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New constraints on location, timing and rates of Cretaceous – Quaternary exhumation of the SE Carpathians (Romania): Insights from low-temperature thermochronology

S. Merten (1,2), L. Matenco (1,3), J.P.T. Foeken (4), F.M. Stuart (4) and P.A.M. Andriessen (1,2)

(1) Netherlands Research Centre for Integrated Solid Earth Science (ISES), (2) Department of Isotope Geochemistry and (3) Department of Tectonics, FALW, Vrije Universiteit, Amsterdam, the Netherlands, (4) Noble Gas Isotope Laboratories, Scottish Universities Environmental Research Centre, East Kilbride, United Kingdom (sandra.merten@falw.vu.nl)

One of the most striking features in the Neogene evolution of the SE Carpathians is the Pliocene to Quaternary uplift of the mountain belt coeval with abnormally high subsidence of its foredeep basin after cessation of Early to Middle Miocene orogenic thrusting. Both the timing and structural position of these deformations are in strong contrast with the general Neogene evolution of the entire external Carpathian domain, where no significant deformation occurred after a main episode of uplift and exhumation related to the Middle Miocene collision.

A large number of uncertainties concerning timing and mechanisms for the late stage evolution of the SE Carpathians exist. Previous apatite fission track (AFT) results indicated that Neogene exhumation in the SE Carpathian Bend Zone started around 5 Ma, much later than in the rest of the East Carpathians (Sanders et al., 1999). However, high AFT age dispersions and low U contents prevented more details on the exhumation history. Combining AFT and (U-Th)/He thermochronology has given the possibility to resolve many of these uncertainties.

In this study, we trace vertical movements along a $\sim$150 km long NW-SE transect,

passing from the Transylvania Basin through the Carpathians fold-and-thrust belt into the foredeep basin, along Buzău Valley. The combined low-temperature thermochronology data indicate a more refined exhumation history for the SE Carpathians. AFT and (U-Th)/He ages generally decrease from Cretaceous in the more internal units, to Middle – Late Miocene for the more external nappes. This confirms the idea of a forward-breaking sequence for the Cretaceous – Miocene contraction episodes. Peak exhumation events overlap the classical defined tectonic stages, with the exception given by the Paleogene age group confirming a suspected, but never demonstrated tectonic event. Furthermore, Miocene contraction of the external East Carpathian nappes was already known to have induced $\sim$4 km of exhumation in the northern and central East Carpathians with rates in the order of $\sim$0.5 mm/yr (Sanders et al., 1999). It was however not recognized that it also induced $\sim$2-3 km of exhumation in the SE Carpathians at similar rates of $\sim$0.6 mm/yr.

In the SE Carpathians the general evolution is overprinted by a much younger exhumation event. Time – temperature histories indicate latest Miocene burial of $\sim$2 km for the external Carpathians. This was followed by a Late Miocene – Pliocene exhumation episode centered at the Audia – Macla and Tarcău nappes, where $\sim$2-3 km of rock was eroded at rates of $\sim$1.0 mm/yr. Around 2 Ma, (U-Th)/He ages and time – temperature histories indicate rapid exhumation for the entire external domain with amounts of exhumation varying from 2-4 km for the Audia – Macla and Tarcău units and 1-3 km for the internal Carpathians and the more external Tarcău units. Overall exhumation rates are in the order of 1.0-1.5 mm/yr. Latest Miocene – Quaternary deformation episodes represent an effect of the interplay between slab processes, such as tearing and break-off or various types of steepening/delamination, and Quaternary inversion of the entire Carpathian-Pannonian system.

References:

Sanders, C.A.E., P.A.M. Andriessen, and S.A.P.L. Cloetingh (1999). Life cycle of the East Carpathian orogen: Erosion history of a doubly vergent critical wedge assessed by fission-track thermochronology. J. Geophys. Res., 104(B12), 29,095 – 29,112.