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THE FIRST OCCURRENCE OF ELBAITE IN POLAND

Abstract. An amphibolite-hosted quartzo-feldspar-mica pegmatite with schorl, green elbaite, spessartine, andalusite, spinel, hyalophane, zircon, columbite and beryl was found near Gilów in the E part of the Góry Sowie gneissic block (Lower Silesia, Poland). The black tourmaline crystals are chracterized by the change of their composition from Mg- and Al-enriched schorl, typical of the Góry Sowie block, to Al- and, Al- and Li-enriched schorl, and to Fe-bearing elbaite. Light green tourmaline corresponds to (Fe,Mn)-bearing elbaite. The crystallization sequence of the tourmaline varieties results from progressive change of composition of pegmatite melts in the last metamorphic stage of a parent sedimentary protolith around 370–380 Ma ago. The stage of Li-bearing tourmaline formation corresponds to crystallization of a phosphate assemblage with ferrisicklerite-sarcopside-graftonite lamellar intergrowths known from other pegmatites of the Góry Sowie block.

Key-words: tourmaline, elbaite, the Góry Sowie gneissic block, Lower Silesia, Poland

INTRODUCTION

Tourmaline is a relatively common mineral in igneous and metamorphic rocks in some geological units of the Polish part of the Sudety Mts. Except green-grey dravite from the pass between Czoło and Wołowa Góra hills near Kowary (the Karkonosze Mts), in all other occurrences it is represented by black, (Al,Mg)-bearing varieties of schorl or less frequent, Al-depleted, Fe-rich tourmaline. The latter is usually enriched in Fe^{3+} as a result of the $(\mathrm{NaFe}^{2+})_{-1}\square\mathrm{Fe}^{3+}$ and the $(\mathrm{Fe}^{2+}\mathrm{OH})_{-1}\mathrm{Fe}^{3+}\mathrm{O}$ substitutions, both typical of the tourmaline group minerals (Foit, Rosenberg 1977). Such tourmaline varieties are common in pegmatoidal secretions within the Izera granitogneisses, some pegmatites of the Karkonosze, Strzegom and Strzelin granite massifs, pegmatites of the Góry Sowie gneissic block, and in some parts of the Śnieżnik metamorphic unit (Pieczka 1996). The coloured varieties of elbaite in the Polish part of the Sudety Mts have not been mentioned in the older, German-language literature.

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As late as the autumn of 2001, one of the authors (K.Ł.) found in the NE part of the Góry Sowie block fragments of a pegmatite with few prismatic crystals of green tourmaline.

The Góry Sowie block is a geological unit of the triangular shape, situated in the central part of the Sudety Mts among Ząbkowice Śląskie, Nowa Ruda and Świdnica, east of Wałbrzych (Fig. 1). The Sudetic Marginal Fault separates the block into an elevated, mountainous, SW part of the Góry Sowie Mts proper, and the down-thrown, NE part, developed as a hilly foreland. The borders with the surrounding units (the metamorphic rocks of the Niemcza dislocation zone to E, the metamorphic envelope of the Upper Carboniferous Strzegom-Sobótka granite massif and Upper Devonian-Lower Carboniferous sedimentary sequence of the Świebodzice depression to N, the Carboniferous-Permian rocks of the Intrasudetic depression and Ordovician-Lower Carboniferous sedimentary sequence of the Bardo basin to SW) are tectonic, while to NE the Góry Sowie block borders on ultrabasic and basic rocks of the Mt. Ślęża ophiolite.

The major rocks of the Góry Sowie block represent oligoclase-biotite paragneisses and migmatites, dated at around 384–370 MA (van Breemen et al. 1988; Bröcker et al. 1998; Timmermann et al. 2000; Aftalion, Bowes 2002). They are accompanied by much less frequent and locally occurring granulites, metamorphosed around 402 ± 1 MA

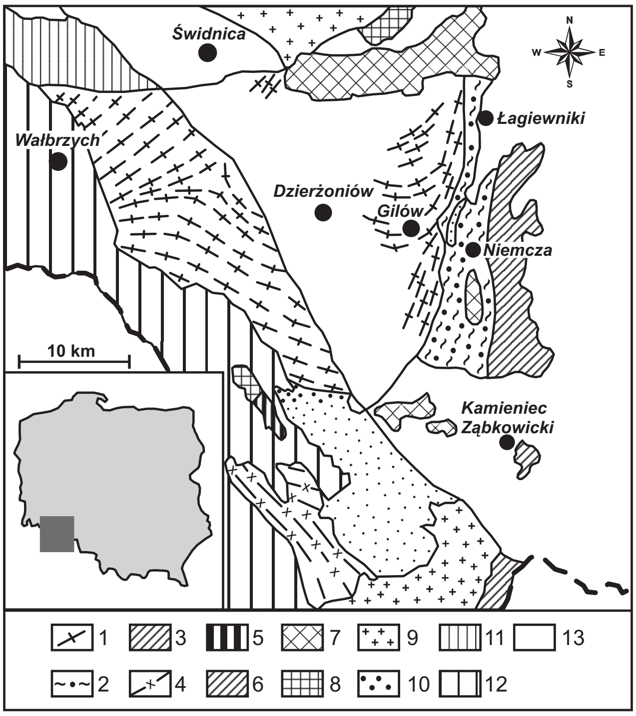

Fig. 1. Geological sketch of the Góry Sowie gneissic block with adjacent units
1 — the Góry Sowie gneisses; 2 — mylonites of the Niemcza Zone; 3 — schists of the Niemcza-Kamieniec Metamorphic Unit; 4 — rocks of the Kłodzko Metamorphic Unit; 5 — diabases of the Nowa Ruda massif; 6 — gneisses and schists of the Złote Mts; 7 — serpentinites; 8 — gabbros; 9 — granitoids; 10 — sedimentary rocks of the Bardo Basin; 11 — sedimentary rocks of the Świebodzice Depression; 12 — sedimentary and volcanic rocks of the Intrasudetic Depresion; 13 — Cenozoic sediments

(light-coloured variety; O'Brien et al. 1997), two-stage metamorphosed amphibolites (402 ± 3 MA and around 380 MA; Brueckner et al. 1996), and serpentinites. In these rocks, particularly in the gneisses and migmatites, can be locally found pegmatite veins or vein-nest bodies, reaching a length of even some tens of metres. More common are fine pegmatoidal secretions, concordant with the textures of the enclosing gneisses and migmatites. The age of the pegmatites was established at 370 ± 4 MA by van Breemen et al. (1988), using Rb-Sr dating of muscovite from the Lutomia pegmatite.

In the Góry Sowie Mts pegmatites predominate such typical minerals as quartz, feldspars (albite-oligoclase, orthoclase, microcline), muscovite, biotite, schorl, garnet transitional members from the almandine-spessartine series, apatite, less frequent are zircon, disthene, sillimanite, rutile, beryl, columbite, cordierite, monacite, xenotime, sarcopside, triplite, hureaulite, magnetite, pyrite, sphalerite, uraninite and goethite (*fide* Lis and Sylwestrzak 1986). Pieczka (2002) found in the Góry Sowie block area a rich assemblage of phosphate minerals with graftonite, ferrisicklerite, sarkopside, beusite, stanekite, alluaudite, hagendorfite, whitlockite, fairfieldite, whitmoreite, earlshannonite, jahnsite, phosphoferrite-kryzhanovskite and apatite, containing small inclusions of monacite, xenotime, uraninite, hematite, pyrite, sphalerite, cuprite, chalcocite, oligonite and, probably, native copper.

A pegmatite with green tourmaline described in this paper was found in an old trenche localized in upper part of a hill in the E, down-thrown part of the Góry Sowie block near Gilów.

DESCRIPTION OF THE PEGMATITE

Fragments of the pegmatite were spotted in an old trench, mingled with soil and accompanied by numerous pieces of amphibolites, which most probably represent the host rock. The pegmatite vein itself is not directly exposed. The fragments of the pegmatite differ slightly in their mineral composition. Usually they represent a typical, medium-grained pegmatite, containing quartz with weak undulatory extinction, white feldspars, light-coloured mica sometimes with pale-greenish tint, numerous crystals of black tourmaline reaching the length of 10 cm, grains of Mn-bearing almandine up to 2–3 cm large, very seldom prisms of green tourmaline up to 4 cm long (Fig. 2), and yellowish beryl up to 2 cm long. Some of the pegmatite fragments are devoid of feldspars and composed mainly of intergrowing booklets of mica with flakes 1–3 cm in size, sporadical, some-millimetre-long black tourmaline crystals, equally fine, dark brownish garnets with composition close to spessartine, and pinkish-red grains of andalusite, reaching some millimetres.

METHODS

Microprobe analyses were carried out in the EDS mode at the Institute of Non-Ferrous Metals in Gliwice (Poland), using a Jeol JCXA-733 Superprobe. The conditions were as follows: accelerating voltage 20 kV, current 20 nA, beam diameter around 2 μm, counting time 60 sec. The contents of Na, Mg, Al, Si, K, Ca, Ti, Mn, Fe, Co, Zn, Ba and F were measured from the Kα lines, while the Ba content from the Lα line. The data were first drift- and dead time-corrected, then ZAF-corrected. The standards included: albite (Na), periclase (Mg), corundum (Al), quartz (Si), MAD-10 (K), wollastonite (Ca), fluorite (F), BaF_2 (Ba) and metallic Ti, Mn, Fe, Co and Zn.

The formulae of the tourmaline varietes were calculated after normalization of atomic contents to 6 Si atoms per formula unit (apfu), and in the case when the amount of octahedral components was higher than 9 apfu to the $\Sigma(Y+Z+Si) = 15$ apfu, assuming the excess of Al above 9(Y+Z) apfu substituting for an Si deficiency. The B_2O_3 content was calculated stoichiometrically, assuming the presence of 3 B atoms pfu. The content of Fe^{3+} was accepted as 5% of the total Fe, as such an amount had been obtained earlier for other dark-coloured tourmaline species from the Góry Sowie area (Pieczka 1996). In the case of elbaite, the total Fe was assumed as Fe^{2+}, while the Li content was estimated as a supplement of octahedral cations to 9 pfu. The $H_2O(+)$ amount was calculated stoichiometrically after supplementing the composition of tourmaline with Fe^{3+}, B and Li.

The chemical composition of white mica was normalized to 12 oxygens, assuming the presence of OH groups in two (OH, F) sites, and applying a relation between the amount of tetrahedral cations $(Si+Ti+Al_T) = 4$ pfu and their charge, which together with the charge of alkalies should total 16 units. The deficiency of alkalies and some excess of Si were accepted as effects of the $\square Si(KAl_T)_{-1}$ substitution. The presence of Li in white mica was tested using AAS, but in the microprobe analyses the Li amount was estimated as supplementing to 6 the charge of the octahedral cations.

The chemical compositions of some other minerals found (Ba-rich feldspar, garnet, andalusite and (Zn-Fe)-bearing spinel) were recalculated after normalizaton to 4, 12, 5 and 4 oxygen atoms, respectively.

X-ray investigations of black and green tourmaline crystals, and also of accompanying garnet and beryl were carried out with a Philips X'pert diffractometer under the following conditions: CuK_α radiation, a graphite monochromator, the range recorded 3–71°(2Θ), the step 0.02°(2Θ)/s, quartz as an internal standard. Unit-cell parameters of tourmaline, garnet and beryl were refined with the PDS'94 computer program.

The Raman spectra of the green elbaite oriented || **c** were obtained from several points using a Jobin-Yvon T-64000 spectrometer equipped with an Argon laser beam ($\lambda = 514.5$ nm).

RESULTS

Tourmaline

Black tourmaline crystals are heterogenous under the microscope. They consist of two colour varieties showing relatively distinct pleochroism in the shades: ω — an intensively blue core and a blue-grey mantle; the latter with grey, blue and pale blue zones parallel to crystal elongation, and also with irregular, intensively blue patches, ε — a colourless core and light pinkish mantle. In some zones of these crystals oriented parallel to the *z* axis, and also in small veins cutting them across as well as in irregular patches, there appear a variety with somewhat lighter pleochroism: ω — light bluish (very delicate), ε — colourless. Within this zone are visible elongated, colourless (both ω and ε) domains arranged parallel to the length of the zone as well as relicts of the major, blue-grey variety (Fig. 3). In some fragments of the bluish-coloured crystals can be observed a very thin rim of colourless tourmaline. Birefringence assessed on the basis of interference colours in the crystals cut parallel to the *z* axis has been estimated at 0.029–0.028 in the strong coloured varieties, 0.021–0.020 in pale blue tourmaline, and 0.014–0.013 in the colourless domains. The heterogeneity of the black tourmaline crystals is also pronounced in BSE images. The crystals of green tourmaline seem to be wholly homogenous. Under the microscope they are colourless, with birefringence around 0.013–0.012.

The blue grey zones predominating in the black tourmaline show composition I presented in Table 1. Analysis II represents the composition of the pale bluish zone parallel to the crystal elongation, while analyses III and IV correspond to the very light-coloured and colourless, elongated patchy zones, visible within the turmaline II. The tourmaline I can be classified as an Mg- and Al-enriched schorl, a typical black tourmaline from the Góry Sowie gneissic block (Pieczka 1996). Its total iron exceeding 2 apfu is the highest of the recorded in this region so far, while the F content, usually low in the Góry Sowie tourmalines, is only 0.01–0.02 apfu in the sample analysed. The unit-cell parameters of the tourmaline I are: $a = 15.979(1)$ Å and $c = 7.171(1)$ Å, and correspond to an Al- and Mg-bearing schorl. The less frequent tourmaline II, although can be classified as the former, reveals a very high Al content, reaching almost one atom of possible three in the triad of the Y octahedra. The amount of Li reaching 0.03 apfu, estimated as a supplement of the Y cations up to the amount of 3 apfu, is negligible, but may be result from the accepted assumptions and/or possible errors in the microprobe analyses. On the other hand, this amount of lithium may be treated as a sign of progressing enrichment in Al and Li that is distinctly visible in tourmalines III and IV (Fig. 4). Both latter varieties forming patchy, elongated zones, despite their comparable Al contents are characterized by more pronounced deficiency of octahedral cations that may be explained by an increasing Li content, an element non-determinable in microprobe analyses. Therefore, the zones with the composition III may be identified as Li-enriched, Al-bearing schorl, while those of analysis IV as Fe-rich elbaite. In the dark tourmaline varieties (from I to IV), the contents of Fe total and Mg progressively decrease while those of Al, Li, traces of Mn and F increase, the process expressed by the change of the Mn/(Mn+Fe) ratio from around 0.03 to 0.07. The tourmaline I normalized to 6 Si pfu indicates the amount of octahedral cations higher than nine, allowed by structural constraints. Normalization of the same analysis to the amount of the octahedral cations and silicon equal to 15 apfu shows a small deficiency of Si (0.04 apfu) that is compensated by an equivalent excess of Al. It has not been possible to recognize fully a role of boron, whose amount particularly in the Li-bearing varieties of tourmaline may exceed 3 apfu, also partly entering

TABLE 1

Representative compositions of schorl and elbaite from the Gilów pegmatite

Component	Schorl				Elbaite		
	I	II	III	IV	V	VI	VII
Na_2O	2.49	2.38	2.62	2.64	2.09	2.62	2.49
CaO	0.09	0.18	0.26	0.27	0.21	0.21	0.15
K_2O	0.03	0.01	0.00	0.00	0.02	0.01	0.02
MgO	1.65	1.34	0.93	0.99	0.00	0.14	0.10
FeO	13.35	10.19	8.98	7.64	2.82	2.95	2.91
Fe_2O_3*	0.78	0.60	0.52	0.45	0.00	0.00	0.00
MnO	0.40	0.56	0.58	0.61	1.90	1.99	1.89
CoO	0.05	0.08	0.02	0.06	0.00	0.04	0.10
ZnO	0.16	0.20	0.10	0.12	0.04	0.05	0.00
TiO_2	0.18	0.19	0.13	0.02	0.09	0.07	0.04
Li_2O*	0.00	0.04	0.55	1.11	1.65	1.48	1.36
Al_2O_3	32.14	34.79	35.37	34.54	38.32	37.90	38.40
B_2O_3*	10.14	10.23	10.40	10.44	10.79	10.64	10.63
SiO_2	34.80	35.32	35.90	36.03	37.25	36.73	36.70
H_2O*	3.10	2.61	2.85	3.35	3.58	3.23	3.11
F	0.03	0.24	0.34	0.44	0.38	0.44	0.49
Total	***99.40***	***98.97***	***99.54***	***98.70***	***99.15***	***98.51***	***98.40***
	Number of ions						
Na	0.828	0.783	0.847	0.854	0.651	0.831	0.789
Ca	0.016	0.033	0.046	0.049	0.036	0.036	0.026
K	0.008	0.002	0.000	0.000	0.004	0.003	0.005
□	0.148	0.182	0.107	0.097	0.309	0.130	0.180
X	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***	***1.000***
Mg	0.421	0.340	0.231	0.247	0.000	0.035	0.025
Fe^{2+}*	1.913	1.448	1.255	1.064	0.380	0.403	0.398
Fe^{3+}*	0.101	0.076	0.066	0.056	0.000	0.000	0.000
Mn	0.059	0.081	0.083	0.085	0.259	0.276	0.262
Co	0.006	0.011	0.003	0.008	0.000	0.005	0.014
Zn	0.021	0.026	0.012	0.015	0.005	0.006	0.000
Ti	0.024	0.025	0.016	0.002	0.011	0.009	0.005
Li*	0.000	0.028	0.367	0.743	1.069	0.970	0.897
Al.	0.456	0.966	0.968	0.780	1.275	1.297	1.399
Y	***3.000***	***3.000***	***3.000***	***3.000***	***3.000***	***3.000***	***3.000***
Al_Z	6.000	6.000	6.000	6.000	6.000	6.000	6.000
B	3.000	3.000	3.000	3.000	3.000	3.000	3.000
Si	5.964	6.000	6.000	6.000	6.000	6.000	6.000
^{IV}Al	0.036						
T	***6.000***	***6.000***	***6.000***	***6.000***	***6.000***	***6.000***	***6.000***
OH*	3.548	2.954	3.183	3.719	3.851	3.523	3.388
F	0.017	0.130	0.180	0.232	0.194	0.226	0.253
O	27.435	27.916	27.637	27.049	26.955	27.251	27.359
Mn/(Mn+Fe)	***0.028***	***0.051***	***0.056***	***0.070***	***0.405***	***0.407***	***0.397***

* Calculated from stoichiometry.

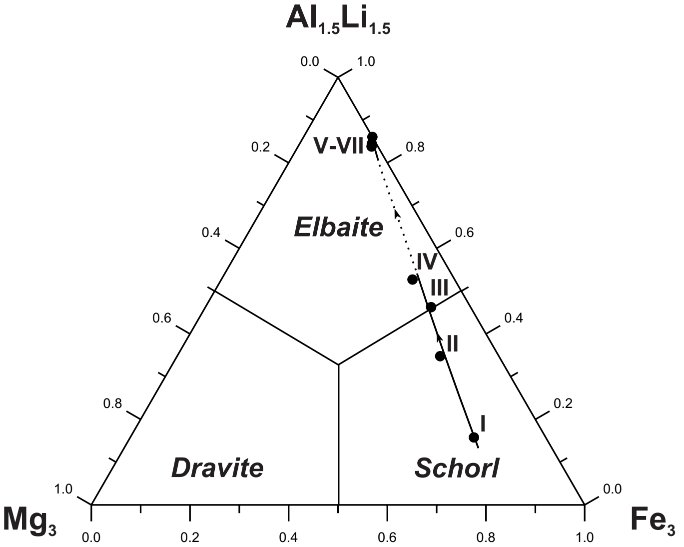

Fig. 4. Compositional trend in tourmaline crystals from the Gilów pegmatite in the Mg_3-Fe_3-$Al_{1.5}Li_{1.5}$ ternary plot: I — (Mg, Al)-enriched schorl, II — Al-bearing schorl, III — Al-bearing, Li-enriched schorl, IV — Fe-rich elbaite, V–VII — (Fe, Mn)-bearing elbaite

tetrahedral sites (Hawthorne 1996; Hughes et al. 2000; Hughes et al. 2001; Hawthorne 2002).

The green elbaite does not show changes in its chemical composition that may be revealed in its BSE images. Within the grain studied, there clearly dominates composition corresponding to analysis VI (Table 1), while the compositions corresponding to analyses V and VII (their differences from analyses VI are, in fact, small) are sporadic.

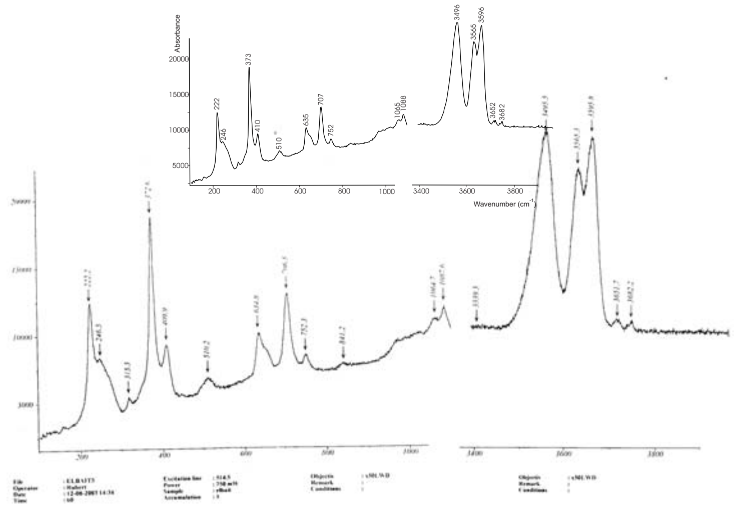

Fig. 5. Raman spectrum of the Góry Sowie Mts elbaite

The features characteristic of this elbaite include: practically constant amounts of Fe (0.38–0.40 apfu), Mn (0.26–0.28 apfu), and F (0.20–0.25 apfu), and as a consequence also the stable Mn/(Mn+Fe) ratio around 0.40–0.41, and additional oscillations of the Li amount around 1 apfu. More significant diversification of the elbaite composition has been noted at the X site occupancy, as in few analyses the amount of Na decreases from 0.85–0.78 apfu, typical Na concentrations not only in the green elbaite but also in the accompanying black tourmaline, to 0.65 apfu. The unit-cell parameters of the green elbaite (composition VI) are: a = 15.884(1) Å and c = 7.115(1) Å, being typical of (Fe,Mn)-bearing elbaites. The Raman spectrum of a prismatic green crystal recorded in the frequency range 100–3800 cm^{-1} (Fig. 5) shows strong similarities with the ones of an elbaite-type tourmaline (Gasharova et al. 1997). The tourmaline studied is characterized by sharp peaks at 222, 373, 707 cm^{-1}, and 3496, 3565 and 3596 cm^{-1}.

Other associated phases

Next to the black tourmaline, the major minerals of the pegmatite studied include white, coarse-tabular feldspar and plates or flakes of pale-coloured mica. Relatively common are fine crystals of garnet, light brownish to dark brownish-red, and equally fine crystals of raspberry-red to red-grey and pink andalusite. Only in BSE images have been observed small inclusions of a Ba-enriched K-feldspar, spinel, zircon, and columbite.

The feldspars are represented almost exclusively by chequered albite. In one case, within a polycrystalline aggregate of white mica and andalusite, a small grain of a Ba-enriched K-feldspar has been found; the grain reveals the composition transitional between orthoclase and celsian with an amount of around 34 mol.% of the $Ba[Al_2Si_2O_8]$ end-member (Table 2). This phase can be identified as hyalophane. An excess of Al above one atom in its composition corresponds well with the amount of bivalent alkali earth cations (Ca+Ba). Although Mn and Fe occur in traces, the Mn/(Mn+Fe) value around 0.25 points to formation of this feldspar in a later stage of pegmatite fractionation.

The white micas show typical features, including their birefringence around 0.035–0.032. Chemical analyses were done on two mica varieties: mica-A — platy, polycrystalline aggregates containing grains of andalusite and fine crystals of dark tourmaline; and mica-B — vein mica aggregates among garnet grains. Both types can be identified as Al-micas, but the B type contains distinctly higher admixtures, particularly of Fe, Mg and Mn, while the A variety is Na-enriched (Table 2). The amount of octahedral Li in the mica-A has been estimated at around 0.11 apfu, while in the mica-B as high as 0.50 apfu. The ratio Mn/(Mn+Fe) ≈ 0.015 and 0.085, respectively, reveals that the flaky mica-B is slightly later than the coarse-platy mica-A.

The garnets are represented by crystals some millimetres to 2–3 cm large, dark brownish red, and smaller ones, light brownish in colour. The darker crystals show the ($Al_{57}Spe_{40}Py_3Gro_{<0.01}$) composition, transitional between almandine and spessartine, with the Mn/(Mn+Fe) ratio of 0.390 (Table 2), and the unit-cell parameter a = 11.566(1) Å. The lighter variety has its unit-cell slightly larger (a = 11.589(1) Å), which

TABLE 2

Representative compositions of tourmaline-associated phases in the Gilów pegmatite

Component	Mica-A	Mica-B	Hyalophane	Garnet	Andalusite	Spinel
Na_2O	0.94	0.35	1.03	0.11	0.09	0.00
CaO	0.03	0.06	0.11	0.12	0.02	0.00
K_2O	9.76	10.35	7.37	0.00	0.04	0.00
BaO			16.68			
MgO	0.18	0.75	0.00	0.70	0.00	0.43
FeO	1.43	3.29	0.56	24.23	1.01	18.26
MnO	0.02	0.30	0.19	16.70	0.01	0.78
ZnO						22.63
TiO_2	0.06	0.07	0.32	0.21	0.02	0.00
Al_2O_3	36.34	32.68	22.67	20.78	62.43	58.09
SiO_2	45.59	45.40	49.83	36.28	36.12	0.00
Li_2O*	0.40	1.84				
H_2O*	4.50	4.46				
Total	***99.25***	***99.54***	***98.76***	***99.12***	***99.72***	***100.20***
	number of ions					
Na	0.122	0.046	0.104	0.017	0.005	0.000
Ca	0.003	0.004	0.006	0.010	0.001	0.000
K	0.830	0.888	0.491	0.000	0.001	0.000
Ba			0.341			
Mg	0.018	0.075	0.000	0.087	0.000	0.019
Fe	0.080	0.185	0.025	1.674	0.023	0.449
Mn	0.001	0.017	0.008	1.168	0.000	0.019
Zn						0.491
Ti	0.003	0.003	0.013	0.013	0.000	0.000
Al	2.856	2.591	1.395	2.023	2.004	2.014
Si	3.040	3.055	2.602	2.996	0.984	0.000
Li*	0.107	0.498				
OH*	2	2				
O	10	10	4	12	5	4
Mn/(Mn+Fe)	***0.015***	***0.086***	***0.253***	***0.390***	***0.009***	***0.028***

* Calculated from stoichiometry

points to a higher amount of Mn in its composition. From the size of the unit-cell it can be concluded that it represents a spessartine species with around 65 mol.% of the spessartine end-member, the highest noted for garnets from the Góry Sowie pegmatites to date (Pieczka et al. 1997).

The raspberry-red andalusite shows traces of admixtures that can be associated with microinclusions of foreign phases, especially of white mica (Table 2). Worth noticing is an amount of FeO around 1 wt.%, probably inducing the intensive reddish colour of this mineral.

Beryl forming short-prismatic crystals, occurs very seldom within basic pegmatite. Its unit-cell: a = 9.219(1) Å and c = 9.196 (2) Å indicates a low-alkali and low-hydrated variety.

In a single BSE image, intergrowths of several crystals of the Al-(Zn-Fe)-spinel with sizes reaching 100 µm were observed within the aggregate of white mica. This phase is practically homogenous, admixture-free, and relations among Zn, Fe, Mn and Mg (Table 2) allow classifying it as a transitional member between gahnite and hercynite with the composition $Gh_{50}He_{46}Ga_2Sp_2$.

CONCLUSIONS

A complex of mudstones and sandstones metamorphosed and migmatized 384–370 Ma ago under low- and medium-pressure conditions (600–770°C/3–8 kbar; Żelaźniewicz 1995, 2003) was the protolith of the Góry Sowie gneisses (van Breemen et al. 1988; Bröcker et al. 1998; Timmermann et al. 2000; Aftalion and Bowes 2002). One of the effects of this progressive metamorphism, particularly in its last stage, included generation of low-temperature, mobile pegmatite melts, rich in SiO_2, Al_2O_3, alkalies (Na_2O, K_2O), volatiles, and some less frequent elements such as Fe, Mn, Be, B, P, F, and locally also Li. Crystallization of these melts gave rise to formation of sometimes extensive systems of veins and nests, composed of coarse-crystalline quartz, feldspars (mainly plagioclase), micas, and some other minerals in the study area: dark, Al- and Mg-enriched schorl, beryl, (Fe-Mn) bering garnets; in the last stages there crystallized an assemblage of Fe-Mn-phosphates with lamellar intergrowths of graftonite, sarcopside and ferrisicklerite (Pieczka 2002).

Quite typical of this pattern is the pegmatite described, occurring in amphibolites near Gilów. Local metamorphism of those amphibolites was determined by Dziedzicowa (1994) as low-pressure granulite facies (770–700°C/3–4 kbar), while the metamorphism of neighbouring gneisses and migmatites at 650–730°C/3–5 kbar (Żelaźniewicz 1995, 2003). The Al- and Mg-enriched schorl of the pegmatite indicates the stage of boron metasomatism and crystallization of dark tourmalines, typical of the Góry Sowie gneissic block. Chequered albite, some-centimetres-large crystals of muscovite, zircon, andalusite and spinel seem to be associated with earlier stages of the pegmatite formation. The two last minerals are without alkalies and manifest the peraluminous character of initial pegmatite melts. The zones with lighter pleochroism, extended lengthwise in some black tourmaline crystals, depleted of typical octahedral cations point to gradually increasing activity first of Al, and then also of Li in later and latest stages of pegmatite fractionation. The outer rim of colourless lithium tourmaline on the Mg- and Al-enriched schorl, and also the crystals of light green (Fe-Mn)-bearing elbaite growing immediately next to the dark tourmaline indicate that the stage of crystallization of lithium phases took place at the final stage of pegmatite formation in the Góry Sowie area. This increasing role of Li and other accessory elements is also manifested by enrichment of the younger forms of light-coloured mica in lithium and the presence of accessory hyalophane. Considering the Mn/(Mn+Fe) ratio values, 0.27–0.28 for ferrisicklerite (Pieczka 2002), around 0.05–0.07 for Li-enriched schorl and micas, and even 0.39–0.40 for green tourmaline, it can be concluded that the Góry Sowie elbaite and Li-enriched white mica are almost simultaneous with ferrisicklerite.

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PIERWSZE WYSTĄPIENIE ELBAITU W POLSCE

Streszczenie

We wschodniej części bloku sowiogórskiego, w okolicy Gilowa, zlokalizowano pośród amfibolitów wystąpienie pegmatytu kwarcowo-skaleniowo-muskowitowego zawierającego schorl, zielony elbait, spessartyn, andaluzyt, spinel, hialofan, cyrkon, columbit i beryl. Kryształy czarnego turmalinu charakteryzują się ewolucją składu chemicznego od typowego dla rejonu Gór Sowich schorlu magnezowo-glinowego, poprzez odmiany glinowe do schorli glinowo-litowych i bogatych w Fe^{2+} elbaitów. Zielony elbait jest ogniwem wzbogaconym w Fe i Mn. Sekwencja krystalizacji kolejnych odmian turmalinu wiąże się z frakcjonacją antektycznego medium pegmatytowego w późnym stadium metamorfozy pierwotnie osadowego protolitu około 370–380 Ma. Stadium tworzenia się wzbogaconych w Li odmian turmalinu odpowiada mniej więcej krystalizacji zespołu fosforanowego z przerostami ferrisicklerytu, sarkopsydu i graftonitu, poznanego z innych pegmatytów bloku sowiogórskiego.

Fig. 2. Green elbaite from the Gilów pegmatite

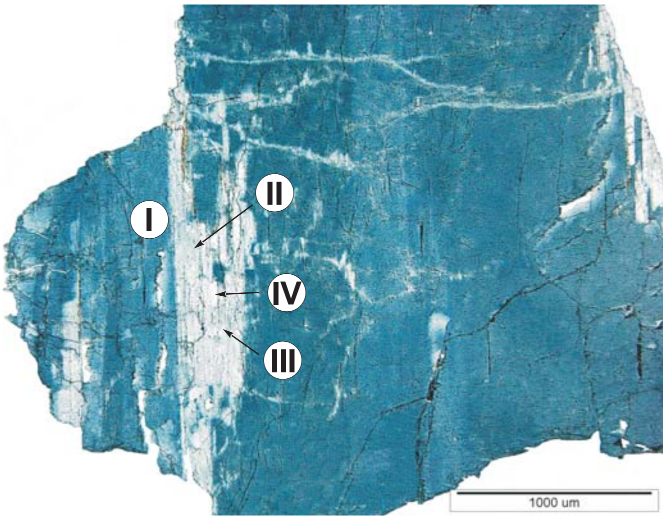

Fig. 3. Zones and veinlets of a late (Al,Li)-bearing tourmaline within schorl from the Gilów pegmatite (1 polar, transmitting light). I–IV denote number of analysis