

CRUISE REPORT

JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY

R/V YOKOSUKA YK14-13 CRUISE

**BIOGEOSCIENTIFIC INVESTIGATION OF THE SOUTHWESTERN END
OF THE MARIANA ARC SYSTEM**

JULY 7, 2014 TO JULY 28, 2014

(YOKOSUKA, JAPAN TO YOKOSUKA, JAPAN)



Table of Contents

List of cruise personnel	ii
Note on using	iii
Acknowledgements	iii
1. General cruise information	1
2. Introduction	2
3. The southernmost Mariana system	2
4. Survey items	4
5. Running cruise narrative	4
6. Summary of the cruise results	7
7. References	8

List of cruise personnel

Dr. Yasuhiko Ohara, Chief Scientist

Hydrographic and Oceanographic Department of Japan, and JAMSTEC

Dr. Hiromi Watanabe, Vice Chief Scientist

JAMSTEC

Dr. Yuta Konno

JAMSTEC

Dr. Tomoyo Okumura

JAMSTEC

Dr. Teruaki Ishii

Fukada Geological Institute

Dr. Fernando Martinez

University of Hawaii

Dr. Ignacio Pujuna

University of Texas at Dallas

Dr. Maryjo Brounce

University of Rhode Island

Mr. Yuji Onishi

Okayama University

Mr. Yusuke Miyajima

Kyoto University

Mr. Shoma Oya

Shizuoka University

Mr. Tomoki Mizuno

Shizuoka University

Ms. Satomi Minamizawa, onboard marine technician

Nippon Marine Enterprises, Ltd.

Notice on using

This cruise report is a preliminary documentation as of the end of the cruise. It may not be corrected even if changes on content are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the Chief Scientist for the latest information before using the report and/or data.

Users of data and/or results on this cruise report are requested to submit their results to the Data Management Group of JAMSTEC.

Acknowledgements

We are grateful to captain Yoshiyuki Nakamura, 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. We finally thank Susan White of the US Fish and Wildlife Service for permitting us to perform this study program in the Marianas Trench Marine National Monument, Mariana Trench National Wildlife Refuge (Special Use Permit #12541-14001).

1. General cruise information

Cruise ID and ship name: YK14-13, R/V Yokosuka

Title of the cruise: Biogeoscientific investigation of the southwestern end of the Mariana arc system

Title of proposal: Biogeoscientific investigation of the southwestern end of the Mariana arc system

Chief-Scientist: Yasuhiko Ohara (Hydrographic and Oceanographic Department of Japan, and JAMSTEC)

Representative of the Science Party: Yasuhiko Ohara (Hydrographic and Oceanographic Department of Japan, and JAMSTEC)

List of participants:

Yasuhiko Ohara (Hydrographic and Oceanographic Department of Japan, and JAMSTEC)
Hiromi Watanabe (JAMSTEC)
Yuta Konno (JAMSTEC)
Tomoyo Okumura (JAMSTEC)
Teruaki Ishii (Fukada Geological Institute)
Fernando Martinez (University of Hawaii)
Ignacio Pujana (University of Texas at Dallas)
Maryjo Brounce (University of Rhode Island)
Yuji Onishi (Okayama University)
Yusuke Miyajima (Kyoto University)
Shoma Oya (Shizuoka University)
Tomoki Mizuno (Shizuoka University)
Satomi Minamizawa (Nippon Marine Enterprises, Ltd.)

Investigation area (Fig. 1): Mariana Trench and Mariana Trough

Cruise period and port calls: July 7 to July 28, 2014 (Yokosuka to Yokosuka)

Shinaki 6500 dive list:

6K-1397: Yasuhiko Ohara (Site A West)
6K-1398: Ignacio Pujana (Site A West)
6K-1399: Tomoyo Okumura (Site A East)
6K-1400: Teruaki Ishii (Site B)
6K-1401: Hiromi Watanabe (Site B)
6K-1402: Yuta Konno (Site C)
6K-1403: Tomoyo Okumura (Site C)
6K-1404: Yasuhiko Ohara (Site C)

2. Introduction and objectives of the cruise

The 3000 km long Izu-Bonin-Mariana (IBM) arc system is an outstanding example of an intraoceanic convergent plate margin. The IBM forearc is a typical nonaccretionary convergent plate margin; the inner trench slope exposes lithologies found in many

ophiolites. To more clearly delineate the geology of the forearc, we have been investigating a ~500 km long region of the Mariana forearc south of ~13°N using the DSV Shinkai 6500 and deep-tow camera since 2006. Discoveries include the presence of MORB-like basalts that formed during subduction initiation (~51 Ma) [Reagan et al., 2010], a region of forearc rifting unusually close to the trench axis, the Southeast Mariana Forearc Rift [Ribeiro et al., 2013a, b], and a serpentinite-hosted ecosystem near the Challenger Deep, the Shinkai Seep Field [SSF; Ohara et al., 2012].

However, there have been no studies on the southern Mariana area west of the Challenger Deep except one [Hawkins and Batiza, 1977], hindering our understanding of the IBM system. The SSF is the serpentinite-hosted ecosystem discovered for the first time in the southern Mariana forearc, hosting robust vesicomid clam communities [Ohara et al., 2012]. This is not associated with serpentinite mud volcanoes as is the case for the forearc from Guam north, instead venting in the forearc facing the Challenger Deep is probably controlled by high angle faulting in the forearc. The discovery of the SSF suggests that serpentinite-hosted vents may be more widespread on the ocean floor than presently known.

The deep geology of the Mariana forearc near the Challenger Deep is dominated by peridotite and is heavily faulted, suggesting that more SSF-type seeps exist along this segment. Hence, **the major objective of the scheduled cruise (YK14-13) was to advance our biogeoscientific understanding of the southern Mariana seafloor west of the Challenger Deep (Figs. 1 and 2).** Especially, we wanted (1) to know the geology and biology of the inner trench slope west of the Challenger Deep (Site A West and Site A East), to test the hypothesis that serpentinite-hosted ecosystems exist there, (2) to know the geology and biology of the southwesternmost tip of the Mariana Trough (Site B) where the backarc basin spreading axis is only 130 km away from the trench axis. The distance between backarc basin spreading axis and trench is abnormally short and hence interesting biogeoscientific phenomena can be expected there. In addition, we set the SSF and its vicinities (Site C) as the contingency site with the objectives to further sample and characterize the SSF.

3. The southernmost Mariana system

The Mariana arc-trench system is a nonaccretionary convergent plate margin where the mantle of the overriding Philippine Sea Plate interacts with fluids released by the subducting Pacific Plate. Subduction to form the IBM arc-trench system began at ~51 Ma (million years) [Reagan et al., 2010; Ishizuka et al., 2011]. Forearc is an important component of a convergent plate margin and is a broad region between the trench axis and the associated volcanic arc. Along the Mariana forearc southwest of Guam, the West Santa Rosa Bank Fault at ~144°15'E marks a major tectonic boundary [Fryer et al., 2003], dividing the Mariana forearc into a stabler northern part and a southern part which is more tectonically active. The southern Mariana forearc faces the world-famous Challenger Deep.

A number of serpentinite mud volcanoes exist in the much broader Mariana forearc to the north. These are found ~30 to ~100 km west of the trench axis [Fryer, 1996; Fryer et al., 1999; Stern et al., 2003], however none is known from the southern Mariana forearc. Instead, serpentinitized peridotite crops out and has been sampled from the inner trench slope along the southern Mariana forearc [Bloomer and Hawkins, 1983; Ohara and Ishii,

1998]. Opening of the southern Mariana Trough (a backarc basin) and the presence of a short and narrow subducted slab west of the West Santa Rosa Bank Fault allows the narrow slab to roll back rapidly, causing the upper plate to stretch and deform. The rapidly deforming upper plate is also characterized by abundant basaltic volcanism near the trench [Ribeiro et al., 2013a, b]. The greater tectonomagmatic activity in the south engendered by the combined effects of backarc extension and rapid rollback of the narrow slab might be responsible for the different geologies of the northern and southern forearc segments [Fryer, 1996; Fryer et al., 1999, 2003; Stern et al., 2003; Gvirtzman and Stern, 2004].

We further argue that backarc regions in the southern Marianas and the region north of Guam should be distinct. For example, the distance between the trench axis to the backarc axis is ~300 km in the northern Mariana system, whereas it is only ~130 km in the south. The southernmost Mariana system therefore consists of forearc and backarc within a very narrow space and no well-defined magmatic arc has developed over the downgoing slab, making this a unique geological region. However, there have been no studies on the western extension of the Mariana Trough backarc basin, in contrast to the better-studied Mariana Trough to the north [e.g., Ohara et al., 2002; Yamazaki et al., 2003].

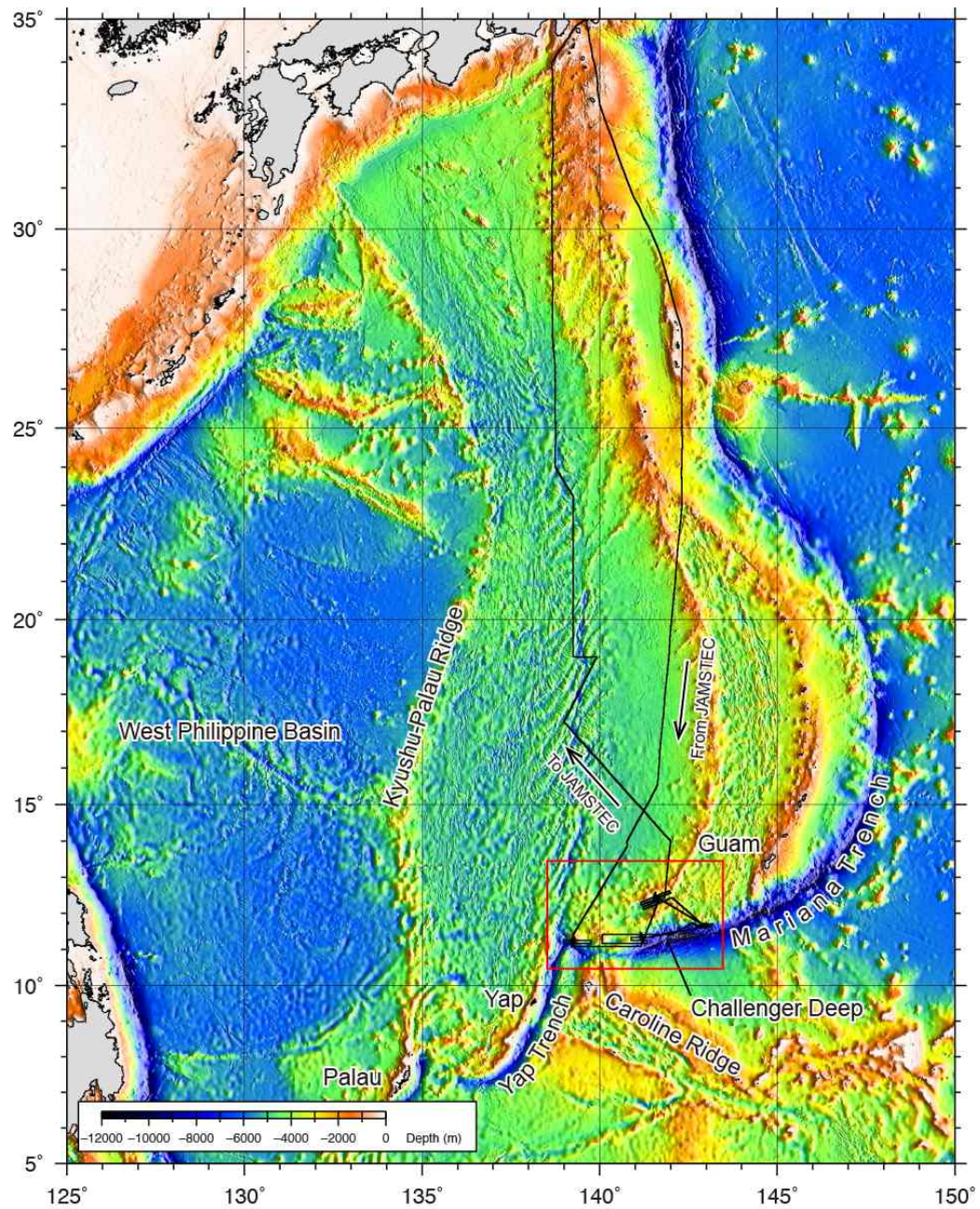


Fig. 1. Index map showing the location of studied area during YK14-13 cruise. The rectangle shown in red indicates the location of Fig. 2. Cruise track lines are also shown.

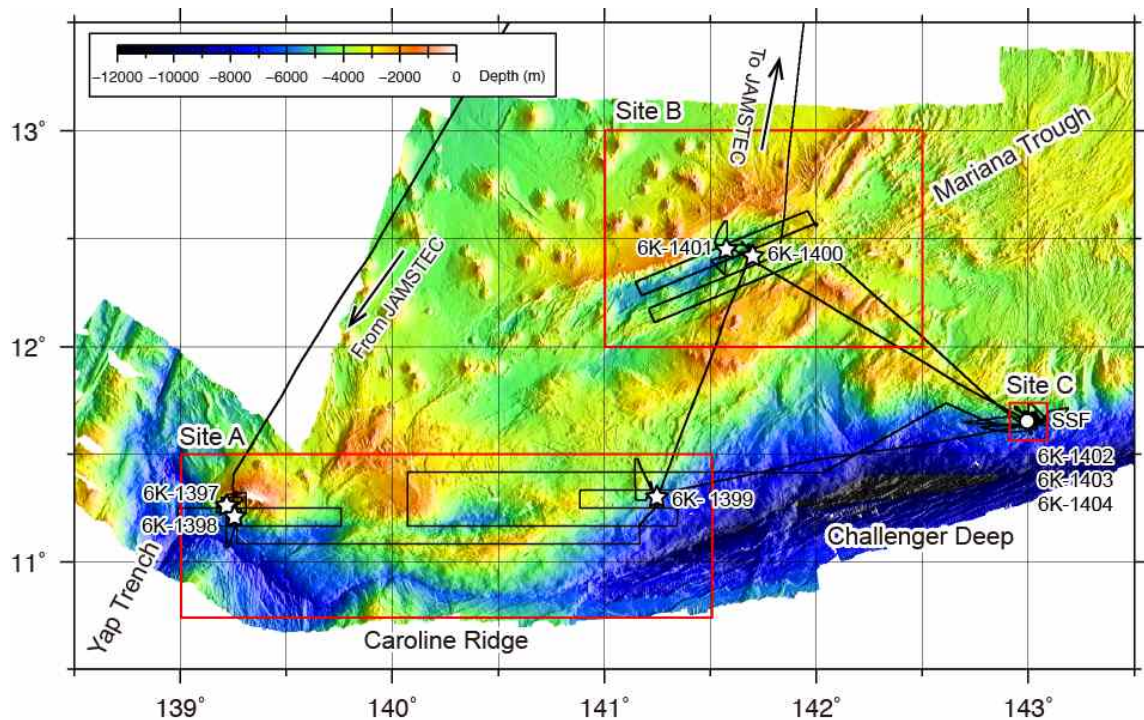


Fig. 2. Location of the dives during YK14-13 cruise. The rectangles shown in red indicate the location of Site A, Site B and Site C. Cruise track lines are also shown.

4. Survey items

During YK14-13 cruise, we have conducted eight Shinkai dives in Site A West, Site A East, Site B and Site C (**Fig. 2**). Because of the large swells from typhoon #10, we were unable to conduct Shinkai dive operations in Site A and Site B during the later phase of the cruise. We therefore decided to take the contingency plan, diving at Site C. Geophysical mapping were done on the selected areas. On our way back to home, a single swath mapping was made along the track within a certain portion of the Parece Vela Basin.

5. Running cruise narrative

Local time (Approximate)	Notes
7-Jul-14	The Yokosuka YK14-13 cruise began. The Yokosuka was underway to the survey area at the Southern Marianas.
9:00	All scientists aboard.
10:00	YK14-13 cruise began.
8-Jul-14	Underway to the survey area. No scientific activities were held during the daytime.
9-Jul-14	Underway to the survey area. Typhoon #8 hit Okinawa Island. Scientists worked on setting up the labs during the daytime.
10-Jul-14	Underway to the survey area. Typhoon #8 hit the mainland of Japan.
11-Jul-14	Underway to the survey area. Typhoon #9 emerged to the west of Guam. The sea condition, however, very good; sometimes glassy water was appeared.

12-Jul-14	The Yokosuka arrived at Site A West. 6K-1397 was conducted. Yasuhiko Ohara as the observer.
0:00	The survey within the Micronesian EEZ is now allowed. The Yokosuka started multibeam survey on the way to the first dive site (6K-1397) at Site A West.
9:03	The Shinkai opened vent, start of 6K-1397 dive. Yasuhiko Ohara as the observer.
11:37	The Shinkai on bottom (6000 m).
15:08	The Shinkai off bottom (4640 m).
17:33	The Shinkai on deck.
13-Jul-14	6K-1398 was conducted at Site A West. Ignacio Pujana as the observer. The Yokosuka conducted geophysical mapping in the night, headed to Site A East.
10:03	The Shinkai opened vent, start of 6K-1398 dive. Ignacio Pujana as the observer.
12:09	The Shinkai on bottom (4683 m).
15:51	The Shinkai off bottom (3430 m).
17:45	The Shinkai on deck.
14-Jul-14	6K-1399 was conducted at Site A East. Tomoyo Okumura as the observer. The Yokosuka conducted geophysical mapping in the night, headed to Site B.
9:02	The Shinkai opened vent, start of 6K-1399 dive. Tomoyo Okumura as the observer.
11:37	The Shinkai on bottom (5920 m).
15:07	The Shinkai off bottom (5147 m).
17:35	The Shinkai on deck.
15-Jul-14	6K-1400 was conducted at Site B. Teruaki Ishii as the observer. The Yokosuka conducted geophysical mapping in the night.
4:00	The Yokosuka arrived at Site B.
9:01	The Shinkai opened vent, start of 6K-1400 dive. Teruaki Ishii as the observer.
11:02	The Shinkai on bottom (4568 m).
15:20	The Shinkai off bottom (3119 m).
17:07	The Shinkai on deck.
16-Jul-14	6K-1401 was conducted at Site B. Hiromi Watanabe as the observer. Because of the typhoon located to the west, the sea condition was presumed to become worse in Site B. The Yokosuka therefore moved to Site C in the night.
9:12	The Shinkai opened vent, start of 6K-1401 dive. Hiromi Watanabe as the observer.
11:48	The Shinkai on bottom (5546 m).
15:10	The Shinkai off bottom (4615 m).
17:29	The Shinkai on deck.
17-Jul-14	6K-1402 was conducted at Site C. Yuta Konno as the observer. Because of typhoon #10 located to the west, the Yokosuka took the contingency plan, diving at the SSF in Site C. Since the survey box for Site C is small (10 NM by 10 NM), no geophysical mapping was conducted.
3:30	The Yokosuka arrived at the SSF.

9:04	The Shinkai opened vent, start of 6K-1402 dive. Yuta Konno as the observer.
11:34	The Shinkai on bottom (5905 m).
14:46	The Shinkai off bottom (5704 m).
17:30	The Shinkai on deck.
18-Jul-14	6K-1403 was conducted at Site C. Tomoyo Okumura as the observer. As was the case for July 17, because of typhoon #10 located to the west, the Yokosuka took the contingency plan, diving at the SSF in Site C. Since the survey box for Site C is small (10 NM by 10 NM), no geophysical mapping was conducted.
9:04	The Shinkai opened vent, start of 6K-1403 dive. Tomoyo Okumura as the observer.
11:32	The Shinkai on bottom (5935 m).
14:51	The Shinkai off bottom (5627 m).
17:28	The Shinkai on deck.
19-Jul-14	6K-1404 was conducted at Site C. Yasuhiko Ohara as the observer. As was the case for July 17, because of typhoon #10 located to the west, the Yokosuka took the contingency plan, diving at the SSF in Site C. Since the sea condition was presumed to become worse also in Site C, 6K-1405 dive was presumed impossible. Therefore, the Yokosuka left the SSF for Site A East for geophysical mapping in the night.
8:59	The Shinkai opened vent, start of 6K-1404 dive. Yasuhiko Ohara as the observer.
11:25	The Shinkai on bottom (5925 m).
14:52	The Shinkai off bottom (5722 m).
17:33	The Shinkai on deck.
20-Jul-14	6K-1405 dive was canceled due to rough sea condition. The Yokosuka conducted geophysical mapping in Site A East.
1:28	The Yokosuka arrived at Site A East.
21:43	The Yokosuka left Site A East for the SSF.
21-Jul-14	6K-1405 dive was again canceled due to rough sea condition. The Yokosuka stayed in Site C for whole day, just being drifted. A tropical depression (to become typhoon #11) had passed us from the daytime to the night.
6:43	The Yokosuka recovered proton magnetometer.
22-Jul-14	Although the weather became fine in the morning, large swells still prevailed. Therefore 6K-1405 dive was again canceled, ending our dive campaign in this cruise. The Yokosuka left the SSF for Site B for geophysical mapping until midnight.
10:40	Since 6K-1405 was finally canceled. The Yokosuka then left the SSF for Site B. Proton magnetometer was not deployed.
16:08	The Yokosuka arrived at Site B, starting geophysical survey.
Midnight	The Yokosuka ended the geophysical survey at Site B, headed to home (via the Parece Vela Basin).
23-Jul-14	Underway to home. Scientists worked in the labs. Single swath mapping in the Parece Vela Basin.
20:00	The Yokosuka started single swath bathymetry mapping in the Parece Vela

Basin.

24-Jul-14	Underway to home. Scientists worked in the labs. Single swath mapping in the Parece Vela Basin.
25-Jul-14	Underway to home. Scientists worked in the labs. Single swath mapping in the Parece Vela Basin.
26-Jul-14	Underway to home. Scientists worked in the labs. Single swath mapping in the Parece Vela Basin was finished in the morning.
5:25	The Yokosuka finished single swath bathymetry mapping in the Parece Vela Basin.
27-Jul-14	Underway to home. Scientists worked in the labs.
28-Jul-14	The Yokosuka arrived in the JAMSTEC pier in the morning. End of the cruise.
9:00	The Yokosuka arrived in the JAMSTEC pier in the morning. End of the cruise.
11:30	YK14-13 scientist disembarked.

6. Summary of the cruise results

Site A West (6K-1397 and 6K-1398) recovered very fresh mantle peridotite associated with troctolite, gabbro and limestone. The limestone preserves the remnants of corals, clearly indicating that the limestone is an accreted material originating from the incoming (colliding) Caroline Ridge. The freshness of the peridotites also indicates that the collision is an ongoing event, resulting in a protruding peridotite ridge along the inner trench slope west of the Challenger Deep. No serpentinite-hosted ecosystems were found in this site.

Site A East (6K-1399) recovered altered and serpentinitized mantle peridotite associated with troctolite and gabbro. No limestone was recovered. This perhaps means that collision of the incoming Caroline Ridge does not affect the geology of the inner slope of the Mariana Trench at the longitude of $\sim 141^{\circ}15'E$. No serpentinite-hosted ecosystems were found in this site.

Site B (6K-1400 and 6K-1401) recovered basalt and gabbro. The Mariana Trough appears to propagate to the west in this region. Therefore the site may represent either the backarc crust or the rifted old arc (West Mariana Ridge) crust.

Site C (6K-1402, 6K-1403 and 6K-1404) revisited the SSF and made biogeochemical samplings of the field, including sediment cores, macro and meio faunas, and Niskin and pressure-tight water samples. Furthermore, 6K-1403 and 6K-1404 discovered new carbonate chimney sites.

Figure 3 shows the typical field observations and samples obtained in YK14-13 cruise.

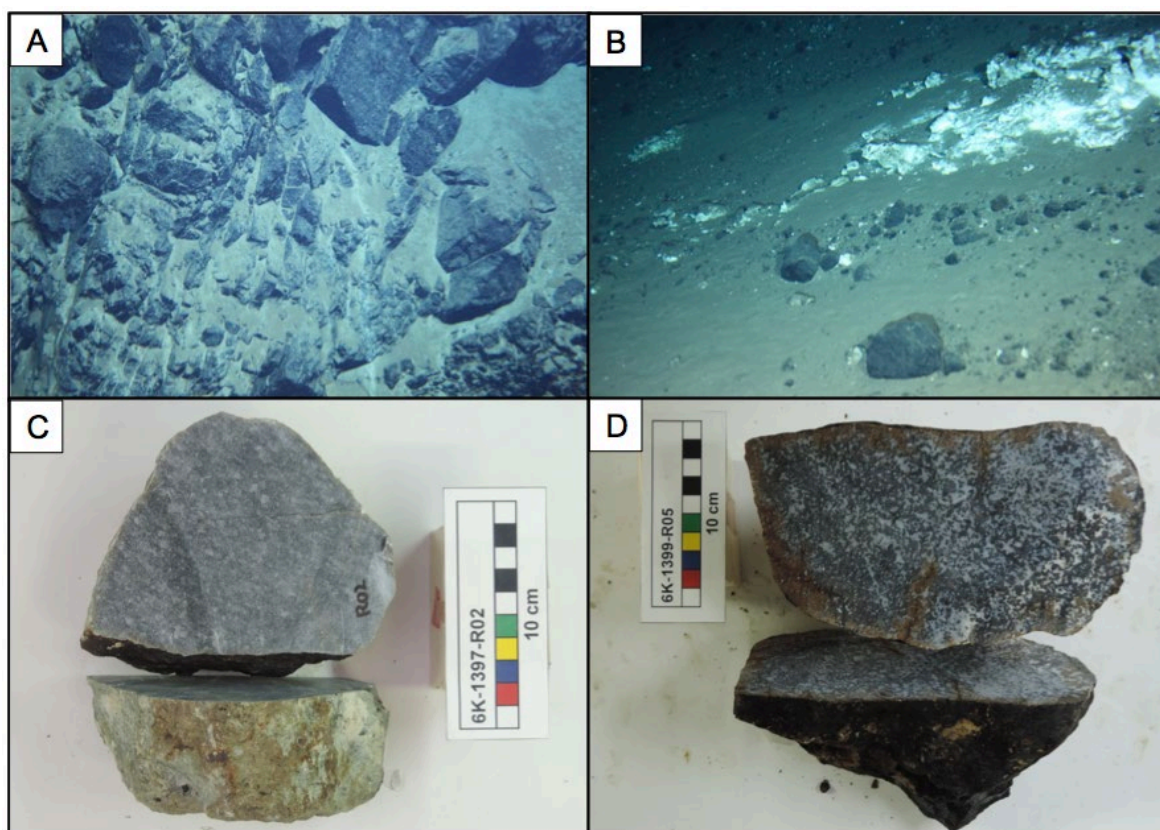


Fig. 3. Field observations and samples.

(A) Outcrop of fresh mantle peridotite observed during 6K-1397.

(B) Limestones observed during 6K-1397

(C) Fresh mantle peridotite collected during 6K-1397.

(D) Troctolite collected during 6K-1399.

7. References

- Bloomer SH, Hawkins JW (1983) Gabbroic and ultramafic rocks from the Mariana Trench: an island arc ophiolite. in *The Tectonic and Geologic Evolution of Southeast Asian Seas and Islands: Part 2*, ed. Hayes DE (*Geophysical Monograph Series*, 27, AGU, Washington DC.), pp 294-317.
- Fryer P (1996) Tectonic evolution of the Mariana convergent margin. *Reviews of Geophysics* 34: 89-125.
- Fryer P et al. (1999) Mariana blueschist mud volcanism: implications for conditions within the subduction zone. *Geology* 27: 103-106.
- Fryer P et al. (2003) Why is the Challenger Deep so deep? *Earth and Planetary Science Letters* 211: 259-269.
- Gvirtsman Z, Stern RJ (2004) Bathymetry of Mariana trench-arc system and formation of the Challenger Deep as a consequence of weak plate coupling. *Tectonics* 23 (TC2011): 10.1029/2003TC001581.
- Hawkins J, Batiza R (1977) Metamorphic rocks of the Yap arc-trench system. *Earth and Planetary Science Letters* 37: 216-229.
- Ishizuka O et al. (2011) The timescales of subduction initiation and subsequent evolution of an oceanic island arc. *Earth and Planetary Science Letters* 306: 229-240.
- Ohara Y, Ishii T (1998) Peridotites from the southern Mariana forearc: heterogeneous fluid supply in mantle wedge. *Island Arc* 7: 541-558.

- Ohara, Y. et al. (2002) Peridotites from the Mariana Trough: first look at the mantle beneath an active backarc basin. *Contributions to Mineralogy and Petrology* 143: 1-18.
- Ohara Y et al. (2012) A serpentinite-hosted ecosystem in the Southern Mariana Forearc. *Proceedings of the National Academy of Sciences of the USA* 109: 2831-2835.
- Reagan MK et al. (2010) Fore-arc basalts and subduction initiation in the Izu-Bonin-Mariana system. *Geochemistry Geophysics Geosystems* 11 (Q03X12): 10.1029/2009GC002871.
- Ribeiro JM et al. (2013a) Geodynamic evolution of a forearc rift in the southernmost Mariana Arc. *Island Arc* 22: 453-476.
- Ribeiro JM et al. (2013b) Nature and distribution of slab-derived fluids and mantle sources beneath the Southeast Mariana forearc rift. *Geochemistry, Geophysics, Geosystems* 14, 4585-4607, DOI: 10.1002/ggge.20244.
- Stern RJ et al. (2003) An overview of the Izu-Bonin-Mariana subduction factory. In *Inside the Subduction Factory*, ed. Eiler J (*Geophysical Monograph Series*, 138, AGU, Washington DC.), pp 175-222.
- Yamazaki T. et al. (2003) Spreading process of the northern Mariana Trough: rifting-spreading transition at 22°N. *Geochemistry Geophysics Geosystems*, 4 (9), 1075, DOI:10.1029/2002GC000492.