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Climate controls on sediment mixing along the Lower Danube River from the Carpathians to the Black Sea

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Abstract: *Over the past 16 million years, the Lower Danube Basin has undergone significant geological evolution driven by interactions among tectonics, climate variability, geomorphology, and human activities. Situated at the convergence of the Carpathians and the Black Sea, this region integrates sediment fluxes from the Southern and Eastern Carpathians, the Apuseni Mountains, and adjacent tectonic provinces. Pronounced relief-related precipitation gradients characterize the basin, with enhanced rainfall over mountainous sectors and reduced precipitation across downstream lowlands. These source regions comprise Variscan metamorphic rocks, Late Cretaceous magmatic arcs, and Neogene volcanic provinces. Basin modeling combined with detrital zircon (DZR) U-Pb geochronology provides insights into climate-sensitive sediment provenance and transport, elucidating relief–climate controls on source-to-sink processes.*

DZR analysis reveals three major age populations in Lower Danube sediments: i) Cambrian–Ordovician ages linked to Peri-Gondwana subduction systems and back-arc basins; ii) Carboniferous ages associated with the Variscan orogeny; and iii) Late Cretaceous to Tertiary ages tied to the Banatitic arc and Neogene volcanism. Western tributaries, including the Jiu, Cerna, and Topolnița rivers, drain high-relief areas subject to intensified orographic precipitation, promoting enhanced runoff, erosion efficiency, and amplified Variscan sediment signatures. In contrast, contributions from the Olt River are limited, reflecting diminished sediment transfer related to hydrological regulation and sediment storage.

Basin modeling integrates geochronological, lithological, geomorphological, and climatic parameters, enabling a quantitative assessment of sediment mixing and downstream transport governed by relief-controlled runoff intensity. The model demonstrates progressive sediment homogenization along the Danube corridor, with tributary influence varying according to precipitation-driven hydrological connectivity. Deltaic sediments preserve regionally integrated signals, offering a comprehensive perspective on climate–relief–sediment coupling within the basin. Anthropogenic modifications, including land-use change and dam construction, have further altered sediment fluxes, enhancing erosion in high-runoff agricultural areas while reducing sediment delivery from regulated catchments.

This study highlights the importance of integrating DZR geochronology with basin modeling to resolve sedimentary responses to precipitation and atmospheric forcing in large transcontinental river systems. The results emphasize both natural relief–climate controls and human-induced alterations of sediment provenance and transport, advancing understanding of coupled atmospheric–hydrological–geomorphic dynamics within the Carpathian–Danube–Black Sea system.

Key words: *Geochronology, Basin mixing, Danube, Carpathians, Source-to-Sink*