Continental rifts and mantle convection: Insights from the East African Rift and a new model of the West European Rift System

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The origin of the Eocene-Oligocene European Cenozoic Rift System (ECRIS) is debated in terms of driving forces, far-field or near field, Alpine slab-pull or active plume. An analysis of residual (non-isostatic) topography over Africa and Europe reveals domains elongated parallel to the absolute motion of plates in a hot-spot reference frame. The East African Rift (EAR) and the ECRIS sit on top of such positive anomalies. A recent whole mantle tomographic model (French et al., 2013; French & Romanowicz, 2015; Davaille & Romanowicz, 2020) shows in addition that the low shear-wave velocity zones of the lower and upper mantle are organized with a bundle of vertical plumes and horizontal fingers pointing in the same direction parallel to the absolute motion of Africa and Eurasia, thus parallel to the main rifts. The case of the EAR and its magmatic extension toward the north across the Arabian Plate is particularly clear with several levels of such fingers. The northward migration of the first volcanism from Ethiopia to Armenia between the Eocene and the Late Miocene suggests that the asthenosphere moves faster than the plates and thus drives plate motion (Faccenna et al., 2013). We propose a simple model where plates are driven by basal drag, following an upwelling from the low-velocity anomalies below Africa and toward subduction zones. The EAR develops as lithospheric weak zones on top of the positive anomalies of residual topography due to the underlying low velocity anomalies elongated parallel to the absolute motion. This indicates an interplay between large-scale convection, a small-scale fingering instability, and lithospheric deformation. The development of the Eocene-Oligocene short-lived ECRIS and its interference with Mediterranean slab dynamics are then discussed in the framework of this simple model.

Mots-Clés : Rift ; convection ; absolute motion ; seismic tomography ; residual topograph

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