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Unravelling the process of continental breakup: a case study of the Australia-Antarctica conjugate margins

Morgane Gillard, Julia Autin, Anne-Marie Karpoff, Gianreto Manatschal, Marc Munschy, Daniel Sauter, and Marc Schaming
EOST, IPGS, CNRS-UMR7516 Université de Strasbourg, France (mgillard@unistra.fr)

Recent studies of rifted margins, in particular of the North Atlantic, resulted in the development of new concepts and models. However, these studies also revealed a number of new questions concerning: the nature and composition of hyper-extended crust and the processes related to crustal thinning; the origin, volume and timing of magmatic rocks; and also how magmatic and tectonic processes are interrelated during rifting. A probably even more fundamental question that remains to be answered is: How do plate boundaries form in divergent systems and how, when and where does the transition from rifting to oceanic seafloor spreading occur? This statement seems at odds with the fact that on most global maps the limit between continents and oceans is mapped as an Ocean Continent Boundary (OCB) using magnetic lineations and other geophysical proxies. Therefore, one could assume that the problem of localizing the initial plate boundary in present-day oceans should be resolved. We will consider different margins including the N- and S- Atlantic sites, however, we give priority to the example of the Australia-Antarctica conjugate margins to discuss location, nature and age of the lithospheric breakup.

The aim of this work is to gather new observations and to develop new methods to determine timing, location, and processes related to the formation of a plate boundary in a magma-poor rift system. In this presentation we focus on preliminary results on the Australia-Antarctica rift system. These results, obtained after a synthesis of geological (dredges, wells) and geophysical (seismic, gravity, magnetic, P-wave velocities) data, show that the conjugate Australia-Antarctica margins are the result of a polyphase rift evolution. Moreover, the architecture and the evolution of the main structural domains display a strong lateral variability. These results suppose a complex temporal and spatial evolution (including different stages of thinning, exhumation and seafloor spreading) with variations occurring across and along the margin. The results also provide new constraints on the proposed East-West diachronous opening and on the two main directions of extension (first NW-SE then N-S). Moreover, we suggest that polyphase detachment faulting may play an important role, in particular during the mantle exhumation phase potentially leading to the breakup and onset of steady state seafloor spreading. Another important observation is that the current interpretations of magnetic anomalies for the breakup identification may not work. Indeed, these interpretations are based on a symmetric model of accretion, whereas in our assumption, the first magnetic anomalies have been recorded during an asymmetric phase related to continental mantle exhumation. The comparison with other magma-poor rifted margins such as the central segment of the South Atlantic or the southern North Atlantic, will allow determining if these observations result from similar processes in magma-poor rifted margins or if they are specific and restricted to the Australian-Antarctic margins.