Tectonics of Gemericum (Inner Western Carpathians) – Inheritor of Complex Double-Stage Collision

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The latest deformation phase in the Bükk Mts. is characterized by the uplift and exhumation of the paleo-mezozoic basement, that has produced the present "inselberg" topography. The traces of this process are well-preserved in the rocks of several outcrops, mainly on the edges of the mountains, where the faults represent not only a structural but a morphological boundary as well, and the vertical displacement reaches some hundred meters. The topographically elevated Mezozoic limestone with steep slopes offer outcrops in a lot of road cuts and quarries, but there are a few outcrops also with Miocene clayey or sandy sediments and rhyolite tuff affected by the faulting.

The aim of the investigations was to ascertain the movement directions in the bounding fault zones on the NE edge and to reconstruct the axial directions of the stress ellipsoid for the stress states leading to the uplift of the Bükk Mts. The paleostress analysis was based on the measurement of slickenline orientations (that is to say, displacement directions) on ten good quality outcrops (quarries and at least 100 m long road cuts with 10–100 displacement vector data) and on several smaller ones (with 1–20 displacement vector data or fault plane orientations only) in the NE part of the Bükk Mts, and it was carried out by the P-T dihedra method (Angelier 1984).

On the NE side of the Bükk Mts. the edge zone consists of several faulted blocks in a stepwise arrangement in a 1–2 km wide, NW-SE striking zone as far as Miskolc, then it continues to the S in a zigzag line. The characteristic fault strikes observed in outcrops are ESE-WNW and N-S. There are two generations of slickenlines on the outcrops of the mountains' edges in general. The first one is very apparent on the planes of almost every joint sets, moreover, it is also present inside the Bükk Mts. in certain sites. The displacement was sinistral strike-slip faulting on the dominant ESE-WNW planes with the S sides moving upward (as a vertical component), and dextral strike-slip faulting on the accessory N-S planes with the W sides moving upward. The second generation is prevalent only on certain outcrops directly at the morphological boundary (in a 100 m proximity). The displacement was thrusting on the dominant N-S planes with W sides moving upward and sinistral oblique-slip movement on the ESE-WNW planes mostly with S sides moving upward, just like in the previous case. The principal stress directions constructed from the first generation data are a horizontal, ENE-WSW $\sigma 1$ (highest compression), a vertical $\sigma 2$ and a horizontal $\sigma 3$. In the case of the second generation, $\sigma 1$ is horizontal and E-W directed, $\sigma 2$ is horizontal and $\sigma 3$ is vertical.

The dating of the deformation events is only indirectly possible, because most of the paleostress data come from Mezozoic rocks. The Lower Miocene sediments in NE and rhyolite tuff in SE are affected by the movements as shown by the faulted position of coal measures and by fault planes, sometimes also with slickenlines. These traces correspond to the movements indicated by the first generation of the slickenlines, so they cannot be older than Carpathian. Remnants of rhyolite tuff (considered as Badenian-Sarmatian, Pelikán 2002) lie directly on Mezozoic rocks on several points of the Bükk Mts. proving the exhumated position and the newly developed burial in the Middle Miocene as well. The thermal modelling based on apatite fission track data showed that up to the end of the Tertiary this cover must have been about 1 km thick on some zones (Dunkl et al. 1994). The oldest cave fillings are similar in age (Hevesi 1980), so the recent exhumation began in the Pliocene-Pleistocene.

According to these constraints, the Bükk Mts. became uplifted and exhumated during the Middle Miocene as a result of an ENE-WSW compression. On the NE edge a NW-SE striking sinistral, transtensional strike-slip fault zone was developed. The faulting proceeded mostly on existing joint sets in the Mezozoic rocks not only in that zone, but also in other zones in the Bükk Mts. while Cenozoic rocks are affected only at the mountains' edges. This phase was either contemporaneous with or followed by a rhyolitic volcanism producing a thick cover again. This cover was eroded almost perfectly during the continuing uplift from the Upper Miocene up to the Quarternary. In that time, the compression became E-W oriented and (with permutation of $\sigma 2$ and $\sigma 3$) thrusting became prevalent instead of strike-slip faulting. This thrusting produced an abrupt breakdown in the morphology on the E edge of the Bükk Mts. When we consider that palaeomagnetic data from NE Hungary show a general 20° counterclockwise rotation during the Mid-Late Miocene (Márton and Fodor 1995), the change in the $\sigma 1$ direction is a consequence of this rotation, and the real orientation was E-W during the whole uplift period.

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