



## **Faulting, cooling and exhumation in the footwall of the Shkoder-Peja Normal Fault (Dinaric-Hellenic junction) and its relation to the western Kosovo basin**

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Syn-orogenic extension is often associated with erosional and tectonic denudation focused in the footwall of large normal faults. The Shkoder-Peja Normal Fault (SPNF) at the junction of the Dinarides and Hellenides in northern Albania and Kosovo trends NE-SW, at high angles to the mountain belt. The SW part of the footwall of this fault is a doubly-plunging, upright fold (Cukali Dome) whose axis trends parallel to the SPNF. To the east, the SPNF footwall comprises the High Karst (HK) and East Bosnian Durmitor (EBD) nappes. The Cukali Dome deforms the Paleogene Dinaric nappes, including the Krasta-Cukali Nappe with its Middle Triassic to Early Eocene sediments. Post-depositional peak temperatures of  $\sim 301 \pm 6^\circ\text{C}$  in the Cukali flysch (youngest sediments of the dome, 55-52 Ma – Ypresian) obtained from Raman analysis of carbonaceous material point to a burial depth of 10-20 km given a geothermal gradient of 15-30°C. Apatite fission-track (AFT) data from three samples of the Cukali flysch yield central ages between  $29 \pm 9$  Ma and  $21 \pm 6$  Ma. Another five from in total eight samples that were collected along two profiles close to the western (Cukali Dome) and the eastern (EBD) ends of the SPNF yield central AFT ages between  $34 \pm 14$  Ma and  $21 \pm 6$  Ma.

Peak temperatures in the foot- and hangingwall of the SPNF exceeded the upper limit of the partial annealing zone (PAZ) for apatite ( $\sim 110^\circ\text{C}$ ), suggesting that the fission tracks in apatites must have been completely reset during burial and before exhumation. This precludes an inherited signal and therefore mixed AFT age populations. Our results indicate burial (involving Dinaric folding and thrusting) followed by exhumation and cooling of the Cukali flysch, and along-strike of the SPNF footwall, happened between Middle Eocene (post-Ypresian, age of the sediments) and Early Miocene (youngest central AFT ages). These AFT ages are  $\geq 4-5$  Ma older than Mid-Miocene syn-rift clastics in the western Kosovo basin in the hanging wall of the SPNF. West-East oriented profiles through the basin show increasing thickness of Mid-Miocene to Plio-Pleistocene sediments to at least  $\sim 1$  km toward the SPNF in the west. Offset of the base of the West Vardar ophiolite nappe (WVO) in the footwall of the SPNF with respect to the top of the WVO at the western Kosovo Basin indicates a minimum vertical throw of 3 km at the eastern SPNF termination near Peja. However, similar AFT ages across the SPNF indicate contemporaneous pre-middle Miocene cooling of both blocks along the SPNF. This indicates that main displacement on this branch of the SPNF pre-dated thermal equilibration to below the PAZ of the AFT system.

Taken together, the data is best explained by one or more normal faults active at two times: (1) faulting on the main SPNF which accommodated Cukali Doming and exhumation of the SPNF footwall no later than late Oligocene-Early Miocene time. (2) Mid-Miocene to Plio-Pleistocene normal faulting, possibly in the hanging wall of (1), that lead to deposition of syn-rift clastics in the Kosovo Basin.