*Mineralia Slovaca, Web ISSN 1338-3523, ISSN 0369-2086*
*52, 2 (2020), 83–102,* 

# Geological structure and tectonometamorphic evolution of the Veporic–Gemeric contact zone constrained by the monazite age data (Slavošovce–Štítnik area, Western Carpathians, Slovakia)

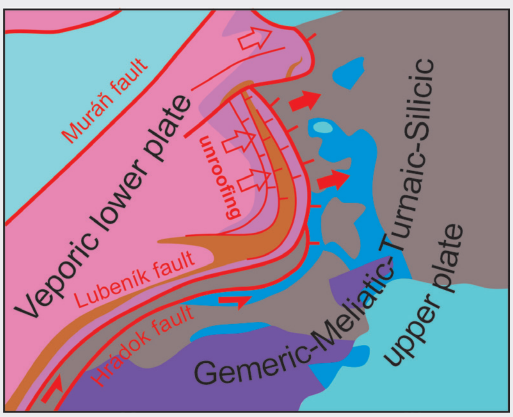
TOMÁŠ POTOČNÝ[1], ŠTEFAN MÉRES[2] and DUŠAN PLAŠIENKA[1]

[1] Comenius University, Faculty of Natural Sciences, Department of Geology and Paleontology, Mlynská dolina, Ilkovičova 6, SK-842 15 Bratislava, Slovakia; potocny9@uniba.sk; dusan.plasienka@uniba.sk
[2] Comenius University, Faculty of Natural Sciences, Department of Geochemistry, Mlynská dolina, Ilkovičova 6, SK-842 15 Bratislava, Slovakia; stefan.meres@uniba.sk

**Abstract:** The investigated area represents a segment of the contiguous Veporic–Gemeric zone characterized by the presence of several major superposed and/or juxtaposed tectonic units, exhibiting contrasting structural and metamorphic histories. Based on the structural, petrological and geochronological (EMPA dating of monazites) investigations, the principal Alpine tectono-metamorphic evolutionary stages were distinguished. Besides Variscan ages from the Veporic granitoids and skarnoids, the monazite dating provided evidence for the latest Jurassic–earliest Cretaceous event (150–140 Ma) in the Meliatic Bôrka Nappe, which was related to its exhumation and thrusting over the Gemeric units. Younger Cretaceous ages (110–85 Ma) were detected in all units involved and were connected with the ongoing shortening and onset of the orogen-parallel extensional exhumation of the Veporic metamorphic dome. Exhumation was governed by the kinematically linked sinistral shearing along the WSW–ENE trending Veporic–Gemeric contact zone (Lubeník and Hrádok fault zones) and by NNW–SSE oriented and east-dipping system of low-angle detachment normal faults that facilitated unroofing of the Veporic dome. Both segments reactivated in different ways the original overthrust contact between the Veporic lower plate and the Gemeric–Meliatic–Turnaic–Silicic upper plate.

**Key words:** Veporic, Gemeric, Meliatic, structural analysis, metamorphism, monazite dating

**Graphical abstract**




**Highlights**

- The Veporic–Gemeric contact zone in central Slovakia embraces three, originally superposed tectonic superunits – the Veporicum (basement and cover), Gemericum (Ochtiná and Volovec units) and Meliaticum (Bôrka Nappe)
- Former thrust contacts were reactivated as kinematically linked system of WSW–ENE trending sinistral fault-shear zones (Lubeník and Hrádok) and NNW–SSE oriented, gently E-dipping low-angle normal faults that facilitated orogen-parallel extensional unroofing of the Veporic metamorphic dome
- EMPA monazite dating provided three age groups – (i) Variscan ages in relic monazites from the mylonitized Veporic granitoids and from a skarnoid body in their contact; (ii) early Alpine monazites from the blueschist-facies Bôrka Nappe record its exhumation and thrusting over the Gemericum; (iii) Upper Cretaceous ages are present in all units and record the exhumation of the Veporic dome and shearing deformation along its peripheries

## Introduction

In general, convergent orogens are characterized by stacking of thick- and thin-skinned thrust sheets composed of rock complexes derived from different paleogeographic and paleotectonic settings. During continuing shortening within the prograding orogenic wedge, the original thrust contacts of major tectonic units are often affected by superimposed deformational and metamorphic processes like transpression, extension, or retrogression. As a result, these contact zones exhibit a complicated inner structure and sometimes patchy record of overprinting tectonic and metamorphic events within the units involved. Consequently, deciphering of structural and metamorphic evolution of the tectonic interface zones is of primary importance for interpretations of the orogen-scale tectonic processes.

In the Western Carpathians, there are at least four such contact or transitional zones that follow boundaries of the principal crustal-scale thrust systems (e.g. Plašienka, 2018 and references therein): (1) the boundary between the Internal and Central Western Carpathians (IWC and CWC, respectively); (2) the contact zone of the Veporic and Gemeric basement-involved thrust sheets of the CWC; (3) the boundary between the Tatric and overriding Veporic thick-skinned thrust sheets of the CWC (known as the Čertovica fault zone or line); (4) the Central to External (EWC) contiguous zone followed by the Pieniny Klippen belt (PKB) – see Fig. 1. The IWC vs. CWC border zone is considered as an ophiolite- and blueschists-bearing suture after closure of the Meliata Ocean by some authors (e.g. Plašienka et al., 1997, 2019; Lexa et al., 2003; Faryad et al., 2005; Dallmeyer et al., 2008; named as the Rožňava–Šugov Suture Zone by Kozur & Mock, 1997). The Čertovica fault zone has been considered as a kind of an intra-continental suture, from which units of the Fatric cover nappe system were derived (e.g. Biely & Fusán, 1967; Andrusov, 1968; Plašienka, 2003; Prokešová et al., 2012). The narrow but lengthy PKB is a surface expression of the crust-scale boundary between the foreland North European Platform overridden by the EWC accretionary wedge (Flysch Belt) and the Cretaceous thrust stack of the CWC units. At the same time, this boundary represents the suture zone after two branches of the Pennine oceanic realms – the southern Piemont–Váh and northern Valais–Magura oceans (e.g. Plašienka et al., 2020 and references therein).

In this contribution, we are dealing with the Veporic–Gemeric contact zone (abbreviated as VGCZ hereafter), which is another "intracontinental suture" of the CWC in central Slovakia. It surrounds the Lubeník fault that is the eastern branch of the Lubeník–Margecany "Line" representing a fault interface between the Veporic and Gemeric basement-involved superunits. VGCZ is characterized by extensive shortening and complicated internal structure that records the original thrust plane of the Gemeric over Veporic, later affected by important transpressional and extensional reactivation. The deformation processes in this structurally complicated area resulted in a superposition and/or juxtaposition of several units that exhibit complex tectonic and metamorphic relationships. In the following, we present the structural, metamorphic and geochronological data providing some constraints on the VGCZ development. The tectonometamorphic evolution of the investigated area is partitioned into several distinctive stages.

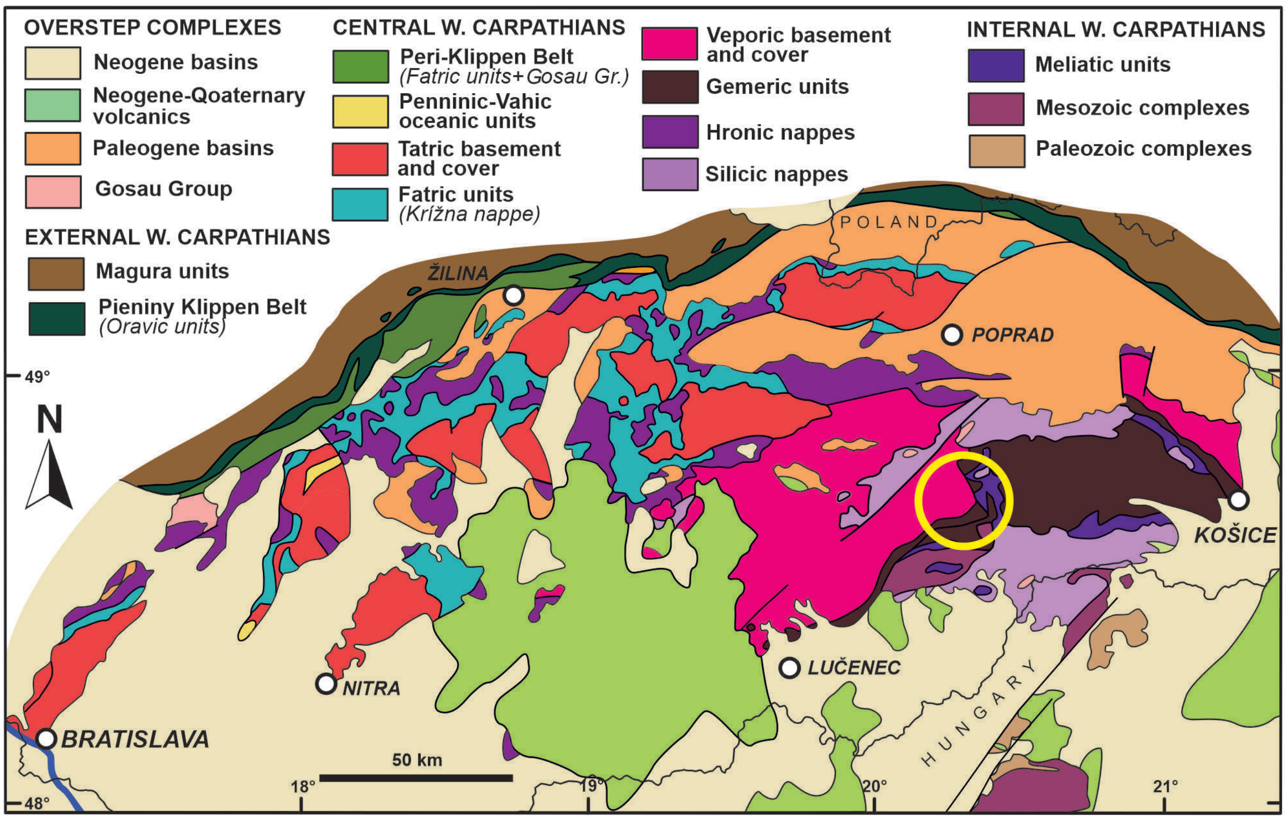



**Fig. 1.** Tectonic sketch map of the Western Carpathians (modified after Plašienka et al., 2019). The circle indicates the investigated area (Fig. 2).

## Geological setting

We investigated about 15 km long and 10 km wide segment of the VGCZ in the NW–SE trending zone that crosses the regional structural trends and follows the valley of Štítnik Brook between Čierna Lehota, Markuška, Honce and Chyžné villages in the eastern part of the Revúcka vrchovina Highland (Fig. 2). This comparatively small region is built up by six juxtaposed or superposed major Western Carpathian tectonic units. The lowermost structural position is occupied by the Veporic basement and cover complexes overridden by the Ochtiná and Volovec units assigned to the Gemeric Superunit, and by tectonic outliers of the Meliatic Bôrka Nappe, as well as the Turňa Unit and Silica Nappe in the southeasternmost part of the region (Fig. 2).

The Veporic Superunit includes the pre-Alpine crystalline basement and the post-Variscan Upper Paleozoic–Triassic sedimentary cover (Revúca Group and Foederata Unit). The Veporic basement is composed of polymetamorphic (Variscan and Alpine) metasediments and scarce metavolcanics (Hladomorná dolina Complex; HDC) intruded by Variscan granitoids of the Vepor pluton (Kráľova hoľa Complex; KHC – cf. Vrána, 1964; Klinec, 1966, 1971). In addition to the polyphase regional metamorphism, the HDC bears also two generations of contact metamorphic assemblages overprinting the regional metamorphic associations. The older medium pressure – high temperature assemblage (Vozárová & Krištín, 1985) is concentrated to exocontacts of the Variscan granitic intrusions with the HDC, typically between Chyžné and Slavošovce villages (Fig. 2). The low pressure-high temperature contact aureole SW of Rochovce village is related to the hidden Upper Cretaceous granitic intrusion (Rochovce granite; Korikovsky et al., 1986; Vozárová, 1990; Poller et al., 2001; Kohút et al., 2013), which was encountered by drilling below the HDC rocks (e.g. Klinec, 1980). Along its southern margin and at the contact with overlying Gemeric units, the HDC is discordantly overlain by clastic deposits of the Permian Rimava Formation forming a part of the South Veporic sedimentary cover (Revúca Group, Vozárová & Vozár, 1988; Vozárová, 1996).

In the area south of the Štítnik Valley, particularly north of Chyžné village (Fig. 2), the KHC granitoids show an intrusion contact into the HDC in the form of sill-like dykes concordant to the metamorphic foliation of the HDC. However, from Slavošovce northwards, the HDC is underlain by the Upper Carboniferous oligomict conglomerates (Háj Hill west of Slavošovce), sandstones and black shales of the Slatviná Formation (Vozárová & Vozár, 1982, 1988; Vozárová, 1996), which are in turn underlain by Permian clastics of the Rimava Formation directly overlying KHC north of Slavošovce (Fig. 2).

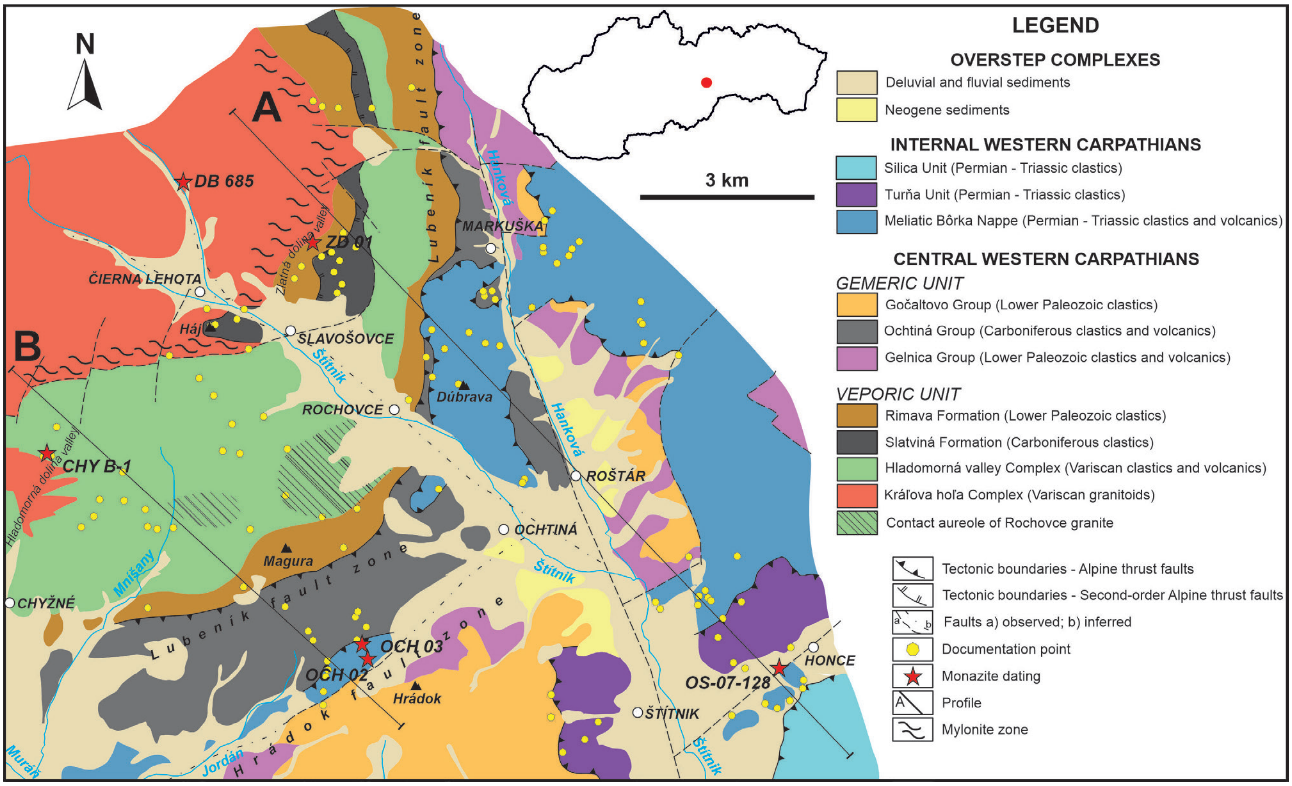



**Fig. 2.** Tectonic map of the investigated area (compiled from maps of Klinec, 1976; Bajaník et al., 1984; Grecula et al., 2009 and from our own observations).

Rocks at the contact of KHC with the Upper Paleozoic cover formations are strongly sheared and accompanied by a mylonitic zone hundreds of metres wide.

In the area north of the Štítnik Valley, the WSW–ENE striking Lubeník fault zone and the parallel regional structural trends are turned to the N–S to NNW–SSE direction. Bedding and metamorphic and mylonitic foliations are gently to moderately east-dipping, while the pervasive stretching lineation remains constantly plunging to the NE to E (Plašienka, 1993; Janák et al., 2001). This structure was known as the "Gemer ramp", i.e. the regional axial plunge of the Veporic below Gemeric units. As a result, the KHC is overlain by a gently east-dipping stack of various units – directly by the Permian cover (Rimava Fm.), next by the Pennsylvanian Slatviná Fm., afterwards by the HDC with the Permian (Rimava Fm.) and further north also Lower Triassic (Lúžna Fm.) cover rocks, and finally by the Gemeric units overlain by the Bôrka Nappe outliers (Fig. 2; 3A). This complicated structure was described as the NW-verging Markuška anticlinal recumbent fold (Zoubek & Snopko, 1954; Zoubek, 1957) with the HDC in its core, or as the Markuška Nappe by Plašienka (1980, 1984). Thanks to the eastward regional axial plunge, structures are obliquely cut by the topography, and interpretation of the cross-sectional morphology of the Markuška fold is enabled in the map view (e.g. Plašienka, 1984).

Along the SW–NE to WSW–ENE trending Lubeník fault zone, rocks of Veporic Rimava Fm. are juxtaposed to the Paleozoic complexes of the Gemeric Superunit. In the direct contact with the Veporic units, the Gemericum is represented by the Ochtiná Unit, which is composed of the Mississippian Ochtiná Group overlain by Pennsylvanian clastics of the Hámor Fm. (e.g. Vozárová, 1996). The Ochtiná Group consists of the Visean Hrádok Formation of flysch-type metasediments interlayered by basic

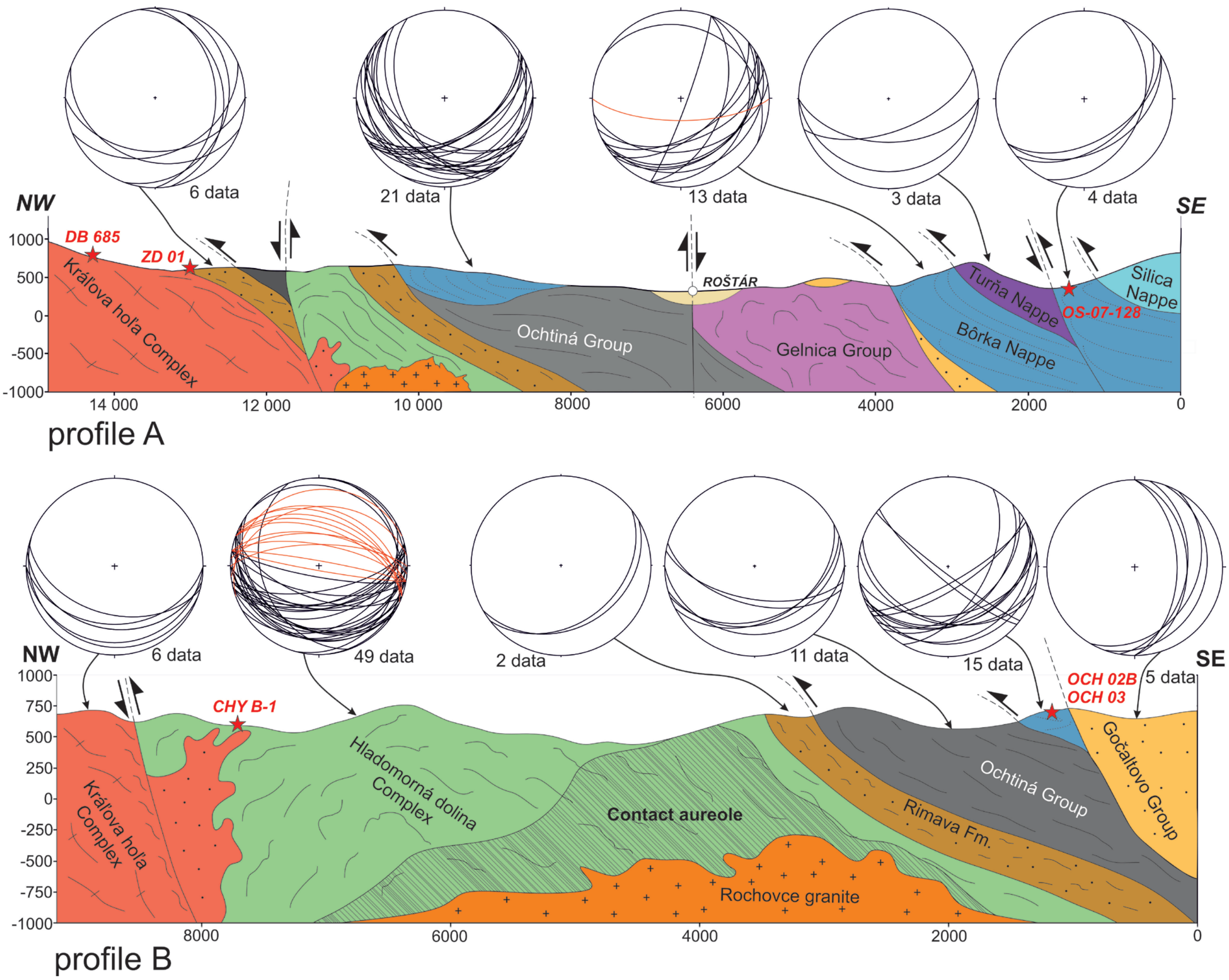



**Fig. 3.** Cross-sections A and B through the investigated area. For their position and legend see Fig. 2. Stereographic plots show orientation of planar structures in different rock complexes (equal area projection, lower hemisphere). Black – the main foliation (sedimentary, metamorphic, mylonitic), red – secondary cleavage.

MORB-type metavolcanics and bodies of ultramafics. The overlying upper Visean–Serpukhovian Lubeník Formation includes black shales, bedded limestones and dolomites and large bodies of metasomatic magnesite (Kozur et al., 1976; Vozárová, 1996).

The Ochtiná Unit is overthrust by the Volovec Unit of the main Gemeric basement-cover thrust sheet represented by the Lower Paleozoic polymetamorphic greenschist-facies volcanosedimentary formations (Gelnica Group) and by the very low-grade Permian clastic metasediments of the Gočaltovo Group (Fig. 2). In several segments of the VGCZ, the Ochtiná Unit is strongly sheared and includes slices from both the footwall Veporic cover and hangingwall Gemeric metabasalts. This was described as a kind of thrust mélange developed along a decoupling zone between the two crustal-scale superunits (Novotná et al., 2015). The boundary of the Ochtiná and Volovec units is formed by the Hrádok fault zone that parallels the Lubeník fault zone in the southern part of the region (Figs 2, 3B). However, continuation of the Ochtiná Unit farther north, after turning of the Lubeník Line to the N–S direction is controversial. In the majority of published maps, various Carboniferous formations between Roštár and Markuška villages (Fig. 2) are assigned to the Zlatník and/or Hámor formations of the North Gemeric Dobšiná Group (e.g. Bajaník et al., 1984). On the other hand, Grecula et al. (2009) classified these rocks as the Hrádok Formation of the Ochtiná Group. We share the latter view in Fig. 2.

The Gemeric Volovec Unit is overridden by the Meliatic Superunit formed by the Bôrka Nappe (Leško & Varga, 1980; Mello et al., 1998) in the investigated area. According to the lithostratigraphic classification of Mello et al. (1998), the Bôrka Nappe includes the lower complex composed of Permian to Lower Triassic continental clastic metasediments with acid metavolcanics that are lithologically correlative with the underlying Gemeric cover formations. The upper complex, which is in part structurally independent, involves the Middle Triassic metacarbonates with intercalations of metabasalts and metavolcaniclastics (Dúbrava Formation) followed by a thick complex of dark-grey phyllites with metasandstone beds and olistostrome bodies of probably Upper Triassic to Lower–Middle Jurassic? age (Hačava Formation).

In the investigated area, rock formations affiliated with the upper complex of the Bôrka Nappe occur as narrow slices within the Hrádok fault zone between the Ochtiná and Volovec units. The Bôrka Nappe covers a comparatively large area on the wide ridge north of Honce village (Fig. 2). This occurrence includes both the lower and upper complexes of the Bôrka Nappe within a N–S trending complex synform known as the Nižná Slaná depression (e.g. Németh, 1994). However, the presence of the Bôrka Nappe on Dúbrava Hill north of Ochtiná (Fig. 2) is disputable. Classified originally as the Upper Carboniferous Dúbrava beds of the Ochtiná Group (e.g. Abonyi, 1971), and assigned to the Gemeric Carboniferous strata also later (Gazdačko, 1995), this occurrence was reinterpreted as the type locality of the Middle Triassic Dúbrava Fm. of the Bôrka Nappe by Mello et al. (1998) afterwards. This interpretation is maintained in the majority of published geological and tectonic maps, except that of Grecula et al. (2009). We have not paid a special attention to this problem yet, but we take on the generally accepted affiliation of the Dúbrava Fm. with the Bôrka Nappe in Fig. 2.

The majority of the Bôrka Nappe rocks underwent the Late Jurassic blueschist-facies metamorphism which was often subsequently affected by the Cretaceous greenschist-facies retrogression (e.g. Faryad & Henjes-Kunst, 1997; Faryad & Hoinkes, 1999; Dallmeyer et al., 2008; Plašienka et al., 2019; Putiš et al., 2019; Nemec et al., 2020). Farther south, the Meliaticum includes also a very low-grade Jurassic syn-orogenic flysch succession with huge olistostrome bodies (Meliata Unit s.s.; Mock et al., 1998; Árkai et al., 2003). Meliatic complexes are always tightly imbricated and form a combined accretionary complex with the overlying Turňa Unit represented by a system of partial nappes and duplexes consisting of low-grade Carboniferous to Triassic metasediments (Lačný et al., 2016). The Silica Nappe is the structurally highest unit of the region, which overlies the Meliatic–Turnaic accretionary complex with a pronounced structural and metamorphic discordance (Reichwalder, 1982). It is composed of the Lower Triassic clastic formations and the thick Middle–Upper Triassic carbonate platform complex.

## Methods

Several methodological procedures were applied during the field research of the investigated area and the subsequent laboratory processing of the obtained data and samples. Field works were focused on structural mapping and sampling. In the laboratory, investigations continued with orientation analysis of measured data and petrographic microanalyses of samples in thin-sections. Several potential samples were selected for microprobe determination of minerals and EMPA dating of monazites.

During the field works, altogether 116 outcrops were documented (Fig. 2), 277 samples (25 oriented) were collected and petrographically described. Structural observations included gathering of oriented data of mesoscopic elements like metamorphic foliation, cleavage, shear zones, joints and folds. The Stereonet software (Cardozo & Allmendinger, 2013) was used for the evaluation of structural data, which are stored in a database for further analyses. Herein, some of the oriented structural data are plotted in the stereographic equal area projection on the lower hemisphere.

Thin-sections from all rock types were subjected to petrological study under the polarized microscope (295 thin sections) and electronic microanalyzer (152 thin sections) to obtain data about the lithology, metamorphism and microstructures. Localities of representative samples referred to in the text and figures are given in Table 1.

Several samples that contain metamorphic monazites were dated by the EMPA method providing crystallization ages using the CAMECA SX-100 electronic microanalyzer at the Laboratory of electron microanalysis of the State Geological Institute of Dionýz Štúr, which specializes in non-destructive microanalysis of solids and image analysis of samples. The chosen method is based on the accurate determination of the content of Th, U and Pb (CHIME – chemical Th-U-total Pb isochron method) in monazites and other proper minerals like xenotime and zircon. Owing to several factors, monazite is the most suitable candidate for this method (e.g. Sulovský et al., 2004). Statistical approach of Montel et al. (1996) was applied for determination of the resulting age and the DAMON program was used for the age recalculations, histograms and isochron plots (Konečný et al., 2004).

## Results

### Structural observations and metamorphic petrography

The structural relationships of the Veporic–Gemeric–Meliatic–Turnaic thrust stack are described along two subparallel, NW–SE trending profile lines in the studied area (Fig. 3A, B). The first profile A is located NE of the Štítnik Valley, where it crosses units of the Veporicum (KHC, HDC, Rimava Fm.), Gemericum (Ochtiná, Gelnica and Gočaltovo groups), Meliaticum (Bôrka Nappe), Turnaicum and Silicicum. The second profile (B in Fig. 3) follows the mountain ridge between the Štítnik and Muráň river valleys and includes from NW to SE the Veporic (KHC, HDC, Rimava Formation), Gemeric (Ochtiná and Gočaltovo groups) and Meliatic units (Bôrka Nappe). The cross-sections A and B are supplemented by structural diagrams showing orientation of the macroscopically

**Tab. 1**
Locations of samples cited in the text and figures.

| NAME | UNIT | GPS |
|---|---|---|
| HR 01 | Bôrka Nappe | 48.6597914N 20.2853714E |
| HR 09 | Bôrka Nappe | 48.6646808N 20.2861653E |
| OCH 02 | Bôrka Nappe | 48.6653611N 20.2932892E |
| OCH 03 | Bôrka Nappe | 48.6673878N 20.2928386E |
| OS-07-128 | Bôrka Nappe | 48.6631361N 20.3943119E |
| HR 06 | Gemeric – Ochtiná Gr. | 48.6732967N 20.2760158E |
| HR 08 | Gemeric – Ochtiná Gr. | 48.6675578N 20.2832472E |
| OCH 05 | Gemeric – Ochtiná Gr. | 48.6701086N 20.2952206E |
| CHY B-1 | Veporic – HDC | 48.6963358N 20.2192642E |
| HÁJ 02 | Veporic – HDC | 48.7138764N 20.2675186E |
| SLV 01 | Veporic – HDC | 48.7032283N 20.2703081E |
| SLV 02 | Veporic – HDC | 48.7019114N 20.2634417E |
| SLV 03 | Veporic – HDC | 48.6985972N 20.2622186E |
| SLV 04 | Veporic – HDC | 48.6972236N 20.2647936E |
| SLV 05 | Veporic – HDC | 48.6903825N 20.2762519E |
| HÁJ 01 | Veporic – mylonite | 48.7186758N 20.2633344E |
| HÁJ 04 | Veporic – mylonite | 48.7202897N 20.2654586E |
| HAN 01 | Veporic – mylonite | 48.7526267N 20.2824747E |
| ZD 01 | Veporic – mylonite | 48.7311464N 20.2821528E |
| OCH 01 | Veporic – Rimava Fm. | 48.6828886N 20.2904139E |
| SLV 08 | Veporic – Rimava Fm. | 48.6881728N 20.2923667E |
| DB 685 | Veporic – skarnoid | 48.7399772N 20.2513825E |

observed foliation planes. These are genetically different, however, since they include both the primary planar structures like bedding in sediments, which is commonly parallel to the superimposed metamorphic schistosity, and secondary deformation-related cleavages and mylonitic foliations. Nevertheless, attitudes of all foliation planes are generally subparallel (with the exception of HDC) and together with boundaries of major tectonic units they define the regional structural pattern and principal trends of the Alpine tectonic edifice of the area.

Structural data gathered from the HDC were collected at numerous surface exposures (Fig. 2). In most cases, the Variscan metamorphic foliation is only weakly affected by Alpine reworking, which is concentrated in narrow mylonite or phyllonite zones. Measured planar structures can be separated into two groups with different attitudes. The primary metamorphic foliation is gently SSW-dipping, while the superimposed cleavage is moderately NNE-dipping (cross-section B in Fig. 3). Nevertheless, both foliations appear to be pre-Alpine.

In general, majority of the measured metamorphic foliation planes outside HDC show moderate dips to the SE, which is correlated with the main Alpine tectonic stages. Alpine metamorphic foliation planes in the Rimava Fm. are parallel to moderately SE-dipping bedding planes (Fig. 3). Structural data from the Ochtiná Group, taken from the ridge between Hrádok and Magura hills (Fig. 3B), show a similar orientation. The same applies to the Bôrka Nappe.

The dip direction data of metamorphic foliations from HDC are clearly oblique to the Alpine foliations measured in the adjacent post-Variscan units, as they show the overall dip direction to the SW to S. This different orientation is considered to be inherited from the pre-Alpine period, as it is indicated also by their exploitation by the Variscan granitoid sills near Chyžné village (Fig. 2).

The HDC includes different types of metasediments (phyllites and gneisses) and basic metavolcanic rocks in the study area. Characteristic feature of metasediments is a very fine-grained matrix composed of garnet, chlorite, biotite, muscovite, quartz, plagioclase ± tourmaline, opaque minerals, monazite and zircon (Fig. 4). Contact metamorphism related to the underlying Rochovce granite intrusion produced porphyroblasts of garnet, biotite, cordierite and andalusite superimposed on the older regional metamorphic paragenesis.

Metabasites of the HDC are massive, medium-grained, grey-green rocks consisting of amphibole, epidote, chlorite and plagioclase, ± apatite, titanite and opaque minerals (Fig. 4C). Contact metamorphosed metabasites are affect by widespread biotitization, older amphibole is often replaced by younger actinolite.

Microstructural observations in thin-sections were performed along with their relationships to the newly-

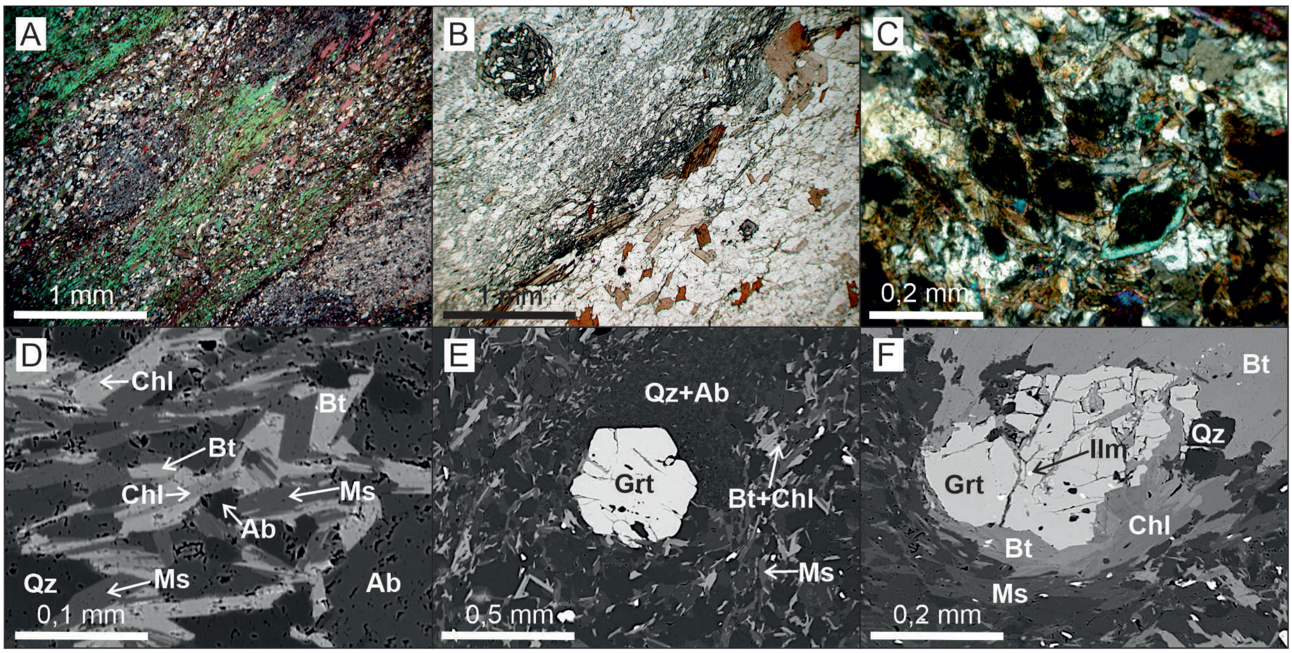



**Fig. 4.** Veporic basement – Hladomorná dolina Complex: A – photomicrograph of contact metamorphosed cordierite-biotitic gneiss (sample SLV 05) in polarized light; B – photomicrograph of muscovite-biotitic gneiss with garnet and well-preserved variable grain-size of the protolith (HÁJ 02); C – photomicrograph of metabasite – epidote amphibolite (SLV 03) in polarized light; D – electron backscattered (BSE) images of fine-grained matrix of garnet-biotitic gneiss (SLV 01); E – BSE image of garnet porphyroblast in a fine-grained matrix (SLV 04); F – BSE image of garnet porphyroblast replaced by biotite and chlorite (SLV 02).

formed metamorphic minerals. In phyllites and gneisses of the HDC, the foliation is defined by alignment of fine-grained aggregate of phyllosilicates in the groundmass, occasionally also by abrupt grain-size changes that might indicate lithological variations of the protolith (Fig. 4B). Growth of porphyroblasts was either syn- or post-kinematic. The first case is documented by Fig. 5B. The garnet porphyroblast contains inclusion trails depicting helicitic microfolds (Fig. 4B). Similar microfolds are present at the contact of the fine- and coarse-grained domains in the thin-section. Since the garnet blastesis is interpreted as generated by intrusion of the Variscan granitoids into HDC, these relationships indicate that this intrusion was syn-kinematic. The different example is shown in Fig. 4A. Large porphyroblasts of cordierite overgrow the gneissic foliation shaped by alignment of fine-grained micas, which also form numerous inclusions in porphyroblasts with the same orientation. Hence the cordierite porphyroblasts grew post-kinematically. Their relationship to the contact aureole of the hidden Rochovce granite, independently from its known Cretaceous age, reveals its post-tectonic intrusion related to the final phases of Alpine tectonic evolution of the area under consideration.

The greenschist-facies Rimava Formation consists of light coloured, medium- to fine-grained siliciclastic metasediments, as well as acidic metavolcanites and metavolcaniclastics (Fig. 5). They are composed of fine-grained, strongly sheared matrix (sericite, quartz, albite, biotite, zircon, tourmaline, xenotime ± opaque minerals) and recrystallized quartz clasts. Fe-oxides are often concentrated along the foliation planes.

Clastic metasediments and metavolcaniclastics of the Permian Rimava Fm. are characterized by distinct foliation formed by thin anastomosing seams and orientation of fine-grained mica-quartz aggregate (Fig. 5). The seams are composed of a dark aphanitic matter that most likely represents an insoluble residue after pressure solution processes. Quartz porphyroclasts show undulose extinction and incipient dynamic recrystallization by low-T grain boundary migration (bulging). Post-kinematic tourmaline overgrows the matrix foliation. These features point to deformation at the low-grade metamorphic conditions during the Alpine orogenesis.

The Ochtiná Group is represented by metaconglomerates, different types of phyllites and metabasalts (Fig. 6). Phyllites are grey to dark grey, fine-grained rocks. They are composed of variable quantities of chlorite, sericite, albite, quartz, garnet and organic matter indicating the greenschist-facies metamorphic conditions. Parallel texture (alternation of layers with different grains size) is common. Grey and grey-green metabasites are characterized by massive and parallel texture. Their greenschist-facies mineral composition includes amphibole, chlorite and epidote. Two generations of amphiboles were detected – older in the cores of porphyroblasts and younger in the rims. Additional minerals are represented by titanite, albite, quartz and opaques. Metaconglomerates have a coarse-grained texture with lithoclasts of quartz and various schists.

Phyllitic black schists of the Ochtiná Group exhibit a pervasive foliation shaped by the uniform orientation of very fine-grained sericite and chlorite. Foliation is enhanced by pressure solution seams enriched in black insoluble material including carbonaceous matter, which separate microlithons augmented by fine-grained quartz (Fig. 6A).

In the investigated area, composition of Triassic–Jurassic rocks of the Bôrka Nappe includes alternating slices of metacarbonates, metabasites and chlorite-sericite phyllites (Dúbrava and Hačava formations; Fig. 7). Metacarbonates – calcite marbles are usually massive, coarse-grained and equigranular and only locally they exhibit compositional layering (Fig. 7A). Indistinct darker thin layers are enriched in quartz, albite, sericite and chlorite (Fig. 7F).

Chlorite, amphibole and epidote dominate in the greenschist-facies metabasites. Metabasites, mostly metavolcaniclastics, also show compositional layering with alternation of microlayers dominated either by epidote and amphibole or by chlorite (Fig. 7B). Ružička

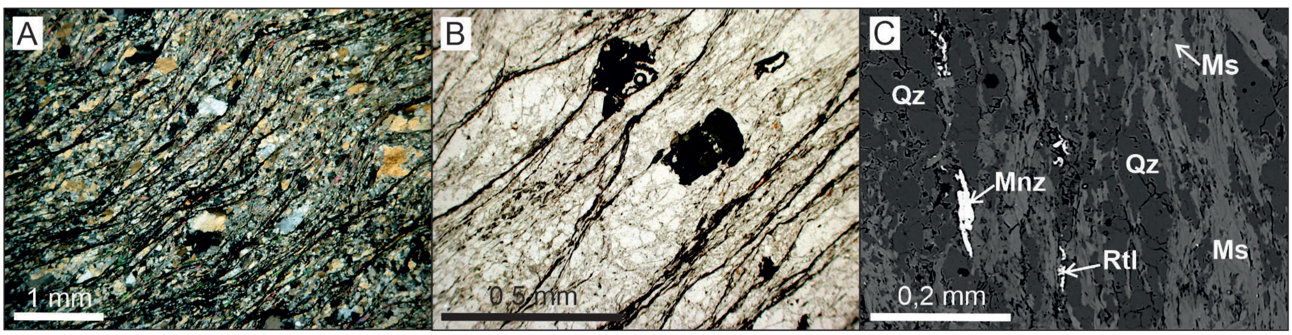



**Fig. 5.** Rimava Formation of the Permian Veporic cover: A – photomicrograph of acid metavolcaniclasics (SLV 08A) in polarized light; B – photomicrograph of acid metavolcaniclasics (SLV 08C); C – electron backscattered (BSE) images of acid metavolcaniclasics (OCH 01-1).

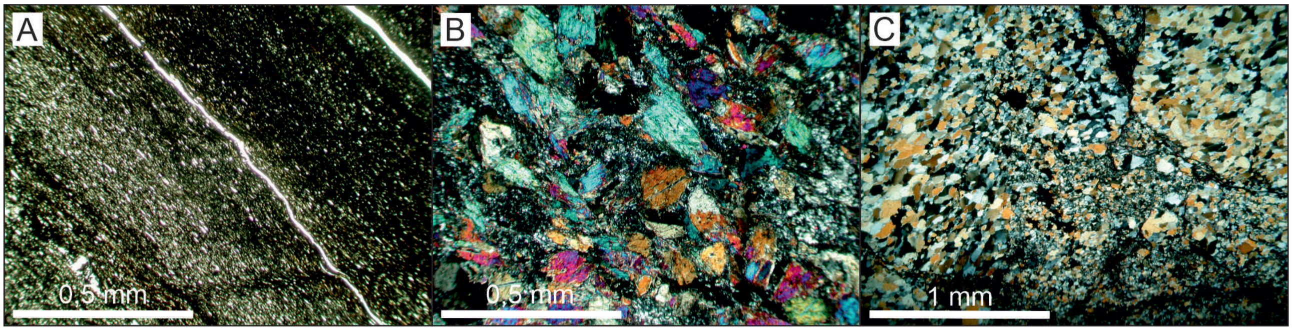



**Fig. 6.** Photomicrographs of rocks of the Gemeric Ochtiná Group: A – graphite-sericite phyllite with very fine-grained matrix (OCH 05-1); B – metabasite with massive texture – metadolerite (HR 08-1) in polarized light; C – metaconglomerate (HR 06-1) in polarized light.

et al. (2019) reported presence of Mg-rich actinolite to tremolite, epidote, titanite, albite and Fe-apatite in metabasites and Mg-rich talc associated with clinochlore in marbles.

Phyllitic schists of the Bôrka Nappe are composed mainly of sericite, paragonite, chlorite, chloritoid, albite and quartz (Fig. 7C–E). Chlorite pseudomorphs after glaucophane are present at the Honce locality. Microstructural investigation of thin-sections from the Hrádok locality revealed that the macroscopically penetrative schistosity is in fact transposition cleavage produced by layer-parallel shortening of pre-existing metamorphic planar structure (Fig. 7E, F). Isoclinal, often rootless intrafolial microfolds partly preserve the original structure and composition (quartz, albite, muscovite, chlorite) in the hinge zones of microfolds, while the fold limbs are strongly compressed with a reduced recrystallized grain size and alignment of phyllosilicates parallel to the new cleavage domains.

In addition, we have studied the mylonitic shear zone that follows approximately the contact of the Veporic basement and cover complexes, especially in the area where SW–NE contact zone turns to the N–S direction near Slavošovce village. The pre-Alpine granitoids (KHC), various Variscan and Alpine polymetamorphic rocks and clastic cover sediments, which were the parental rocks, exhibit a different degree of mylonitization from protomylonites (low degree) to ultramylonites (highest

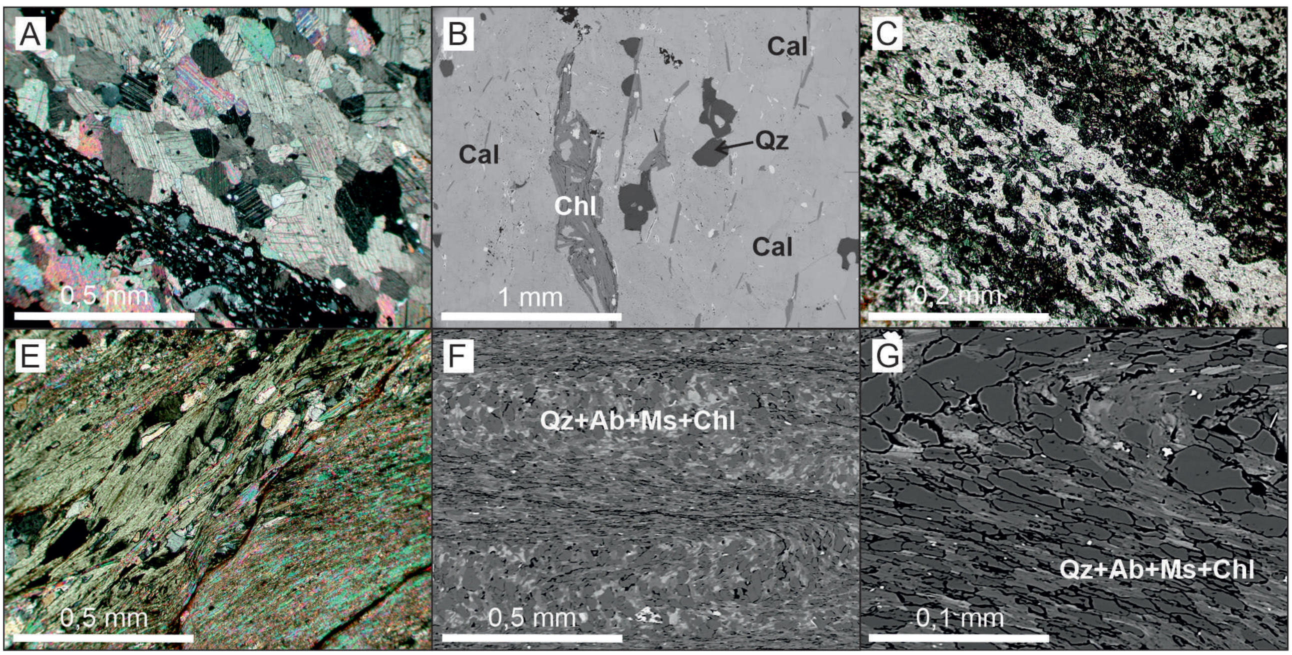



**Fig. 7.** Bôrka Nappe: A – photomicrograph of alternation of fine-grained chloritic phyllites and coarser-grained metacarbonates (HR 09-1) in polarized light; B – BSE image of marble with mineral impurities of quartz and chlorite (HR 09-1). C – photomicrograph of alternation of bands with predominance of quartz, albite and carbonate (lighter) and chlorite, epidote and actinolite (darker) (HR 01-1); D – photomicrograph of fine-grained sericite-chloritic phyllite (OCH 02B); E – electron backscattered (BSE) image of very fine-grained sericitic phyllite (OCH 03-5); F – detail of E.

degree). Partially preserved primary mineral composition of parental rocks can be observed in protomylonites (Fig. 8A), specifically in part sericitized and albitized K-feldspars (100–200 μm), muscovites and ilmenites (100 μm). Matrix of protomylonites forms 10–50 % of rock composition and includes mainly quartz, sericite, chlorite, biotite and albite. Zircon, ilmenite, rutile, apatite, allanite, xenotime, monazite and Fe-oxides are the less represented phases.

Mesomylonites (Fig. 8B, C) represent a medium degree of mylonitization and contain 50–90 % of matrix. In the mesomylonites, we observed significantly deformed relicts of K-feldspar, ilmenite, rutile and two generations of monazite.

Ultramylonites (Fig. 8E, D) represent the highest degree of mylonitization and show a penetrative foliation with typical dark-grey or black colour and more than 90 % of matrix. Mineral composition of the matrix includes very fine-grained chlorite, biotite, quartz, albite, sericite, paragonite, apatite, rutile, ilmenite and Fe-oxides with less amount of zircon, xenotime and monazite. The dark colour of the ultramylonites is caused by sub-microscopic chlorite, quartz and ore minerals (< 5 μm).

### *Monazite dating*

The first set of monazite age data come from rock complexes occurring along the A profile line (Fig. 2). We investigated composition of a skarnoid body occurring within the Variscan granitoids of KHC near Čierna Lehota village (Figs 2, 3A). The mineral composition is dominated by garnet, biotite and ore minerals, other common minerals include amphibole (grunerite-cummingtonite series), ilmenite, apatite, chlorite, muscovite, albite, K-feldspar, quartz and accessories like allanite, rutile and two generations of monazite (Fig. 9).

The older monazites Mnz1 show a rounded habitus, dimensions from 10 μm to 30 μm and always form inclusions in garnets. EMPA dating of Mnz1 revealed the Devonian–Carboniferous boundary ages (359 ± 4.2 Ma). The younger monazite generation (Mnz2) occurs permanently out of the garnets, most commonly in biotite or quartz. Mnz2 have a dendritic, strongly irregular habitus and are present in layers 30 μm to 100 μm thick along with older allanite. Mnz2 has the early Late Cretaceous age of 92 ± 7.2 Ma (Fig. 9).

Two generations of monazites were identified also in the protomylonitic granite of the KHC from the Zlatná dolina Valley NE of Slavošovce (Figs 2, 10). Older monazites Mnz1 are located in domains preserving the primary granitic fabric and have dimensions from 100 μm to 50 μm (Fig. 10A, B). Their crystallization age is approximately 355 Ma. The younger, smaller (±10 μm; Fig. 10C, D) monazites are restricted to the Alpine mylonitic foliation planes and provided ages around 110 Ma.

We obtained other two distinct monazite age groups from the mylonitic granite and garnet-biotite gneiss located at the contact of KHC and HDC NE of Chyžné

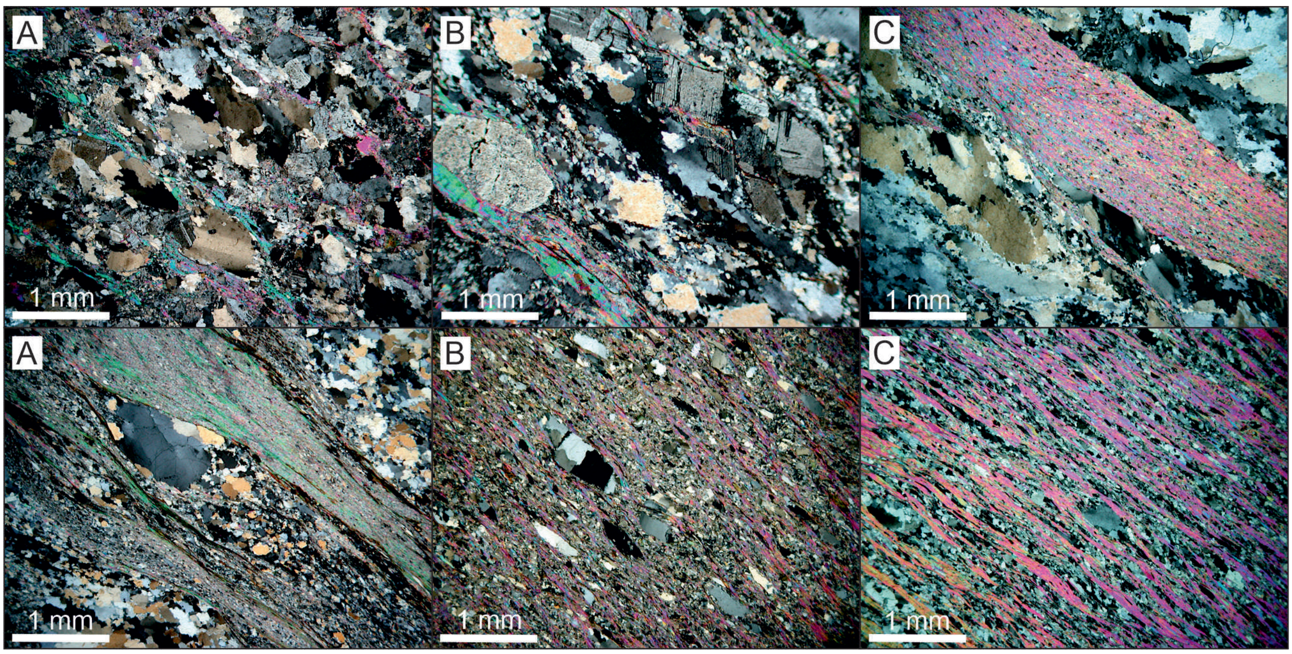



**Fig. 8.** Photomicrographs documenting development of mylonitization in granitoids: A – protomylonite (sample ZD 01); B – protomylonite (HÁJ 04); C – mesomylonite (HÁJ 01E); D – mesomylonite (HÁJ 04); E – ultramylonite (HÁJ 01A); F – ultramylonite (HAN 01C). Mylonitic foliation is defined by relic mica porphyroclasts and fine-grained sericite formed by breakdown of feldspars. Crossed polars in all images.

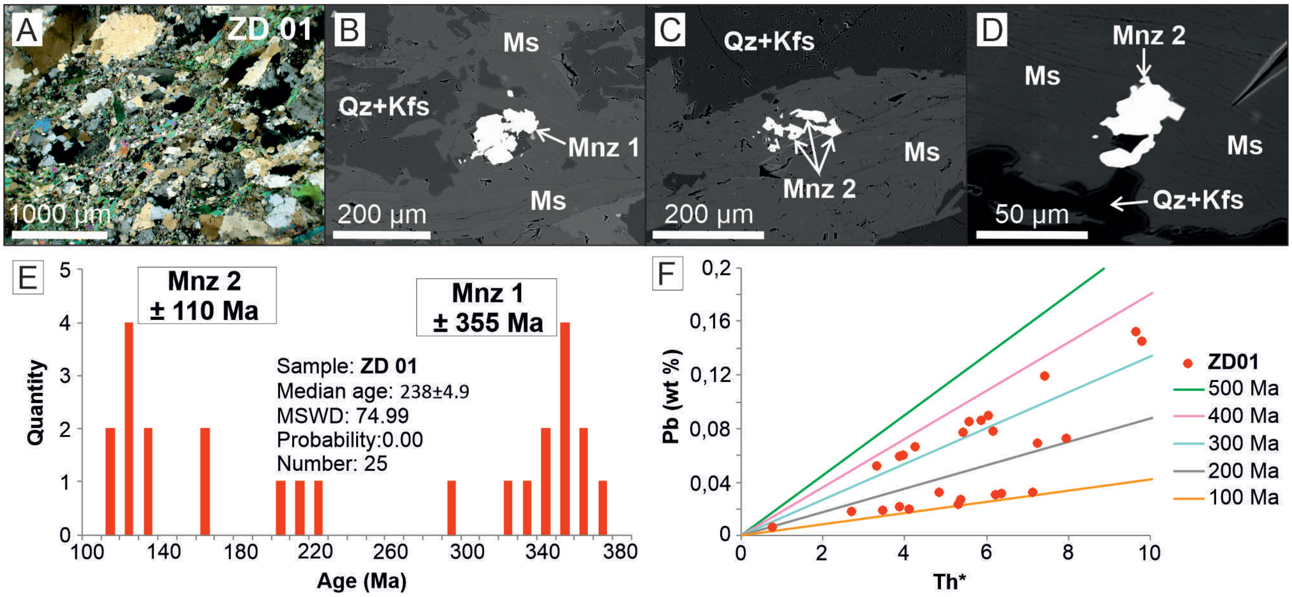



**Fig. 9.** Results of chemical (EMPA) U-Th-Pb dating of monazites from skarnoid body of the Veporic basement – Čierna Lehota locality (DB 685): A – photomicrograph of garnetiferous skarnoid; B – BSE image of older monazite Mnz1 occurring as inclusion in garnet; C – BSE image of younger monazite Mnz2 associated with biotite and muscovite; D – BSE image of younger dendritic monazites Mnz2; E – histogram with resultant 2 monazites ages groups; F – Pb vs. Th* (wt %) age monazite isochron diagram (Th* = Th + 3.15 wt %).

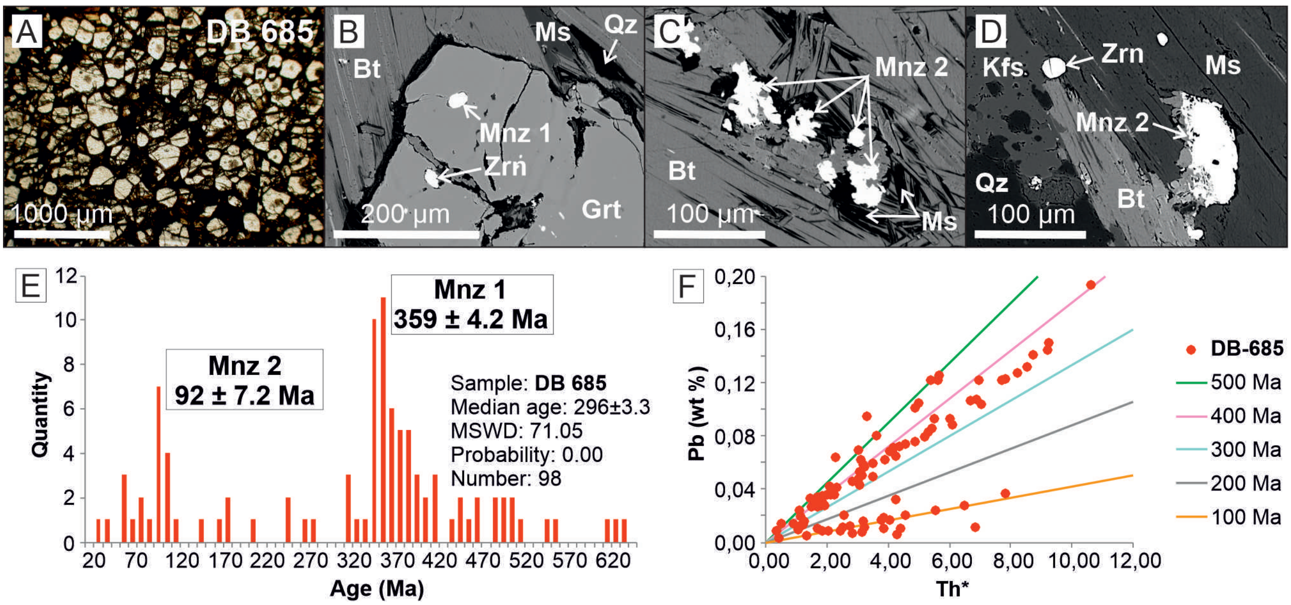



**Fig. 10.** Results of chemical (EMPA) U-Th-Pb dating of monazites from granite mylonite of the Veporic basement at Slavošovce – Zlatná dolina (sample ZD 01): A – photomicrograph of characteristic protomylonitic texture; B – BSE images of older monazites Mnz1 in relics of former granite; C and D – BSE image of younger monazite Mnz2 in deformed domains; E – histogram with resultant 2 monazites ages groups; F – Pb vs. Th* (wt %) monazite isochron age diagram (Th* = Th + 3.15 wt %).

village (cross-section B in Fig. 2). Older monazite ages (around 355) Ma were obtained from the mylonitic granite, while younger monazite with ages around 88 Ma were identified in the garnet-biotite gneiss (Fig. 11). An analogous monazite age 88 Ma was obtained from the metamorphosed cordierite-biotite gneiss (HDC) near the contact with the Permian Rimava Fm. NE of Magura Hill.

Two other, but different monazite age groups were acquired also from sericite-chlorite phyllites of the Bôrka Nappe (locality Hrádok, 5 km south of Slavošovce; Figs

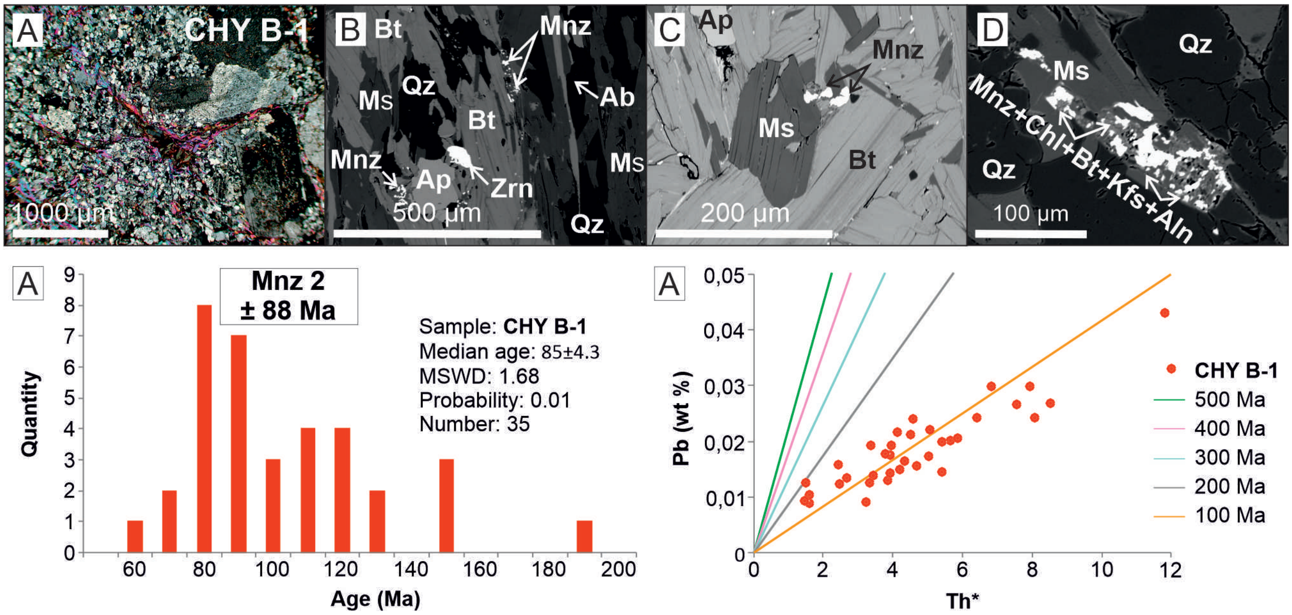



**Fig. 11.** Results of chemical (EMPA) U-Th-Pb dating of monazites from muscovite-biotite gneiss with garnet at Chyžné – Hladomorná dolina (sample CHY B-1): A – photomicrograph of gneissic structure, crossed polars; B – D BSE images of monazite appearance; E – histogram of measured ages; F – Pb vs. Th* (wt %) monazite isochron plot (Th* = Th + 3.15 wt %).

2 and 12). These monazites are very fine-grained (below 30 µm, frequently below 15 µm). EMPA dating of the sample OCH 02B provided two different age groups: 139 ± 13 Ma and 97 ± 5 Ma; the other sample OCH 03 gave 151 ± 5 Ma and 103 ± 4 Ma. Older monazites Mnz1 occur in the coarser-grained microlithons (Fig. 12B) and younger monazites Mnz2 are always present as elongated grains aligned within the very fine-grained cleavage domains transposing older metamorphic layering (Fig. 12C and D).

Further on, numerous post-kinematic idiomorphic porphyroblasts of monazites (30–500 µm in size) were observed in the sericite-chlorite phyllites of the Bôrka Nappe (locality Honce, 10 km SE of Slavošovce; Fig. 13). Monazites show a typical oscillation zonation which is reflected in their chemical composition. The EMPA dating of these monazites provided two, but rather indistinct age groups again: (1) 147 ± 17 Ma and (2) 89 ± 18 Ma.

## Discussion

### *Monazite age data*

In general, three age groups were encountered by the EMPA-CHIME dating of monazites. The first Group 1 is restricted to the Variscan granitoids of the Veporic basement (KHC) and products of its contact metamorphic-metasomatic transformation of neighbouring rocks. The Group 1 is represented by the Mnz1 from the skarnoid body 359 ± 4.2 Ma and Mnz1 from mylonitized granitoids at the contact with the post-Variscan cover sediments that yielded the age of approximately 355 Ma. These data are interpreted as the intrusion age of the KHC granitoids in the Slavošovce area.

The second Group 2 of ages was detected only in rocks of the Meliatic Bôrka Nappe. Mnz1 generation from the Hrádok locality provided ages 139 ± 13 Ma and 151 ± 5 Ma, Mnz1 from Honce yielded 147 ± 17 Ma. These ca 150–140 Ma ages (Tithonian–Berriasian) are slightly younger than those of the peak blueschist-facies metamorphic assemblages between 170 and 150 Ma (Oxfordian–Kimmeridgian) reported from the Bôrka Nappe by Maluski et al. (1993), Faryad and Henjes-Kunst (1997) and Dallmeyer et al. (2005, 2008). The latest Jurassic – earliest Cretaceous ages were interpreted as having been related to the post-subduction collisional exhumation of the Bôrka Nappe and its thrusting over the Gemeric units (Plašienka et al., 2019).

The third Group 3 of monazite ages was detected in all analysed rock complexes. They are revealed by Mnz2 data from the Veporic skarnoid and mylonitized granitoids (92 ± 7.2 and about 110 Ma, respectively), monazites from the HDC gneisses (ca 88 Ma) and by Mnz2 from localities of the Bôrka Nappe (97 ± 5, 103 ± 4 and 89 ± 18 Ma). Generally, the early Upper Cretaceous ages roughly between 110 and 85 Ma (Albian–Santonian) correspond to the thrust stacking stage and maximum burial of the Veporic metamorphic complex, which was followed by its exhumation related to the shortening along the outer Veporic margin and underthrusting of the Veporic thrust wedge by the Tatric-Fatric crustal sheet (Janák et al., 2001; Dallmeyer et al., 2005; Jeřábek et al., 2012; Plašienka, 2018).

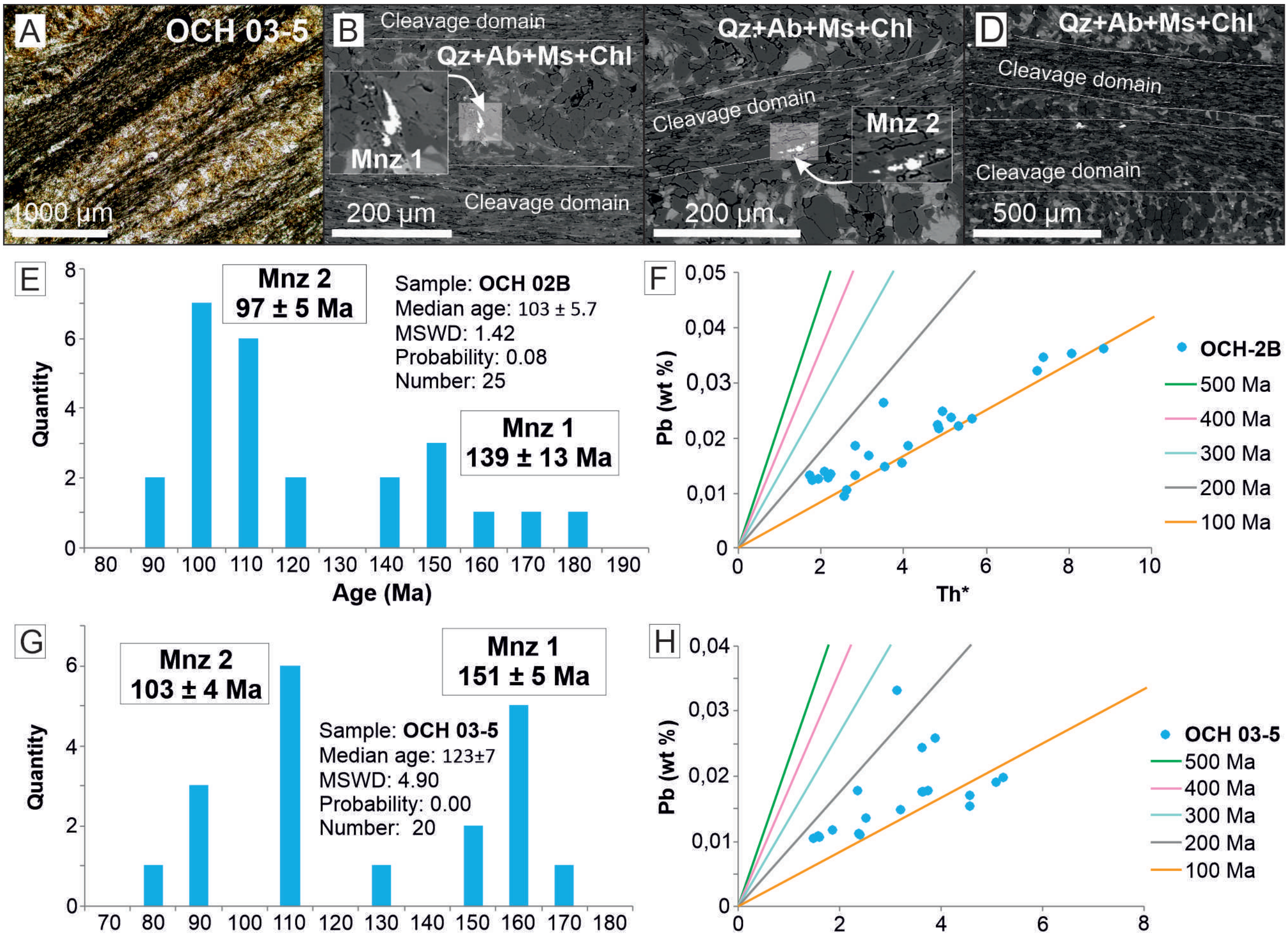



**Fig. 12.** Results of chemical (EMPA) U-Th-Pb dating of monazites from sericite-chlorite phyllite of the Bôrka Nappe – Hrádok locality (samples OCH 02B and OCH 03): A – photomicrograph of compositional layering of phyllite; B – BSE image of older monazite Mnz1; C and D – BSE images of elongated monazite grains Mnz2 occurring within the cleavage domain; E – histogram with resultant 2 monazites ages groups from the OCH 02B sample (adapted from Plašienka et al., 2019); F – Pb vs. Th* (wt %) monazite age isochron diagram of the OCH 02B sample (Th* = Th + 3.15 wt %). G – histogram with resultant 2 monazites ages groups from the OCH 03 sample; H – Pb vs. Th* (wt %) monazite age isochron diagram of the OCH 03 sample (Th* = Th + 3.15 wt %).

Due to a low content of radiogenic elements in monazites from the Bôrka Nappe, the gathered age data display a comparatively large scatter. Nevertheless, the textural relationships of the monazite growth to microstructures the host phyllites suggest some significant conclusions. Two monazite generations from the Hrádok samples clearly show their different relations to the microstructures – older Mnz1 is preserved in the equigranular and coarser-grained microlithons with indistinct foliation forming cores of isoclinal microfolds, where it grew together with other peak metamorphic minerals. On the other hand, younger Mnz2 are restricted to the fine-grained, pervasively foliated lithons that formed by strong compression and reduction of microfold limbs (Fig. 12). Therefore, the obtained age data are interpreted as directly dating distinct tectonic events – the Group 2 monazite ages 150–140 Ma likely indicate the first phases of exhumation of the Bôrka rocks from the subduction channel and their subsequent thrusting over the Gemeric units. The Group 3 monazites Mnz2 that yielded ages around 100–90 Ma provide dating of a compressional event connected with commencement of the sinistral transpressional activity within VGCZ along the Lubeník and Hrádok fault zones (e.g. Lexa et al., 2003; Novotná et al., 2015).

Monazites from the Honce locality show a very different depiction. Allocation into two age groups is less pronounced, almost indistinct. Monazites form large, oscillatory zoned idiomorphic crystals overgrowing the pre-existing planar fabric with numerous inclusions of older mineral phases. These features would indicate a long-termed monazite growth, possibly over tens of Myr, in the "post-tectonic", kinematically stable conditions. However, decreasing Th content in zoned crystals and some retrograde recrystallization (pseudomorphs of

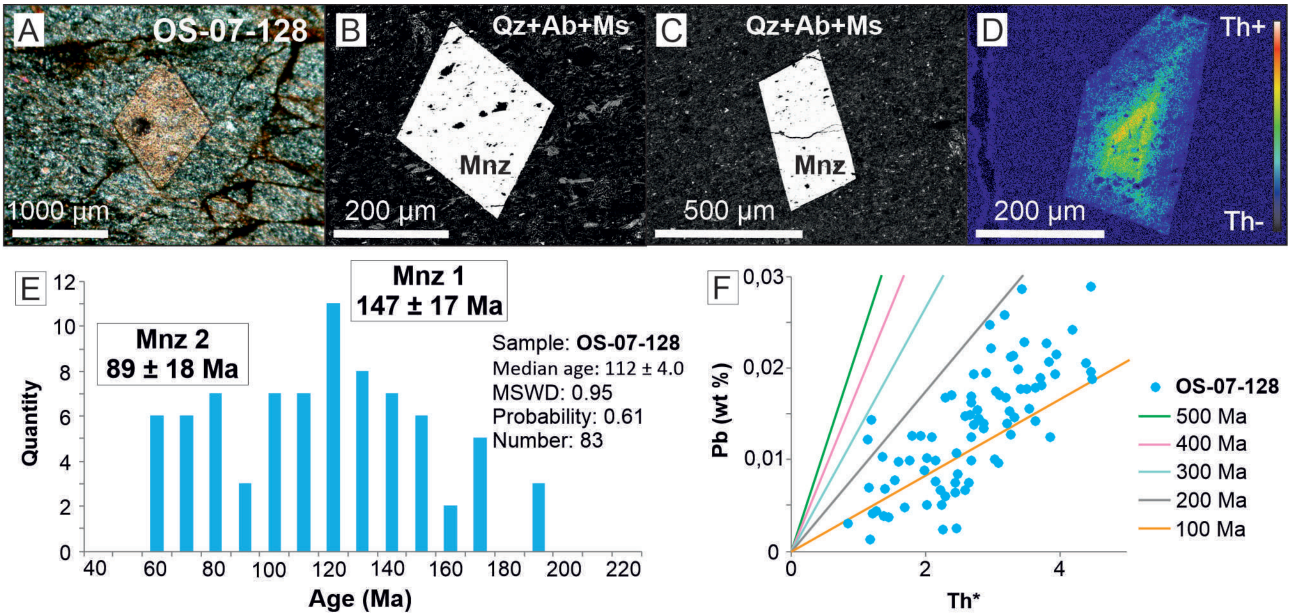



**Fig. 13.** Results of chemical (EMPA) U-Th-Pb dating of monazites from sericite-chlorite phyllite of the Bôrka Nappe – Honce locality (OS-17-128): A – photomicrograph of a big monazite porphyroblast; B and C – electron backscattered (BSE) images of idiomorphic monazites in very fine-grained matrix; D – X-ray compositional map of thorium content in monazite; E – histogram with resultant 2 monazites ages groups (adapted from Plašienka et al., 2019); F – Pb vs. Th* (wt %) age monazite isochron diagram (Th* = Th + 3.15 wt %).

chlorite after glaucophane, see Fig. 8B in Plašienka et al., 2018) might indicate decreasing P-T metamorphic conditions from the blueschist to the greenschist facies.

### *Structure and tectonic evolution of the area*

The age constraints for the Alpine tectonic evolution of broader surroundings of the VGCZ were reviewed by Plašienka (2018 and references therein). Our new results help to refine the tectonic scenario proposed there as follows:

The oldest tectonic event that resulted from the closure of the Meliata Ocean was the exhumation of the blueschist-facies Meliatic complexes (Bôrka Nappe) that postdated the peak high-pressure metamorphism (160–150 Ma) and occurred during the latest Jurassic, most probably in the 150–145 Ma time span. Subsequently, the Bôrka rocks were welded with the anchimetamorphic Meliatic ophiolitic mélanges and wildflysch sediments, as well as with the overriding Turnaic units derived from the southern Meliata margin. This united accretionary complex was then thrust over the Gemeric – former northern passive margin of the Meliata Ocean at around 145–140 Ma (Fig. 14).

Progressing contraction of the collisional zone brought about shortening of the Gemeric and overlying units with development of the Gemeric cleavage fan (140–135 Ma), and their ensuing thrusting over the Veporic basement-cover substratum (135–125 Ma). This latter event is partly registered also by the oldest exhumation-related low-temperature thermochronological data from the Bôrka Nappe (130–120 Ma; Putiš et al., 2014).

The time interval 125–100 Ma is poorly constrained, but data from the deeply buried Veporic basement complexes indicate attainment of the peak metamorphic conditions in the lower amphibolite facies associated with development of the main metamorphic schistosity in the Veporic rocks.

After 100 Ma, heterogeneous exhumation of the Veporic metamorphic dome commenced, as revealed by large-scale upright folding and some cooling-related geochronological data. It was initiated by positive inversion of the northern Veporic margin of the Fatric Zliechov basin and start of underthrusting of the Fatric basement substratum below the Veporic thrust wedge.

During the stage 90–70 Ma, the map-scale pattern of the principal fault-shear zones in the investigated area originated (Fig. 14). It was also the main phase of exhumation of the southern Veporic metamorphic dome. Cooling below ca 300 °C has been documented by various low-temperature geochronological methods – Rb/Sr and $^{40}Ar/^{39}Ar$ on muscovite and biotite, zircon fission-tracks (see reviews by Putiš et al., 2009; Vojtko et al., 2016; Plašienka, 2018). As revealed by structural data, exhumation was achieved by orogen-parallel extensional unroofing (Plašienka, 1993; Hók et al., 1993; Madarás et al., 1996; Janák et al., 2001; Jeřábek et al., 2007, 2012; Németh et al., 2012; Bukovská et al., 2013). The kinematic pattern of map-scale fault and fold structures was controlled by the general N–S compression. Former Lower Cretaceous thrust faults like the Lubeník and Hrádok faults were reactivated as SW–NE to WSW–ENE trending, transpressional oblique-slip sinistral shear zones affecting several kilometres wide VGCZ that continues eastward into the so-called Trans-Gemer shear zone (TGSZ; e.g. Lexa et al., 2003; Németh et al., 2012; Fig. 14). The VGCZ–TGSZ was kinematically linked with the N–S to NNW–SSE striking segment of the former Lubeník thrust fault, which was reactivated as an east-dipping, low-angle normal fault system (lanf in Fig. 14). These extensional detachment faults are accompanied by wide mylonitic zones, especially along the Veporic basement/cover contact (see above), and were the principal structures that facilitated exhumation of the Veporic metamorphic dome by an eastward unroofing of the Gemeric and overlying units. The NNW–SSE trending Nižná Slaná depression with preserved erosional remnants of the Meliatic and Silicic nappe outliers represents a kind of a roll-over synform developed at the trailing edge of listric E-dipping detachment fault system (ros in Fig. 14). Low-angle normal faulting led also to a large omission of the hanging-wall units just at the Veporic–Gemeric boundary, like for instance at Dúbrava Hill between Rochovce and Markuška villages (Fig. 2). In the central parts of the Veporic dome, slices of Gemeric rocks (Ochtiná Group) overlying Veporic Foederata cover thus represent typical extensional allochthons (Plašienka & Soták, 2001). The Rochovce granite intrusion, dated to 80–75 Ma (Hraško et al., 1999; Poller et al., 2001; Kohút et al., 2013; ri in Fig. 14) occurs just at the turning point of the VGCZ from the WSW–ENE to the NNW–SSE strike. It is inferred that it was the place where tensile stresses were concentrated and facilitated the granite intrusion into comparatively shallow depths.

The succeeding latest Cretaceous–Paleogene tectonic development of the area was connected with the final

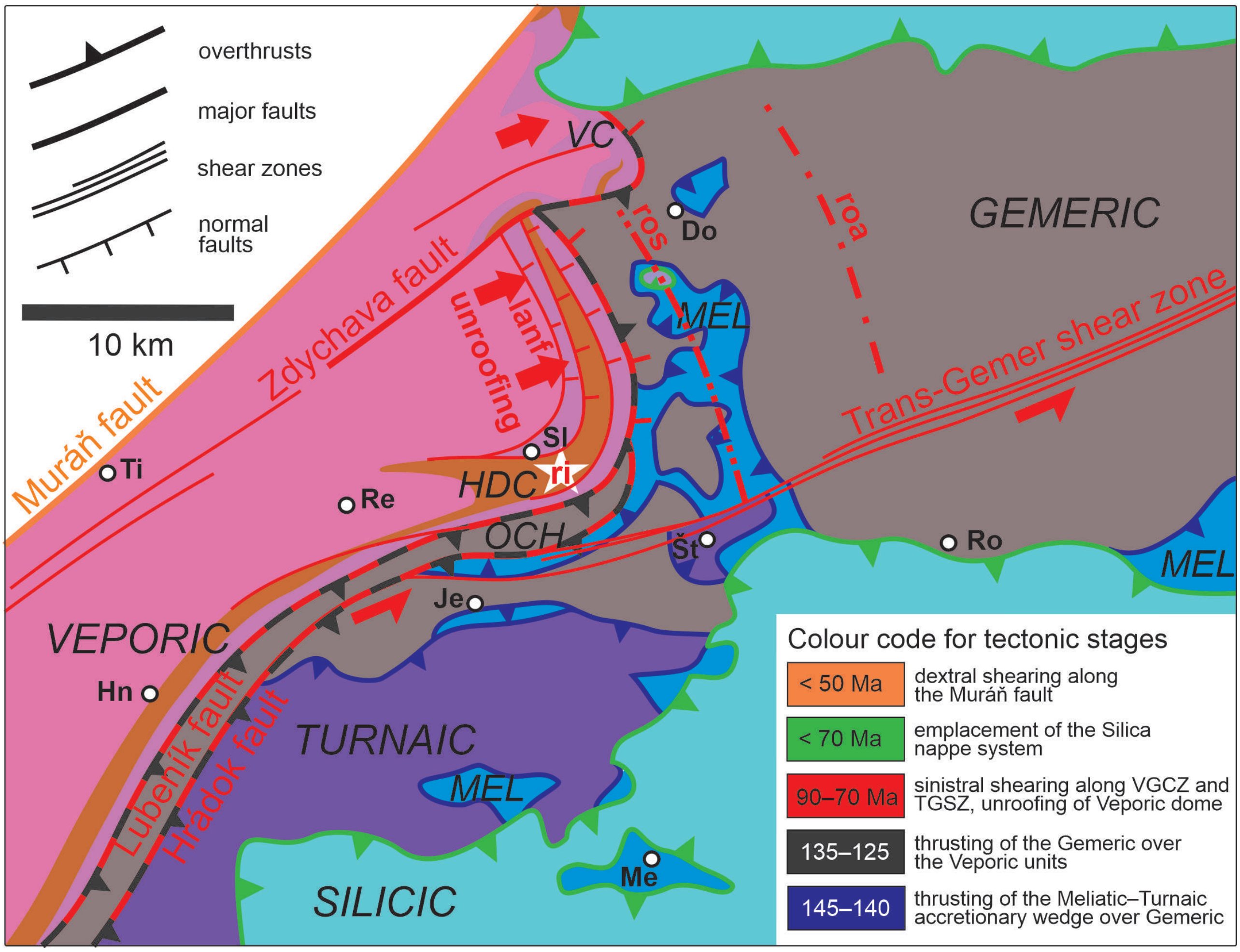



**Fig. 14.** Kinematic framework of the Veporic–Gemeric thrust system. See text for explanations. Abbreviations: HDC – Hladomorná dolina Complex; VC – Veporic cover complexes (Revúca Group and Foederata Unit, including Markuška Nappe); OCH – Ochtiná Unit; lanf – low-angle normal faults; ros – roll-over synform; roa – roll-over anticline; ri – Rochovce granite intrusion. Towns/villages: Ti – Tisovec; Hn – Hnúšťa; Re – Revúca; Je – Jelšava; Sl – Slavošovce; Št – Štítnik; Do – Dobšiná; Ro – Rožňava; Me – Meliata.

exhumation and overall cooling recorded by very low-grade thermochronological data, like the apatite fission-track and (U-Th)/He dating methods (Putiš et al., 2014; Vojtko et al., 2016). However, this seemingly quiet period was interrupted by emplacement of the Silicic cover nappe system that overlapped the underlying structures with a pronounced metamorphic and structural discordance. Still younger are some important brittle strike-slip faults like the Muráň fault (e.g. Marko, 1993; Pelech & Kronome, 2019; Fig. 14).

Although our EMPA monazite age data seldom show narrow age ranges, they at least partly fit the scenario outlined above. The Variscan monazite age data around 360–355 Ma from granitoids and their contacts generally correspond to the known monazite ages from the Veporic granitoids (e.g. Finger et al., 2003; Hraško, 2005). The Alpine monazites from mylonitic granitoids (ca 110 Ma) are by some 20 Ma older than the suggested age of the corresponding mylonitic zones. We presume that these monazites might have formed during the peak Alpine metamorphic conditions (stage 3 of the scenario) and occur as relics in the mylonitic matrix, together with the Variscan monazites.

Older monazites (Group 2, 150–140 Ma) from the Bôrka Nappe suit with the scenario stages 1 to 2. However, interpretation of younger monazites makes some problems. In samples from the Hrádok locality, Mnz2 generation is clearly confined to the superimposed cleavage domains. Their age range 100–90 Ma would fit with the stage 4, i.e. with a compressional event producing tight upright folds with penetrative axial-plane crenulation cleavage (e.g. Jeřábek et al., 2012). Deformation concentrated in comparatively weak rocks, like mica schists within the Zdychava shear zone, black shales of the Ochtiná Group, and Bôrka phyllites. Afterwards (stage 5), these weak zones were transformed to the sinistral transpressional belts, typically along the VGCZ and TGSZ. However, another Bôrka locality at Honce village occurs out of VGCZ–TGSZ shear zone and is characterized by large zoned porphyroblasts that overgrow the matrix foliation. Hence, they likely grew in a low-strain domain during longer time in a kinematically little disturbed setting and reflect slow exhumation from the blueschist to the greenschist conditions. However, it is a preliminary conclusion and this issue would need further detailed investigations.

## Conclusions

The investigated area represents a typical polymetamorphic and polydeformed region that embraces several superposed and/or juxtaposed major tectonic units. We have attempted at deciphering the structural-metamorphic history of rock complexes included by the field-based structural analysis and mapping, and petrographic-mineralogical analyses of a number of samples collected from all units present in the area.

Three principal tectono-metamorphic events can be discerned based on our petrologic and structural investigations and monazite age data: (1) the oldest monazite ages (Group 1, ca 360–355 Ma) from the skarnoid body and from the mylonitized granites indicate the Variscan contact metamorphosis resulting from intrusion of granitoids into the Lower Paleozoic metasedimentary protolith; (2) the monazites age Group 2 around 150–140 Ma from sericite-chlorite phyllites of the Bôrka Nappe likely indicates exhumation related to thrusting of the Meliatic accretionary wedge over the lower-plate Veporic and Gemeric units, following subduction of the Meliata Ocean; (3) the youngest monazite age Group 3 between 110 and 85 Ma detected in all analysed rock complexes records the Alpine overprint of the Veporic basement simultaneously with recrystallization of the Meliatic complexes during the main phase of the Western Carpathian nappe stacking and commencement of the extension-related exhumation of the Veporic metamorphic dome associated with transpressional shearing along the Veporic–Gemeric contact zone.

In spite of a significant scatter, the gathered monazite EMPA age data together with petrological and microstructural observations generally correspond to various phases of tectonic evolution of the Veporic–Gemeric contiguous zone, the investigated region of which represents one of the key areas.

## Acknowledgements

Financial support from the Grant Agency for Science, Slovakia (project VEGA 1/0085/17) and from the Slovak Research and Development Agency (project APVV-17-0170) is gratefully appreciated. Authors wish to express their gratitude to reviewers Ľubomír Gazdačko (Košice) and Ján Madarás (Bratislava) for their constructive comments.

## References

Abonyi, A., 1971: The stratigraphical-tectonical evolution of the Gemeride Carboniferous. *Geol. Práce, Spr., 57, 339–348* (in Slovak with English summary).

Andrusov, D., 1968: Grundriss der Tektonik der nördlichen Karpaten. *Bratislava, Ver. Slov. Akad. Wiss., 188 p.*

Árkai, P., Faryad, S.W., Vidal, O. & Balogh, K., 2003: Very low-grade metamorphism of sedimentary rocks of the Meliata unit, Western Carpathians, Slovakia: implications of phyllosilicate characteristics. *Int. J. Earth Sci., 92, 68–85.*

Bajaník, Š. (ed.), Ivanička, J., Mello, J., Reichwalder, P., Pristaš, J., Snopko, L., Vozár, J. & Vozárová, A., 1984: Geological map of the Slovenské rudohorie Mountains – eastern part 1 : 50,000. *Bratislava, D. Štúr. Inst. Geol.*

Biely, A. & Fusán, O., 1967: Zum Problem der Wurzelzonen der subtatrischen Decken. *Geol. Práce, Zpr., 42, 51–64*.

Bukovská, Z., Jeřábek, P., Lexa, O., Konopásek, J., Janák, M. & Košler, J., 2013: Kinematically unrelated C-S fabrics: an example of extensional shear band cleavage from the Veporic Unit (Western Carpathians). *Geol. Carpath., 64, 103–116*.

Cardozo, N. & Allmendinger, R.W., 2013: Spherical projections with OSXStereonet. *Comp. Geosci., 51, 193–205*.

Dallmeyer, R.D., Németh, Z. & Putiš, M., 2005: Regional tectonothermal events in Gemericum and adjacent units (Western Carpathians, Slovakia): Contribution by the $^{40}Ar/^{39}Ar$ dating. *Slovak Geol. Mag., 11, 2–3, 155–163.*

Dallmeyer, R.D., Neubauer, F. & Fritz, H., 2008: The Meliata suture in the Carpathians: regional significance and implications for the evolution of high-pressure wedges within collisional orogens. In: Siegesmund, S., Fügenschuh, B. & Froitzheim, N. (eds): Tectonic aspects of the Alpine--Dinaride-Carpathian system. *Geol. Soc., London, Spec. Publ., 298, 101–115*.

Faryad, S.W. & Henjes-Kunst, F., 1997: Petrological and K-Ar and $^{40}Ar$-$^{39}Ar$ age constraints for the tectonothermal evolution of the high-pressure Meliata unit, Western Carpathians (Slovakia). *Tectonophysics, 280, 141–156*.

Faryad, S.W. & Hoinkes, G., 1999: Two contrasting mineral assemblages in the Meliata blueschists, Western Carpathians, Slovakia. *Min. Mag., 63, 489–501*.

Faryad, S.W., Spišiak, J., Horváth, P., Hovorka, D., Dianiška, I. & Józsa, S., 2005: Petrological and geochemical features of the Meliata mafic rocks from the sutured Triassic oceanic basin, Western Carpathians. *Ofioliti, 30, 1, 27–35*.

Finger, F., Broska, I., Haunschmid, B., Hraško, Ľ., Kohút, M., Krenn, E., Petrík, I., Riegel, G. & Uher, P., 2003: Electron-microprobe dating of monazites from Western Carpathian basement granitoids: plutonic evidence for an important Permian rifting event subsequent to Variscan crustal anatexis. *Int. J. Earth Sci., 92, 86–98*.

Gazdačko, Ľ., 1995: Lithological content and relation of the Bôrka nappe to ultrabasics in the surrounding of Markuška and Kobeliarovo villages. *Miner. Slov., 37, 214–216* (in Slovak with English abstract).

Grecula, P. (ed.), Kobulský, J., Gazdačko, Ľ., Németh, Z., Hraško, Ľ., Novotný, L. & Maglay, J., 2009: Geological map of the Spiš-Gemer Ore Mts. 1 : 50,000. *Bratislava, St. Geol. Inst. D. Štúr.*

Hók, J., Kováč, P. & Madarás, J., 1993: Extensional tectonic of the western part of the contact area between Veporicum and Gemericum, Western Carpathians. *Miner. Slov., 25, 172–176* (in Slovak with English summary).

Hraško, Ľ., 2005: Geological, age and lithological characteristics of the Lower Carboniferous granitoids in the Kohút zone of the Veporic. *Miner. Slov., 37, 217–219* (in Slovak with English summary).

Hraško, Ľ., Határ, J., Huhma, H., Mäntäri, I., Michalko, J. & Vaasjoki, M., 1999: U/Pb zircon dating of the Upper Cretaceous granite (Rochovce type) in the Western Carpathians. *Krystalinikum, 25, 163–171*.

Janák, M., Plašienka, D., Frey, M., Cosca, M., Schmidt, S.Th., Lupták, B. & Méres, Š., 2001: Cretaceous evolution of a metamorphic core complex, the Veporic unit, Western Carpathians (Slovakia): P-T conditions and in situ $^{40}Ar/^{39}Ar$ UV laser probe dating of metapelites. *J. Metamorphic Geol., 19, 197–216*.

Jeřábek, P., Stünitz, H., Heilbronner, R., Lexa, O. & Schulmann, K., 2007: Microstructural-deformation record of an orogen-parallel extension in the Vepor Unit, West Carpathians. *J. Struct. Geol., 29, 1722–1743*.

Jeřábek, P., Lexa, O., Schulmann, K. & Plašienka, D., 2012: Inverse ductile thinning via lower crustal flow and fold-induced doming in the West Carpathian Eo-Alpine collisional wedge. *Tectonics, 31, TC5002*.

Klinec, A., 1966: Zum Bau und Bildung des Veporiden-Kristallin. *Sbor. geol. Vied, Západ. Karpaty, 6, 7–28* (in Slovak with German summary).

Klinec, A., 1971: The main tectonic elements in the eastern Veporides. *Geol. Práce, Spr., 57, 105–109* (in Slovak with English summary).

Klinec, A., 1976: Geological map of the Slovenské rudohorie and the Nízke Tatry Mts. 1 : 50,000. *Bratislava, D. Štúr Inst. Geol.*

Klinec, A., 1980: Contiguous zone of Gemerides and Veporides enlightened by well near Rochovce. *Geol. zbor. Geol. Carpath., 31, 537–540*.

Kohút, M., Stein, H., Uher, P., Zimmerman, A. & Hraško, Ľ., 2013: Re-Os and U-Th-Pb dating of the Rochovce granite and its mineralization (Western Carpathians, Slovakia). *Geol. Carpath., 64, 71–79*.

Konečný, P., Siman, P., Holický, I., Janák, M., & Kollárová V., 2004: Methodics of monazite dating using an electron microprobe. *Miner. Slov., 36, 225–235* (in Slovak with English summary).

Korikovsky, S.P., Janák, M. & Boronichin, V.A., 1986: Geothermometry and mineral equilibria during recrystallization of garnet mica schists and cordierite-bearing hornfelses in the Rochovce granite aureole (Slovak Ore Mts., Rochovce-Chyžné district). *Geol. Zbor. Geol. Carpath., 37, 607–633* (in Russian with English abstract).

Kozur, H. & Mock, R., 1997: New paleogeographic and tectonic interpretations in the Slovakian Carpathians and their implications for correlations with the Eastern Alps and other parts of the Western Tethys. Part II: Inner Western Carpathians. *Miner. Slov., 29, 164–209*.

Kozur, H., Mock, R. & Mostler, H., 1976: Stratigraphische Neueinstufung der Karbonatgesteine der unteren Schichtenfolge von Ochtiná (Slowakei) in das oberste Visé und Serpukhovian (Namur A). *Geol. Paläont. Mitt., 6, 1–29*.

Lačný, A., Plašienka, D. & Vojtko, R., 2016: Structural evolution of the Turňa Unit constrained by fold and cleavage analyses and its consequences for the regional tectonic models of the Western Carpathians. *Geol. Carpath., 67, 177–193*.

Leško, B. & Varga, I., 1980: Alpine elements in the West Carpathian structure and their significance. *Miner. Slov., 12, 97–130*.

Lexa, O., Schulmann, K. & Ježek, J., 2003: Cretaceous collision and indentation in the West Carpathians: View based on structural analysis and numerical modeling. *Tectonics, 22, 6, 1066*.

Madarás, J., Hók, J., Siman, P., Bezák, V., Ledru, P. & Lexa, O., 1996: Extension tectonics and exhumation of crystalline basement of the Veporicum unit (Central Western Carpathians). *Slovak Geol. Mag., 3–4/96, 179–183*.

Maluski, H., Rajlich, P. & Matte, P., 1993: $^{40}$Ar-$^{39}$Ar dating of the Inner Carpathian Variscan Basement and Alpine mylonitic overprinting. *Tectonophysics, 223, 313–337*.

Marko, F., 1993: Kinematics of Muráň fault between Hrabušice and Tuhár village. In: Rakús, M. & Vozár, J. (eds): Geodynamic model and deep structure of the Western Carpathians. *Conf., Symp., Sem., Bratislava, D. Štúr Inst. Geol., 253–261*.

Mello, J., Reichwalder, P. & Vozárová, A., 1998: Bôrka nappe: high-pressure relic from the subduction-accretion prism of the Meliata ocean (Inner Western Carpathians, Slovakia). *Slovak Geol. Mag., 4, 261–273*.

Mock, R., Sýkora, M., Aubrecht, R., Ožvoldová, L., Kronome, B., Reichwalder, P. & Jablonský, J., 1998: Petrology and stratigraphy of the Meliaticum near the Meliata and Jaklovce Villages, Slovakia. *Slovak Geol. Mag., 4, 223–260*.

Montel, J.M., Foret, S., Veschambre, M., Nicollet, C. & Provost, A., 1996: Electron microprobe dating of monazite. *Chem. Geol., 131*, *37–53*.

Nemec, O., Putiš, M., Bačík, P., Ružička, P. & Németh, Z., 2020: Metamorphic conditions of Neotethyan Meliatic accretionary wedge estimated by thermodynamic modelling and geothermobarometry (Inner Western Carpathians, Slovakia). *Minerals, 10, 1094*.

Németh, Z., 1994: Alpine tectonics in the Nižná Slaná Depression (contact zone between Gemericum and Veporicum, Western Carpathians). *Miner. Slov., 26, 399–410* (in Slovak with English summary).

Németh, Z., Radvanec, M., Gazdačko, Ľ. & Kobulský, J., 2012: Variscan tectonic setting vs. Alpine overprint in Gemericum (Inner Western Carpathians): Their role in the recent distribution of tectonic units in the eastern part of the territory as expressed in significant localities. *Miner. Slov., Geovest., 44, 1, 8–15*.

Novotná, N., Jeřábek, P., Pitra, P., Lexa, O. & Racek, M., 2015: Repeated slip along a major decoupling horizon between crustal-scale nappes of the Central Western Carpathians documented in the Ochtiná tectonic mélange. *Tectonophysics, 646, 50–64*.

Pelech, O. & Kronome, B., 2019: Structural analysis in the wider zone of Muráň fault between Šumiac and Tisovec. *Geol. Práce, Spr., 134, 33–48* (in Slovak with English summary).

Plašienka, D., 1980: Nappe position of the Hladomorná dolina group on the Foederata group in the Dobšiná half-window. *Geol. Zbor. Geol. Carpath., 31, 609–617*.

Plašienka, D., 1984: Represents the Markuška nappe an interconnecting element between the Veporic and Gemeric units? *Miner. Slov., 16, 187–193* (in Slovak with English summary).

Plašienka, D., 1993: Structural pattern and partitioning of deformation in the Veporic Foederata cover unit (Central Western Carpathians). In: Rakús, M. & Vozár, J. (eds): Geodynamic model and deep structure of the Western Carpathians. *Conf., Symp., Sem. Bratislava, D. Štúr Inst. Geol., 269–277*.

Plašienka, D., 2003: Development of basement-involved fold and thrust structures exemplified by the Tatric-Fatric-Veporic nappe system of the Western Carpathians. *Geodinam. Acta, 16, 21–38*.

Plašienka, D., 2018: Continuity and Episodicity in the Early Alpine Tectonic Evolution of the Western Carpathians: How Large-Scale Processes Are Expressed by the Orogenic Architecture and Rock Record Data. *Tectonics, 37, 3, 2029–3079*.

Plašienka, D. & Soták, J., 2001: Stratigraphic and tectonic position of Carboniferous sediments in the Furmanec Valley (Muráň Plateau, Central Western Carpathians). *Miner. Slov., 33, 29–44* (in Slovak with English summary).

Plašienka, D., Grecula, P., Putiš, M., Kováč, M. & Hovorka, D., 1997: Evolution and structure of the Western Carpathians: an overview. In: Grecula, P., Hovorka, D. & Putiš, M. (eds): Geological evolution of the Western Carpathians. *Miner. Slov., Monogr., 1–24i*.

Plašienka, D., Méres, Š., Ivan, P., Sýkora, M., Soták, J., Lačný, A., Aubrecht, R., Bellová, S. & Potočný, T., 2019: Meliatic blueschists and their detritus in Cretaceous sediments: New data constraining tectonic evolution of the West Carpathians. *Swiss J. Geosci., 112, 55–81*.

Plašienka, D., Bučová, J. & Šimonová, V., 2020: Variable structural styles and tectonic evolution of an ancient backstop boundary – the Pieniny Klippen Belt of the Western Carpathians. *Int. J. Earth Sci., 109, 4, 1355–1376*.

Prokešová, R., Plašienka, D. & Milovský, R., 2012: Structural pattern and emplacement mechanisms of the Krížna cover nappe (Western Carpathians, Slovakia). *Geol. Carpath., 63, 13–32*.

Poller, U., Uher, P., Janák, M., Plašienka, D. & Kohút, M., 2001: Late Cretaceous age of the Rochovce granite, Western Carpathians, constrained by U-Pb single-zircon dating in combination with cathodoluminiscence imaging. *Geol. Carpath., 52, 41–47*.

Putiš, M., Frank, W., Plašienka, D., Siman, P., Sulák, M. & Biroň, A., 2009: Progradation of the Alpidic Central Western Carpathians orogenic wedge related to two subductions: constrained by $^{40}$Ar/$^{39}$Ar ages of white micas. *Geodinam. Acta, 22, 1–3, 31–56.*

Putiš, M., Danišík, M., Ružička, P. & Schmiedt, I., 2014: Constraining exhumation pathway in accretionary wedge by (U-Th)/He thermochronology – Case study on Meliatic nappes in the Western Carpathians. *J. Geodynam., 81, 80–90*.

Putiš, M., Soták, J., Qiu-Li, L., Ondrejka, M., Xian-Hua, L., Zhaochu, H., Xiaoxiao, L., Nemec, O., Németh, Z. & Ružička, P., 2019: Origin and age determination of the Neotethys Meliata basin ophiolite fragments in the Late Jurassic – Early Cretaceous accretionary wedge mélange (Inner Western Carpathians, Slovakia). *Minerals, 9, 652*.

Reichwalder, P., 1982: Structural characteristic of root zones of some nappes in innermost parts of West Carpathians. In: Maheľ, M. (ed.): Alpine structural elements: Carpathian--Balkan-Caucasus-Pamir orogene zone. *Bratislava, Veda, 43–56*.

Ružička, P., Bačík, P. & Kurylo, S., 2019: Mineralogical characteristics of marbles associated with basalt metapyroclastics and chlorite schists from the locality Markuška (Slovak

Republic). *Bull. Mineral. Petrol., 27, 2, 247–258* (in Slovak with English abstract).

Sulovský, P., Čopjaková, R. & Škoda, R., 2004: Possibility and constraints of CHIME dating method. *Zpr. geol. Výzk. v r. 2003 (Geosci. Res. Reports in 2003, Czech Geol. Survey), 37, 122–125* (in Czech with English abstract).

Vojtko, R., Králiková, S., Jeřábek, P., Schuster, R., Danišík, M., Fügenschuh, B., Minár, J. & Madarás, J., 2016: Geochronological evidence for the Alpine tectono-thermal evolution of the Veporic Unit (Western Carpathians, Slovakia). *Tectonophysics, 666, 48–65.*

Vozárová, A., 1990: Development of metamorphism in the Gemeric/Veporic contact zone (Western Carpathians). *Geol. Zbor. Geol. Carpath., 41, 475–502.*

Vozárová, A., 1996: Tectono-sedimentary evolution of late Paleozoic basins based on interpretation of lithostratigraphic data (Western Carpathians, Slovakia). *Slovak Geol. Mag., 3–4/96, 251–271.*

Vozárová, A. & Krištín, J., 1985: Changes in chemical composition of garnets and biotites from contact aureole of Alpine granitoides in southern part of Veporicum. *Západ. Karpaty, Sér. Mineral. Petrogr. Geochém. Metalogen., 10, 199–221* (in Slovak with English summary).

Vozárová, A. & Vozár, J., 1982: New lithostratigraphical division of the basal part of the cover of Southern Veporicum. *Slovak Geol. Mag., 3–4/96, 251–271* (in Slovak with English summary).

Vozárová, A. & Vozár, J., 1988: Late Paleozoic in West Carpathians. *Bratislava, Geol. Inst. D. Štúr, 314 p.*

Vrána, S., 1964: Petrogenese des Veporiden Kristallin in der Umgebung von Slavošovce. *Geol. Práce, Zpr., 33, 5–29* (in Czech with German summary).

Zoubek, V., 1957: Grenze zwischen den Gemeriden und Veporiden. *Geol. Práce, Zoš., 46, 38–50* (in Czech with German summary).

Zoubek, V. & Snopko, L., 1954: Zpráva o mapování styku veporid a gemerid mezi Slavošovci a Rejdovou (in Czech; Mapping report about the contact of the Veporides and Gemerides between Slavošovce and Rejdová villages). *Zpr. geol. Výzk. v r. 1954, 211–213.*

# Geologická stavba a tektonometamorfný vývoj kontaktnej zóny veporika a gemerika dokumentovaný rádiometrickými vekmi monazitu (oblasť Slavošovce – Štítnik, stredné Slovensko)

Skúmané územie sa nachádza pozdĺž stykovej zóny stredoslovenského veporika a priľahlého gemerika v miestach, kde sa lubenícko-hrádocká zlomová zóna prudko stáča zo smeru ZJZ – VSV do smeru SSZ – JJV (obr. 1). Tento systém zlomov, pôvodne spojený s násunom gemerika na veporikum, bol neskôr modifikovaný transpresnou a extenznou reaktiváciou. Výsledkom deformačných procesov v štruktúrne komplikovanej oblasti bola superpozícia niekoľkých jednotiek, ktoré vykazujú zložité tektonické a metamorfné vzťahy. Na relatívne malom území tu v tesnom kontakte vystupujú viaceré základné tektonické jednotky stavby Západných Karpát: v najnižšej štruktúrnej pozícii je veporický fundament a jeho mladopaleozoicko-triasový sedimentárny pokryv (revúcka skupina a föderatská jednotka), na veporikum je pozdĺž lubeníckej línie nasunuté gemerikum (ochtinská a volovská jednotka) a v jeho nadloží meliatikum (príkrov Bôrky), turnaikum a silicikum (obr. 2, 3).

Fundament veporika je pozdĺž stykovej zóny reprezentovaný súborom polymetamorfovaných sedimentov s ojedinelým výskytom bázických metavulkanitov (komplex Hladomornej doliny), do ktorých intrudovali variské granitoidy veporského plutónu (kráľovohoľský komplex). Kontakt granitoidov a ich metamorfného plášťa je sprevádzaný prejavmi kontaktnej metamorfózy v priľahlom komplexe Hladomornej doliny a metasomatózy (teleso skarnoidov pri Čiernej Lehote). Tento kontakt bol ale výrazne postihnutý aj naloženou alpínskou mylonitizáciou. Sedimentárny obal veporického fundamentu reprezentujú klastické metasedimenty revúckej skupiny. Vrchnokarbónske slatvinské súvrstvie je zložené z oligomiktných konglomerátov, pieskovcov a tmavých bridlíc. Nadložné permské rimavské súvrstvie predstavuje súbor siliciklastických metasedimentov a acidných metavulkanoklastík. Pozdĺž lubeníckej línie je v priamom tektonickom kontakte s rimavským súvrstvím spodnokarbónska ochtinská jednotka gemerika. Reprezentuje ju súbor konglomerátov a pieskovcov a rôzne typy fylitov v asociácii s bázickými horninami (hrádocké súvrstvie) a karbonátmi s tmavými bridlicami (lubenícke súvrstvie). Nadložie ochtinskej skupiny tvorí volovská jednotka gemerika, ktorú zastupuje gelnická a gočaltovská skupina. Staropaleozoickú gelnickú skupinu predstavuje varisky nízko metamorfovaný vulkanosedimentárny komplex. Jej sedimentárny obal reprezentujú permské klastiká gočaltovskej skupiny. V oblasti kontaktu ochtinskej skupiny a volovskej jednotky sa pozdĺž hrádockej zlomovej zóny vyskytujú tektonicky obmedzené šupiny meliatskeho príkrovu Bôrky (obr. 2, 3). Príkrov Bôrky zastupuje dúbravské súvrstvie. Je to komplex metamorfovaných karbonátov v asociácii s bázickými metavulkanoklastikami a jemnozrnnými metasedimentmi.

Územie má zložitú stavbu a ešte zložitejší tektonometamorfný vývoj, ktorý sme sa pokúsili interpretovať na základe podrobného štruktúrneho, petrologického a geochronologického výskumu. Mikroštruktúrne pozorovania a petrografické údaje z analyzovaných horninových komplexov opísané v texte sú ilustrované na obr. 4 až 8. Vyplýva z nich polymetamorfný a polydeformačný charakter skúmaných jednotiek, ktorý je kombináciou viacerých fáz predalpínskeho (v prípade variského fundamentu) a alpínskeho tektonometamorfného vývoja.

Z vybraných vzoriek sa chemickou mikrosondovou datovacou metódou (EMPA) analyzovali monazity viacerých generácií. Získané vekové údaje možno rozdeliť na tri skupiny (obr. 9 až 13): 1. mylonitizované veporické granitoidy a skarnoidy poskyli okrem mladších alpínskych aj variské veky reliktných monazitov okolo 360 – 355 mil. r.; 2. len vo fylitoch príkrovu Bôrky boli identifikované veky medzi 150 a 140 mil. r. a interpretované ako etapa exhumácie a nasunutia meliatsko-turnaického akrečného komplexu na podložné gemerikum; 3. mladšie kriedové veky zhruba medzi 110 a 85 mil. r. sa zistili vo všetkých jednotkách, interpretujeme ich ako záznam počiatkov exhumácie veporického metamorfného dómu a strižných deformácií po jeho okrajoch.

Vývojový tektonický model (obr. 14) predpokladá, že exhumácia prebiehala na kinematicky spojitom systéme širokej sinistrálnej strižnej zóny pozdĺž lubenícko-hrádockej zlomovej zóny smeru ZJZ – VSV a nízkouhlových, na východ sklonených zlomov smeru SSZ – JJV na východnom okraji veporika pozdĺž tzv. gemerskej rampy. Nízkouhlové zlomy, sprevádzané širokými mylonitovými zónami hlavne v granitoidoch veporického fundamentu bezprostredne pod sedimentárnym obalom, boli hlavnými štruktúrami, na ktorých prebehlo exhumačné odstrešenie vrchnokriedového veporického metamorfného dómu. Takzvaná vrása (resp. príkrov) Markušky predstavuje systém násunových šupín vrchných častí juhoveporického fundamentu (komplex Haldomornej doliny) a metasedimentov revúckej skupiny, šikmo narezaných eróziou v dôsledku osového ponoru veporika pod gemerikum. Nižnoslanská depresia s troskami príkrovu Bôrky a silického príkrovu (Radzim) je interpretovaná ako synforma v apikálnej časti nízkouhlového zlomového systému so značnou extenznou redukciou komplexov podložného gemerického fundamentu. Predpokladáme, že vrchnokriedová intrúzia rochovského granitu využila oslabenú zónu s koncentráciou tenzných napätí na ohybe lubenícko-hrádockých zlomov na prienik do relatívne plytkých úrovní stavby stykovej zóny. Veporické komplexy tak počas vrchnokriedového vývoja reprezentovali spodnú platňu a komplexy gemerika a nadložných jednotiek vrchnú platňu extenzného tektonického systému.

Doručené / Received: 4. 11. 2020
Prijaté na publikovanie / Accepted: 18. 2. 2021