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Topographic evolution of a continental indenter: The eastern Southern Alps

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The topographic evolution of the eastern Southern Alps (ESA) is controlled by the Late Oligocene - Early Miocene indentation of the Adriatic microplate into an overthickened orogenic wedge emplaced on top of the European plate. Rivers follow topographic gradients that evolve during continental collision and in turn incise into bedrock counteracting the formation of topography. In principle, erosional surface processes tend to establish a topographic steady state so that an interpretation of topographic metrics in terms of the latest tectonic history should be straightforward. However, a series of complications impede deciphering the topographic record of the ESA. The Pleistocene glaciations locally excavated alpine valleys and perturbed fluvial drainages. The Late Miocene desiccation of the Mediterranean Sea and the uplift of the northern Molasse Basin led to significant base level changes in the far field of the ESA and the Eastern Alps (EA), respectively. Among this multitude of mechanisms, the processes that dominate the current topographic evolution of the ESA and the ESA-EA drainage divide have not been identified and a number of questions regarding the interaction of crustal deformation, erosion and climate in shaping the present-day topography remain.

We demonstrate the expected topographic effects of each mechanism in a 1-dimensional model and compare them with observed channel metrics. Modern uplift rates are largely consistent with long-term exhumation in the ESA and with variations in the normalized steepness index (k_{sn}) indicating a stable uplift and erosion pattern since Miocene times. We find that k_{sn} increases with uplift rate and declines from the indenter tip in the northwest to the foreland basin in the southeast. The number and magnitude of knickpoints and the distortion in longitudinal channel profiles similarly decrease towards the east. Most knickpoints probably evolved during Pleistocene glaciation cycles, but may represent the incrementally reactivated, buried incision signal triggered by the Messinian desiccation of the Mediterranean Sea. Changes in slope of χ-transformed channel profiles coincide spatially with the Valsugana - Fella fault linking crustal stacking and uplift induced by indenter tectonics with topographic evolution. Gradients in χ across the ESA-EA drainage divide imply an ongoing, north-directed shift of the Danube-ESA watershed. This implies that ESA streams spread to the domain of the EA by drainage divide migration and river capture events. As already observed in the Adige catchment, the Periadriatic fault system loses its significance for the morphological evolution of the EA-ESA. The observed northward migration of the ESA-EA drainage divide is most likely driven by a base level rise in the northern Molasse basin, which leads to a growth of the ESA and Rhine catchments at the expense of the Danube drainage area.

We conclude that the regional uplift pattern controls the geometry of ESA-EA channels, while base level changes in the far field control the overall architecture of the orogen by drainage divide migration (Robl et al., 2016).

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