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Andrzej KOZŁOWSKI[1], *Paul METZ*[2]

POST-MAGMATIC MINERALISATION IN THE GRANITOIDS OF THE STRZELIN MASSIF, SW POLAND – A FLUID INCLUSION STUDY

INTRODUCTION

The Strzelin crystalline massif in Lower Silesia, SW Poland, consists of the metamorphic unit comprising Upper Precambrian – Cambrian gneisses, older Precambrian or Lower Paleozoic schists and younger Middle Devonian schists (Oberc-Dziedzic 1999a), intruded by a complex assembly of stock and dyke granitoids of Variscan age dated for 347±12Ma to 330±6Ma (Oberc-Dziedzic 1999b). The granitoids contain moderately abundant pegmatite pockets, veins and metasomatic zones. Till now, preliminary fluid inclusion data for the post-magmatic mineralisation in the Strzelin granitoids were published by Stępisiewicz (1977), and the suggestions on the characteristics of fluids which altered Strzelin granite were proposed by Ciesielczuk and Janeczek (1999), and Ciesielczuk (2001). The chlorite geothermometry for the post-magmatic deposits in this granite was given by Ciesielczuk (2002).

SAMPLES AND METHODS

The pegmatite parageneses, studied in the current project, consisted of the mi-nerals listed in Table 1 and white albite, biotite and muscovite. Veins contained varieties of quartz, micas, K- and Na-feldspars, chlorite, laumontite, prehnite, fluo-rite and ore minerals. The sequence in Table 1 from garnet to calcite is the general crystallisation sequence found by petrographic methods. Zeolites crystallised later than earliest cleavelandite, and ore minerals essentially together with smoky and gray quartz, and chlorite; only bismuth was younger. The 56 samples of the post-magmatic assemblages (31 pegmatites and 25 veins) were used for the fluid inclu-sion investigations. The samples came from the biotite granite quarries at Strzelin and Mikoszów, and from the biotite-muscovite granite quarry at Gębczyce. Fluid inclusions were studied according to the procedure described by Marcinowska and Kozłowski (2003). The total of 1006 inclusions was investigated in all the samples (Table 1). The size of fluid inclusions ranged from ca. 50 µm in quartz, fluorite and calcite to less than 1 µm in zircon, epidote and garnet. The smallest investigated inclusions (in zircon and garnet) were 2.5 µm long and ca. 1 µm wide.

[1] *Institute of Geochemistry, Mineralogy and Petrology, Faculty of Geology, Warsaw University, al. Żwirki i Wigury 93, 02-089 Warszawa, Poland, e-mail akozl@geo.uw.edu.pl*
[2] *D-31061 Alfeld/Leine, Hinsiekweg 11A, Germany (Prof. Emeritus of Tübingen University)*

RESULTS

The results of the studies of 1006 fluid inclusions (Table 1) yielded temperature ranges of the post-magmatic mineralisation in the Strzelin granitoids from 570 to 100°C and pressure from 1.4 to 0.8 kbar. The earliest solutions were pneumato-lytic, and after condensation the hydrothermal ones had total concentrations 6–7 wt. % with dominating NaCl and appreciable content of KCl. During decrease of temperature to 250–200°C the total concentration of the mineral-forming solutions increased

Table 1. Crystallisation conditions of the post-magmatic minerals in the Strzelin granites

Mineral	Fluid inclusion data (*N* – number of the studied inclusions)								
	Filling	*Tcr*, °C	*P*, kb	*S*, wt. %	NaCl	KCl	$CaCl_2$	CO_2	*N*
Gray quartz	G	*570*–430	*1.4*	?	?	?	?	+	74
	L	460–290	1.4-0.9	7–12	50–80	0–20	0–40	+	127
Morion, smoky	G	*460*–350	*1.4*-0.8	?	?	?	?	+	39
quartz	L	390–230	1.2-0.8	10–17	50–70	0–15	20–50	+	179
Rock crystal	L	250–120	0.9-0.8	1.5–18	70–95	0–5	5–30	+	155
Garnet	L	450–430	1.4	7–8	80	15	5	+	9
Topaz	L	455–410	1.4	6–9	85	15	–	+	7
Beryl	L	440–410	1.4	7–9	85	15	–	+	11
Tourmaline	L	420–390	1.4-1.3	7–9	80	15	5	+	10
Apatite	L	430–320	1.3-0.9	8–9	80	10	10	+	12
Sphene	L	440–400	1.4	7–8	80	10	10	+	8
Zircon	L	450–420	1.4	7–10	70	20	10	+	9
Cleavelandite	L	340–190	1.1-1.0	10–15	60	10	30	+	41
Prehnite	L	*195–170*	*~1.0*	14–16	65	10	25	?	19
Apophyllite	L	200–160	0.9	14–15	65	10	25	+	23
Epidote	L	230–180	*0.9*	14–15	65	10	25	+?	17
Fluorite	L	240–140	0.9-0.8	14–18	50-65	0–10	25-40	+	59
	L	300-260	1.0-0.9	13–14	70	10	20	+	14
Chlorite*	L	210–180	0.8	14–15	50	15	35	+	11
	L	160–150	0.8	5.4	70	10	20	+	10
Calcite	L	190–<90	0.8	1.5–14	60-80	5-10	10-35	+;–	73
Stilbite*	L	210–140	0.8	5–14	60-80	5-10	10-35	+;–	10
Laumontite*	L	230–170	0.8	14–15	50-65	0–10	25-40	+;–	14
Chabasite*	L	200–140	0.8	5–14	60-80	5-10	10-35	+;–	8
Pyrrhotite*	L	340–280	1.1	9–16	50–70	10	20–50	?	6
Pyrite*	L	280–170	1.0-0.9	14–15	65	10	25	+;–	14
Chalcopyrite*	L	350–260	1.1-1.0	10–14	65	10	25	+;–	15
Sphalerite*	L	345–220	1.1-1.0	10–15	60–65	10	25–30	+;–	19
Molybdenite*	L	350–300	1.1-1.0	8–12	70–75	0–10	15–25	+;–	9
Galena*	L	190–140	0.8	3–13	70-80	5-10	10-35	+;–	5
Aikinite*	L	230	0.8	12	80	5	15	?	3
Emplectite*	L	220	0.8	12	80	5	15	?	5
Bismuth*	L	190	0.8	14	80	0	20	?	6

Tcr, P crystallisation temp. and pressure, *S* total salinity, salt components in % of total content. Asterisks mark minerals, which occurred as inclusions in quartz, fluorite and calcite in the same growth zones as fluid inclusions and that were the basis of their parent fluid characteristic; G mainly gas, L mainly liquid; italics mean approximate values; "+" CO_2 present, "–" CO_2 absent; "?" determination impossible. Mineral identification by the WDS method.

to 15–18 wt. %, with high contents of $CaCl_2$. Afterwards, concentrations decreased to 3–1.5 wt. % and the solutions became again of the NaCl type. The lat-ter change was found earlier by Stępisiewicz (op. cit.), but the recent study did not confirm his statement on the very high concentration of Al in fluids. This author's rough determinations of decrepitation temperatures of sulphide minerals by metho-dic reasons cannot be compared to the values determined for the respective mine-rals in this study. The conditions of formation of chlorites, zeolites and ore mine-rals were determined from fluid inclusions in the growth zones of quartz, fluorite and calcite, in which the included grains of the listed minerals were found, thus the obtained values may be extended to these minerals. The presence of carbon dioxi-de in the mineral-forming fluids is common, what made possible to determine pres-sure of crystallisation of the minerals. The hydrothermal origin of the 0.5–1 mm zircon grains found in the quartz-chlorite assemblage, was recognised. Ciesielczuk (2002) obtained by chlorite thermometers 358 or 208°C as formation temperatures of this mineral, and she discarded these values. One her value meets the range 210–180°C obtained from inclusions and further precise recognition is reasonable.

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