New Structural Observations along the Vértessomló Line and Implications for Structural Evolution of the Trasndanubian Range (Western Hungary)

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The Transdanubian Range (TR) can represent the highest Austroalpine nappe emplaced onto other Austroalpine units in the mid-Cretaceous (Tari 1994, Fodor et al. 2003). Its internal structure is marked by two large synclines (Tari 1994). Several denudation phases of Albian–early Eocene age levelled all formations to an extensive edge plain (Kaiser 1997). Because of Cenozoic cover and successive deformation events, most of the outcropping part of the TR Permo-Mesozoic rocks exposes the southeastern limb of this large syncline, from the Balaton highland up to the Vértes hills.

The Vértessomló Line (VL) is obliquely cutting across the TR in the northern part of the Vértes Hills, where the strike of the 'monocline' is turning from NE to easterly trend (Taeger 1909, the fault was named originally Somló-Szár fault). Along the VL the Mesozoic sequence occurs in two repeating belts (Császár et al. 1978). The displacement can be best determined using the boundary of Hauptdolomite and Dachstein Limestone Formations and their transitional Fenyőfő Member. These formation boundaries show a sinistral jump across the VL; the amount of separation in map view is around 6 km (Balla and Dudko 1989). These authors extended the VL eastward, and combined with some Eocene to early Miocene faults and gave the name Vértessomló-Nagykovácsi Line. To explain the repetition of the Mesozoic formations, late Cretaceous reverse (Császár et al. 1978), Miocene sinistral (Balla and Dudko 1989) or multiphase strike-slip movement (Maros 1988) was postulated.

Surface mapping, field structural measurements, borehole data, geological cross sections, and imaging of certain pre-Tertiary surfaces permit to reconstruct the evolution of the fault and connect to other structures of the TR. The Vértessomló Fault is trending E-W and only slightly disrupted by younger cross-cutting faults. The southern side of the fault is composed of Upper Triassic, reduced Jurassic-Berriasian and Aptian-Albian sediments, while the northern part is mainly composed of Upper Triassic rocks. All along the fault, the southern side is folded and upright to slightly asymmetric, southvergent fold(s) can be mapped (Taeger 1909, Maros 1988, Bíró 2003). Fold shape is generally gentle to moderate in Triassic, but the Aptian-Albian show close to tight folds, sometimes with overturned limb. Fold axes are mainly sub-parallel to the VL, but deviations occur locally.

Small-scale contractional structures (reverse faults, duplexes) formed before and during the folding (partly described by Maros 1988). Slickenside lineation and the attitude of faults permitted the reconstruction of pre-folding stress field. Compression was oriented NNW-SSE, sub-perpendicular to slightly oblique to the VL (Fig. 1).

Cross sections clearly suggest that the VL is a north-dipping reverse fault, with a displacement of 0,5–1,5 km. Near the fault, small-scale imbrications were mapped and penetrated by the borehole Vst-8 (Császár 1995). The northern hanging wall also shows some gentle folds. Particularly, an anticline can be detected north of the VL, interpreted as a ramp anticline (Fig. 1).

ENE-WSW compression can also be documented along the fault at some sites. The role of this stress field is questionable, can be correlated to Paleocene? or to early Cretaceous faulting (Fodor 1998, Albert 2000, respectively).

It is not easy to determine exactly the timing of reverse motion. Aptian to early Albian formations are involved in the folding, but the continuation of the fault in subsurface middle-late Albian formations is doubtful (Császár 1995, 2002). Geometry of the pre-Tertiary surface clearly shows that the main deformation (folding and imbrication) of Mesozoic rocks terminated before the denudation event of latest Cretaceous–early Eocene age. Eocene abrasional shoreline clearly covers the fossilised VL in its central segment (Fodor and Bíró 2004). Three to four faulting phases deformed the pre-Tertiary surface. The characteristic stress fields are similar to those described in other part of the TR by Márton and Fodor (2003). Very gentle, (monoclinal) fault-related folding, sub-vertical strike-slip or normal faults slightly modified the Cretaceous structural geometry (Fig. 1), and, among other effects, dismembered the continuous VL. It is to note that this fault cannot be merged with the Nagykovácsi Line, because they have different age and kinematics; we suggest to keep the Vértessomló Line name for the fault crossing the Vértes Hills (Fig. 1, inset).

The VL occurs where the southern syncline of the TR seems to terminate, and bound the syncline on the northern side. This role is similar what the Bakonybél thrust plays more to the southwest, in the Bakony Mts. (Tari 1994). Two differencies may exist between the two faults. The Bakonybél thrust is NE trending, formed by NW-SE compression, (Fodor 1998, Albert 2000) and has pre-middle Albian age (Fodor 1998). The Vértessomló Line is E trending, formed by N-S compression and seems to be slightly younger, middle to late? Albian. This suggests that the direction of compression changed in space or in time, from NW-SE in the south to N-S in the central-north TR. This change may be the result of a temporal propagation of compressional structures.

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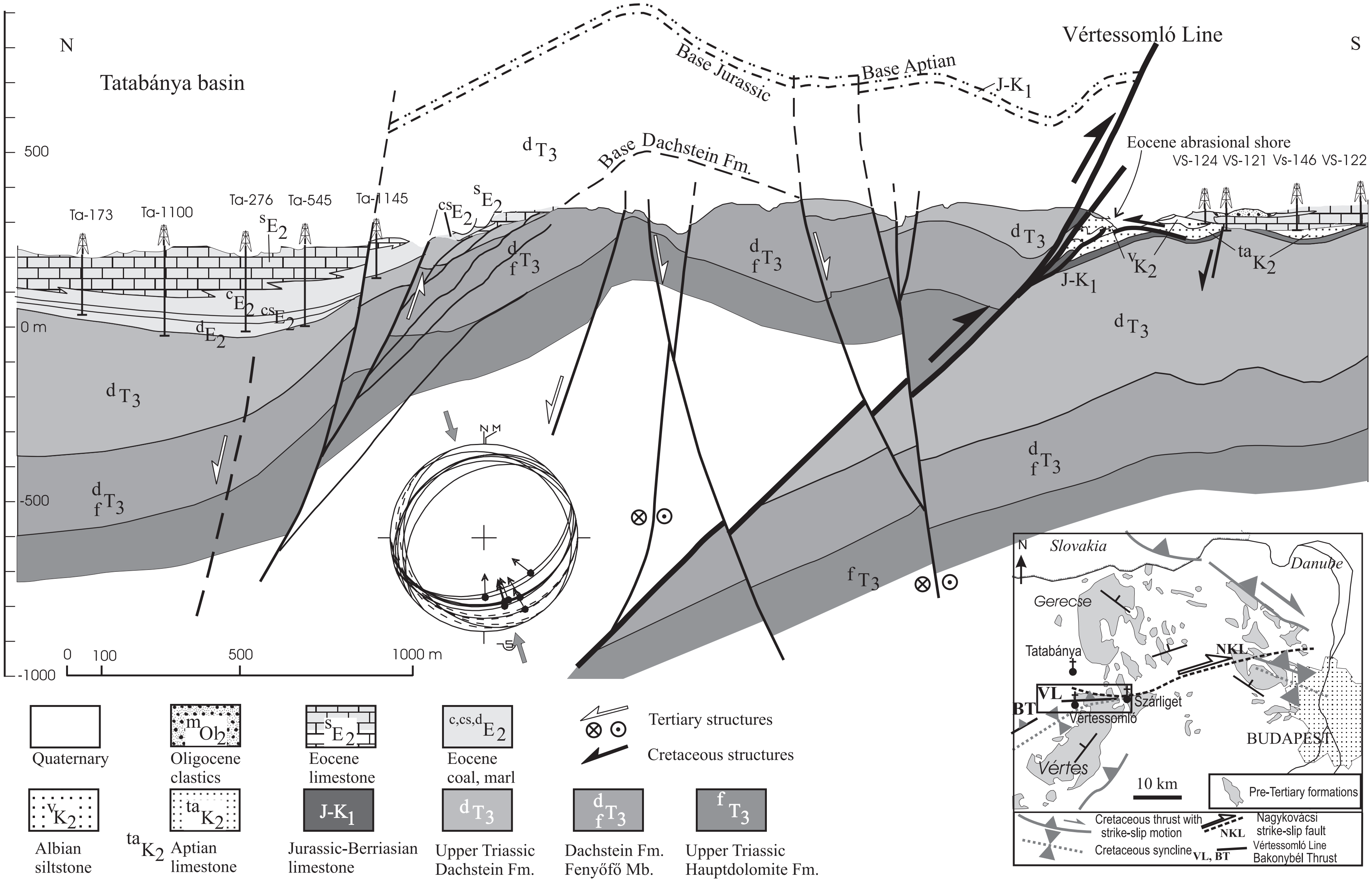

■ **Fig. 1.** N-S cross section through the central Vértessomló Line. Note imbrication and overturned folds in mesozoic rocks along the fault. Inset shows the location of the study area. Stereogram demonstrate stress field and fault pattern in an Aptian outcrop on the section, close to the main fault.

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Ductile Deformation Studies of Anchimetamorphic Sequences in the Bükk Mts., NE Hungary

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The Paleo-Mesozoic anchimetamorphic series of the Bükk Mountains (NE Hungary) are showing similar stratigraphic and tectonometamorphic development to those of the Inner Dinarides (Balla 1987, Csontos 1999, Protić et al. 2000, Filipović et al. 2003). Displacement of the Bükk Unit from the Dinaric margin to the present position along a large-scale fault zone was accompanied by a significant counter-clockwise rotation (Márton and Fodor 1995). In the Bükk Mountains regional dynamothermal metamorphism (160–120 Ma, peak metamorphism around the younger age limit) and a subsequent Late Cretaceous (80–95 Ma, interpreted as cooling age) metamorphic event was reported (Dunkl et al. 1994, Árkai et al. 1995), with the lack of any earlier (Variscan) metamorphism and/or deformation. The ductile deformation is combined or followed by the emplacement of small-scale nappe slices, imbricates and olistoliths, which often have an uncertain timing. The large-scale folding and thinning of anchimetamorphic series was well outlined by previous geological mappers (Balogh 1964, Csontos 1988, Less et al. 2002). However, the intensity and style of the layer-parallel flattening and the axial plane foliation is sometimes hardly observable, and strongly depends on the lithologic conditions and on the position inside the major, folded structure. The ductile deformation is mainly attributed to the early, synmetamorphic phases (Csontos 1999, Németh and Mádai 2004); later events are showing more brittle tectonic style.

Our investigation was aimed to characterize deformation patterns, especially those of ductile behaviour. Working methods were based on detailed field observations and microtectonic investigations on oriented samples taken from scattered, mostly stratigraphically controlled sites of the Bükk Paleo-Mesozoic. Field measurements were followed by deformation analysis of the samples. Different techniques were applied, including microscopic study of thin sections and acetate peels, combined with image-statistic evaluation of the sections and the three scanned, polished surfaces perpendicular to each other.

In the less deformed, massive limestone bodies, where sedimentary structures are partly preserved, bedding-parallel flattening can be traced in zones with a thickness of some cm-s or dm-s. Their deformation ellipsoid (which can be reconstructed for ooidal, oncoidal limestones using texture-statistic method, Fry 1979) is predominantly oblate (lenticular). The maximum elongation (if observable) of such clasts is generally not horizontal, and it is subparallel to the general cleavage and to the E-W trending, but later arched strike of the series. The deformation ellipsoid of the same rock type becomes more elongated (prolate), when it is placed close to the hinge zone of a tight fold. In outcrops and samples containing less competent rock types, simple shear can be traced along the cleavage and the bedding-parallel foliation planes at the limbs of the S-vergent folds, formed in the main folding phase. At right angles to the originally E–W striking, but now arched (and therefore SW–NE, then W–E, then NW–SE tending) anticline–syncline structures, shear criteria indicate different, but mainly top to S movement. Parallel to the subhorizontal lineation, significant elongation can be measured from boudinaged and splitted segments of cherty layers and crinoid fragments. Another, lineation-parallel shearing is also observable in outcrops as well as in thin sections. Probably this dataset is a result of different mechanisms. During the prograde stage of the deformation, planes with different orientations (and different shearing senses on them) become subparallel to the foliation. In cases, when the re-folded sequence gives the same shear criteria, this layer-parallel shearing can also be considered as earlier than syn-cleavage folding. In this case, the first, bedding-parallel deformation has a shear component as a consequence of an early tectonic event.