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The rift to drift transition at non-volcanic margins: Insights from numerical modelling

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Non-volcanic rifted margins exhibit very little evidence of synrift magmatism, even where the continental crust has been thinned to such an extent that the mantle has been exhumed across a transitional zone (up to $\sim$100km wide), called the continent–ocean transition (COT). Using dynamical models of rifting, we explore how extension velocity, mantle composition and potential temperature influence the nature and extent of the COT and compare our results to observations at the West Iberia margin (WIM) and the ancient margins of the Liguria-Piemonte Ocean (LP) now exposed in the Alps. We find a first order relationship between extension velocity and the amagmatic exposure of mantle at the COT. For very slow half extension velocities, ($<$6mm/yr), mantle exhumation begins before melting. At these velocities, by the time melting starts at the rift centre, the area of exhumed mantle has moved sideways creating a COT, the width of which increases with decreasing velocities. However, at 10mm/yr, a velocity probably appropriate for the exhumation of mantle at the WIM and LP, melting starts prior to mantle exhumation. In this case, our models show that by the time mantle exhumation starts, a $\sim$4.5km column of melt has been produced, much more than the $\sim$2km maximum mean melt thickness inferred at the COT of these margins. Even considering that 25% of the produced melt may be trapped in the mantle, as in slow-spreading mid-ocean ridges, still more melt is produced in the models than inferred from observations. Thus, extension velocity alone cannot explain the practical absence of synrift magmatism at the COT of the WIM and LP. We find that the formation of a wide, amagmatic COT requires that either the mantle was depleted in basaltic constituents by $>$ 10% prior to rifting or that its potential temperature was $\sim$50° C lower than normal

($\leq$1250° C).