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Continental breakup in the Iberia-Newfoundland rift: a mantle perspective

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The Iberia-Newfoundland rift system is, apart from the Alpine Tethys margins, the only rift system from which we have direct access to mantle rocks. During ODP Legs 103, 149, 173 and 210, 6 drill holes penetrated exhumed mantle, which, together with seismic and magnetic data, enabled to define an up to 200 km wide Zone of Exhumed Continental Mantle (ZECM) that separate thinned continental from oceanic crust within the ocean continent transitions (OCT) of the Iberia and Newfoundland conjugate margins. Although the tectonic processes are not yet in detail understood, there is strong evidence that mantle was uplifted and exhumed to the seafloor along detachment faults. More recent investigations and numerical modeling suggest that mantle uplift and exhumation occurred in different phases during rifting. Moreover, there is clear evidence that distributed deformation continued over more than 10 myr after onset of formation of a crust showing an unambiguous oceanic magnetic anomaly (M3 $\sim$128Ma). Final break-up, here referred to as the irreversible localization of deformation within a stable and spatially well-defined spreading centre; did not occur before Late Aptian time.

The mantle evolution is similarly complex and polyphase. For the first time, analysis of mantle rocks from a complete transect across an OCT including its conjugate margins have been collected and permit the characterization of the scale of upper mantle heterogeneity in extensional systems that pass from evolved stages of rifting to ultra-slow seafloor spreading. The existence of several mantle domains exposed close to the seafloor along magma-poor rifted margins and ultra-slow spreading ridges provide important clues to constrain the processes by which new oceanic crust is formed. Here we summarize the results from two areas that might be exemplary to the precursor evolution of ultraslow spreading ridges, like Gakkel ridge.

Serpentinized spinel peridotites drilled of Newfoundland at Site 1277 have relic mineral compositions similar to the most depleted abyssal peridotites worldwide and can be modeled as a residue after extraction of 14 to 20-25% melting of a fertile lherzolite source. By comparing mantle minerals from Newfoundland and Iberia, we show that the southern North Atlantic upper mantle between Iberia-Newfoundland (at $\sim$120Ma) houses geochemical discontinuities between ODP Sites 1070 and 1277. The peridotites from the Iberia margin are, on average, less depleted, heterogeneous, and locally equilibrated with plagioclase indicating local melt impregnation and stagnation, and thus refertilizing previously depleted peridotite. This process predates mantle exhumation and is probably related to rapid exhumation during early rifting. The near-absence of basalts clearly shows that the depletion signature in these peridotites is inherited and simple crust-mantle relationships cannot be established.

Overall, there seems a strong asymmetry in mantle compositions between the Newfoundland and Iberia margins, which is either related to a different exhumation history, to inheritance, or a combination of both. The locus of breakup is probably an ancient suture zone of Caledonian or older age. We emphasize that mantle heterogeneity perpendicular to spreading axes are as important as along-axis variations, in particular for the temporal evolution. The results from the peridotite basement favor a more complex history than simple subcontinental mantle exhumation, and indicate that mantle uplift prior to exhumation is locally coupled to melt-infiltration. This process has important implications for the rheology and the thermal evolution of magma-poor margins, and control isostasy during final rifting.