

## Neotectonics of the Carpathians: Lessons learned from tectonic geomorphology

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Neotectonic studies in the Carpathians have focused mainly on the effects of large-scale domal uplifts and open folding above marginal zones of thrust and imbricated map-scale folds, deformation of fluvial terraces related to reactivated pre-Quaternary faults, morphometric indicators of young tectonic activity, and rarely to the structural characteristics of young faulting. Neotectonic faults tend to be associated with the margins of the Orava–Nowy Targ Basin at the boundary between the Inner and Western Carpathians, as well as some regions within the Outer Carpathians. Quaternary grabens within the Orava–Nowy Targ Basin, oriented E–W, reveal throws of up to 120 m. Reactivation of the northern boundary fault of the Pieniny Klippen Belt was shown to have occurred as late as in the Holsteinian. Minor vertical block movements of oscillatory character (0.5–1 mm/yr) were detected along faults cutting the Pieniny Klippen Belt. In the Pliocene and Quaternary the Polish Carpathians witnessed differential vertical and some remnant horizontal movements, resulting in the formation of elevated and subsided areas. Valleys of the Outer Carpathians bear 5 to 9 terrace steps of Quaternary age. Most of Pleistocene terraces are strath or complex-response terraces; the Weichselian and Holocene steps are usually cut-and-fill landforms, except those located in the neotectonically elevated structures, characterized by the presence of young straths. Longitudinal profiles of individual strath terraces frequently show divergence, convergence, upwarping, downwarping, or tilting that can

be indicative of young tectonic control. Examples based on detailed examination of deformed straths and fluvial covers in selected segments of the main Outer Carpathian rivers appear to indicate Quaternary reactivation of both normal and thrust faults in the bedrock. The latter are mostly confined to the eastern portion of the Outer Carpathians. In the western portion of the Outer West Carpathians, middle and late Pleistocene reactivation of early Neogene thrust surfaces was documented in the Beskid Żywiecki Mts. Differentiated mobility of reactivated as normal Miocene strike-slip faults (oriented N–S to NNW–SSE and NNE–SSW) in the medial portion of the Dunajec River drainage basin appears to be indicated by the results of long-profile analyses of deformed straths, usually of early and middle Pleistocene age. A small normal, seismogenic fault on the NW margin of the Nowy Sącz Basin probably originated in Eemian or early Weichselian times. Quaternary uplift of the marginal part of the Beskid Niski Mts. (W–E to WNW–ESE), in the mid-eastern portion of the Outer Carpathians of Poland, was estimated at 100–150 m, including no more than 40 m of uplift after the Elsterian stage. Analyses of different morphometric indices (abnormal river bed gradients, hypsometric integrals, valley floor width-valley height ratios, stream-length gradient indices, and others) point to the presence of several longitudinal zones, subparallel to the structural grain of the area and showing recent uplift due to buckling of frontal parts of imbricated slices.