NEW DATA ON P–T CONDITIONS OF VARISCAN AND ALPINE METAMORPHISM FROM THE ČIERNA HORA MTS., VEPORIC UNIT, WESTERN CARPATHIANS (SLOVAKIA)

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Abstract: P-T conditions for Variscan and Alpine metamorphism in the Čierna Hora Mts. Veporicum unit are estimated using mineral compositions in metabasites. Temperature and pressure of 610 ± 20°C and 9 ± 1 kbar for Variscan metamorphism were obtained for garnet amphibolites in the basement rocks. Mineral assemblages involving prehnite, pumpellyite, epidote, chlorite, albite and white mica, in the Permian diorite of the Choč nappe indicated P-T conditions of 250 ± 25°C and 3 kbar that related to Alpine nappe emplacement in this part of the Western Carpathians.

Key words: Variscan, Alpine metamorphism, Čierna Hora Mts., Veporicum unit, Western Carpathians

Introduction

P-T conditions of 520 – 625 ^{o}C/3-4.5 kbar for Variscan metamorphism in the Čierna Hora Mts basement rocks were calculated by Jacko et al., (1990). Metamorphic temperature of 200 – 300°C for Alpine metamorphism, relating either to the emplacement of the Choč nappe or to successive shearing within regionally significant shear zones, are considered by illite crystallinity and metamorphic minerals in cover and nappe rocks (Korikovskij et al.,1989,1992). In this contribution, we present revised peak P – T conditions data for Variscan metamorphism from the two complexes of Čierna Hora Mts.: the Bujanová complex and the underlying Lodina complex. Alpine nappe emplacement P-T conditions are estimated using mineral assemblages in metadiorite in the late Palaeozoic formations of the Choč nappe, forming klippes either on Mesozoic sequences or directly on the basement rocks of the region (Fig.1).

Geological setting

The Branisko and the Čierna Hora Mts., form the most eastern morphostructural elevation of the Veporic unit in the Western Carpathians. They consist of three structural levels: the Variscan basement rocks, the late Palaeozoic/ Mesozoic cover formations and the late Palaeozoic/Mesozoic outliers of the Choč nappe. All these sequences are penetratively folded by the Alpine NW – SE fold set which is strongly imbricated by SW dipping shear zones of NW-SE direction. The most important Margecany shear zone of the same spatial position separates the Veporicum and Gemericum units from each other (Fig. 1). Both the Branisko and the Čierna Hora Mts., are dissected by post – Paleogene mainly NE-SW, NW - SE and N –S faults.

The Variscan basement rocks in the Branisko and Čierna Hora Mts., consist of three local lithostructural complexes that belong to Middle (MLU) and Upper (ULU) lithostructural units (Jacko, 1995; Bezák, et al., 1997. The MLU is represented by Lodina complex, composed of diaphtorised gneisses with intercalations of amphibolites and micaschists. The Miklušovce complex, consisted of strongly foliated migmatites and scarce intrafolial aplite-granite bodies and the Bujanová and/or Patria complex, represented by gneisses, migmatites, amphibolites with slab-like granite intrusive are parts of the MLU (Fig. 1). Amphibolites occur in various amounts in all three complexes and form several meters thick intrafolial – lensoidal bodies. In the Bujanová complex they are mostly affected by migmatitization. A largest lens of amphibolite (up 150 m in thickness) from this unit contains ca. 1.5 m thick body of serpentinized ultramafic rock.

The cover sequences are represented by late Carboniferous to Malmian formations. The Choč nappe pile with late Carboniferous to late Triassic formations occurs mostly along northern margin of the Branisko Mts. In the Čierna Hora Mts., the Choč nappe forms isolated klippes of late Palaeozoic basal sequences with small dikes amphibole-pyroxene diorite of Permian age. The dioritic dikes have caustic exo-contacts with late Carboniferous and Permian rocks.

Petrography and mineralogy

Samples selected for this study come from amphibolites of the Lodina and Bujanová complexes and metaultramafite in the Bujanová complex and from the Permian metadiorite of the Cretaceous Choč nappe. The amphibolites consist mostly of amphibole, plagioclase with variable amounts of quartz, locally garnet and accessory rutile, ilmenite and apatite. Some amphibolites adjacent to granite contain biotite and K-feldspar. Amphibole is magnesiohornblende, tschermakite, ferro-tschermakite and rarely alumino-ferrotschemakite with $Al^{VI} > 1.0$ occurs adjacent to garnet. Some amphibole varieties are rich in Na =0.5-0.8 and Na^{M4} = 0.3-0.5 a.f.u. Garnet is generally rich in almandine and grossular (Alm_{52-67}, Grs_{23-31},Py_{4-7}, Sps_{2-18}). Mn content decreases while Mg and X_{Mg} increase towards the rims. Anorthite content in plagioclase ranges between (An_{19-43}). Accessory muscovite, found as inclusion with epidote in garnet from Bujanová complex, has Si = 3.188 a.f.u. Phengite (Si = 3.3 a.f.u.) replaces plagioclase. Accessory ilmenite has MnO = 2.51 with 5.5 %

geigilite content. Zoisite content in epidote ranges between 40-50 %, however higher zoisite value (Zo = 72 %) come from epidote, associated with muscovite and occurring as inclusion in garnet.

The metaultramafite body of cca. 2 m length occurs within amphibolite of the Bujanová complex and consists of pargasitic amphibole, antigorite and small amounts of clinopyroxene, ilmenite-magnetite and phlogopite (X_{Mg} = 0.89). Clinopyroxene and amphibole represent igneous phases in the rock. Rhomohedral-shaped pseudomorphs of antigorite, enclosed in amphibole, suggest the presence of olivine as primary phase in the rock. Based on normative mineral contents the ultramafic rock corresponds to pyroxene-amphibole peridotite with 55 vol % olivine, 20 vol % diopside 10 %. Amphiboles has similarly to pyroxene relatively high X_{Mg} = 0.82-0.86 that confirm comagmatic origin of these two minerals

The Permian metadiorite of the Choč nappe is a coarse-grained rock with relic ophitic structure. It is formed by tabular plagioclase (2-3 mm) and pseudomorphs of chlorite and epidote after amphibole and locally after clinopyroxene. Within intergranular spaces and at the rims of plagioclase myrmekite of quartz + K-feldspar occurs. Plagioclase is partly replaced by fine-grained epidote, pumpellyite and rare prehnite. Beside individual grains pumpellyite forms inclusions in epidote. Locally present titanite forms up to 2 mm large grains, which contain inclusions of plagioclase and epidote. Brownish green amphibole is replaced by epidote, chlorite and by pale green amphibole. Accessory amounts of phengitic white mica (Si = 3.388 a.f.u.), calcite and apatite also present. The relic igneous pyroxene is diopside and the brownish green amphibole corresponds to magnesio hornblende. Metamorphic amphibole is actinolite. All analysed pumpellyite grains are rich in $X_{Fe}{}^{3+}$ = 0.3-0.4 and X_{Mg} = 0.4-0.5. Epidote associated with pumpellyite has low high Fe^{3+} content with clinozoisite end-member composition (X_{al} = 0.1 – 0.4). Chlorite associated with pumpellyite has X_{Mg} = Mg/(Mg+Fe^{2+}) around 0.5.

Metamorphic conditions

Garnet-amphibole thermometry (Graham and Powell, 1984) yielded average temperature of 572 ^{o}C for the Lodina and 618 ^{o}C for the Bujanová complexes (Fig. 2). Similar P-T conditions (520-540 ^{o}C for the Lodina and 620-625 ^{o}C for the Bujanová complex) were obtained by Korikovsky et al., (1990) and Jacko et al., (1990) who. Temperatures of 650-700 ^{o}C at 5-10 kbar gave amphibole-plagioclase thermometry of Holland and Blandy (1994) for both complexes. Pressures calculated by garnet-amphibole-plagioclase-quartz barometry (Kohn and Spear, 1990) range between 7.1 - 10.6 (average 9.7 kbar at 600 ^{o}C) for the Lodina and 8.15 kbar for the Bujanová complex. Average temperature and pressure of 641 and 11.2 kbar for the Lodina complex yielded equilibrium reactions calculated using TWEEQ program (Berman, 1996) in the system CMASH. Relatively higher temperature of 710 °C at 10.9 kbar was obtained for the Bujanová complex.

The presence of prehnite + pumpellyite + epidote + albite assemblage well define P-T field of very low-grade metamorphism in the Permian metadiorite. Thermodynamic calculations for this rock were obtained using software program Thermo-Calc (Holland and Powell, 1996). The calculated equilibrium reaction for this assemblage crosses the prehnite-pumpellyite facies at 240 ^{o}C/3 kbar to 360 ^{o}C/3.8 kbar (Fig. 2). The higher pressure limit based on this calculation is confirmed by the presence of only small amount of prehnite comparing to pumpellyite and by the reactions involving actinolite and plagioclase which intersect each other at 3.8-4.0 kbar/250 ^{o}C. Although the phengite barometry was tested for temperature higher then 350 ^{o}C (Massonne and Schreyer, 1987), possible extrapolation of Si- isopleths of phengite (Si = 3.38 a.f.u.) associated with K-feldspar suggests relatively higher pressure for this rock. Temperature of 250 ^{o}C for sedimentary sequences of the Choč nappe was previously calculated by illite crystallinity in pelitic rocks (Korikovsky et al., 1992). The assemblage with prehnite and pumpellyite from metadiorite of the Choč nappe were described by Vrána and Vozár (1969) in Nižna Boca from Nízké Tatry Mts.

Discussion and conclusion

The studied metabasites from basement units preserve equilibrium assemblages of amphibolite facies condition and locally also relics of primary igneous phases. P-T conditions of 520-550 oC/8-10 and 650-625 ^{o}C/10 were obtained by various thermometers for the Lodina and Bujanová complex respectively. Similar temperatures, but lower pressure for the Čierna Hora Mts., were reported by Korikovskij et al., (1990) and Jacko et al., (1990). Zoning character in garnet indicates mostly progressive Variscan metamorphism in these rocks. Geological position and textural relations in metamorphic rocks indicate thermal overprint, resulted by granite formation and migmatization of basement rocks.

In many regionally metamorphosed terranes, pumpellyite commonly coexists with, prehnite, epidote and actinolite (Liou et al., 1985). The presence of only accessory prehnite in the assemblage Pmp + Act + Ep (+ Chl + Ab + Qtz) suggests deeply buried volcanic of considerable thickness and has been used as an index assemblage for the pumpellyite-actinolite facies. Consistently with petrogenetic grid in very low-grade rocks (Liou et al., 1985) minimum metamorphic temperature of 200-250 ^{o}C at 0.5-3.0 kbar for the study metadiorite is considered by the lack of zeolite. The calculated P-T conditions are consistent with previous data on Alpine overprint in this area and also fits well with the degree of Cretaceous collisional metamorphism, in the Gemericum unit which reached ca 350-400 ^{o}C /5-6 kbar (Faryad and Dianiška, 1999).

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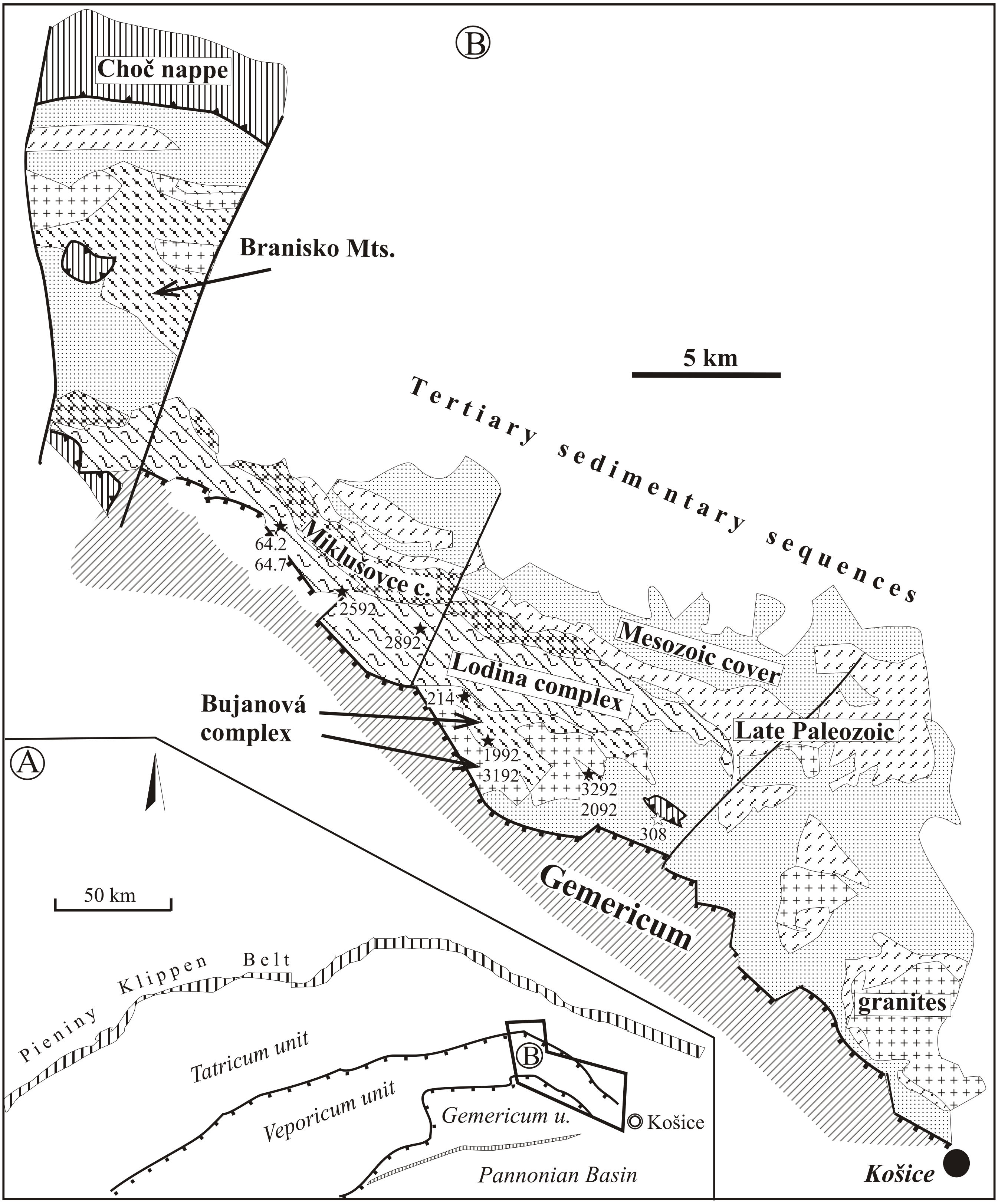
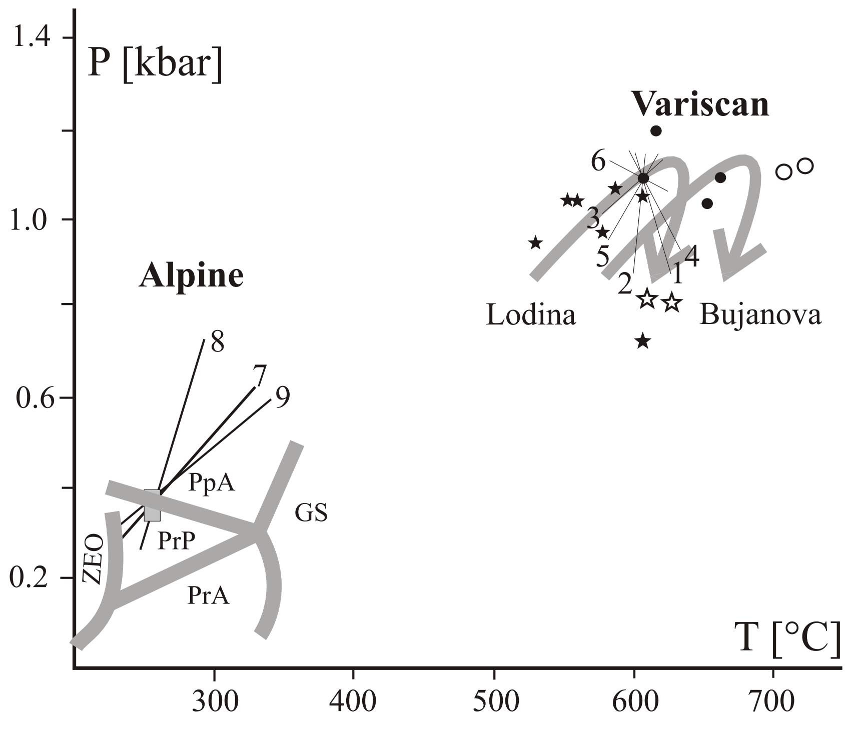
Fig. 1A. Position of the Čierna Hora and Branisko Mts. in the rame of the Western Carpathians. B. Schematic geological map of the Čierna Hora and adjacent Branisko Mts. (Polak et al., 1997). Stars show sample locations.

Fig. 2. Calculated P-T conditions for Variscan metamorphism in basement rocks of the Lodina and Bujanová Complexes and for Alpine metamorphism based on metadolerite in the choč nappe. Circles are intersections of reaction 1-6 reactions involving amphibole, garnet and plagioclase and were calculated using TWQ program (Berman, 1996). Stars are temperatures and pressure obtained by Gr-Amph-(Pl-Qtz) thermo(barometry). Open symbols are from Bujanová and solid from Lodina complexes. Reactions are calculated using Thermo-Calc programs (Holland and Powell, 1996): (7) Pmp + Qtz = Cz + Chl + Pre + W, (8) Pmp + Chl + Qtz = Cz + Tr + W, (9) Pmp + An = Cz + Chl + Qtz + W. Facies boundaries for low-grade rocks are according to Liou et al. (1985): ZEO-zeolite, PrA-prehnite-actinolite, PrP-prehnite-pumpellyite, PA-prehnite-actinolite and GS-greenschist facies.



B
Choč nappe
Branisko Mts.
5 km
Tertiary sedimentary sequences
Miklušovce c.
64.2
64.7
2592
2892
Mesozoic cover
Lodina complex
214
Bujanová complex
1992
3192
3292
2092
308
Late Paleozoic
Gemericum
granites
Košice
A
50 km
Pieniny Klippen Belt
Tatricum unit
Veporicum unit
Gemericum u.
Košice
Pannonian Basin


P [kbar]
1.4
1.0
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300
400
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Variscan
Alpine
Lodina
Bujanova
6
3
5
2
1
4
8
7
9
PpA
PrP
PrA
GS
ZEO