

Further data concerning the pressure character of the Hercynian metamorphism in the West Carpathians (Czechoslovakia)

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ABSTRACT. — New data on the pressure character of the Hercynian metamorphism in the Czechoslovak West Carpathians are presented and discussed. Geobarometric estimations are based on the b_0 values of muscovites from phyllites.

Three sample populations are considered, corresponding to a total of 172 new b_0 values. One sample population (phyllites from the Brusník Anticline) gives a mean b_0 value of 8.994 Å ($s = 0.005$; $n = 60$). The other two sample populations (Štós Formation from the Gemicum; Predná Holá Complex from the Veporicum) supply significantly lower b_0 values, due to the high Al-content of the rocks, shown by the systematic occurrence of paragonite.

These new analytical data confirm that, in the West Carpathians as well as in the central part of the Alpine-Mediterranean Belt, the Hercynian metamorphism recorded in the phyllites, is of low-pressure (metamorphic thermal gradient about 40°C/km), with only one exception (Poiana Rusca, South Carpathians, Romania).

Key words: Hercynian metamorphism, pressure character, muscovite b_0 values, West Carpathians, Czechoslovakia.

RIASSUNTO. — Nel presente lavoro sono riportati e discussi nuovi dati riguardanti il carattere barico del metamorfismo Ercinico nei Carpazi Occidentali (Cecoslovacchia). Le stime geobarometriche sono basate sui valori di b_0 delle muscoviti presenti in campioni di filladi.

Sono prese in considerazione tre diverse popolazioni di campioni, per un totale di 172 nuove misure di b_0 . Il primo gruppo è costituito da campioni di filladi dell'Anticlinale di Brusník e fornisce un valore medio di b_0 pari a 8.994 Å ($s = 0.005$; $n = 60$). I valori di b_0 delle altre due popolazioni di campioni (rispettivamente provenienti dalla Formazione di Štós nel Gemicum, e dal Complesso di Predná Holá nel Veporicum), sono signifi-

cativamente inferiori, a causa dell'alto contenuto in Al nelle rocce indicato dalla presenza sistematica di paragonite.

Questi nuovi dati analitici confermano che nei Carpazi Occidentali, così come nella parte centrale della Fascia Alpino-Mediterranea, il metamorfismo Ercinico registrato nelle filladi risulta essere di bassa pressione (con gradiente termico metamorfico intorno ai 40°C/km), con una sola eccezione (Poiana Rusca, Carpazi Meridionali, Romania).

Parole chiave: Metamorfismo Ercinico, carattere barico, valori di b_0 di muscoviti, Carpazi Occidentali, Cecoslovacchia.

Introduction

In the last few years the pressure character of metamorphic events has received much more attention than in the past, not only for gather additional data for interregional comparisons, but also as a powerful tool for the geodynamic interpretation of metamorphic events.

In this context, attempts at classifying the pressure character of the Hercynian metamorphism have also recently been carried out in the West Carpathians. Low-grade metapelites from various localities in the Gemicum were taken into consideration (SASSI & VOZÁROVÁ, 1987), using the b_0 values of potassic white mica for geobarometric purposes (SASSI, 1972; SASSI

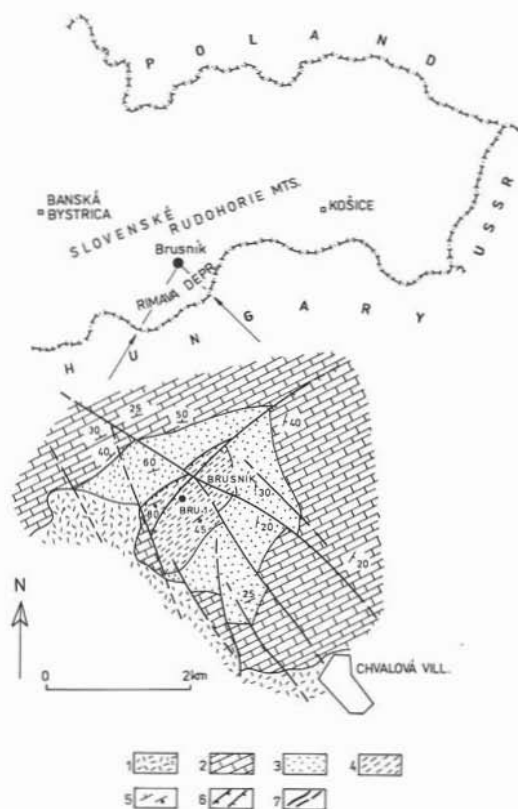


Fig. 1. — Paleozoic in Brusník Anticline with location of borehole BRU-1 (map compiled according to MELLO & VOZÁROVÁ, in VESS et al., 1986).

1) Neogene volcanics and sediments; 2) Mesozoic sequences of Silica nappe (Lower and Middle Triassic); 3) multicolored sediments of Brusník Formation (Permian); 4) Paleozoic phyllites with minor marbles, metalydites and acid metavolcanoclastics; 5) bedding, scistosity; 6) overthrust; 7) fault, supposed fault.

& SCOLARI, 1974; GUIDOTTI & SASSI, 1976, 1986).

In the present paper three sample populations of metapelites from three different rock sequences were taken into consideration. They are: 1) Predná Hol'a Complex; 2) Štós Formation; 3) Brusník Anticline. In each case only metapelites of suitable metamorphic grade (lower greenschist facies), bulk composition (as indicated by SASSI & SCOLARI, 1974) and oxidation grade (as indicated by GUIDOTTI & SASSI, 1976) were taken into consideration. However, the occurrence of paragonite was ascertained in some of the samples, as will be discussed later.

Recalling that three main tectonic units make up the West Carpathians (from lowest to highest: Tatricum, Veporicum, and Gemicum), from the structural point of view the Štós Formation belongs to the Gemicum while the Predná Hol'a Complex belongs to the Veporicum; the Brusník Anticline is a separate rock sequence of problematic structural classification, very similar to the Early Paleozoic sequences of the Gemicum.

The other Early Paleozoic rock sequences in the West Carpathians display either a significant Alpine metamorphic overprint or a relatively high pre-Alpine metamorphic grade, and so they cannot be used for the characterization of the Hercynian greenschist facies metamorphism. Therefore, the data presented in this paper represent the maximum information which can be obtained from greenschist-facies terrains concerning the pressure character of the Hercynian metamorphism in the West Carpathians. The only further data which could complete an overall pressure classification of the pre-Alpine greenschist-facies terrains in the Czechoslovak West Carpathians can be obtained from the Janov Grun Complex (Veporicum) and the main area of the Rakovec Group, to which Štós Formation belongs.

Phyllites from the Brusník Anticline

This phyllitic sequence outcrops, associated with small amounts of metamorphic limestones, lydites and acidic volcanoclastics, in the ambit of an anticline completely surrounded by the Mesozoic sediments of the Silica Nappe. The structural classification of this anticline is problematic, although it displays lithological similarities with the Gemicum. Fig. 1 shows the main geological features of this area and the location of the borehole from which the phyllites considered here come.

Sixty samples of these phyllites were analyzed for the b_0 value of potassic white micas, following the analytical procedures suggested by SASSI (1972) and SASSI & SCOLARI (1974). In the ambit of the SiO_2 - Al_2O_3 - Na_2O - K_2O - H_2O system, the mineral assemblage in all samples is muscovite-

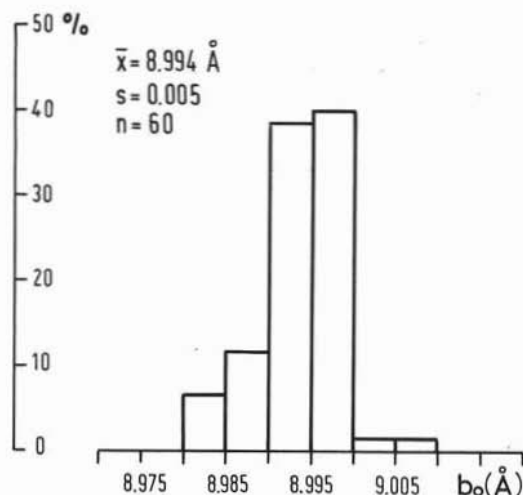


Fig. 2. — Histogram of the muscovite b_0 values in the paragonite-free phyllites from Brusník Anticline. Average value (\bar{x}), standard deviation and number of samples are also shown.

albite-quartz. Small amounts of chlorite also occur. Paragonite was not detected by means of the standard X-ray diffraction analyses.

From the chronological point of view:

- sedimentation age is assumed to be pre-Westphalian (on the base of conodonts, F. Ebner - personal communication);
- metamorphic age is assumed to be Hercynian, considering that the overlying Late Paleozoic sediments do not display significant Alpine metamorphic crystallization.

All 60 b_0 values of the potassic white micas obtained from these metapelites fall in a relatively small range, between 8.981 and 9.006 Å, with an average value of 8.994 Å (standard deviation = 0.005). Their frequency distribution is shown in Fig. 2.

These data clearly indicate the low pressure character of the Hercynian metamorphism recorded in the Early Paleozoic sediments of the Brusník Anticline.

Štós Formation

The Štós Formation was defined as a part of the Rakovec Group which, after the Gelnica Group (see SASSI & VOZÁROVÁ, 1987, for the corresponding b_0 values), is the largest

Early Paleozoic sequence in the Gemericum. This formation is not directly connected to the Rakovec Group (Fig. 3), but is lithologically similar to its basal part (BAJANIĆ et al., 1981).

The main part of the Štós Formation consists of low-grade, laminated metasiltstones interlayered with fine-grained metasandstones and phyllites and rare basic metavolcanoclastics.

The sedimentation age of the Štós Formation is presumed to be Devonian-Lower Carboniferous, because these rocks underlie the Upper Carboniferous-Permian cover. Furthermore, lithic fragments of Štós Formation rocks occur within the clastic sediments of the above-mentioned Upper Paleozoic cover.

The 57 rock samples considered for b_0 measurements of muscovites were taken from two phyllitic horizons close to the village of Štós (Fig. 3).

X-ray diffraction analyses indicated the systematic occurrence of paragonite in these samples. Therefore, with reference to the SiO_2 - Al_2O_3 - Na_2O - K_2O - H_2O system, the mineral assemblage in all these samples is muscovite-paragonite-albite. Chlorite is the typical Fe-Mg phase: as a consequence of the occurrence of paragonite, the b_0 values of potassic white mica from these Al-rich metapelites cannot be compared to those from muscovite-albite metapelites (SASSI, 1972), and are expected to be significantly lower (GUIDOTTI & SASSI, 1976; GOMEZ-PUGNAIRE et al., 1978).

The analytical results fully confirm the above expectations: all b_0 data fall in the range 8.972-8.993 Å, the average value being 8.980 Å (standard deviation = 0.005). These very low b_0 values, the frequency distribution of which is shown in Fig. 4, cannot be directly interpreted as monitoring extremely low pressure values, for the above reasons.

However, some inferences on pressure character can still be made if the few quantitative data which are available concerning the decrease of muscovite b_0 in Al-rich metapelites are taken into due consideration. These few data, concerning the difference D between muscovite average b_0

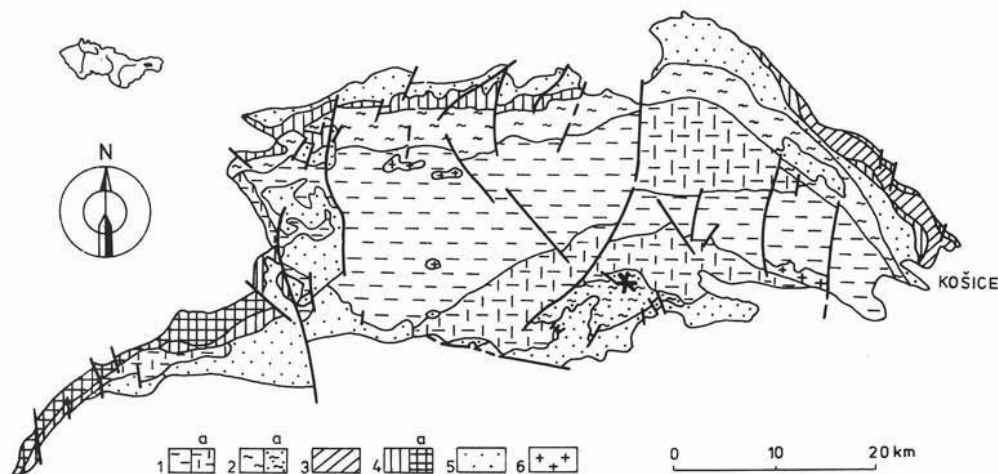


Fig. 3. — Geological sketch of Gemicum (taken from BAJANIK et al., 1984). Asterisk: location of rock samples considered for muscovite b_0 measurements.

1) Gelnica Group; 1a) Drnava Formation; 2) Rakovec Group; 2a) Štós Formation; 3) Črmel Group; 4) Dobšiná Group; 4a) Ochtiná Formation; 5) Late Paleozoic and Mesozoic sequences; 6) Permian-Mesozoic granitoids.

values in Al-rich (paragonite-bearing mineral assemblage) and Al-poorer (paragonite-free mineral assemblages) metapelites are summarized below:

— Sierra de Baza area, Betic Cordilleres (Alpine metamorphism): $D = 0.0122$ (GOMEZ-PUGNAIRE et al., 1978);

— phyllites interlayered within calcschists,

Tauern Window, Eastern Alps (Alpine metamorphism): $D = 0.014$ (GUIDOTTI & SASSI, 1986; and unpublished data);

— Gemicum phyllites, Czechoslovak West Carpathians (Hercynian metamorphism): $D = 0.011$ (SASSI & VOZAROVA, 1987).

These data are not sufficient for a general quantitative extrapolation. However, they do indicate that, in three different regions, D values are relatively very close each to each other, and that they do not seem to be significantly controlled by the difference in pressure existing between metamorphism in the three above mentioned areas. Consequently, it is reasonable to assume that, in the paragonite-free phyllites from the Štós Formation, the average muscovite b_0 value should be around 8.992 \AA (i.e. approx. 0.012 \AA higher than that of 8.980 \AA found in the paragonite-bearing rock samples).

If this reasonable assumption is correct, the pressure character of the Hercynian metamorphism recorded in the Štós Formation is identical to that in the phyllites from the Brusník Anticline.

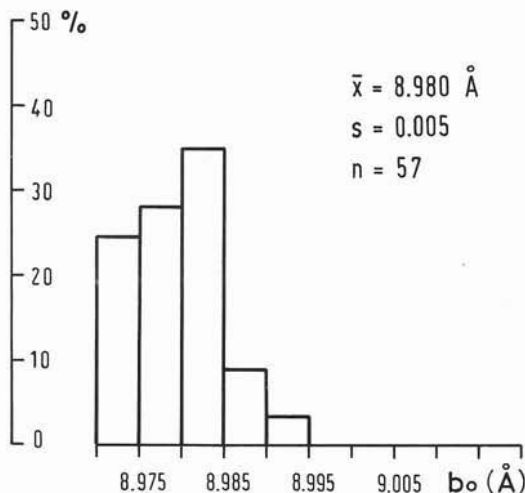


Fig. 4. — Histogram of the muscovite b_0 values in the paragonite-bearing phyllites from Štós Formation. Average value (\bar{x}), standard deviation and number of samples are also shown.

Predná Hol'a Complex

While the two above rock sequences

TABLE 1

Summary of the muscovite b_0 values found in the phyllites from the West Carpathians (Czechoslovakia)

	Sample population	x	s	n	Reference
A	Crmel Group (Gemicum)	8.997 Å	0.003	51	SASSI & VOZAROVA, 1987
	Gelnica Group (Gemicum)	8.999 Å	0.002	8	SASSI & VOZAROVA, 1987
	Brusnik Anticline	8.994 Å	0.005	60	present paper
B	Crmel Group (Gemicum)	8.983 Å	0.002	4	SASSI & VOZAROVA, 1987
	Gelnica Group (Gemicum)	8.986 Å	0.004	47	SASSI & VOZAROVA, 1987
	Ochtina Formation (Gemicum)	8.986 Å	0.005	134	SASSI & VOZAROVA, 1987
	Stos Formation (Gemicum)	8.980 Å	0.005	57	present paper
	Predna Holá Complex (Veporicum)	8.891 Å	0.005	55	present paper

A) paragonite-free phyllites

B) paragonite-bearing phyllites

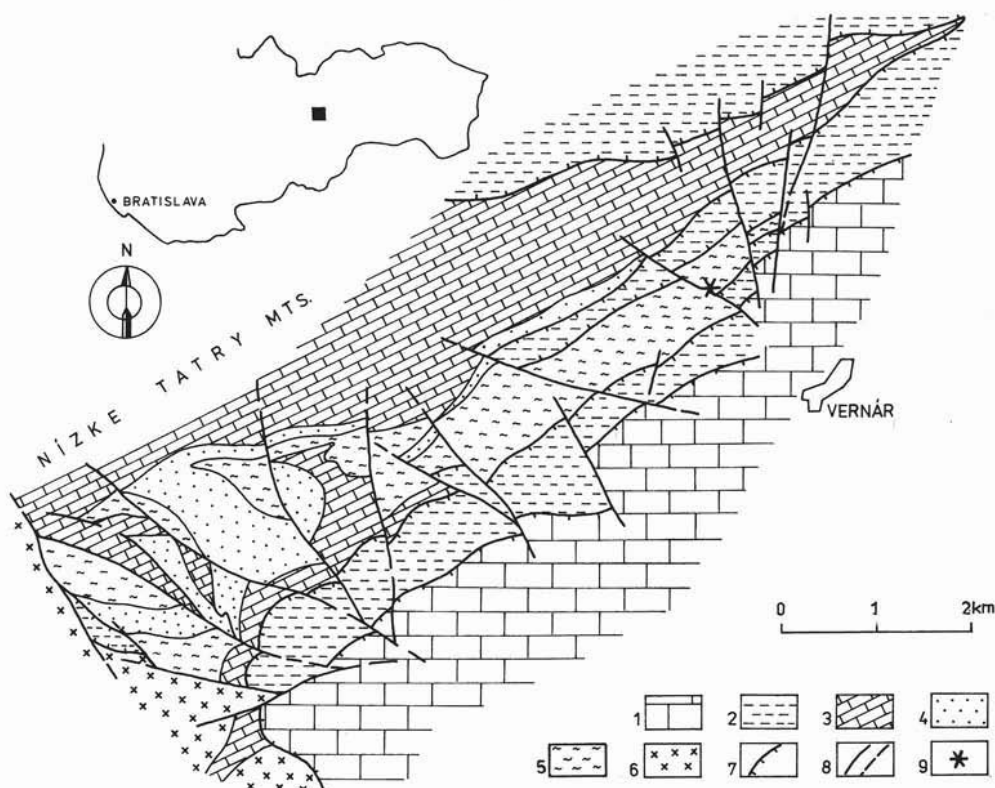


Fig. 5. — Predná Holá Complex near Vernár village, eastern part of Nízke Tatry Mts. (taken from VOZÁROVÁ & VOZÁR, 1988).

1) Gemicum: Mesozoic of Stratená Group; 2) Hronicum: Late Paleozoic of Ipolica Group; 3-6) Veporicum: 3) Mesozoic of Veľký Bok Group; 4) sediments of Ľubietová Group (Permian); 5) metamorphosed sediments, volcanics and volcanoclastics of Predná Holá Complex (Early Paleozoic); 6) granitoids, migmatites, gneisses of Kráľova Holá Complex; 7) overthrust; 8) location of rock samples considered for muscovite b_0 measurements.

belong, either certainly (Štós F.) or probably (phyllites of Brusník A.), to the Gemicum, the Predná Hol'a Complex (Fig. 5) belongs to the Veporicum, to the structural megaunit tectonically interposed between the overlying Gemicum and the underlying Tatricum.

The basal part of the Predná Hol'a Complex includes phyllites with thin intercalations of fine-grained metasandstones. Metavolcanoclastics of basaltic to keratophyric composition are abundant in the upper part, with thin intercalations of black metapelites.

Palyonological data indicate the Devonian-Lower Carboniferous sedimentation age of the Predná Hol'a Complex (PLANDEROVA, in BAJANÍK et al., 1979). Metamorphism is assumed to be Hercynian, because the Alpine reworking in the overlying Upper Paleozoic rocks mainly consists of cataclastic effects, identical to those occurring in the Mesozoic rocks and clearly different from the pervasive metamorphic textures typical of the Predná Hol'a phyllites.

Fifty-five samples of the Predná Hol'a phyllites were taken into consideration for b_0 measurements of muscovite. In this sample population too, X-ray diffraction analyses revealed the systematic occurrence of paragonite. Therefore, as a consequence of the high Al content in the rock bulk composition, b_0 values lower than those which should be found in the corresponding paragonite-free phyllites are expected.

In fact, all 55 b_0 muscovite values obtained from the Predná Hol'a phyllites fall in the range 8.972–8.988 Å, the average value being 8.981 Å (standard deviation = 0.005). Therefore, the situation is identical to that found in the Štós Formation phyllites, when mineral assemblage and b_0 values are considered, as the b_0 frequency distribution in Fig. 6 also shows.

The above considerations indicate that the interpretations proposed for the Štós phyllites are also strictly appropriate for the Predná Hol'a phyllites. The conclusion is that the metamorphic pressure conditions were identical in these two phyllitic sequences.

Conclusion

The data presented in this paper allow the

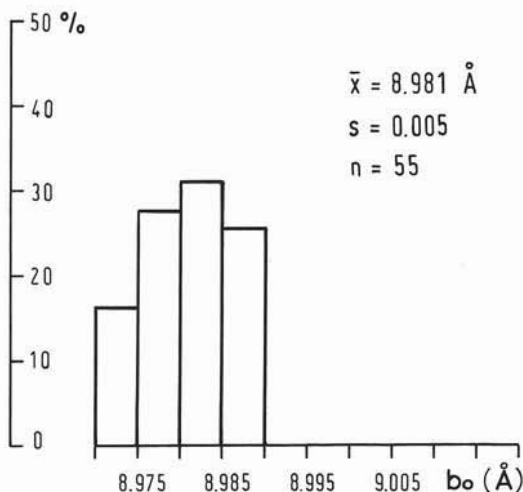


Fig. 6. — Histogram of the muscovite b_0 values in the paragonite-bearing phyllites from Predná Hol'a Complex. Average value (\bar{x}), standard deviation and number of samples are also shown.

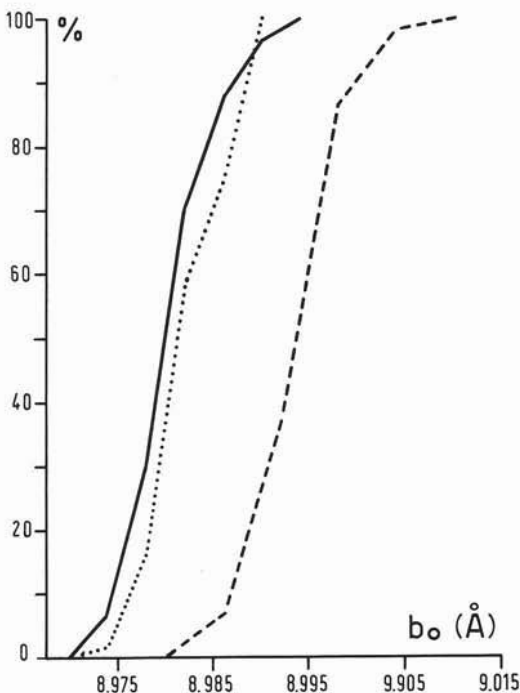


Fig. 7. — Cumulative frequency curves of the muscovite b_0 values in the paragonite-bearing phyllites from the Štós Formation (dotted line) and from the Predná Hol'a Complex (solid line), and in the paragonite-free phyllites from the Brusník Anticline (dashed line).

following conclusions to be proposed.

1) The pressure conditions of the Hercynian metamorphism recorded in the phyllites of the Brusník Anticline correspond to about 3 Kb, if the data presented by SASSI & SCOLARI (1974) and GUIDOTTI & SASSI (1986) are taken as reference.

2) Similar pressure values can be admitted in both the Štós Formation and the Predná Hol'a Complex. In fact, the significantly lower b_0 values found in muscovite from these phyllites (Fig. 7) are due to the higher Al-content in these rocks, as demonstrated by the systematic occurrence of paragonite in them.

3) In terms of metamorphic thermal gradient, values close to 40°C/km may reasonably be assumed on the basis of the muscovite b_0 values obtained from these rocks and the muscovite b_0 isopleths proposed by GUIDOTTI & SASSI (1986).

4) Identical values of both metamorphic pressure and thermal gradient prevailing during the Hercynian metamorphism may be admitted for all low-grade metapelites in the Czechoslovak West Carpathians, if the data presented by SASSI & VOZÁROVÁ (1987) are also taken into consideration.

5) As regards interregional comparisons, the new data discussed in the present paper confirm the general picture summarized by SASSI & VOZÁROVÁ (1987, p. 79): the Hercynian metamorphism recorded in the low-grade metapelites from the central part of the Alpine-Mediterranean Belt turns out to be systematically related to low-pressure conditions (i.e. high metamorphic thermal gradients), with the single exception found by KRAUTNER et al. (1976) in the Poiana Rusca Massif (South Carpathians, Romania).

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