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Does episodic lithospheric thinning trigger rift migration and hyper-extension? New insights from U-Th-He thermochronometry in the Alpine Tethys margins

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Rifted continental margins commonly record multiple stages of diffuse crustal stretching ahead of strain focusing, which culminates in complete crustal excision and lithospheric breakup. Rift migration and focusing have been attributed to a variety of mechanisms, ranging from localized thermal softening of the continental lithosphere, either by plume activity of through rift-related depth-dependent thinning, to structural inheritance from the earlier tectonic history.

This study addresses the processes responsible for rift migration and focusing of deformation in the Central Atlantic-Alpine Tethys system as recorded in the Italian Southern Alps. The latter provide an east-west section across the proximal and distal margin of the Adriatic continental micro-plate, where a complex Mesozoic rift migration history has long been recognized: poly-phase Middle Triassic to Lower Jurassic crustal stretching, recorded in the Lombardian basin, in the central part of the Southern Alps, was followed by westward rift migration, into the Cusio-Biellese-Canavese area, starting from the Pliensbachian. Rift migration was coupled with hyperextension, leading to mantle exhumation to the seafloor and eventually to the formation of a new plate boundary at the western edge of the Adriatic plate in the late Middle Jurassic.

The relationship between thermal state of the upper crust and this well-known episode of rift migration are addressed with a newly acquired low-Temperature thermochonological dataset. U-Th-Sm-He zircon (ZHe) ages from basement rocks located in the uppermost crust during Mesozoic rifting display a progressive westward younging, from 280-240 Ma in the proximity of the Lombardian basin to ca. 200 Ma at the westernmost edge of the study area, in the Cusio-Biellese domain. In the latter area, rocks originally located at 2.5-3 km depth underwent a heating-cooling cycle in the uppermost Triassic, when thermal gradients > 60-70°C/km were locally established. This new evidence for episodic re-heating at upper crustal levels confirms earlier reports of hot fluid influx in the uppermost Triassic throughout the Ivrea-Verbano Zone, a continental basement unit originally located at middle to lower crustal depth along the western edge of the Adriatic plate. The regional thermal perturbation detected here pre-dated the earliest evidence for extensional deformation, which, in the Cusio-Biellese domain, is provided by ZHe ages up to 170±10 Ma in detrital zircons from syn-tectonic Pliensbachian-Toarcian sandstones.

These results indicate that the western part of the Adriatic margin underwent a crustal-scale heating-cooling cycle ahead of a rift migration episode. Episodic heating of a yet largely undeformed crustal section, without significant evidence of concomitant magmatism, is best explained as resulting from depth-dependent thinning of the mantle lithosphere. This tectonic process, together with the resulting thermal perturbation, may be responsible for strain partitioning within a relatively narrow area, eventually culminating in hyper-extension and lithospheric breakup.