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CONSTRAINTS ON P-T CONDITIONS OF HIGH-GRADE METAMORPHISM IN THE GÓRY SOWIE MTS, WEST SUDETES

Abstract. P-T conditions of metamorphism that affected the Góry Sowie Mts gneisses (West Sudetes, SW Poland) were determined with use of garnet-biotite (GB) and muscovite-biotite (MB) geothermometry, and muscovite geobarometry on selected rocks. Granulite and sillimanite-bearing layered gneiss from the Bystrzyckie Lake region (northern part of the Góry Sowie Mts) revealed GB temperatures 652 ± 35°C. To the south, layered gneiss and metapegmatite from the Przygórze area yielded similar GB temperatures (660 ± 28°C), lower MB temperatures (613 ± 25°C) and pressures 6.4 ± 1.4 kbar. In the central part of the massif, finely laminated gneiss and diatexite from the Potoczek region revealed MB temperatures 596 ± 24°C and pressures 5.2 ± 0.7 kbar. A similar temperature (600 ± 25°C) was obtained out of a flaser gneiss from the Kietlice region in the Fore-Sudetic part of the Góry Sowie Block. Differences between GB and MB results might be related to different speed of ion diffusion between coexisting minerals. We suggest that reported data are related to initial midcrustal exhumation and coeval amphibolite facies metamorphism.

Key-words: geothermobarometry, gneisses, granulites, Góry Sowie Mts, Bohemian Massif, West Sudetes

INTRODUCTION

The Góry Sowie Block, located in SW Poland, is an allochtonous terrane that underwent a polyphase thermal evolution (e.g. Żelaźniewicz 1987, 1990). Metamorphic assemblages preserved within the massif include granulite and metabasite units enveloped by a widespread amphibolite-facies matrix. Previous authors have described thermal and barometric histories of the Góry Sowie; however estimates of the conditions of metamorphism that affected main rock types — gneisses and migmatites — were based mainly on the presence of mineral paragenesis in these rocks and structural investigations (e.g. Kryza 1981; Żelaźniewicz 1987, 1990). Quantitative methods were

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selectively used mainly to determine metamorphic conditions of metabasites and granulites (e.g. Kryza et al. 1996; O'Brien et al. 1997). Geothermobarometry (e.g. garnet--biotite geothermometry and garnet — Al_2SiO_5 — plagioclase geobarometry) was also used to determine P-T conditions of metamorphism that affected migmatitic gneisses, which enclose metabasites (e.g. Kryza, Pin 1998, 2002). These results indicate that migmatitic gneisses were metamorphosed in peak of metamorphism conditions of 825–875°C and 9.5–11 kbar (Kryza, Pin 1998, 2002). In this paper we report new results from thermobarometric analyses on selected rocks from the Góry Sowie, obtained with use of garnet-biotite and muscovite-biotite geothermometry, and muscovite geobarometry.

GEOLOGICAL BACKGROUND

The Góry Sowie Block — located in West Sudetes, SW Poland — is divided by NW-SE trending Sudetic Marginal Fault into two portions: the Góry Sowie Mts. and the Fore-Sudetic Block (Fig. 1). Paragneisses and migmatites are dominant rock types within this metamorphic complex, with minor amounts of granulites, metabasites, eclogites, peridotites and calc-silicate rocks (e.g. Kryza 1981; Żelaźniewicz 1987, 1990).

The typical composition of gneisses and migmatites is quartz, oligoclase and biotite, with additional sillimanite, muscovite, K-feldspar or cordierite occurring as index minerals. Secondary minerals distinguished are: garnet, kyanite, apatite, zircon, monazite and iron oxides. Most gneisses are interpreted as metamorphosed greywackes and various pelitic-psamitic rocks (e.g. Kryza 1981; Żelaźniewicz 1987). As an alternative, Kröner and Hegner (1998) proposed that many gneisses have a magmatic protolith, as illustrated by zircon geochronology.

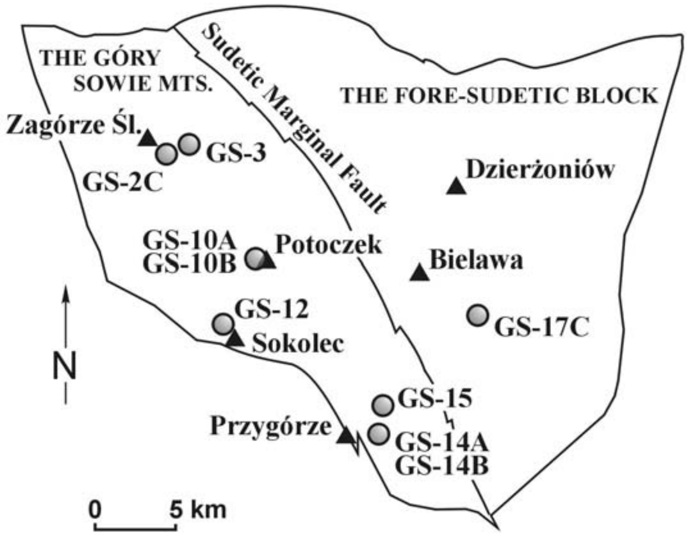

Fig. 1. Sketch of the Góry Sowie Block with sampling locations (modified after Budzyń et al. 2004)

Granulites occur in three close locations in the Bystrzyca Górna–Zagórze Śląskie region (N part of the massif) and are associated with mantle-derived peridotites. A fourth location of granulite occurrence is in the Sieniawka area (NE part of the Góry Sowie Block). Granulites are composed of quartz, plagioclase, garnet, kyanite, rutile and retrogressed micas (biotite and muscovite). Present position of granulites and peridotites is interpreted as a result of tectonic movements that incorporated these rocks into the Góry Sowie gneisses during initial exhumation into the midcrust (e.g. Żelaźniewicz 1985).

Amphibolites usually occur as fine and thin lenses within gneisses (e.g. Żelaźniewicz 1995) and are distinguished by a mineral composition of: hornblende, biotite, plagioclase (andesine-labradore), garnet, pyroxene and — rarely — quartz (Żelaźniewicz 1987). Less common amphibolites with quartz are likely metamorphosed tuffs (Żelaźniewicz 1995). The remaining amphibolite varieties represents mafic rocks and their origin might be related to fractionation of mantle material, which intruded during midcrustal (10–12 km) deformation (Dziedzicowa 1994; *fide* Żelaźniewicz 1995).

SAMPLE SELECTION AND METHODS OF INVESTIGATION

During standard petrographic investigations the suitability of 31 collected samples for geothermobarometric analyses was determined. The highest priority during sample selection was the presence of non-retrogressed garnet-biotite and/or muscovite-biotite pairs, which could register maximum temperatures and/or pressures of metamorphism during amphibolite-facies conditions. As a result of these restrictions eight samples from four regions within the Góry Sowie were selected. Additionally, one sample from the Kietlice region (Fore-Sudetic part of the Góry Sowie Block) was chosen.

Chemical determinations and XRD analyses

Mineral chemistry analyses were performed on a JEOL JXA-50A electron microprobe at the Department of Mineralogy, Petrography and Geochemistry, AGH, Kraków, using silicate and oxide mineral standards. Operating conditions were as follows: accelerating voltage 15 kV, beam current 20 nA, counting time 40 seconds and the beam diameter of 2–5 μm focused on the polished thin section coated with carbon. Twenty-five mineral grains from 9 samples were analysed in 44 spots.

Back-scattered electron images, as well as EDS analyses along garnet traverses, were obtained in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University, Kraków.

Four samples were chosen for geobarometric XRD analyses using the methodology suggested by Sassi and Scolari (1974). Each rock slice remaining from thin section preparation was polished to obtain a smooth surface perpendicular to the foliation. The $d_{060,\,33\bar{1}}$ muscovite spacing was measured with use of a Phillips X'Pert diffractometer. A pattern was recorded in the range of 59–63° 2Θ (CuK_{α} radiation). Quartz present in the rock matrix was used as an internal standard.

Geothermobarometric methods

Three quantitative methods were chosen to determine P-T conditions of metamorphism: garnet-biotite and muscovite-biotite geothermometers, and muscovite geobarometer.

Garnet-biotite geothermometer

Garnet-biotite Fe-Mg exchange geothermometer is one of the most widely used methods for middle-upper amphibolite-facies rocks. This method is based on the reaction:

$$\underset{\text{almandine}}{Fe_3Al_2[SiO_4]_3} + \underset{\text{phlogopite}}{KMg_3[(F,OH)_2 \mid AlSi_3O_{10}]} = \underset{\text{pyrope}}{Mg_3Al_2[SiO_4]_3} + \underset{\text{annite}}{KFe_3[(OH)_2 \mid AlSi_3O_{10}]}$$

Various calibrations of garnet-biotite geothermometer were tested, including Ferry and Spear (1978), Hodges and Spear (1982), Perchuk and Lavrent'eva (1983), Dasgupta et al. (1991), Bhattacharya et al. (1992) and Holdaway (2000). Maximum differences between temperatures obtained for one sample with use of these calibrations were up to ca. 220°C. Previously (e.g. Gordon et al. 2003; Budzyń et al. 2004) we reported data determined using Bhattacharya's et al. (1992) garnet-biotite geothermometer with Hackler and Wood's (1989) mixing parameters. In this paper we propose use of Holdaway's (2000) garnet-biotite geothermometer, which also takes into account assumed Fe^{3+} values of biotite (11.6%) and garnet (3%) based on the Mössbauer analyses of Dyar (1990) and Guidotti and Dyar (1991). This calibration of garnet-biotite geothermometer is probably the best one currently available (for more details see Holdaway 2000, 2004). A program (GB, the Garnet-Biotite Geothermometer by Holdaway) was used to calculate temperatures of garnet-biotite pairs from their chemical analyses. Average volume Margules parameters of Ganguly et al. (1996), Berman and Aranovich (1996), and Mudhopadhyay et al. (1997) for garnet were used. Taking into consideration ferric iron in the structure of minerals we obtained lower garnet-biotite temperatures by about 10–15°C.

During selection of garnet-biotite pairs for analyses crystallographic orientation of biotite was considered. As a result of that, coexisting minerals with low Θ (the angle between the normal to biotite (001) plane and the interface with garnet) were selected. Chosen analyzed spots in garnet-biotite pairs were close to mineral contact (spot distance within the range 60–120 μm). Temperatures were calculated in combination with muscovite geobarometer, with three exceptions (samples GS-2C, GS-3 and GS-17C), where temperatures were calculated for P = 5 kbar.

Muscovite-biotite geothermometer

The second method chosen for temperature estimations is muscovite-biotite geothermometer (Hoisch 1989) based on exchange reaction:

$$KMg_3[(F,OH)_2 \mid AlSi_3O_{10}] + KAl_2[(OH,F)_2 \mid AlSi_3O_{10}] =$$

phlogopite muscovite

$$= K(MgAl)[(OH)_2 \mid Si_4O_{10}] + K(Mg_2Al)[(OH)_2 \mid Al_2Si_2O_{10}]$$

celadonite eastonite

Analytical spots were located close to contact between minerals (spot distance within the range 60–100 μm). Temperatures were calculated in combination with muscovite geobarometer, except samples GS-12 and GS-15, where temperatures were calculated for P = 5 kbar.

Muscovite geobarometer

Ramírez and Sassi's (2001) muscovite geobarometer was chosen to determine maximum pressures of metamorphism. This method is based on changes of the muscovite $d_{060,33\bar{1}}$ cell dimension, which monitors the baric conditions of metamorphism. These changes are result of the increasing celadonite substitution related to a pressure increase. During XRD analyses, analytical procedure was repeated five times for GS-14A and three times for GS-14B to estimate analytical error.

RESULTS

Mineral chemistry and XRD results

Microanalyses were concentrated on rim values of minerals chosen for geothermometric calculations. In four selected samples (sillimanite-bearing layered gneiss GS-2C; layered gneiss GS-14A; metapegmatite GS-14B; flaser gneiss GS-17C) garnets form subhedral to anhedral blasts, up to *ca* 2 mm in diameter. Some of them contain biotite or quartz inclusions. These garnets — in which crystallization took place during progressive, amphibolite-facies metamorphism — are represented by almandine (Table 1). They have composition of $Alm_{0.61–0.76}Spess_{0.05–0.22}Py_{0.08–0.17}Gross_{0.03–0.10}$. In contrast, one sample (granulite GS-3) contains garnets with retrogressive features. Some of these grains have reaction coronas that emerged during retrogression in the contact with rutile, plagioclase or micas. Quartz, plagioclase, biotite and rutile occur as inclusions. Garnet rim and core compositions in this sample are $Alm_{0.49–0.55}Spess_{0.02}Py_{0.31–0.39}Gross_{0.08–0.12}$ and $Alm_{0.48–0.53}Spess_{0.02}Py_{0.30–0.36}Gross_{0.11–0.15}$ respectively.

A biotite population that should achieve chemical composition in equilibrium with garnets during maximum temperatures of metamorphism was chosen for analyses. Chemical compositions in mica grains free of chlorite or muscovite interlayers were analysed. Biotite has an Fe/(Fe+Mg) ratio of 0.52–0.66 with two values out of this range:

TABLE 1

Selected analyses of garnets

Component [wt. %]	GS-2C Grt 2	GS-2C Grt 3	GS-2C Grt 7	GS-2C Grt 8	GS-3 Grt 1	GS-14A	GS-14B	GS-17C
SiO_2	39.36	39.67	38.12	39.40	41.47	38.46	37.88	39.64
Al_2O_3	21.39	20.63	20.75	20.88	23.17	20.59	20.32	21.71
TiO_2	0.22	0.22	0.23	0.22	0.24	0.27	0.25	0.24
FeO	32.81	32.15	32.71	32.11	24.13	29.90	26.64	30.40
MgO	2.42	2.75	2.50	2.78	7.55	2.11	2.26	4.36
MnO	4.59	4.66	4.97	4.61	1.05	7.78	9.35	2.05
CaO	1.61	1.96	1.14	0.91	4.10	2.84	2.61	3.40
Total	102.40	102.04	100.41	100.90	101.71	101.96	99.32	101.80
Number of cations*								
Si	3.08	3.11	3.05	3.11	3.09	3.05	3.06	3.06
Al	1.97	1.91	1.96	1.94	2.04	1.92	1.90	1.98
Ti	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Fe	2.15	2.11	2.19	2.12	1.50	1.98	1.80	1.96
Mg	0.28	0.32	0.30	0.33	0.84	0.25	0.27	0.50
Mn	0.30	0.31	0.34	0.31	0.07	0.52	0.64	0.13
Ca	0.13	0.16	0.10	0.08	0.33	0.24	0.23	0.28
Total	7.93	7.93	7.95	7.90	7.88	7.98	7.95	7.94
Fe/(Fe+Mg)	0.88	0.87	0.88	0.87	0.64	0.89	0.87	0.80
Content of end members								
X_{Py}	0.10	0.11	0.10	0.12	0.31	0.08	0.09	0.17
X_{Alm}	0.75	0.73	0.75	0.75	0.55	0.66	0.61	0.68
X_{Gross}	0.05	0.06	0.03	0.03	0.12	0.08	0.08	0.10
X_{Spess}	0.11	0.11	0.12	0.11	0.02	0.17	0.22	0.05

* Number of cations on the basis of 12 oxygen atoms; total Fe = Fe^{2+}.

0.28 (sample GS-3) and 0.39 (sample GS-17C) (Table 2). Mica compositions for muscovite-biotite geothermometry are presented in Table 3. Analytical XRD results document muscovite b_0 values within the range 8.9988–8.9994 Å (Table 4).

TABLE 2

Selected analyses of selected biotites (Bt) and muscovites (Mu)

Composition [wt. %]	GS-2C Bt 2	GS-3 Bt	GS-10A Bt	GS-10A Mu	GS-14A Bt 1	GS-14A Bt 2	GS-14A Mu	GS-14B Bt 1
SiO_2	37.06	38.51	38.11	46.91	37.60	38.65	46.27	37.99
Al_2O_3	20.81	19.14	19.74	38.64	17.04	18.29	35.34	18.35
TiO_2	2.92	4.67	3.40	0.19	3.17	2.80	1.36	2.09
FeO	19.55	9.55	19.89	1.44	22.77	20.20	2.12	19.28
MgO	7.04	13.75	8.17	0.66	7.67	8.60	0.75	7.57
K_2O	9.14	9.20	9.11	9.18	10.31	10.66	11.04	9.60
Na_2O	n.a.	n.a.	n.a.	0.64	n.a.	n.a.	1.96	n.a.
Total	96.53	94.82	98.44	97.65	98.57	99.21	98.85	94.87
Number of cations*								
Si	2.76	2.78	2.78	3.02	2.81	2.83	3.01	2.88
Al	1.82	1.63	1.70	2.93	1.50	1.58	2.71	1.64
Ti	0.16	0.25	0.19	0.01	0.18	0.15	0.07	0.12
Fe	1.22	0.58	1.21	0.08	1.42	1.24	0.12	1.22
Mg	0.78	1.48	0.89	0.06	0.86	0.94	0.07	0.86
K	0.87	0.85	0.85	0.75	0.98	1.00	0.92	0.93
Na	n.a.	n.a.	n.a.	0.08	n.a.	n.a.	0.25	n.a.
Total	7.60	7.57	7.61	6.93	7.75	7.73	7.15	7.65
Fe/(Fe+Mg)	0.61	0.28	0.58	0.55	0.62	0.57	0.61	0.59

* Number of cations on the basis of 11 oxygen atoms; total Fe = Fe^{2+}; n.a. — not analyzed.

TABLE 3

Compositions of analyzed micas for muscovite-biotite geothermometry

Sample symbol	K^{ideal}_{R1}	$X^B_{Mg} - X^B_{[6]Al}$	X^B_{Mg}	$X^B_{[6]Al}$	X^B_{Ti}	X^B_{Fe}	X^M_{Mg}
GS-10A	0.474 ↑	0.138 ↓	0.296 ↓	0.158	0.062	0.404	0.032
GS-10B	0.436	0.152 ↓	0.287 ↓	0.135	0.068	0.436	0.032
GS-12	0.624 ↑	0.122 ↓	0.257 ↓	0.135	0.044	0.495 ↑	0.040
ght GS-14A	0.499 ↑	0.178	0.313 ↓	0.135	0.051	0.412	0.037
GS-14B	0.400	0.238	0.362	0.124	0.049	0.393	0.040
GS-15	0.695 ↑	0.151 ↓	0.259 ↓	0.108	0.073	0.470 ↑	0.054 ↑

Explanations of symbols: $K^{ideal}_{R1} = X_{cel}X_{eas} / X_{phl}X_{ms}$; $X^M_{Mg} = Mg/2$;
$X^M_{[6]Al} = (Al + Si - 4)/2$; $X^B_{Mg} = Mg/3$; $X^B_{[6]Al} = (Al + Si - 4)/3$; $X^B_{Fe} = Fe/3$; $X^B_{Ti} = Ti/3$ (for more details see Hoisch 1989); ↑ — data higher than range given by Hoisch (1989);
↓ — data lower than range given by Hoisch (1989).

TABLE 4

X-ray diffractometry results

Sample symbol	GS-10A	GS-10B	GS-14A (1)	GS-14A (2)	GS-14A (3)
$d_{060,33\bar{1}}$ [Å]	1.4991	1.4990	1.4999	1.4999	1.4998
$b_0 = 6 \cdot d_{060,33\bar{1}}$ [Å]	8.9946	8.9940	8.9994	8.9994	8.9988
Sample symbol	GS-14A (4)	GS-14A (5)	GS-14B (1)	GS-14B (2)	GS-14B (3)
$d_{060,33\bar{1}}$ [Å]	1.4991	1.4994	1.4994	1.4991	1.4988
$b_0 = 6 \cdot d_{060,33\bar{1}}$ [Å]	8.9946	8.9964	8.9964	8.9946	8.9928

Geothermobarometry results

In the northern part of the Góry Sowie Mts, samples (GS-2C and GS-3) revealed temperatures of ca. 652 ± 35°C (Table 5; Fig. 2). Point analyses along traverse in garnet from granulite (GS-3) allowed us to ascertain slight zonation with a retrogressive rim (Fig. 3 and 4). However, this zonation is probably related to ion diffusion between the garnet and inclusions. Two samples (GS-14A and GS-14B) from the Przygórze area yielded

TABLE 5

Temperatures and pressures yielded by analyzed samples

Sample symbol	Rock type	Method		
		Grt-Bt	Mu-Bt	Mu
		T [°C]	T [°C]	P [kbar]
GS-2C	sillimanite-bearing layered gneiss	652 ± 35	—	—
GS-3	granulite	646 ± 25	—	—
GS-10A	diatexite	—	594 ± 22	5.2 ± 0.7
GS-10B	finely laminated gneiss	—	597 ± 22	5.2 ± 0.7
GS-12	flaser gneiss	—	*635 ± 22*	—
GS-14A	layered gneiss	657 ± 25	610 ± 22	6.6 ± 1.2
GS-14B	metapegmatite	662 ± 25	615 ± 22	6.2 ± 1.2
GS-15	flaser gneiss	—	*712 ± 22*	—
GS-17C	flaser gneiss	600 ± 25	—	—

Grt-Bt — garnet-biotite geothermometer (Holdaway 2000); Mu-Bt — muscovite-biotite geothermometer (Hoisch 1989); Mu — muscovite geobarometer (Ramírez and Sassi 2001); *Italic* — data with questioned reliability (explanation in text).

similar results of garnet-biotite geothermometry (660 ± 28°C) and pressures 6.4 ± 1.4 kbar. These samples revealed lower temperatures (613 ± 25°C) with use of muscovite-biotite geothermometry. In the central part of the Góry Sowie temperatures of 596 ± 24°C and

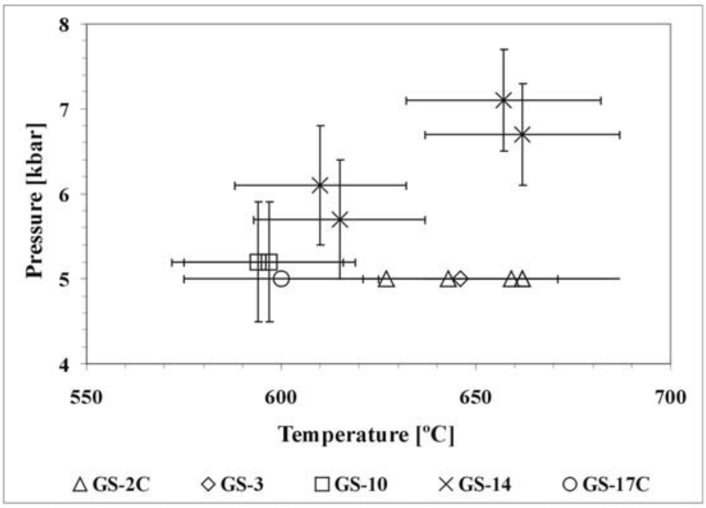

Fig. 2. Results of P-T determinations obtained with use of garnet-biotite geothermometry, muscovite-biotite geothermometry and muscovite geobarometry

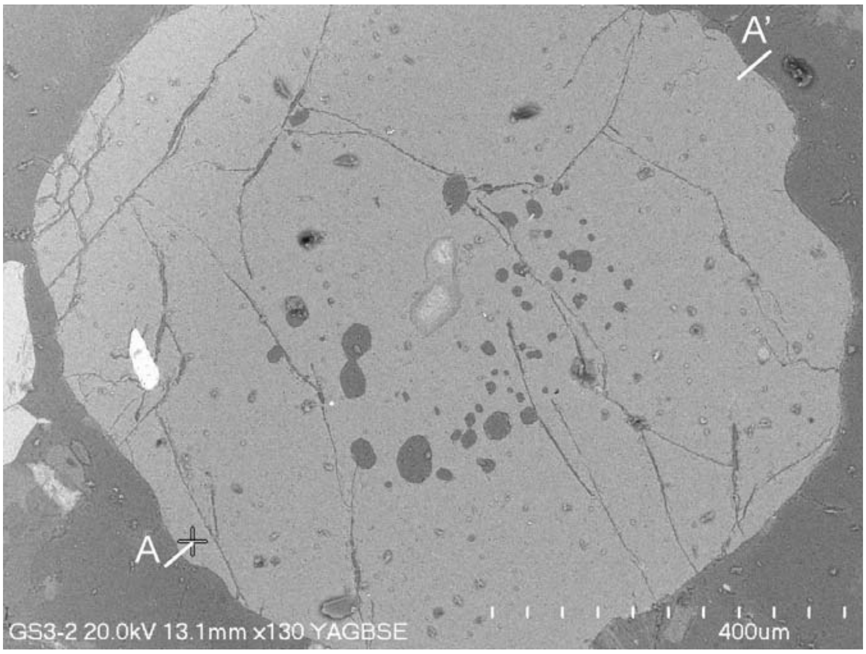

Fig. 3. Backscattered electron image showing garnet from the granulite (GS-3). Profile along traverse A-A′ is shown at Fig. 4

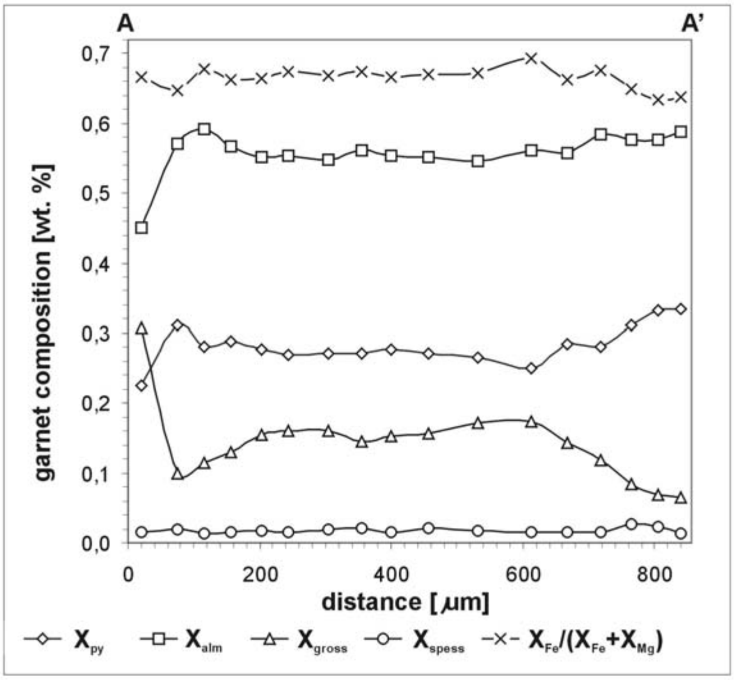

Fig. 4. Plots of garnet composition along A-A' traverse (as shown in Fig. 3)

pressures 5.2 ± 0.7 kbar were determined. Additionally one sample (GS-17C) from the Kietlice region (the Fore-Sudetic Block) yielded temperatures of 600 ± 25°C.

The disparity determined between mica compositions in four analysed samples (GS-10A, GS-10B, GS-14A and GS-14B; Table 3) and the elemental range in the calibration data set (Hoisch 1989) probably do not influence our geothermometry data. Larger differences in case of two samples (GS-12 and GS-15) cause us to question the reliability of temperatures obtained from both samples (Table 5, in italics); these results will not be consider in further discussion.

DISCUSSION

Analytical differences between the results of the geothermometers might be interpreted as a result of different speeds of ion diffusion between coexisting minerals (especially in case of GS-14A and GS-14B). Temperatures obtained with use of muscovite-biotite geothermometer are probably lower than maximum temperatures of metamorphism. According to Spear (1991), fast cooling ratio affirmed with use of thermochronological investigations (e.g. Oliver, Kelley 1993; Bröcker et al. 1998; Marheine et al. 2002; Zahniser et al. 2003) may be conducive to the preservation of equilibrium between garnet and biotite achieved at maximum temperatures of metamorphism. Moreover, garnet rim with smaller Θ biotite shows higher Mg/(Mg+Fe) values, which leads to higher temperature estimation (Usuki 2002). Therefore, even if the chemical composition changed during cooling, maximum temperatures should be within the range of calibration error of our results.

Geothermobarometry results have revealed that selected rocks from the Góry Sowie Mts were metamorphosed under middle-upper amphibolite facies conditions. Conditions of peak of metamorphism that affected selected Góry Sowie gneisses were up to *ca* 687°C and *ca* 7.8 kbar (including calibration error value). These data are consistent with, if not slightly higher-temperature than previously published P-T estimations for the peak regional metamorphic event in the massif (e.g. Kryza 1981; Żelaźniewicz 1987, 1990, 2003). Similar P-T values — based on garnet-aluminosilicate-plagioclase and garnet-biotite equilibria — were registered previously in migmatitic gneisses by Kryza and Pin (1998, 2002): 670–750°C at 4.8–6.8 kbar for the mineral rim compositions. Slight inconsistence of our data with these results might be related to metabasites that are enclosed within migmatitic gneisses investigated by the mentioned authors.

Temperatures and pressures obtained out of two samples (GS-14A and GS-14B) from the same outcrop revealed that pegmatites intruded into the gneissic complex before peak of metamorphism. Both rocks registered conditions of later metamorphic events.

We suggest that these P-T constraints are related to the beginning of the midcrustal exhumational stage of the granulite assemblages, coeval with widespread regional metamorphism (Fig. 5). Isothermal decompression of the terrane, and initial exhumation of the gneisses and migmatites — which enclose granulites and metabasites — to mid-crustal depths most likely took place *ca* 380–370 Ma (e.g. Van Breemen et al. 1988; Bröcker et al. 1998; Timmermann et al. 2000; Gordon et al. 2003; Zahniser et al.

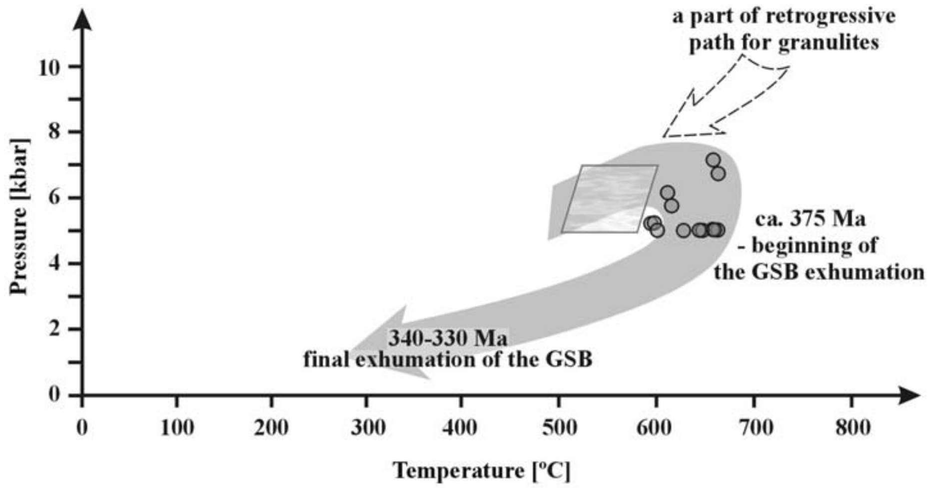

Fig. 5. P-T-t path for gneisses and migmatites determined using data presented in this paper (filled circles). P-T conditions of earlier metamorphic event (M_1) according to Żelaźniewicz (1990) are shown as the box. Dating after Van Breemen et al. (1988), Oliver and Kelley (1993), Bröcker et al. (1998), Timmermann et al. (2000), Gordon et al. (2003) and Zahniser et al. (2003). A part of retrogressive path for granulites determined using data from Żelaźniewicz (1990), Kryza et al. (1996) and O'Brien et al. (1997) GSB — the Góry Sowie Block

2003). Later, probably weaker Variscan tectonometamorphic events resulted in final exhumation of the Góry Sowie Block at 340–330 Ma (e.g. Oliver, Kelley 1993; Zahniser et al. 2003).

CONCLUSIONS

1. We interpret analytical differences between the data obtained with use of garnet-biotite geothermometer and muscovite-biotite geothermometer as a result of different speeds of ion diffusion within mineral pairs.

2. Geothermobarometry results, presented in this paper, revealed that selected rocks from the Góry Sowie Mts were metamorphosed at middle-upper amphibolite facies conditions.

3. P-T constraints are related to the beginning of the midcrustal exhumational stage of the granulite assemblages coeval with widespread regional metamorphism, which most likely took place *ca* 380–370 Ma.

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WARUNKI CIŚNIEŃ I TEMPERATUR METAMORFIZMU WYSOKIEGO STOPNIA W GÓRACH SOWICH, SUDETY ZACHODNIE

Streszczenie

Warunki temperatur i ciśnień metamorfizmu wybranych skał z Gór Sowich (Sudety Zachodnie, SW Polska) zostały określone przy zastosowaniu geotermometrów granat-biotyt (GB) i muskowit-biotyt (MB) oraz geobarometru muskowitowego. Gnejs warstewkowy z sillimanitem i granulit z rejonu jeziora Bystrzyckiego (północna część Gór Sowich) wykazały temperatury 652 ± 35°C (GB). W przypadku gnejsu warstewkowego i metapegmatytu z rejonu Przygórza (południowa część masywu) otrzymano temperatury 660 ± 28°C (GB) i 613 ± 25°C (MB) oraz ciśnienia 6,4 ± 1,4 kbar. Zarejestrowane warunki metamorfizmu gnejsu cienkolaminowanego i diateksytu z okolic Potoczka wyniosły 596 ± 24°C (MB) i 5.2 ± 0,7 kbar. Do badań wybrano ponadto jedną próbkę z przedgórskiej części bloku sowiogórskiego — otrzymane temperatury metamorfizmu gnejsu smużystego z rejonu Kietlic wyniosły 600 ± 25°C (GB).

Różnice pomiędzy otrzymanymi danymi przy użyciu dwóch geotermometrów — co ma miejsce np. dla próbek z centralnej części Gór Sowich — mogą być wynikiem różnic w szybkości dyfuzji jonów pomiędzy minerałami. Otrzymane dane są najprawdopodobniej związane z początkową ekshumacją bloku sowiogórskiego i towarzyszącym metamorfizmem regionalnym w warunkach facji amfibolitowej.