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Timing of tectonic subsidence, accretion and exhumation of the Western Carpathian Flysch by apatite fission track and (U-Th)/He thermochronology

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The Outer Western Carpathians are a north-verging fold-and-thrust belt composed largely of Lower Cretaceous to Lower Miocene flysch sediments arranged into several nappes. Organic maturation, clay diagenesis and fluid inclusion data of the different flysch units indicate that the nappes experienced thermal overprint up to 160 °C during their sedimentary and tectonic burial (Hurai et al. 2002, Jarmolowicz-Szulc and Dudok 2005).

We have performed apatite fission track and (U-Th)/He thermochronology (AFT and AHe, respectively) on volcanic ash layers and vitrinite reflectance measurements on organic rich pelites of Western Carpathian Flysch in order to reconstruct the thermal and structural evolution of the flysch belt. The mean Dpar of the apatite crystals are between 2.6 and 3 μm and the microprobe analyses yield typically chlorine-rich mineral chemistry, thus both kinetic parameters indicate rather high closure temperature for the dated apatites. All apparent AFT and AHe ages are younger than the age of sedimentation. The ages show a complex areal pattern: the AFT ages are between 30 and 20 Ma in the western part of the Podhale Flysch and in the innermost part of the Magura nappe. In the Silesian nappe the apparent ages cover a wider ranger between 29.5 and 9.7 Ma. The track lengths are between 13.6 and 15.0 μm. The AHe ages form a tight cluster around 11 Ma.

Considering the new low-temperature age constraints combined with paleotemperature determinations by organic maturation and clay mineralogy we have modelled the thermal evolution of the Carpathian nappes by HeFTy software (Ketcham, 2005). The modelling resulted in slightly different time-temerature paths for the different structural units. All samples, however, show a common pattern: a rapid increase of the burial temperature is followed by rapid cooling in case of nearly all modelled samples. After the end of sedimentation the temperature has reached the total reset conditions of apatite FT chronometer (>130 °C) usually within 2 to 3 million years. The effective heating time is typically very short, and soon after the thermal climax the flysch nappes were already cooling. The cooling rates were variable, but in some cases very high rates were detected (up to 50°/Ma). The three major segments common in the thermal histories of the different nappes are: (i) rapid heating related to the tectonic burial during subduction processes, (ii) the abrupt turn in the thermal histories interpreted as response to the onset of accretion, and (iii) rapid cooling following accretion generated by normal faulting that exhumed some slabs of the accretionary complex much faster than the overall erosional exhumation.

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