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Surface processes forcing on rift magmatism: insights from numerical modeling

Pietro Sternai (1,2)

(1) Department of Earth Sciences, University of Geneva, Geneva, Switzerland (pietro.sternai@unige.ch), (2) Now at the Department of Earth and Environmental Sciences, University of Milano-Bicocca, Milano, Italy

Continental rifting involves subsidence and uplift of the surface topography and recent research has shown that erosion and sedimentation involve mechanical and thermal effects on the lithosphere rheology, which condition the structural evolution of continental rifts. Whether and how the rheological implications of surface processes may also affect the magmatic history of continental rifting, however, is still largely unknown. Here, I use coupled thermo-mechanical geodynamic and landscape evolution numerical modeling to investigate the first order relationships between erosion, sedimentation and magmatism in extensional settings. A detailed parametric study on plate extension and erosion/sedimentation rates as well as on the lithospheric and asthenospheric structure, thermal regime and composition allows defining the extent to which and the mechanisms through which surface processes may affect the magmatic evolution of continental rifts. Results suggest that efficient surface processes may enhance crustal melting by thermal blanketing and Moho lowering. Efficient surface processes also inhibit asthenospheric decompression melting by lithospheric loading due to sedimentation into the rift basin. The surface processes forcing on rift magmatism appears particularly pronounced when the crust is thinner than $\sim$40 km, the extension rate is slower than $\sim$2 cm/a and the asthenosphere potential temperature is below 1230 °C. Thus, surface processes may have conditioned the magmatic history of several volcanic rifts and passive margins worldwide, which implies an additional means of linkage between plate tectonic and climatic changes throughout the Earth's history. Feedbacks between surface processes and the structural evolution of continental rifts through magmatism and a contribution from surface processes to the establishment or abortion of volcanic and non-volcanic rifts also appear plausible, although these possibilities require further investigations.