Almost all images exhibit loglinear CSDs some of them with "humped" patterns at the smallest sizes. Extensive quantitative modeling shows that most of the loglinear CSD cannot be modeled as closed (batch) system because this produces more pronounced "humps" (due to diminishing available melt content). It is inferred that especially in injection veins hematite crystallized in open system where the loglinear pattern is generated through removal of older (bigger) crystals out of the system. The hematite crystals thus began to crystallize in moving melt and only in particular places (e.g. between clasts) where the melt was locked, it crystallized as a batch. Solidification times were calculated using conductive cooling equations (Jaeger 1968): for cooling from 1100 to 600 °C, latent heat 100 calg^{-1}, sheet thickness 1 cm, ê = 0.008 cm^{2}s^{-1} the time is 62 s. For such a time, hematite CSDs in pseudotachylyte melts record extreme values of nucleation and growth rates: initial nucleation rate $J_0 = 5 \times 10^4$ to 5×10^6 cm^{3}s^{-1} and $G = 5 \times 10^{-5}$ cms^{-1}. The latter value is 5 orders of magnitude greater than ilmenite growth rates from basalt lava lakes and results from very high undercoolings values of the thin melt sheet injected into relatively cool rock.

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Structural Geometry of the Krí•na Unit in the Donovaly Area: Inferences for the Emplacement Mechanisms of Thin-Skinned Cover Nappes

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The classic Krížna Nappe appears in the so-called core mountains of the Central Western Carpathians (CWC), which are the Upper Tertiary horst structures. There, the Krížna Nappe overlies the Tatric basement and cover complexes and is overridden by higher cover nappe units (the Choč nappe s.l., or Hronic nappe system). The traditionally defined Krížna Nappe consists exclusively of detached Mesozoic (Upper Scythian to Cenomanian) sedimentary succession in an allochthonous position, overlying various Tatric rocks, most commonly mid-Cretaceous flysch complexes (up to Early Turonian in age). However, the Krížna Nappe is only a part, though the most extensive and important one, of a large tectonic thrust system – the Fatricum (defined originally by Andrusov et al., 1973; redefined by Plašienka, 1999). The Fatric superunit includes, in addition to the Krížna Nappe s.s., its roots closely related to the anchimetamorphic Veľký Bok Unit, which is partly confined to the Northern Veporic basement (Fig. 1). Some frontal Fatric units were, after their nappe emplacement, incorporated into the intricate structure of the Pieniny Klippen Belt, where they were subjected to a renewed Upper Cretaceous and Tertiary sedimentation and deformation, unlike the classic Krížna Nappe. These are the Manín, Drietoma, Haligovce and probably some other partial units (Maheľ, 1983), and suspectably also the controversial Klape Unit (Plašienka, 1995). They were amalgamated with the representative Klippen Belt (Oravic) units, as the Czorsztyn and Kysuca-Pieniny, during the Lower Tertiary.

Typically, the Krížna Nappe sedimentary successions were detached from their mostly disappeared substratum along the horizon of Upper Scythian shales and evaporites. This substratum is locally exposed in the basal basement duplexes that were stripped off the underthrust Fatric basement and thrust over the southern Tatric margin (Rázdiel Unit in the Tribeč Mts. – Hók et al. 1994; Staré Hory Unit in the Donovaly area – Jaroš 1971; Fig. 1). The pre-Alpine basement is composed dominantly of orthogneisses, its tegument cover comprises the Permian redbeds and Lower Scythian quartzose sandstones. The detached Krížna Nappe s.s. involves Middle Triassic platform carbonates, Upper Triassic shales, sandstones and evaporites (Carpathian Keuper Fm.), Rhaetian fossiliferous limestones and variegated Jurassic – Cretaceous sequences. The Jurassic strata are differentiated into two paleogeographically distinct successions – – the widespread basinal Zliechov Succession and the slope and swell Vysoká Succession. The former consists of a thick complex of well-bedded pelagic marly and siliceous sediments, the latter is dominated by shallow-marine bioclastic and sandy limestones and builds up the frontal nappe subunits in a lower structural position in relation to the principal Zliechov Unit. Lower Cretaceous strata are more uniform, formed by pelagic marly limestones and shales, locally with submarine hyalobasanitic lava flows, and terminated by Albian – Cenomanian siliciclastic flysch deposits including "exotic" conglomerates. These sedimentary complexes can be described in terms of pre-rift (Triassic), syn-rift (Lower Jurassic), post-rift (Middle Jurassic – Lower Cretaceous) and syn-orogenic (mid-Cretaceous) depositional systems (Plašienka 1999).

Lithological variations within the nappe body result in its distinct mechanical stratification. The nappe sole is formed by weak shales and evaporites, overlain by a strong massive carbonate layer (basal buttress) some 500 – 1000 m thick. The weak Keuper rocks provide a secondary detachment horizon within the nappe body and the well-bedded Jurassic to Lower Cretaceous strata constitute the thick (1000–2000 m) incompetent nappe core. Structures at their roof indicate the presence of a third detachment horizon, along which the poorly lithified incompetent mid-Cretaceous flysch complexes were peeled off and accumulated in the frontal parts of the Krížna Nappe system (Plašienka 1999).

The Krížna Nappe complexes were derived from a basinal area some 50–100 km wide, which was formed by Early Jurassic rifting and extension of a former uniform Triassic shelf of the northern flanks of the Tethys Ocean. The presence of continuous Triassic–Jurassic successions and absence of ophiolitic rocks reveal that the Zliechov Basin was floored by a continental, though attenuated crust. The surface geological criteria clearly testify this crustal segment disappeared between the Tatric and Veporic thick-skinned basement sheets, the suture being formed by the Čertovica Line (e.g. Biely and Fusán 1967). The deep seismic section 2T shows the Tatric slab to continue southward under the Veporic wedge up to middle and lower crustal levels in the distance of at least 50 km (cf. Tomek 1993). This underthrust crustal unit was interpreted as the Fatric basement and its tegument, the original substratum of the detached Mesozoic sedimentary complexes of the Krížna Nappe and related units (Plašienka 1995, 1999). The Čertovica Line represents a contact of two former margins of the Zliechov Basin characterized by a more-or-less normal, less thinned continental crust and by slope and swell Jurassic facies.

The evolutionary tectonic model of the Krížna nappe (Plašienka and Prokešová 1996; Plašienka 1999) assumes that the inversion of the Zliechov Basin and the generation of the Fatric nappe system proceeded in several steps. In mid-Cretaceous times, the Zliechov Basin was progressively shortened through underthrusting of its basement and tegument complexes below the Veporic thrust wedge. The sedimentary filling was detached along the lower detachment horizon and formed an initial fold-and-thrust stack prograding outwards. Simultaneously, the terrigenous syn-orogenic flysch prisms fed by rising hinterland domains were deposited in the piggy-back basins. After the complete elimination of the Zliechov Basin substratum, its Tatric and Veporic margins came into collision and the detached Fatric thrust stack was pushed over the frontal southern Tatric ramp, from which the frontal Fatric elements (the Vysoká- and Manín-type), with slope and ridge-related sedimentary Jurassic successions, were torn off. In the Upper Turonian, the Krížna Nappe elements gravitationally glided northward in a diverticulation manner, from the southern Tatric elevation over the unconstrained basinal northern Tatric areas. Finally, the frontal elements of the backstop Veporic basement wedge overrode the southern Tatric basement and cover – former northern passive margin of the Zliechov Basin. The imbricated basement duplexes were sheared off the substratum below the lower décollement in the Zliechov Basin (probably by reactivation of extensional normal faults) and imbricated during climbing over and gliding down the frontal Tatric ramp.

Structural record is partitioned into several deformation stages, principally the first two of them were formed during generation and emplacement of the Fatric units. The rear parts of the Fatric system (the Veľký Bok Unit) display a rich structural association formed under low- to very low-grade metamorphic conditions. The first stage includes bedding-parallel foliation, stretching lineation and flow folds in calcite-rich media, macrostructures include large-scale recumbent to northward-plunging folds, all with top-to-the-N to NW kinematics. These originated at the northern tip of the Veporic wedge overriding the underthrust Fatric basement (Fig. 1). The second stage produced crenulation cleavages and upright folds during collision of the Veporic wedge with the northern, Tatric margin of the Zliechov Basin. In the Krížna Nappe itself, these two stages are represented by compressional structures as intrastratal detachment zones associated with cleavage with S-C geometry and stretching lineation, mesofolds and ”digitations” formed during initial décollement and ramp-flat shortening of the Zliechov Basin sedimentary filling. These contractional structures were passively transported during the gravitationally driven final emplacement of the nappe sheet. Structures related to the gliding event are extensional, commonly C’-type shear bands and extensional vein systems.

Geological edifice of the Donovaly area nicely illustrates the structural relationships at the passage from the Staré Hory basement duplex to the Krížna Nappe proper. The subautochthonous Tatric basement and cover is composed of Variscan granitoids, Scythian sandstones and shales, and Middle Triassic Gutenstein limestone and Ramsau dolomite. Keuper Fm. is missing due to a syn-rift erosion and probably Lower to Upper

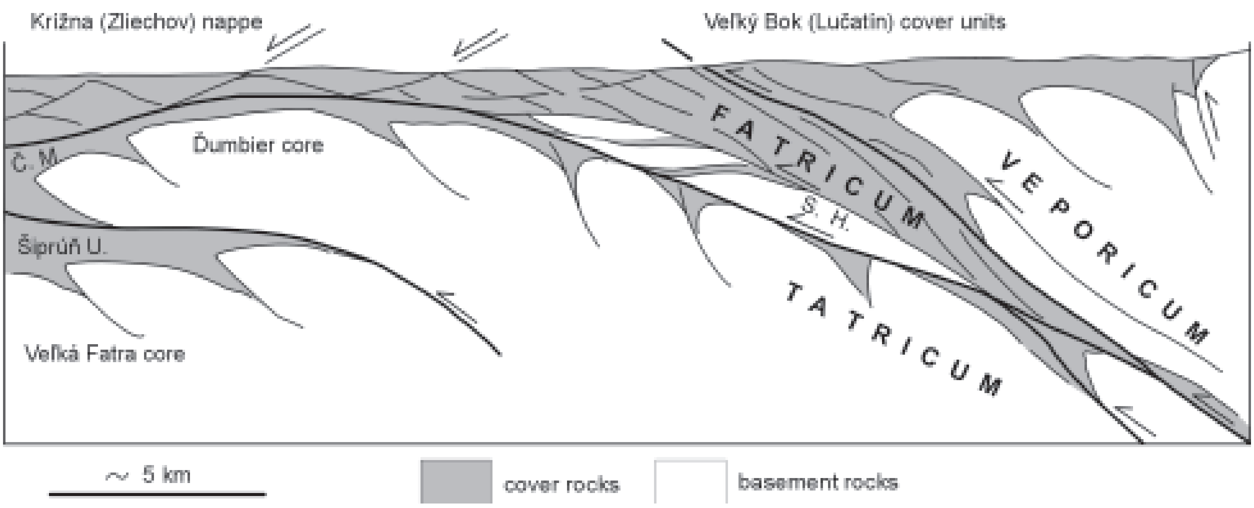

Fig. 1. Schematic tectonic section through the rear Fatric elements in the Banská Bystrica area. S.H. – Fatric Staré Hory Unit, Č.M. – Tatric Červená Magura Succession.

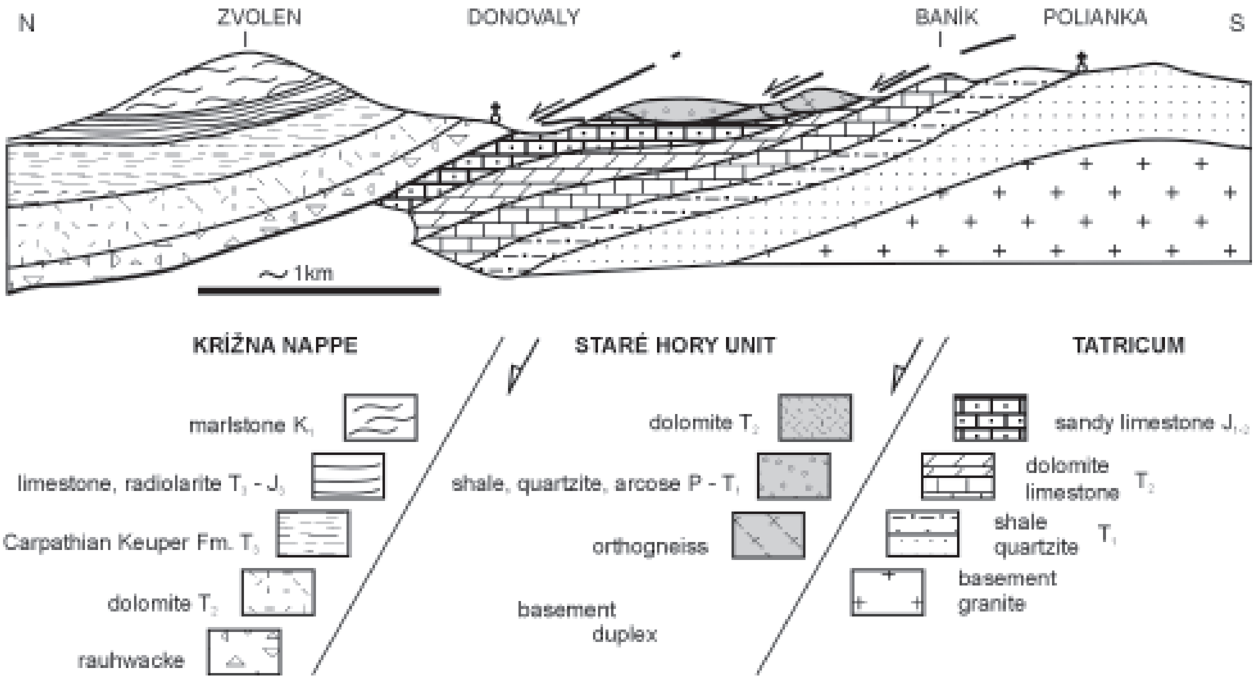

Fig. 2. Geological profile of the Donovaly region.

Jurassic strata are represented by sandy limestones and massive marbles. Going from the south to the north, this Tatric cover (Donovaly Succession) is overridden by a crystalline basement rocks (orthogneisses, migmatites), Permian red-beds, Lower Triassic quartzites and shales, and finally directly by the Middle Triassic carbonates followed by the complete Upper Triassic to Lower Cretaceous Zliechov Succession (Fig. 2). Several imbricates are distinguished within the basement duplex, their boundaries are dipping to the north, i.e., towards the foreland. The nappe sole is accompanied by huge masses of overpressured cataclastic carbonate breccias (rauhwackes), which accommodated almost all deformation related to the final nappe-gliding event (Plašienka and Soták 1996; Milovský et al. 1999).

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Mesozoic Structural Evolution of the Central Western Carpathians

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The Central Western Carpathians (CWC), located between the Meliata and Penninic-Vahic oceanic sutures, originated by shortening and stacking of a continental domain which was related to Europe during the Late Paleozoic and Triassic and to Adria during the Cretaceous and Tertiary. The crustal-scale basement/cover sheets (Tatric, Veporic and Gemeric superunits) and