doi : 10.17596/0003182

CRUISE REPORT

JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY

R/V YOKOSUKA YK11-08 CRUISE

TECTONICS OF A DYING BACKARC BASIN AS REVEALED BY A DIVE STUDY OF THE GODZILLA MEGAMULLION

OCTOBER 5, 2011 TO OCTOBER 25, 2011

(JAMSTEC TO KOBE, JAPAN)

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Users of the data and/or results of this cruise are requested to submit their results to Data Integration and Analysis Group, JAMSTEC (diag-dmg@jamstec.go.jp).

Acknowledgements

We are grateful to captain Koji Sameshima, the Shinkai operation team manager Toshiaki Sakurai, the crew of R/V Yokosuka , and the Shinkai team for their outstanding efforts to make this scientific program successful. We also thank JAMSTEC for their support of this project. The U.S. science group acknowledges the support of a National Science Foundation grant to the University of Houston.

1. General cruise information

Cruise number / ship name: YK11-08 / R/V Yokosuka

Title of the cruise: “Tectonics of a dying backarc basin as revealed by a dive study of the Godzilla Megamullion”

Chief-Scientist / Affiliation: Yasuhiko Ohara / Hydrographic and Oceanographic Department of Japan (also at IFREE-JAMSTEC)

Proposal number and scientific title: S11-49 “Tectonics of a dying backarc basin as revealed by a dive study of the Godzilla Megamullion”

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Investigation area: Godzilla Megamullion (Parece Vela Basin) (Figs. 1 and 2)

Cruise period and port calls: Oct. 5 to 25, 2011 (JAMSTEC to Kobe)

Shinaki 6500 and deep-towed camera dive list (Fig. 3a and b):
6K-1270: Yasuhiko Ohara (Northeastern slope of the bottom part of the West Shoulder Ridge)
6K-1271: Wendy Nelson (Southwestern slope of the northeastern half of the Hat Ridge)
6K-1272: Katsuyoshi Michibayashi (Northern slope of the potential neo-volcanic ridge of segment S1)
6K-1273: Jonathan E. Snow (Southwestern slope of the northeastern tip of the Hat Ridge)
6K-1275: Hiroyuki Yamashita (Northern slope of the northern tip of the Neck Peak along the same track line of YKDT-63 in YK09-05 cruise)
6K-1276: Teruaki Ishii (Eastern slope of the ridge delineating the eastern limit of the Neck Peak region)
YKDT-113 (Southwestern off-axis abyssal hill of segment S1)
YKDT-114 (Southwestern off-axis abyssal hill of segment S1)
YKDT-115 (Northern slope of the western tip of the West Shoulder Ridge)
YKDT-116 (Western slope of the western tip of the West Shoulder Ridge)
YKDT-117 (Northern slope of the small ridge connected to the northern tip of the Neck Peak)
YKDT-118 (Northern slope of the small ridge connected to the mid part of the Neck Peak)

2. Introduction

Oceanic core complexes (OCCs) are domal bathymetric highs, generally characterized by axis-normal corrugations, higher mantle Bouguer anomalies, and peridotite and gabbro exposures. OCCs have been recognized mostly along slow-spreading ridges; these occurrences in intermediate- and ultraslow-spreading ridges are less common (e.g., Tucholke et al. 2008; Blackman et al. 2009). OCCs are interpreted as exhumed footwalls of low-angle detachment faults (Cann et al. 1997; Blackman et al. 1998; Tucholke et al. 1998; Escartín et al. 2003; MacLeod et al. 2009). The Godzilla Megamullion is the largest known OCC, and is located in an extinct backarc basin in the Philippine Sea: the Parece Vela Basin (PVB) (Fig. 1).

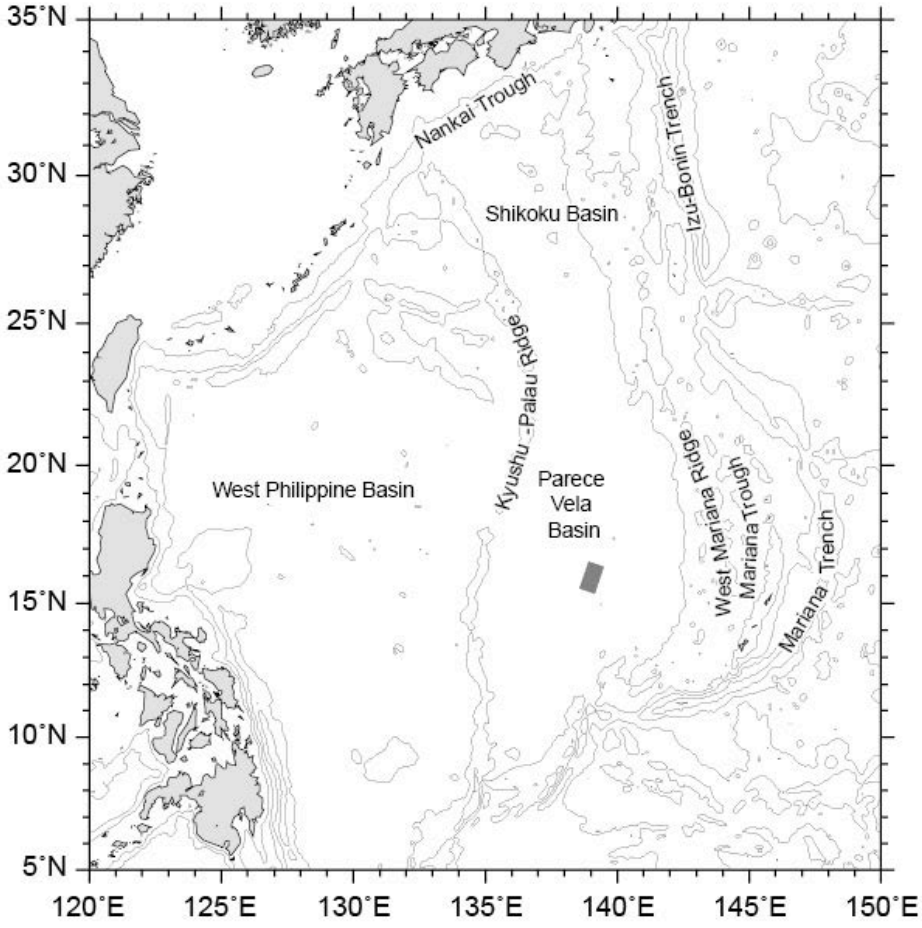

Fig. 1. Index map of the Philippine Sea, showing the location of the Parece Vela Basin. The grey shaded box indicates the location of the Godzilla Megamullion.

The Philippine Sea is composed of three large basins divided by the Kyushu-Palau and West Mariana Ridges (both are remnant arcs). This region evolved through three episodes of arc formation, rifting and backarc spreading (Karig 1971). Based on poorly constrained magnetic data, we believed that the basin was active from 26 to 12 Ma at an intermediate-spreading rate of 8.8–7.0 cm/year full-rate (Okino et al. 1998; Ohara et al. 2001, 2003). After the extinction of the PVB at 12 Ma, backarc spreading resumed in the currently active Mariana Trough, creating the West Mariana Ridge. The tectono-magmatic characteristics of Godzilla Megamullion were thus thought unusual and paradoxical. Although a higher magmatic budget is expected for a fast- to intermediate-spreading ridge,

the PVB shows features indicating a smaller magmatic budget, including oceanic core complexes and abundant peridotites and gabbros (Ohara et al., 2001, 2003). Many peridotites in the PVB are much less depleted than those exposed at comparable spreading rates on other mid-ocean ridge systems (Ohara et al. 2001, 2003; Ohara 2006).

The latest Zircon U-Pb dating of gabbroic and leucocratic rocks from Godzilla Megamullion reveals that exhumation of the 125-km long detachment surface lasted for ~4 m.y., with continuous magmatic accretion at the spreading axis (Tani et al., 2011). The estimated denudation rate of the OCC was ~2.5 cm/y; significantly slower than the previous estimate based on magnetic data. The latest magmatism occurred at ~7.9 Ma or later, significantly younger than a previous estimate of 12 Ma. The new age data indicate that the terminal phase of PVB spreading was not at intermediate spreading rates, with a significant decline and asymmetry accompanying formation of Godzilla Megamullion in a "dying" backarc spreading segment. The results of the recent cruise including the last Shinkai diving expedition (YK09-05) also support a slow- to ultraslow-spreading environment for Godzilla Megamulllion, such as increased melt stagnation in the shallow mantle, and decreasing degree of partial melting of the peridotites towards the termination of Godzilla Megamullion.

The motivation why we have conducted the cruise (YK11-08) was thus to understand the processes of the terminal phase of PVB spreading that was responsible for the formation of the world's largest OCC.

3. Objectives of the cruise

Our previous studies have produced a number of important new observations about the processes of the terminal phase of PVB spreading. Following these results, the principal objectives of YK11-08 cruise were to test two important hypotheses by in-situ dive operations using the Shinkai 6500 and deep-tow camera:

(i) The intermediate-spreading PVB became a slow to ultraslow-spreading environment during the middle of the Godzilla Megamullion formation period; thereby thickening of the lithosphere was occurred towards the rift axis.
(ii) The tectonics of the terminal phase of the Godzilla Megamullion formation was similar to that of the ultraslow-spreading ridges, such as the presence of mantle slab (Snow et al., 2011). The spreading of PVB was terminated at 4.8 Ma (the age of the alkaline basalts from the Head Peak dated by Ishizuka et al., 2004).

4. Survey items

During YK11-08 cruise, we have conducted six Shinkai and six YKDT dives (Fig 3a and b). Geophysical mapping (bathymetry and gravity) were done on the areas that were left uncovered by the previous surveys.

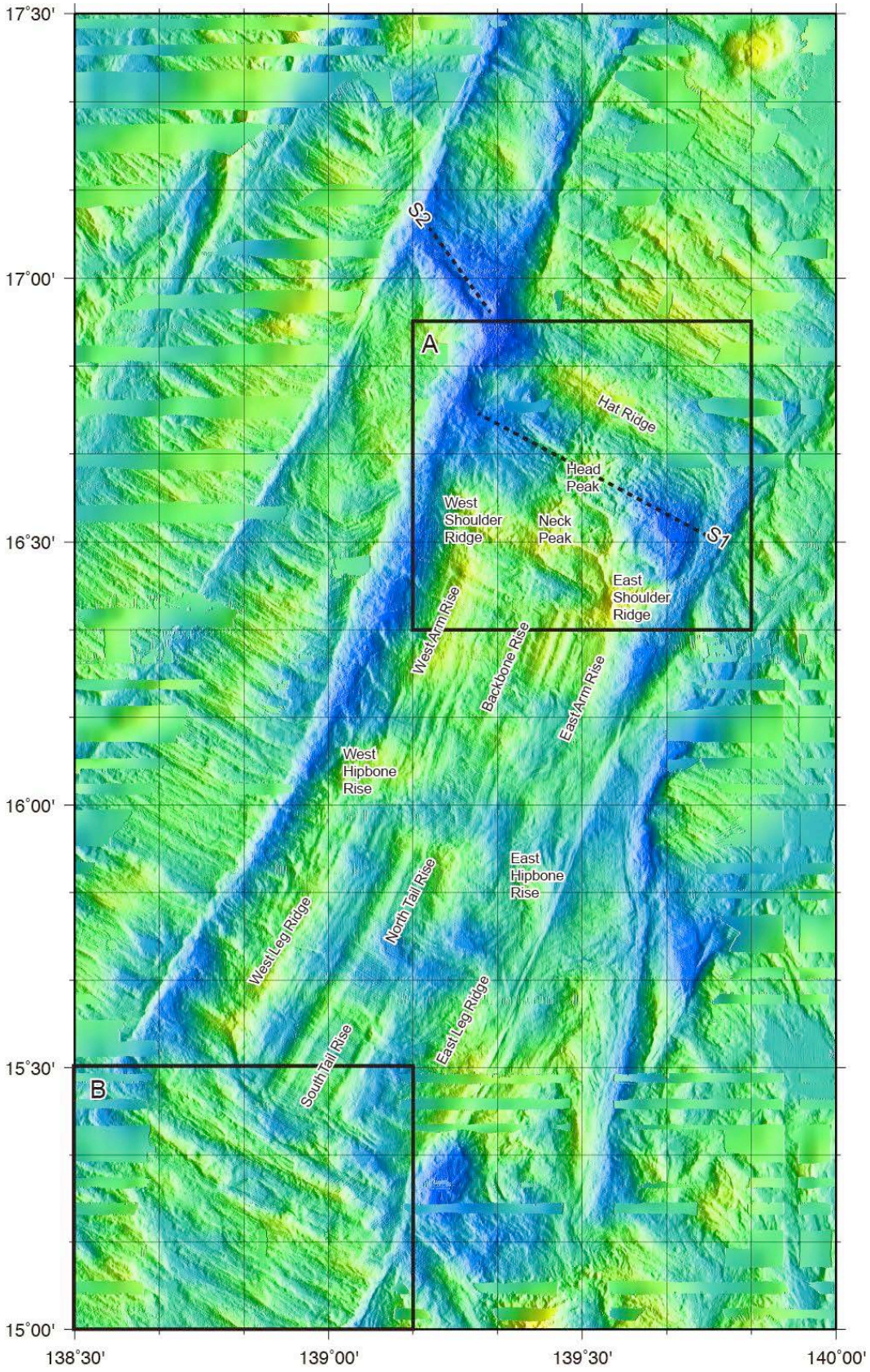

Fig. 2. Bathymetry of the Godzilla Megamullion and its surroundings. Names for individual bathymetric components on the Godzilla Megamullion are shown. Extinct rift axis of the Parece Vela Rift is marked by dotted lines (S1 and S2 after Ohara et al., 2001). Blow-up bathymetry for A and B is shown in Fig. 3a and b.

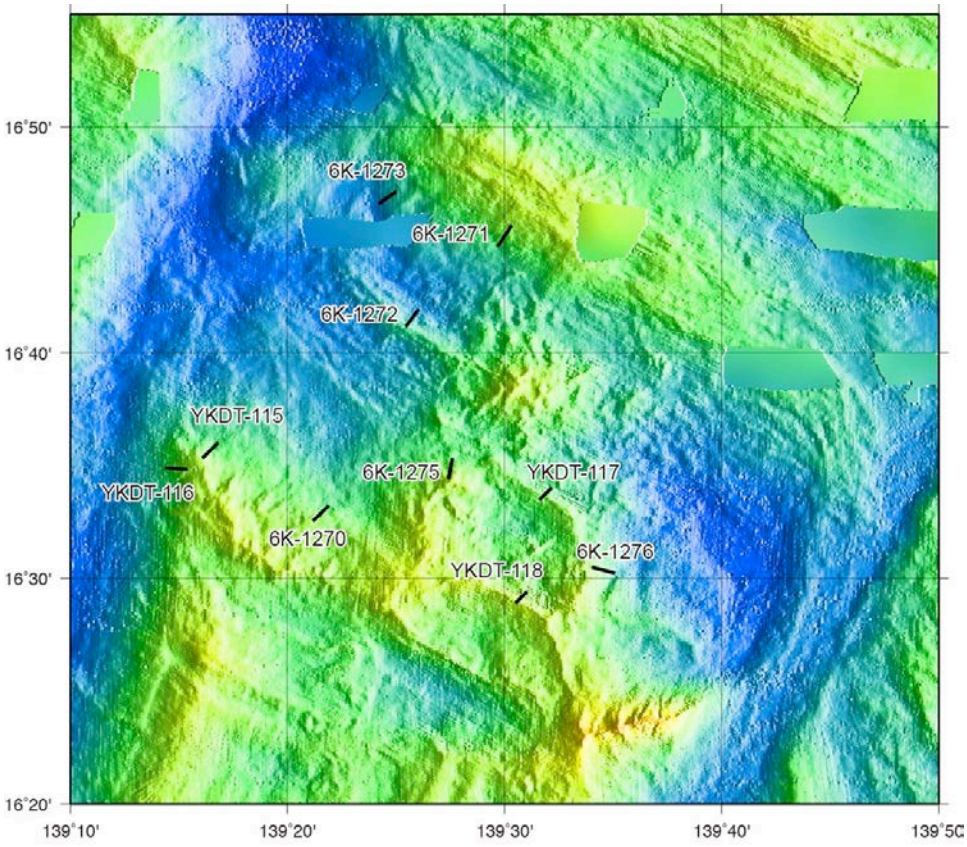

Fig. 3a. Bathymetry of the rift axis area of the Godzilla Megamullion. Locations of the Shinkai 6500 and deep-tow camera dives during the cruise are shown.

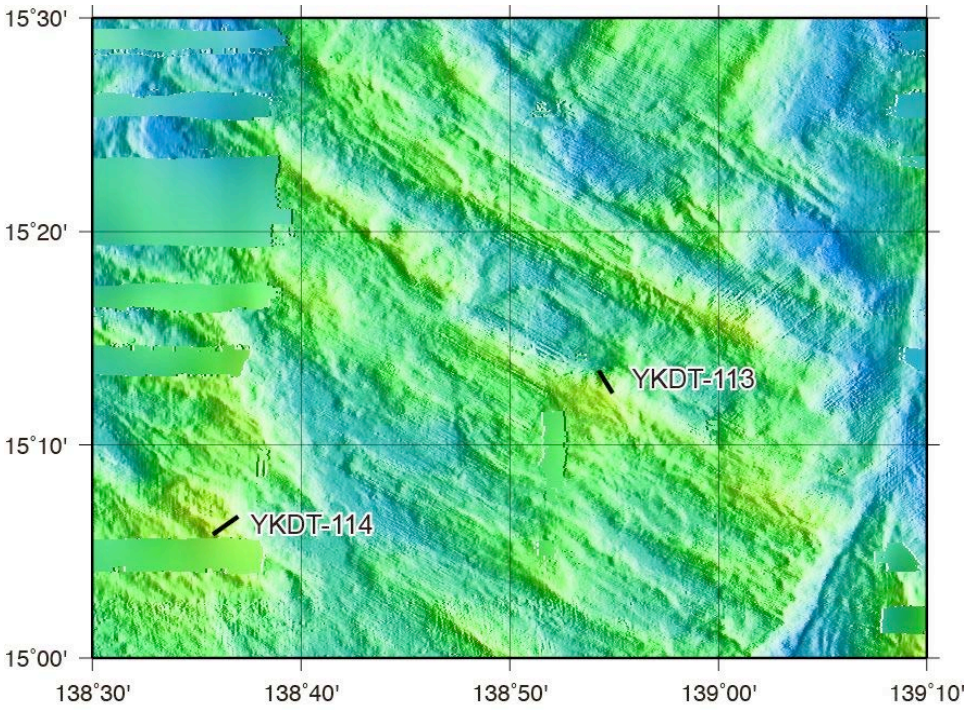

Fig. 3b. Bathymetry of the off-axis area of the segment S1. Locations of the deep-tow camera dives during the cruise are shown.

5. Running cruise narrative

Local time (Approximate)	Notes
05-Oct-11	**The Yokosuka YK11-08 cruise began. The Yokosuka was underway to the Godzilla Megamullion area. A rough sea weather condition was encountered all day, forcing to cancel science meeting.**
Around noon	Scientists arrived at the Yokosuka moored in the JAMSTEC wharf.
15:00	YK11-08 cruise began.
06-Oct-11	**The Yokosuka was underway to the Godzilla Megamullion area. A rough sea weather condition was encountered all day, forcing to cancel science meeting.**
All day	No activities were held, because of a rough sea weather condition.
07-Oct-11	**The Yokosuka was underway to the Godzilla Megamullion area. A reratively rough sea weather condition was encountered all day.**
09:30	The first science meeting was held at the No. 1 laboratory. Yasuhiko Ohara made an introduction of the cruise. Cruise onboard seminor schedule was decided.
08-Oct-11	**The Yokosuka was underway to the Godzilla Megamullion area.**
00:00	Ship's clocks used Guam local time (UTC + 10 h) during this cruise.
09-Oct-11	**The Yokosuka arrived at the Godzilla Megamullion area in late afternoon. Site survey for the dive sites was conducted in the evening.**
14:20	XBT was deployed
10-Oct-11	**6K-1270 was conducted along the northeastern slope of the bottom part of the West Shoulder Ridge. Yasuhiko Ohara as the observer.**
09:55	6K-1270 started (the Shinkai opened vent).
11:57	The Shinkai on bottom (4704 m).
15:37	The Shinkai off bottom (4188 m); total 13 rocks and 3 scoops were sampled.
17:32	The Shinkai on deck.
11-Oct-11	**6K-1271 was conducted along the southwestern slope of the northeastern half of the Hat Ridge. Wendy Nelson as the observer.**
09:52	6K-1271 started (the Shinkai opened vent).
11:53	The Shinkai on bottom (4684 m).
15:31	The Shinkai off bottom (4177 m); total 14 rocks and 2 scoops were sampled.
17:25	The Shinkai on deck.
12-Oct-11	**6K-1272 was conducted along the northern slope of the potential neo-volcanic ridge of the segment S1. Katsuyoshi Michibayashi as the observer.**
08:59	6K-1272 started (the Shinkai opened vent).
11:20	The Shinkai on bottom (5553 m).
15:16	The Shinkai off bottom (4903 m); total 13 rocks and 1 push core were sampled.
17:22	The Shinkai on deck.
13-Oct-11	**6K-1273 was conducted along the southwestern slope of the northeastern tip of the Hat Ridge. Jonathan Snow as the observer.**
08:54	6K-1273 started (the Shinkai opened vent).

11:17	The Shinkai on bottom (5751 m).
15:08	The Shinkai off bottom (5228 m); total 13 rocks and 1 scoops were sampled.
17:43	The Shinkai on deck.
14-Oct-11	**The Yokosuka was underway to the off-axis area to the south.**
13:22-17:50	Bathymetric survey for dive 6K-1275 and YKDT was conducted.
15-Oct-11	**The Shinkai Team rigged the YKDT system. The Yokosuka conducted the site survey for the YKDT at the off-axis area, followed by bathymetric box survey.**
08:46	XBT was deployed
16-Oct-11	**YKDT-113 and -114 were conducted at the southwestern off-axis abyssal hills of the segment S1. The Yokosuka conduncted bathymetric box survey in the night, and then moved to the axial area of the segment S1.**
07:25	YKDT-113 started (the deep-tow camera was put in the water).
08:58	The YKDT on bottom (4620 m).
09:41	The YKDT off bottom (4215 m).
11:05	The YKDT on deck.
13:06	YKDT-114 started (the deep-tow camera was put in the water).
14:35	The YKDT on bottom (4515 m).
15:17	The YKDT off bottom (4244 m).
16:42	The YKDT on deck.
17-Oct-11	**YKDT-115 was conducted along the northern slope of the western tip of the West Shoulder Ridge. YKDT-116 was then conducted along the western slope of the western tip of the West Shoulder Ridge.**
07:19	YKDT-115 started (the deep-tow camera was put in the water).
08:50	The YKDT on bottom (4561 m).
09:39	The YKDT off bottom (4153m).
11:02	The YKDT on deck.
13:00	YKDT-116 started (the deep-tow camera was put in the water).
14:27	The YKDT on bottom (4477 m).
15:31	The YKDT off bottom (4005 m).
16:51	The YKDT on deck.
18-Oct-11	**YKDT-117 and -118 were conducted at the northern slopes of small ridges connected to the northern tip of the Neck Peak. The Yokosuka conduncted bathymetric box survey in the night.**
07:10	YKDT-117 started (the deep-tow camera was put in the water).
08:46	The YKDT on bottom (4572 m).
09:23	The YKDT off bottom (4100 m).
10:47	The YKDT on deck.
13:03	YKDT-118 started (in the water).
14:27	The YKDT on bottom (4009 m).
15:50	The YKDT off bottom (3547 m).

17:09	The YKDT on deck.
19-Oct-11	**6K-1275 was conducted along the northern slope of the northern tip of the Neck Peak along the same track line of YKDT-63 in YK09-05 cruise. Hiroyuki Yamashita as the observer.**
09:57	6K-1275 started (the Shinkai opened vent).
11:49	The Shinkai on bottom (4460 m).
15:39	The Shinkai off bottom (3723 m); total 12 rocks and 1 scoops were sampled.
17:23	The Shinkai on deck.
20-Oct-11	**6K-1276 was conducted along the eastern slope of the ridge delineating the eastern limit of the Neck Peak region. Teruaki Ishii as the observer. The Yokosuka started steaming to Kobe in the night.**
09:57	6K-1276 started (the Shinkai opened vent).
12:06	The Shinkai on bottom (4893 m).
15:41	The Shinkai off bottom (4100 m); total 7 rocks and 1 scoops were sampled.
17:34	The Shinkai on deck.
21-Oct-11	**The Yokosuka was underway to Kobe.**
22-Oct-11	**The Yokosuka was underway to Kobe.**
23-Oct-11	**The Yokosuka was underway to Kobe.**
24-Oct-11	**The Yokosuka was underway to Kobe.**
00:00	Ship's clocks were adjusted to Japan local time (UTC + 9 h).
25-Oct-11	**The Yokosuka arrived in Kobe in the morning. End of the cruise.**
10:00	YK11-08 scientists disembarked.

6. Summary of the dive results

The Shinkai and YKDT dives (total 12 dives) obtained the data that can be testable the hypotheses noted above. The main results obtained by diving studies are (Fig. 4):

- It turns out that the West Shoulder Ridge consists of peridotite and fractionated gabbro (6K-1270, YKDT-115, YKDT-116).
- It turns out that the Hat Ridge, which is conjugate to the West and East Shoulder Ridges, consists of peridotite (6K-1271, 6K-1273).
- It turns out that the small ridge on the rift axis of the segment S1 is in fact the neo-volcanic ridge of the segment, yielding pillow lavas (6K-1272).
- It turns out that the Neck Peak and its surroundings consist of complex mixture of peridotite, gabbro and basalt (6K-1275, 6K-1276, YKDT-117, YKDT-118).
- Basalts for Ar-Ar dating were successfully recovered from the southwestern off-axis abyssal hills of segment S1 (YKDT-113, YKDT-114).

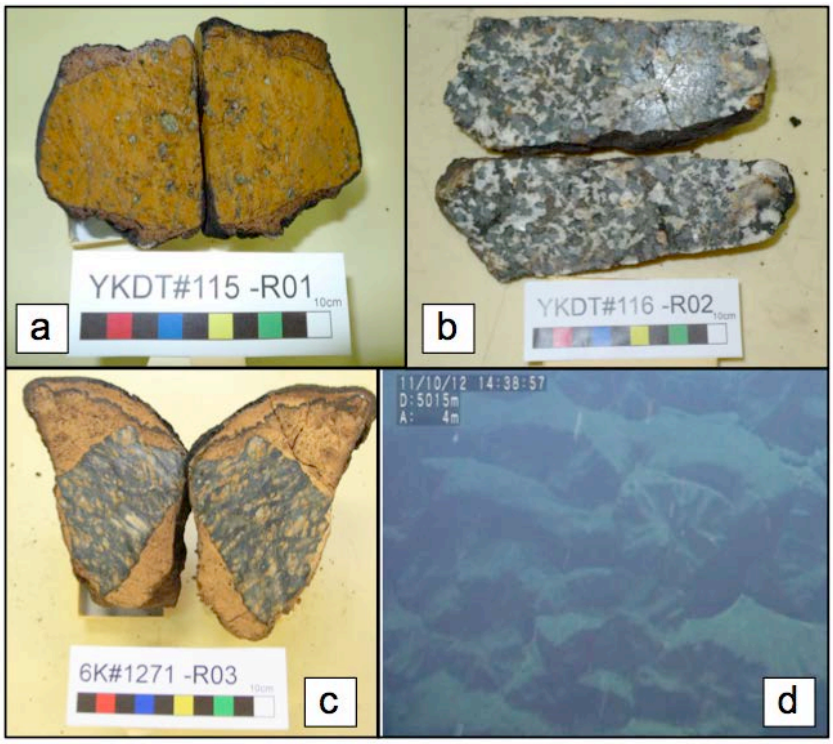

Fig. 4. (a) Peridotite from the West Shoulder Ridge (YKDT-115-R01). (b) Oxide-gabbro from the West Shoulder Ridge (YKDT-116-R02). (c) Peridotite from the Hat Ridge (6K-1271-R03). (d) An outcrop of pillow-lava of the potential neo-volcanic ridge (6K-1272).

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