High, medium and low pressure assemblages from the Czech part of the Královský Hvozd Unit (KHU) in the Moldanubian Zone of SW Bohemia

Vysoko-, středně- a nízkotlaké minerální asociace z české části jednotky Královského hvozdu v moldanubiku jihozápadních Čech (Czech summary)

(*11 text-figs.*)

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The Královský Hvozd Unit (KHU), conventionally belonging to the Monotonous Group of the Moldanubicum, shows an important lithological heterogeneity. Thus, position of isograds based on index minerals (Vejnar 1963, 1991) was revised from this point of view. The first entry of staurolite follows the main lithological boundaries between metapelitic rocks and those of more greywacke character. The main three lithological segments of the KHU that have been distinguished preserve different PT-evolution stages. The lithologically variegated northern segment underwent a higher-pressure event (450 °C/10 kb). This segment conserves metamorphic record without equivalence in the whole Moldanubian Zone. Taking into account the spatial relation of the rocks bearing HP/LT assemblages to the Central Bohemian Fault, an allochtonous position of at least parts of this northern segment seems to be probable. On the Bavarian side, Silurian microspores have been found in low-grade rocks at similar structural level (Reitz 1992). Nevertheless, the possibility, that a specific event of Moldanubian history has been here preserved, cannot be completely excluded. The SE-segment of gneisses of greywacke affinity conserves a progressive Barrovian trend ranging from 500 °C/5.5 kb to 590 °C/6.5 kb and the SW-segment of metapelites s.s. shows the subsequent low-pressure overprinting ranging from 525 °C/1.5 kb to 575 °C/2 kb. The very high heat flow estimated from the PT-calculations witnesses an exclusive contact (periplutonic) kind of metamorphism in this segment.

Key words: metamorphism of pelitic rocks, low-grade metamorphism, medium-grade metamorphism, low-pressure metamorphism, medium- to high-pressure metamorphism, phengite barometry, petrogenetic grid, bulk rock chemistry, Variscides, Moldanubian Zone

Introduction

The Královský Hvozd Unit (KHU) comprises a region in the SW part of the Bohemian Massif near the contact of the Moldanubicum and Bohemicum (also Zone Teplá-Barrandian, or ZTT). The two units are separated by the Central Bohemian Fault (CBF) (Fig. 1).

Conventionally, the KHU is defined as a part of the Monotonous Group of the Moldanubicum, whose metamorphic conditions did not reach sillimanite isograd (Vejnar 1963). Because of its relatively low-grade metamorphic character, it was designated as the „roof of the Moldanubicum“ (Fischer 1938).

According to previous research, (Vejnar 1963, 1991) on the Czech side a former Barrovian medium-pressure metamorphism defined by kyanite, staurolite and sillimanite I zones, was followed by a low-pressure metamorphism (cordierite + K-feldspar zones) and subsequently a contact (periplutonic) metamorphism with andalusite, cordierite II and prismatic sillimanite, as index minerals.

On the Bavarian side, the main metamorphism was syn- to post-tectonic with WNW-ESE folding, and it was of a low-pressure type only (Blümel – Schreyer 1976, 1977).

The aim of this study is to present information on PT-evolution of some rock samples representing the main lithological and structural segments of the KHU.

Geological setting

The Královský Hvozd Unit is separated in the NW from the Zone Teplá-Barrandian (ZTT) represented by the Kdyně Massif with CBF (Fig. 1).

In the NE, beyond the KHU border (sillimanite isograd), there are either muscovite-bearing and muscovite-free, or cordierite-bearing gneisses, which belong to the Variegated Group of the Moldanubicum (Fig. 1). The prevailing foliation, as well as the lithological boundaries are oriented NE-SW and dip to the NW: towards the east progressing migmatization is observed (Fig. 1). In the KHU, this structure is in part preserved and in part refoliated by NW-SE trending foliation.

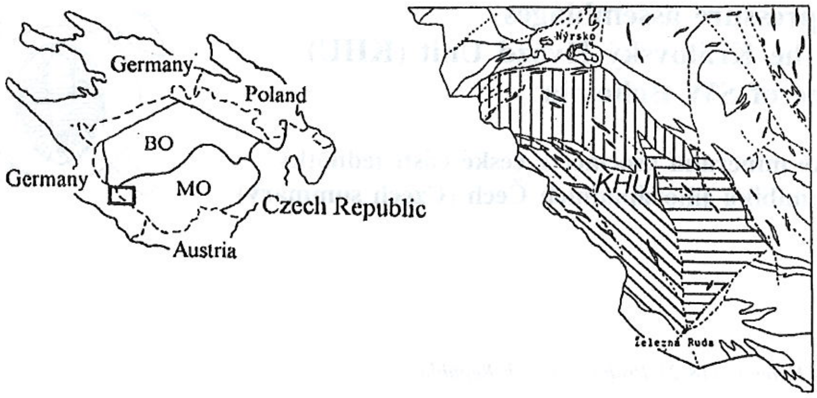
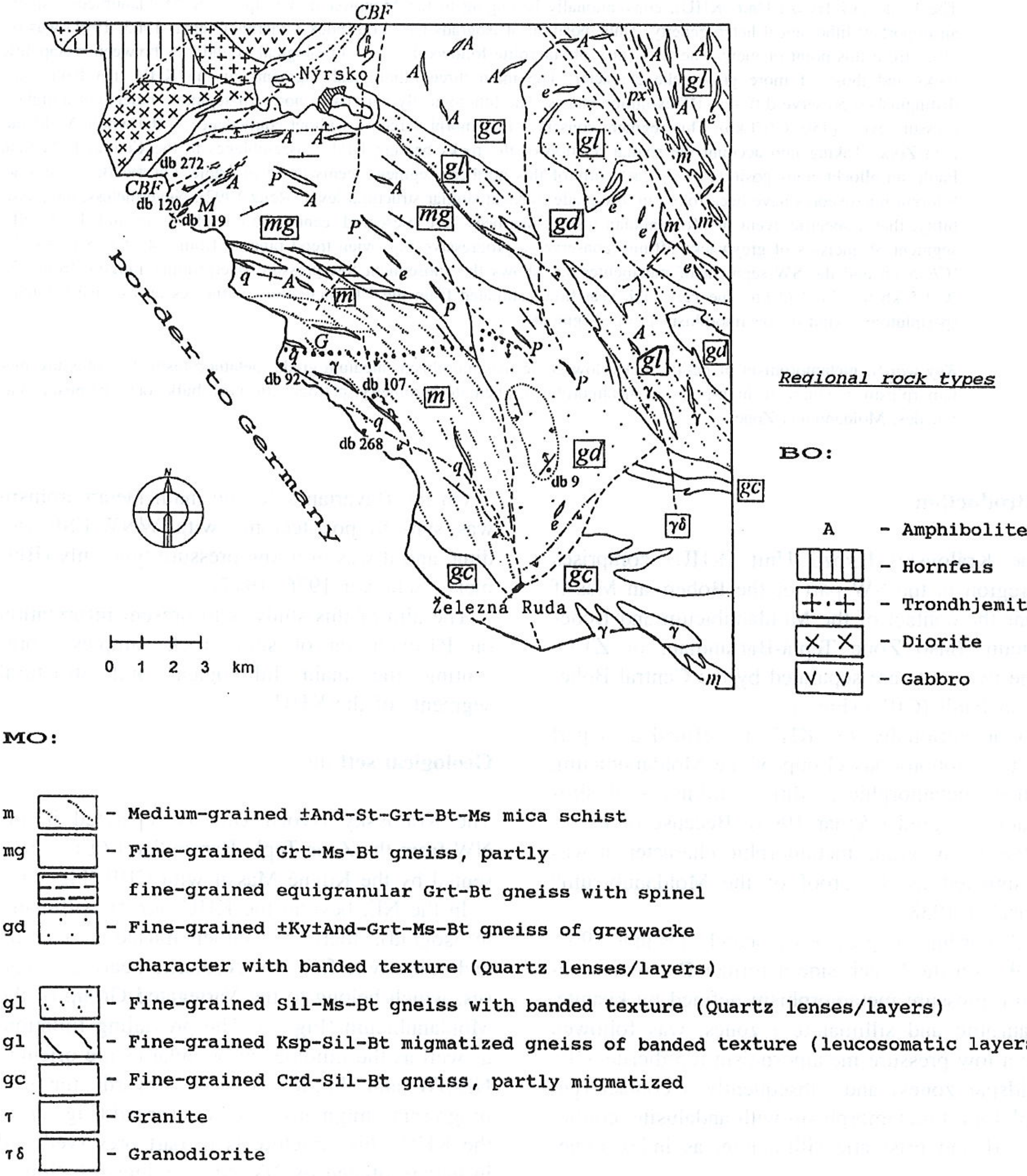


Fig. 1. Geological scheme of the KHU (Královský Hvozd Unit) with metamorphic isograds BO – Bohemicum; MO – Moldanubicum; CBF – Central Bohemian Fault



In the SE, a granitic body with a mantle of cordierite-gneiss mantle occurs.

Lithostructural characterization of the KHU

The KHU itself is composed of three main lithological segments, differing also in preservation of distinct, successive deformational events (Fig. 1):

The northern segment belongs to the Variegated Group of the Moldanubicum in the lithological (not stratigraphic) point of view. It is represented by fine-grained garnet-muscovite-biotite gneisses with relic staurolite, or kyanite, respectively. There are many intercalations of amphibolites, calc-silicate rocks, marbles and graphitic schists present. Close to the CBF, these rocks have a phyllitic character. On the Bavarian side, Silurian microspores (± Ludlow) have been recognized in the biotite mica schists (Reitz 1992). The prevailing foliation near the CBF trends NE-SW and further east is overprinted by NW-SE trending foliation (Babůrek 1991).

The south-eastern segment comprises fine-grained garnet-muscovite-biotite gneisses of greywacke character (up to 50% of plagioclase) with a banded texture, carrying staurolite and andalusite, or kyanite. The older foliation system (NE-SW, dipping to the NW), has been progressively refoliated to the NW-SE direction, dipping steeply to the SW. The structural overprinting becomes prominent towards the W.

The south-western segment of the KHU is represented by medium-grained garnet-biotite-muscovite mica schists with staurolite, andalusite, tourmaline, ilmenite. The ubiquitous NW-SE trending foliation, dipping NE, and a monotonous character of the rocks with quartzite intercalations as the only lithological alternative to the pelitic rocks, distinguishes this segment from the neighbouring ones. The presence of staurolite distinguishes this part of KHU from the northern segment. Nevertheless, the onset of staurolite represents no metamorphic isograd but it is due to the lithological contrast between both units. Micaschists from the SW-segment are Al-oversaturated (Al_2O_3 often exceeding 22 wt%) while gneisses from the N-segment contain Al_2O_3 around 15 wt%.

The northern part of KHU

The lithological variability of the northern part of the KHU makes the use of the first entry of any index mineral for the purpose of metamorphic zonation mapping difficult. This variability provides for use of several geothermobarometers for various lithological types.

Mylonitized granites, graphite-bearing dolomitic marbles and phyllitic schists were used for thermobarometric study.

The mylonitized granites and graphite-bearing dolomitic marbles occur in the westernmost part of the northern segment of KHU, intercalated in the surrounding gneisses. They are both up to several tenths of meters wide and several hundred meters long.

The mylonitized granite bodies (Fig. 1) comprise a very fine-grained matrix of quartz, K-feldspar, muscovite, Mg-rich biotite and albitic plagioclase (sampling point db 120). K-feldspar also forms large porphyroclasts up to 5 mm long (Fig. 5).

Muscovite shows very high phengitic substitution (3.3-3.42 Si_{pfu}) which is symmetric in the tetrahedral and octahedral sites (Fig. 6). Thus the presence of trivalent iron in the muscovite should be very low. Furthermore, the mineral assemblage of the mylonitized granite is very close to the

<u>*Minor rock types*</u>

q - Quartzite
c - Marbles
e - Calc-Silicate Rocks
A - Amphibolite
px - Pyroxenite
G - Orthogneiss
M - Mylonitic granitoid
T - Granite
P - Granite Porphyry

<u>*Additional symbols*</u>

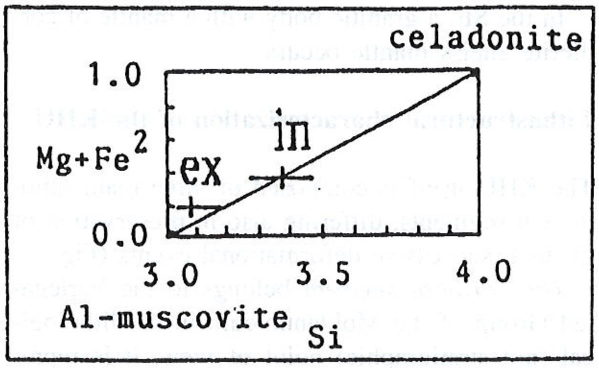
- Lithological boundary
- Fault
- Kyanite-in isograd
- Andalusite-in isograd
- Sillimanite-in isograd
- Strike and dip of foliation
- Bearing of fold axis

db 272 - Sampling point

Fig. 1.

KMASH system (see Table 1). The KMASH system was used for the calibration of the phengite barometry (Massonne – Schreyer 1987). However, no temperature estimate could be obtained from this rock for the purpose of location of the mineral assemblage on the Si-isopleth curve of 3.3-3.42 Si_{pfu} (Massonne – Schreyer 1987). Hence more suitable mineral assemblages from the neighbouring marbles were used for estimate of temperatures.

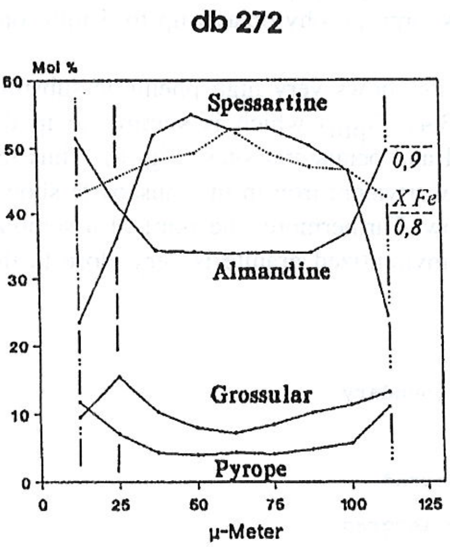
The mineral assemblage of marbles in the close neighbourhood of the mylonitized granite body (sampling point db 119) is represented by calcite (0.X mm size range), dolomite (0.0X mm size range) and accessory quartz, chlorite (X_{Mg} ~ 0.95) and margarite (X_{Na} ~ 0.24). The calcite-dolomite thermometer (Powell – Condliffe – Condliffe 1984) and calcite thermometer (Rice 1977) give values of 425-455 °C (curve 3, Fig. 7). The investigation of carbon isotopic composition (Hladíková 1992, unpublished data) shows, that there is only a very slight (if any) isotopic reequilibration between the carbonate and graphite carbon as it is typical for temperatures not exceeding approximately 450 °C. The absence of aragonite (curve 4, Fig. 7) and the upper stability curve for the presence of margarite in the marble (curve 5, Fig. 7), contribute to constraining PT-position of the rocks investigated (Fig. 7).



in: muscovite core composition
Si ~ 3.38
Fe ~ 0.151
Mg ~ 0.235

ex: muscovite rim composition
Si ~ 3.09
Fe ~ 0.147
Mg ~ 0.057

Fig. 3. The degree and symmetry of phengitic substitution in muscovite in the fine-grained phyllitic mica schist of the northern part of KHU (single grain composition range from core [in] to rim [ex], sampling point db 272)



— — - rim of garnet as inclusion in plagioclase
——·— - rim of garnet in the matrix
———— - rim of garnet both as inclusion and in the matrix

Fig. 2. Zonation profile of garnet from the fine-grained phyllitic mica schists of the northern part of KHU (sampling point db 272)

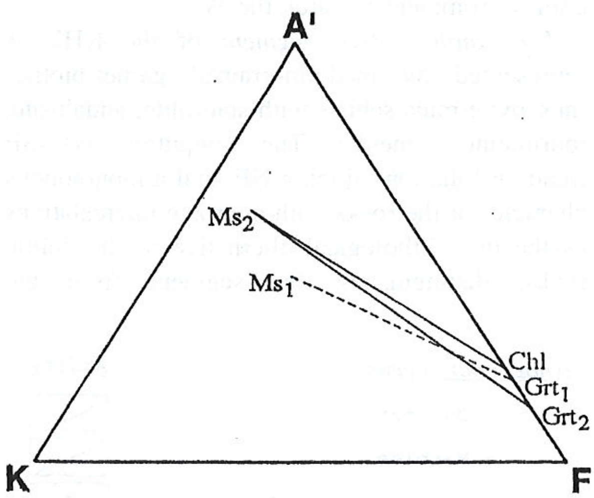


Fig. 4. A'KF diagram of mineral assemblages in the fine-grained phyllitic mica schist of the northern part of KHU (sampling point db 272)

Ms_1 – Muscovite core composition
Ms_2 – Muscovite rim composition
Chl – Chlorite from matrix assemblage
Grt_1 – Garnet core composition
Grt_2 – Garnet rim composition

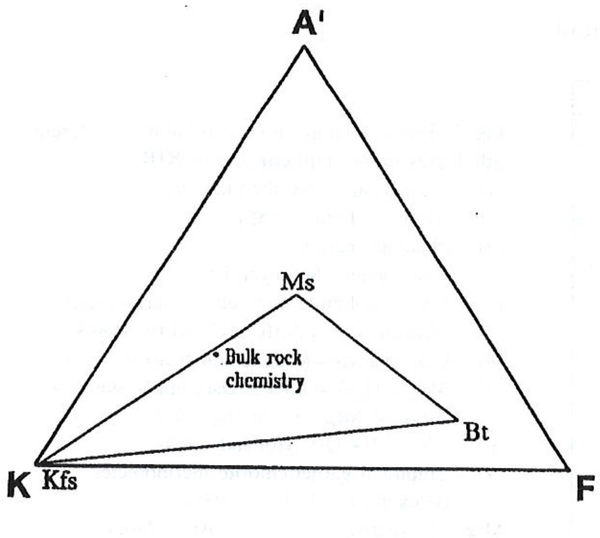
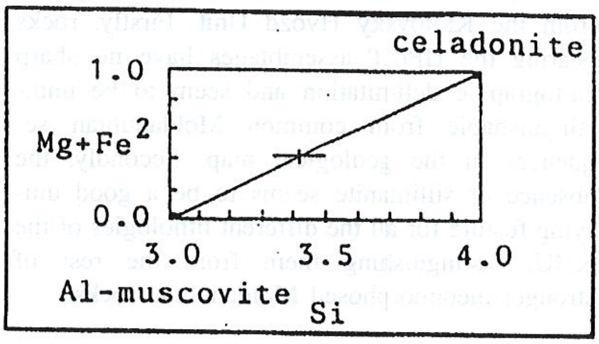


Fig. 5. A'KF diagram of mineral assemblages in the mylonitized granite of the northern part of KHU (sampling point db 120)
Kfs – K-Feldspar
Bt – Biotite
Ms – Muscovite



Si ~ 3.42
Fe ~ 0.162
Mg ~ 0.288

Fig. 6. The degree and symmetry of phengitic substitution in muscovite from the mylonitized granite of the northern part of KHU (single grain composition from the core, sampling point db 120)

Structurally overlying the above mentioned mylonitized granites and graphitic dolomitic marbles, close to the CBF and parallel to its strike, there are fine-grained phyllitic schists, with the following assemblage: quartz (~ 50 vol %), albite, garnet, chlorite, muscovite and ilmenite. Biotite is absent (sampling point db 272).

Garnet grains, up to 100 μm in diameter, occur either in the matrix, or included in albite porphyroblasts. In the latter case they are by one third smaller. Their zonation shows a bell-shaped spessartine curve, compensated by variation in almandine and pyrope. The Fe/Fe+Mg ratio decreasing from core to rim of the garnet grains (Fig. 2), indicates increasing temperature during growth (i.e. prograde metamorphic evolution) (Spear et al. 1991). Garnets in the matrix differ from those included in albite porphyroblasts. In matrix garnets the grossular curve switches from increasing to decreasing trends in the outermost zones – a feature absent in garnets enclosed in albite (Fig. 2).

As the coexisting plagioclase is a homogeneous albite (An_{02}-An_{03}), there was another Ca-bearing phase present, (e.g. margarite, epidote, ...), providing calcium to the growing garnet, and the variation in grossular should not be used as a pressure indicator.

Muscovite also shows a compositional zoning. Cores exhibit phengitic substitution (3.38 Si_{pfu}), decreasing to the rims (3.09 Si_{pfu}). Fe^{3+} does not take part in the phengite substitution and therefore its important content in muscovite should not enable to regard the total iron content for the purposes of phengite barometry (Massonne – Schreyer 1987). Nevertheless, in contrast to the rims of muscovite, core composition is characterized by the symmetry of silica substitution for aluminium in the tetrahedral position, and of the substitution of Mg+Fe sum for Al in the octahedral positions. Thus, trivalent iron is expected to be unimportant (Fig. 3). Moreover, the only Fe-Ti accessory is ilmenite and magnetite is absent in this phyllitic rock.

Chlorite coexisting with garnet in the matrix has X_{Mg} ~ 0.59.

For the purpose of geothermobarometric application, the following two mineral assemblages were taken into account (Fig. 4):
(1) Coexisting phengitic muscovite (Ms_1) and garnet (Grt_1) in their first stages of growth as characterized by core compositions;
(2) matrix assemblage muscovite-chlorite-garnet rim (Ms_2-Chl-Grt_2) (because of the supposed fractional crystallization model).

For assemblage 1, the garnet-muscovite thermometer (Hynes – Forest 1988) yields temperatures of 450 °C (curve 1, Fig. 7); the phengite barometer (Massonne – Schreyer, 1987) gives a pressure value of 8 kb (curve 2, Fig. 7), corresponding to the temperature indicated above. As there is no K-

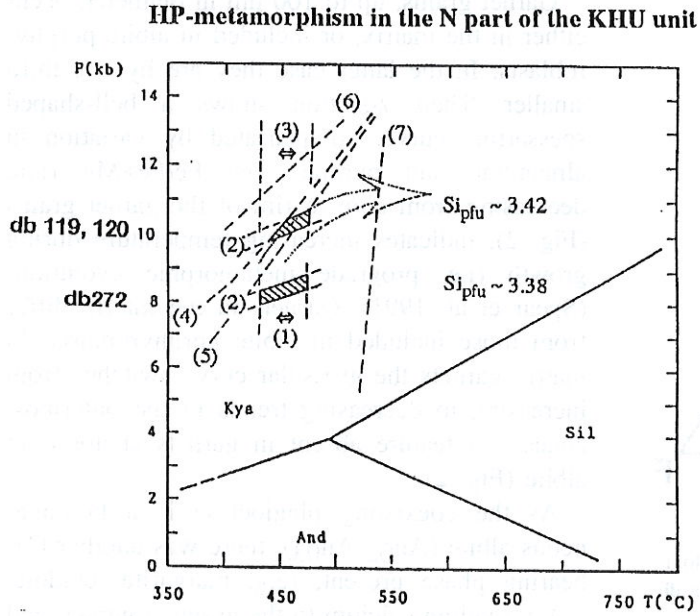


Fig. 7. Pressure-temperature evolution of different lithologies in the northern part of KHU
(1) – Garnet-muscovite thermometer (Hynes – Forest 1988)
(2) – Phengite barometer (Massonne – Schreyer 1987)
(3) – Calcite-dolomite and calcite thermometer (Powell – Condliffe – Condliffe 1984)
(4) – Calcite/aragonite transition (Carlson 1980)
(5) – Mrg + H_2O = Lws + Dsp, upper stability curve of Mrg (Chatterjee 1974)
(6) – Ab = Jd + Qtz (Holland 1980)
(7) – Empirical garnet-chlorite thermometer (Dickenson – Hewitt 1986)
Mrg – Margarite; Ab – Albite
H_2O – Vapour; Jd – Jadeite
Lws – Lawsonite; Otz – Quartz
Dsp – Diaspor

feldspar present in the rock, this pressure estimate should represent a minimum value (Fig. 7). A strong symmetry of phengitic substitution and absence of Fe^{3+}-bearing Fe-Ti accessories exclude content of trivalent iron in muscovite.

In assemblage 2, the asymmetrical phengitic substitution of muscovite rim (Fig. 3) makes it useless for barometric purposes. As mentioned above, the fractional crystallization of garnet is here supposed. Thus, only the outermost rim of growing grain is in equilibrium with the matrix assemblage. Fe-Mg cation exchange between garnet and chlorite was measured in the immediate contact of both minerals (analysed points taken ca 2 μm from each other). An empirical garnet-chlorite thermometer (Dickenson – Hewitt 1986) approximately quantifies increasing temperature conditions during garnet growth and hence the prograde metamorphism (curve 7, Fig. 7).

The phengite barometer (Massonne – Schreyer 1987) used on muscovite of the mylonitized granite (db 120) yields a pressure estimate of 10 kb for the supposed temperature of 450 °C (Fig. 7). This information is supported by the taramite-albite assemblage of metabasic rocks found in the corresponding structural position about 3 km to the east (Babůrek, unpublished data).

Thus, metamorphism in the northern segment of KHU, bound to the CBF, has an intermediate character between MP/LT and HP/LT (Fig. 7). The dotted arrow in Fig. 7 corresponds to supposed PT-evolution of this segment, as in the underlying rocks of the SW-segment metabasites with pargasite have been found, the PT-position of which is situated at the peak of the arrow vector (Babůrek, unpublished data). Despite of the fact that the PT conditions distinguished seem to be extraordinary for Moldanubian rocks, there are no good reasons for exclusion of this segment from the Královský Hvozd Unit. Firstly, rocks bearing the HP/LT assemblages have no sharp cartographic delimitation and seem to be undistinguishable from common Moldanubian sequences in the geological map. Secondly, the absence of sillimanite seems to be a good unifying feature for all the different lithologies of the KHU, distinguishing them from the rest of stronger metamorphosed Moldanubian rocks.

The south-eastern part of KHU

For the purpose of PT-quantification of the Barrovian metamorphism in the KHU, rock samples from the small area of kyanite zone in the south-eastern segment of banded gneisses of greywacke character have been chosen.

The foliation of this segment corresponds to that of the Variegated Group (NE-SW). It is refolded to a NW-SE direction and kyanite porphyroblasts are oriented with their long axis parallel b-axis of the younger structural set (NW-SE, steep SW-dipping) (Fig. 1).

Two different mineral assemblages from one rock sample are considered (Fig. 8 and 9):
(1) Assemblage I comprises inclusions in garnet: (Ms_1-Chl-Bt_1-Grt_1-Pl_1) (Fig. 8 and/or 9);
(2) Assemblage II consists of matrix minerals: (Ms_2-Bt_2-Grt_2-Pl_2-Ky) (Fig. 8 and/or 9).

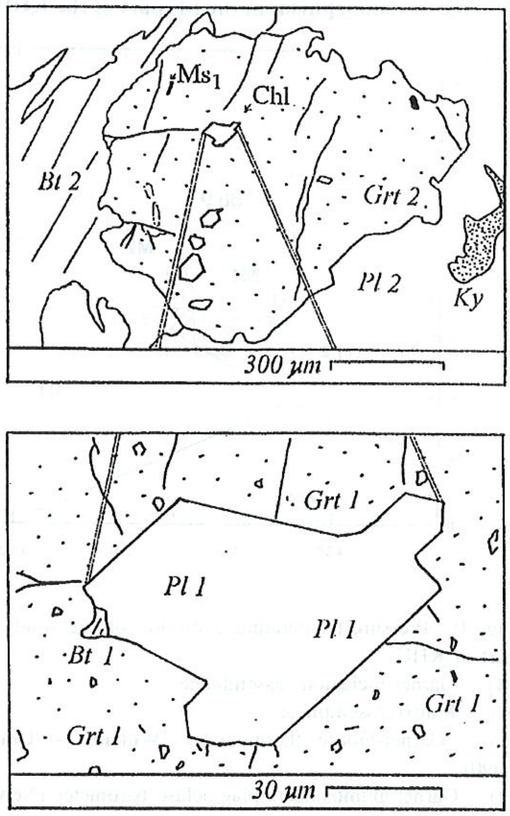


Fig. 8. Mineral assemblages of the banded gneiss of greywacke character from the south-eastern part of KHU in thin section scheme (sampling point db 9)
Ms_1 – Muscovite from garnet inclusion assemblage
Chl – Chlorite from garnet inclusion assemblage
Bt_1 – Biotite from garnet inclusion assemblage
Bt_2 – Biotite from rock matrix assemblage
Grt_1 – Garnet core composition
Grt_2 – Garnet rim composition
Pl_1 – Plagioclase from garnet inclusion assemblage
Pl_2 – Plagioclase from matrix assemblage
Ky – Kyanite from matrix assemblage

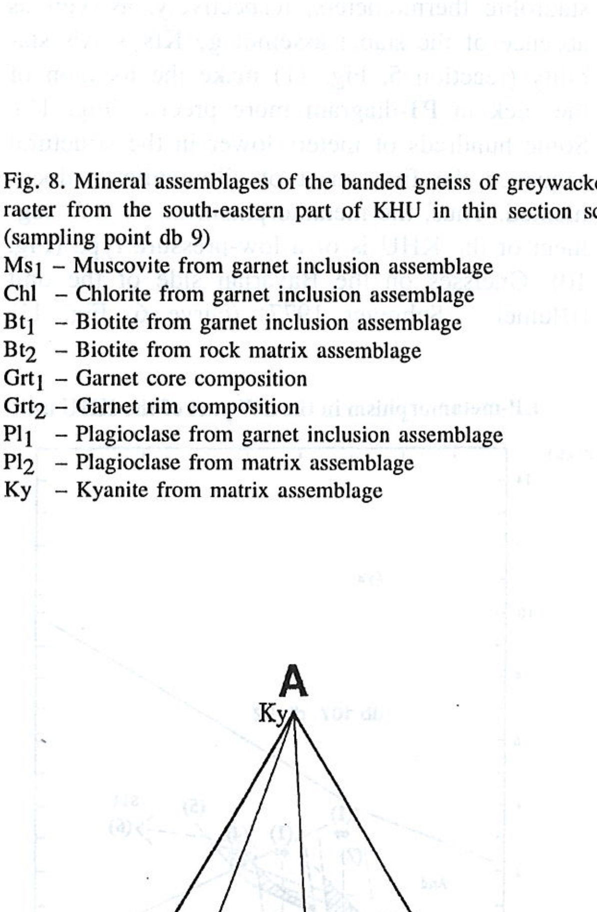


Fig. 9. AFM diagram of mineral assemblages in the banded gneiss of greywacke character from the south-eastern part of KHU (sampling point db 9)
Chl – Chlorite from garnet inclusion assemblage
Bt_1 – Biotite from garnet inclusion assemblage
Bt_2 – Biotite from rock matrix assemblage
Grt_1 – Garnet core composition
Grt_2 – Garnet rim composition
Ky – Kyanite from matrix assemblage

Ad (1) The inner parts of garnet with Fe/Fe+Mg about 0.88, contain euhedral plagioclase inclusions with normal zonation and a higher Ca-content (An_{34} ~ core, An_{25} ~ rim), and biotite with X_{Mg} ~ 0.52, as well as chlorite and phengitic muscovite with paragonite substitution (X_{Na} ~ 0.43, Si_{pfu} ~ 3.23).

The garnet-biotite thermometer (Williams – Grambling 1990) and GASP barometer (Newton – Haselton 1981) yield following conditions: T ~ 500 °C/5.5 kb (domain „M1“, Fig. 10).

Ad (2) The matrix assemblage consists of the outermost rim of garnet (Fe/Fe+Mg ~ 0.825), a more sodic plagioclase than the inclusion type and without zonation (An_{12}), kyanite, biotite (X_{Mg} ~ 0.54) and muscovite with only slight phengite and paragonite substitution (X_{Na} ~ 0.17, Si_{pfu} ~ 3.09).

The garnet-biotite thermometer (Williams – Grambling 1990) and GASP barometer (Newton – Haselton 1981) yield following PT-conditions: 590 °C/6.5 kb) (domain „M2“, Fig. 10).

The latter PT-conditions are close to the kyanite/sillimanite boundary thus explaining the sillimanite isograd in the structurally underlying rocks in the close vicinity (Fig. 1). Taking into account a possible slight re-equilibration, the PT-curve shown was probably somewhat rotated in the clock-wise direction from the original position (Spear et al. 1991).

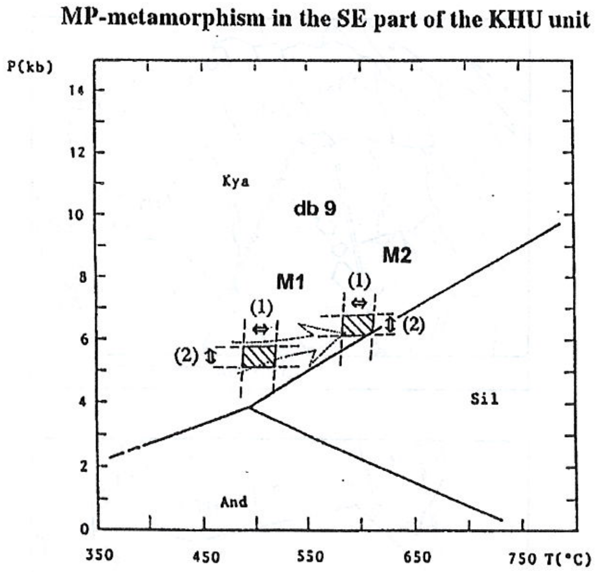


Fig. 10. Pressure-temperature evolution of the south-eastern part of KHU
M_1 – Garnet inclusions assemblage
M_2 – Matrix assemblage
(1) – Garnet-biotite thermometer (Williams – Grambling 1990)
(2) – Garnet-alumosilicate-plagioclase barometer (Newton – Haselton 1981)

The south-western part of KHU

Considering the structurally underlying rocks, medium-grained mica schists strongly prevail among them. Their equilibrium assemblage changes from staurolite-biotite-garnet (the latter partly consumed) (-chlorite-muscovite-quartz), to andalusite-biotite-garnet-staurolite (the latter progressively consumed)(-muscovite-quartz) (Fig. 11) (Babůrek 1994). Further to the SW, sillimanite occurs.

The mineral assemblage mentioned as the first one, i.e. st-bt-grt (garnet partly consumed) (plus chl-ms-qtz) occurs in micaschists 2-3 km eastwards from the Czech/Bavarian border (db 107, Fig. 11). The very beginning consumption of garnet rims, only relic chlorite without contact with muscovite, and equilibrated textural features of the couple staurolite and biotite witness for crossing of the univariant reaction curve grt + chl + ms = st + bt + qtz + H_2O (Spear – Cheney 1989). X_{Mn} of garnet, and combination of garnet-biotite, or garnet-staurolite thermometers, respectively, locate PT-position of this rock into the lower amphibolite facies and very low pressure range (500-525 °C/1-2 kb) (Fig. 10).

The structurally underlying micaschists with the mineral assemblage and-bt-grt-st (the latter progressively consumed or enclosed in andalusite) (plus ms-qtz) occur along the international boundary near the Osser Mountain (db 92, Fig. 10). The very beginning instability of staurolite, abundance of garnet, biotite and mainly andalusite, indicate crossing the univariant curve of the reaction st + ms + qtz = grt + bt + and + H_2O (Spear – Cheney 1989). Garnet-biotite, or garnet-staurolite thermometers, respectively, as well as absence of the stable assemblage Kfs + Als stability (reaction 5, Fig. 11) make the location of the rock in PT-diagram more precise (Fig. 11). Some hundreds of meters lower in the structural sequence the first onset of sillimanite is documented. Thus, the metamorphism in the SW segment of the KHU is of a low-pressure type (Fig. 10). Gneisses on the Bavarian side of the unit (Blümel – Schreyer 1977) (curve 6, Fig. 11)

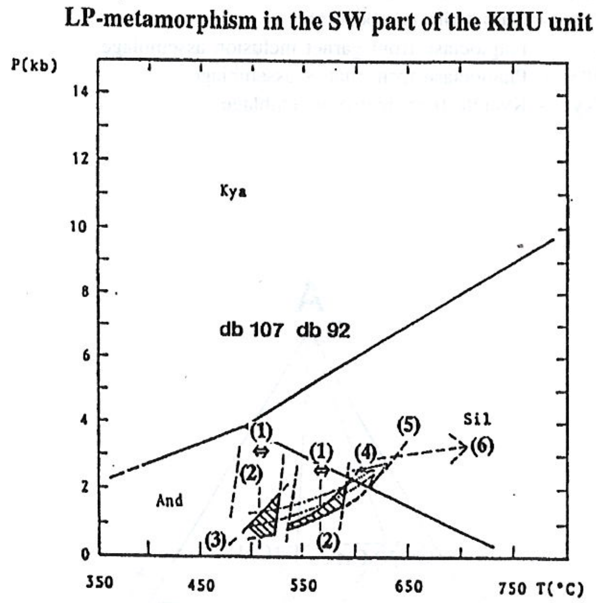


Fig. 11. Pressure-temperature evolution of the south-western part of KHU
(1) – Garnet-biotite thermometer (Williams – Grambling 1990)
(2) – Garnet-staurolite thermometer (Perchuk 1969)
(3) – Grt + Chl + Ms = St + Bt + Qtz + H_2O (X_{Mn} ~ 0.04) (Spear – Cheney 1989)
(4) – St + Ms + Qtz = Grt + Bt + And + H_2O (Spear – Cheney 1989)
(5) – Ms + Qtz = Als + Kfs + H_2O (Spear – Cheney 1989)
(6) – PT-path supposed for Bavarian Sil-Kfs and Crd-Kfs gneisses (Blümel – Schreyer 1976)

Grt – Garnet	H_2O – Vapour
Chl – Chlorite	And – Andalusite
Ms – Muscovite	Als – Alumosilicate
St – Staurolite	Kfs – K-Feldspar
Bt – Biotite	Sil – Sillimanite
Qtz – Quartz	Crd – Cordierite

Table 1. Microprobe analyses of studied samples

Northern segment of KHU

Sampling point db 272

	Ms_1 (No.8)	Chl (No.29)	Grt_1 (No.2)	Grt_2 (No.28)	Pl (No.16)
	wt%				
Na_2O	0.57	0.46	0.02	0.20	11.23
K_2O	9.73	–	0.02	0.03	0.04
CaO	–	0.01	2.60	5.21	0.67
MnO	0.02	0.79	23.25	12.62	0.10
FeO	2.65	20.87	15.04	20.77	0.13
MgO	2.32	16.46	1.05	2.08	0.04
Al_2O_3	28.30	21.92	20.74	20.32	19.81
SiO_2	49.78	25.37	37.46	37.55	68.14
TiO_2	0.10	0.13	0.05	0.09	0.06
Total	93.35	85.96	100.24	99.01	100.25

Sampling point db 119

	Mrg (No.32)	Chl (No.31)	Cal (No.40)	Dol (No.39)
	wt%			
Na_2O	1.37	0.23	0.07	0.20
K_2O	0.00	–	–	–
CaO	10.06	0.14	55.18	30.72
MnO	–	0.04	0.04	0.03
FeO	0.04	2.84	0.14	1.00
MgO	0.19	29.54	0.61	20.05
Al_2O_3	47.17	23.64	–	–
SiO_2	33.65	28.45	0.15	0.11
TiO_2	0.02	0.04	–	–
Total	92.68	85.14	55.98	52.15

Sampling point db 120

	Ms (No.71)	Bt (No.72)	Fsp (No.1)	Pl (No.2)
	wt%			
Na_2O	0.14	0.06	0.49	12.06
K_2O	10.98	9.36	16.08	0.03
CaO	–	–	–	0.04
MnO	0.03	0.09	0.04	0.07
FeO	2.86	16.89	–	–
MgO	2.79	10.29	0.13	–
Al_2O_3	27.77	18.12	18.72	20.09
SiO_2	51.49	37.55	65.16	70.21
TiO_2	0.08	0.65	0.05	–
Total	100.67	97.03	100.33	102.18

Note: For thermobarometric purposes were used following pairs:
Nrs. 2 and 3, Nrs. 7 and 9, Nrs. 25 and 26, Nrs. 20 and 32, Nrs. 2 and 4, Nrs. 83 and 96, Nrs. 32 and 38.

(Table 1 – continued)

South-eastern segment of KHU

Sampling point db 9					
	Ms_1 (No.39)	Bt_1 (No.25)	Bt_2 (No.7)	Grt_1 (No.26)	
wt%					
Na_2O	1.39	0.12	0.31	0.08	
K_2O	7.71	9.39	9.15	0.00	
CaO	-	-	-	2.27	
MnO	-	0.24	0.14	5.04	
FeO	1.42	17.31	17.33	31.59	
MgO	0.65	10.37	11.21	2.48	
Al_2O_3	35.09	20.21	19.78	20.35	
SiO_2	47.97	36.55	36.52	37.84	
TiO_2	1.24	0.99	1.25	-	
Total	95.21	95.05	95.35	99.63	
	Grt_1 (No.2)	Grt_2 (No.9)	Grt_2 (No.20)	Pl_1 (No.3)	Pl_2 (No.32)
wt%					
Na_2O	-	0.14	0.20	8.98	9.22
K_2O	0.03	0.03	0.01	0.14	0.09
CaO	2.67	2.70	2.38	5.35	2.42
MnO	4.02	2.95	2.97	-	0.13
FeO	32.17	31.93	32.70	0.50	0.71
MgO	2.89	3.80	3.69	-	-
Al_2O_3	20.72	20.99	20.84	23.49	19.44
SiO_2	38.15	38.69	38.27	63.12	67.66
TiO_2	0.01	0.03	0.09	-	-
Total	100.64	101.16	101.34	101.27	99.28

corresponding to a still lower structural position project as a higher-T continuation of conditions indicated by our samples.

As andalusite overgrows kyanite in some places, the low-pressure metamorphic path seems to be younger than the medium-pressure one.

The PT-calculations yield data typical of a high heat flow record. This can lead to the characterization of the LP-metamorphism of the SW-segment as a contact (periplutonic) one.

Conclusions

From the data presented it can be seen, that there are at least three kinds of PT-trajectories in the Královský Hvozd Unit. As it is often observed in the Bohemian Massif, rocks of contrasting pressure evolution can be exposed together in close proximity due to their complex tectonic evolution. Thus, the interpretation of the contrasting PT-paths requires additional constraints provided also by geochronology and kinematic analysis.

The more lithologically variegated northern segment underwent a higher-pressure event (450 °C/10 kb), at least in structural levels related to the Central Bohemian Fault. This segment conserves metamorphic record without equivalence in the whole Moldanubian Zone.

A subsequent, probably Early Variscan medium-pressure metamorphism conserved in the SE part of KHU and yielding progressive Barrovian conditions (from 500 °C/5.5 kb to 590 °C/6.5 kb) was further by a low-pressure stage (PT-path ranging from 525 °C/1.5 kb to 575 °C/2 kb) (dating of cooling age corresponds to 320 Ma – Kreuzer 1989). A nearly isobaric, very low-pressure progressive character of this last metamorphic stage of probably Late Variscan age witnesses for its contact (periplutonic) character.

The temporal relations mentioned above are based on the observed refoliation of NE-SW

(Table 1 – continued)

South-western segment of KHU

Sampling point db 107					
	Ms (No.27)	Chl (No.14)	Bt (No.18)	Grt (No.19)	St (No.23)
wt%					
Na_2O	1.45	0.82	0.41	0.04	0.18
K_2O	8.45	0.02	7.47	–	0.04
CaO	–	0.02	–	0.39	–
MnO	–	0.07	–	1.63	0.04
FeO	1.32	30.27	25.10	39.04	13.99
MgO	0.34	9.70	6.66	1.64	1.26
Al_2O_3	35.62	21.89	18.41	20.68	53.11
SiO_2	45.41	22.82	31.94	36.53	26.94
TiO_2	0.32	0.03	1.51	0.10	0.56
Total	92.77	85.83	91.40	100.10	96.27

Sampling point db 92					
	Ms (No.36)	Chl (No.35)	Bt (No.34)	Bt (No.96)	St (No.38)
wt%					
Na_2O	1.53	0.15	0.35	0.32	0.96
K_2O	9.44	–	9.06	8.84	–
CaO	–	0.00	–	–	0.05
MnO	0.02	0.20	0.11	0.19	0.47
FeO	2.37	24.33	19.69	19.99	12.34
MgO	0.48	13.86	9.24	9.62	1.48
Al_2O_3	35.10	22.17	18.78	18.63	53.72
SiO_2	46.38	24.29	35.39	35.63	27.31
TiO_2	0.36	0.18	2.35	1.76	0.55
Total	95.61	85.17	94.87	94.83	97.07

Sampling point db 92					
	Bt (No.4)	Grt (No.83)	Grt (No.2)	Grt (No.32)	Crd (No.33)
wt%					
Na_2O	0.20	0.13	0.20	–	0.34
K_2O	7.91	–	0.01	0.01	–
CaO	–	2.03	1.75	1.80	–
MnO	0.41	4.58	4.11	5.57	0.53
FeO	20.71	32.29	33.10	31.74	7.78
MgO	8.20	2.84	2.69	2.48	8.02
Al_2O_3	18.92	20.54	20.68	20.15	32.27
SiO_2	35.58	38.14	38.50	37.29	48.61
TiO_2	1.98	0.05	–	0.05	0.05
Total	93.74	100.56	101.03	99.19	97.54

trending structures carrying the HP/LT assemblages by younger NW-SE structures, bearing MP- and LP-assemblages (Babůrek 1991). Andalusite overgrowing kyanite witnesses still younger age of the low-pressure metamorphic record in the SW-segment of KHU.

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Vysoko-, středně- a nízkotlaké minerální asociace z české části jednotky Královského hvozdu v moldanubiku jihozápadních Čech

Jednotka Královského hvozdu, konvenčně řazená do monotónní série moldanubika, se vyznačuje významnou litologickou heterogenitou. Z tohoto hlediska byla proto revidována pozice izográd indexových minerálů (Vejnar 1963, 1991). První výskyt staurolitu sleduje hlavní litologické rozhraní mezi metapelity s.s. a horninami spíše drobového charakteru. Byly rozlišeny tři hlavní litologické segmenty, které uchovávají různá stadia teplotně tlakového vývoje jednotky Královského hvozdu. Litologicky pestrý s. segment prodělal výšetlaký a nízkoteplotní vývoj (450 °C/10 kb), který nemá v moldanubiku ekvivalent. Vzhledem k blízkosti hornin s tímto vývojem k tektonické zóně českého švu lze předpokládat jejich alochtonní pozici. Na bavorské straně byly v horninách obdobného metamorfního stupně i strukturní pozice identifikovány silurské mikrospory (Reitz 1992). Nelze však vyloučit, že zde v s. segmentu byla konzervována specifická etapa vývoje moldanubika. Jihovýchodní segment rul drobového charakteru uchovává prográdní barroviensky trend s PT-hodnotami od 500 °C/5.5 kb pro minerály uzavřenin v granátu do 590 °C/6,5 kb pro minerály v základní hmotě horniny. Jihozápadní segment metapelitů s.s. vykazuje následný nízkotlaký vývoj s PT-hodnotami od 525 °C/1,5 kb ve vyšších strukturních patrech segmentu do 575 °C/2 kb v jejich podloží. Významný tepelný tok, předpokládaný na základě termobarometrie, dokládá výrazný kontaktní (periplutonický) charakter metamorfózy tohoto segmentu.