Philippine Sea and East Asian plate tectonics since 52 Ma constrained by new subducted slab reconstruction methods

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The Philippine Sea plate is a large marginal sea between the major Pacific, Indo-Australia and Eurasia/Sundaland plates. The history of Philippine Sea plate motions since its inception around 52 Ma is controversial and uncertain, due in large part to lost lithospheric record at the circum-Philippine Sea plate subduction zones and other East Asia convergent plate boundaries. Nonetheless, continued research on the Philippine Sea plate is motivated by its importance for northeast Asia tectonics, including Taiwan, the Philippines, SW Japan-Ryukyus, the South China Sea, the Izu-Bonin-Marianas arcs, and other southeast Asia marginal seas.

In this study we show a Philippine Sea and adjacent East Asia plate tectonic reconstruction back to 52Ma constrained by twenty-eight slabs mapped in 3D from global tomography, with a total subducted area of ~25% of global oceanic lithosphere. New slab constraints include subducted parts of existing Pacific, Indo-Australian, and Philippine Sea oceans, plus the wholly subducted proto-South China Sea and the newly discovered "East Asian Sea" ocean. Mapped slabs were structurally restored to a spherical Earth surface using newly-developed unfolding methodologies and input to globally-consistent plate reconstructions using Gplates software.

Important new constraints include:
(1) the northern Philippine Sea Ryukyu slab is short (~1000 km) relative to >2000km northward Philippine Sea motion constrained by paleomagnetism. This requires an intervening, now-subducted ocean south of the Ryukyus and SW Japan in the Eocene. Our plate reconstructions show this to be the 'East Asia Sea' and the Pacific;
(2) the Marianas Pacific subduction zone remained within ±200 km of its present location since 48±10Ma based on a slab wall extending to >1000km depths;
(3) a major (8000 km x 2500 km) swath of lower mantle flat slabs represents a vanished "East Asia Sea" ocean that existed between the Pacific and Indian Oceans at 52Ma. The northern East Asia Sea played the role of the proto-Philippine Sea;
(4) the Caroline backarc basin moved with the Pacific based on an overlapping and coeval Caroline LIPS and hotspot track and proto-Caroline slab locations.

Our preferred plate model involves a Philippine Sea origin near the Manus plume (150°E/0°) at a Pacific-East Asian Sea junction. Large westward motion and post-40Ma clockwise rotation (~60°) were driven by late Eocene-Oligocene collision with the Caroline/Pacific plate. We predict a Miocene arc-arc collision between a northern Philippine Sea arc and the SW Japan-Ryukyu continental margin. Our observed slab age-depths fit within a 1.8±0.8 cm lower mantle sinking rate. Digital files, including plate-model animations and Gplates compatible unfolded slab shapes and rotation files will become publically available to serve as a platform for further refinements or testing alternative tectonic scenarios.

Keywords: Philippine Sea plate, plate tectonic reconstructions, subducted slabs

