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Geodynamics of the Carpathian-Pannonian region: Insights from low temperature thermochronology of the Polish and Ukrainian Carpathians

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In recent years, the geodynamic evolution of the Carpathian-Pannonian region has been the subject of a heated scientific debate. This orogenic system formed between the Late Jurassic and the Neogene by the collision of the Alcapa and Tisza-Dacia microplates with the European Platform, and assumed its present-day configuration mainly during the Miocene, when the extensional Pannonian Basin formed in a retro wedge position, while compression was still active along the Carpathian front.
The most common and widely accepted interpretation for the Miocene evolution of this region is based on a classical back-arc extension model and subsequent astenospheric upwelling and slab break-off. Nonetheless several authors proposed other possible driving mechanisms for the formation of the Pannonian Basin, such as lithosphere delamination or lithospheric gravitational instability.
Thermochronometry provides important constrains to the depths of burial and to the timing and rates of exhumation. Each geodynamic scenario proposed for the Carpathian-Pannonian region implies a different spatial distribution of burial and a different timing of exhumation. In this work we use a compilation of several low-temperature thermochronometric datasets, referred to the Polish and Ukrainian Carpathians, to evaluate their compatibility with the different geodynamic models proposed so far. In order to achieve this goal we examine the spatial distribution of burial depths and of ages and rates of exhumation and we put them in relation with (i) the spatial trend of the relief, (ii) heat flow, (iii) crustal and lithospheric thickness, and (iv) structural setting. We propose a subdivision of the Polish and Ukrainian Carpathians in three different tectonic domains, based on geophysical and structural parameters. Each single area is characterized also by different burial-exhumation history and requires a specific explanation in terms of driving processes. In particular, we infer that exhumation occurred by erosion of the wedge during thrusting in the western area, by erosion and tectonic denudation driven by post-thrusting extension in the central sector, and by erosion of the uplifting wedge after the end of thrusting in the eastern sector. Based on the non-homogeneous burial depths inferred for the western and central sectors, we suggest the lack of a subducting slab and subsequent break-off in these areas. Furthermore, the distribution of exhumation ages along the chain is not compatible with a clockwise (E to SE ward) progressive slab break-off, the youngest ages being located in the central area, at the Polish-Ukraine boundary.
Our results are consistent with the hypothesis that Miocene extension of the Carpathian-Pannonian region was triggered by gravitational instability and subsequent lithosphere downwelling, below the Carpathians mountain belt, and astenosphere upwelling below the Pannonian Basin. This process is compatible with the burial-exhumation distribution observed along the study region. Furthermore, it is able to explain both the coupled crustal extension and lithospheric thickening observed in the central sector (Poland-Ukraine boundary) and the progressive transition between the extending and subsiding Pannonian Basin and the uplifting Carpathians in the eastern area.