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Reconstruction of the Ukrainian Carpathians fold-and-thrust belt from low-temperature thermochronology and tectono-stratigraphic analysis.

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The Carpathians fold-and-thrust belt resulted from the accretion of sediments during subduction of the European slab in the Cenozoic, and the collision of the ALCAPA and Tisza-Dacia blocks with the East European margin in the Early-Middle Miocene. In this study we unravel the history of nappe stacking and the thermal evolution of the Ukrainian Carpathians wedge by combining low-temperature thermochronology and tectono-stratigraphic analysis.

We collected 11 sandstone samples for (U-Th)/He and fission-track dating on detrital apatites and zircons. The resulting thermochronological data were modelled using QTQt to constrain the time-temperature paths independently for several nappes. We compare the results with the burial histories of the respective nappes as derived from their stratigraphy.

All zircon (U-Th)/He (ZHe) ages in our samples are older than the depositional age of the corresponding strata; they are thus non-reset and thought to mark sediment provenance. We identified two groups of ZHe ages; a younger group with ages around 130 Ma to 90 Ma in the inner nappes, and an older group with ZHe ages around 450 Ma to 200 Ma in the outer belt. Potential sources for these zircons are thought to be the Tisza-Dacia basement and its sedimentary cover for the younger ZHe age group, and the East European shield and/or its sedimentary cover for the zircons with older ZHe ages in the external nappes. Apatite (U-Th)/He (AHe) ages are mostly <20 Ma and show a trend of progressive younging toward the outer nappes. Apatite fission-track (AFT) ages display a similar pattern with overall younging of the central age from the inner to the outer nappes, except for the outermost Skyba nappe where AFT central ages are around 10 My older than in the adjacent Krosno nappe.

Modelling the sample time-temperature paths from AHe, ZHe and AFT data permits to unravel the chronology of nappe stacking. Most of the AFT samples are partially reset, allowing to better constrain the burial and exhumation pathways. The inner Magura and Marmarosh nappes started cooling from a peak burial temperature of 100 ± 5°C at 40 to 29 Ma. Our two samples from the following nappes, Burkut and Rakhiv, show younger cooling ages with an onset at 24 ± 2 Ma and at ~10 Ma, respectively, and significantly higher burial temperatures (≈150 °C) than the other nappes,

provoking the total resetting of AFT ages. The next nappe, Krosno, started cooling between 21 and 17 Ma from peak burial temperatures of 100 ± 8°C. The Skyba nappe started cooling between 22 and 16 Ma. Whereas the onset of this cooling is similar to the Krosno nappe, the maximum burial temperature of Skyba is higher (130 ± 5°C) and at odds with the minor thickness (<1500 m) of the sedimentary overburden.

These results indicate potential out-of-sequence thrusting and/or significant erosional exhumation in the innermost nappes. For the middle nappes, burial by tectonic overthrusting and/or kilometre-scale syn-tectonic sedimentation is required. The higher temperatures experienced by the outermost nappes can resulted from overthrusting and complete erosion of the middle nappes.