# Cruise Summary

**1. Cruise Information**

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|---|---|
| Cruise ID | KR11-10 |
| Name of vessel | KAIREI |
| Title of the cruise | Deployment and recovery of BBOBS's and OBEM's in Northwest Pacific Ocean |
| Chief scientist [Affiliation] | Hisashi Utada [ERI, Univ. Tokyo] |
| Co-Chief Scientist | Hajime Shiobara [ERI, Univ. Tokyo] |
| Representative of the Science Party [Affiliation] | Hisashi Utada [ERI, Univ. Tokyo] |
| Title of proposal | New phase of Ocean Hemisphere Project: Imaging the normal oceanic mantle by advanced ocean bottom observations |
| Cruise period | Nov.16 – 30, 2011 |
| Ports of call | JAMSTEC Yokosuka - Sendai |
| Research area | Northwest Pacific Ocean |
| Research area map | See Fig. 1. |

**2. Overview of the observation**

**2.1. Purpose and background**

We proposed and funded by Grant-in-aid for specially promoted research (JSPS) to conduct a research program in 5 years toward understanding of the mantle dynamics from an innovative observational approach by answering two fundamental questions in Earth science:

**(a)** ***What is the physical condition for the lithosphere-asthenosphere boundary (LAB)?***

**(b)** ***Is the mantle transition zone (MTZ) a major water reservoir of the Earth?***

The "normal" ocean floor is the best window to approach these questions as it allows us to see the inside of the Earth through it without the disturbance due to the thick and heterogeneous continental crust. However, any approach, if ever attempted, has not yet been successful because of technological difficulties in obtaining high-quality geophysical data in the ocean.

The present investigators had led the Ocean Hemisphere network Project (OHP) in 1996-2001, in which a network of geophysical observatories was built in the western Pacific region. Data from the OHP network, especially from broadband seismographs on land and under water, precise magnetometers, submarine cables to measure electric field, successfully provided improved global images of the Earth's interior in terms of seismic velocities and electrical conductivity (e.g., Utada et al., ***GRL***, 2003). During the OHP project, we had also developed a set of new portable ocean bottom instruments, broadband ocean bottom seismometers (BBOBSs) and ocean bottom electro-magnetometers (OBEMs).

These new observation technologies have been fully utilized in the 5-year Stagnant Slab Project (SSP) that succeeded the OHP since 2004. In the SSP, we have carried out a long-term (3 years in total) joint observation of BBOBSs and OBEMs in the Philippine Sea (Shiobara et al., ***EOS***, 2009) to study the MTZ where the subducted Pacific slab appears to be stagnating. We have made significant contributions to the SSP by obtaining results such as the estimation of water content in the MTZ by joint interpretation of seismic and electromagnetic tomography (Koyama, Utada et al., ***AGU Monograph***, 2006) and the seismic evidence for water transportation deep into the mantle by subducting slab (Kawakastu & Watada, ***Science***, 2007). We also revealed the upper mantle structure in this region by analyzing BBOBS data (Isse et al. *PEPI*, 2010) and OBEM data (Baba et al., *PEPI*, 2010). From the northwest Pacific Ocean, Kawakatsu et al. (*Science*, 2009) presented seismic evidence that indicates the lithosphere-asthenosphere boundary to be a sharp seismic discontinuity. Integration of these pieces of evidence obtained by existing technology is undoubtedly useful to solve two questions, but it is not enough.

Recently, we developed further innovative instruments (**BBOBS-NX**: broadband ocean bottom seismometer next generation; **EFOS**: Earth electric field observation system). By improving the mechanical coupling between the sensor housing and seafloor sediments, the **BBOBS-NX** enables us to record horizontal seismic motions, as well as vertical ones, with a typical noise level comparable to land observations. This gives us a strong advantage over other OBS's because it allows us to apply station-based powerful seismic analysis methods commonly used on land, such as the receiver function and shear-wave splitting analyses, for ocean bottom data. The **EFOS**, on the other hand, measures the electric voltage difference at the seafloor by using a 10 km long cable. Compared to the OBEM measuring the electric field with a spacing of only 5 m, it successfully reduces the noise level to 1/10 or lower so as to provide reliable estimates of electromagnetic responses in a wide period range (1,000-500,000 s) that have high sensitivity to the electrical conductivity in the upper mantle and in the MTZ. Therefore, we are now capable of providing strong constraints to answer the two questions **(a)** and **(b)** listed above by applying our advanced observational technologies to the "**normal oceanic mantle**" (as opposed to the mantle beneath subduction zones, hot spots or mid-oceanic ridges).

This cruise is conducted in the first year of the five year project as a 'pilot experiment', in which **BBOBS-NX** and **EFOS** are deployed together for the first time in our experience, as well as BBOBS's and OBEM's of conventional type. We expect it provides a good opportunity to train ourselves for instrumentations, observations, data processing and analyses. This will be an essential step to complete the main observation phase of the project, which is planned in 2011-2014.

**2.2. Research Areas and observations**

Area map and station distribution of the present cruise are shown in Figs. 1 and 2, respectively. Operation planned at each station is summarize as follows:

(1) NM02 and NM03
   a. Acoustic communication with BBOBS-NX and OBEM installed last year. Sending a release command to OBEM.
   b. Deployment of OBEM to the site.
   c. Recovery of OBEM from the site.
   d. Positioning the installed OBEM.

(2) NM01, NM04, and NM05
   a. Acoustic communication with BBOBS and OBEM installed last year.
   b. Sending a release command to both instruments.
   c. Deployment of BBOBS to the site.
   d. Recovery of BBOBS and OBEM from the site.
   e. Positioning the installed BBOBS and checking its operation status.

(3) NM12, NM17, NM20, and NM23
   a. Bathymetric survey.
   b. Deployment of BBOBS and OBEM to the site.
   c. Positioning these instruments and checking the operation status of BBOBS.

(4) NM15, NM18, NM21, NM22, and NM25
   a. Bathymetric survey.
   b. Deployment of BBOBS to the site.
   c. Positioning the installed BBOBS and checking its operation status.

(5) NM07, NM11, NM14, NM16, NM19, and NM24
   a. Bathymetric survey.
   b. Deployment of OBEM to the site.
   c. Positioning the installed OBEM.

**2.3 Corrections for the cruise plan**

We originally planned to visit the area A first and then the area B, but the weather in the area A had been rough and seemed to have little hope to recover at the beginning of the cruise. Therefore we changed the plan so that we first visit the area B and deploy both BBOBS and OBEM at each of 8 stations in the area. Remaining ship time was devoted to recover and deploy as many instruments in the area A as possible.

**2.4 Summary of result**

In the following, result of observation is summarized in the order of completion date.

November 20 (Area B, NM19): Deployment of BBOBS and OBEM. Positioning of installation point.

November 21 (Area B, NM21, NM18): The same as above.

November 22 (Area B, NM20, Nm23, NM25): The same as above.

November 23 (Area B, NM24, NM22): The same as above.

November 24 (Area B, NM20): Detailed bathymetric survey.

November 27 (Area A, NM04): Recovery and deployment of BBOBS and OBEM*. Positioning of installation point.

* The OBEM recovered from NM04 was in normal operation after recovery. We have retrieved data from this instrument and found that continuous geomagnetic and electric field data were recorded since June 15, 2010.

The present project "New phase of the Ocean Hemisphere Project: Imaging the normal oceanic mantle by advanced ocean bottom observations" is partially supported by the JSPS Grant-in-aid for Specially Promoted Research (22000003).

**調査海域図**

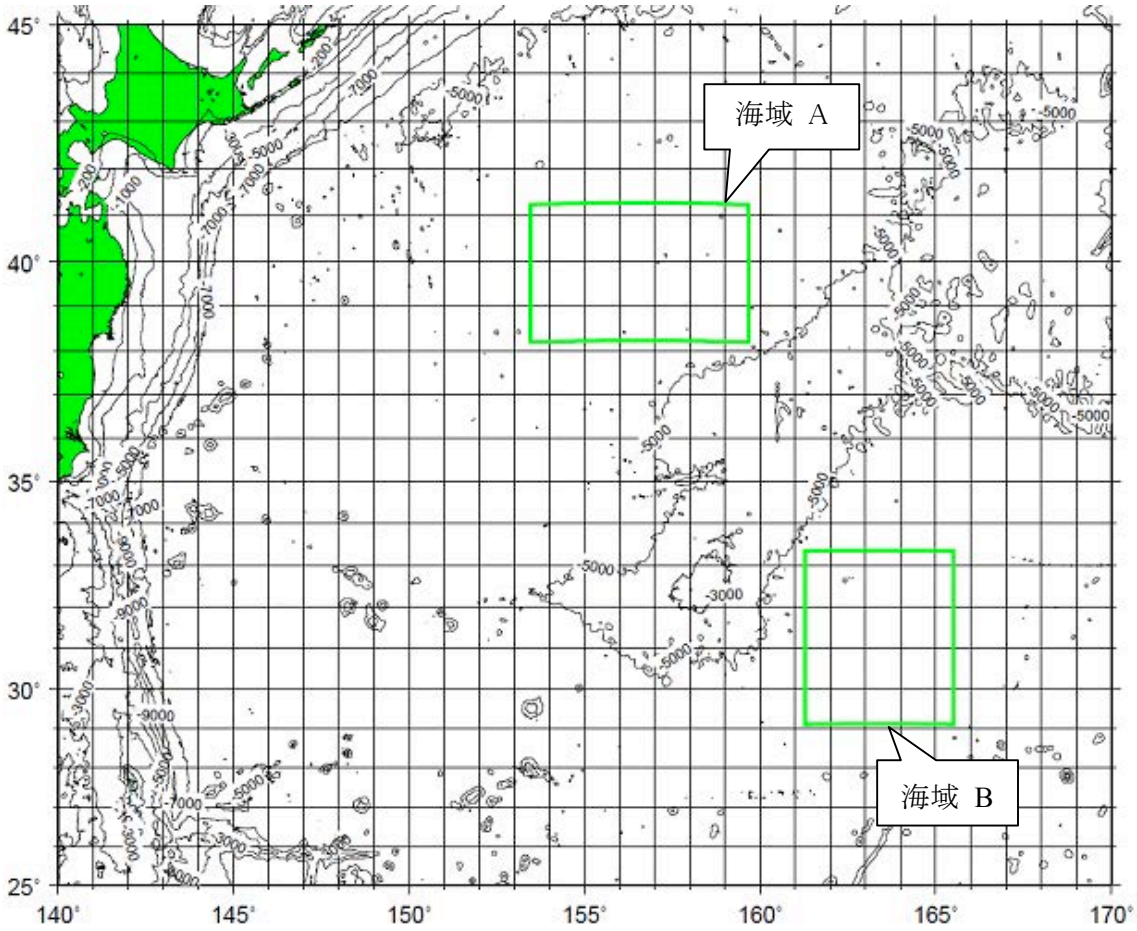


図 1. 本航海の調査海域図。

海域 A: シャツキー海台の北西海域で、平成 20 年度の KR10-08 航海に置いて、新型の BBOBS-NX と EFOS を含む海底観測機器を 5 地点に設置してある。本研究ではのべ 12 地点での長期観測が計画されている。

海域 B: シャツキー海台の南東海域で、本研究では新型の装置を含み８地点で観測を行う計画である。

Fig. 1. Area map of the present cruise.

The area A: North-west of the Shatsky Rise where ocean bottom instruments including BBOBS-NX and EFOS were deployed at 5 stations in KR10-08 in June 2010. In this study, long-term observations are carried out at 12 stations in total.

The area B: South-east of the Shatsky Rise where long-term observations are carried out at 8 stations in total.

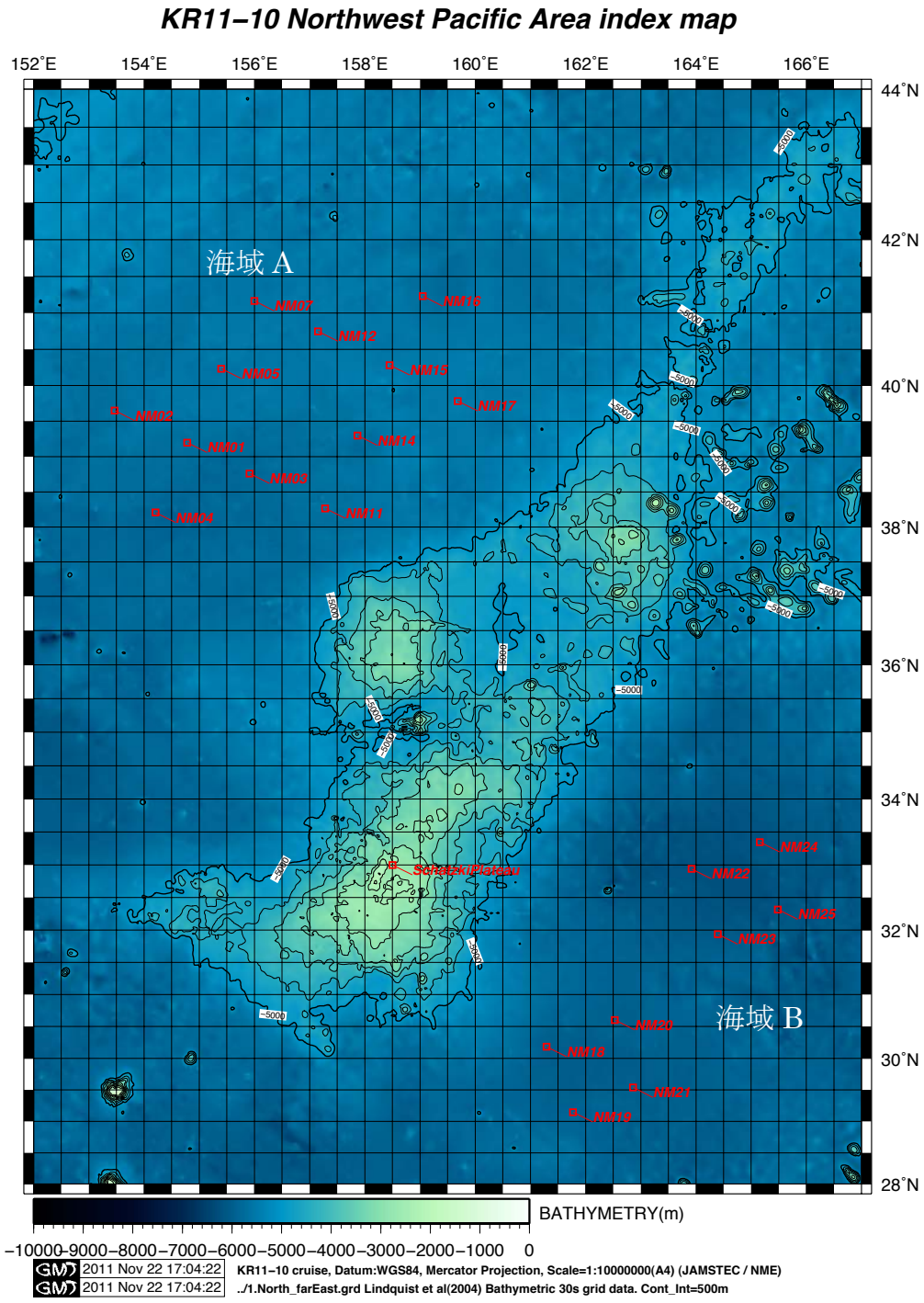


図 2　全体計画における海域 A および B の観測装置設置予定地点配置図。

Fig. 2. Planned station distribution in the area A and B in the entire project.