International Ridge-Crest Research: **Back Arc Basins**

Parece Vela Rift and Central Basin Fault revisited - STEPS-IV (Structure, Tectonics and Evolution of the Philippine Sea) - Cruise summary report

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Introduction

An enigmatic large linear structure in the Philippine Sea, the Central Basin Fault (CBF) was first found and named by Hess (1948). It occupies the central part of the West Philippine Basin (WPB), one of several backarc basins in the Western Pacific. The CBF is a WNW-ESE trending 1,000 km-long linear structure with a notable rift valley like a slow spreading ridge.

We mapped areas around the CBF during the KR98-01, KR98-12, and KR99-10 cruises. Our results made it clear that the CBF was a slow spreading center in a backarc basin. French R/V L'Atalante cruises (DAVAPUS from Davao to Pusan in 1994 and KAONOUM from Kaoshiung to Noumea in 1996) had two long single transect lines across the West Philippine Basin by using SIMRAD EM-12-Dual multibeam swath mapping system and major structures of the CBF were mapped (Deschamps *et al*., 1999). We also took sediment and rock samples and performed heat flow measurements at several points of the CBF and West Philippine Basin during the KR98-01 and KR99-10 cruises. Two Shinkai 6500 dives were performed in 1996. These dives collected photographs, videos and basalt samples from both walls of the CBF axial valley. Based on chemistry, the basalts were found to have a backarc basin affinity (Fujioka *et al*., 1999). However, despite these advances, numerous unsolved questions regarding the geology and geophysics of the West Philippine Basin still remain.

East of the West Philippine Basin lies the Parece Vela Basin which exhibits two trends of magnetic lineations. The analyses of these magnetic lineations made it clear that the Parece Vela Basin had two episodes of spreading history; the 1st was an EW fast spreading event, having several propagations to the north, followed by a NE-SW trending, slow spreading stage accompanied by amagmatic spreading (Ohara *et al*., 1996, 1997; Kasuga and Ohara, 1997;

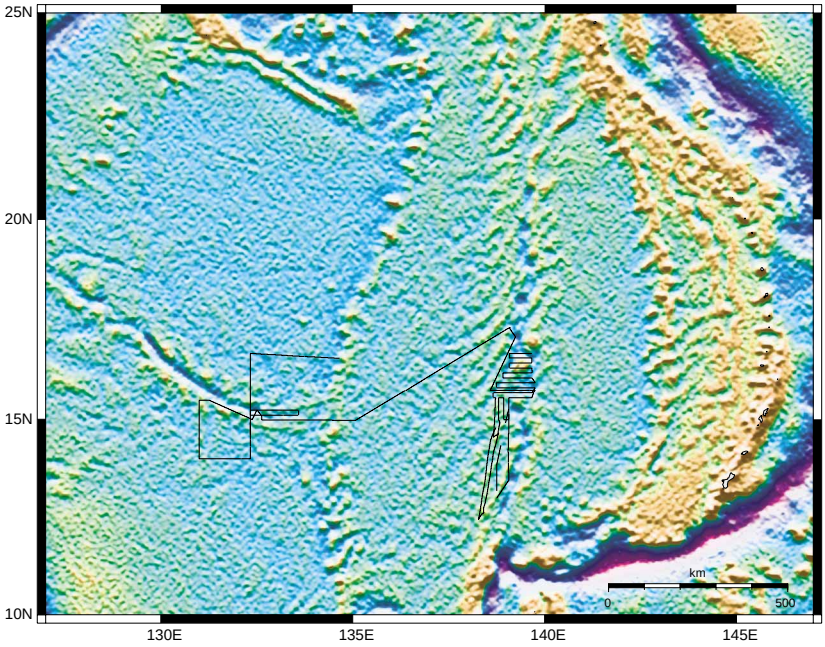

Figure 1. Map of the survey areas showing the ship's tracks during the STEPS-IV cruise.

Okino *et al*., 1998, 1999). Recently Ohara and others (in preparation) recognized three megamullion structures along the Parece Vela Rift and of these they noted the existence a huge megamullion-like structure called Giant Core Complex (GCC) in the area surrounded by 15°30'N, 16°30'N, 138°30E, 139°30'E. This structure has notable transform-parallel mullion-like structure.

In the light of these prior discoveries, we set out to further investigate the origins and evolution of the West Philippine Basin. This latest cruise focused on data collection from three different areas, the Parece Vela Rift, GCC and CBF, using the R/V Yokosuka, JAMSTEC. The scientific plan consisted of surface ship observations of gravity, bathymetry and magnetics (both proton and three-component magnetometer) and deep-towed proton magnetometer apparatus. The cruise, YK00-01 "STEPS-IV", Structure, Tectonics and Evolution of the Philippine Sea-IV, started at Guam pier on 26th January and ended at Guam pier again on 14 February. The cruise was conducted as a JAMSTEC project, under the umbrella of SEAS (Science of South East Asian Seas) and the InterRidge program. Scientists from France, the Philippines as well as Japanese universities and research institutions assembled onboard the Yokosuka in order to address the above stated scientific objectives.

The major objectives of this cruise were two-fold: 1) to investigate the precise magnetic reversal pattern of an extinct spreading ridge by the deep-towed proton magnetometer and 2) investigate the evolution of the Parece Vela Basin and the West Philippine Basin by elaborated swath mapping. The areas studied included segments of the Parece Vela Rift, the megamullion GCC, the eastern part of the CBF axis, as well as several transit lines from Parece Vela Basin to CBF across the Kyushu Palau Remnant Arc.

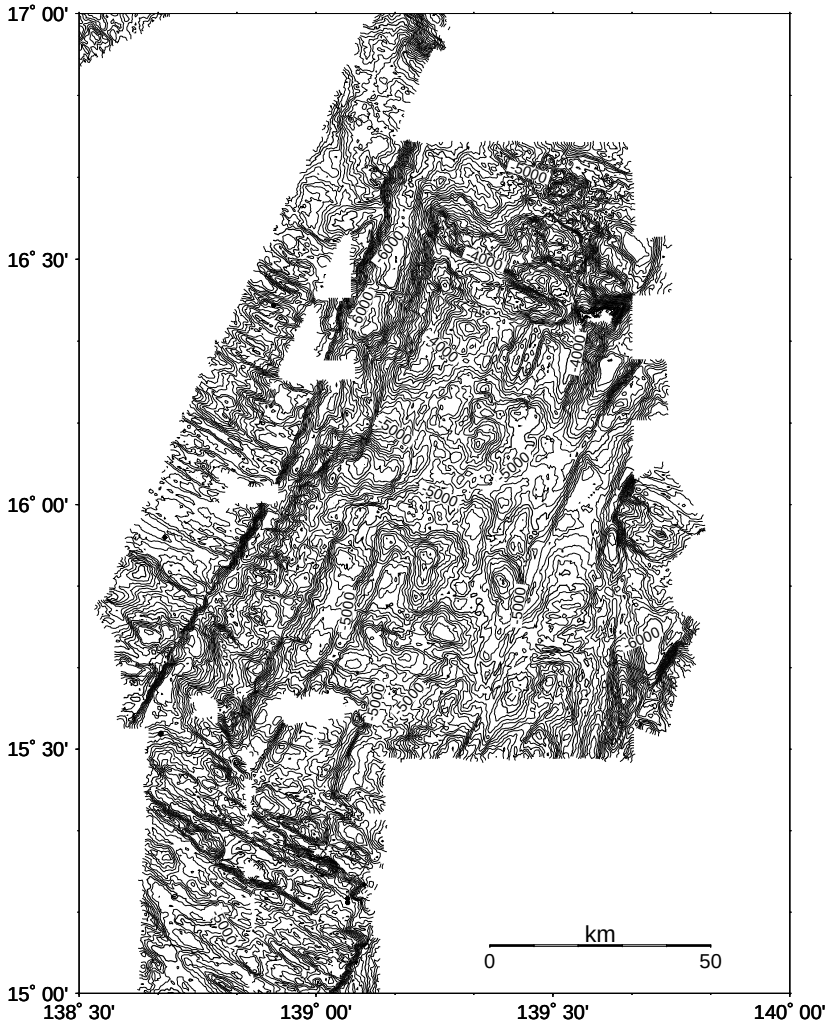

Figure 2a. Bathymetric map of the Giant Core Complex (GCC) in the Parece Vela Basin.

Results

During the YK00-01 STEPS-IV cruise, the following results were obtained for the Parece Vela Basin and the CBF. Figure 1 shows the ship' tracks of the STEPS-IV cruise.

1. Bathymetry and morphology

We conducted swath surveys using the SeaBeam 2112 system. The survey covered 930 miles of track in box surveys around the GCC and 730 miles in the eastern Central Basin Fault (E-CBF).

Morphology of the GCC

Previous results conducted by the Hydrographic Department of Japan allowed us to recognize at least three megamullion-like structures near three segments of the

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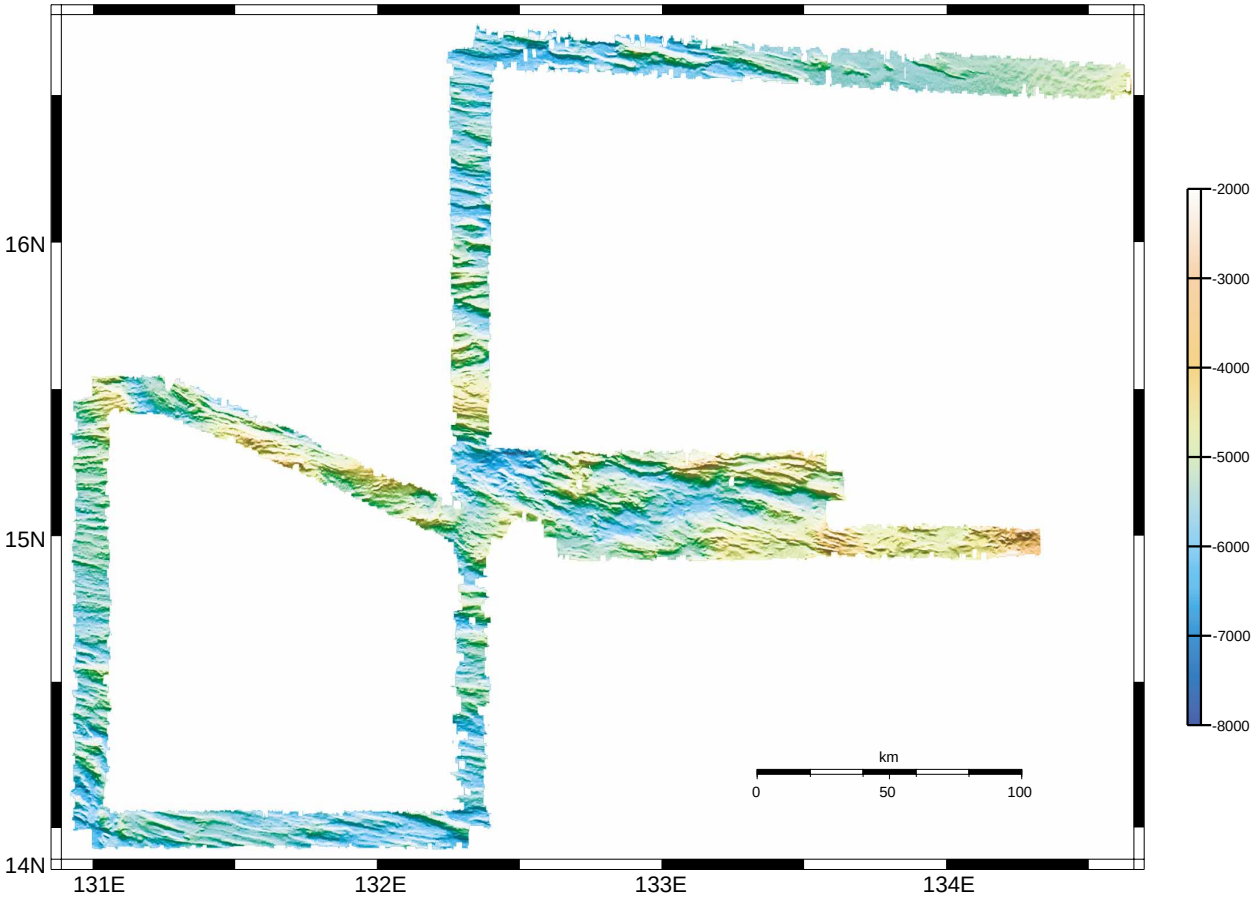

Figure 2b. Bathymetric map of the Eastern Central Basin Fault (E-CBF).

Parece Vela Rift from 16° - 19°N, and 139° - 140°E including the IPOD Trough named by the Russian scientists. This was the first finding of the megamullion structure from the backarc basins in the world (Ohara *et al*., in prep.). During this cruise we mapped one of the three mullions called the Giant Core Complex. The GCC occupies the southwestern half of the extinct spreading segment at around 16°N and the surface of the GCC is characterized by corrugations running parallel to the fracture zones. (Fig. 2a). We recognized three types of structures, prominent fracture zone-parallel mullion structures orientated NE-SW, as well as clear Break Away and Termination structures. The size of GCC is 120 km long and 57 km wide and covers an area of 7125 km^2, which is ten times greater than those reported from the Atlantic Ridge (Tucholke *et al*., 1997). This is the largest megamullion ever reported, therefore this should be called "Gigamullion". Serpentinized peridotites and gabbros were recovered from the IPOD Trough and the GCC (Shcheka, *et al*., 1995; Ohara *et al*., 1996; Fujioka *et al*., 1998). The peridotite composition varied from fertile lherzolite to depleted harzburgite. Many peridotite samples had evidence of mantle-melt interaction (Ohara *et al*., in prep.). Proton magnetometer survey across the GCC was also conducted across segment 3 and the result was compared with other segments.

Morphology of the E-CBF

We conducted three EW and two NS lines at the E-CBF, close to the junction with the Kyushu-Palau Ridge. We used two more lines, one transit line tracing a previous JAMSTEC cruise and a French cruise line obliquely crossing the CBF for the morphologic analysis. We made a small box at the E-CBF (Fig. 2b). The spreading fabrics trend at 290° was almost parallel to the axial valley. The boundary of the CBF and the Kyushu-Palau Remnant Arc was identified as a negative gravity anomaly along the 134°E line based on the Satellite Gravity Anomaly map (Sandwell and Smith, 1997) but the spreading fabrics of the CBF continue as far as 133°40'E. The axial valley of the CBF terminated at 133°40'E getting shallower to the east from

133°10'E. The rough spreading fabrics of the seafloor on both sides of the E-CBF, in comparison with western and central parts of the West Philippine Basin, can be interpreted either by a slower spreading rate or a smaller magmatic supply when compared with those of the slow spreading, Mid-Atlantic Ridge and fast spreading, East Pacific Rise.

Transit lines

We had two long transit lines from the Parece Vela Rift to the E-CBF across a "chaotic terrain" of the west half of the Parece Vela Basin. This terrain consisted of isolated and elevated dome-like blocks (maximum relief was up to 1500m), capped by axis-normal lineations and associated deeps. Ohara *et al.* (in prep.) interpreted these isolated dome-like blocks to be analogues of megamullion structures.

2. *Geophysics*

We conducted geophysical surveys on the gravity and magnetic properties together with swath mapping by using a gravity meter, a proton magnetometer, the shipboard three-component magnetometer and a DTPM system. An additional three component magnetometer, which was recently developed by scientists at Chiba University was also used parallel to the shipboard three component magnetometer. Gravity and magnetic data will be analysed in the near future to elucidate the crust and upper mantle structure, as well as the magnetic lineations of the West Philippine Basin and the Parece Vela Basin.

3. *Deep Tow Proton Magnetometer*

We conducted surveys along a transect (195 nautical miles, NE to SW) by using DTPM under the following conditions. The ship's speed was 1.7-2.4 knot, (average, 2.2 knot) with respect to the ground, and the towing depth was 2100-3000 m below sea surface. The chosen line was across one segment of the Parece Vela Rift covering both NE and SW sides of the extinct spreading centers. High resolution magnetic intensity peaks were identified along the line and we correlated small peaks with theoretical magnetic reversal pattern to get a more precise evolutionary history of the later stage of the Parece Vela Basin formation (Fig. 3). Online data transmission system worked successfully during the survey.

Summary

A geophysical swath survey and a Deep-Towed Proton Magnetometer survey were carried out using the R/V Yokosuka, JAMSTEC in the vicinity of the Parece Vela Rift and the CBF during a 20 day cruise in Jan-Feb 2000. A huge megamullion called Giant Core Complex was fully mapped, including its corrugated

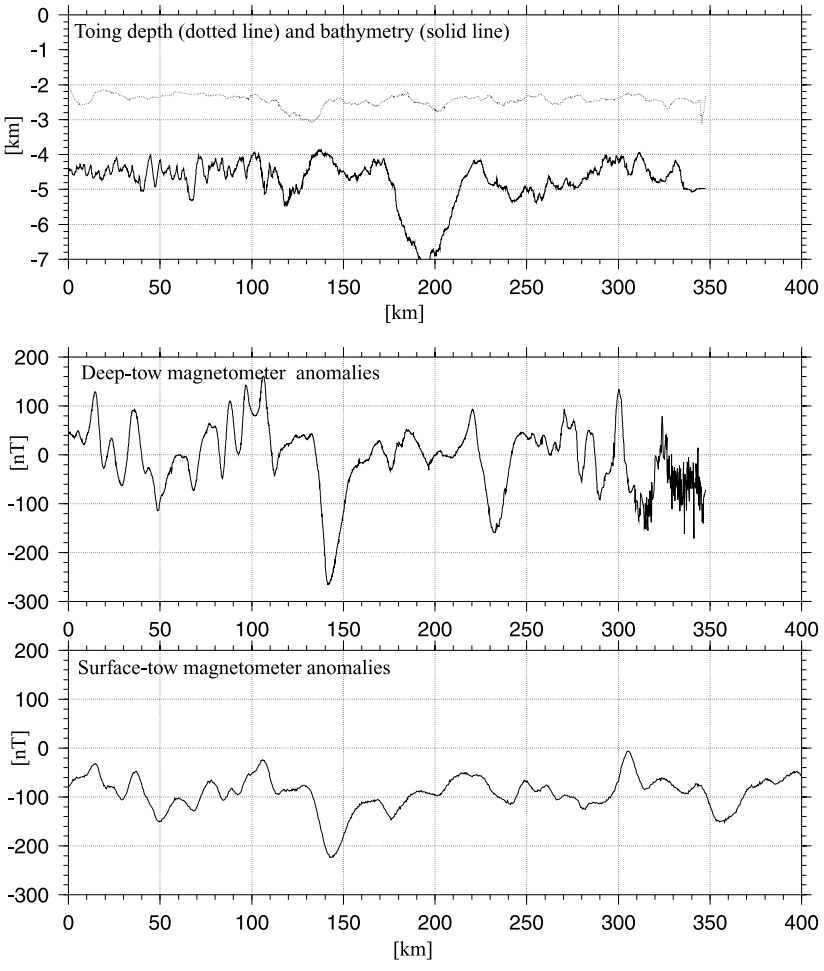

Figure 3. Deep Tow Proton Magnetometer (DTPM), a comparison with the surface proton magnetometer. A topographic cross section along the NE-SW survey line across one segment of the Parece Vela Basin.

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surface structure, as well as termination and break away points. A deep-towed proton magnetometer survey was performed across one segment of the Parece Vela Basin to obtain fairly good magnetic signals for a better understanding of the spreading history. The easternmost segment of the CBF was also mapped near its junction with the Kyushu Palau Ridge. Two N-S lines were acquired across the extinct spreading center, perpendicular to the spreading fabrics for age determination from magnetic anomalies. These new data contribute to our knowledge on the last spreading phases of both the Parece Vela Basin and the West Philippine Basin.

Acknowledgments

The scientific party of STEPS-IV cruise expresses its thanks to all the officers and crew of the Yokosuka who assured the smooth and safe operations of geophysical swath mapping and Deep-Towed Proton Magnetometer survey in the Philippine Sea even under rough sea condition. We thank K. Suyehiro, K. Tsujii and all the JAMSTEC personnels for their vigorous support and help in the preparation of the cruise. Thanks are also due to K. Tamaki of ORI, University of Tokyo and to N. Seama of Chiba University.

References

Deschamps, A., Lallemand, S., Dominguez, S., The last spreading episode of the West Philippine Basin revisited, Geophysical Research Letters, vol. 26, 14, 2073-2076, 1999.

Fujioka, K., Fujiwara, T., Kanamatsu, T., Okino, K., Hilde, T.W., Honza, E., Ishii, T., Ikehara, K., Matsuoka, H., Hisada, K., Ohara, Y., Tsuchihashi, M., Haraguchi, S., Kato, K., Kawamura, K., Kaneko, G., Takasugi, H., Takahashi, M., Kodera, T., and Motoo, T., Morphology of Mariana Trench and and Central Basin Fault- preliminary results of KR9801 cruise-. JAMSTEC J. Deep Sea Res., 14, 163-192, 1998.

Fujioka, K., Okino, K., Kanamatsu, T., Ohara, Y., Ishizuka, O., Haraguchi, S., and Ishii, T., An enigmatic extinct spreading center in the West Philippine backarc basin unveiled, Geology, v.27 1135-1138,1999.

Hess, H. H., Major structural features of the western north Pacific, and interpretation of H. O. 5989 bathymetric chart, Korea to New Guinea. Bull. Geol. Soc. Am., 59, 417-446, 1948.

Kasuga, S. and Ohara, Y., 1997. A new model of back-arc spreading in the Parece Vela Basin, northwest Pacific margin. The Island Arc, 6, 316-326.

Ohara Y., Kasuga S. and Ishii T., Peridotites from the Parece Vela Rift in the Philippine Sea: Upper mantle material exposed in an extinct back-arc basin. Proceedings of the Japan Academy , 72, Ser. B, 118-123, 1996.

Ohara, Y., Kasuga, S., Okino, K. and Kato, Y., Survey maps Philippine Sea structures. EOS, Transactions, American Geophysical Union., 78, Number 48, 555, 1997.

Okino, K., Kasuga, S. & Ohara, Y., A new scenario of the Parece Vela Basin Genesis. Mar. Geophys. Res.20, 21-40, 1998.

Okino, K., Ohara, Y., Kasuga, S. and Kato, Y., The Philippine Sea: New survey results reveal the structure and the history of the marginal basin, Geophysical Research Letters, vol.26, 15, 2287-2290, 1999.

2000 Western Pacific Geophysics Meeting

SEAS and InterRidge Joint Business Meeting

Evening of 28th June , 2000

Convernors: Masataka Kinoshita (SEAS) and Hiromi Fujimoto (IR Back-Arc Basin WG)

Place: Meeting room in the WPGM conference building in Tokyo

SEAS (Science of East Asia Seas) and InterRidge Back-arc Basin Working group will exchange the information of recent activities of offshore research of the western Pacific by the Asian countries. We also discuss about the possible coordination of future researches in the western Pacific.