Rifting and Breakup of the Proto-Izu-Bonin Arc and Early Seafloor Spreading in the Southern Shikoku Basin

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The Philippine Sea constitutes one of the best areas globally to study the complete tectonic evolution of a backarc spreading system, specifically the Shikoku Basin, which is bounded by the active Izu-Bonin arc to the east, and the Kyushu-Palau Ridge (interpreted remnant Eocene - Oligocene arc of the Proto-Izu-Bonin arc and backarc system) to the west.

To investigate the development of the Proto-Izu-Bonin backarc system, in particular the nature of rifting, breakup, and backarc seafloor spreading, we have analyzed high-quality, deep penetration multichannel seismic reflection (MCS) data, in conjunction with swath bathymetry, satellite-derived free-air gravity, and marine magnetic data, across the central Kyushu-Palau Ridge and southern Shikoku Basin. To complement analyses of these primary data, we have calculated stretching (beta) factors for the crust and plate strength of the arc.

Basement of the Kyushu-Palau Ridge has been deformed by normal faulting, forming small sedimentary basins and sediment ponds. Analysis of the structures suggests that the Kyushu-Palau Ridge formed as part of the active Proto-Izu-Bonin arc in early Tertiary time, and was separated from the active portion of that arc by rifting, breakup, and backarc seafloor spreading starting in Oligocene time.

On the basis of these marine geological and geophysical data and their interpretations, we propose the following model for the Cenozoic tectonic evolution of the Proto-Izu-Bonin arc and backarc system, incorporating previous Izu-Bonin tectonic reconstructions: (a) rifting of the Proto-Izu-Bonin arc (Eocene - Oligocene volcanic arc's intra-arc rifting), (b) breakup of the Proto-Izu-Bonin arc, and then (c) continuous Shikoku Basin spreading and separation of the Kyushu-Palau Ridge as a remnant arc.

Swath bathymetry data delineate the distribution of the Kyushu-Palau Ridge seamounts, rift blocks, and ridges that form a 'zigzag' pattern; volcanism overprinting rift-related normal faults; and a presumed volcanic ridge near the arc-ocean transition that trends perpendicular to the strike of the initial Shikoku Basin spreading axis. These observations suggest contemporaneous late-stage Kyushu-Palau Ridge arc volcanism and initial Shikoku Basin spreading ridge volcanism. To explain these two types of magmatism coexisting, we propose a mechanism of 'arc-ridge interaction,' active during breakup of the Proto-Izu-Bonin arc, that is similar to hotspot-ridge interaction.

During initial spreading of the southern Shikoku Basin, 'chaotic terrain' characterized by five newly identified oceanic core complexes and anomalously thin oceanic crust formed in the southwestern Shikoku Basin. This suggests that spreading of the southern Shikoku Basin was characterized by relatively weak magmatic activity. The basic architecture of the Proto-Izu-Bonin rift system and its tectonic evolution are comparable to those of weakly magmatic passive continental margins that have experienced deep crustal and/or upper mantle material exhumation.