Cruise Summary

1. Cruise Information

Cruise ID	KR12-14
Name of vessel	KAIREI
Title of the cruise	Deployment and recovery of BBOBS-NX's and EFOS's by Kaiko 7000-II and deployment 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	Aug.17 – Sep.05, 2012
Ports of call	Sendai - JAMSTEC Yokosuka
Research area	Northwest Pacific Ocean (Northwest and southeast of the Shatsky Rise)
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).

In KR10-08 conducted in June 2010, we started a pilot experiment of the NOMan project, in which two BBOBS-NX's and one EFOS are deployed together for the first time in our experience, as well as 3 BBOBS's and 5 OBEM's of conventional type. We expected this pilot experiment would provide us a good opportunity to train ourselves for instrumentations, observations, data processing and analyses.

The previous cruise of the NOMan project, KR11-10 was planed as the first phase of the main observation of the project, recovering instruments deployed in the pilot experiment, and deploying more

number of BBOBS-NX's and EFOS's as well as BBOBS's and OBEM's. However, we had to change our cruise plan so that only conventional instruments (BBOBS's and OBEM's) which do not need KAIKO 7000-II dive operation are going to be recovered and deployed. The recovery and deployment of advanced instruments (BBOBS-NX's and EFOS's) are postponed to be conducted in the summer of 2012, which is the present cruise KR12-14. The KR11-10 cruise was carried out from November 16 to 30, 2011. Due to a bad weather condition, we recovered only one BBOBS and one OBEM at the site NM04, and re-installed them in the area A. In the area B, we successfully deployed 8 BBOBS's and 8 OBEM's, respectively. Every instrument was equipped with batteries sufficient for two-year deployment, so to be recovered in the summer of 2013.

The present cruise is the most important one in the NOMan Project. We plan to recover 3 BBOBS's, 2 BBOBS-NX's, 1 EFOS recorder and 4 OBEM's from the pilot experiment, and deploy 6 BBOBS-NX's and 4 EFOS's (one replacement and three new installations), as well as 6 BBOBS's and 8 OBEM's. Most of the instruments will be recovered in the summer of 2014 after two years' deployment.

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:

Because of the trouble of KAIKO 7000-II at the beginning of the cruise and limited ship time, it was considered as difficult to complete the original cruise plan if we do not cut several installations. After a serious discussion with participated scientists, we decided to give up to visit area B and to install as many instruments as possible in area A.

In summary, installations at sites NM19 and NM24 in area B are cancelled. In the new plan, we added NM15 in area A as a site with installation by KAIKO 7000-II dive operation. Site NM01 was also change to a site with installation by dive operation.

On the transit from NM12 to NM 16, there was a serious trouble of MNBES for many hours. Because a dive operation is not allowed without bathymetric survey data, we decided to change the location of NM16 about 16 miles to the south where bathymetry is available. In order to avoid unexpected trouble of MNBES for remaining sites of the cruise, we selected substitute locations for MN17 and MN14 where bathymetry is not available

2.4 Summary of result

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

The present cruise, KR12-14, was originally planned for 20 days with 7 days for surface deployment and recovery, 7 days for KAIKO 7000-II dive operation, and 6 days for transit. We planned to visit 15 sites in the study area, including 13 sites in area A and 2 in area B. However, the plan was changed during the initial stage of the cruise to visit sites only in area A in order to optimize the observation network within the available ship time. As a result, we visited 10 sites for deployment and/or recovery of ocean bottom instruments, and 4 sites to conduct MNBES for future deployment. Thus the present cruise completed building the observation network in area as planned except the EFOS-6 at site NM03. Installation of several advanced instruments and replacement of conventional instruments have to be carried out in area B in next summer, in addition to planned deployment/recovery of instruments in 2013.

In the following, results of observation are summarized in the order of completion.

August 19 (Area A, NM02): Recovery of OBEM. Deployment of BBOBS-NX and OBEM. Positioning of settled points. Bottom installation of BBOBS-NX by KAIKO 7000-II was not completed due to a trouble (dive #557).

August 20 (Area A: NM04): Recovery of and deployment of BBOBS. Positioning of settled point. Call of OBEM at the bottom.

August 20 (Area A, NM01) No replay from BBOBS at the bottom. Recovery of OBEM. Deployment of BBOBS and positioning of its settled point.

August 21 (Area A, NM05): Recovery and deployment of BBOBS and OBEM. Positioning of settled points.

August 21 (Area A, NM02) Rearrangement of BBOBS-NX by KAIKO 7000-II (dive #558).

August 22 (Area A, NM03) No reply from OBEM deployed in 2010, Deployment of OBEM and BBOBS-NX. Positioning of settled points. A return trip to NM10 for bathymetric survey by MNBES.

August 23 (Area A, NM03) Rearrangement and recovery of BBOBS-NX by KAIKO 7000-II (dive #559). A return trip to NM06 for bathymetric survey by MNBES.

August 24 (Area A, NM03) Recovery and replacement of data recorder of EFOS by KAIKO 7000-II. Observation of implosion of glass sphere of OBEM by KAIKO 7000-II (dive #560).

August 25 (Area A, NM15) Deployment of BBOBS-NX and OBEM. Positioning of settled points. Rearrangement of BBOBS-NX by KAIKO 7000-II (#561).

August 26 (Area A, NM12) Deployment of BBOBS and OBEM. Positioning of settled points.

August 26 (Area A, NM16) Deployment of EFOS, OBEM and BBOBS-NX. Positioning of settled points.

August 27 (Area A, NM16) Rearrangement of BBOBS-NX and installation of EFOS cable by KAIKO

7000-II (dive #562).

August 28 (Area A, NM17) Deployment of BBOBS. Positioning of settled point.

August 28 (Area A, NM14) Deployment of EFOS, OBEM and BBOBS-NX. Positioning of settled points.

August 29 (Area A, NM11) Bathymetric survey by MNBES.

August 30 (Area A, NM08) Bathymetric survey by MNBES.

August 31 (Area A, NM14) Rearrangement of BBOBS-NX and installation of EFOS cable by KAIKO 7000-II (dive #563).

September 1 (Area A, NM01) Deployment of EFOS, OBEM and BBOBS-NX

September 1 (Area A, NM01) Rearrangement of BBOBS-NX and installation of EFOS cable by KAIKO 7000-II (dive #564).

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).