post-orogenic Late Hercynian or Early-Alpine pre-orogenic stage in the Silicicum Superunit.

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Pseudotachylyte from the High Tatras: Petrology and Kinetics of Crystallisation

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Pseudotachylyte is a vein rock formed due to frictional melting associated with a seismic event. Fault-related pseudotachylytes are relatively common in thrust zones developed in basement rocks having experienced rapid uplift (the Alps, Appalachians, Caledonides, Carpathians). They form along the so-called generation surfaces accommodating the seismic slip. Pseudotachylyte was found at several places in the Vysoké Tatry (southern slope of Gerlach) and Západné Tatry Mts. The High Tatra occurrences are related to NNE striking faults with a steep dip of 75–90° both to ESE and WNW.

Three samples were studied showing different pseudotachylyte – host rock relations: (1) Pt-222, an injection vein in moderately cataclased and retrograded granite, (2) Pt-226, injected dilation fractures (Riedel shears) anastomosing from a generation surface, (3) Pt-650, curly injection veins in strongly cataclased rock (breccia). The three samples from three different places reveal similarities in mineralogical compositions on one hand, and great differences in mineral proportions and overall compositions on the other hand.

Melting relations. All samples are composed of matrix (crystallized melt) consisting of hematite (3–35%), albite and K-feldspar, and clasts dominated by feldspars and quartz. The proportions of matrix minerals are highly variable what results in melt compositional trends apparently controlled by biotite (Pt-222) or hematite (Pt-226, 650). In the sample Pt-222 K_2O contents correlate with Fe_2O_3, melt compositions lying between the source (cataclased) granite and biotite. It is therefore inferred that primary melt originated by preferential dehydration melting of biotite whose proportion in melting assemblage was 20–50 wt.% (based on biotite and pseudotachylyte melt FeO_{tot} contents). Thus, the melts have disequilibrium compositions governed by proportions of entering phases rather than by phase equilibria. Water liberated into the melt enabled further melting of quartz and feldspars. The Pt-226 and 650 samples exibit different major element trends where the Fe_2O_3 (hematite) increases are not accompanied by K_2O. It is noted that the hematite proportion increases towards tips of dilation fractures, so the most obvious way how to explain this feature seems to be hematite fractionation. This possibility is, however, not considered plausible because no reason is seen why hematite crystals should be preferentially fractionated and transported. Rather, melt differentiation (possibly by successive melting involving earlier pseudotachylyte matrix) is considered, beacuse it is the iron- and water rich melts with low viscosity which are sucked into the most distant dilation fractures.

P-T-X conditions. The presence of hematite (instead of original granitic ilmenite) indicates high oxidation conditions in the melt. Hematite is rather pure containing only 0.5–4.5 wt.% TiO_2 which gives f_{O2} values similar to those of hematite-magnetite buffer. The high oxidation is explained by complete water dissociation at high temperatures and subsequent hydrogen escape. The latter must have been very effective due to extreme surface/volume ratio of pseudotachylyte vein system. The temperature cannot be estimated directly in non-equilibrium melt. Zirconium solubility may provide an indirect estimate: the Zr concentration (170 ppm) gives the saturation temperature 755 °C. Since no zircon was found in the studied matrices (SEM images) the actual melt temperature must have been higher so that zircon could not have precipitated. Cataclasite as a related rock suggests brittle conditons in the failure zone. Pressure-temperature conditions during deformation/recrystallization have been estimated from the cataclasite assemblage biotite-chlorite-plagioclase-muscovite-epidote-hematite-quartz using THERMOCALC v.2.7 program and thermodynamic data of Holland and Powell (1998). Linearly independent reactions between coexisting mineral phases in the cataclasite yield average *P-T* conditions of 400–450 °C and 2–3 kbar. This temperature refers to a retrogressive (re-hydration) phase in the cataclasite following the seismic event.

Kinetics. Kinetic considerations are based on hematite crystal size distribution (CSD) measurements made on more than 40 BSE images and the CSD theory of Marsh (1988, 1998).

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^2s^{-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^3s^{-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 Krí•na Nappe appears in the so-called core mountains of the Central Western Carpathians (CWC), which are the Upper Tertiary horst structures. There, the Krí•na Nappe overlies the Tatric basement and cover complexes and is overridden by higher cover nappe units (the Choè nappe s.l., or Hronic nappe system). The traditionally defined Krí•na 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 Krí•na 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 Krí•na Nappe s.s., its roots closely related to the anchimetamorphic Ve¾ký 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 Krí•na Nappe. These are the Manín, Drietoma, Haligovce and probably some other partial units (Mahe¾, 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 Krí•na 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 Tribeè 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 Krí•na 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