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Geophysical approaches to the Mariana back-arc spreading system

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We will give an overview on recent results of four different geophysical approaches to Mariana back arc spreading system; 1) swath bathymetry with sidescan backscatter images and vector geomagnetic anomaly to reveal the tectonics of Mariana Trough, 2) gravity anomaly with bathymetry to estimate variation in crustal thickness that corresponds to variation in melt production along the axis, 3) marine magnetotelluric (MT) experiments to map the distribution of melt within the mantle and/or dehydration of the mantle wedge through estimation of the electrical resistivity structure, and 4) magnetometric resistivity (MMR) experiments to reveal hydrothermal circulation system beneath the hydrothermal vents at spreading axes of Mariana Trough through estimation of the resistivity structure.

Vector geomagnetic anomaly is especially useful to identify crustal ages in Mariana Trough, because it is near the geomagnetic equator and the total intensity anomaly profiles, which are conventionally used, are obscure to identify geomagnetic lineations. Sidescan backscatter images are also useful to identify the present spreading axis. These advantages help us to clarify the location and time of the rifting-to-spreading transition in the northern Mariana Trough, which was controversial previously (Yamazaki et al., 2003), and allow us to reveal the tectonics of Mariana Trough.

Kitada et al. (in press) have compiled extensive gravity and bathymetry data for the whole Mariana Trough. The crustal thickness variation along the spreading axis was estimated from the Mantle Bouguer Anomalies (MBA). Different features in crustal thickness, its variation, and segment length for each segment, allow us to identify four distinct regional differences in magmatic activity along the spreading axis of Mariana Trough. Different features in the MBA for off-axis areas suggest that these four regions have existed since Mariana Trough started spreading. Comparison between our results of crustal thickness and previous geochemical results indicates that less-magmatic spreading segments with thin crust, which are locally distributed, probably result from mantle source depleted of water and incompatible elements. This suggests that lateral compositional variation exists on a segment scale in the mantle source beneath the spreading axis.

A marine MT experiment using ocean bottom electromagnetometers (OBEMs) was carried out in the central Mariana area from 2001 to 2002 to elucidate resistivity structure from Pacific plate to Parece-Vela basin through Mariana trough. 2-D structure obtained from the data shows that the mantle resistivity decrease from several hundreds or more to several tens or less ohm-m at the depth of 60-70 km beneath Mariana Trough (Baba et al., 2005). This feature is interpreted that the upper resistive mantle is result from drying out of olivine due to partial melting while the lower resistivity area is in wet condition. Moreover, a new MT transect across the central Mariana subduction-arc-back arc system using 33 OBEMs, 7 OBEs, and 7 OBMs at 40 sites, is ongoing by a Japan, US, and Australia collaborative research effort to address issues of hydration of the mantle wedge resulting from subduction, and the nature and distribution of subsequent melting (Seama et al., 2006).

The MMR sounding system has been newly developed by Kobe University and JAMSTEC as a joint research to derive the resistivity structure of a shallow part of the oceanic crust. Tada et al. (2005) used this system at hydrothermal sites of the Alice Springs Field on the spreading axis of the central Mariana Trough, and two resistivity structure models were estimated: one for the axial OBMs, and another for the off-axis OBMs. A region of lower resistivity between depths of 100-300 m is identified only in the on-axis model, suggesting that the hydrothermal source probably exists beneath the spreading axis, and that the size of this source is smaller than 700 m.