acta
geologica
polonica

Vol. 29, No. 2 Warszawa 1979

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Columbite from the Strzelin massif, Lower Silesia

ABSTRACT: Columbite, bearing inclusions of tapiolite-mossite, occurs in the quartz-feldspathic pegmatite in the neighbourhood of Romanów village, Strzelin granitoid massif, Lower Silesia. The composition of columbite yielded formula $Fe_{0.60}Mn_{0.31}Ti_{0.16}Nb_{1.97}O_6$, and the X-ray studies revealed its disordered structure. The investigated niobium minerals probably crystallized at temperature close to 200°C rather than to 300—350°C under action of solutions responsible also for albitization of microcline.

INTRODUCTION

Niobium minerals are known to be relatively rare in the Sudetes and Sudetic Foreland in Lower Silesia. The oldest finding of the 0.5 cm large crystal of columbite in the pegmatitic vein was noted from Owiesno near Dzierżoniów in the foothills of the Owl Mts (Pilati 1863; *fide* Traube 1888). Moreover, pegmatitic veins from the Strzegom granitoid massif contain a small number of minute columbite grains (Bolewski 1965). Hence, the half-millimeter-long columbite crystals found in the pegmatite occurring inside serpentinite at Jordanów, are supposed to be connected with the Strzegom massif (Lis & Sylwestrzak 1979). Some anhedral grains of columbite were identified in the pegmatitic assemblage at Biała Dolina near Szklarska Poręba in the Karkonosze granitoid massif (Gajda 1960). An occurrence of columbite in "Kugelgranit" (*i.e.* "ball pegmatite"; *cf.* Karwowski & Kozłowski 1972) in the same massif, in the vicinity of Jelenia Góra was formerly stated by Berg (*fide* Lis & Sylwestrzak 1980). Pegmatites in granite-gneiss at Markocice near Bogatynia contain niobium minerals, tentatively determined as columbite and tapiolite (Banaś & Kucha 1969). A report exists on seemingly iron mossite from a location (Banaś & Kucha 1975) named enigmatically "the marginal zone of the Łużyce granitoids".

These above data are the only ones on tapiolite-mossite minerals in Poland. A complete list of the other niobium minerals in Lower Silesia is given elsewhere (Lis & Sylwestrzak 1980). Columbite described in the present paper is the first finding of this mineral in the Strzelin granitoid massif.

GEOLOGICAL SETTING

The studied columbite was found in pegmatite exposed along the right side of the stream about 0.8 km NNW from the village Romanów in the middle part of the Strzelin Hills (Text-fig. 1*A*). The pegmatite presents a lenticular body (the maximum thickness 70 cm, the visible length ~ 2 m) in the Strzelin granite-gneisses. Those wall-rocks of the pegmatite, together with calc-silicate rocks and mica-sillimanite schists, belong probably to the Proterozoic rock series (Oberc

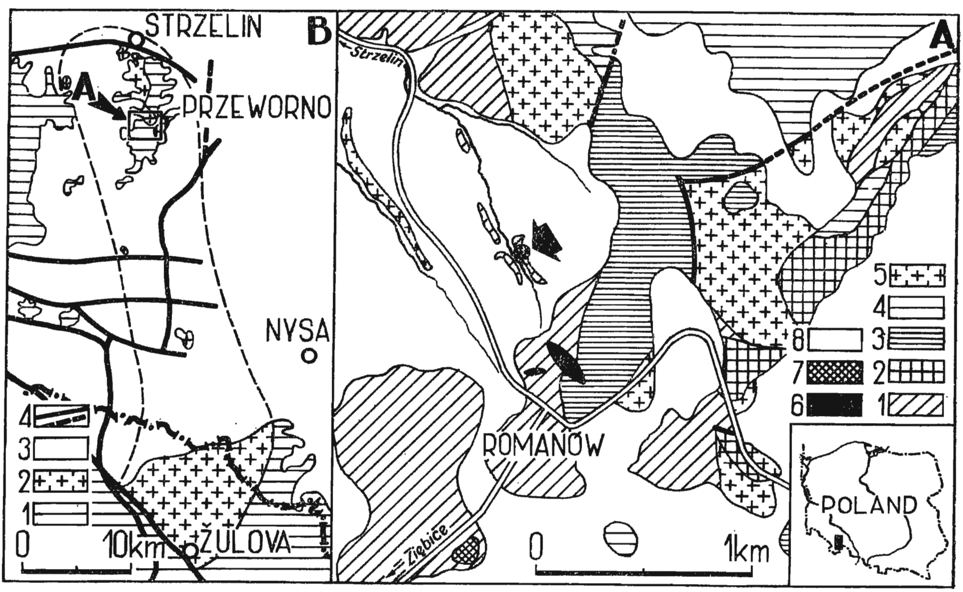

Fig. 1. Geological map of the vicinity of Romanów (**A**), *after* Wójcik (1964): *1* granite-gneisses, *2* calc-silicate rocks, *3* mica-sillimanite schists, *4* quartzite and quartzite schists, *5* granitoids, *6* pegmatites, *7* basalts, *8* Quaternary deposits; generalized geological map of the Strzelin massif (**B**): *1* metamorphic rocks, *2* granitoids, *3* Tertiary and Quaternary deposits, *4* faults
Location of the columbite-bearing pegmatite is marked by arrow in fig *1A*

1966; Wójcik 1968, 1974). This series surrounds the Strzelin granitoids of Variscan age (Text-fig. 1*B*), developing thermic contacts (Borkowska 1961, Bereś 1969). Extensive activity of post-magmatic solutions yielded here a rich sulfide assemblage (Olszyński 1973). Contact metamorphism, especially in schists altered to andalusite-sillimanite hornfels, caused formation of iron and titanium oxides as well as iron and copper sulfides (Olszyński 1972). In hornfels and adjacent granite-gneiss, two big pegmatitic zones are known (Text-fig. *1A*) both of them being similar to that one bearing the investigated columbite.

PEGMATITE

Pegmatite bearing the studied columbite consists almost exclusively of macroscopically yellowish perthite and gray quartz presenting together granophyric intergrowths. The third component, microscopically colorless muscovite, is subordinate.

Microcline bears two varieties of perthitic lamellae. The first one is rare and it is developed as tiny needles parallel to the murchisonite cleavage. The second ones are very common, and they are featured by thick, rather irregular strips, often parallel one to another, but somewhere being also coincide, fork-shaped or making up irregular patches. This second variety of perthite lamellae commonly forms continuous rim around quartz crystals (Pl. 1, Figs 1 and 2). It also develops more extensively along the boundary of two different grains of microcline (Pl. 1, Fig. 3), or along cracks and edges of crystals. If any, thus, only the first variety may be interpreted as the product of exsolution. The second variety is undoubtedly connected with infiltration of albitizing solutions.

Quartz presents roughly faceted intergrowths, but microscopic investigation reveals its tendency to obtain the rounded, almost reniform outline (Pl. 1, Fig. 1). Probably, the former straight-edged intergrowths were transformed during metasomatic perthitization by crystallization of the additional rim of quartz. This also supports the suggestion of alteration of the primary microcline-quartz pegmatite. Mosaic, oval or elongated aggregates of quartz grains were also occasionally found in this pegmatite.

Muscovite forms individual small flakes, only rarely occurring as larger, irregular aggregates (Pl. 7, Fig. 4).

COLUMBITE

The studied columbite is a composite grain with dimensions $8 \times 3 \times 3$ mm that crystallized in the margin of a quartz nest (Pl. 2, Fig. 1). It has the distinct (010) cleavage, iron-black colour and metallic lustre. The grain is subhedral.

Inside the grain, numerous quartz inclusions of microscopic size are visible (Pl. 2, Fig. 3). In the reflected light columbite has typical gray-white color with the distinct brownish tint. Bireflectance and anisotropy are weak; light extinction suggest that the whole grain is one crystal or the aggregate of uniformly oriented crystals. Deep-red internal reflections prove that the studied columbite has composition with the prevailence of Fe over Mn (*cf.* Uytenbogaardt & Burke 1971).

The investigated columbite grain is cracked, especially in its marginal parts (Pl. 2, Figs 2 and 3). The fractures are filled with very fine-grained porous aggregate, consisting of columbite chips, pale-yellow sulfide, and a mineral with optical features similar to native bismuth. The identification of the latter minerals is tentative due to their minute grain size.

The analysed columbite bears also small inclusions of the ore mineral (Pl. 2, Fig. 4) which on the basis of its optical features may be determined as tapiolite-mossite.

Chemical analysis of the studied columbite (Table 1) yielded formula $Fe_{0.60}\,Mn_{0.31}\,Ti_{0.16}\,Nb_{1.97}\,O_6$. Tantalum content was lower than

Table 1

Chemical composition of columbite from Romanów

Component	weight %
FeO	12.63
MnO	6.53
TiO_2	2.98
Nb_2O_5	77.05
Ta_2O_5	<0.5
Total	99.19

Colorimetric methods; FeO, MnO and TiO_2 determined by B. Kuroczko, M. Sc., Nb_2O_5 and Ta_2O_5 by A. Kozłowski

0.5 wt % and very close to the detection limit. This chemical and phase composition was supported by the *IR* absorption spectrum (Text-fig. 2), typical of the columbite structure (*cf.* Gadsden 1975, Boldyrev 1976). A weakly increasing absorption in the range of 3 µm is connected with the presence of small amounts of water in KBr used for preparation of pellets rather than with any kind of hydratation of the mineral.

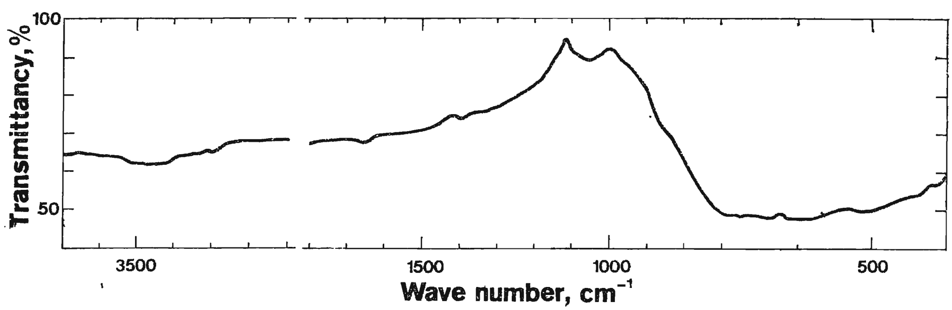

Fig. 2. Infrared absorption spectrum of columbite from Romanów; KBr pellet, 0.66 mg of sample per 1 cm²

The *X*-ray powder patterns, confirming the identification of the mineral as columbite, revealed the absence of all reflections with the (hkl) indices having k ≠ 3n (Table 2 and Text-fig. 3). This fact proves that the studied columbite from Romanów has completely disordered structure (Text-fig. 4), i.e. there exists no preference for either Fe, Mn or Nb (plus virtually Ta) in occupying of the cation positions in the crystal lattice (Komkov 1974). The only other obtainable *X*-ray pattern of the Polish columbite from Jordanów (Table 2) shows partly

Table 2

X-ray powder patterns of columbites

hkl	Romanów Strzelin massif		Jordanów (Lis & Sylwestrzak, 1979)		Disordered columbite (Komkov, 1974)		Ordered columbite (Komkov, 1974)	
	I	d, Å	I	d, Å	I	d, Å	I	d, Å
020	-	-	5	7.2	-	-	7	7.22
110	-	-			-	-	3	5.35
130	41	3.65	31	3.68	32	3.667	40	3.697
040	-	-	5	3.59	-	-	8	3.611
131	100	2.97	100	2.98	100	2.995	100	2.990
200	7	2.866	7	2.87	9	2.871	8	2.883
002	11	2.564	6	2.54	14	2.582	14	2.548
201	22	2.501	9	2.50	18	2.509	18	2.508
060	6	2.366	6	2.38	10	2.383	10	2.407
221	-	-			-	-	2	2.370
151	-	-			-	-	2	2.300
032	5	2.253			2	2.277	2	2.252
231	7	2.208	4	2.21	2	2.221	2	2.225
132	6	2.094	4	2.09	8	2.113	7	2.097
042	-	-			-	-	2	2.081
241	-	-			-	-	3	2.060
202	5	1.909	3	1.90	6	1.920	8	1.910
260	5	1.824	5	1.83	6	1.834	6	1.847
152	-	-			-	-	3	1.813
330	16	1.771	8	1.77	11	1.777	12	1.785

disordered structure. However, the attempt of calculation of the order/ /disorder index $I_{040} : I_{060} = f(S)$, where *S* — degree of order/disorder of the structure, yielded value 0.83, whereas the highest value for columbite equals 0.8. The so high index value, and the absence of some k ≠ 3n reflections is assumingly connected with the fact that the sample from Jordanów might be a mixture of crystals with various order/discorder degree and/or variable composition, especially Nb:Ta ratio.

CONCLUSIONS

The data obtained from chemical and X-ray studies of columbite, proving its completely disordered structure, permit to present some genetic conclusions. Experimental studies revealed that disordered

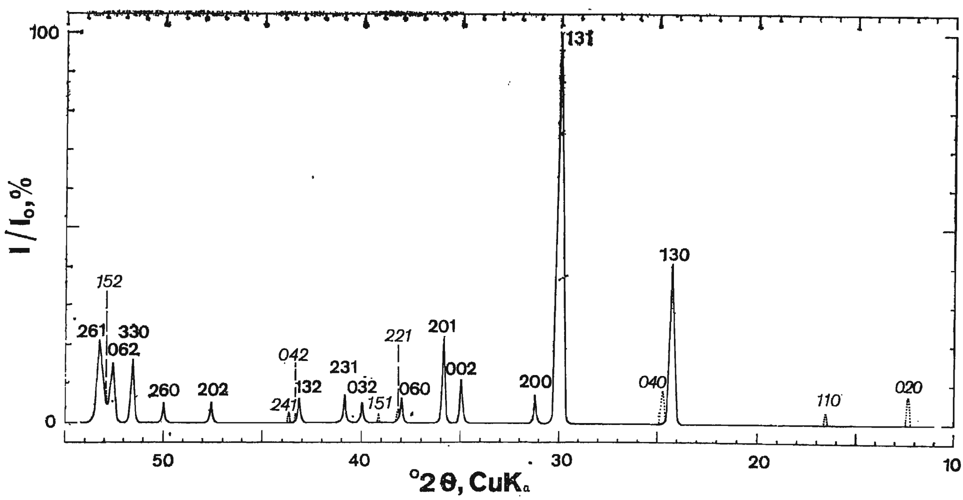

Fig. 3. X-ray powder pattern of columbite from Romanów; reflections typical of the ordered columbite are indicated by dotted line and italics

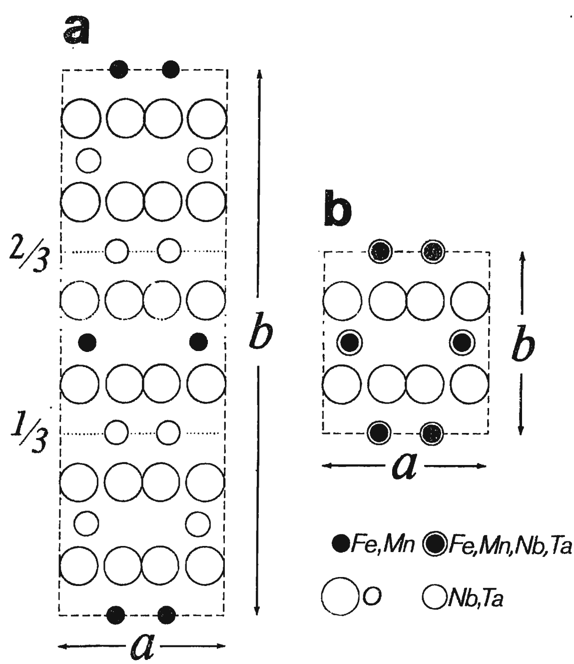

Fig. 4. Structure of the ordered (**a**) and disordered (**b**) columbite, projected on the plane (001); *after* Komkov (1974)

columbite is typical of rather low temperature of crystallization (Komkov 1974, and references cited therein), and columbite from Romanów should not be therefore regarded as of high-temperature origin. A series of hydrothermal syntheses of columbite and tapiolite (Komkov & Dubik 1974) elucidated the conditions of the forming and of the co-existence of crystal phases in the system $FeNb_2O_6$ — $MnNb_2O_6$ — $FeTa_2O_6$ — $MnTa_2O_6$. In the phase diagram of that system for temperature 200°C and 300—350°C (Text-fig. 5), the composition of the studied columbite falls into two-phase field of co-existence of compounds with columbite and tapiolite structures at temperature 200°C, but it is out of this field at temperature 300—350°C, appearing then in the one-phase columbite field. Since the inclusions in the studied columbite are most probably tapiolite-mossite, thus the above two minerals suggest their crystallization conditions typical of the two-phase field. Hence, the crystallization temperature should be rather close to 200°C than to 300—350°C, if pressure (P_{H_2O}) was not drastically different from 2000 bar.

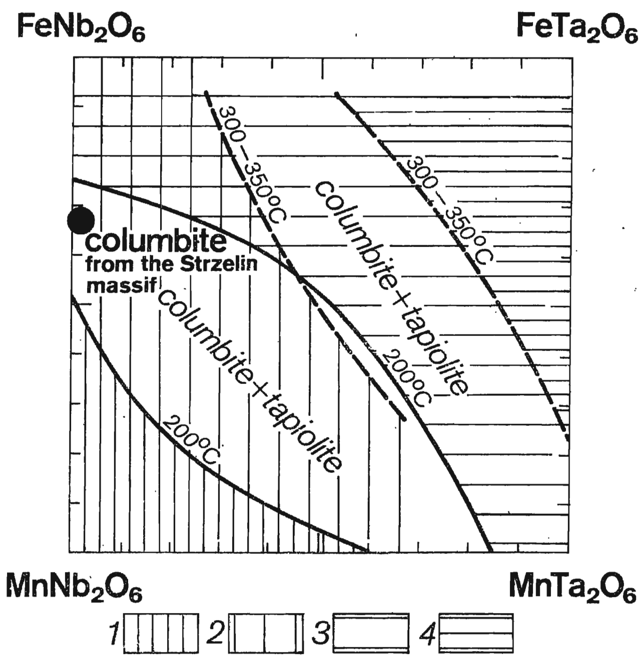

Fig. 5. Phase diagram of the system $FeNb_2O_6$ — $MnNb_2O_6$ — $FeTa_2O_6$ — $MnTa_2O_6$, P_{H_2O} = 2000 bar

1 — columbite stability field at 200°C, 2 — increase of the columbite stability field at 300—350°C; 3 — decrease of the tapiolite stability field at 300—350°C from 200°; 4 — tapiolite stability field at 300—350°C; *after* Komkov & Dubik (1974)

The general geochemical feature is also apparent that, under the action of Na-rich solutions, niobium is transported and precipitated rather than tantalum. A solution of high sodium activity caused the forming of infiltration perthite in microcline and it probably might be also the parent solution of columbite. Similar geochemical relations between sodium metasomatism and niobium concentration were also recognized in other areas. For instance, wolframites crystallizing from Na-rich solutions in the Karkonosze massif contained Nb prevailing 10—100 times over Ta (Kozłowski, Karwowski & Olszyński 1975). Likewise, Nb-bearing rutile occurring in sodium metasomatites in the Izera Hills, appears to be poor in tantalum (Karwowski 1977).

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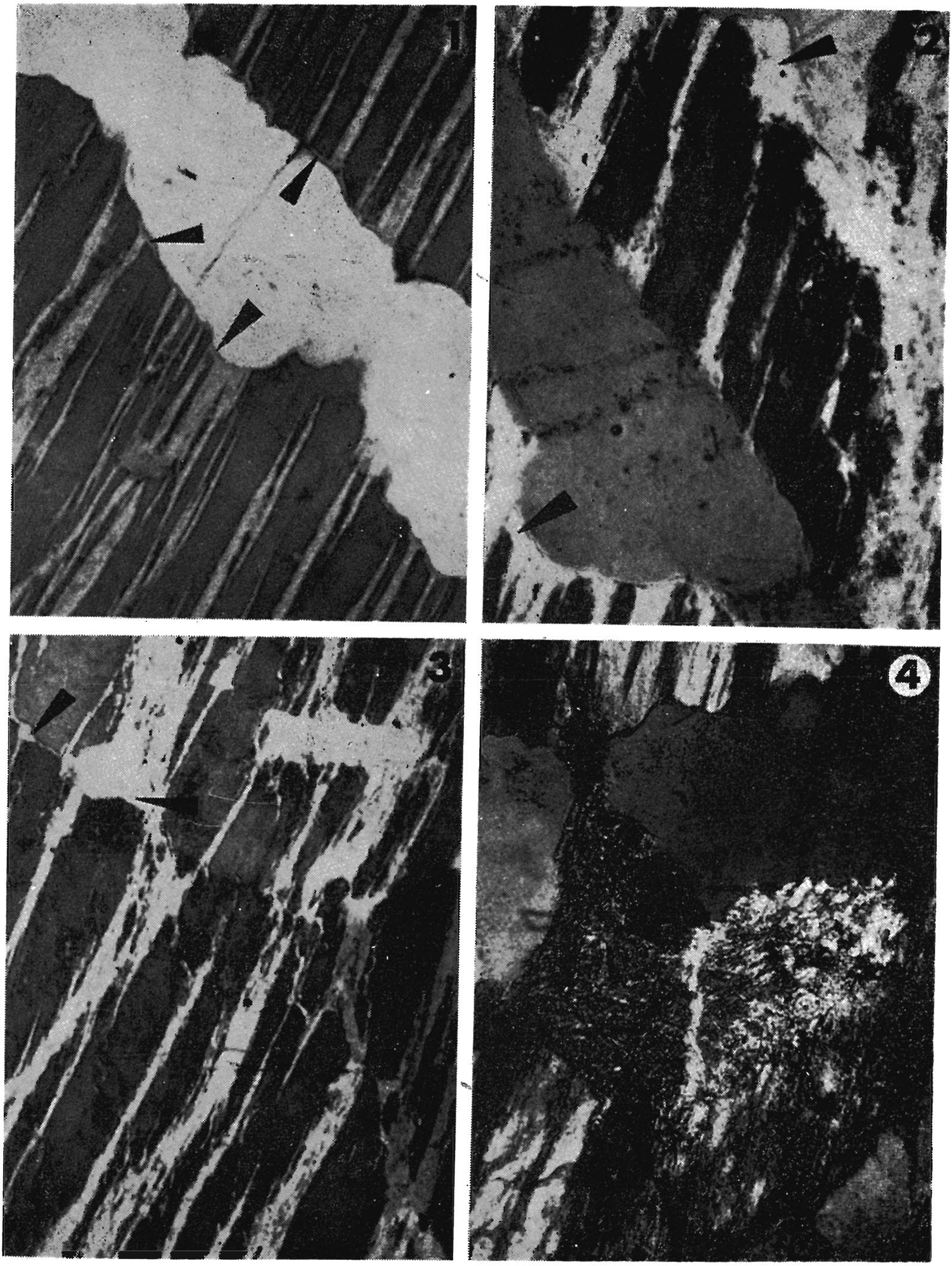
KOLUMBIT Z MASYWU STRZELIŃSKIEGO

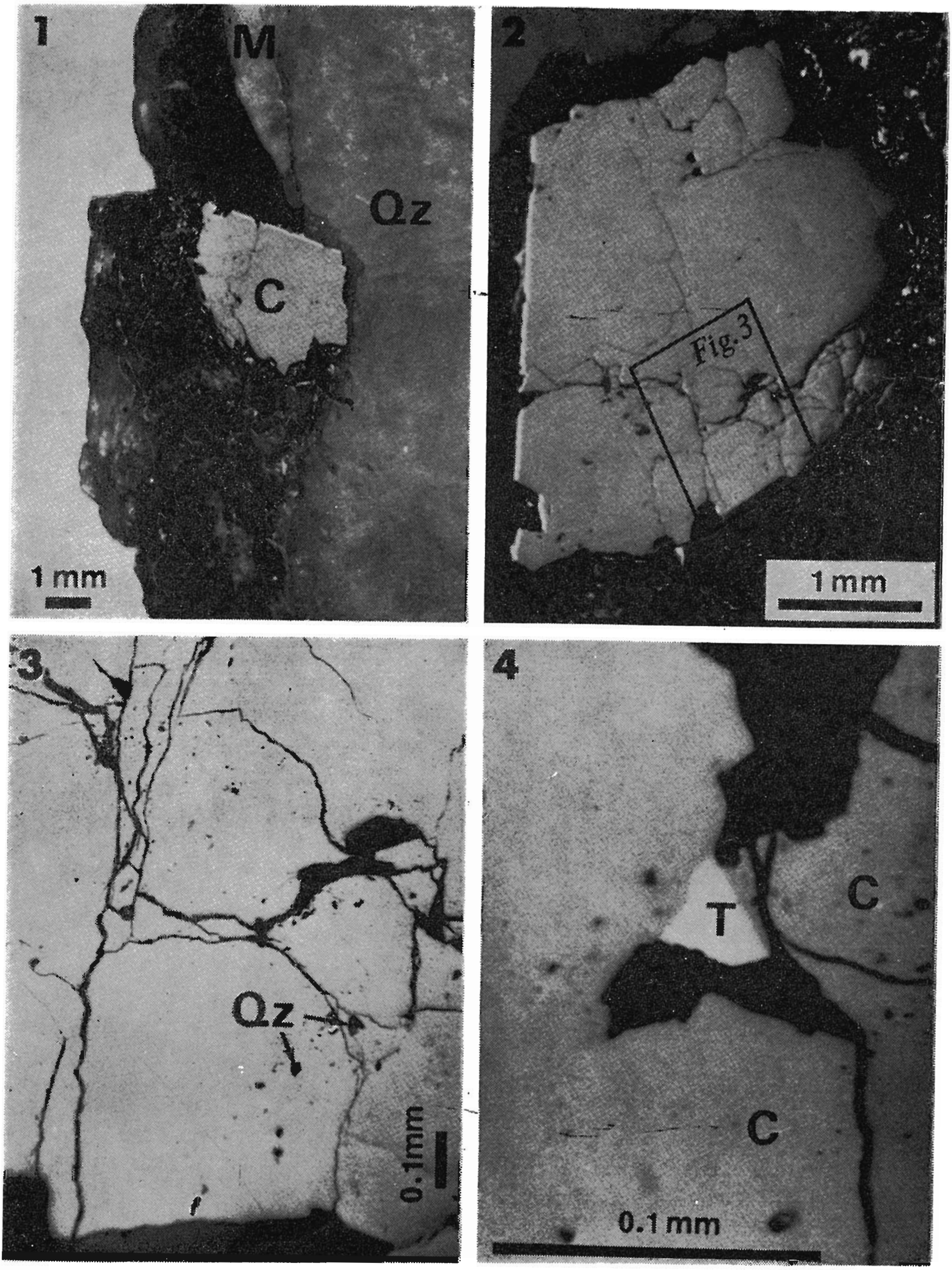
(Streszczenie)

W pegmatycie kwarcowo-skaleniowym odsłaniającym się w okolicy Romanowa w strzelińskim masywie granitoidowym stwierdzono występowanie kolumbitu z wrostkami tapiolitu (*patrz* fig. 1 oraz pl. 1—2). Skład kolumbitu odpowiada formule $Fe_{0.60}Mn_{0.31}Ti_{0.16}Nb_{1.97}O_6$ (*patrz* tab. 1). Widmo adsorbcji w podczerwieni jest typowe dla kolumbitu (fig. 2), zaś analiza rentgenostrukturalna wskazuje na nieuporządkowaną strukturę tego minerału (tab. 2 oraz fig. 3—4). Badany kolumbit krystalizował w temperaturze około 200°C (*patrz* fig. 5) w związku z zaznaczającą się w pegmatycie metasomatozą sodową.



1 — Granophyric intergrowths of quartz and perthitized microcline; note the reniform outline of quartz, and the albite rim along the quartz/microcline boundary
2 — Perthite in microcline between quartz grains; note very wide albite rims along the grain boundaries
3 — Perthite; albite developed also along the boundary of two microcline grains
4 — Muscovite in quartz-microcline pegmatite

Nicols crossed, × 60; albite along the boundaries of grains is arrowed



1 — Columbite in quartz-microcline pegmatite
2 — Columbite; reflected light, nicols oblique
3 — Close-up view of part of Fig. 3, fractures and quartz inclusions in columbite are visible; reflected light, parallel nicols
4 — Tapiolite in columbite; reflected light, nicols crossed

In all figures: **C** — columbite, **T** — tapiolite, **Qz** — quartz, **M** — microcline