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TOURMALINE FROM PRECAMBRIAN ROCK IN OUED DAMRANE (NORTH ALGERIA)

Abstract. The paper deals with mineralogical characteristics of tourmaline from quartz–tourmaline rock occurring within Precambrian volcanites in Oued Damrane region (NW part of Algerian Sahara). The study was carried out using microscope, X-ray, thermal, infrared spectroscopic, chemical and emission spectrographic methods. All the data indicate that the tourmaline examined should be defined as schörl containing small amount of dravite member.

INTRODUCTION

The Oued Damrane region is situated in SW part of the mountain range Ougarts in NW area of the Algerian Sahara, 45 km from Tabelbala and about 70 km from Béchar–Tindouf highway (Fig. 1).

The name Oued Damrane structure was accepted for the zone of outcropping Precambrian volcanic and sedimentary rock complex, localized in W part of "oued" bearing the same name. From structural viewpoint this zone is localized within the axis of anticline formed during Hercynian orogenesis. Precambrian volcanites in question are represented by basalts, andesites, dacites, trachites, rhyolites, as well as corresponding tuffs and volcanic agglomerates. Usually these rocks are strongly altered. This refers especially to basalts, subjected to silification, chloritization and epidotization. Within this rock complex, particularly in its andesite–basalt series, there occurs quartz–tourmaline rock, examined in more detail by the present author. Preliminary investigations of the samples collected in 1985–1987 were carried out in the laboratory in Kenadsa E.RE.M Unite Béchar and supplemented by instrumental methods in the Institute of Geology and Mineral Deposits of the Academy of Mining and Metallurgy in Cracow.

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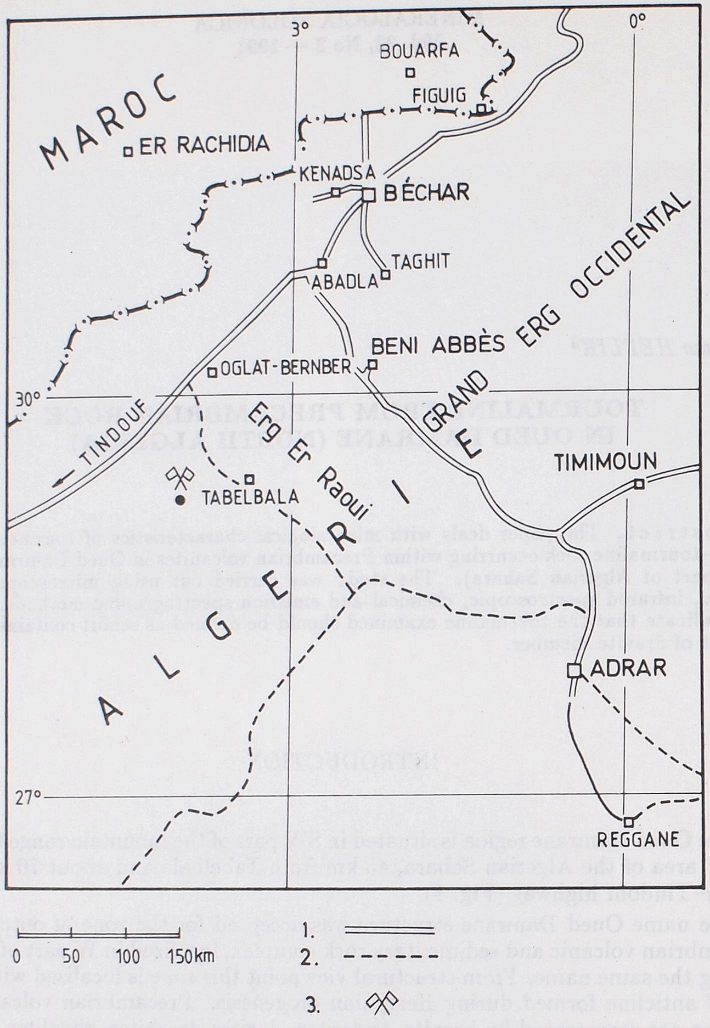

Fig. 1. Geologic sketch map of the Oued Damrane region
1 — main roads, *2* — secondary roads, *3* — Oued Damrane region

GEOLOGICAL SETTING

The outcrops of Precambrian rocks in the Oued Damrane zone show NW-SE strike, being, in its broadest part, about 10 km wide and 30 km long. This zone, approximately 260 sq. km in area, represents elevated but strongly eroded volcanic structure showing negligible depression and heights from 2–3 to 10–15 m in size. The highest elevations in this zone consist of Late Precambrian rocks represented by rhyolites. Precambrian rocks of the Oued Damrane zone are dipping to SE under

Cambrian and Ordovician sequences, whilst in NW, NE and E parts younger rock series are exposed. About 40 percent of the area in question is covered by alluvial and eluvial deposits.

The Oued Damrane Structure consists of very diversified sedimentary and volcanic rock complex. The latter is composed of andesite–basaltic and rhyolite formations. There also occur hypabyssal and intrusive rocks, forming dikes and, less common, sills. Hypabyssal rocks are represented by gabbro–basalts and microgabbros, whilst intrusives by dolerite dikes, usually 1 m thick, monzonites and quartz diorites. These rocks are accompanied by calcite, quartz–calcite, barite and barite–quartz veins. Petrographic characteristics of these volcanites and their alteration products are presented in another paper (Heflik, in press).

The outcrop of quartz–tourmaline rock is situated within volcanic series of the Oued Damrane zone. The shape of this body, approximately 25 m long and 1 m wide, is not clear. The rock is black in colour, compact and contains small euhedral tourmaline crystals.

MINERALOGICAL STUDY

The rock consists nearly entirely of mutually irregulary distributed quartz and tourmaline grains, accompanied by small amounts of haematite. Granoblastic quartz grains are usually corroded and intergrown by fine acicular crystals of tourmaline. They are showing uneven extinction. The average mineral composition of this rock, resulting from micrometric analysis, is as follows: 60 vol. percent quartz, 35 vol. percent tourmaline, 5 vol. percent haematite.

Tourmaline crystals, up to 5 mm long and 2 mm wide, occur, most commonly, as radial and compact aggregates or as individual acicular crystals. In all the cases they are elongated according to Z axis. In thin sections the tourmaline crystals show distinct pleochroism from olive-green (ϵ) to greenish blue (ω), often exhibiting zonal or spotty structure, even within the same grain. These optical properties are characteristic of ferrugineous tourmaline (schorl).

X-ray diffraction pattern of the tourmaline examined, presented in Table 1, is compared with reported for dravite and schorl (Sosjedko, Mishchenko 1986). It is evident that the mineral in question displays all the characteristic reflections of schorl, corresponding to the following *hkl* values: 511, 431, 440, 342, 603 and 550.

DTA curve of tourmaline from Oued Damrane rock exhibits two strong and two weak endothermic effects as 750 and 950°C and at 140, 570 and 1330°C respectively (Fig. 1). According to Kauffman and Dilling (1950) and Kurylenko (1950, 1951, 1953), very strong endothermic effect initiated at 140°C with a maximum at 750°C is caused by loss of chemically combined water. The strongest endothermic effect with a maximum at 950°C is due to the loss of boron. Weak endothermic bending marked at 570°C is related with polymorphic transformation of β-quartz. High-temperature exothermic effects at 1150 and 1320°C are due to the melting of tourmaline and indicate that this mineral consists of two members of the tourmaline group — dominating schorl and subordinate dravite. The former is melting in the range 1150–1320°C whilst for the latter this process proceeds up to about 1380°C.

Infrared absorption spectrum of tourmaline in question is characterized by the presence of the following bands: 475, 520, 710, 750, 780, 1030, 1140, 1280 and 1330 cm^{-1}. The majority of them (710, 750, 1030, 1280 and 1330 cm^{-1}) is characteristic of BO_3 ion occurring within schorl lattice (Moenke 1962, Plyusnina *et al.* 1969,

Table 1

X-ray powder diffraction data for tourmaline

hkl	*1*		*2*		*3*	
	d (Å)	I_{100}	*d* (Å)	I_{100}	*d* (Å)	I_{10}
1	2		3		4	
101	6.40	42	6.35	35	6.37	5
021	5.00	16	4.97	17	4.98	3
300	4.62	10	4.61	9	4.60	3
211	4.24	45	4.27	45	4.27	10
220	4.00	65	3.99	47	3.98	9
012	3.49	100	3.46	100	3.45	4
131	3.39	10	3.38	8	3.38	1
401			3.07	6		
410	3.03	13	3.018	8	3.01	1
122	2.97	100	2.951	100	2.94	6
321	2.91	9	2.900	7	2.89	1
312	2.63	9	2.615	8	—	
051	2.59	70	2.580	98	2.57	9
042	2.50	4	2.485	4	—	
241	2.46	5	2.455	3	2.45	2
003	2.406	22	2.383 }	28	—	
232	2.385	25	2.373 }		—	
511	2.354	13	2.346	15	2.34	2
600			2.305	2	—	
502	2.197	13	2.188	16	2.181	1
431	2.170	10	2.167	10	2.166	2
303	2.132	20	2.117 }	20	2.127	4
422	2.118	9	2.110 }		—	
223	2.060	25	2.046 }	55	—	
152	2.049	40	2.040 }		2.049	4
161	2.029	8	2.023	9	2.036	4
440	2.001	6	1.996	4	1.981	2
342	1.927	25	1.919	30	1.914	2
413	1.882	9	1.870	10	—	
621	1.858	5	1.852	7	—	
612	1.824	2	1.817	2	1.821	7
333	1.786	10	1.776	10	—	
024	1.744	8	{ 1.731	6	—	
072	{ 1.736	1–2	{ 1.729		—	
532	{ 1.736		{ 1.729		—	
214	1.704	1–2	—		—	
262	1.695	4	1.690	4	1.672	1
603	1.666	22	1.657	15	1.658	1
271	1.649	10	1.644	12	1.642	1
550	{ 1.601	22	1.597	9	1.595	2
404	{ 1.599		{ 1.588		—	
452	1.591	4	{ 1.587	9	—	
811	1.580	1	—		—	
324	1.569	1–2	1.557	3	—	
461	1.550	1–2	1.549	5	1.544	1
900	{ 1.538	2	1.537	5	—	
443	{ 1.537		{ 1.530	5	—	
722	1.531	2	{ 1.529		—	
820	{ 1.513		1.509	5	—	
054	{ 1.511	20	1.501	18	—	
244	1.486	8	1.475	5	—	
514	{ 1.460		{ 1.451		1.451	2
713	{ 1.459	22	{ 1.452	21		
642	1.455	7	{ 1.450		—	

Table 1 (continued)

1	2		3		4	
740	{ 1.438	8	1.434	5	—	
015	{ 1.434		{ 1.422		—	
372	{ 1.432		{ 1.427	14	—	
651	{ 1.422		{ 1.421			
191	{ 1.422	8	{ 1.421		1.419	1
434	{ 1.414		{ 1.405		—	
633	{ 1.413	18	{ 1.407	4	1.382	3
125	—		—		1.376	3
164	1.372	2	1.364		1.373	4
10.01	1.362	10	1.358	5	—	
315	1.352		{ 1.340	4	—	
912	{ 1.346	3	{ 1.344		—	
562	{ 1.346		{ 1.344		1.333	4
660	{ 1.334	12	{ 1.331	5	—	
704	{ 1.333		{ 1.326		—	
553	{ 1.332		{ 1.327		—	
354	{ 1.333		{ 1.326		—	
045	{ 1.331		{ 1.321		—	
10.10	{ 1.316	12	1.313	8	1.315	5
624	{ 1.315		1.308	5	—	
235	{ 1.314		{ 1.304	5	—	
832	—		{ 1.307		—	
571	—		{ 1.303		—	
903	—		1.292	3	—	
0.10.2	—		1.290		—	
930	{ 1.282	20	{ 1.279	4	1.279	4
823	{ 1.279		{ 1.275			
505	{ 1.279		1.270	12		

1 — Black tourmaline (dravite type; Sosjedko, Mishchenko 1986)
2 — » (schorl type; Sosjedko, Mishchenko 1986)
3 — » (schorl type; Oued Damrane)

Table 2

Vibration frequencies (cm^{-1}) of BO_3 ion in tourmalines

Mineral	V_1	V_2	V_3	V_4
Schorl x_1	~ 1000	755 712	1343 1280 1254	~ 680
Dravite x_2	~ 1000	720 735	1357 1260	~ 610
Elbaite x_3	~ 1100	726 730	1347 1303	~ 650
Synthetic tourmaline x_4	1000	724	1300	
Tourmaline from Oued Damrane	1030	750 710	1330 1280	

x_1, x_2, x_3, x_4 — data after Plyusnina and Woskriesienskaja (1974)

1974). The frequencies of vibrations of this ion for individual varieties of tourmaline (Plyusnina *et al.* 1974) and for that examined are presented in Table 2.

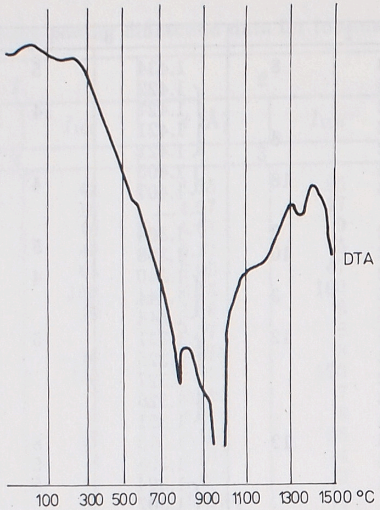

Fig. 2. DTA curve of tourmaline from Oued Damrane

Pure tourmaline sample for chemical analysis, ca. 20 g in weight, was obtained from the rock studied first by mechanical treatment under binocular microscope and, subsequently, by repeated separation from numerous quartz intergrowths in bromoform.

The results of chemical analysis are presented in Table 3 and compared with the composition of different varieties of tourmaline after Kunitz (1929), Harada (1939), Schaller (1913), El Hinnawi and Hofmann (1966).

The formula of tourmaline from Oued Damrane, calculated on the basis of 31 (O, OH, F), is as follows:

$$(Na_{1.18}K_{0.7}Ca_{0.11}) \cdot (Fe^{2+}_{1.85}Mn_{0.09}Mg_{0.05}Fe^{3+}_{0.17}\ Al_{0.89}Ti_{0.05}Li_{0.11}) \cdot Al_{6.00}B_{2.69}Si_{6.16}O_{27.00}(OH_{2.26}O_{1.63}F_{0.11})$$

The observed slightly abnormal balance of O^{2-} ions is not exceptional since it also results e.g. from the analysis of schorl from Kurobira, Yamanasi Prefecture, Japan (Harada 1939). As follows from the above formula, the tourmaline in question should be defined as schorl containing small admixture of magnesian dravite. This conclusion is confirmed by optical features: refractive indices and birefringence, which are distinctly lower than those reported for pure schorl ($n_\omega = 1.648$, $n_\epsilon = 1.621$, $\Delta = 0.027$).

The results of spectrochemical emission analysis are shown in Table 4.

DISCUSSION AND CONCLUSIONS

All the presented data indicate that tourmaline from Precambrian rock Oued Damrane region should be defined as schorl containing low dravite admixture. Schorl is a characteristic mineral of boron-bearing pneumatolytic activity related with granitoid intrusions. Usually it occurs in top parts of these intrusions, en-

Table 3

Tourmaline analyses

	1	Schorl 2	Dravite 3	Elbaite 4	Elbaite 5
SiO_2	35.47	35.10	35.96	37.89	36.28
TiO_2	0.38	0.33	0.14	0.04	0.01
B_2O_3	8.97	9.38	10.73	10.28	11.38
Al_2O_3	33.64	34.07	30.85	43.85	43.33
Fe_2O_3	1.28	0.56	—	—	0.26
FeO	12.71	14.37	0.76	0.11	—
MnO	0.61	0.10	—	0.11	0.10
MgO	0.19	1.45	13.67	—	0.14
CaO	0.61	0.46	2.41	0.07	0.44
Na_2O	3.51	2.15	1.63	2.43	2.36
K_2O	0.31		0.09	—	0.03
Li_2O	0.16	—	—	1.66	1.95
F	0.28	—	—	0.10	0.95
H_2O^+	1.95	1.95	4.16	3.47	3.41
H_2O^-	—	0.30	—	—	—
	100.07	100.22	100.40	100.01	100.64
O=F	0.10	—	—	0.04	0.40
Total	99.97	100.22	100.40	99.97	100.24
ω	1.660	1.668	1.637	1.651	1.635
ϵ	1.621	1.638	1.616	1.630	1.618
Δ	0.028	0.030	0.021	0.013	0.017
D	—	—	3.050	3.05	—
Numbers of ions on the basis of 31 (O, OH, F)					
Si	6.160	6.071	5.759	5.942	5.657
B	2.689	2.802	2.965	2.782	3.062
Al	6.000	6.000	5.826	6.000	6.000
Al	0.886	0.950	—	2.106	1.965
Fe^{3+}	0.167	0.073	—	—	0.030
Mg	0.049	0.374	3.262	—	0.032
Ti	0.050	0.044	0.017	0.005	0.001
Li	0.112	—	—	1.046	1.224
Fe^{2+}	1.846 } 4.564	2.080 } 4.34	0.101 } 4.32	0.014 } 3.94	— } 4.06
Mn	0.090	0.014	—	0.014	0.013
Na	1.182	0.722	0.506	0.739	0.714
Ca	0.114	0.085	0.414	0.012	0.073
K	0.068	—	0.018	—	0.006
OH	2.259 } 2.374	2.254	4.444	3.635 } 3.68	3.547 } 4.02
F	0.115	—	—	0.050	0.468

1 — Schorl, Oued Damrane, N Algeria (W. Heflik, and Laboratorium Kenadsa)
2 — Brow dravite, dolomite rock, Gouverneur, New York State (Kunitz 1929) and W. Kunitz and E. H. Wulfing
3 — Dark blue centre from zonal tourmaline (schorl), granite, Kurobirg, Yamanasi Prefecture, Japan (Harada 1939) and S. Komatu
4 — Elbaite, Elba (Schaller 1913) and W. T. Schaller
5 — Elbaite (rose-red rim, colourless core), Alto Ligonha, Mozambique (El-Hinnawi, Hofmann 1966)

riched in volatiles, and in microgranitic and aplitic apophyses. Besides, schorl is very common in granitic pegmatites, where sometimes it occurs as large prismatic crystals. It is also abundant in contact pneumatolytic rocks, as e.g. greisens. In some of these rocks it is even the major mineral. Magnesian tourmalines (dravites)

Table 4

Emission spectral analytical data for tourmaline of Oued Damrane

Element	Content (wt.%)	Element	Content (wt.%)
Mn	$3 \cdot 10^{-2}$	Bi	$< 10^{-4}$
Ni	$2 \cdot 10^{-3}$	Cd	$< 10^{-3}$
Co	$< 10^{-3}$	As	$< 10^{-2}$
Ti	$1 \cdot 10^{-1}$	P	$< 10^{-1}$
V	$7 \cdot 10^{-3}$	Ba	$< 10^{-2}$
Cr	$7 \cdot 10^{-3}$	Sr	$< 10^{-2}$
Mo	$4 \cdot 10^{-4}$	Zr	$< 10^{-2}$
W	$< 10^{-3}$	Nb	$< 10^{-3}$
Cu	$6 \cdot 10^{-3}$	Be	$< 10^{-4}$
Ag	$3 \cdot 10^{-5}$	Li	$0.3 \cdot 10^{-3}$
Pb	$0.5 \cdot 10^{-3}$	La	$< 10^{-2}$
Zn	$< 10^{-2}$	Y	$< 10^{-3}$
Sn	$1 \cdot 10^{-4}$	Hg	$< 10^{-2}$
Sb	$< 10^{-3}$		

occur predominantly in metamorphic and metasomatic rocks. It is also met in basic igneous rocks subjected to boron metasomatism, in which it is accompanied by accinite and datolite. Dravites are often essential constituents of these rocks. Similar tourmaline concentrations are reported from spilosites and adinoles (Agrell 1941) and Otago schists from New Zealand (Hutton 1939). In this case the source of boron is granitic magma. The Mg/Fe ratio and Ca content in these tourmalines are considered as indicating the rock type related with tourmalinization process. Sometimes it is possible to evaluate this portion of magnesium which was introduced into tourmaline due to metasomatic processes.

The analyzed tourmaline from Oued Damrane occurs in a dislocation zone within andesite–basaltic rock series. Geological conditions of occurrence of its parent rock are not quite clear. It is the product of boron-bearing pneumatolytic fluids, genetically related with these volcanics or associated hypabyssal or intrusive rocks. As follows from this study, intrusive magmatic activity took place after andesite–basaltic volcanism (older) but before the rhyolitic one (younger). Intrusive phenomena were accompanied by hydrothermal activity which resulted in the formation of quartz–calcite–barite veins. In the present author's opinion, complex geological–geophysical studies in this area are necessary to explain in detail the origin of Precambrian tourmaline-rich rock in the Oued Damrane region.

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PHOTOGRAPH CAPTIONS

PLATE II

Phot. 1. Radial tourmaline aggregates in the quartz–tourmaline rock from Oued Damrane. 1 nicol. Magn. 30 ×.

Phot. 2. Radial tourmaline aggregates in the quartz–tourmaline rock from Oued Damrane. Crossed nicols. Magn. 30 ×.

Wiesław HEFLIK

TURMALIN Z PREKAMBRYJSKICH SKAŁ Z OUED DAMRANE (PÓŁN. ALGIERIA)

Streszczenie

W pracy przedstawiono charakterystykę mineralogiczną turmalinu wchodzącego w skład skały kwarcowo–turmalinowej, występującej w obrębie prekambryjskich wulkanitów w rejonie Oued Damrane (w północno-zachodniej części Sahary Algierskiej, fig. 1). W badaniach zastosowano obserwacje mikroskopowe w świetle przechodzącym, analizę rentgenograficzną (tab. 1), termiczno-różnicową (fig. 2), spektrofotometryczną w podczerwieni (tab. 2), chemiczną (tab. 3) i spektralną (tab. 4).

Badany turmalin tworzy trzy formy skupień: promieniste, zbite agregaty oraz pojedyncze igiełki. Przeważają skupienia o budowie promienistej. Maksymalne rozmiary kryształów tego minerału wynoszą: długość ok. 5 mm, a średnica ok. 2 mm. Makroskopowo jest to minerał o barwie czarnej. W płytce cienkiej ujawnia silny pleochroizm: ϵ — oliwkowozielony, ω — zielonkawoniebieski, nieraz pasowo lub plamiście zmienny w jednym i tym samym krysztale. Własności te są charakterystyczne dla turmalinu żelazistego (skorylu). Potwierdzają to również pozostałe, uzyskane w niniejszej pracy wyniki badań.

Określony na podstawie przeliczeń analizy chemicznej wzór tego minerału jest następujący:

$$(Na_{1.18}K_{0.7}Ca_{0.11}) \cdot (Fe^{2+}_{1.85}Mn_{0.09}Mg_{0.05}Fe^{3+}_{0.17}\,Al_{0.89}Ti_{0.05}Li_{0.11})$$
$$\cdot\, Al_{6.00}B_{2.69}Si_{6.16}O_{27.00}(OH_{2.26}O_{1.63}F_{0.11})$$

Analizowany turmalin z Oued Damrane występuje w strefie dyslokacji w kompleksie skał formacji andezytowo–bazaltowej, w nieustalonych dotychczas bliżej warunkach geologicznych. Jest on produktem boronośnej pneumatolizy, genetycznie związanej z wulkanitami tej formacji, bądź też ze współwystępującymi z nią skałami hipabisalnymi (gabrobazaltami i mikrogabrem) lub intruzywnymi: dolerytami, monzonitami, diorytami kwarcowymi i andezytami hornblendowo–kwarcowymi.

Dokładne wyjaśnienie genezy skały kwarcowo–turmalinowej, a zwłaszcza występującego w niej turmalinu z Oued Damrane, możliwe będzie dopiero po przeprowadzeniu w tym terenie kompleksowych badań geologiczno–geofizycznych i skonfrontowaniu ich wyników z niniejszymi rezultatami badań mineralogiczno–petrograficznych.

OBJAŚNIENIA FIGUR

Fig. 1 Szkic sytuacyjny rejonu Oued Damrane.
1 — drogi główne, *2* — drogi podrzędne, *3* — rejon Oued Damrane.

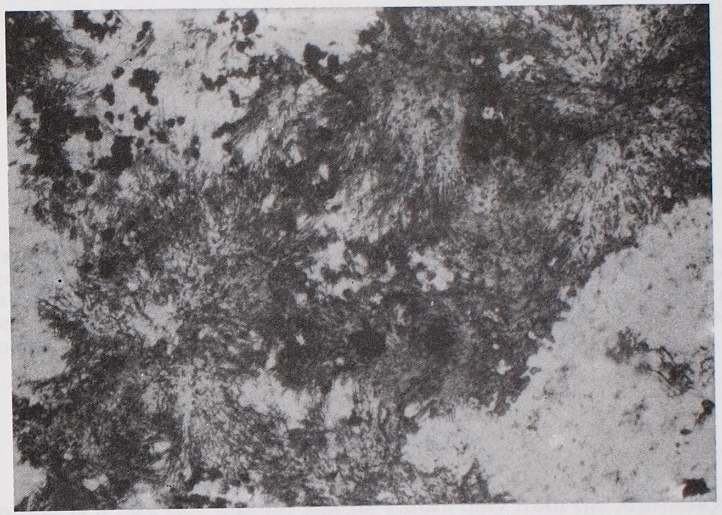
Fig. 2 Krzywa DTA turmalinu z Oued Damrane.

OBJAŚNIENIA FOTOGRAFII

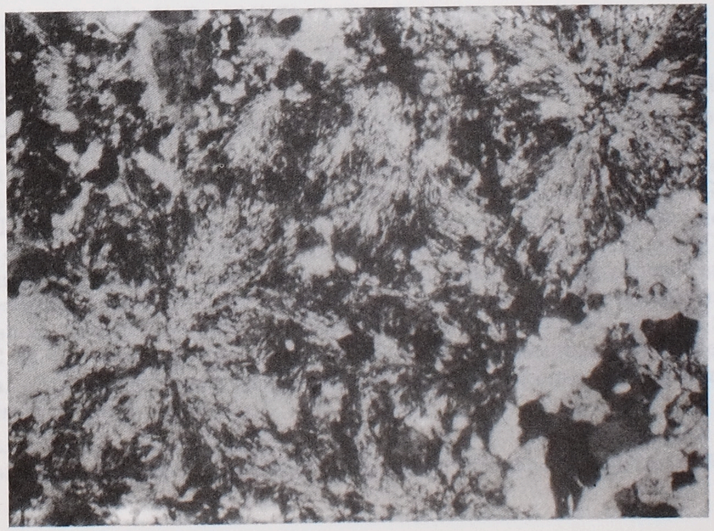
PLANSZA II

Fot. 1 Skupienia promieniste turmalinu w skale kwarcowo–turmalinowej z Oued Damrane. 1 nikol. Pow. 30 ×.

Fot. 2 Skupienia promieniste turmalinu w skale kwarcowo–turmalinowej z Oued Damrane. Nikole X. Pow. 30 ×.



1.



2.