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KAIREI Cruise Report

KR12-18

Research dive by KAIKO7000II

Shikoku Basin, Philippine Sea

November 12 – 25, 2012

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

Contents

1. Cruise Information

1.1. Cruise number

KR12-18

1.2. Ship's name

KAIREI

1.3. Title of the cruise

Research dive by KAIKO7000II

1.4. Titles of the proposal

• Monitoring of tsunamis by long-term seafloor EM observation

• Experimental studies for development of ocean bottom seismometers in the next generation

1.5. Cruise period

November 12 – 25, 2012

1.6. Port call

Port of Shingu – Jamstec, Yokosuka

1.7. Research Area

Shikoku Basin, Philippine Sea

1.8. Research Map

Refer to Figs. 1 & 2

2. Researchers

2.1. Chief Scientist

Hiroaki Toh [Graduate School of Science, Kyoto University]

2.2. Representatives of Science Party

Hiroaki Toh [Graduate School of Science, Kyoto University]

Hajime Shiobara [Earthquake Research Institute, University of Tokyo]

2.3. Science party

Hiroaki Toh [Graduate School of Science, Kyoto Univ., chief]

Hajime Shiobara [Earthquake Research Institute, Univ. Tokyo, co-chief]

Yozo Hamano [IFREE, JAMSTEC, support]

Noriko Tada [IFREE, JAMSTEC, support]

Hiroko Sugioka [IFREE, JAMSTEC, support]

Aki Ito [IFREE, JAMSTEC, support]

Takuto Minami [Graduate School of Science, Kyoto Univ., support]

Issei Kawashima [Faculty of Science, Kyoto Univ., support]

2.4. Captain, crew and KAIKO operation team

2.4.1. Captain and crew of the R.V. KAIREI

Captain	MASAYOSHI ISHIWATA
Chief Officer	HIROAKI MASUJIMA
2nd Officer	ISAO MAEDA
3rd Officer	HIDEHIKO KONNO
Chief Engineer	TADASHI ABE
1st Engineer	KANUNORI NOGUCHI
2nd Engineer	RYUZO MIKAMI
3rd Engineer	YOSHIHIRO OTSUGA

Chief Electronics Operator	NASU TOKINORI
2nd Electronics Operator	SHUNSUKE FUKAGAWA
3rd Electronics Operator	TAKATOMO SHIROZUME
Boat Swain	TADAHIKO TOGUCHI
Able Seaman	TAKAO KUBOTA
Able Seaman	YOSHIAKI MATSUO
Able Seaman	SAIKAN HIRAI
Sailor	HIROTAKA SHIGETA
Sailor	YOSHIHIRO OGAWA
Sailor	YASUNOBU KAWABE
No.1 Oiler	KAZUAKI NAKAI
Oiler	SHINYA SUGI
Oiler	MASANORI UEDA
Assistant Oiler	DAIKI IGARASHI
Assistant Oiler	AOI TAKAMIYA
Chief Steward	ISAO MATSUMOMTO
Steward	HIDEO FUKUMURA
Steward	KAZUHIRO HIRAYAMA
Steward	NAKAMICHI KANDA
Steward	MANAMI TAKAHASHI

2.4.2. KAIKO operation team

Operation Manager	ATSUMORI MIURA
2nd ROV Operator	KIYOSHI TAKISHITA
2nd ROV Operator	TOMOE KONDO
2nd ROV Operator	TETSUYA ISHITSUKA
2nd ROV Operator	SHIGERU KIKUYA
2nd ROV Operator	SEIJI SHIGETAKE
3rd ROV Operator	SHOTA IHARA
3rd ROV Operator	TAKUMA GOTO

2.5. Marine Technician

Takuya Onodera	Nippon Marine Enterprises, LTD.

3. Observation

3.1. Observation

3.1.1. Purpose and the background

The objective of the first proposal is to make a feasible study of a new method for tsunami monitoring by electromagnetic (EM) observation. To achieve this, long-term EM observation at the seafloor is indispensable as well as development of a new type of sensors such as a seafloor EM station with a precise pressure gauge. The present proposal is based on collaboration between Graduate School of Science, Kyoto University and IFREE, JAMSTEC and use of ROV is essential at the time of sea experiments in order to establish a semi-permanent EM tsunami observatory at the seafloor.

The purpose of the second proposal is the practical test observation of our newly developed instruments, the broadband ocean bottom seismometer of the next generation with tilt measurement (BBOBST-NX), the new ultra deep ocean bottom seismometer (NUDOBS), and the vector tsunami meter (VTM). The BBOBST-NX has the same construction of the BBOBS-NX, which is already in practical use, except for the additional function to obtain mass position signals from two horizontal components of the broadband sensor. The NUDOBS is the OBS of a completely new concept design that can be deployed up to 10000m depth without using any underwater cables nor the traditional anchor releasing system. Some experimental OBSs in such deep water had been tried several times, but there were no good results from the viewpoint of the instrumental development. The VTM is a combination of the ocean bottom electro-magnetometer (OBEM) and the differential pressure gauge (DPG) as the new integrated instrument, which is based on the idea of the first proposal.

3.1.2. Observations

Not only the seafloor EM field but also the seismic wave and ocean bottom pressure should be monitored over a significantly long duration of time in order to establish a new method for tsunami early warning. The kinetic measurements will be combined with those of the seafloor EM field to give unprecedentedly detailed properties of tsunamis. For instance, tsunami-induced magnetic signals in the horizontal

components enable direction finding of tsunami propagation while the ocean bottom pressure and the vertical geomagnetic component is the direct measure of tsunami height. The combination, therefore, give us information on tsunami kinetic fields such as dispersive/non-dispersive nature of specific tsunamis.

The BBOBS-NX, the ocean bottom Doppler current profiler (OBDC), the NUDOBS and the VTM are planned to deploy closely each other at the T08 site (about 4900m depth) in the southwestern tip of the Shikoku Basin, where several BBOBS and BBOBS-NX were deployed since 2005. To minimize the operation time of the ROV, they are tried to arrive at the seafloor within distances of 200m. All instruments will be recovered in the KR13-03 cruise.

3.1.3. Methods and instruments

A SeaFloor ElectroMagnetic Station (SFEMS3) with a differential pressure gauge (DPG) was deployed at Site WPB (the West Philippine Basin) in place of the already installed SFEMS5 that had been also equipped with a DPG. A buoy system was attached to SFEMS3 so as to give it sufficient buoyancy for ROV KAIKO7000II to handle it easily in seawater. In addition, an ROV homer (the acoustic responder) was specially arranged and equipped with SFEMS3 in order to guarantee quick spotting and relative positioning of SFEMS3 w.r.t. SFEMS5 at the seafloor. The DPGs enable a new interdisciplinary collaboration among Geomagnetism, Seismology and Oceanography to study ocean dynamics using the simultaneous geoelectromagnetic and pressure fluctuations.

Although the BBOBS-NX has been applied for our large-scale research project, the goal of the development is still far away, because the goal is the BBOBS-NX of capability to operate without the ROV, like as the self pop-up type OBS. In this observation, as the first step to realize it, the effect of existing a large object inside of the sensor unit is examined. The OBDC is also deployed to measure the environmental condition. As it is the first test for the NUDOBS that is designed as the free-fall deployment and self pop-up recovery type OBS, all its function at the seafloor should be checked from the ROV through the dive in this cruise and the recovery dive in Feb. 2013. This time, the first function to become the observation mode is observed. It is also the first observation for the VTM, to examine its function. With the

BBOBST-NX and the OBDC deployed nearby, seismic and tilt signals in a long period range and the bottom current data will be used to examine the VTM data to understand its performance in detail.

3.1.4. Research results

Thanks to the capability of the ROV and pertinent navigation by R/V KAIREI, the two SFEMSs were placed within a distance of 14.3 m at the seafloor. After the delivery of the new SFEMS (SFEMS3) by the ROV, the old SFEMS (SFEMS5) was successfully retrieved also by KAIKO 7000II. The old SFEMS was found to have successfully recorded continuous geoelectromagnetic time-series in addition to associated attitude data for 21 months with an interval of two minutes. The DPG attached to SFEMS5 recorded variations of ocean bottom pressure for 2 months by 10 Hz sampling, which turned out to contain the tsunamis caused by the M9 megaquake on March 11, 2011. Surface tow of a proton precession magnetometer was also conducted around WPB whenever it was possible.

Drop positions of the NUDOBS, the OBDC and the BBOBST-NX were determined after the arrival of the VTM at the seafloor, which has ability of the SSBL positioning. Except for the OBDC, which was drifted 130m away in the northwest direction, three other instruments were located within about 60m distance. At that time, it was found that the BBOBST-NX could not work partly through the underwater communication by the acoustic transponder system. On the next day, the dive (#588) was started to move the OBDC nearby the VTM at first, then the ROV observed the NUDOBS's function commanded from the ROV through the underwater communication, and finally we tried to control the BBOBST-NX again. As it was sure that the problem could not be solved, we decided to pick up the BBOBST-NX to the ship and to repair and re-deploy for the possible dive on the next day. The reason of the trouble was found at the underwater cable within a few hours after it was on the deck. By replacing the cable set, the BBOBST-NX became ready in the night and was dropped in the next morning before the dive (#589), then it arrived at the seafloor close to the NUDOBS again. The ROV work was smoothly performed until the final process, putting the titanium sphere housing above the sensor unit by using the base made of a large diameter plastic tube, which was settled successfully inside of the sensor unit. Finally, we stopped to do it

due to difficulty because of too small room of size, and the sphere was settled close to the sensor unit, as this situation could make the similar test condition of our purpose. We have a plan to put the titanium sphere housing on the base and make one-day observation before the recovery in the next cruise.

3.2. Cruise log

2012/11/12 Sail out, proceeding to the research area.

Weather: Fine but cloudy, Wind direction: WSW, Wind force: 4 (Moderate breeze), Wave: 4 (Sea moderate), Swell: 4 (Moderate average), Visibility: 8 n.m., (33-04.3'N, 136-05.6'E) 12:00JST

08:00	Onboard
09:00	Let go all shore line, left SHINGU for research area.
10:00-10:25	Carried out shipboard education & training for scientists
10:25-10:45	Briefing on KAIKO 7000II operation
16:40-17:00	KONPIRA Ceremony

2012/11/13

Weather: Cloudy, Wind direction: West, Wind force: 4 (Moderate breeze), Wave: 3 (Sea slight), Swell: 3 (Moderate short), Visibility: 8 n.m., (27-19.8'N, 135-46.2'E) 12:00 JST

Proceeding to the research area.

2012/11/14

Weather: Fine but cloudy, Wind direction: NNE, Wind force: 4 (Moderate breeze), Wave: 3 (Sea slight), Swell: 2 (Low swell long), Visibility: 8 n.m. (22-13.9'N, 135-20.8'E) 12:00 JST

Proceeding to the research area.

2012/11/15 Deploy SFEMS3 at WPB.

Weather: Fine but cloudy, Wind direction: NE, Wind force: 6 (Strong breeze), Wave: 4 (Sea moderate), Swell: 3 (Moderate short), Visibility: 8 n.m. (19-19.8'N, 135-06.6'E) 12:00 JST

05:50	Arrival at Site WPB.
05:56	Launch XBT at 19-23.9924N, 135-07.0129E.
06:23-06:46	Carried out MBES mapping survey.
08:19	Launch SFEMS3 at 19-19.3819N, 135-06.6980E.
11:36	SFEMS3 arrived at the seafloor (Depth=5688m).
11:42-12:35	SSBL calibration commenced.
14:05-17:00	Carried out surface tow of a proton magnetometer.

2012/11/16 Measuring magnetic anomalies by a proton magnetometer.

Weather: Fine but cloudy, Wind direction: NE, Wind force: 6 (Strong breeze), Wave: 5 (Sea rough), Swell: 4 (Moderate average), Visibility: 8 n.m. (19-22.0'N, 135-10.0'E) 12:00 JST

08:00	KAIKO 7000II dive suspended due to rough sea.
08:28-16:37	Carried out surface tow of a proton magnetometer.
18:40	Proceeded to the SFEMS3 installation site.

2012/11/17 Measuring magnetic anomalies by a proton magnetometer.

Weather: Fine but cloudy, Wind direction: East, Wind force: 4 (Moderate breeze), Wave: 4 (Sea moderate), Swell: 4 (Moderate average), Visibility: 8 n.m. (19-26.0'N, 135-04.0'E) 12:00 JST

06:00	Arrived at the SFEMS3 point.
08:30	KAIKO 7000II dive suspended due to rough sea.
09:31	Launched a proton magnetometer.
09:56	Commenced grid survey of magnetic anomalies around WPB.

2012/11/18 KAIKO 7000II Dive #587.

Weather: Fine but cloudy, Wind direction: ENE, Wind force: 3 (Gentle breeze), Wave: 3 (Sea slight), Swell: 3 (Moderate short), Visibility: 8 n.m. (19-19.5'N, 135-06.7'E) 12:00 JST

03:50	Finished the grid survey and proceeded to dive point.
06:02	The proton magnetometer recovered.
07:29	Launched KAIKO 7000II.
10:06	KAIKO 7000II arrived at the seafloor (Depth=5692m).

12:04	KAIKO 7000II left the seafloor (Depth=5690m).
14:48	Recovered KAIKO 7000II.
15:25	Recovered SFEMS5.
15:55-18:02	Carried out SSBL Calibration of SFEMS3.

2012/11/19 Recover the auxiliary mooring system attached to SFEMS3

Weather: Fine but cloudy, Wind direction: WSW, Wind force: 2 (Light breeze), Wave: 2 (Sea smooth), Swell: 2 (Low swell long), Visibility: 8 n.m. (20-43.7'N, 135-30.5'E) 12:00 JST

05:00	Released the mooring system.
06:05	Spotted on the sea surface.
06:14	The mooring system on deck.
06:15	Proceeded to the Shikoku Basin.

2012/11/20 Deploy VTM, NUDOBS, OBDC and BBOBST-NX.

Weather: Fine but cloudy, Wind direction: North, Wind force: 4 (Moderate breeze), Wave: 3 (Sea slight), Swell: 2 (Low swell long), Visibility: 8 n.m. (25-46.0'N, 137-00.5'E) 12:00 JST

09:00	Arrived at the Shikoku Basin.
09:02	Launched XBT at (25-36.7841N, 136-58.5067E).
09:44-10:06	Carried out MBES mapping survey.
10:46	Launched VTM at (25-46.01N, 137-07.54E).
	Arrived at (25-45.9437N, 137-00.4837E, Depth=4894m).
13:33	Launched NUDOBS at (25-46.0192N, 137-00.5171E).
	Arrived at (25-45.9603N, 137-00.5156E, Depth=4898m).
13:42	Launched OBDC at (25-46.0291N, 137-00.5025E).
	Arrived at (25-46.0365N, 137-00.4657E, Depth=4902m).
13:46	Launched BBOBST-NX at (25-46.0650N, 137-00.4896E).
	Arrived at (25-45.9590N, 137-00.4978E, Depth=4895m).
14:15-16:25	Carried out semi-circle calibration.

2012/11/21 KAIKO 7000II Dive #588.

Weather: Fine but cloudy, Wind direction: North, Wind force: 4 (Moderate breeze), Wave: 3

(Sea slight), Swell: 3 (Moderate short), Visibility: 8 n.m. (25-46.0'N, 137-00.4'E) 12:00 JST

06:00	Arrived at the dive site.
07:42	Launched KAIKO 7000II and Dive #588 commenced.
10:17	KAIKO 7000II arrived at the seafloor (Depth=4905m).
14:05	KAIKO 7000II left the seafloor (Depth=4901m).
16:31	Recovered KAIKO 7000II.
16:36	Recovered BBOBST-NX.

2012/11/22 KAIKO 7000II Dive #589.

Weather: Fine but cloudy, Wind direction: ENE, Wind force: 2 (Light breeze), Wave: 1 (Calm), Swell: 1 (Low swell sea), Visibility: 8 n.m. (19-19.5'N, 135-06.7'E) 12:00 JST

05:51	Launched BBOBST-NX at 25-45.9582N, 137-00.5528E.
	Arrived at (25-45.9755N, 137-00.5314E, Depth=4896m).
06:50-07:17	Carried out BBOBST-NX semi-circle calibration.
08:26	Launched KAIKO 7000II and Dive #589 commenced.
10:59	KAIKO 7000II arrived at the seafloor (Depth=4901m).
12:53	KAIKO 7000II left the seafloor (Depth=4901m).
15:22	Recovered KAIKO 7000II.
16:30	Left the research area.
17:00	Proceeded to Jamstec, Yokosuka.

2012/11/23 Transit to Jamstec, Yokosuka.

Weather: Overcast, Wind direction: SW, Wind force: 5 (Fresh breeze), Wave: 4 (Sea moderate), Swell: 3 (Moderate short), Visibility: 4 n.m., (30-37.0'N, 136-00.0'E) 12:00 JST

08:30-09:30	Boat, fire, collision station drill at 29-45N, 136-00E.

2012/11/24

Weather: Cloudy, Wind direction: West, Wind force: 4 (Moderate breeze), Wave: 3 (Sea slight), Swell: 3 (Moderate short), Visibility: 8 n.m., (27-19.8'N, 135-46.2'E) 12:00 JST

Transit to Jamstec, Yokosuka.

2012/11/25

09:00 Arrival at Jamstec, Yokosuka.

4. Acknowledgements

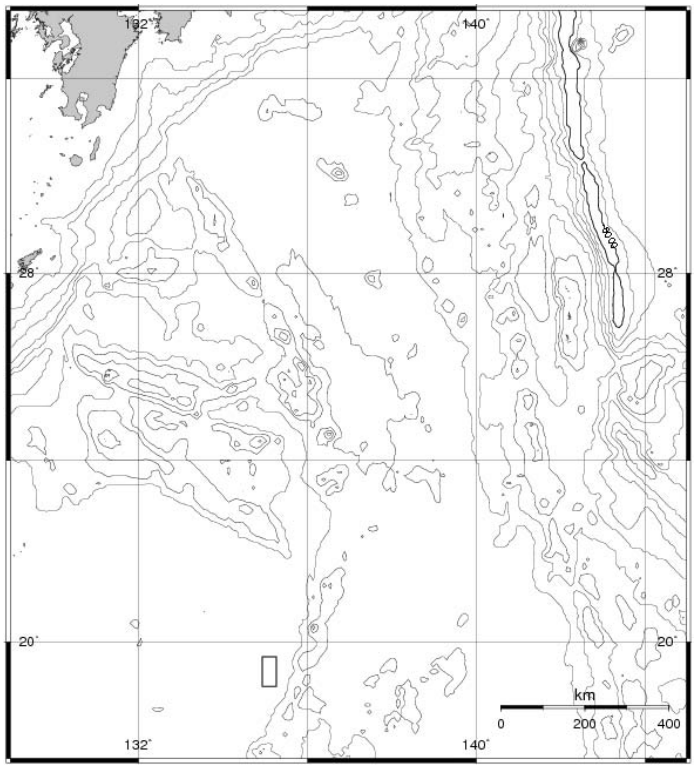
We are indebted to the skillful help of crew members of R/V KAIREI and the operation team of ROV KAIKO 7000II at the time of the sea experiments. The shipboard party expresses its sincere thanks to the cordial land support given by IFREE, JAMSTEC and Graduate School of Science, Kyoto Univ. in addition to ERI, Univ. Tokyo.

5. Notice on use

This cruise report is a preliminary documentation as of the end of the cruise. It may not be corrected even if changes on content (i.e. taxonomic classifications) are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the Chief Scientist for the latest information before use.

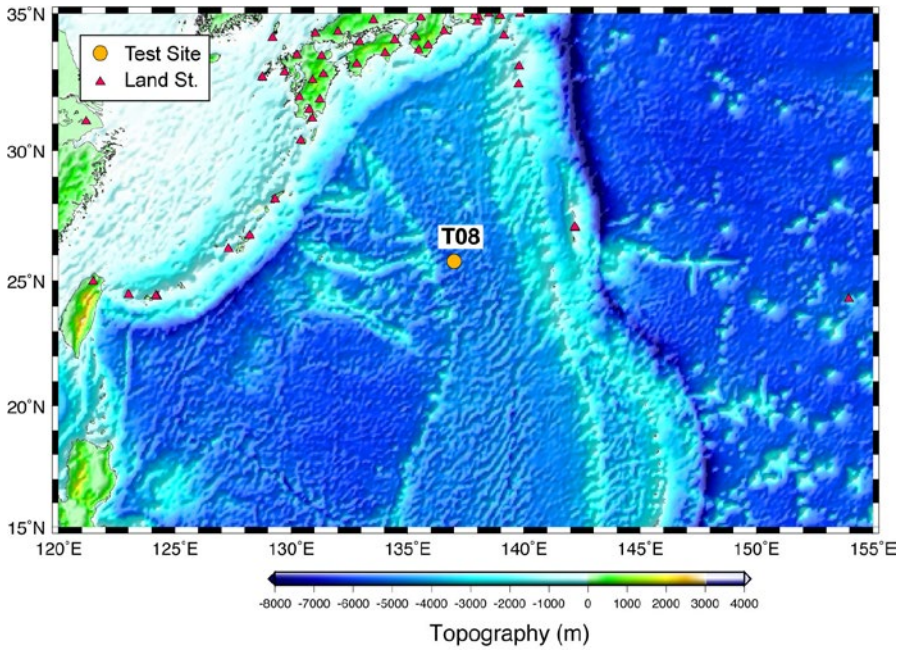
Users of data or results of this cruise are requested to submit their results to Data Integration and Analysis Group (DIAG), JAMSTEC.

Figure 1



The dive site WPB is within the small rectangular area in the lower left of this figure.

Figure 2



The dive site T08.