Orographic precipitations control the structural and magmatic evolution of continental rifts: the East African Rift System

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Geodynamic processes leading to continental rifting shape the surface of our planet, opening up new oceanic seaways and controlling the location and evolution of igneous provinces and sedimentary basins. The rupturing of the continental lithosphere is primarily caused by magma-assisted intra-plate and mantle-flow endogenous forces, but surface processes contribute substantially to the structural and magmatic evolution of rifts. In this context, the effect of lateral erosion gradients on the evolution of continental rifts is generally overlooked, notwithstanding the orographic forcing imposed on precipitation and erosion patterns by the high domal topography generated at rift systems. We address this aspect of continental rifting by means of fully coupled thermomechanical geodynamic numerical modeling, accounting for a rheologically stratified lithosphere, rock partial melting, and surface processes proportional to stream power. Results show that the magma migration and strain localisation patterns due to intra-plate and mantle flow related extension are deflected by up to hundreds of kilometres toward the region of enhanced erosion, depending on the integrated strength of the continental lithosphere. Rheological heterogeneities within the continental lithosphere, which exert a primary control on the localisation of extensional strain, may greatly enhance this climatic control on rifting. The Northern East African Rift, where off axis magmatism occurs on the wetter and more eroded Ethiopian margin, and the Central East African Rift, where a western magma-poor branch and an eastern magma-rich branch developed along pre-existing structures wrapping around the rheologically strong Tanzania craton, provide natural examples of these findings.

Mots-Clés : Continental rifting, Orographic precipitation, East Africa Rift System, Numerical modeling

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