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Formation and evolution of magma-poor margins, an example of the West Iberia margin

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The West Iberia-Newfoundland (WIM-NF) conjugate margins have been geophysically and geologically surveyed for the last 30 years and have arguably become a paradigm for magma-poor extensional margins. Here we present a coherent picture of the WIM-NF rift to drift evolution that emerges from these observations and numerical modeling, and point out important differences that may exist with other magma-poor margins world-wide. The WIM-NF is characterized by a continental crust that thins asymmetrically and a wide and symmetric continent-ocean transition (COT) interpreted to consist of exhumed and serpentinised mantle with magmatic products increasing oceanward. The architectural evolution of these margins is mainly dominated by cooling under very slow extension velocities (<∼6 mm/yr half-rate) and a lower crust that most probably was not extremely weak at the start of rifting. These conditions lead to a system where initially deformation is distributed over a broad area and the upper, lower crust and lithosphere are decoupled. As extension progresses upper, lower, crust and mantle become tightly coupled and deformation localizes due to strengthening and cooling during rifting. Coupling leads to asymmetric asthenospheric uplift and weakening of the hanginwall of the active fault, where a new fault forms. This continued process leads to the formation of an array of sequential faults that dip and become younger oceanward. Here we show that these processes acting in concert: 1) reproduce the margin asymmetry observed at the WIM-NF, 2) explain the fault geometry evolution from planar, to listric to detachment like by having one common Andersonian framework, 3) lead to the symmetric exhumation of mantle with little magmatism, and 4) explain the younging of the syn-rift towards the basin centre and imply that unconformities separating syn- and post-rift may be diachronous and younger towards the ocean. Finally, we show that different lower crustal rheologies lead to different patterns of extension and to an abrupt transition to oceanic crust, even at magma-poor margins.