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Post-Jurassic tectonic evolution of Southeast Asia

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The accretionary growth of Asia, linked to long-term convergence between Eurasia, Gondwana-derived blocks and the Pacific, resulted in a mosaic of terranes for which conflicting tectonic interpretations exist. Here, we propose solutions to a number of controversies related to the evolution of Sundaland through a synthesis of published geological data and plate reconstructions that reconcile both geological and geophysical constraints with plate driving forces.

We propose that West Sulawesi, East Java and easternmost Borneo rifted from northern Gondwana in the latest Jurassic, collided with an intra-oceanic arc at ∼115 Ma and subsequently sutured to Sundaland by 80 Ma. Although recent models argue that the Southwest Borneo core accreted to Sundaland at this time, we use volcanic and biogeographic constraints to show that the core of Borneo was on the Asian margin since at least the mid Jurassic. This northward transfer of Gondwana-derived continental fragments required a convergent plate boundary in the easternmost Tethys that we propose gave rise to the Philippine Archipelago based on the formation of latest Jurassic-Early Cretaceous supra-subduction zone ophiolites on Halmahera, Obi Island and Luzon.

The Late Cretaceous marks the shift from Andean-style subduction to back-arc opening on the east Asian margin. Arc volcanism along South China ceased by ∼60 Ma due to the rollback of the Izanagi slab, leading to the oceanward migration of the volcanic arc and the opening of the Proto South China Sea (PSCS). We use the Apennines-Tyrrhenian system in the Mediterranean as an analogue to model this back-arc. Continued rollback detaches South Palawan, Mindoro and the Semitau continental blocks from the stable east Asian margin and transfers them onto Sundaland in the Eocene to produce the Sarawak Orogeny. The extrusion of Indochina and subduction polarity reversal along northern Borneo opens the South China Sea and transfers the Dangerous Grounds-Reed Bank southward to terminate PSCS south-dipping subduction and culminates in the Sarawak Orogeny on Borneo and ophiolite obduction on Palawan. We account for the regional plate reorganizations related to the initiation of Pacific subduction along the Izu-Bonin-Mariana Arc, the extrusion tectonics resulting from the India-Eurasia collision, and the shift from basin extension to inversion on Sundaland as an indicator of collision between the Australian continent and the active Asian margin.

We generate continuously closing and evolving plate boundaries, seafloor age-grids and global plate velocity fields using the open-source and cross-platform GPlates plate reconstruction software. We link our plate motions to numerical mantle flow models in order to predict mantle structure at present-day that can be qualitatively compared to P- and S- wave seismic tomography models. This method allows us to analyse the evolution of the mantle related to Tethyan and Pacific subduction and to test alternative plate reconstructions. This iterative approach can be used to improve plate reconstructions in the absence of preserved seafloor and conjugate passive margins of continental blocks, which may have been destroyed or highly deformed by multiple episodes of accretion along the Asian margins.