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Inter-relationship between tectonic, magmatic and sedimentary processes during hyperextension and breakup: constraints from the southern North Atlantic and exposed analogues in the Alps and Pyrenees

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The discovery of hyperextended crust, associated with either exhumed mantle or variable amounts of magmatic additions is at the origin of a paradigm shift in the research of rifted margins. At present, little is known about how deformation and magmatic processes interact during lithospheric thinning and breakup, what are the magmatic systems and depositional environments, sedimentary facies, the kinematics and age of structures, or the subsidence and thermal history of hyperextended domains. In my presentation I will therefore review key observations made along the Iberia-Newfoundland, Bay of Biscay-Pyrenean and Alpine Tethys rift systems and will try to show how they may impact our thinking and understanding of hyperextended systems in present-day margins.

The study of the Iberia-Newfoundland and the Bay of Biscay enabled to define and map rift domains and to restore these domains in order to quantify the total amount of extension as well as to investigate their relation to inherited structures and define the kinematics of these complex rift systems. This observation questions the existence of sharp and well-defined ocean-continent boundaries as well as some of the well-accepted concepts such as the breakup unconformity, the nature and significance of first magnetic anomalies in ocean continent transitions and the simple assumptions about the relation between strain and magma production.

In contrast to the large-scale observations made along the present-day margins, the study of ancient rift systems preserved in the Pyrenees and Alps enables to get access to rocks, structures, as well as the sedimentary systems that are related to hyperextension. The most prominent structures observed in hyperextended domains are a set of extensional detachment faults. The study of these fault systems show that they are far more complex as previously assumed. These detachment faults are polyphase, interact in a complex way with ductile layers and are associated with sedimentary systems that migrate while new crust or mantle is exhumed, leading to characteristic sag-type architectures. Fluids and magmatic processes are intimately linked with the evolution of these exhumation systems, controlling the rheological and thermal evolution of the extending lithosphere during the final rift stages

The lessons learned from the combination of onshore and offshore analogues in magma-poor rifted margins might not explain the observations made along magma-rich margins, however, they may help to re-evaluate and rethink some to the concepts and processes that were (are) used to describe these margins, in particular about the relative importance of crustal/lithospheric thinning prior to magmatic breakup at magma-rich rifted margins.