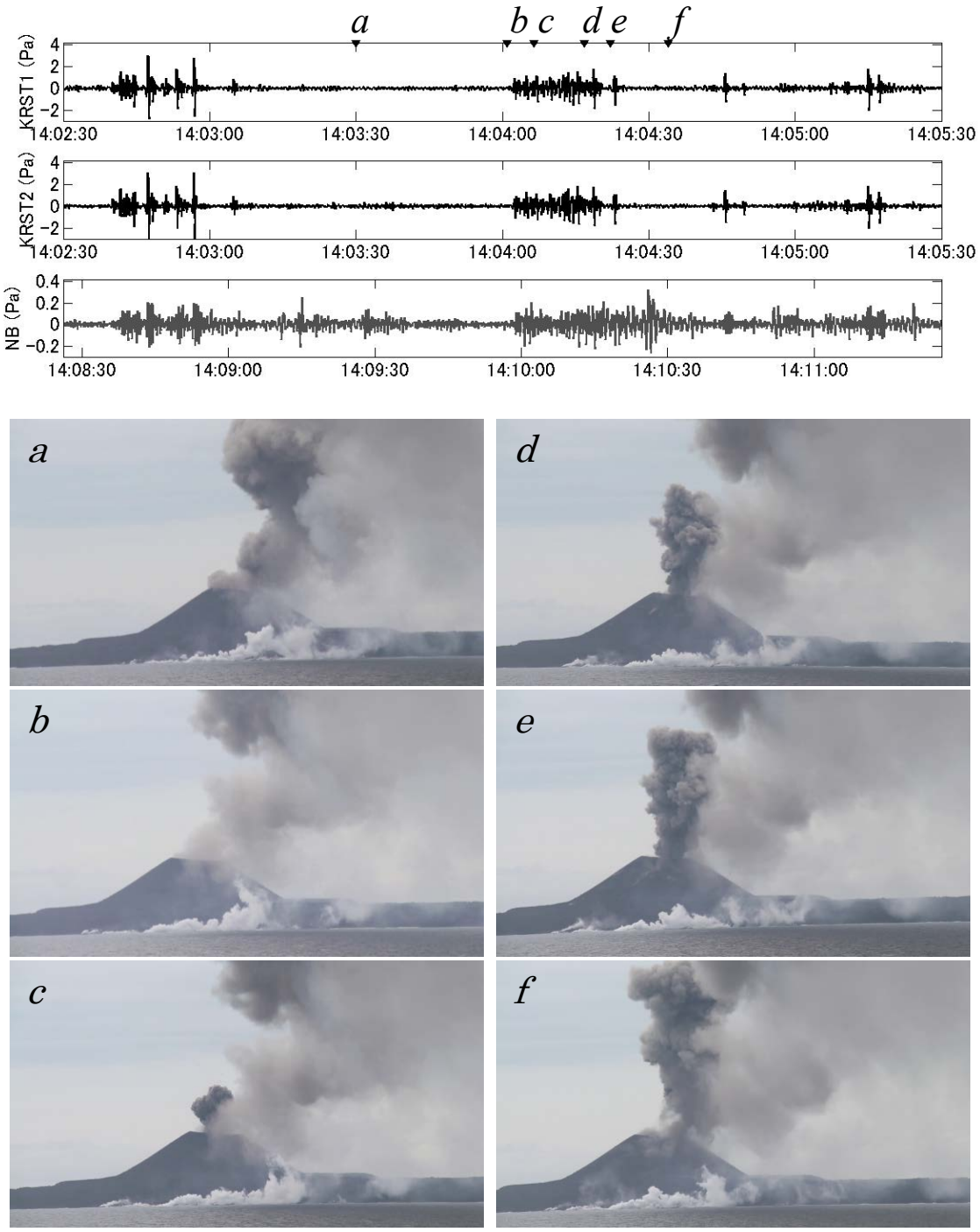

Figure 4: Example for infrasound waveforms associated with the Nishino-shima volcanic activity recorded on the deck of the KAIREI and corresponding photographs at the times marked by “a” to “f”.

Figure 5: Photographs of the volcanic rocks of R01 (upper left), R02 (upper right), R03 (lower left) and R04 (lower right) sampled by KAIKO Mk-IV.

Table 1: Location of SFEMS and LTOBSs

	Launched latitude (deg-min)	Launched longitude (deg-min)	Settled latitude (deg-min)	Settled longitude (deg-min)	Settled depth (m)
SFEMS	27-11.982N	141:00.529E	27-11.940N	141-00.424E	2218
LTOBS1	27-12.029N	141-00.512E	27-11.940N	141-00.424E	2177
LTOBS2	27-13.350N	140-56.298E	27-13.315N	140-56.268E	1258
LTOBS3	27-18.252N	140-54.348E	27-18.167N	140-54.219E	1335
LTOBS4	27-17.400N	140-49.200E	27-17.265N	140-49.052E	1389
LTOBS5	27-11.898N	140-49.902E	27-11.928N	140-49.895E	1238

Table 2: Information of sampled volcanic rocks

	Date and Time (JST)	Sampled latitude	Sampled longitude	Sampled depth (m)	Size (cm)	Weight (kg)
R01	2015/02/26 14:21	27-11.9606N	141-00.4154E	2138	28x23x17	11.3
R02	2015/02/26 14:43	27-11.9383N	141-00.3763E	2133	13x15x7	1.8
R03	2015/02/26 14:54	27-11.9378N	141-00.3802E	2133	-	-
R04	2015/02/26 15:16	27-11.9202N	141-00.3608E	2129	10x5x5	0.4