Cruise Summary

1. Cruise Information

Cruise number	KR10-08
Ship name	KAIREI
Title of the cruise	Research dives by KAIKO-7000II
Chief Scientist	Hisashi Utada [ERI, Univ. Tokyo]
Co-chief scientist	Hajime Shiobara [ERI, Univ. Tokyo]
Title of proposal	New phase of Ocean Hemisphere Project: Imaging the normal oceanic mantle by advanced ocean bottom observations
Cruise period	10– 25 June, 2010
Port call	Yokosuka Shin-ko – JAMSTEC, Yokosuka
Research Area	Northwest Pacific Ocean
Research Map	Refer to Figure 1

2. Overview of 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).

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

The present has three target areas in the northwest Pacific Ocean. The area 1 (northwest of the Shatsky Rise) is the main target of this cruise where the sea floor is considered as 'normal'. It consists of five sites (Fig. 2), which are named Site 1 – Site 5. BBOBS-NX is deployed at Site 2 and 3, while EFOS at Site 3. At each of sites 1, 4 and 5, BBOBS is deployed. OBEM will be deployed at every Site in Area 1. The areas 2 and 3 are supplementary where we are going to retrieve instruments, OBEM and SFEMS, respectively, which are deployed in previous cruises. These instruments are supposed to have recorded electromagnetic variation data for no less than a year that will be useful for the scientific objective of the present proposal as well as for their original scientific purposes.

2.3. Research result

Although recovery of OBEM by Kaiko-7000II at Area 2 was planned on the way to Area 1, it was postponed because of the rough weather. We arrived at Site 2 of Area

1 on June 13, 2010, and carried out a topographic survey by SEABEAM around the site 2 till 6 h. At this site, we deployed OBEM, BBOBS-NX and buoyed EFOS. The descending speed of EFOS was found to be only 30 m/min or so. After confirming EFOS's landing on to the bottom, we carried out positioning three instruments by LBL. The relative distance between BBOBS-NX and EFOS was about 200 m, and that between EFOS and OBEM was only about 80 m. It was also found that the sensor of BBOBS-NX was tilted by about 10 degrees, which is out of controllable range.

On June 14, 2010, we performed the first Kaiko-7000II dive in this cruise, which is the dive #478. We tried to move the recording unit beside the sensor, and to correct the tilt of BBOBS sensor. The whole operation took about two hours. Then we tried to install cable for EFOS. Four mooring ropes we removed from a top of EFOS, cable drum was untied to the anchor, and then the cable drum was unlocked by the manipulator of Kaiko-7000II. All these operations were successful. Then the vehicle tried to dock to the cable drum for installation. It attempted three times. Finally the vehicle carried the drum with the safety system locked, and dropped the drum on to the sea floor. We tried to observe the situation of the drum and the cable, but found that a serious trouble occurred in the thruster system of Kaiko-7000II. The Kaiko-7000II was immediately retrieved on board.

In the morning and evening of June 15, we deployed BBOBS and OBEM by a free fall at Sites 1 and 4, respectively. The position of each instrument was calibrated by LBL . Inspection on the thruster trouble conducted by the Kaiko team clarified that it is due to the trouble in communication circuits. After a correspondence with the maker, we decided to go to the Hachinohe port to receive spare parts. It took 3 days. By replacing all circuit boards in trouble, the Kaiko team successfully repaired the thruster system, which enabled us to carry out further dive operations.

We returned to the site 2 of the Area 1 in the morning of June 19. Here the second dive of Kaiko-7000II in this cruise was attempted, following the deployment of BBOBS-NX. The recording device was untied from the sensor, and replaced on the seafloor. From visual inspection, it was noted that the penetrating depth of the sensor 'U' was not enough, and so we corrected it by pushing the sensor head by the Kaiko-7000II's front basket. The operation was completed. After the retrieval of Kaiko-7000II, we deployed OBEM.

On June 20, we shifted to Site 5, where BBOBS and OBEM were deployed.

On June 21 and 22, we tried to install EFOS cable by Kaiko-7000II. The first trial on June 21 was terminated by a trouble of the cable drum. Installation distance was about 450 m. At the second trial on June 22, we successfully recovered the trouble of

previous attempt, and installation became stable at a speed of 0.4 – 0.5 kt. However, we could not complete this operation due to the rough weather. We terminated installing cable at the distance slightly exceeding 3 km. The cable drum with remaining distance was left at the termination point. Although the installation itself was incomplete, we have obtained useful information for further development of EFOS from the experience of this cruise.

In summary, all operations planed for Area 1 were successfully completed, except the cable installation at Site 3. Operations planed for Area 2 an Area 3 were not conducted because the given ship time was limited.

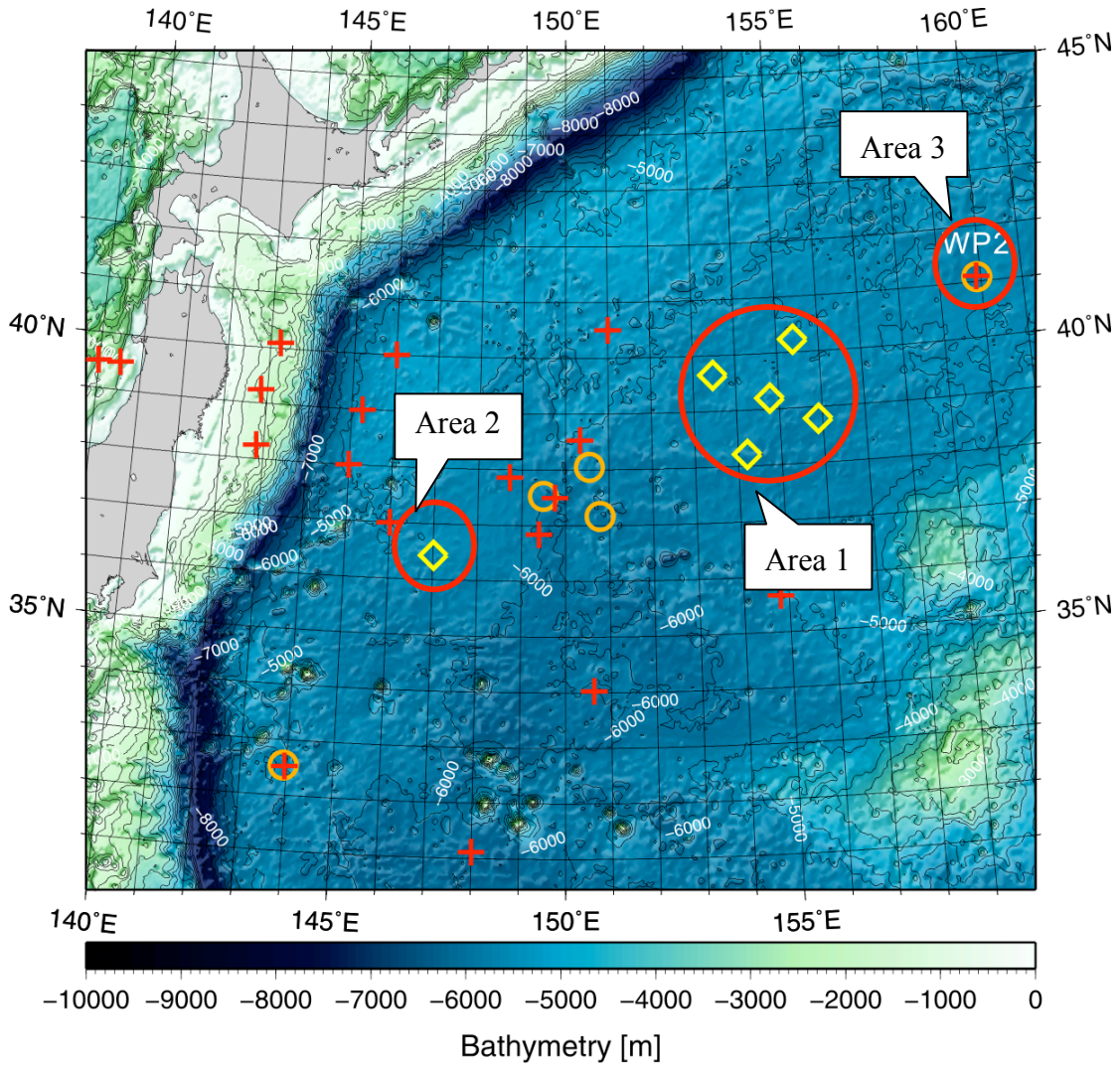

Figure 1. Map of research areas. Site locations of previous projects are shown by circle (BBOBS site) and plus (OBEM site).

Area 1: Main area of the present research which includes fives seafloor observation sites to be installed by the present cruise.

Area 2: Research area of second priority with s site where an OBEM is to be recovered by Kaiko-7000II.

Area 3: Research area of third priority with a site (WP-2) where a SFEMS is to be recovered.

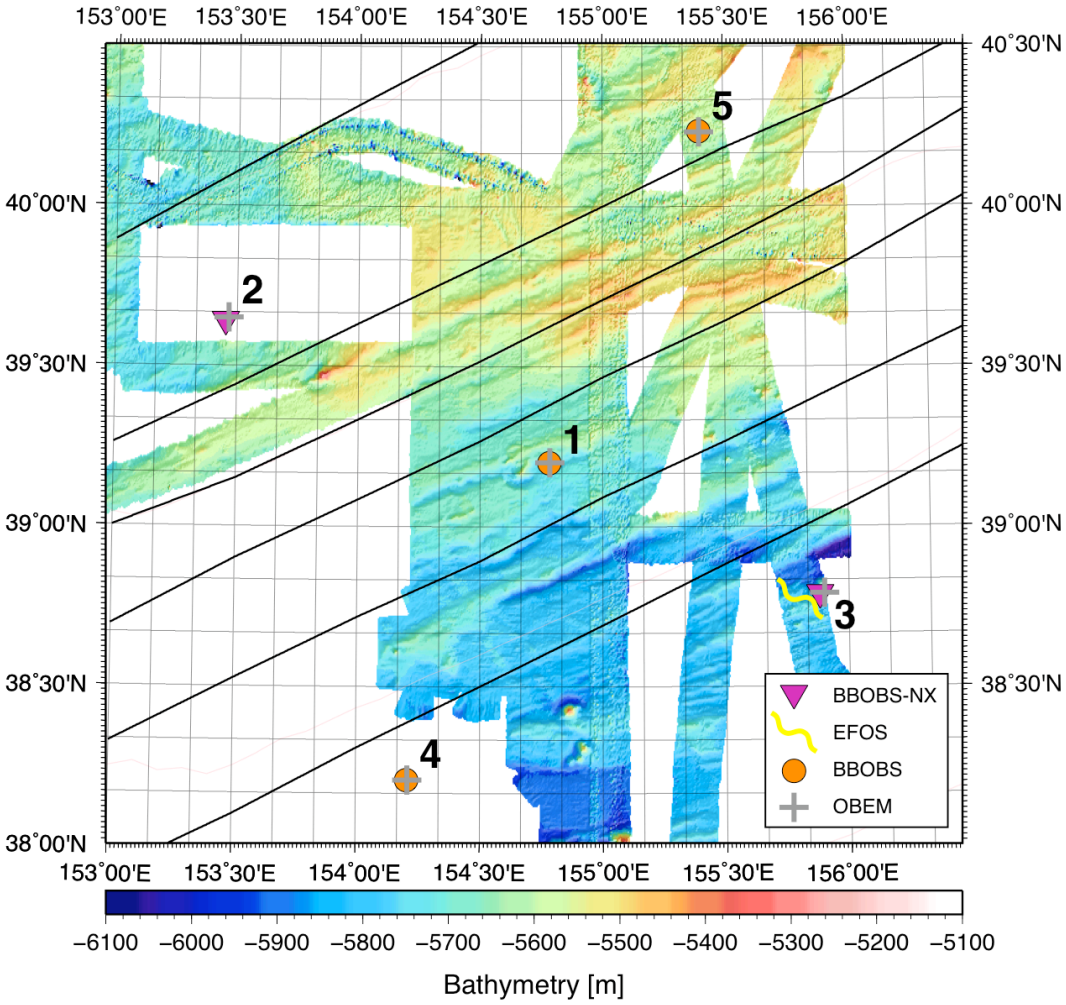

Figure 2. Site location map of the Area 1.