"core and mantle" structures, as well as the width and deformation of mechanical e-twins in large calcite crystals.

The strongest deformation was detected in mylonitized limestones. These rocks occur in shear zones, their texture is characterized by "c-axis fibre type" CPO, that indicates dynamic recrystallization. Relicts of coarse, strongly-twinned crystals ("cores") flow in these rocks in the broad "mantle" of the dynamically recrystallized matrix.

Out of shear zones, the appearance of "core and mantle" structures is a general feature, too. Here the core corresponds to the strongly-twinned large crystals, while the mantle is a rim of recrystallized calcite grains with d ~ 20–30 μm size. The thickness of the mantle and the deformation style of mechanical twins depend on the intensity of shear strain. During small strain, only twins form in the large crystals, mantle does not develop. Conversely, in strongly-strained limestones a broad mantle develops around the coarse grains, which include curved and recrystallized twins. The microcrystalline matrix of these rocks shows an a-axis fibre type CPO or it lacks CPO that points to the appearance of grain boundary sliding (GBS) as the dominant deformation mechanism. Applying these strain patterns, the shear strain developed during the early deformation phase can be estimated between $\gamma = 0{,}3$–5. The latter value characterises the shear zones. The average twin-width in the coarse calcite grains exceeds 5 μm which indicates that twinning took place above 200 °C.

The results obtained from strain patterns of the coarse-grained calcite aggregates and mechanical twins in the Eastern Bükk correlates well with metamorphic grade indicators, measured directly in limestones such as Conodont Color Alteration Index (CAI) (Sudar and Kovács in press) and measured in other rock types, using mineral assemblages, IC and vitrinite reflectance data (Lelkes-Felvári et al. 1996). The epizonal metamorphism correlates with strain patterns such as dynamic recrystallization, strongly developed core and mantle structures, curved and recrystallized calcite twins with at least 5 microns width. The anchizonal metamorphism correlates with dynamic recrystallization and GBS, with less-developed core and mantle structures, curved or straight twins with 3–6 microns width.

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The Miocene Transpressional Tectonics along the Pieniny Klippen Belt (Zázrivá, Western Carpathians)

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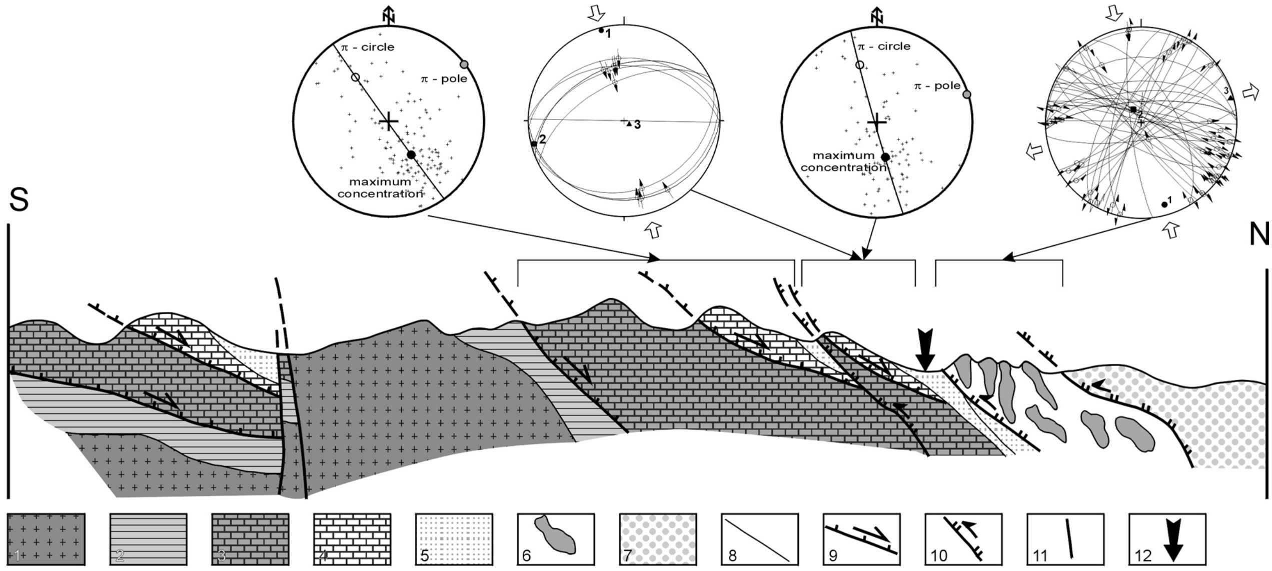
Meso-Neoalpine tectonic evolution of the Western Carpathians was controlled by long lasting (Upper Cretaceous – recent) squeezing between the North European Platform and promoted the Apulia-Adria microcontinent pushed by the Africa lithospheric plate to the north. It led to the strong dominance of the north-verging tectonic structures within the Outer Western Carpathians (Flysch Belt), where asymmetric accretionary orogenic wedge was created due to the consumption of a quasi-oceanic Peninic (Vahic) crustal slab. Nevertheless, south-verging, high-angle thrusts have been already described in the eastern part of the Pieniny Klippen Belt (Nemčok and Rudinec 1990, Plašienka et al. 1998). The south vergent reverse faulting in studied area has been first suggested by Matějka (1931) in the Medzirozsutce saddle and later accepted in tectonic interpretation of the area (Haško and Polák 1978). During the last years, we have had an opportunity to study systematically the zone of tectonic junction of the Central and Outer Western Carpathians in the eastern part of the Malá Fatra Mts. and the Kysucké vrchy Mts. From structural analysis supported by detail geological mapping has resulted that the geological structure in tight contact with the Pieniny Klippen Belt zone is really strongly affected by



■ **Fig. 1.** Idealised tectonic cross-section of the Central and Outer Western Carpathian junction area along Zázrivka River valley (according to Haško & Polák 1978, modified). 1) The crystalline of the Tatric supernit; 2) the Mesozoic cover of the Tatric superunit; 3) The Fatric superunit (Krížna nappe); 4) The Hronic superunit (Choč nappe); 5) The Central Carpathian Paleogene Basin sediments; 6) The Pieniny Klippen Belt; 7) The Magura supernit; 8) Lithological boundaries; 9) Meso-Alpine thrust, 10) Neo-Alpine thrust, 11) fault; 12) Localization of the outcrop Zázrivá/Terchová road crossing with deformed Paleogene sediments

backthrusting. Field structural evidences of southvergent reverse faulting (i.e. backthrusting in relation to the polarity of the orogene) were observed and analysed within the Periklippen zone of the Orava segment of the Pieniny Klippen Belt near Zázrivá village. The wider area is occupied by four tectonic units listed from the north to the south (Fig. 1):

a) Pieniny Klippen Belt,
b) Central Carpathian Paleogene Basin,
c) Fatric and Hronic units,
d) Tatric unit.

The background knowledge concerning the geology and tectonics of the area has come from the geological maps and investigations of Andrusov and Kuthan (1943), Haško and Polák (1978), Potfaj (1974, 1979, 1998), Samuel and Haško (1978), Rakús (1984), Aubrecht et al. (2004), Marko et al. (2004).

Post-Oligocene folding and backthrusting is recorded in mesoscale structures observed in the outcrops, as well as it results from the analysis of bedding attitudes of the Paleogene sediments. The sediments of the Central Carpathian Paleogene Basin south of Pieniny Klippen Belt in the Zázrivá valley, geodynamically representing a post-nappe unit are fairly strongly affected by tectonic faulting and folding. Both, faults and folds could have been generated during the same tectonic event, under NNW-SSE oriented maximum principal stress axis σ_1. We suppose, that faulting and folding observed south of the Pieniny Klippen Belt are genetically related to large-scale backthrusting (south vergent thrusting).

The backthrust tectonic style of the area is evident from the map-scale structures too. A slice of the Paleogene sediments, tectonically incorporated along south-vergent large-scale thrusts to the Mesoszoic nappe units is interpreted in the geological map.

A large-scale picture of the backthrust tectonic style south of the Pieniny Klippen Belt emerges from the deep reflection 2T seismic profile (Tomek et al. 1987, Tomek 1993). There are recorded very distinctive crustal-scale north-dipping reflectors, which as we believe represent southern branch of the post-Paleogene positive flower structure developed due to the Miocene transpressional shearing in between the Outer and the Central Western Carpathians.

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Paleo-Stress Determination in Boreholes Drilled in the Boda Siltstone Formation (Mecsek Mts., Hungary) with the ImaGeo® Corescanner System

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In the frame of the geological research for final disposal of high-level radioactive waste, several boreholes were drilled in the Boda Siltsone Formation (Mecsek Mountains, Southern Hungary).

The Boda Siltstone Formation is an upper Permian (250 to 260 Ma) shallow lacustrine facies, reddish brown, monotonous, albititic, partly cross-bedded or laminated but mainly poorly bedded siltstone with conglomerate, sandstone, and dolomitic intercalations. It was deposited in continental sedimentary conditions, in arid-semiarid climate. The thickness of the whole formation is ~1000 m. The sedimentary basin cyclically dried out. Tepee structures, ripple marks, ichnofossils, concretions are common (Hámos 1999).

In several boreholes structural geologic investigation was carried out (Bat–4, D–5, D–6, Bak–5, Eg–1, Eg–2). With the help of the Imageo Coresanner system the cores were oriented with the help of borehole televiewer (BHTV) images (Maros and Palotás 2000, Maros and Pásztor 2001). When no BHTV images were available in a borehole, the orientation was done upon the assumption of the dip of the bedding, which is locally quite monotonous. Boreholes D–5 and D–6 were horizontal, drilled from an underground shaft, the others were vertically drilled from the surface.

The detailed tectonic description and the stress field analysis based on slickenlines revealed the main brittle deformational phases from a synsedimentary Permian event to Neogene deformation events. The spatial distribution and frequencies of the sedimentary phenomena, the different fractures, infillings, and slickensides were analysed and correlated across the boreholes. The different infilling generations were bound to different joint sets.

The Permian synsedimentary deformation was probably characterised by a NNW-SSE tension. Fractures and calcite filled tension gashes were formed parallel to the bedding. Bedding planes were reactivated by a NW–SE compression during the middle Cretaceous. This deformation led to the formation of the West Mecsek anticline. Some drillholes (Bat–4, D–5, D–6) were located on its NNW dipping northern limb, boreholes Bak–5, Eg–1, Eg–2 represent the SSE dipping limb. This deformation can be the same as described by Benkovics et al. (1997). The fold was overprinted by a strike-slip type deformation, with NNE-SSW compression and ESE-WNW tension. A prominent NE-SW trending fault zone formed in this stress field (e.g. Büdöskút zone). This zone was composed of transtensional and transpressional segments. The former was characterised by narrow graben-like structures, one of which was penetrated by one of the horizontal boreholes. In the fault zone part of the northern limb of the West Mecsek anticline was rotated to a SE dipping position. The deformation might have occurred in the late Cretaceous, but the zone could be reactivated in the Tertiary as well. The youngest phase was marked by a NNE-SSW compression, inducing N-S trending dextral and NE-SW trending sinistral faults, often coated with calcite infillings. This deformation was also noted by Csontos and Bergerat (1992).

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