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Investigating the Influence of Uplift on the Central European Drainage Pattern using a Landscape Evolution Model

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The evolution of river systems in Central Europe has been extensively studied. Nevertheless, the mechanisms that led to river reversals and the formation of a cuesta landscape remain poorly understood. There has been considerable speculation as to the reasons behind the radical change in the flow direction of the rivers Main and Neckar. The lowering of the Upper Rhine Graben (URG) and the subsequent lowering of the associated base level have often been proposed as explanation for a complete river reversal. However, this is a questionable assumption, as it does not account for other contributing factors such as lithospheric folding. To gain a deeper understanding of the controlling mechanisms of river system evolution in Central Europe, we employed terrain analysis and numerical landscape evolution modelling using TopoToolbox and the recently developed landscape evolution model TTLEM 3D.

The evolution of the Central European drainage pattern commenced at the transition from the Cretaceous to the Paleocene, marked by a dome-shaped exhumation event in Europe. This event gave rise to the development of a radial river network. Some rivers, such as the Wörnitz and the Brenz, retain the flow direction established at that time. In contrast, although the direction of the Neckar's course remains unchanged, the river now flows in the opposite direction to that of the past. The subsequent formation of the URG in the Eocene was associated with a significant lowering of the rift valley, as well as an uplift of the rift shoulders and a tilting of southern Germany to the east-southeast. The rivers were not initially connected to the URG or reversed in their flow. When the stress field in Europe changed to a northwest-southeast oriented compression regime in the Miocene, the lithosphere was folded from the Alpine front to the North Sea in connection with the second phase of the formation of the Alps. River reconstructions indicate a reversal of the Neckar and Main rivers in this time period, which aligns with the observed uplift and subsidence pattern of the lithospheric folds. Our simulations demonstrate that the river reversal was only possible through the complex interplay between various tectonic mechanisms, which in turn led to the development of the landscape as we know it today.

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