

Geologic constraints on motion of the Philippine Sea Plate: Evidence for CCW rotation of the plate motion vector relative to Eurasia in the Pleistocene

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Geologists have long recognized the possible significance of a change in motion of the Philippine Sea Plate (PSP) in the middle to late Cenozoic (Huchon, 1983; Seno and Maruyama, 1984), although the detailed timing and kinematics have remained elusive. The most recent reconstructions suggest a ~50° counterclockwise rotation of the plate motion vector relative to Eurasia possibly as recently as 2 Ma (Wu et al., 2015), which would have significant implications for the tectonics of east-central Asia. In southern Japan, for example, CCW rotation of the plate motion vector predicts a change from generally orthogonal plate convergence to the present NW-directed and oblique motion. In Taiwan, in contrast, plate convergence obliquity would decrease significantly. To better understand and possibly better constrain the geometry, kinematics and timing of this change in motion, we review the geologic histories of different geologic units and terranes along the boundary of the PSP, including: the Okinawa Trough, Kyushu and Shikoku Islands, Kumano Basin, Boso and Miura Peninsulas, the southern Marianas, the Philippines and Taiwan. Several areas in southern Japan also appear to provide critical constraints on the kinematics and timing of a possible change in motion. For example, geological and geophysical studies of the Median Tectonic Line on Shikoku Island document a change from thrusting to right-lateral strike-slip faulting at about ~0.8 Ma (Mizuno, 1999; Sato et al., 2015)). This change in kinematics and timing is consistent with previous ideas on the age of formation of the Nankai forearc sliver (~0.8 Ma) based primarily on geologic and geomorphic data from Shikoku Island (Ohmori, 1978; Saito, 1999; Okamura, 1990). Hayman et al. (2012) also documented a CCW rotation in the shortening direction deep in the Nankai accretionary prism just south of Shikoku Island, although the timing of this rotation was only constrained to be younger than ~5 Ma (the age of the youngest deformed sediments). Further seaward, but still in the accretionary prism, Gulick et al. (2010) and Sacks et al. (2013) show a transition from shortening perpendicular to the plate boundary to extension perpendicular to the boundary <1.0 Ma. They suggest this change may reflect changes in subduction zone dynamics. Alternatively, the change to extension may relate to the decrease in the rate of convergence across the prism as the plate motion changed from nearly orthogonal to more oblique at ~1.0 Ma. Yamaji et al. (2003) interpreted a similar suite of faults in eastern Nankai to be related to a similar change plate motion at ~1 Ma. Finally, in Taiwan, Hsu et al. (2016) have proposed an acceleration in rock uplift at ~0.8 Ma based on low-temperature thermochronology data that may reflect an acceleration in plate convergence related to changing plate motions. Taken together, these observations suggest that a significant change in the plate motion vector (i.e., CCW rotation) occurred relatively recently and probably < 1 Ma.

Keywords: Philippine Sea Plate, Nankai, Southwest Japan, Plate motions