Submission date 02/Oct./2014

Cruise Summary

1. Cruise Information

Cruise ID KR14-10

Name of vessel Kairei and Kaiko 7000II

Title of the cruise

New phase of Ocean Hemisphere Project: Imaging the normal oceanic mantle by advanced ocean bottom observations (Northwest Pacific Ocean)

Chief scientist [Affiliation] Hisashi Utada [ERI, University of Tokyo]

Title of proposal Same as the cruise title

Cruise period From September 9 to October 2, 2014

Ports of departure / call / arrival From Shiogama to Yokosuka

Research area The Northwest Pacific Ocean and off Miyagi, off Boso, and off Ibaraki areas

Research map See attached Figure 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 (Kawakatsu & 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. In KR11-10 conducted in November 2011, we deployed BBOBSs and OBEMs at all sites in area B and completed a replacement of BBOBS and OBEM at NM04 in Area A. Deployment of area A was completed by KR12-14 in August 2012, in which 6 BBOBS-NXs and 3 EFOSs were installed by dive operations of Kaiko 7000II, as well as BBOBSs and OBEMs. Later we have carried out two cruises by chartered vessel Kaiyu (OOC Inc.). In August 2013, a cruise was conducted to maintain observation arrays of BBOBSs and OBEMs in areas A and B. In June 2014, explosive sources were shot at four points around the array in area A to explore shallower structures, and then all BBOBSs and OBEMs (except those collocated with EFOS) were retrieved from area A.

The present cruise is the most important one in the NOMan Project, in which we plan to recover as

many seafloor instruments as possible from areas A and B. Long-term observation data from this cruise will make a significant contribution to the completion of the scientific purpose of the NOMan project.

2.2 Operations in plan and instruments (cf. attached Figure 1)

(1) Locations of planned dive operation

NM01, NM02, NM03, NM14, NM15, NM16 in area A

Substitutions:

NM19, NM21 in area B, area D, or area E

(2) Operations by ROV Kaiko 7000II

a. Recovery of BBOBS-NX at NM01, NM02, NM03, NM14, NM15, NM16

b. Recovery of EFOS recorder at NM01, NM03, NM14, NM16

c. Search and recovery of EFOS cable bobbin at NM03

d. Recovery of BBOBS with trouble in acoustic system at NM01, NM19 and area D

e. Recovery of OBEM with trouble in release system at NM02

f. Recovery of OBEM with trouble in acoustic system at NM03, NM16, NM21 and area E

(3) Operations by R/V Kairei

a. Recovery of instruments (BBOBS, OBEM, VTM) by self pop-up at NM20, NM22, NM23, NM24, NM25, area D)

b. Deployment of OBEM when EFOS recorder is not recovered at NM01, NM03, NM14, NM15

c. Bathymetric, gravimetric and geomagnetic surveys

2.3 Results

Sep. 11 Recovery of VTM in area D

Sep. 12 Recovery of 2 OBEMs by self pop-up at NM02 in area A

Sep. 13 Recovery of EFOS recorder and BBOBS-NX by dive operation at NM01 in area A

Sep. 15 Recovery of BBOBS-NX and OBEM by dive operation at NM02 in are A

Sep. 16 Recovery of BBOBS-NX by dive operation at NM15 in area A

Sep. 17 Recovery of EFOS recorder and BBOBS-NX by dive operation at NM16 in area A

Sep. 18 Recovery of EFOS recorder and BBOBS-NX by dive operation at NM14 in area A

Sep. 21 Recovery of BBOBS by dive operation at NM01 in area A

Sep. 22 Search for OBEM by Kaiko (unsuccessful).

Recovery of BBOBS-NX by dive operation at NM03 in area A

Deployment of OBEM at NM03 in area A

Sep. 24 Recovery of BBOBS and OBEM by self pop-up at NM20 in area B

Sep. 25 Recovery of BBOBS by dive operation at NM19 in area B

Sep. 26 Search for OBEM by Kaiko, and recovery of only concrete anchor at site NM21 in area B.

Sep. 27 Recovery of BBOBS by self pop-up at NM23 in area B.

Recovery of BBOBS by self pop-up at NM22 in area B.

Recovery of BBOBS and OBEM by self pop-up at NM24 in area B.

Sep. 28 Recovery of BBOBS by self pop-up at NM25 in area B.

Table 1 Number of instruments recovered/installed in the present cruise.

	BBOBS-NX	EFOS	BBOBS	OBEM, VTM	Others
Recovery by dive	6	3	2	1*	1**
Recovery by self pop-up			5	7	
Installation				1	

* Titanium case imploded

** Only concrete anchor