Geophysical swath mapping of the Parece Vela Rift and Central Basin Fault in the Philippine Sea - STEPS-IV cruise summary report-

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A geophysical swath survey and a Deep-Towed Proton Magnetometer survey were carried out using the *R/V Yokosuka* of JAMSTEC at the Parece Vela Rift and the Central Basin Fault and its adjacent area, during a 20 day cruise from Guam (departure January 26, 2000) to Guam, (arrival February 14, 2000). A huge megamullion called Giant Core Complex was fully mapped and corrugated surface structure, termination and break away were recognized. A deep-towed proton magnetometer survey was performed across one segment of the Parece Vela Rift to obtain fairly good magnetic signals for a better understand the spreading history. The easternmost segment of the Central Basin Fault was also mapped near its junction with the Kyushu-Palau Ridge. Two N-S lines were acquired across the extinct spreading center, normal to the fabrics for age determination from magnetic anomalies. These new data sets contribute to our knowledge on the last spreading phases of both the Parece Vela Basin and the West Philippine Basin.

Keywords : Philippine Sea, Central Basin Fault, Parece Vela Rift, West Philippine Basin, Megamullion, Giant Core Complex, Slow spreading, Corrugated surface, Magnetic signals

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1. 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 around the CBF during the KR98-01, KR98-12, and KR99-10 cruises. Our result 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 WPB 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 WPB 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 problems still exist on the geology and geophysics of the WPB.

East of the WPB lies the Parece Vela Basin (PVB) which exhibits two trends of magnetic lineations. The analyses of these magnetic lineations made it clear that the PVB had two episodes of spreading history; one was an EW fast spreading having several propagation to the north and followed by a NE-SW trending slow spreading stage accompanied by amagmatic spreading (Ohara et al., 1996, 1997; Kasuga & Ohara, 1997; Okino et al., 1998, 1999).

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

In the light of these prior discoveries, we will address the following major issues on the present cruise: 1) How did the WPB originate and develop, and what is its relationship with CBF ? 2) What is the nature of the magnetic properties and GCC structure of the PVB ? The present cruise will focus on these major problems in three different areas, the PVR, GCC and CBF, using the *R/V*

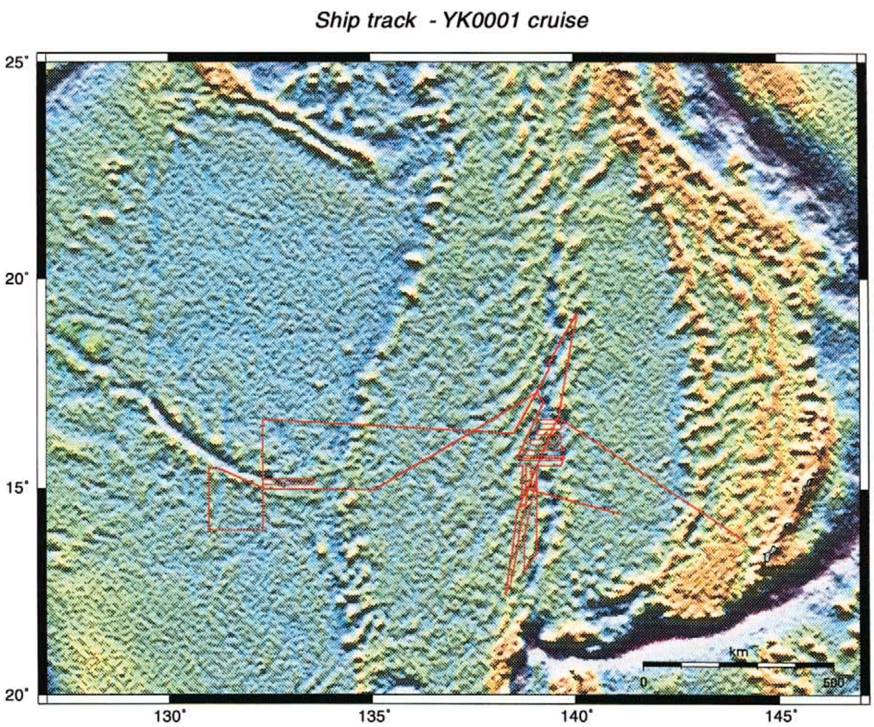

Fig. 1 Index map of the survey areas with ship's tracks of the STEPS-IV cruise

Yokosuka of JAMSTEC. The scientific plan consists of surface ship observations of gravity, bathymetry and magnetics (both proton and three-component magnetometer) and deep-towed proton magnetometer apparatus.

The present 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 14th February during 20 days was done as a JAMSTEC project, as well as under the umbrella of SEAS (Science of South East Asian Seas) and the InterRidge program. Scientists from France, Philippine and Japanese university and institutions assembled onboard Yokosuka in order to address the above stated scientific objectives.

2. Major Objectives

The major objectives of the STEPS-IV cruise are 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 PVB and WPB by the elaborated swath mapping both PVB and CBF. The areas studied were one segment of PVR, GCC, a megamullion and eastern part of CBF axis. Several transit lines from PVB to CBF via Kyushu-Palau Remnant Arc (KPRA).

3. Results

During the YK00-01 STEPS-IV cruise, the following results were obtained for the PVB and the CBF. Figure 1 shows the ship’s tracks of the STEPS-IV cruise.

3.1. Bathymetry and morphology

We conducted swath surveys using the SeaBeam 2112 system, a Lacoste-Romberg gravity meter, a pro-

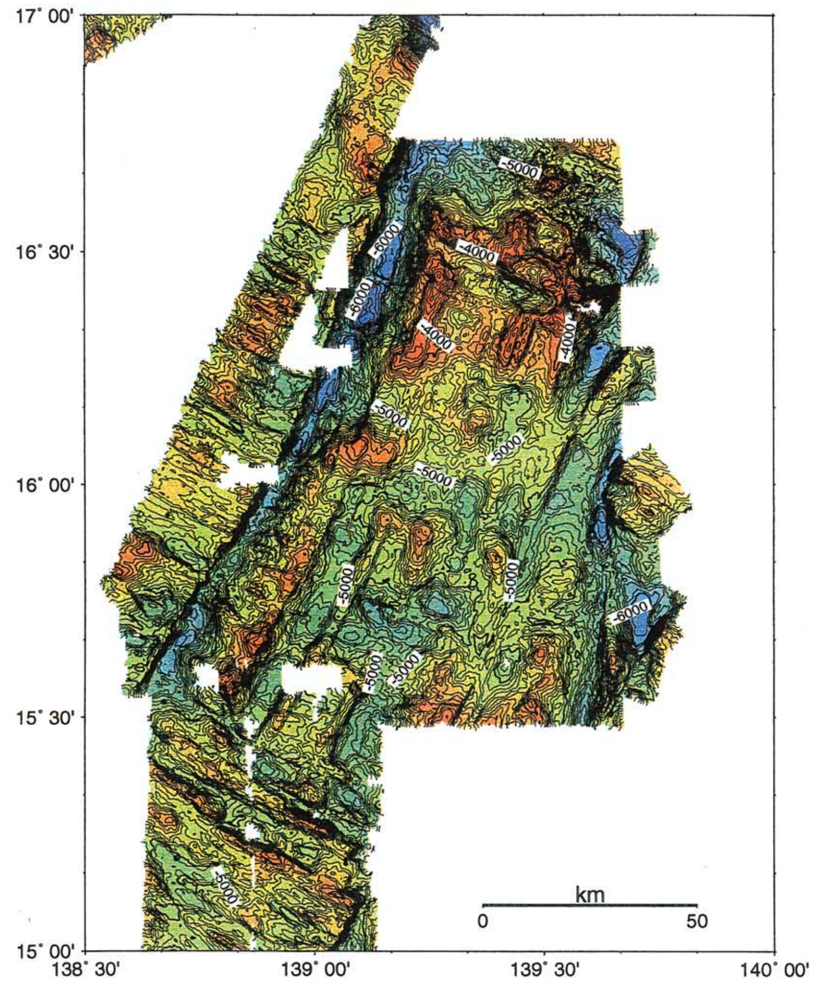

Fig. 2 Bathymetric map of the GCC (Giant Core Complex) in the PVB

ton magnetometer and shipboard three-component magnetometer. The survey covered 930 miles of track in box surveys around the GCC and 730 miles in the eastern CBF (E-CBF).

3.1.1. Morphology of GCC

Previous results being conducted by the Hydrographic Department of Japan have allowed us to recognize at least three megamullion-like structures near three segments of the PVR from 16° to 19°N, and 139°-140°E including 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 preparation). During this cruise we mapped one of the three mullions called GCC.

The GCC occupies the southwestern half of the extinct spreading segment at around 16°N forming a "Japanese Straw Sandal" shape (Fig. 2). The surface morphology of the GCC looks like an old Japanese slipper, "Straw Sandal". We recognized prominent fracture zone-parallel mullion structures which trend NE-SW, clear Break Away and Termination (Fig. 3). The size of GCC is 65 miles x 31 miles, 120 km long and 57 km wide, (7125 km^2) which is ten times larger than those

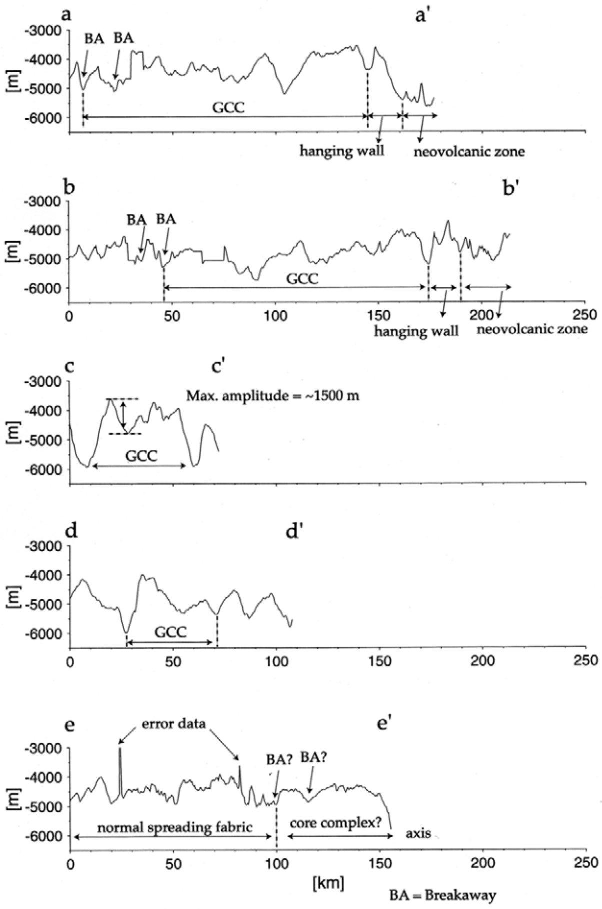

Fig. 3 Topographic cross sections of the GCC.

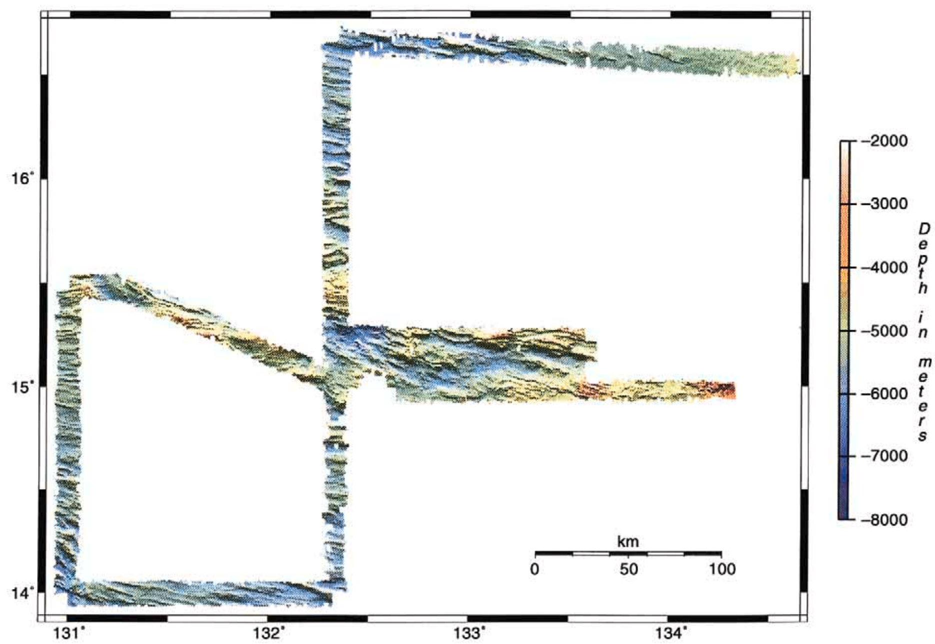

Fig. 4 Bathymetric map of the E-CBF (Eastern Central Basin Fault)

reported from the Atlantic Ridge (Tucholke et al., 1997; 1998). This is the largest megamullion ever reported, therefore this should be called "Gigamullion".

Serpentinized peridotites and gabbros are recovered from IPOD Trough and the GCC (Shcheka, et al., 1995; Ohara et al., 1996; Fujioka et al., 1998; 1999). The peridotite composition varies from fertile lherzolite to depleted harzburgite. Many peridotite samples have 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.

3.1.2. Morphology of E-CBF

We have conducted three EW and two NS lines at the E-CBF, close to the junction with the KPR. We used two more lines, one transit line of the previous cruise and one French cruise line obliquely crossing the CBF for the morphologic analysis. We made a small box at the E-CBF and made a precise swath survey (Figs. 4 & 5). N-S topographic cross sections are in Fig. 6. The spreading fabrics trend 290° almost parallel to the axial valley. The boundary of the CBF and the KPRA is 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 continues as far as 134°40'E. The axial valley of the CBF terminated at 139°40'E getting shallower to the east from 133°10'E. This suggests that the origin of

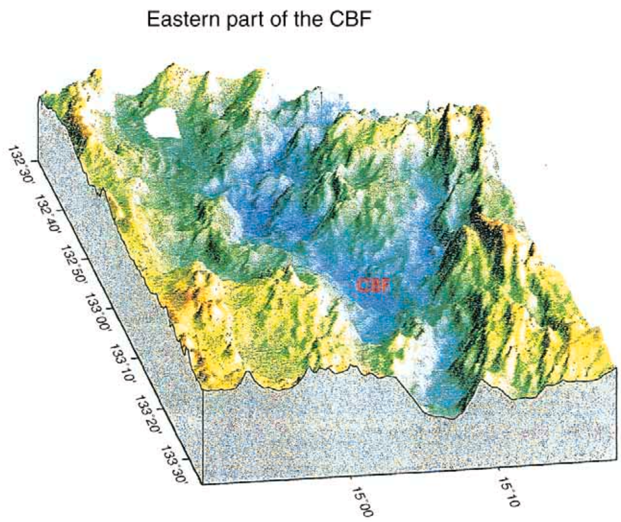

Fig. 5 Whale-eye's view of the E-CBF

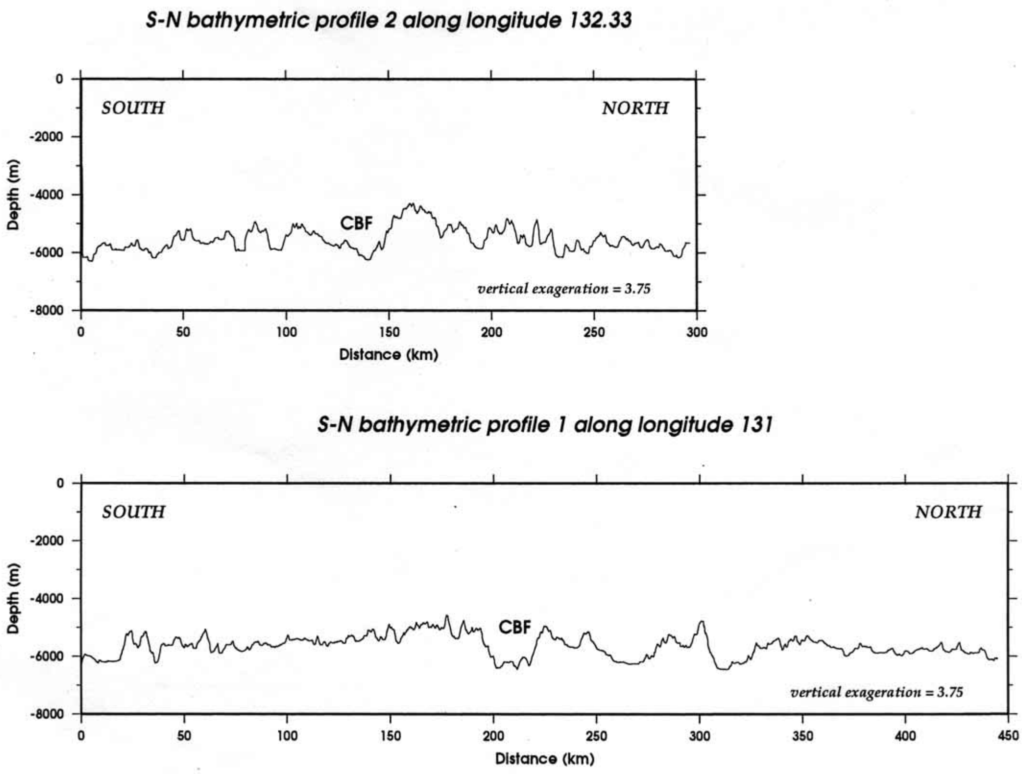

Fig. 6 Topographic cross sections of the WPB (NS line)

the structural boundary between CBF and KPR may lie at the deeper part.

The rough spreading fabrics of the seafloor on both sides of the E-CBF, in comparison with western and central parts of the WPB, 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..

3.1.3. Transit lines

We had two long transit lines from the PVR to the E-CBF via "chaotic terrain" of the west half of the PVB. This terrain consists of isolated and elevated dome-like blocks (maximum relief is up to 1500m), capped by axis-normal lineations and associated deeps. Ohara et al. (in prep.) assumed these isolated dome-like blocks are analogues of megamullion structures.

3.2. Geophysics

We conducted geophysical survey on the gravity and magnetic properties together with swath mapping by using SeaBeam, a gravity meter, a proton magnetometer, shipboard three-component magnetometer and a Deep-Towed Proton Magnetometer, DTPM system. Good quality data were obtained along all the track lines. The additional three component magnetometer which was newly developed by scientists of the Chiba University was also used parallel to our 3-componet magnetometer. Gravity and magnetic data will be treated after the cruise to elucidate the crust and upper mantle structure, as well as the magnetic lineations both of the WPB and PVB.

3.3. Deep-Towed Proton Magnetometer

We conducted a total 195 miles NE to SW line by using DTPM under the following conditions. The ship's speed was 1.7-2.4 kt, (±2.2 kt in average) with respect to ground, and the towing depth was 2100-3000 m below sea surface. The line was chosen across one segment of the PVR covering both NE and SW sides of the extinct spreading centers. High resolution magnetic intensity peaks were identified along the line and we had correlated small peaks with theoretical magnetic reversal pattern to get a more precise evolution history of the later stage of the PVR (Fig. 7). Online data transmission system worked successfully during the survey.

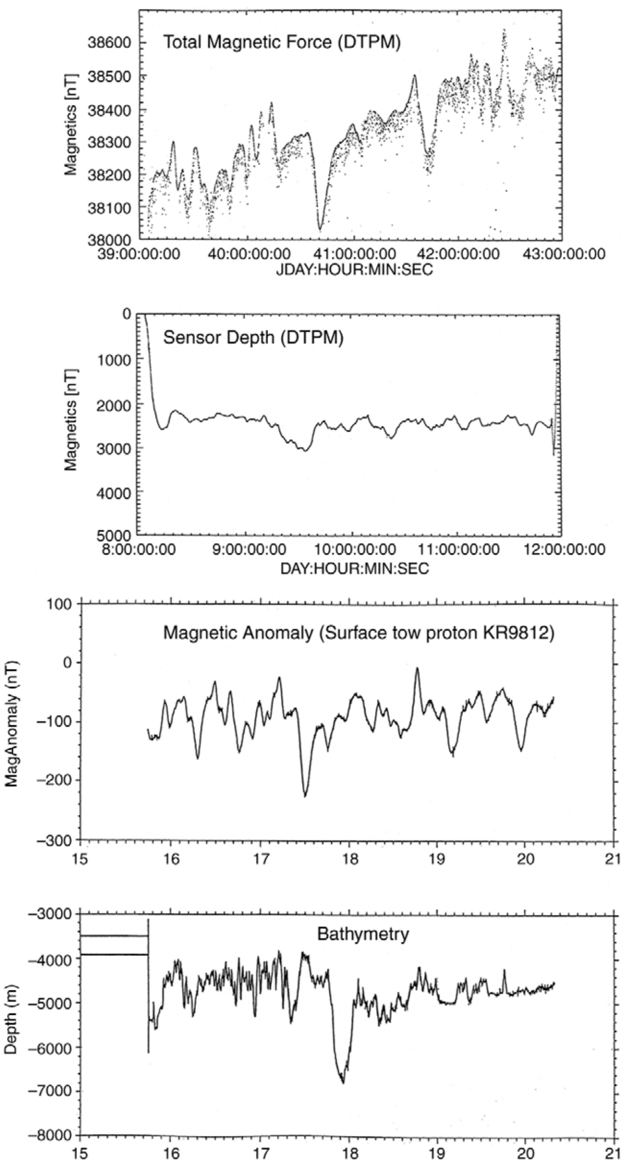

Fig. 7 DTPM (Deep-Towed Proton Magnetometer) line across one segment of the PVB in comparison to the surface proton magnetometer, topographic cross section along the survey line

4. Discussion

The size of the GCC is 120 km long and 57 km wide (7125 km^2) which is ten times larger than those reported from the Mid-Atlantic Ridge (Tucholke et al., 1997; 1998). We just found only one GCC within the survey area of the PVR but in future similar structures will be found more if we have an elaborated swath mapping. Tucholke and others (1997; 1998) explained the origin of the megamullion by the extension tectonics similar to the origin of the metamorphic core complex in the Basin and Range Province, USA. In the slow spreading center the size of the megamullion is something one tenth of the GCC and magmatic and amagmatic spreading do occur along the non-transform offsets. However it is quite unusual to have such a huge amagmatic mass near the spreading center. A possible answer is intermediate or fast spreading ridge also have a megamullion during the amagmatic stage but there was no report of such a megamullion in the East Pacific Rise, yet.

The eastern part of the CBF was mapped and the fabric diagnostic to the fast spreading ridge was recognized. Previous results showed the slow spreading fabrics in the middle part and rather fast spreading fabric at the western part of the CBF therefore this is a new evidence of the CBF as for the junction between KPR and CBF. This means that the history of the spreading of the WPB was slow in the middle part but fast at the eastern and western edges owing to a possible hot spot and/or hot region origin. It is possible that the history of the spreading of the WPB will be more complex modes including different rates of the spreading. This may be in relation to the initiation of the rifting and spreading of the Shikoku and Parece Vela Basin during the last stage of the spreading of the WPB.

5. Summary

A geophysical swath survey and a Deep-Towed Proton Magnetometer survey were carried out using the *R/V Yokosuka* of JAMSTEC at the Parece Vela Rift and the Central Basin Fault and its adjacent area, during a 20 day cruise from Guam (departure January 26, 2000) to Guam, (arrival February 14, 2000). A huge megamullion called Giant Core Complex was fully mapped and corrugated surface structure, termination and break away were recognized. 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 understand the spreading history. The easternmost segment of the Central Basin Fault 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 set contribute to our knowledge on the last spreading phases of both the Parece Vela Basin and the West Philippine Basin.

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