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Metamorphic rocks in the basement of the Carpathians between Bielsko-Biała and Cracow

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The petrological studies revealed characteristics of the metamorphic rocks in the Lachowice–Stryszawa–Ślemień area. It has been shown basing on the macro- and microscopic observations, thermal and chemical analyses that these rocks display features of metapsamites (locally metagreywackes) and metapelites, which are the products of the lowest grade of metamorphism — the greenschists facies. In the geological part of the paper the structural system of the erosional surface of the crystalline rocks as well as an extent of the sediments older than Miocene (Fig. 1) is analysed. The crystalline basement of the Bielsko-Biała–Cracow region is discordantly covered with the younger sediments of different geological systems. With respect to their age, the metamorphic rocks studied correspond to the Cadomian or even older orogeny.

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INTRODUCTION

In the Bielsko-Biała–Cracow region the metamorphic rocks have been stated in over twenty boreholes. The results of studies from some drillings have been already published. The metamorphic rocks from numerous new boreholes drilled within the last period are discussed in the present paper.

The following studies were conducted: macro- and microscopic studies, thermal and chemical analyses. The results have led to a genetical classification of the rocks under research as well as the degree of metamorphic alterations of these rocks has been determined.

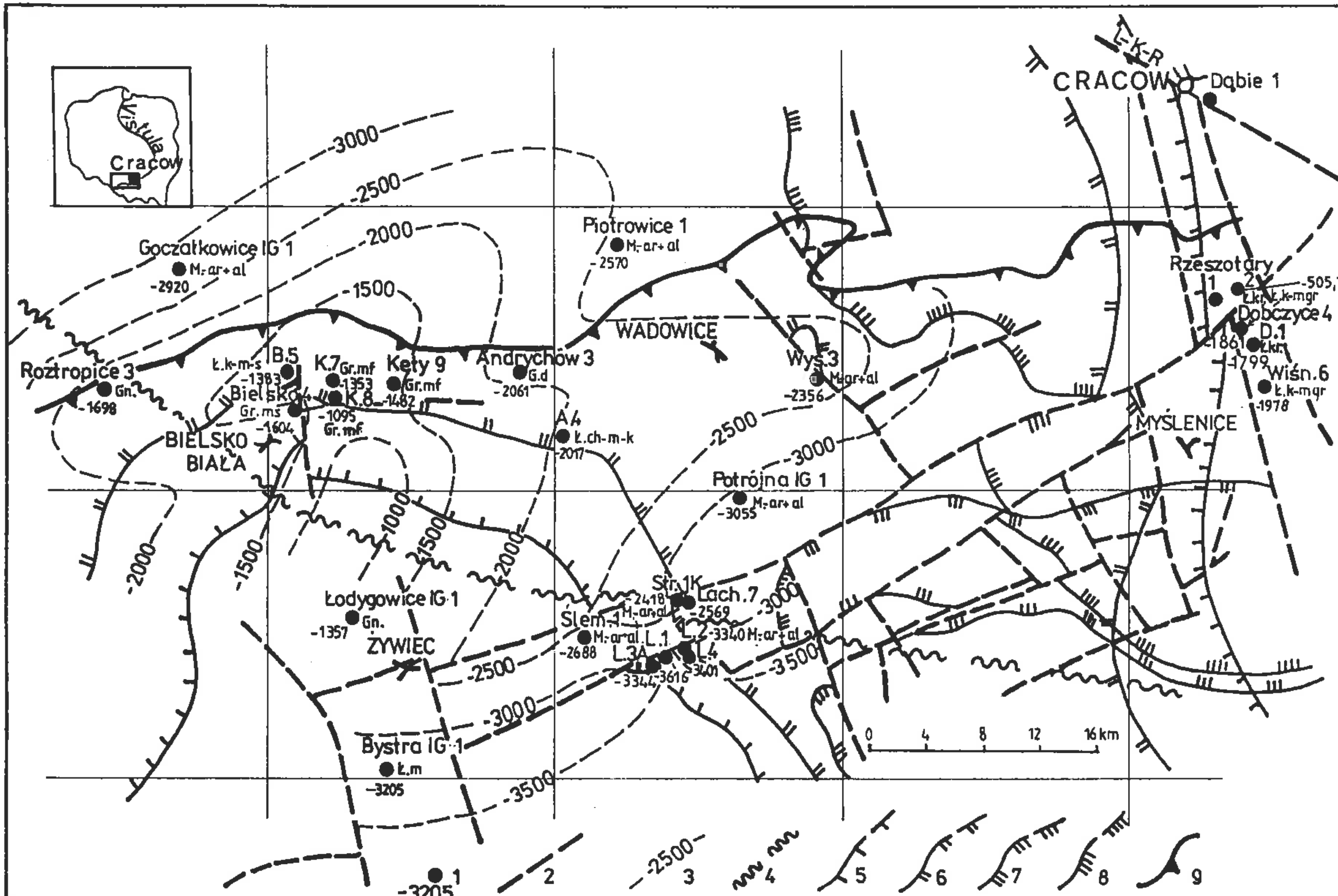
Geological and structural relations of the rocks studied have been discussed in aspect of the hitherto conducted studies of the material from the earlier boreholes. Age relations of the rocks as well as their extent have been concerned, too.

PREVIOUS STUDIES

The metamorphic rocks in the basement of the Carpathians, which underlie the Palaeozoic formations, have been known for many years.

The earliest metamorphic rocks of the basement in the Bielsko-Biała–Cracow region were recognized in 1909 (W. Petrascheck) in the Rzeszotary 1 borehole. According to the studies of S. Kreutz (*fide* J. Nowak, 1927) there occur different crystalline rocks, granite muscovite gneiss, chlorite and chlorite-muscovite schists with interlayers and intercalations of grey and greyish-green crystalline limestones.

The Rzeszotary 1 had been for many years the only borehole with the metamorphic rocks recognized in the West Carpathian basement. In 1954, however, still west of Bielsko-Biała, another drilling — the Puńców 1 borehole was done (K. Konior, A. Tokarski, 1959). The crystalline schists and


Vistula
Cracow
CRACOW
Ł-K-R
Dąbie 1
Piotrowice 1
M-ar+al
-2570
Goczałkowice IG 1
M-ar+al
-2920
-3000
-2500
-2000
-1500
-1000
-3500
WADOWICE
Wys.3
-2356
Rzeszotary
Dobczyce 4
D.1
Wiśn.6
-1978
-1799
-505,7
MYŚLENICE
Roztropice 3
Gn.
-1698
B.5
-1383
K.7
-1353
Kęty 9
Gr.mf
-1482
Andrychów 3
G.d
-2061
Bielsko 4
Gr.ms
-1604
K.8
-1095
Gr.mf
BIELSKO
BIAŁA
A 4
Ł.ch-m-k
-2017
Potrójna IG 1
M-ar+al
-3055
Łodygowice IG 1
Gn.
-1357
ŻYWIEC
Str.1K
-2418
Lach.7
-2569
Ślem.1
M-ar+al
-2688
L.1
L.2
-3340
L.3A
L.4
-3344
-3616
-3401
Bystra IG 1
Ł.m
-3205
0
4
8
12
16 km
1
-3205
2
-2500
3
4
5
6
7
8
9

gneisses formed due to the alteration of the clayey-sandy sedimentary rocks were found there.

The second borehole (Rzeszotary IG 2) displaying metamorhic rocks in the area discussed was drilled in the elevated Rzeszotary Block (Fig. 2B) (J. Burtan, 1962). A. Pelczar and T. Wieser (1962) describe these rocks as gneisses, amphibolites and metaamphibolites due to retrogressive metamorphism.

W. Heflik and K. Konior (1964, 1965, 1967*a*) describe the metamorphic rocks (metasomatic granitoids) from the Bielsko 4 borehole (Fig. 2A). According to these authors (W. Heflik, K. Konior, 1974*c*) the granitoids discussed were formed from the sandy rocks which underwent regional and metasomatic alterations due to the pressure and the temperature.

The granitoid rocks (Fig. 2A) from the Kęty 7, 8, 9 boreholes (W. Heflik, K. Konior, 1970, 1971, 1974*c*) display a similar character of the alterations. The authors quoted believe that the origin of these rocks was a result of the two-fold alteration of the sedimentary rocks, with a participation of the metasomatic processes. These rocks display the highest degree of metamorphism in the region under discussion.

The Andrychów 3 borehole (Fig. 2B) is the next borehole in the present list. The crystalline rocks here are completely different from those presented above. They have abyssal magmatic origin. W. Heflik and K. Konior (1967*b*, 1974*c*) described them as the diallague-olivine gabbro and compared to the similar rocks from the Nowa Ruda region in the Lower Silesia.

The metamorphic rocks occur as mica-chlorite-quartz schists in the Andrychów 4 borehole (Fig. 2B) (W. Heflik, K. Konior, 1970, 1974*c*). They are the least altered ones within the sandy-clayey greenschists facies.

The intensive geological search within the next several years has led to the further recognition of the geological structure of the area, in that — to the discovery of new sites with the metamorphic rocks. These rocks have been noticed south of Rzeszotary (Fig. 2B) in the following boreholes: Dobczyce 1 (W. Heflik, K. Konior, 1972, 1974*c*) and Dobczyce 4 (W. Heflik, K. Konior, 1974*a*).

In the first drilling mentioned, there occur crystalline schists which represent altered primary clayey-sandy-carbonate sediments. The degree of metamorphism of these rocks is weaker than that of quartz-biotite-chlorite ones from Puńców 1 and Bielsko 5 but stronger than that of chlorite-mica-quartz schists from the Andrychów 4 borehole. A kind of similarity may be observed when comparing the metamorphic rocks drilled in the Dobczyce 1 and Rzeszotary IG 2 boreholes, those from the last borehole being more altered, however.

The metamorphic rocks from the Dobczyce 4 borehole have also origined from the alteration of the sandy-clayey sediments in the greenschists and amphibolite-epidote facies. They display a distinct similarity to the metamorphic rocks drilled in the Dobczyce 1 and Rzeszotary IG 2 boreholes.

The similar metamorphic rocks occur also further to the south (Fig. 2B) in the Wiśniowa 6 borehole (W. Heflik, K. Konior, 1974*b*). They were formed due to the alteration of the sandy-clayey-carbonate sediments in the greenschists and amphibolites facies. In all the boreholes situated in the area of the Rzeszotary Horst (Fig. 1) the metamorphic rocks occur in general as quartz-mica schists with garnets and gneiss interlayers.

The crystalline basement is built of schistous and hornfelse gneisses in the Łodygowice IG 1 borehole (Fig. 2B) (T. Wieser, 1974). T. Wieser concers them as similar to the rocks from the Puńców 1 borehole.

In the borehole Bystra IG 1, southmost in this region, the mica schists are the most frequent metamorphic rocks (T. Wieser, 1978). They differ from the crystalline rocks from Łodygowice IG 1, due to the absence of gneisses. According to the cited author this fact points to metamorphism characterized by the lower pressure and temperature in Bystra IG 1.

Less altered rocks, as metapelites, metaaleurites and metapsamites represent another type of the metamorphic rocks in the consolidated basement in the Bielsko-Biała–Cracow region. They are concerned as the greenschists facies and were described in the following boreholes (Figs. 1 and 2): Goczałkowice IG 1 (A. Kotas, 1973*a*, *b*, 1982; S. Cebulak, A. Kotas, 1982), Potrójna IG 1, Piotrowice 1 (A. Ślączka, 1976) as well as noticed in Wysoka 3 (Fig. 2A). In that last borehole the rocks under discussion occur as red-brownish metaargillites with green schliers, of a dip of about 40°. They underlie the Cambrian sandstones developed in the platform habit, typical for the Upper Silesian Massif.

Fig. 1. Top of the metamorphic basement in the Bielsko-Biała–Cracow–Żywiec region, with an outline of extent of sediments older than Miocene
1 — boreholes which have reached the metamorphic rocks and coordinate of their top (in metres); 2 — faults (L–K–R — dislocation zone Lubliniec–Cracow–Rajbrot); 3 — isohypses of the top of metamorphic basement; 4 — southern extent of Lower Cambrian; 5 — extent of Devonian; 6 — extent of Carboniferous; 7 — extent of Lower Triassic; 8 — extent of Jurassic; 9 — thrust-line of the Carpathians; letter symbols show the type of the rock in the basement: M.ar+al — metaargilites + metaaleurolites; Ł.kr — crystalline schists; Ł.m — mica schists; Ł.ch-m-k — chlorite-mica-quartz schists; Ł.m-sk-k — mica-feldspar-quartz schists; Ł.k-m-s — quartz-mica-sericite schists; Ł.k-mgr — quartz-mica schists with garnets; Gr.ms — metasomatic granitoids; Gr.mf — metamorphic granitoids; G.d. — diallague gabbro; Gn. — gneisses

Strop podłoża metamorficznego w rejonie Bielska-Białej–Krakowa–Żywca, z zarysem zasięgów osadów starszych od miocenu
1 — otwory wiertnicze, które nawierciły utwory metamorficzne i rzędna głębokości ich stropu (w metrach); 2 — uskoki (L–K–R — strefa dyslokacyjna Lublińca–Krakowa–Rajbrota); 3 — izohipsy stropu podłoża metamorficznego; 4 — południowy zasięg dolnego kambru; 5 — zasięg dewonu; 6 — zasięg karbonu; 7 — zasięg dolnego triasu; 8 — zasięg jury; 9 — linia nasunięcia Karpat; symbole literowe wskazujące typ skały w podłożu: M.ar+al — metaargility + metaaleurolity; Ł.kr — łupki krystaliczne; Ł.m — łupki mikowe; Ł.ch-m-k — łupki chlorytowo-mikowo-kwarcowe; Ł.m-sk-k — łupki mikowo-skaleniowo-kwarcowe; Ł.k-m-s — łupki kwarcowo-mikowo-serycytowe; Ł.k-mgr — łupki kwarcowo-mikowe z granatami; Gr.ms — granitoidy metasomatyczne; Gr.mf — granitoidy metamorficzne; G.d — gabro diallagowe; Gn. — gnejsy

About 100 m of the metamorphic rocks below the Devonian were drilled recently (1996) in the Roztropice 3 borehole, 14 km west of Bielsko-Biała (Figs. 1 and 2A). According to the petrographical studies of J. Lisek (unpublished materials) in three drilling cores there occur migmatite gneisses.

To complete the description of the metamorphic rocks present in the Polish part of the Western Carpathians the gneisses from Ustroń 3 (W. Heflik, K. Konior, 1974*c*) and crystalline schists with gneisses from Krasna 1 near Cieszyn (W. Heflik, W. Moryc, 1996) should be mentioned. They have originated from the sandstone alteration, too, and belong to the group of the crystalline rocks known from Puńców 1 and in general to those metamorphic ones from Łodygowice IG 1 and Bystra IG 1.

The crystalline rocks of the consolidated basement of the Carpathians belong to the wide Bruno-Vistulicum zone (A. Dudek, 1980), which covers the southwestern prolongation of its Polish part as well. The rocks continue in the basement of the Moravian part of the Western Carpathians, being known there from many boreholes. They occur as paragneisses, metamorphic schists, migmatites and other crystalline rocks (J. Tomšik, 1972; A. Dudek, 1980; E. Menčik *et al.*, 1983; A. Dudek, V. Spička, 1975).

According to A. Dudek (*op. cit.*) the crystalline basement is mainly built of the biotite-plagioclase paragneisses, migmatized in the southeastern part and of migmatites (Krasna 1 — the borehole in the Czech part, Kozlovice SW 1, SV 4). Three years later when summarizing the studies conducted in the basement of the Miocene of the Moravian-Silesian Beskydes and their foreland, E. Menčik *et al.* (1983) had already newer data in this region which confirmed the structure of the crystalline basement presented earlier by A. Dudek (*op. cit.*).

DESCRIPTION OF METAMORPHIC ROCKS

The boreholes in this region are grouped in the southern part of the area under discussion (east of Żywiec) between Bystra IG 1 and Potrójna IG 1 (Fig. 1). They have been drilled recently, the drillings being still in progress. The results of the studies on the material from these boreholes have not been published yet.

In their general profile below the Carpathian flysch and the Miocene deposits, the boreholes cut the Palaeozoic rocks of different thickness (Fig. 3), reaching the metamorphic rocks (in the Ślemień 1 borehole — even directly below the Miocene). The boreholes discussed are placed south of the regional Żywiec–Rzeszotary Fault (Fig. 1). This fault displaying a run of SW–NE divides the area into two parts — the northern one, which covers the majority of the boreholes described above, and the southern one — in the central part of which there lie boreholes of the Lachowice–Stryszawa–Ślemień area. That last region is additionally cut by several smaller faults which divide it into three small, separated tectonic blocks of Lachowice, Stryszawa and Ślemień (Fig. 1).

The description of the metamorphic rocks is presented individually for each of these tectonic blocks.

THE LACHOWICE BLOCK

The metamorphic rocks were found in the Lachowice 1, 2, 3A and 4 boreholes. They occur directly either under the Lower Devonian clastic rocks (Lachowice 1, 2, 4) or the Middle Devonian carbonate ones (Lachowice 3A) (Fig. 3).

Macroscopic lithological characteristics. The most complete section of the metamorphic rocks is in the Lachowice 1 borehole. About 390 m of these rocks were drilled there, resulting in 9 drilling cores placed about 50 m one from the other.

They are alternating mudstones, greywackes and quartzite sandstones, compact, steel-grey, strongly diagenetized and partly altered of the metaaleurite type as well as grey, green and red claystones (metapelites) similar to the phyllitic rocks. Interlayers of compact, weakly altered (metadiagenesis) dark mudstones are frequent.

In general — the rocks under description display an outlook of the greywackes type with distinct features of metamorphic alterations. They are strongly fractured, cleavaged and cut with veinlets of the thickness up to 1.5 cm (sometimes with nests to 5 cm) of pinky-white quartz or, sporadically, calcite. The veins are at least of two generations. The older one of thickness of about 1 mm cuts the rock at the angle of 45°. The younger one displays the thickness ranging from 0.5 to 1.5 cm and the dip of about 75°.

The quartz veins cut all the rock types present in the profile, in that also claystones (metapelites) which form intercalations of the thickness of some tens centimetres to even more than 1 m. The veins show a heterogeneity in their concentration — in some parts they are abundant, in the other — less frequent or totally absent. Some veins are broken or displaced at the scale of some or over dozen millimetres within the core due to small faults.

The dip of the layers is not always distinct ranging in general from 45 to 80° which points to a significant unconformity in comparison to almost horizontal Devonian layers.

In the Lachowice 2 borehole the metamorphic rocks occur discordantly (dip of 43–80°) under the almost flat Lower Devonian sediments. About 51 m (Fig. 3) of these rocks were drilled resulting in 5 cores. They are generally similar to the rocks from Lachowice 1, being, however, more fractured and displaying a domination of mudstones and claystones (metapsamites, metapelites).

The same type of the rocks in the consolidated basement was noticed in the boreholes Lachowice 3A (40 m drilled) and Lachowice 4 (70 m drilled). Two generations of quartz veins are characteristic there, too, as well as steep dip of the layers (Fig. 3) which underline the discordance in relation to the overlying flat Devonian deposits.

Microscopic observations. The petrographical studies of the rocks under discussion were conducted in the Lachowice 2 and 1 boreholes.

In the first case the research was conducted on three samples. The first sample (Table 1, depth of 3869 m) is represented by metapsamites. It is possible to observe primary detrital material with distinct metamorphic features heterogeneously distributed in the cementing mass. Quite frequently the quartz veins of variable thickness cut the rocks. The rock

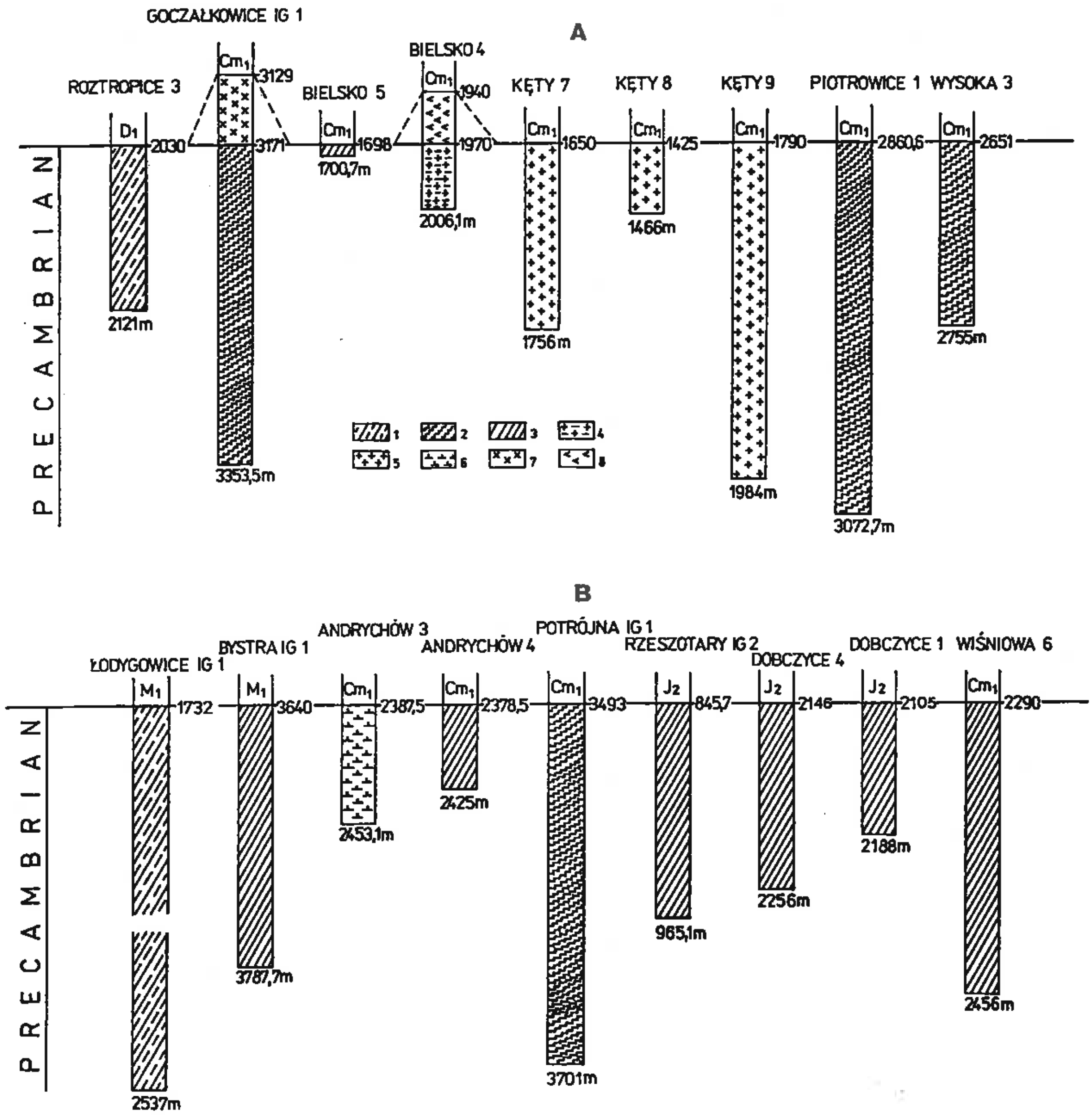


Fig. 2. Profiles of the crystalline rocks in the boreholes in the Bielsko-Biała–Cracow region (determinations of rocks after bibliography quoted in the text): A — NW part of the studied area, B — S and SE part of the studied area

1 — gneisses; 2 — rocks of greenschists facies (metaargilites, metapelites, metaaleurolites, metapsamites, metaconglomerates, phyllites); 3 — metamorphic schists; 4 — metasomatic granitoids; 5 — metamorphic granitoids; 6 — diallague gabbro; 7 — intrusion of gabbrodiabases; 8 — teschenites; M_1 — Lower Miocene; J_2 — Middle Jurassic; D_1 — Lower Devonian (Emsian); Cm_1— Lower Cambrian

Profile skał krystalicznych w otworach wiertniczych rejonu Bielska-Białej–Krakowa (określenia skał według literatury cytowanej w tekście): A — NW część badanego obszaru, B — S i SE część badanego obszaru

1 — gnejsy; 2 — utwory facji zielonych łupków (metaargility, metapelity, metaaleuryty, metapsamity, metakonglomeraty, fyllity); 3 — łupki metamorficzne; 4 — granitoidy metasomatyczne; 5 — granitoidy metamorficzne; 6 — gabro diallagowe; 7 — intruzja gabrodiabazów; 8 — cieszynity; M_1 — miocen dolny; J_2 — jura środkowa; D_1 — dewon dolny (ems); Cm_1 — kambr dolny

structure is disordered. Feldspars, quartz and some clasts form detrital material with distinctly sharp edges and variation in granulometry. Potassium feldspars are predominant and correspond mostly to the well preserved orthoclase. Individuals of potassium feldspar intergrown with quartz similarly to the script-like structure are present, too. Plagioclases display characteristic polysynthetic twins after the albite law. Due to the measurements of the extinction angle in the cross-sections perpendicular to (010) the maximum angle (010)/α' equals to 8° which results in about 12% An content of the plagioclases.

Table 1

General mineral composition (in volume percentage) of metapsamites and metapelites from the boreholes Lachowice 1 and 2, Stryszawa 1K and Ślemień 1, calculated basing on the planimetrical analysis

Component	Number of sample						
	1	2	3	4	5	6	7
Muscovite	68.5	64.0	45.0	78.0	0.5	45.0	28.0
Quartz	20.0	8.0	35.0	17.0	69.0	39.0	25.0
K-feldspar	5.0	1.0	6.0	–	8.0	5.0	8.0
Plagioclase	3.0	2.0	8.5	–	20.0	8.0	12.0
Biotite	–	–	0.5	–	2.5	3.0	–
Carbonates	1.5	10.0	4.0	3.0	–	–	1.5
Chlotites	1.5	14.5	0.8	–	–	–	15.0
Pyrite	0.5	0.5	0.2	–	trace	–	–
Zircon	–	–	–	trace	trace	–	–
Epidote	–	–	–	1.0	trace	trace	10.0
Fe-oxides	–	–	–	1.0	trace	trace	0.5

1 — metapsamite, Lachowice 2, depth 3868–3872 m, box I (depth 3869 m); 2 — metapelite, Lachowice 2, depth 3868–3872 m, box II (depth 3870 m); 3 — metapsamite, Lachowice 2, depth 3868–3872 m, box IV (depth 3872 m); 4 — metapelite, Lachowice 1, depth 4508–4512 m, box I (depth 4509 m); 5 — metapsamite, Stryszawa 1K, depth 2939–2941 m, box II (depth 2940.5 m); 6 — metapsamite, Stryszawa 1K, depth 2969–2971 m, box I (depth 2970 m); 7 — metapsamite, Ślemień 1, depth 3269–3301 m (typical)

Quartz has the weak, wavy extinction. Some clasts are built of potassium feldspars, albite and acid oligoclase. Texture and mineral content of them is characteristic for the extrusive magmatic rocks which correspond to the trachites.

In the rocks studied, individual pseudomorphs after dark minerals, possibly pyroxenes and amphiboles, filled with calcite and ion oxides are present, too.

Muscovite occurs in the rocks discussed in several forms, as small flakes in fabric, forming occasionally the aggregates similar to pseudomorphs after feldspar; in individual typical flakes; in tie-like aggregates which differ distinctly from the background. Minute calcite intercalations in the fabrics are also present.

The quartz veins of thickness reaching 1 cm are characteristic for the rocks discussed. Quartz occurs in form of mosaic aggregates with a heterogeneous extinction. Fine calcite aggregates and chlorite are locally present in the veins. Chlorite corresponds to sherdianite due to its nearly straight extinction in the cross-section perpendicular to (010), its distinct pleochroism in grass-green colours and its subnormal interference colours.

The second sample (Table 1) represents metapelites with indistinct stratiform structure, often cut with quartz veins. Fine-flaked muscovite, chlorite, quartz and intergrowths of fine-crystalline calcite form the main rock mass. Vein quartz has a mosaic structure. It is accompanied by chlorite displaying the same features as in the sample number one (sherdianite), and by carbonates.

In the sample from the depth of 3872 m (Table 1, sample 3) there occurs metapsamite developed similarly to that in sample number 1. The slight difference corresponds to the homogeneous extinction and to morphology characteristic to the individuals of pyrogenic origin.

The general mineral composition of the rocks described is shown in Table 1.

In the Lachowice 1 borehole the sample from the depth of 4509 m was studied (Table 1). These are metapelites with a distinct layered structure. These are metapelites built of alternated beds formed of fine muscovite flakes (often sericite), separated by the quartz layers, fine-grained, variable in their thickness and irregular in their run (Pl. I, Fig. 5). In the neighbourhood small concentrations of calcite may be seen. Some irregularly dispersed aggregates of iron oxides and individuals of detrital, well rounded zircon occur in the rocks discussed, too. Epidote is also present.

The general mineral composition of the rocks (in volume percentage) counted basing on the planimetrical analysis is presented in the Table 1 (sample 4).

THE STRYSZAWA BLOCK

This block occurs north-east of Lachowice Block (Fig. 1). The metamorphic rocks were stated there in two boreholes: Stryszawa 1K and Lachowice 7. In the Stryszawa 1K borehole they occur directly below the carbonate deposits of the Middle Devonian (Fig. 3), while in the Lachowice 7 one — below the sandstones assumed as the platform rocks of the Lower Cambrian (M. Narkiewicz, 1996).

Macroscopic lithologic characteristics. The Stryszawa 1K borehole was the directed drilling — the thickness and depth values presented below represent, therefore, the data calculated from the apparent to true ones, i.e. those corresponding to the vertical conditions.

About 24 m of the metamorphic rocks were drilled here (Fig. 3) resulting in two drilling cores taken from the lower part of the profile. They are grey and brownish-grey metapsamites with abundant biotite. They display a strong fractures with entirely frequent polished surfaces, mostly of the clay rocks. Veins of the thickness ranging from 0.5 to 1.0 cm mostly built of white quartz, less frequently of calcite, are common. Some fissures of a cleavage character contain pyrite accumulations.

The dip of the strata is not seen (lack of stratification). In case of its existence, however, the dip would have only the apparent character due to the directed drilling and non oriented core.

The metamorphic rocks in the Lachowice 7 borehole were stated in 42 m of the profile (Fig. 3). They form two drilling cores.

They correspond to the altered violet-red and green, compact, fractured metapelite and aleurite rocks, with pinky-white quartz veins. The cut the main rocks at the angle of 45°. The dip is indistinct, being probable in the interval of 30–45°. The rocks are typical for the consolidated Precambrian basement.

Microscopic observation. The microscopic studies were conducted in both the drilling cores taken from the Stryszawa 1K borehole.

In the upper core at the depth of 2940.5 m (Table 1, sample 5) there occurs metapsamite of distored structure (Pl. I, Fig.

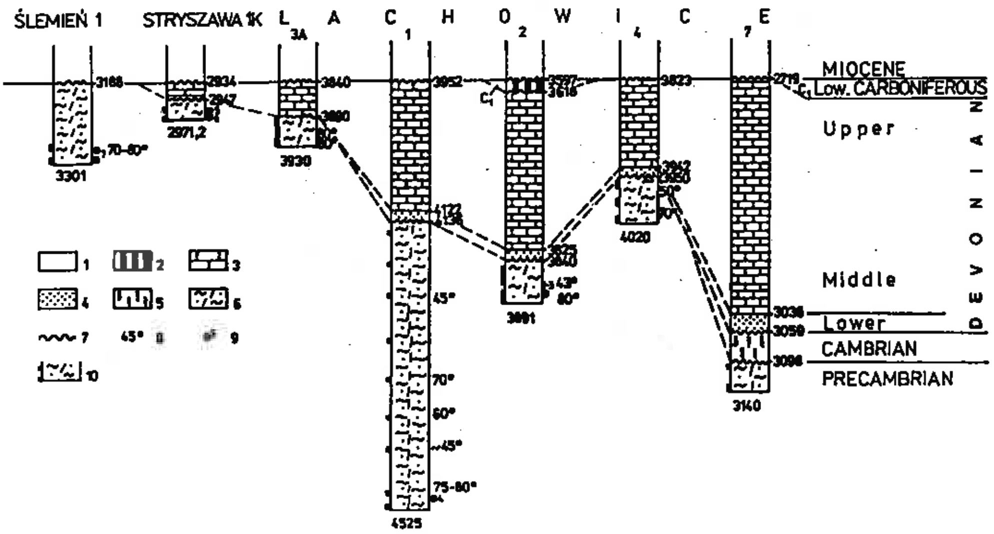


Fig. 3. Correlation of sub-Miocene deposits in the Lachowice–Stryszawa–Ślemień region
1 — Miocene; 2 — Lower Carboniferous — limestones, clayey in places; Devonian: 3 — carbonate deposits, 4 — sandstones and mudstones; 5 — Lower Cambrian — sandstones; 6 — Precambrian — metapsamites and metapelites, quartz veins; 7 — unconformity surfaces; 8 — dip of strata; 9 — core samples analysed (numbering according to Table 1); 10 — cored Precambrian

Korelacja utworów podmioceńskich w rejonie Lachowic–Stryszawy–Ślemienia
1 — miocen; 2 — karbon dolny — wapienie, miejscami zailone; dewon: 3 — utwory węglanowe, 4 — piaskowce i mułowce; 5 — kambr dolny — piaskowce; 6 — prekambr — metapsamity i metapelity, żyły kwarcowe; 7 — powierzchnie niezgodności; 8 — upady warstw; 9 — zbadane próbki rdzeni (numeracja zgodna z tab. 1); 10 — odcinki profilu prekambryjskiego z pobranymi rdzeniami

6) similar to that in the Lachowice 2 borehole. Two main components are present in the rock — predominating grains and the cementing mass. The mineral composition is in general as follows: quartz, feldspars, biotite and rare muscovite. Two first minerals are sharp — edged, strongly differentiated in their granulometry, in limits of the psamitic fraction, however.

Quartz displeys a weak wavy extinction, some grains having a hardly observable lamellae structure. Among feldspars two types are present. Plagioclases dominate. They occur in majority as the flakes with a distinct polysynthetic twinning, in some cases the twinning lamellae are somehow inconsequent. As it results from the measurements of the extinction angle in the cross-sections perpendicular to (010), the maximum angle (010)/α' equals to 13° which points to acid oligoclase with about 9% of the anortite molecule.

Potassium feldspars show some distinct variability. The tabular forms — corresponding to microcline — with two perpendicular twinning systems (albitic and periclinic) are predominant. Twinning is not very sharp, generally — weak. Some individuals are dotty in character. The majority of them have underwent the process of infiltration microperthitization. Orthoclase grains are present, too, being also altered due to the same process. Intergrowths of the potassium feldspar (orthoclase) with plagioclase may be also observed.

All feldspar varieties show traces of a weak sericitization.

Muscovite and biotite are the products of alteration. Biotite flakes are small in size. Their average length equals to 0.08 mm. The mineral displays pleochroism in the following colours: α — greenish-yellow, $\beta = \gamma$ — dark green. These features are characteristic for the biotite with a low iron (Fe_2O_3) content. This mineral fills the intergranular space between quartz and feldspars.

Zircon and minerals from the epidote group are the sporadical components of the rock under discussion. Zircon forms rounded, similar to spheritic, forms, connected to the primary detrital material. Minerals from the epidote group are the typical metamorphic products. They have no pleochroism (or a very weak one) which points to their low content of iron.

The quartz pelite, fine-flaked muscovite and calcium carbonate (calcite) form the cementing mass in the rocks discussed. This mass is in many places cut with the quartz veins in which the quartz grains are fine and form a mosaic structure. Flake minerals often occur in "a tress-like" arrangement.

The mineral composition of the rocks (volume percentage) is presented in Table 1.

Metapsamites of a distinct layered structure also occur in the second drilling core at the depth of 2970 m (Table 1, sample 6). They are the rocks built of the same components as in the upper core, however, in different quantitative proportions to each other. Muscovite (hydromuscovite) is their main mineral. It is formed as fine shreds accumulating into more or less regular microlayers, which underline the structure of the rock. Biotite is present, too, forming locally lepidoblasts.

The mineral composition of the metamorphic rocks from the Stryszawa 1K borehole is presented in Table 1 (samples 5 and 6). It can be stated from the comparison of these two samples and the rocks from the Lachowice 2 borehole, that the metapsamites in the lower core of that last drilling mentioned (sample 6) are most intensively altered. This conclusion is drawn basing on the presence of the muscovite and biotite lepidoblasts as well as on the distinct layered structure.

THE ŚLEMIEŃ BLOCK

It occurs west of the Stryszawa and north-west of the Lachowice Blocks (Fig. 1). The regional Żywiec–Rzeszotary Fault forms its northern boundary. Only one borehole (Ślemień 1) was drilled in this area. The metamorphic rocks were found there directly below the Lower Miocene deposits.

The macroscopic lithological characteristics. 113 m were drilled in the borehole under discussion resulting in two drilling cores. The rocks correspond mostly to the metapelites, less frequently to metaaleurites and metaquartzites. They are dark grey and compact, with numerous sericite and red clay schliers manifested on the fractural surfaces. The rocks are densily cut with white, bluish-white or pink quartz veins of the thickness of about 1 cm. Red coloured quartz veins are also present being accompanied with the schliers of the same colour which show secondary alterations. These veins cut the rock under description in three manners in respect to the distinct dip of the layers, namely: perpendicularly, obliquely and parallelly, in that last case filling the interlayered space. The dip is steep in the limits of 70–80°.

Microscopic observations. The petrological studies of the metamorphic rocks were conducted in both the drilling cores from the Ślemień 1 borehole on two samples from each. The rocks represent the same metamorphic type and are metapsamites (Table 1, sample 7; Pl. I, Fig. 7).

In majority they have lepidoblastic texture and indistinct schistous structure. The main minerals are: muscovite, quartz, feldspars, chlorites and minerals from the epidote group. Iron oxides are subordinate. Fine-flakes of muscovite form the background. They occur as small layers of a different thickness, being often intergrown with chlorite, minerals from the epidote group and quartz. Chlorite has the following characteristics: the oblique extinction in the plane (010) reaches 5°; it is optically positive; its pleochroism has green and blue colours; the interference colours are normal. These features correspond to sherdianite.

Epidote mostly forms aggregates, less frequently it occurs as separate grains. It displays a weak pleochroism: α — colourless, β — lemon yellow, γ — yellowish-green. It is homogeneously dispersed in the rock.

Quartz occurs in two manners: either as individual grains irregularly dispersed in the rock or as veins (Pl. I, Fig. 8). Quartz grains have uniform extinction and sometimes form intergrowths with the potassium feldspars. The vein quartz is accompanied by large chlorite accumulations.

Feldspars are represented both by potassium and plagioclase varieties. The plagioclases are dominant. They correspond to acid oligoclase with a distinct polysynthetic twinning. The maximum angle (010)/α' measured in the plane perpendicular to (010) equals to about 10° which suggests its being the oligoclase with about 12% of anorthite molecule. The potassium feldspars are represented by orthoclase. Both types of the feldspars have sharp edges of the grains, are fresh and differ in granulometry. They are heterogeneously dispersed in the rock.

Calcite occurs in the neighbourhood of the larger epidote aggregates.

Iron oxides are mostly represented by hematite.

The general mineral composition of the rocks under description calculated basing on the planimetric analysis is presented in Table 1 (sample 7).

It results from the facts presented above that the rocks from the lower drilling core the Ślemień 1 borehole (depth interval of 3269–3301 m) represent metapsamites, it means the weakly altered rocks of the greenschists facies of the lowest grade. Their primary detrital material has probably origined from the destruction of the abyssal acid magmatic rocks (possibly granites with pegmatites). The sharpness of the quartz and feldspar grain edges points to a short transport.

Thermal studies. Curves of the thermal analysis of the metamorphic rocks found in three tectonic blocks discussed above are presented in Figure 4. The numbering of the curves corresponds to the numbers of samples explained in Table 1.

As it is seen from the run of the curves (Fig. 4) the thermal effects are registered in similar temperatures. These are the endothermic effects in temperatures of 573, 740–680 and 740–800°C as well the exothermic ones in 200–330 and 420–450°C. The first of the endothermic effects is caused by the polymorphic alteration of β into α quartz. Temperatures registered in the interval of 740–800°C are connected with dissociation of carbonates. The exothermic effect in the interval of 420–450°C results from the pyrite disintegration, mostly oxidation of iron from Fe^{2+} to Fe^{3+}. The exothermic effect registered in the lowermost temperatures (200–330°C) is caused by the combustion of the organic matter.

Chemical studies. The results of the chemical studies of the rocks from three boreholes characteristic for each of the tectonic blocks discussed are shown in Table 2. As above —

Table 2

Results of chemical analyses of metapsamites (in weight percentage)

Components	Number of sample		
	3	6	7
SiO_2	66.92	69.27	61.86
Al_2O_3	16.44	17.83	20.68
Fe_2O_3	1.38	2.11	3.48
TiO_2	0.52	0.57	0.28
CaO	0.87	0.61	0.81
MgO	3.36	1.53	2.71
K_2O	3.52	2.61	4.52
Na_2O	3.36	3.65	3.51
Calcination loss	3.22	1.36	1.77
Total	99.59	99.54	99.62
H_2O^-	0.15	0.11	0.16

3 — Lachowice 2, depth 3868–3872 m, box IV (depth 3872 m); 6 — Stryszawa 1K, depth 2969–2971 m, box I (depth 2970 m); 7 — Ślemień 1, depth 3298–3301 m, box I (depth 3299 m)

numbers of the samples are identical with those in Table 1. All samples chemically analysed correspond to metapsamites. As it has been already mentioned they represent weakly altered rocks in the lowermost grade of the greenschists facies.

As it is seen in Table 2 the most distinct differences occur in the content of Al_2O_3, sum of alkalies (K_2O +Na_2O) and of iron (Fe_2O_3). The highest aluminium oxide content (20.68%) in the metapsamites from the Ślemień 1 borehole is accompanied with high alkali content, which is connected with the abundance of potassium feldspars, muscovite and acid oligoclase in the rocks discussed. The increased iron content is due to the chlorite (sherdianite) and epidote abundance. Variability in the calcination loss, extremely high in the sample from the Lachowice 2 borehole, is connected with an increased percentage of carbonates (calcite) there.

It can be stated, however, that the chemical analyses do not show really distinct differences which confirms the results of the preceding petrological studies.

It results from the conducted mineralogical and petrological studies that the metamorphic rocks from the Lachowice, Stryszawa and Ślemień boreholes represent the same type-metapsamites and metapelites.

The metapsamites are built of granular quartz, potassium feldspars, plagioclases, subordinate zircon and minerals from the epidote group as well as of the cementing mass with a predominance of fine-flaked muscovite (sporadically developed as lepidoblasts), biotite and carbonates. Due to their high feldspar percentage these rocks should be accounted to metagreywackes. The most strongly altered rocks in the complex under discussion are the metapsamites from the Stryszawa 1K borehole (depth 2970 m) which display a distinct layered structure. The other ones are built of very fine-grained quartz, sericite and chlorite. The detrital material in the metapsamites (metagreywackes) is not rounded and non-sorted. It was transported for a short distance in the water environment, probably by the surficial flows, and quickly deposited in the water reservoir. The sediment, which has consequently led to the present metapelite interlayers, was accumulated in the periods of the indistinct difference in height of the exposed rock complexes under erosion in relation to the sedimentary environment.

It can be stated from the mineral character of the detrital material of the rocks under discussion that the alimentation area was built of the crystalline rocks, mainly of granitoids, pegmatites and partly of the acid effusive rocks. The proof is here the abundance of potassium feldspars, acid oligoclase, quartz (in that also of pyrogenic character) as well as fine zircon grains. Some increase in temperature and pressure influenced the sediments after their diagenesis leading to the formation of metapsamites and metapelites, i.e. to the rocks of the lowest grade of metamorphism — of the greenschists facies. In case of the metapelites we deal with the schists which have not been altered into phyllites yet.

The metaaleurolites and metagreywackes were formed in the same conditions of temperature and pressure. The alteration processes in these rocks have influenced only such the minerals as layered silicates, kaolinite, illite and micas in contrary to the detrital minerals as feldspars, quartz and zircon, stable in these conditions.

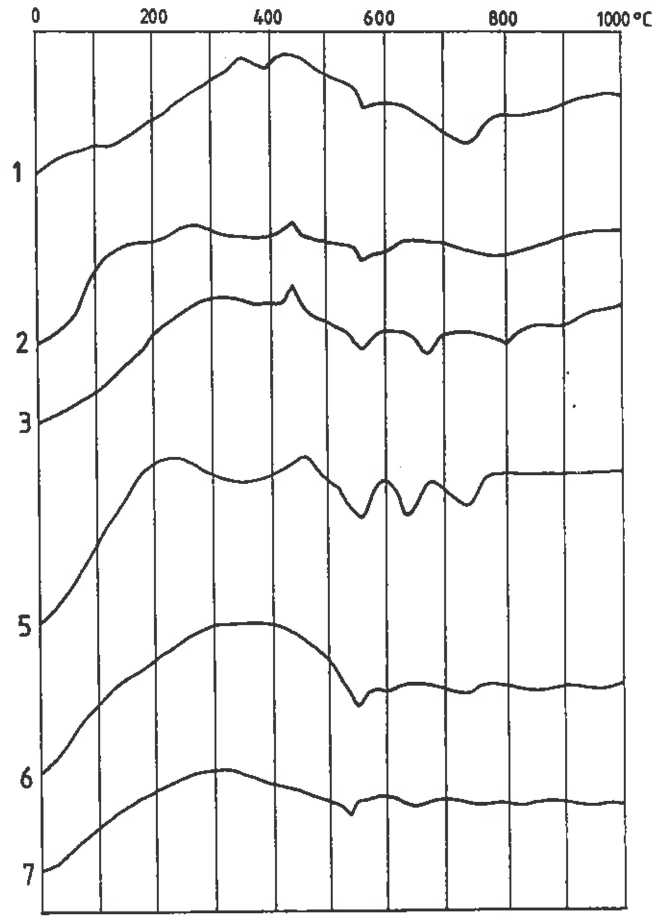


Fig. 4. Curves of thermal analysis
1–7 — numbers of samples as in explanations in Table 1

Krzywe termicznej analizy różnicowej
1–7 — numery próbek zgodne z objaśnieniami zamieszczonymi w tab. 1

STRUCTURAL PATTERN OF THE CRYSTALLINE ROCKS

The structural pattern of the erosional surface of the crystalline rocks in the area of Bielsko-Biała–Cracow as well the extent of the superimposed rocks older than the Miocene is presented in Figure 1. The pattern is based on the studies of all the boreholes reaching these rocks as well as on the geophysical results.

The map presents only the boreholes which have reached the consolidated basement since the studies of this basement were the aim of the research. The erosional surface of the metamorphic rocks shows the maximum elevation in the region of Kęty and Bielsko-Biała being there contoured with the isohypse of –1500 m. In this zone K. Konior (1978) assumed the maximum elevation of the erosional elevation called "the Wygniznów Uplift". According to new data the culmination of this uplift occurs probably between the Kęty 8 and Łodygowice IG 1 boreholes, south of that first mentioned, and may reach even –1000 m.

The erosional elevation between Kęty and Łodygowice (Fig. 1) deepens towards the south, the north and the east creating the periclinal form in the Wysoka region. The extent of the deepening of the erosional surface is as follows: in the eastern direction (Wysoka 3 until the depth of –2356 m), northern (Piotrowice 1 until –2570 m; Goczałkowice IG 1 until –2920 m) and in the south (Łodygowice IG 1 until –1357 m and Potrójna IG 1 until –3055 m). Further to the south, on the other side of the Żywiec–Rzeszotary Fault, this surface is thrown down to the depth below –3000 m (the region between the Bystra IG 1 and Lachowice 4 boreholes). The erosional elevation of the crystalline basement continues towards the west. This conclusion is supported by the results of the studies on the Czech side since in the Bystřice 2 borehole placed 10 km south-east of Puńców the top of the metamorphic rocks, covered there with a thin bed of the Eggenburgian sediments, occurs almost at the same depth as in Kęty–Łodygowice area (not much deeper than at –1000 m — A. Jurkova *et al.*, 1983, p. 154).

On that basis we can assume that the boreholes which occur between Cieszyn and Bielsko-Biała, Ustroń 3, Puńców 1 and Krasna 1 (the borehole at the Polish side — W. Heflik, W. Moryc, 1996) are situated already at the northern slope of the erosional elevation under discussion.

In the Rzeszotary Horst zone the crystalline basement occurs entirely high, its depth oscillating from about –500 m in the area of Rzeszotary to below –2250 m in the Dobczyce region. It is therefore elevated at about 1700 m in respect to the Mogilany Block thrown down from the west and at about 1100 m — to the Borzęta Block situated south of the Żywiec–Rzeszotary Fault. In both these blocks the Cambrian deposits were not drilled through and the erosional surface occurs there below –2226 and –3368 m, respectively.

The structural pattern of the consolidated crystalline basement described above shows distinct differences in respect to the structural scheme presented by K. Konior (1978). The differences result from different causes, especially from divergent interpretations of stratigraphy in some boreholes (e.g. an assumption of the existence of the Silurian rocks in the Piotrowice 1 borehole), from the subjective determination of the depth of the surface in the drillings where it was not reached. The cited author did not take into consideration dislocations which play an important role in the area discussed (especially in case of the regional Żywiec–Rzeszotary Fault).

It should be, namely, stressed that the present structural pattern of the erosional surface does not correspond to the primary structure which might be concluded from the suggestion on the existence of significant relief and diversified palaeotopography (Z. Kowalczewski, 1990). The erosional processes were only responsible for small-scale relief, while large differences in depth result from the block tectonics. There exist numerous post-Miocene faults in the area which cut and displace the sediments, too. A downthrust of the Miocene deposits at the southern side of the Żywiec–Rzeszotary Fault e.g., has also resulted in variability in the occurrence of the sub-Miocene rocks, in that — the crystalline ones, too. The differences in depth are also caused by the older faults as e.g., the pre-Jurassic ones limiting the Rzeszotary Horst. These faults generated the erosion of the Devonian and Lower Cambrian sediments from the horst area as well as a distinct differentiation in depth of the top surface of the metamorphic rocks in this block in relation to the outer, downthrown block elements of Mogilany and Liplas–Raciborsko.

The similar differentiation is manifested in the Lubliniec–Cracow–Rajbrot dislocation zone. In the area under discussion this zone runs most probably through Cracow (Fig. 1) and separates the southern region of the Upper Silesian Massif (genetically related to Gondwana) from the Małopolska Massif (M. Jachowicz, W. Moryc, 1995).

Some relation may be observed when comparing the petrological character of the metamorphic rocks in the basement of the Polish Carpathians with the structural pattern. The maximum altered rocks are the metamorphic granitoids from the Kęty 7, 8 and 9 boreholes and the metasomatic granitoids from Bielsko 4. They were drilled in the elevation zone of the erosional high of the crystalline basement. That high continues south-westwards which corresponds to the higher grade of metamorphism of the crystalline rocks in the elevated part. The alteration of the rocks in the Roztropice 3 and Łodygowice IG 1 in respect to the Bystra IG 1 boreholes and those in the Lachowice region is here the proof. The present-day pattern of the occurrence of the metamorphic rocks is very characteristic. The rocks of the lowest metamorphic grade, i.e., those of the character close to the products of the greenschists zone, lie outside the highly altered rocks of the area, within the largest structural depression. Three regions should be mentioned here, namely: Bystra–Lachowice, Potrójna–Wysoka and Piotrowice–Goczałkowice.

The similar pattern has been already mentioned by A. Ślączka (1976) and W. Brochwicz-Lewiński *et al.* (1986). The cited authors underlined the possibilities of an interpretation of the metamorphic rocks as occurring in the large anticlinal structure with the crystalline rocks in the core enveloped with the rocks of metaargilite type. This relationship is probably not so simple, but some regularities may take place.

The crystalline basement of the Bielsko-Biała–Cracow area is discordantly covered with the younger sediments. These are the Lower Cambrian rocks (Fig. 1) which form a cover extending approximately from Goczałkowice–Lachowice 7 north- and eastwards until the edge of the Rzeszotary Horst.

The Devonian sediments are at present widespread extending from this horst towards the west to the Lachowice region (U. Baran *et al.*, 1997; Fig. 1), lying in some places directly on the crystalline basement without the Lower Cambrian deposits. In the Bystra–Łodygowice region a characteristic elevation is present, being devoid of the Devonian. The metamorphic rocks are here covered directly by the Lower Miocene deposits. Further to the west, the Devonian sediments form the next synclinal zone Ustroń–Puńców–Krasna (W. Heflik, W. Moryc, 1996). The extent of the Devonian sediments is constrained in the south, at the Czech side, by the Bystřice 2 borehole where similarly to the Bystra–Łodygowice region the crystalline basement is covered only by the Miocene deposits.

The extent of the Carboniferous rocks (Fig. 1) is similar to that of the Devonian and distinctly manifests the south-eastern prolongation of the Upper Silesian Coal Basin.

Triassic and Jurassic display an evidently discordant, erosional course of their boundaries in respect to the Upper Palaeozoic systems. That concerns especially the Triassic sediments (represented only by Buntsandstein, possibly with some Permian rocks in the lower part) which occur as lobes of different size (Zawoja, Sucha IG 1, Jachówka, Trzebunia, Tokarnia IG 1) being equivalents of the sediments widely extending further to the east and north, outside the boundaries of the area under discussion.

The Middle and Upper Jurassic sediments widespread east of the Wysoka 3, Leńcze IG 1 (finished in the Carboniferous rocks) and Potrójna IG 1 boreholes (Fig.1) are the youngest sub-Miocene rocks. Towards the east they lie discordantly on the Buntsandstein, Carboniferous and Devonian sediments while within the Rzeszotary Horst — on the altered Precambrian rocks.

The sub-Miocene extent of the Meso-Palaeozoic systems discussed above was delimited basing on all the drillings which pierce the Miocene rocks. As it has already been mentioned, Figure 1 shows only boreholes which have reached the metamorphic rocks.

AGE OF THE METAMORPHIC ROCKS

Many attempts have been made determine the age of the crystalline rocks of the basement of the Upper Silesian Massif. The oldest rocks covering the crystalline ones were initialy believed to be of the Lower Devonian age. Discrepancies in the determinations were, therefore, significant since the age and consolidation could have been assumed both as the Early Palaeozoic or Precambrian ones. After drilling the Rzeszotary structure either the Caledonian age of the rocks was assumed (J. Nowak, 1927; J. Znosko, 1962, 1966) or their Caledonian metamorphism (J. Borucki, M. Sałdan, 1965). A. Pelczar and T. Wieser (1962) accepted the Caledonian or Precambrian age of the rocks. The other authors (J. Burtan, 1962; W. Heflik, K. Konior, 1971, 1972, 1974*c*; W. Heflik, 1982) considered these rocks as Precambrian. W. Heflik and K. Konior (1971) have proved that the Precambrian sediments of the Rzeszotary Uplift were altered in the Sandomierz phase of the Caledonian orogeny.

The identification of the Lower Cambrian sediments in the area under discussion has great significance for determining the age of the crystalline rocks. Since then all the altered rocks below the platform Lower Cambrian ones have been considered as the Precambrian (A. Kotas, 1982; A. Ślączka, 1976, 1982; S. Cebulak, A. Kotas, 1982; Z. Buła, 1994; Z. Buła, M. Jachowicz, 1996).

The Lower Cambrian deposits cover the crystalline rocks in the area extending from Goczałkowice, Bielsko-Biała and Lachowice 7 borehole towards the north and east (Fig. 1) until the region of the Rzeszotary Horst. The metamorphic rocks found in the boreholes in this area (with an exception of the Andrychów 3 borehole where magmatic rocks occur) must be, therefore, older than the Lower Cambrian. There exists also a distinct unconformity between the rock complexes since those Cambrian ones are almost horizontal in contrary to the steeply inclined metamorphic ones.

Due to the facts presented above it is of a great importance to re-evaluate the hitherto cited isotope age data. The studies of J. Borucki and M. Sałdan (1965) relate the age of the metamorphism of the crystalline rocks in the Rzeszotary 2 borehole to the Early Caledonian period. The age determined for these rocks may be concerned problematic when taking into account the discussion of the measurements (J. Burchart, 1971). There is only a low probability that the crystalline rocks of the Rzeszotary Horst strongly differ in their age from the similar rocks situated further to the west which must be older than the Lower Cambrian (Fig. 1). The rocks of the latter age occur in the Rajbrot region, further eastwards of Rzeszotary (M. Jachowicz, W. Moryc, 1995), which in the context of their occurrence in the basement of the Western Carpathians points to the conclusion of their primary existence as the cover of the metamorphic rocks in the Rzeszotary Horst. The present-day absence of these rocks is a result of the pre-Jurassic erosion. The value of 870 Ma, i.e. Cadomian, re-calculated to 837 Ma after J. Burchart (1971) seems, therefore, to be resonable as the age of the amphibolite from the Rzeszotary 2 borehole (depth of 946–947 m — S. Siedlecki *et al.*, 1965).

The hitherto conducted isotope age determinations are rare, especially in the part of the consolidated basement under discussion. More age data are needed, mostly from the newer boreholes. Some additional information, however, may be obtained from the results of isotope age determinations by Czech geologists in Morawy area, including the northwestern region adjacent to the Polish part of the Western Carpathians.

In the central part of the Moravian fragment of the Carpathian Foredeep the dating of the amphiboles and biotite from the granitoids from the Slavkov 2 borehole points to the Cadomian consolidation of the crystalline basement (A. Dudek, V. Šmejkal, 1968). The age data oscillate there in the range of 550–620 Ma (A. Dudek, 1980). E. Menčik *et al.* (1983) take the results of the isotope age studies in the boreholes close to the Polish boundary into account and give the following values: in Krasna 1 — muscovite age of 526 Ma, in Raškovice-Ja 7 — biotite age of 660 Ma, muscovite — 610 Ma, in Kozlovice SV 4 — biotite age of 640 Ma. In the Krasna 1 borehole the metamorphic paragneisses have been cut by two plutonic veins (diorites) the K/Ar age of which equals to 621 Ma for the amphiboles and 558 Ma for biotite (A. Dudek *fide* E. Menčik *et al.*, 1983). The isotope age of these diorites may be related to the Cadomian orogeny, while basing on the geological evidence, the metamorhic rocks must be older.

The results of the studies presented above seem to confirm the opinion of A. Dudek (1980) that the crystalline Bruno-Vistulicum rocks were consolidated not later than in the Cadomian orogeny, perhaps even earlier. Such an interval comprises even apparently anomalous results of dating for the rocks from the Rzeszotary 2 borehole (837 Ma — J. Burchart, 1971) as well as those from the Dražovice 2 drilling (1065–1410 Ma — A. Dudek, 1980).

At the end of the discussion of age relations, the K/Ar data for muscovite from the Lower Cambrian clastic sediments in the Upper Silesian Massif should be mentioned (Z. Belka *et al.*, 1996). The muscovite was analysed in the Lower Cambrian sediments from the Goczałkowice IG 1, Potrójna IG 1, Borzęta IG 1 and Klucze 1 boreholes. The K/Ar data fall into the range of 542–566 Ma. The cited authors suggest that the muscovite dated could had been eroded from the rocks of the Cadomian age, possibly from the Brno batolite (A. Dudek, J. Melkova, 1975).

It can be accepted as a final conclusion that the metamorphic rocks of the basement of the Western Carpathians should be related to the Cadomian, or even older orogeny.

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SKAŁY METAMORFICZNE W PODŁOŻU KARPAT MIĘDZY BIELSKIEM-BIAŁĄ A KRAKOWEM

Streszczenie

Skały metamorficzne podłoża Karpat Zachodnich znane są z dwudziestu kilku otworów wiertniczych (fig. 1). Dotychczas utwory te zbadane zostały (fig. 2) w rejonie horstu rzeszotarskiego (W. Petrascheck, 1909; J. Burtan, 1962; A. Pelczar, T. Wieser, 1962; W. Heflik, K. Konior, 1972, 1974*a–c*), w strefach: Bielska-Białej–Kęt–Andrychowa (W. Heflik, K. Konior, 1964, 1965, 1967*a*, 1970, 1971), Piotrowic–Potrójnej (A. Ślączka, 1976, 1982), Łodygowic–Bystrej (T. Wieser, 1974, 1978) i w kilku wierceniach między Cieszynem a Bielskiem-Białą (K. Konior, A. Tokarski, 1959; A. Kotas, 1973, 1982; S. Cebulak, A. Kotas, 1982; W. Heflik, K. Konior, 1974*c*; W. Heflik, W. Moryc, 1996).

Wyniki nowych wierceń (dotychczas nie publikowanych) z rejonu Lachowic–Ślemienia–Stryszawy (fig. 3) wykazały występowanie nowych stanowisk z tymi utworami. Są to skały metapsamitowe i metapelitowe o słabym stopniu metamorfizmu w facji zielonych łupków. Szczegółowe badania makro- i mikroskopowe (tab. 1), chemiczne (tab. 2) i termiczne (fig. 4) świadczą o ich przynależności do tego samego typu przeobrażeń genetycznych.

Utwory metamorficzne występujące w podłożu mezo-paleozoicznym (miejscami podmioceńskim) na obszarze Bielska-Białej–Krakowa tworzą zróżnicowaną strukturalnie powierzchnię erozyjną (fig. 1) dodatkowo przeciętą szeregiem uskoków. Niektóre z nich, jak strefa Lublińca–Krakowa–Rajbrota lub uskok Żywca–Rzeszotar mają charakter regionalny i wpływają przy tym wybitnie na układ strukturalny tej powierzchni.

Na północ od uskoku Żywca–Rzeszotar powierzchnia erozyjna skonsolidowanego podłoża metamorficznego jest najsilniej wyniesiona w rejonie Bielska-Białej–Kęt, gdzie osiąga wysokość prawie –1000 m. Ku południowi, północy i wschodowi powierzchnia ta wyraźnie się obniża, dochodząc w rejonie Piotrowic i Wysokiej do głębokości rzędu –2500 m. Dalsze obniżenie się tej powierzchni uwydatnia się w południowej strefie tego obszaru, przekraczając w strefie dotychczas zbadanej wiertniczo (Bystra–Lachowice) najprawdopodobniej –3500 m. Obniżenie tej powierzchni w tej strefie ma niewątpliwie związek z regionalnym uskokiem Żywca–Rzeszotar, zrzucającym obszar położony na południe od niego. Uskoki powodujące zróżnicowanie układu strukturalnego nie tylko tej powierzchni, ale powierzchni innych podmioceńskich systemów geologicznych, odgrywają główną rolę w budowie tektonicznej tego obszaru. Odzwierciedleniem tego jest głębokość powierzchni utworów krystalicznych występujących w strefie horstu rzeszotarskiego (Rzeszotary ok. –500 m) w stosunku do zrzuconego od zachodu bloku Mogilan–Borzęt, występującego przynajmniej o 1000–1700 m niżej.

W budowie geologicznej i charakterze petrograficznym skał metamorficznych zarysowuje się pewna zbieżność z ich układem strukturalnym. W strefie najsilniej wyniesionego podłoża (Bielska-Białej–Kęt–Andrychowa) występują granitoidy, a zatem skały o najwyższym w tym rejonie stopniu metamorfizmu. Po zewnętrznej, północnej, wschodniej i południowej stronie tego garbu występują utwory słabo zmetamorfizowane, o typie facji zieleńcowej. Być może można się tu doszukiwać pewnej prawidłowości, wymaga to jednak jeszcze dalszych, dodatkowych badań.

W świetle dotychczasowych badań utwory metamorficzne, zarówno z obszaru Polski, jak i Czech, należy dziś uznać za skały prekambryjskie, związane z działalnością kadomskiej, a być może nawet starszej orogenezy. Wskazują na to również nieliczne wprawdzie, ale dość sugestywne, badania radiometryczne.

EXPLANATIONS OF PLATE

PLATE I

Fig. 5. Quartz vein in metapelite; Lachowice 1 borehole, depth 4509 m, crossed nicols, x 40

Żyła kwarcowa w metapelicie; otwór Lachowice 1, głęb. 4509 m; nikole skrzyżowane, 40 x

Fig. 6. Metapsamite; Stryszawa 1K borehole, depth 2940.5 m; crossed nicols, x 40

Metapsamit; otwór Stryszawa 1K, głęb. 2940,5 m; nikole skrzyżowane, 40 x

Fig. 7. Metapsamite; Ślemień 1 borehole, depth 3269–3301 m; crossed nicols, x 40

Metapsamit; otwór Ślemień 1, głęb. 3269–3301 m; nikole skrzyżowane, 40 x

Fig. 8. Metapsamite with quartz veins; Ślemień 1 borehole, depth 3269–3301 m; crossed nicols, x 40

Metapsamit z żyłami kwarcowymi; otwór Ślemień 1, głęb. 3269–3301 m; nikole skrzyżowane, 40 x

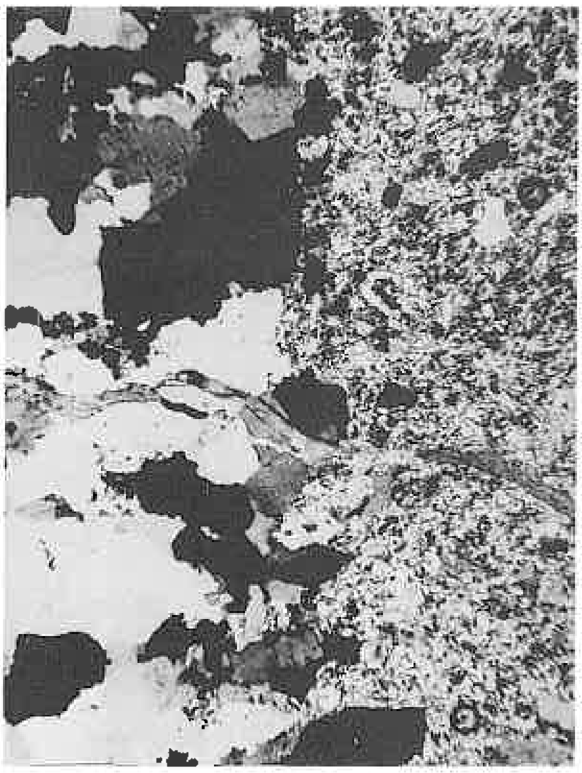

Fig. 5

Fig. 6

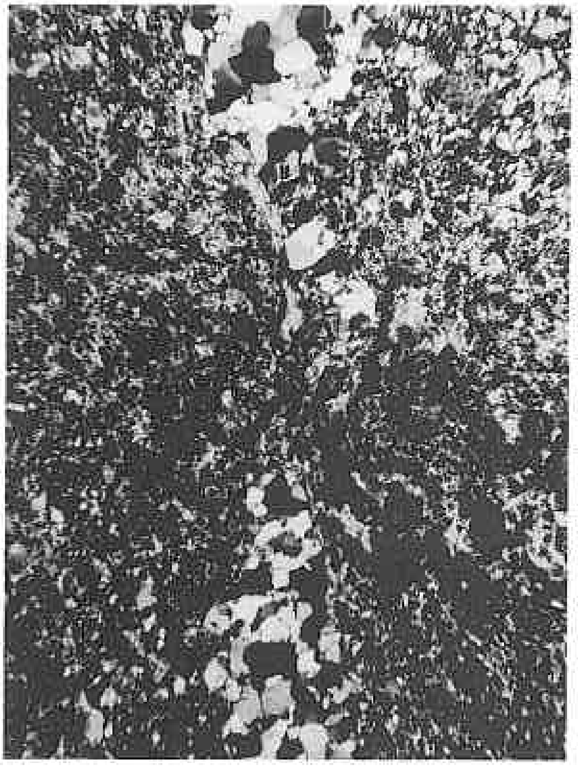

Fig. 7

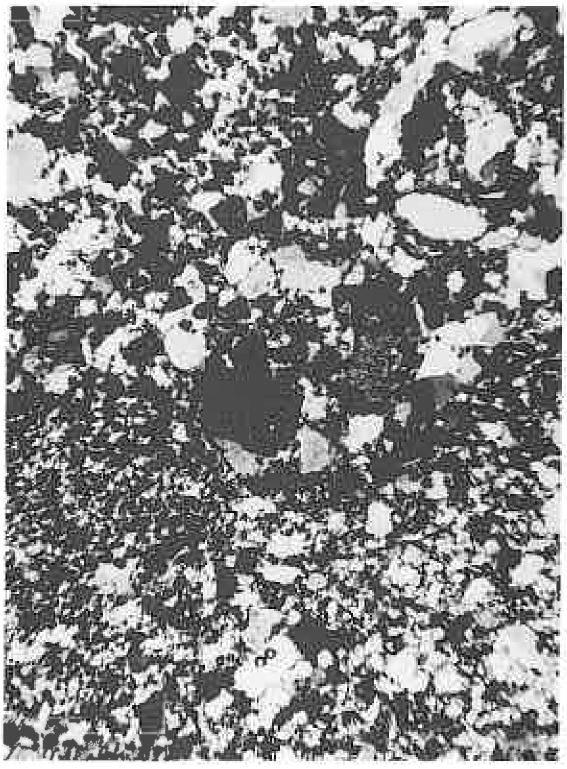

Fig. 8

Władysław MORYC, Wiesław HEFLIK — Metamorphic rocks in the basement of the Carpathians between Bielsko-Biała and Cracow