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The evolution of a back-arc rift basin: regional plate kinematics and its effect on the surrounding palaeo-environment, Tsushima Strait, southern Sea of Japan

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The lithospheric response to extension and the interaction of mantle and crust dynamics has been studied extensively in rift basins in a divergent continental setting. Despite the geometric similarities in extensional structures, back-arc rift basins that are a result of local extension in an overall convergent tectonic setting are commonly overlooked. Previous work on back-arc basins shows how the interplay between the subducting slab, the over-riding plate, and magmatism affects upper-crustal deformation and related sedimentation patterns, however, the controls on these processes during rifting remain unclear. Since natural hazards like earthquakes and tsunamis have been linked to movement along rift-related structures, there is a need to better understand the evolution of these extension related structures.

The Sea of Japan is a Cenozoic back-arc rift basin that initiated from ∼25 Ma due to the interaction of the Pacific and Philippine Sea plates subducting under the Eurasian plate. Rapid fan-shaped opening of the southern Sea of Japan with clock-wise rotation of SW Japan occurred between ∼18 – 16 Ma. Here we investigate the evolution Tsushima Strait that connects the southern Sea of Japan with the Pacific Ocean. We evaluate extensive 2D seismic reflection, high-resolution gravity, and borehole data, in addition to previously published geological data from the surrounding region to (i) identify rift-related structures and features related to subsequent tectonic events, and (ii) reconstruct the palaeo-geography of the southern Sea of Japan region.

We observe horsts and (half-) grabens with oblique components and negative flower structures. More than 5400 m of synrift sediments accumulated within ∼2 Myr, containing benthic foraminifera suggesting a deepening marine environment, and pollen associated with a subtropical climate. This infers that during the rapid fan-shaped opening of the back-arc rift basin, a warm Tsushima current flowed into Sea of Japan and the local climate changed from warm to subtropic. From ∼15 Ma, rift structures are abruptly inverted or cross-cut by thrust faults and wedge thrusts, with microfossils and pollen suggesting a fast decrease in palaeo-waterdepth and cooling climate, respectively. We propose that a tectonic sill developed at this time which cut off the subtropical Tsushima current to the Sea of Japan. Sub-horizontal Pliocene sediments covering the compressional structures suggest a weakening of the compressive stress from ∼6 Ma.

The development of the Sea of Japan back-arc rift basin can be seen into the context of regional Cenozoic plate dynamics around Japan. The abrupt change to a compressive stress regime from ∼15 Ma may be related to the arrival at SW Japan of the young, hot Shikoku Basin that developed as a back-arc rift on the northern edge of the Philippine Sea plate that overrides the Pacific plate. The Pliocene weakening of compressional stress may be associated with a change in dynamics of the Shikoku Basin subducting under SW Japan. Our results suggest a complex interplay between local processes, specifically deformation in the overriding plate and evolving palaeo-geography, and regional plate kinematics during both extension and compression.