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Continental breakup of Marginal Seas

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Marginal Seas are extensional basins formed in a convergent setting near active subduction zones. They are characterized by a short life (< 25 Ma), as well as unstable and changing directions of seafloor spreading. However, the processes related to their formation from rifting to seafloor spreading initiation remain debated (supra-subduction convection/extension, slab-pull). This problem is further compounded by the fact that our understanding of continental breakup used to be derived from the evolution of magma-poor and magma-rich Continent-Ocean Transitions (COT) of the Atlantic margins.

Here, we describe the tectono-magmatic processes occurring during continental breakup by investigating the COT structures of three main Marginal Seas located in the Western Pacific, namely the South China Sea, the Coral Sea and the Woodlark Basin. All three examples formed under rapid extension rates and propagation of seafloor spreading. Although each marginal basin is unique, we show that the three of them show a narrow COT (typically < ~20 km), where final extension is accommodated by the activity of mainly one low-angle normal fault. Extension is contemporaneous with an important magmatic activity emplaced in the distalmost part of these margins as volcanoes, dykes and sills. Such sharp juxtaposition of continental crust against igneous oceanic crust in these COTs suggests that a rapid shift from rifting to spreading occurred.

Rapid localization of extensional deformation during continental breakup has major implications for partial melting generation. The evolution of extensional structures is controlled by the interplay of lithospheric thinning, asthenosphere upwelling and decompression melting. High extension rate prevents conductive cooling allowing the focusing of volcanic activity in sharp COTs, quickly evolving to magmatic accretion. Fast extensions rates during the formation of Marginal Seas are likely directed by kinematic boundary conditions directly or indirectly controlled by nearby subduction zones. Such mode of continental breakup is probably not limited to Marginal Seas but only enhanced in such settings.

Keywords: Rifting; continental breakup; marginal seas; low-angle normal fault; continent-ocean transition