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Lithosphere extension and magmatism at volcanic passive margins

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We present onshore and offshore evidences suggesting that volcanic passive margins are distinct in origin and evolution from non-volcanic hyper-extended margins. Consecutively, they should not be integrated in a single evolutionary process and do not necessarily represent the ultimate stage of an hyper-extension with or without mantle exhumation. Volcanic passive margins usually form in mobile areas between cratonic areas which may have been submitted to long-term periods of divergence and convergence or strike-slip tectonics. In the NE-Atlantic, for example, a complete illustration of a Wilson cycle is illustrated between Greenland and Baltica cratonic areas. From the Devonian to the end of the Jurassic, the Caledonian orogenic crust has suffered from a number of wrench and extensional tectonic stretching episodes. The late-Jurassic/Early Cretaceous extension was severe, leading to extreme crustal thinning (e.g. Rockall Through, Vøring Basin, Lofoten Basin) and was followed by a long-term regional thermal subsidence of the NE-Atlantic lithosphere. Meanwhile, pre-thinning lithospheric thickness was restored progressively during $\sim$80 Myr, in spite of some tectonic reactivation occurring in Late Cretaceous (e.g. Outer Vøring Basin) resulting in little coeval stretching and thinning. During the Paleocene (or even earlier, especially in the Rockall area) a regional mantle melting event occurred. The mantle melted in specific locations but led ultimately to a large igneous province formation during the onset of breakup. The NE-Atlantic continental crust was at this time extremely heterogeneous due to its tectonic inheritance but we think that generally the lithosphere was much thicker than during the Jurassic-Cretaceous event, and thus much stronger. Although we must consider the existence of some extension during the latest Cretaceous and Paleocene, the main stretching and thinning event leading to volcanic passive margins formations and successful break-up occurred regionally during the Eocene, at the edge of the cratonic areas. In the NE-Atlantic, volcanic margins develop often along the thickest Phanerozoic crusts (such as Hatton Bank or Fugløy crusts, with cumulated thinning factor of solely $\sim$1.3 from the Palaeozoic). In some cases, they also appear to develop along much thinner crusts. However, in such cases a huge gap in time and dynamical contexts exists between the old Phanerozoic building and the final Latest-Cretaceous (?)-Eocene events that led to break-up. In such a situation, the initial extensional shaping of the crust should lead to a stronger rheology after lithospheric restoration. Therefore, the breakup might be difficult to reach without, notably, the providential input of magma within the lithosphere probably associated with localized thermal advection of the mantle lithosphere at craton edges. To conclude, any attempt to describe the breakup as a continuous and ultimate result of an extreme lithosphere thinning with mantle exhumation seems to us very hazardous when dealing with volcanic margins.