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The effect of magma poor and magma rich rifted margins on continental collision dynamics

Valeria Turino[1], Valentina Magni[2], Hans Jørgen Kjøll[3], and Johannes Jakob[4]
[1]University of Miami, Rosenstiel school of Marine and Atmospheric Science (RSMAS), Department of Marine Geosciences (MGS), United States of America (valeria.turino@rsmas.miami.edu)
[2]The Centre for Earth Evolution and Dynamics (CEED), Department of Geosciences, University of Oslo, Norway
[3]Department of Geosciences, University of Oslo, Norway
[4]Geological Survey of Norway (NGU), Trondheim, Norway

The transition between continental and oceanic lithosphere in rifted margins can display a wide range of characteristics, which primarily depend on the regional tectonic evolution. Rifted margins form when continents rift apart and are commonly characterized by a thinned transition zone between the continental crust and the oceanic crust. The velocity and duration of the rifting process influence the dimensions and geometry of the passive margin. Rifted (or passive) margins are often subdivided in a magma-rich type and a magma-poor type, where the magma-rich are characterized by large input of mafic melt, derived from the mantle, into the crust. Magma-poor rifted margins on the other hand are characterized by much less magma production during the rifting process. This causes high variability in the geometry and rheology of passive margins.

The aim of this work is to understand how different types of passive margins can influence the dynamics of continental collision. We modelled subduction using the finite element code Citcom and to describe the dynamics of continental collision we mainly focused on the time and position of the slab break-off after the collision and on the fate of the passive margin material.

We compared these models as a function of various parameters (e.g., margin length, density, and viscosity), in order to understand how the architecture of a passive margin affects the dynamics of continental collision. We find that passive margins have a noticeable impact on subduction, as we observe a large variability in slab break-off times (about 10–70 Myr after continental collision) and depth (about 200–450 km). Furthermore, the factor that shows the largest impact on subduction dynamics is the rheology of the passive margin. Our results show that for both magma-poor and magma-rich margins, part of the margin does not subduct but, instead, exhumes and accretes to the overriding plate. Importantly, the amount of accreted material to the overriding plate is much larger when the passive margin is magma-poor compared to the magma-rich case. This is consistent with geological observations that fossil magma-poor passive margins are preserved in many mountain ranges, such as the Alps and the Scandinavian Caledonides, whereas remnants of magma-rich rifted margins are scarce. Because, in our models, the slab break-off occurs inboard of the LCB, magma-rich rifted margin may only be preserved when the density of the LCB is similar to that of the rest of the continental plate. Therefore magma-rich rifted margins are prone to be

subducted and recycled into the mantle. Importantly, our results show that rifted margin type controls the architecture of the subsequent collisional phase of the Wilson cycle.