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The interplay between tectonics, sediment dynamics and gateways evolution in the Danube system from the Pannonian Basin to the western Black Sea

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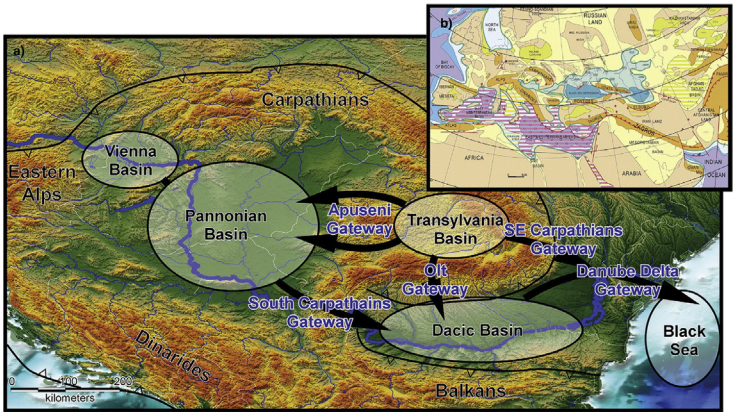
HIGHLIGHTS

- Tectonic and sedimentological background of human-induced changes in basin systems
- Focus on the recent past evolution of the Danube River–western Black Sea system
- Source to sink analysis of basins connectivity and gateway evolution
- Tectonic vertical movements, basin evolution and key events for sediment routing
- Model of understanding basins fragmentation during continental collision

GRAPHICAL ABSTRACT



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ABSTRACT

Understanding the natural evolution of a river–delta–sea system is important to develop a strong scientific basis for efficient integrated management plans. The distribution of sediment fluxes is linked with the natural connection between sediment source areas situated in uplifting mountain chains and deposition in plains, deltas and, ultimately, in the capturing oceans and seas. The Danube River–western Black Sea is one of the most active European systems in terms of sediment re-distribution that poses significant societal challenges. We aim to derive the tectonic and sedimentological background of human-induced changes in this system and discuss their interplay. This is obtained by analysing the tectonic and associated vertical movements, the evolution of relevant basins and the key events affecting sediment routing and deposition. The analysis of the main source and sink areas is focused in particular on the Miocene evolution of the Carpatho-Balkanides, Dinarides and their sedimentary basins including the western Black Sea. The vertical movements of mountains chains created the main moments of basin connectivity observed in the Danube system. Their timing and effects are observed in sediments deposited in the vicinity of gateways, such as the transition between the Pannonian/Transylvanian and Dacian

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basins and between the Dacian Basin and western Black Sea. The results demonstrate the importance of understanding threshold conditions driving rapid basins connectivity changes superposed over the longer time scale of tectonic-induced vertical movements associated with background erosion and sedimentation. The spatial and temporal scale of such processes is contrastingly different and challenging. The long-term patterns interact with recent or anthropogenic induced modifications in the natural system and may result in rapid changes at threshold conditions that can be quantified and predicted. Their understanding is critical because of frequent occurrence during orogenic evolution, as commonly observed in the Mediterranean area and discussed elsewhere.

1. Introduction

The distribution of sediment fluxes is linked with the natural connection between source areas situated in actively uplifting mountain chains and deposition in plains, deltaic systems and, ultimately, in capturing oceans and seas. This defines an integrated source to sink system. The Danube River–western Black Sea is one of the most active European systems in terms of sediment re-distribution, posing significant societal challenges and vulnerabilities (Figs. 1 and 2, Cloetingh et al., 2005; Matenco and Andriessen, 2013). The present-day situation is related to human changes superposed over a recent geological evolution that includes not only long-term processes such as tectonic-induced vertical motions or fluvial sediment routing, but was significantly conditioned by events taking place in a specific geological situation.

Understanding source to sink systems that evolved during the last stages of mountain building requires the analysis of orogenic processes that fragmented associated sedimentary basins. These basins become gradually shallow, filled at high sedimentation rates during rapid orogenic exhumation. Such collisional fragmentation associated with major deltaic processes filling up multiple basins separated by subaerial

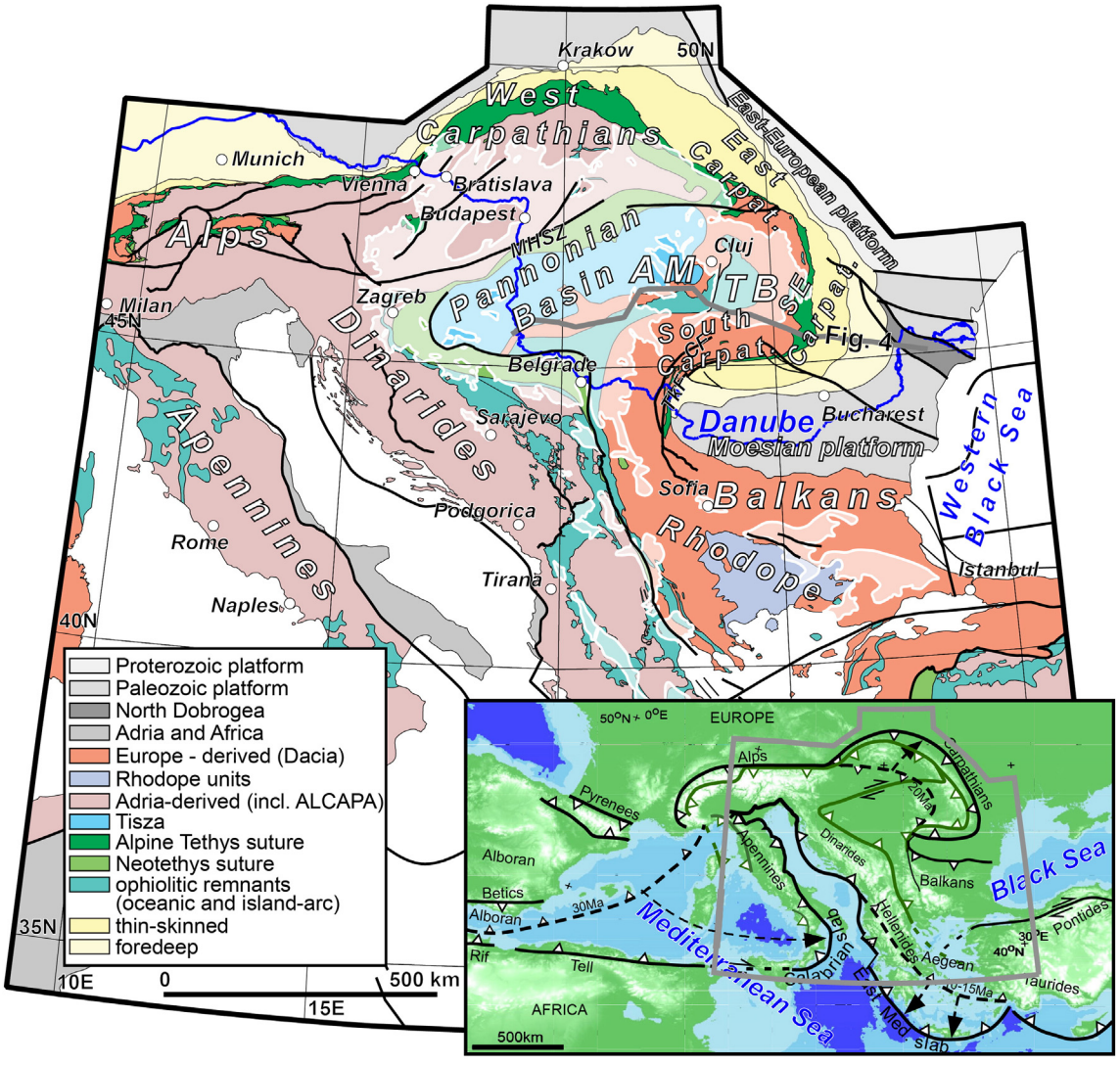

Fig. 1. Tectonic map of the Alps–Carpathians–Dinaridic–Hellenidic system (simplified from Schmid et al., 2011) with the extent of the Pannonian, Transylvanian (white transparent background) and Dacian basins, as well as the Black Sea. The grey line is the location of Fig. 4 AM — Apuseni Mountains; TB — Transylvanian Basin; TkF — Timok Fault; CF — Cerna Fault. The lower inset is the location of the map in the system of European Mesozoic–Cenozoic orogens. Dashed black line is the position of the orogenic front prior to the onset of extension associated with the roll-back of the Calabrian, Aegean and Carpathian slabs (modified from Wortel and Spakman, 2000).

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