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The Lower Palaeozoic sediments in the Upper Silesian Block*

The Lower Palaeozoic sediments in the Upper Silesian Block are represented by the Lower Cambrian Sub-Holmia Zone (the Borzęta Formation) and the Lower Cambrian Holmia Zone (the Goczałkowice Formation). Sediments of the Borzęta Formation occur only in the eastern and likely in the northern part of the Upper Silesian Block. They are covered in transgressively by sediments of the Goczałkowice Formation also of Lower Cambrian age. Thickness of the Lower Cambrian sediments increases from the south and south-west to the east and north. In the eastern part of the block, a total thickness of the Lower Cambrian reaches approx. 3000 m. The northern part of the Upper Silesian Block is the area where only partial profiles of the Middle Cambrian and Ordovician have been recognized. Sediments of both the Cambrian and Ordovician within the Upper Silesian Block differ with respect to their tectono-stratigraphic development from the Lower Palaeozoic and Vendian rocks occurring within the western part of the Małopolska Block. Close neighbourhood of both types of development suggests that tectonic contact of both blocks exists along a narrow (approx. 0.5 km) tectonic zone.

INTRODUCTION

A research program had been carried out at the Polish Geological Institute between the years 1990 and 1995, aimed at working out the lithostratigraphy of the Lower Palaeozoic sediments encountered in boreholes located between Lubliniec and Kraków (in the north-eastern margin of the Upper Silesian Coal Basin) — Fig. 1. The research included lithological-petrographic and stratigraphic study of archival cores and drill cutting samples. Due to some circumstances suggesting the existence in the Olkusz area of the Lower Cambrian rocks similar to those recognized in the area of Goczałkowice – Bielsko-Biała – Myślenice (Fig. 1), the core study also included core samples recovered from boreholes located south- and south-westwardly of Kraków (Wiśniowa 3 and 6, Borzęta IG 1, Głogoczów IG 1, Piotrowice 1, and Potrójna IG 1; Fig. 1). Acritarchs were employed to

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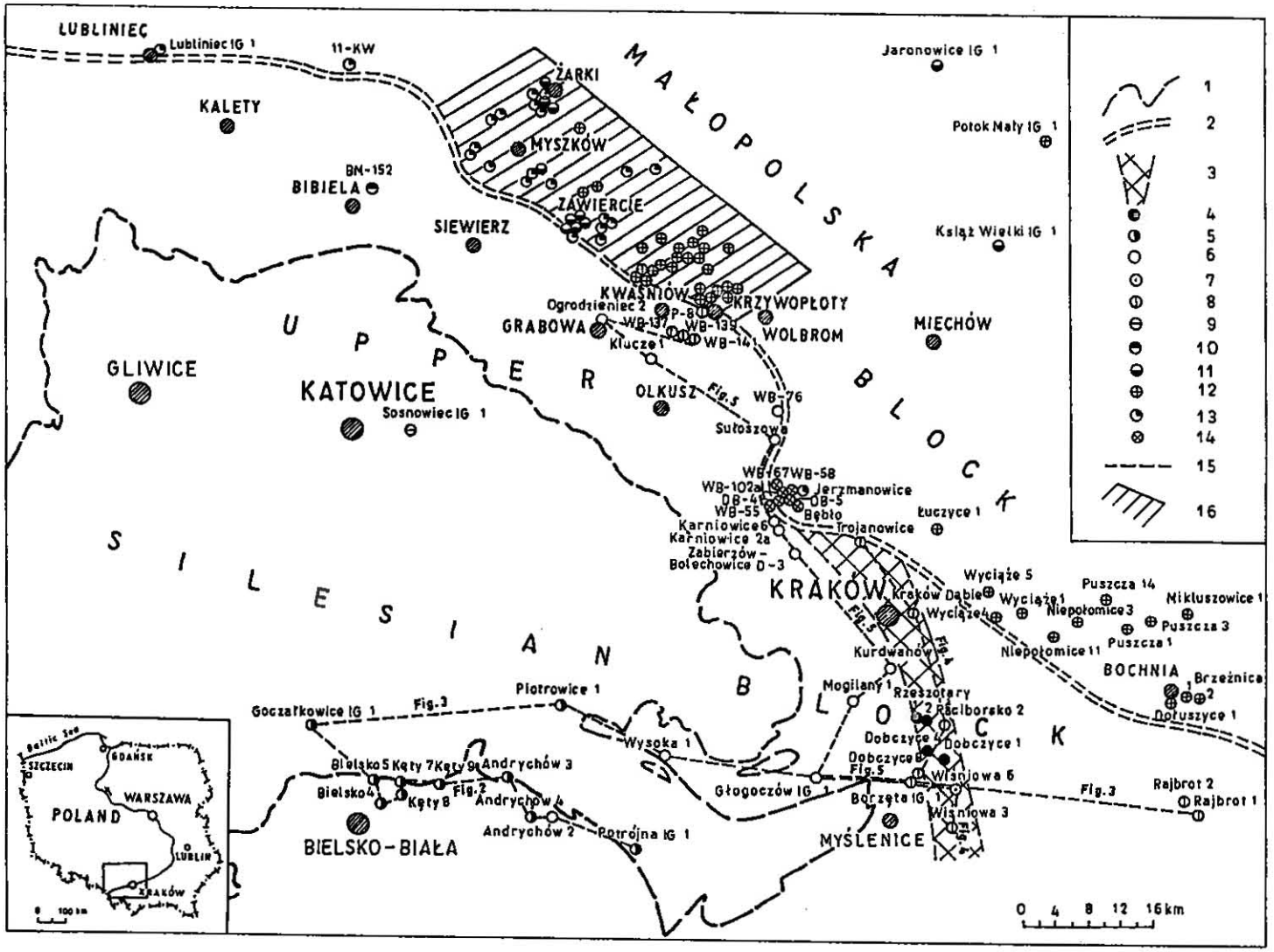
LUBLINIEC
Lubliniec IG 1
11-KW
KALETY
BIBIELA
BN-152
SIEWIERZ
ŻARKI
MYSZKÓW
ZAWIERCIE
MAŁOPOLSKA BLOCK
Jaronowice IG 1
Potok Mały IG 1
Książ Wielki IG 1
KWAŚNIÓW
KRZYWOPŁOTY
WOLBROM
MIECHÓW
Ogrodzieniec 2
P-8
WB-137
WB-139
WB-141
GRABOWA
Klucze 1
GLIWICE
KATOWICE
UPPER SILESIAN BLOCK
Sosnowiec IG 1
OLKUSZ
Fig.5
WB-76
Sułoszowa
WB-167
WB-58
WB-102a
Jerzmanowice
DB-4
DB-5
WB-55
Bębło
Karniowice 6
Karniowice 2a
Zabierzów-Bolechowice D-3
Trojanowice
Łuczyce 1
KRAKÓW
Wyciąże 5
Kraków Dabie
Wyciąże 1
Wyciąże 4
Puszcza 14
Niepołomice 3
Nikluszowice 1
Puszcza 3
Puszcza 1
Niepołomice 11
Kurdwanów
Fig.4
BOCHNIA
Brzeźnica
Rzeszotary
Mogilany 1
Piotrowice 1
Goczałkowice IG 1
Fig.3
Wysoka 1
Dobczyce 4
Dobczyce 1
Dobczyce 6
Wiśniowa 6
Głogoczów IG 1
Borzęta IG 1
Wiśniowa 3
MYŚLENICE
Rajbrot 2
Rajbrot 1
Bielsko 5
Kęty 7
Kęty 9
Andrychów 3
Bielsko 4
Kęty 8
Fig.2
Andrychów 4
Andrychów 2
Potrójna IG 1
BIELSKO-BIAŁA
Baltic Sea
SZCZECIN
GDAŃSK
WARSZAWA
POLAND
LUBLIN
KRAKÓW
0 100 km
0 4 8 12 16km
1
2
3
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5
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14
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16

date the age of rocks; results of this part of the study have already been published (Z. Buła, 1994; M. Jachowicz, 1994).

What is presented hereafter deals with the results of the lithostratigraphic study of the Lower Palaeozoic sediments within the Upper Silesian Block. Due to very diversified state of knowledge of rocks in particular areas (Fig. 1), the Upper Silesian Block has been subdivided into regions. Profiles of the Lower Palaeozoic, representative for particular regions, have been compared with each other with respect to earlier studies. Lithology of rocks has been characterized and stratigraphy discussed, and results of micropalaeontological study presented. Against such a background, areal distribution of main features of development of the sedimentation of rocks was clearly defined along with their thickness. A question of eastern and northern boundary of the Upper Silesian Block has also been discussed here.

Separate characteristics deals with sediments of the Lower Cambrian in the Goczałkowice IG 1 borehole. Due to the finding of the Lower Cambrian trilobites, this profile is considered to be a reference one for rocks recognized beneath the carbonate Middle Devonian rocks in boreholes situated eastwards of Goczałkowice–Bielsko-Biała (A. Kotas *et al.*, 1973; A. Ślączka, 1976; K. Konior, 1980).

Results obtained have inclined the authors to propose a new lithostratigraphic subdivision of the Lower Cambrian within the Upper Silesian Block (Figs. 2–5); reference has also been made to the earlier division (A. Kotas, 1982*b*). Units distinguished in the Lower Cambrian profile will formally be defined in Z. Buła's work (in preparation).

Fig. 1. Location map of boreholes with the Lower Palaeozoic and Precambrian rocks within the Upper Silesian and Małopolska Blocks

1 — boundary of the Upper Silesian Coal Basin (after Z. Buła, A. Kotas, 1994); 2 — tectonic zone separating the Upper Silesian Block from the Małopolska Block; 3 — Rzeszotary Horst; 4–10 — boreholes within the Upper Silesian Block with rocks of: 4 — Precambrian, 5 — Lower Cambrian, Holmia Zone (the Goczałkowice Formation) and Precambrian, 6 — Lower Cambrian, Holmia Zone (the Goczałkowice Formation), 7 — Lower Cambrian, Sub-Holmia Zone (the Borzęta Formation) and Precambrian, 8 — Lower Cambrian, Sub-Holmia Zone (the Borzęta Formation), 9 — Middle Cambrian, 10 — Ordovician; 11–14 — boreholes situated within the Małopolska Block, with rocks of: 11 — Lower Cambrian–Vendian, Ordovician, Silurian, 12 — Lower Cambrian-Vendian, 13 — Silurian, 14 — no determinated age; 15 — lines of correlation charts; 16 — area where the Lower Palaeozoic and Vendian sediments were recognized in detail

Mapa lokalizacji otworów wiertniczych, w których rozpoznano skały dolnopaleozoiczne i prekambryjskie na blokach górnośląskim i małopolskim

1 — granica Górnośląskiego Zagłębia Węglowego (według Z. Buły, A. Kotasa, 1994); 2 — strefa tektoniczna oddzielająca bloki górnośląski i małopolski; 3 — horst Rzeszotar; 4–10 — otwory usytuowane na bloku górnośląskim, w których rozpoznano skały: 4 — prekambru, 5 — kambru dolnego holmiowego (formacja z Goczałkowic) i prekambru, 6 — kambru dolnego holmiowego (formacja z Goczałkowic), 7 — kambru dolnego subholmiowego (formacja z Borzęt) i prekambru; 8 — kambru dolnego subholmiowego (formacja z Borzęt), 9 — kambru środkowego, 10 — ordowiku; 11–14 — otwory usytuowane na bloku małopolskim, w których rozpoznano skały: 11 — kambru dolnego-wendu, ordowiku, syluru, 12 — kambru dolnego-wendu 13 — syluru, 14 — dolnopaleozoiczne o nieokreślonym wieku; 15 — linie profili korelacyjnych; 16 — obszar szczegółowego rozpoznania utworów dolnopaleozoicznych i wendyjskich

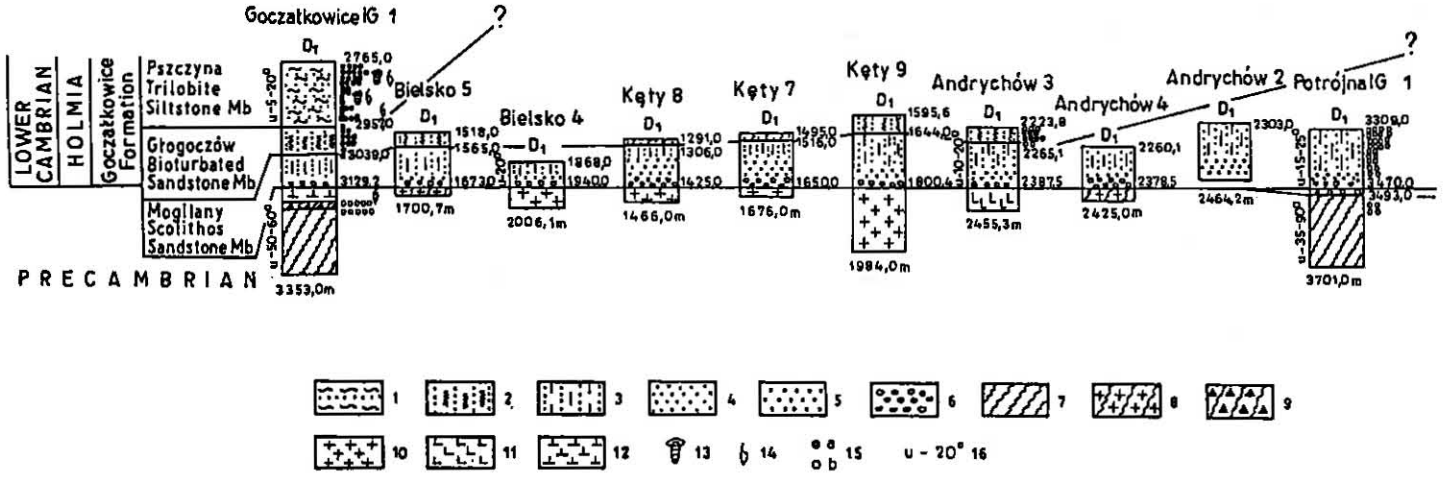


Fig. 2. Profiles of the Lower Cambrian in the region of Bielsko-Biała – Potrójna

1 — sandy siltstones with inserts of sandstones; 2 — bioturbated sandstones; 3 — *Scolithos* sandstones; 4 — fine- and medium-grained sandstones; 5 — medium- and coarse-grained sandstones; 6 — conglomerates; 7 — anchimetamorphic rocks; 8 — metamorphic rocks; 9 — breccias of anchimetamorphic rocks; 10 — granitoids; 11 — diallage gabbro; 12 — gabbro-diabases; 13 — trilobites; 14 — brachiopods; 15 — samples for study of acritarchs, with: a — positive results, b — negative results; 16 — dip of beds; D_1 — Lower Devonian

Profile kambru dolnego z rejonu Bielska-Białej – Potrójnej

1 — mułowce piaszczyste z wkładkami piaskowców; 2 — piaskowce bioturbacyjne; 3 — piaskowce skolitusowe; 4 — piaskowce drobno- i średnioziarniste; 5 — piaskowce średnio- i gruboziarniste; 6 — zlepieńce; 7 — skały anchimetamorficzne; 8 — skały metamorficzne; 9 — brekcje skał anchimetamorficznych; 10 — granitoidy; 11 — gabro diallagowe; 12 — gabrodiabazy; 13 — trylobity; 14 — brachiopody; 15 — próbki do badań akritarch, z których uzyskano wyniki: a — pozytywne, b — negatywne; 16 — upad warstw; D_1 — dewon dolny

DEVELOPMENT AND STRATIGRAPHY OF THE LOWER PALAEOZOIC SEDIMENTS

THE LOWER CAMBRIAN IN THE GOCZAŁKOWICE IG 1 BOREHOLE

A. Kotas (1973*a*, *b*, 1982*b*) was the first to characterize in detail the Lower Cambrian profile encountered in this borehole. He has stated that the Cambrian keeps here the characteristic tri-partite lithological-facial sequence. He has differentiated particular parts of this sequence as the following members (in ascending order): *Scolithos* Sandstone, Bioturbated Sandstone, and Trilobite Siltstone, and has designated this sequence as a whole with the term of the Goczałkowice Formation (Fig. 2).

Transgressive character of this sequence is evidenced by gradational changes in lithology of sediments. A lower part of the ***Scolithos* Sandstone Member** is formed (after A. Kotas, 1982*b*) by fine-grained polymictic-quartz conglomerates. An upper part of this member is composed of quartz unequigranular sandstones poorly sorted, in places with admixture of fine gravel, with inserts of both rusty and brown-red siltstones. Cement in conglomerates and sandstones is of hydromicaceous-hematite type, also of quartzitic one.

The **Bioturbated Sandstone Member** consists of alternating layers of light green fine-grained quartz sandstones, with quartz-carbonate cement, and of grey-green sandy siltstones.

The topmost part of the Lower Cambrian profile, i.e. the **Trilobite Siltstone Member** contains dominant siltstones, grey and greenish sandy siltstones with thin (up to 15 cm) inserts of grey fine-grained sandstones.

Abundant and varied assemblage of trace fossils were found in the Lower Cambrian rocks in the Goczałkowice IG 1 borehole and in boreholes in the area of Bielsko-Biała – Potrójna and Goczałkowice – Głogoczów. As a result of burrowing, the original structure of the Cambrian rocks is frequently deformated or completely obliterated. Neither detailed studies of these fossils have been carried out nor their classification proposed so far. The trace fossils of *Scolithos* type occurring in sandstones of the lower part of the Lower Cambrian profile have been considered to be the representative ones. They occur as tubes of small diameter (1–4 mm), perpendicular to depositional surfaces, filled up with sandy material. Length of individual tubes is from several to around 30 cm (K. Konior, A. Ślączka, 1972; A. Ślączka, 1976, 1982; A. Kotas, 1982*b*).

Trilobites occurring in the upper part of the Cambrian profile in the Goczałkowice IG 1 borehole have been identified by S. Orłowski (1975). *Schmidtiellus panovi* (Samsonowicz) is the index fossil for the Holmia Zone of the Lower Cambrian age.

A study of organic microscopic remains from this borehole has been carried out by M. Moczydłowska (Z. Kowalczewski *et al.*, 1984, 1985). She has found (1983) that acritarchs characteristic for the Lower Cambrian Holmia Zone occur in the upper part of the Cambrian profile composed of the Bioturbated Sandstone Member and in the Trilobite Siltstone as well. Acritarchs are mentioned in the works by Z. Kowalczewski *et al.* (1984, 1985) and Z. Kowalczewski (1990) to be found in the Goczałkowice IG 1 borehole at the depth of 3177.6–3180.2 m indicating the Middle Cambrian or even earlier age of rocks in this interval which were earlier considered by A. Kotas (1982*a*, *b*) as the Precambrian ones (Fig. 2). It should be further noticed that the study by M. Moczydłowska (1993) has not confirmed the

presence of acritarchs in the depth interval cited. Also negative results have been presented by M. Jachowicz (1995) after a study of 10 rock samples collected from the depth interval of 3170.5 to 3181.0 m. With respect to such results, the idea presented by Z. Kowalczewski (Z. Kowalczewski *et al.*, 1984, 1985; Z. Kowalczewski, 1990) on reversed position of the Cambrian rocks in the Goczałkowice IG 1 borehole can be considered no longer valid. A repeated micropalaeontological study of these cores by M. Jachowicz, particularly on the majority of samples collected from the depth of 2771.0–3032.0 m has revealed abundant (in excess of 300 specimens per slide) well preserved acritarchs characteristic for the Lower Cambrian Holmia Zone. The acritarch assemblage includes: *Skiagia ornata* (Volkova) Downie, *S. ciliosa* (Volkova) Downie, *S. compresa* (Volkova) Downie, *Archaeodiscina umbonulata* Volkova, *Multiplicisphaeridium dendroideum* (Jankauskas) Jankauskas et Kirjanov, and *Heliosphaeridium dissimilare* (Volkova) Moczydłowska.

THE LOWER CAMBRIAN IN THE REGION OF BIELSKO-BIAŁA – POTRÓJNA

Clastic rocks recognized here (Fig. 1) between carbonates of the Middle Devonian and the Precambrian metamorphic and anchimetamorphic rocks have for long been assigned to the Lower Devonian (K. Konior, 1968, 1969, 1980). Later, A. Kotas (A. Kotas *et al.*, 1973) and A. Ślączka (1976), considering the results of the study of the Lower Cambrian in the Goczałkowice IG 1 borehole, have kept in the Lower Devonian only those topmost parts of the clastic deposits occurring here and in adjoining areas, whose age has been documented in some boreholes by psilophytic flora and microflora (K. Konior, 1969; K. Konior, E. Turnau, 1973; E. Turnau, 1974). Rocks occurring below, with lithological-sedimentological and biofacial features and characteristic assemblages of trace fossils, similar to that of the Lower Cambrian rocks in the Goczałkowice IG 1 borehole have been considered by both the authors as the Lower Cambrian.

From comparison between profiles of the Lower Cambrian (Fig. 2) [compiled on the basis of data contained in the A. Ślączka (1976) and K. Konior's (1980) works as well as in archival material worked out by A. Kotas] a conclusion can be drawn that equivalents of the *Scolithos* Sandstone Member occur here; in some boreholes, equivalents of the Bioturbated Sandstone Member of the Goczałkowice Formation have also been recognized. The Cambrian rocks occurring in this region have been described in detail by K. Konior (1968, 1969) and A. Ślączka (1976).

The Lower Cambrian age has been confirmed in one borehole only (Andrychów 3). In the upper part of the Cambrian profile, G. Vidal (*fide* W. Brochwicz-Lewiński *et al.*, 1986) has found acritarchs characteristic for the Holmia Zone of the Lower Cambrian. In the upper part of the Cambrian profile in the Kęty 9 borehole, E. Turnau (1974) has found organic microscopic remains indicating that rocks are older than Devonian. Disputable is the determination of Cambrian age of rocks in the Potrójna IG 1 borehole as suggested by M. Moczydłowska (Z. Kowalczewski *et al.*, 1984, 1985). She has found individual acritarchs in one sample only (the depth interval of 3356.5–3363.5 m); representative species has been identified as *Timofeevia phospohoritica* Vanguestaine of vertical extent from the Middle Cambrian to Tremadoc and early Arenig. Based on this, rocks from the Potrójna IG 1 borehole has been assigned by M. Moczydłowska and Z. Kowalczewski (Z. Kowalczewski *et al.*, 1984, 1985; Z. Kowalczewski, 1990; M. Moczydłowska, 1993) to the Middle Cambrian and distinguished by Z. Kowalczewski (1990) as the Jaszczurowa Sandstone

Formation. Repeated micropalaeontological study (M. Jachowicz, 1995) on 18 samples of siltstones from the depth of 3326.3–3432.0 m has not revealed determinable organic microscopic remains despite double maceration. In the light of this negative result it has been assumed that the results of earlier investigations carried out by M. Moczydłowska cannot represent a reliable estimate of the age of rocks from the Potrójna IG 1. Considering the results of lithological and sedimentological studies (A. Ślączka, 1976, 1985), the sandstone complex in the Potrójna IG 1 borehole with characteristic trace fossils of the *Scolithos* type has been reckoned as the Lower Cambrian and acknowledged as the equivalent to the *Scolithos* Sandstone Member of the Goczałkowice Formation (Fig. 2).

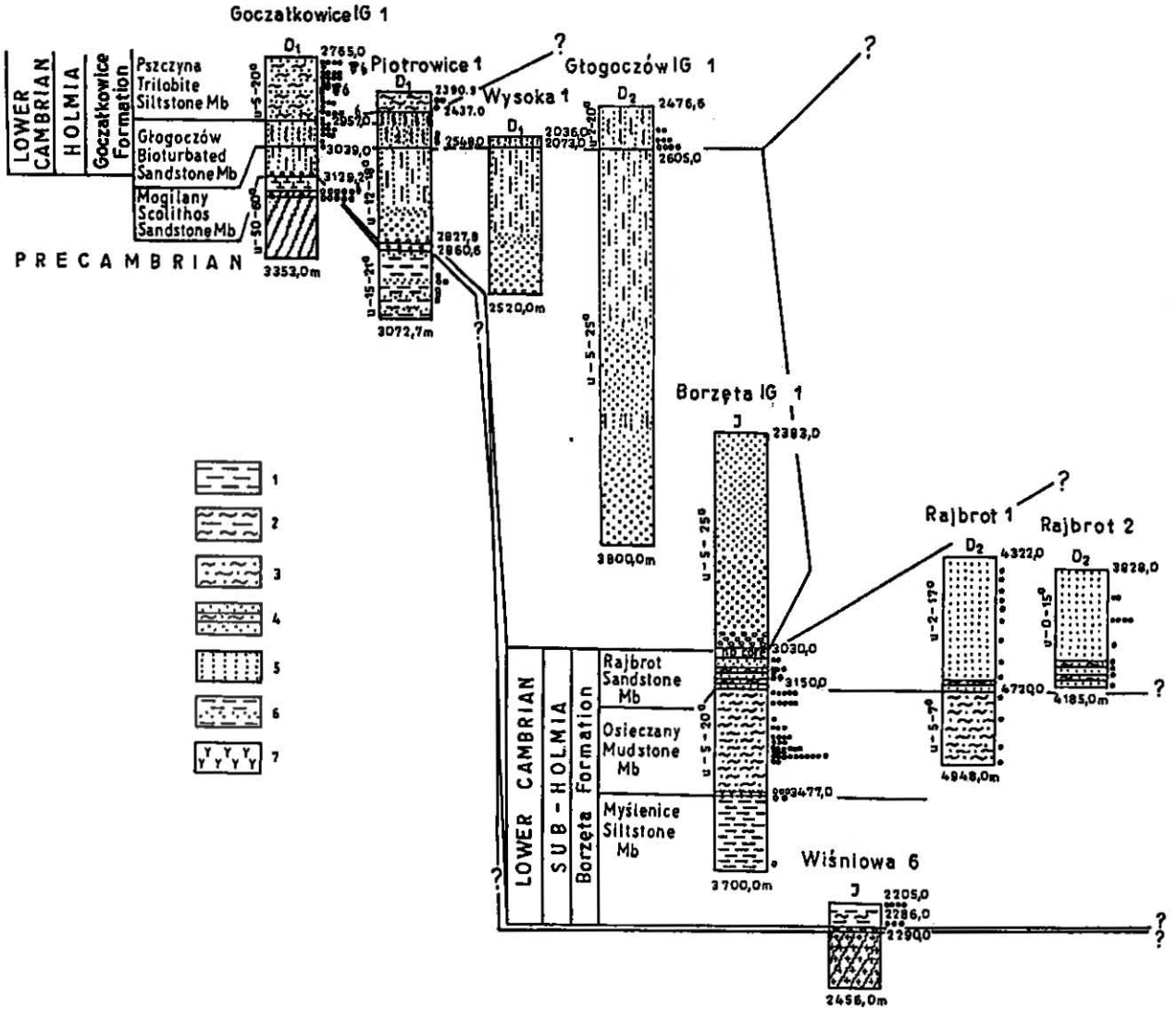
Thickness of the Lower Cambrian sediments occurring in this region is weakly differentiated. Thickness of the *Scolithos* Sandstone Member increases significantly eastwards of Bielsko-Biała (Fig. 2).

THE LOWER CAMBRIAN IN THE REGION OF GOCZAŁKOWICE – MYŚLENICE – RAJBROT

The Lower Cambrian rocks similar to those recognized in the Goczałkowice IG 1 borehole were encountered in the Piotrowice 1, Wysoka 1, and Głogoczów IG 1 boreholes (Fig. 1). From comparison of the Cambrian profiles (Fig. 3) [compiled on the basis of data contained in the works by S. Gucik (1975), A. Ślączka (1976), and K. Konior (1980) and in archival materials worked out by A. Kotas] a conclusion can be drawn that equivalents to the *Scolithos* Sandstone and Bioturbated Sandstone Members occur in these boreholes; as to the Piotrowice 1 borehole, the Trilobite Siltstone Member was also identified. It is worth to emphasize that the thickness of the bottom member of this formation — the *Scolithos* Sandstone (Fig. 3) — became multiplied eastwards of Goczałkowice. Description of the Cambrian rocks from the Piotrowice 1, Wysoka 1, and Głogoczów IG 1 boreholes has been presented in the works of S. Gucik (1975), A. Ślączka (1976), and K. Konior (1980).

More complete palaeontological documentation exists for the Lower Cambrian rocks occurring between Goczałkowice and Głogoczów than for the previous region. From the topmost part of the Cambrian profile in the Wysoka 1 borehole, E. Turnau (1974) has obtained assemblages of microscopic organic remains similar to that from the Kęty 9 borehole. G. Vidal (*fide* W. Brochwicz-Lewiński *et al.*, 1986) found scarce Cambrian acritarchs in the Piotrowice 1 borehole at the depth of 2410.0–2411.0 m; however, they do not provide a background for detailed age dating. More abundant acritarch assemblages representative for the Lower Cambrian Holmia Zone have been recovered by M. Jachowicz (1995) from the Bioturbated Sandstone Member in the Piotrowice 1 and Głogoczów IG 1 boreholes as well as from the Trilobite Siltstone Member in the Piotrowice 1 borehole.

Nine rock samples from the depth interval of 2536.1–2581.4 m in the Głogoczów IG 1 borehole have been examined for microflora. Determinable microflora has been found in 5 samples from the interval of 2536.1–2575.9 m. No traces of microflora have been found in remaining samples despite scrupulous searching. Positive samples contained abundant (in excess of 150 specimens per slide) and very well preserved acritarchs. Specimens show neither traces of carbonization nor considerable damage; they are light yellow and orange. More important genera and species include: *Heliosphaeridium dissimilare* (Volkova) Moczydłowska, *Skiagia ornata* (Volkova) Downie, *Tasmanites bobrowskiae* Ważyńska, *Asteridium,* and *Ceratophyton.* These forms are accompanied by abundant representatives


Goczałkowice IG 1
Piotrowice 1
Wysoka 1
Głogoczów IG 1
Borzęta IG 1
Rajbrot 1
Rajbrot 2
Wiśniowa 6
LOWER CAMBRIAN
HOLMIA
Goczałkowice Formation
Pszczyna Trilobite Siltstone Mb
Głogoczów Bioturbated Sandstone Mb
Mogilany Scolithos Sandstone Mb
PRECAMBRIAN
SUB-HOLMIA
Borzęta Formation
Rajbrot Sandstone Mb
Osieczany Mudstone Mb
Myślenice Siltstone Mb
1
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3
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7

of genus *Leiosphaeridia.* In order to obtain comparative material, rock samples from the depth interval of 2410.4–2542.8 m in the Piotrowice 1 borehole have been examined again. Five samples contained abundant (in excess of 200 specimens per slide) and well preserved assemblages of acritarchs. More important forms include: *Multiplicisphaeridium dendroideum* (Jankauskas) Jankauskas et Kirjanov, *Skiagia ornata* (Volkova) Downie, *S. compressa* (Volkova) Downie, *Granomarginata, Pterospermella,* and *Heliosphaeridium.*

New data, extremely useful for the Lower Cambrian profile has been acquired as a result of study on the Borzęta IG 1 borehole (Fig. 1). Clastic rocks of questionable age have been described by S. Gucik (1973) at the depth of 2383.0–3700.0 m (Fig. 3), below the Jurassic (comp. Z. Buła, 1994). A microfloral study carried out at that time, provided no basis for reliable assessment of their stratigraphic position. S. Gucik was of the opinion that these rocks were Permian-Carboniferous in age, and that the underlying rocks with remnants of gigantostracans would conditionally be assigned the Cambrian. However, Z. Buła (1994) claimed the Cambrian age of the sub-Jurassic rocks in this borehole.

As a result of present study in the Borzęta IG 1 borehole, 2 rock complexes have been distinguished due to their visible differences in lithology and facial development: the lower complex at the depth of 3030.0–3700.0 m and the upper complex at the depth of 2383.0–3030.0 m.

The lower complex, composed of tri-partite regressive sequence, was distinguished as the Borzęta Formation. It is composed (in ascending order) of grey and dark grey claystones of greenish to cherry-red tint, locally grading into siltstones (the Myślenice Siltstone Member). No lamination is present in these rocks; however, a leaf-like fissility is fairly visible. Dominant in the middle part of the complex (the Osieczany Mudstone Member) are sandy siltstones with horizontal or lenticular laminae of fine-grained sandstones, in places with inserts (up to 15 cm thick) of light grey or pink-grey fine-grained sandstones with carbonate cement and thin interbeddings of grey-green claystones. The upper part of the complex (the Rajbrot Sandstone Member) contains alternating beds of light grey or light pink, quartz or arcosic, fine-grained sandstones, in places cross-laminated (small scale), and grey-green or grey siltstones with wavy and lenticular lamination and with interbeds of fine-grained sandstones.

The upper complex is represented (in ascending order) by light grey and pink-grey fine-grained conglomerates interbedded with unequigranular sandstones. They are overlain by dominant cherry-red or brown-red medium- to coarse-grained cross-bedded (large scale) sandstones. Sandstones prevail in the upper part; they are cherry-red or brown-red, fine-

Fig. 3. Profiles of the Lower Cambrian in the region of Goczałkowice – Myślenice – Rajbrot

1 — claystones; 2 — claystones and siltstones; 3 — sandy siltstones with inserts of sandstones; 4 — alternating beds of sandstones and siltstones; 5 — fine-grained sandstones laminated with siltstones; 6 — weakly metamorphosed sandstones and claystones; 7 — diabases, lamprophyres; D_2 — Middle Devonian; J — Jurassic; for other explanations see Fig. 2

Profile kambru dolnego z rejonu Goczałkowic – Myślenic – Rajbrota

1 — iłowce; 2 — iłowce i mułowce; 3 — mułowce piaszczyste z wkładkami piaskowców; 4 — naprzemianległe ławice piaskowców i mułowców; 5 — piaskowce drobnoziarniste laminowane mułowcami; 6 — piaskowce i iłowce słabo zmetamorfizowane; 7 — diabazy, lamprofiry; D_2 — dewon środkowy; J — jura; pozostałe objaśnienia jak na fig. 2

and medium-grained, cross-bedded (small scale) with intraclasts of brown-red siltstones. They are rhythmically interbedded with brown-red sandy siltstones. The upper complex is the equivalent of the *Scolithos* Sandstone Member of the Goczałkowice Formation (Fig. 3). This is indicated by the appearance of both sandstone and siltstone lithotypes, with petrographic character similar to those rocks that occur in the profile of the *Scolithos* Sandstone Member in the neighbouring Głogoczów IG 1 borehole (A. Pelczar, 1973, 1975).

A total of 54 samples were taken for organic remnants from the Borzęta IG 1 borehole in the lower complex at the interval of 3053.1–3647.7 m. 49 samples from the depth 3053.1–3368.0 m were positive. All of them contain very rich assemblages of microfossils, with predominant appearance of such genera as *Leiosphaeridia, Granomarginata,* and *Tasmanites.* They are associated with abundant cyanobacteria as a dominant constituent, and algae from the genus *Tyrasotaenia.* Sparse specimens of genus *Ceratophyton* are also present, which were recently classified among the animal kingdom (O. Fatka, M. Konzalova, 1995). Similar microfossil assemblages are known in the sediments of the Lower Cambrian Sub-Holmia Zone.

Sediments similar to those in the lower part of the Borzęta IG 1 profile, with the same sequence, were encountered below the carbonate Middle Devonian deposits in the Rajbrot 1 and 2 boreholes (Fig. 3) (M. Jachowicz, W. Moryc, 1995). More complete profile of the Lower Cambrian Sub-Holmia Zone was obtained in the Rajbrot 1 borehole (Fig. 3). According to W. Moryc (M. Jachowicz, W. Moryc, 1995), the lower part of the Cambrian profile is composed of siltstones, sandy siltstones, claystones — dark grey, grey-green and pink-red in places. There are inserts of sandstones which are fine-grained, mostly arcosic, grey and pink-grey. Thickness of sandstone inserts is less than 20 cm. The upper part of the profile (also in the Rajbrot 2 borehole) contains dominant sandstones that are mostly fine-grained (infrequently medium-grained), of greywacke or arcosic character, grey, pink, and grey-green in places. They are interbedded or laminated with dark grey, grey-green and in places pink-red siltstones and claystones. Assemblages of microscopic organic remains found in the rocks of both the Rajbrot 1 and 2 boreholes are similar to those of the Borzęta IG 1 borehole (M. Jachowicz, 1995; M. Jachowicz, W. Moryc, 1995).

These data clearly indicate that the Lower Cambrian Sub-Holmia rocks (the Borzęta Formation) in the Myślenice – Rajbrot area are older than rocks of the Lower Cambrian Holmia Zone (the Goczałkowice Formation) in the area between Goczałkowice and Głogoczów (Fig. 3). It is difficult to define the extent of the Borzęta Formation westwards of Myślenice. Both in the Głogoczów IG 1 and Wysoka 1 boreholes as well as in the nearby Mogilany 1 borehole, sediments of the Goczałkowice Formation (Figs. 3, 5) were not pierced. Rock complexes represented in the Piotrowice 1 borehole by weakly metamorphosed black clayey shales and arcosic sandstones (W. Heflik, K. Konior, 1973), and in the Potrójna IG 1 borehole — by metapelites, metaaleurites, and metaarcoses (A. Ślączka, 1976, 1982) — found below the sediments of the Goczałkowice Formation and separated from it by a bed of polymictic conglomerate of insignificant thickness (A. Ślączka, 1976, 1982, 1985) — are facially different from rocks in the profile of the Borzęta Formation. Rocks from the Piotrowice 1 and Potrójna IG 1 boreholes, noted in such structural position, were weakly metamorphosed. Metamorphism has not been observed in rocks of the Borzęta Formation. Palynologic study by M. Jachowicz (1995) of anchimetamorphic rocks from these boreholes and from the Goczałkowice IG 1 borehole gave no results.

In the light of what is stated here, it is difficult to consider the anchimetamorphic rocks encountered in the Piotrowice 1, Potrójna IG 1, and Goczałkowice IG 1 boreholes as the time-equivalents of the Borzęta Formation. It is likely that following the earlier assumptions of A. Ślączka (1976, 1982, 1985) and A. Kotas (1982*a*, *b*), they represent the Precambrian.

THE LOWER CAMBRIAN IN THE REGION OF WIŚNIOWA – TROJANOWICE

The region of Wiśniowa – Trojanowice includes the Rzeszotary Horst which was earlier known as the Rzeszotary Anticline (J. Nowak, 1927) or the horst-like Rzeszotary Elevation (J. Stemulak, E. Jawor, 1963), or the Rzeszotary Elevation (K. Konior, 1974). In some boreholes (Rzeszotary 1 and 2, and Dobczyce 1 and 4; Fig. 1) situated within this horst, the metamorphic and magmatic rocks were encountered immediately under the Jurassic deposits (J. Nowak, 1927; A. Pelczar, T. Wieser, 1962; W. Heflik, K. Konior, 1972, 1974*a*). In the Wiśniowa 6 borehole located southwards of Rzeszotary (Fig. 1), W. Heflik and K. Konior (1974*b*) have distinguished sedimentary rocks occurring between Jurassic and metamorphic rocks (at the depth of 2205.0–2286.0 m); they are underlain by 4 m layer of conglomerates and unequigranular sandstones (Figs. 3, 4). As described by W. Heflik and K. Konior (1974*b*), these sedimentary rocks consist of dark grey siltstones with fine mica, laminated with dark grey claystones. Similar rocks were encountered under the Jurassic (at the depth of 2509.0–2534.0 m) in the nearby Wiśniowa 3 borehole (R. Zając, personal communication; Fig. 4). There are thin inserts of clayey conglomerates among siltstones and claystones. In their lower part they are underlain by conglomerates that are composed of fragments of sedimentary and magmatic rocks with silty-arenaceous cement (Fig. 4).

The sub-Jurassic rocks in the Wiśniowa 6 borehole have been reckoned as Silurian (W. Heflik, K. Konior, 1974*b*) or Cambrian (Z. Kowalczewski, 1990). As a result of the study of microscopic organic remains in samples of siltstones and claystones collected from the Wiśniowa 3 borehole (3 samples from the depth of 2519.0–2522.5 and 2532.0–2534.5 m) as well as from the Wiśniowa 6 borehole (7 samples from the depth of 2226.5–2232.0 and 2286.0–2289.5 m), M. Jachowicz (1995) has determined cyanobacteria microfossils with dominant genus *Leiosphaeridia* associated with abundant individual specimens of *Tasmanites* and *Ceratophyton*. These assemblages indicate the Lower Cambrian age (Sub-Holmia Zone) of deposits.

Complexes of clastic deposits of doubtful stratigraphic position were encountered in boreholes located north of Rzeszotary (in the Kraków area). In the Trojanowice borehole (Fig. 1), clastic rocks were found at the depth of 206.0–237.0 m, under the Jurassic deposits; S. Bukowy (1960) has described these rocks as "...dark grey shales with indistinct fissility and lamination, affected by strong diagenesis..." (Fig. 4). Palynologic study of these rocks were carried out by A. Jachowicz (1960) and M. Brzozowska (1960). A. Jachowicz's results have been negative; in contrast, M. Brzozowska has recorded the presence of the badly preserved Upper Carboniferous megaspores. Based on this, S. Bukowy (1960) included the sub-Jurassic rocks at Trojanowice in the Upper Carboniferous. As the result of repeated examination of microscopic organic remains in 11 samples of sub-Jurassic rocks from this borehole (M. Jachowicz, 1995), abundant (in excess of 100 specimens per slide) organic assemblages have been found. The genus *Leiosphaeridia* and abundant cyanobacteria are dominant. Specimens of the genera *Leiovalia, Tasmanites,* and *Ceratophyton* have also been found. They document the Lower Cambrian (Sub-Holmia Zone) age of these sediments.

The question of age of rocks encountered under the Jurassic in the Kraków-Dąbie borehole (Fig. 1), at the depth of 322.0–395.0 m (Fig. 4) remains disputable in the light of results obtained in Trojanowice and Wiśniowa. They were described by F. Rutkowski (1930) as olive-yellow shales, passing downwards into grey, compact shales silicified in places, with mica plates on bed surfaces, dipping to NNE at an angle of 25°; they were included in the Carboniferous. Other description of these rocks has been presented by S. Z. Różycki (1953): they are olive-green rocks "...deserving of being called the sericitic schist or even phyllite...", and has classified them as Silurian. This idea has been supported by J. Znosko (1963, 1965) and K. Konior (1974). Controversies between both descriptions of these palaeontologically undocumented sub-Jurassic rocks has made it difficult to define their stratigraphic position according to lithological criteria. In the light of results of stratigraphic study of the sub-Jurassic rocks in Trojanowice and Wiśniowa, the rocks in Kraków-Dąbie can be classified [after taking into account the F. Rutkowski's (1930) description] as belonging to the Lower Cambrian Sub-Holmia Zone.

All of data dealing with the Wiśniowa 3, Trojanowice, and probably Kraków-Dąbie boreholes as well as the structural position of rocks in the Wiśniowa 6 borehole indicate that: (1) the Rzeszotary Horst continues from Rzeszotary to the north of Kraków (Fig. 1); (2) top of metamorphic rocks occurring under the Lower Cambrian Sub-Holmia Zone or directly under the Jurassic is rising up from the south to the north to reach its culmination in the Trojanowice area; (3) clayey-silty sediments of the Lower Cambrian Sub-Holmia Zone, representing the lower member of the Borzęta Formation (Fig. 4) in the Rzeszotary horst zone only in places escaped the pre-Jurassic erosion.

The stratigraphic position of clastic rocks encountered under the Jurassic in the Dobczyce 8 borehole (at the depth of 2302.0–2405.0 m) situated nearby the Borzęta IG 1 borehole (Fig. 1) is problematic. As reported by R. Zając (personal communication), their upper part (to the depth of 2307.6 m) consists of sandy conglomerates and white-greyish unequigranular sandstones. Below them there occur grey-green or pink and red fine-grained sandstones, laminated with dark grey claystones in their topmost part. So far, these rocks have been classified as Lower Devonian (K. Konior, 1974) or Carboniferous (P. Karnkowski, 1977).

The present authors are of the opinion that in the light of results of the study of the Borzęta IG 1 borehole, rocks encountered in the Dobczyce 8 borehole should be recognized as the Lower Cambrian ones. It is not excluded that the sandy conglomerates and unequigranular sandstones from the upper part of the profile are equivalent to the *Scolithos* Sandstone Member of the Goczałkowice Formation, and the fine-grained sandstones — to the Rajbrot Sandstone Member of the Borzęta Formation (Fig. 4).

THE LOWER CAMBRIAN IN THE REGION OF MOGILANY – GRABOWA

A complex of sandstones with trace fossils of *Scolithos* type, approx. 1400 m thick, was encountered in the Mogilany 1 borehole (Fig. 1) under the Middle Devonian carbonates (K. Konior, 1974, 1980; A. Ślączka, 1976). With respect to the Lower Cambrian profile in the nearby Głogoczów IG 1 borehole (Fig. 1), this complex constitutes undoubtfully the equivalent of the *Scolithos* Sandstone Member of the Goczałkowice Formation (Fig. 5).

Further to the north, between Kurdwanów and Grabowa (the Ogrodzieniec 2 borehole), fragments of profiles of Palaeozoic rocks of variable lithology, mostly palaeontologically

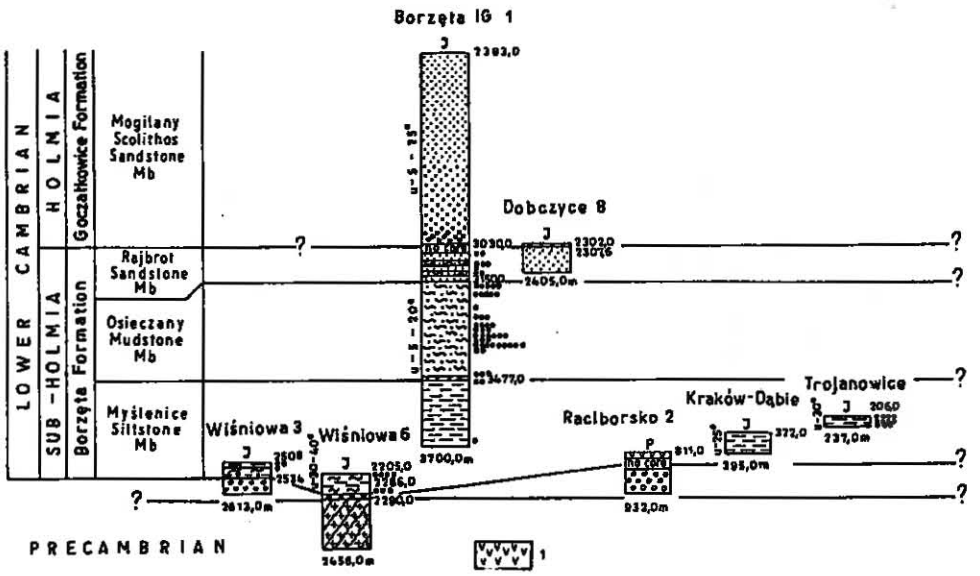
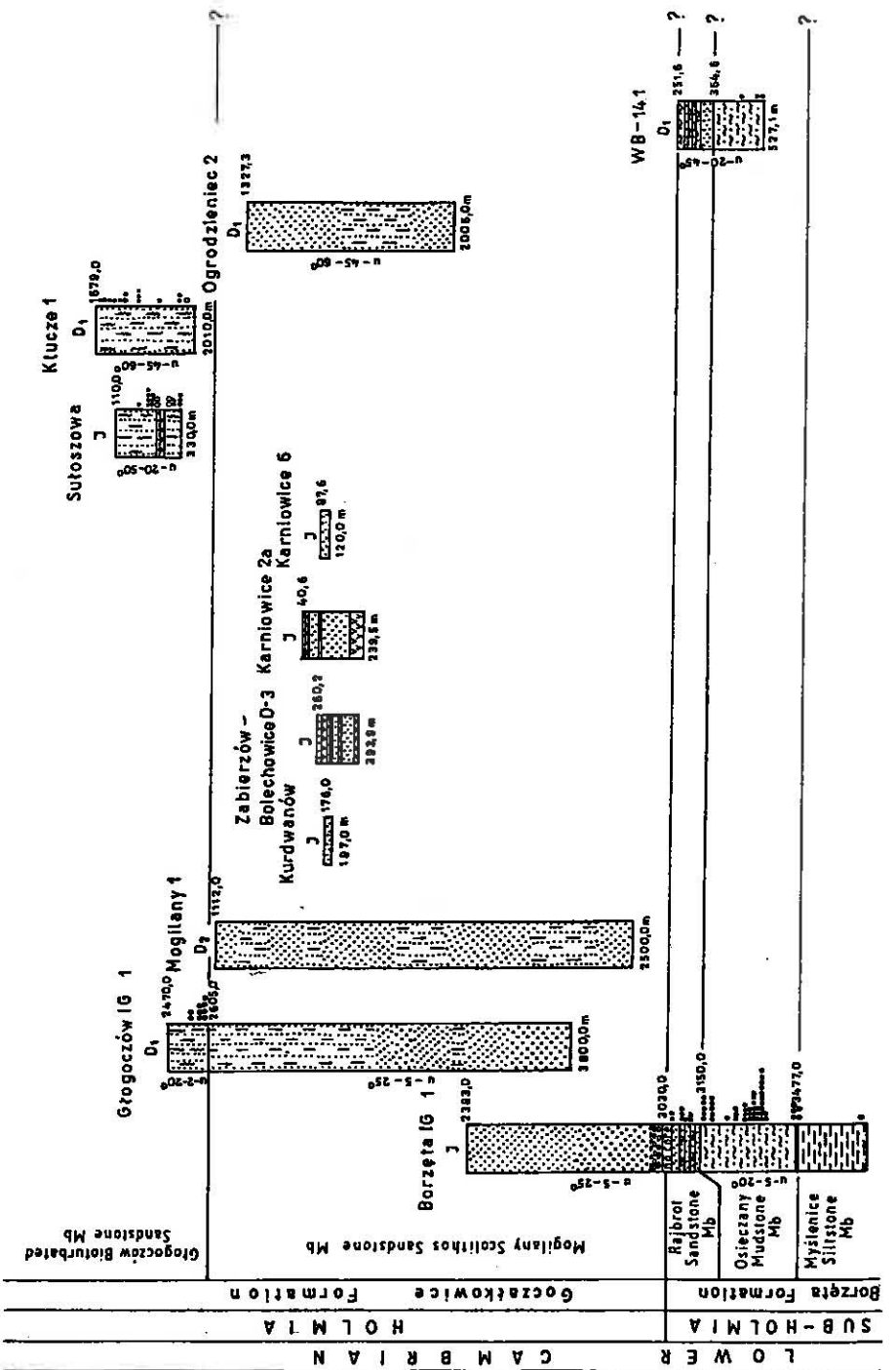


Fig. 4. Profiles of the Lower Cambrian in the region of Wiśniowa – Trojanowice
1 — magmatic rocks — porphyres, lamprophyres; P — Permian; for other explanations see Fig. 2 and 3
Profile kambru dolnego z rejonu Wiśniowej – Trojanowic
1 — skały magmowe — porfiry, lamprofiry; P — perm; pozostałe objaśnienia jak na fig. 2 i 3

undocumented were encountered in 11 boreholes (Figs. 1, 5) under the Devonian or directly under the Mesozoic deposits. A considerable disaccord existed till present in the assessment of their stratigraphic position and origin.

It was M. Tarnowska (1989) who described a complex of fine- to coarse-grained, mostly quartz sandstones, pink, light grey, light red with clasts of red-brown siltstones, and with thin inserts of brown ferriferous siltstones — encountered in the Ogrodzieniec 2 borehole (Fig. 1) under the Lower Devonian, at the depth of 1327.3–2006.0 m (Fig. 5). Variable trace fossils, abundant in places, were found in the sandstones; among them, M. Tarnowska (1989) has identified the ichnogenera *Scolithos* sp. and *Arenicolithes* sp. She is of the opinion that *Scolithos* sp. is widespread, especially in the Lower Cambrian sandstones, and is considerably different from those *Scolithos* forms that are known from the Devonian of the Holy Cross Mts. M. Tarnowska (1989) emphasizes that this profile contains "...some rock lithotypes that are analogous to those described by A. Kotas (1973*a*, *b*, 1982*b*) and A. Ślączka (1976, 1982) in the Lower Cambrian profile in the southern zone of the Upper Silesian Coal Basin".

Comparing the *Scolithos* sandstones from the Ogrodzieniec 2 borehole with lithologically and facially similar *Scolithos* sandstones from the Mogilany 1 borehole (Fig. 5), C. Harańczyk (1994*a*) has expressed an opinion that these rocks have represented "..the Late Silurian Alpine-type molasse filling up the Cracovides foredeep". However, the presence of Lower Cambrian acritarchs (representative for the Holmia Zone) in rocks overlying the *Scolithos* sandstones in the Głogoczów IG 1 borehole (M. Jachowicz, 1995, see above)


LOWER
CAMBRIAN
SUB-HOLMIA
HOLMIA
Borzęta Formation
Goczałkowice Formation
Rajbrot Sandstone Mb
Osieczany Mudstone Mb
Myślenice Siltstone Mb
Mogilany Scolithos Sandstone Mb
Głogoczów Bioturbated Sandstone Mb
Grogoczów IG 1
Mogilany 1
Zabierzów – Bolechowice O-3
Kurdwanów
Karniowice 2a
Karniowice 6
Sutoszowa
Kluczе 1
Ogrodzieniec 2
Borzęta IG 1
WB-14.1

excludes the Silurian age of the *Scolithos* sandstones recognized in this borehole as well as in the Mogilany 1 and Ogrodzieniec 2 boreholes (Fig. 5).

Sub-Devonian rocks at the depth of 1679.0–2010.0 m in the neighbouring Klucze 1 borehole have been described by C. Harańczyk (1994*a*, *b*) as of the same age and origin with those encountered in the Ogrodzieniec 2 borehole (Figs. 1, 5). They are (Z. Buła, 1994) composed of fine-grained quartz sandstones grading into light grey quartzites with green or cherry-like tint, rhythmically interbedded or laminated with dark grey and grey-brown (with green tint) sandy siltstones. There are relatively abundant trace fossils occurring on the lamination planes. Similar complex of rocks was recognized under the Jurassic in the Sułoszowa borehole (Fig. 1), at the depth of 110.0–330.0 m (Fig. 5). Rocks, described here by S. Bukowy (1975), consist of greywacke type fine-grained sandstones that are grey-green and locally grey-red, laminated with grey-green siltstones. Thicker beds of sandy siltstones occur in places; they are grey-green, interbedded with claystones and quartz sandstones passing into quartzites. S. Bukowy (1975) has noted that the siltstones contain trace fossils; later, in 1982, he has claimed the sub-Jurassic rocks from Sułoszowa "...to be similar to the *Scolithos* sandstones known in the Lower Cambrian at Goczałkowice". These rocks are dissected by magmatic rock intrusions: microgranites, diorites, and diabases.

Based on M. Jachowicz's (1994, 1995) examination of acritarchs recovered from the Klucze 1 (11 samples from the depth of 1680.0–1960.0 m) and Sułoszowa (17 samples from the depth of 198.1–330.0 m) boreholes, the Holmia age (Lower Cambrian) of rocks under study has been documented. The acritarch assemblages defined here are abundant (more than 300 specimens per slide), and very well preserved. Changes of organic matter are evidenced by light brown and brown colour. More important species include: *Skiagia ornata* (Volkova) Downie, *S. ciliosa* (Volkova) Downie, *S. scottica* Downie, *S. orbiculare* (Volkova) Downie, *Archaeodiscina umbonulata* Volkova, *Estiastria minima* Volkova, and *Alliumella baltica* Fanderflit. They are associated with abundant representatives of the following genera: *Pterospermella, Heliosphaeridium,* and *Comasphae-ridium.*

The presence of similar acritarch assemblages in the Sułoszowa, Klucze 1, and Głogoczów IG 1 boreholes (the upper part of the Cambrian) along with similar lithologic and facial features of sediments indicate that the equivalents of the Bioturbated Sandstone Member of the Goczałkowice Formation were recognized at Sułoszowa and Klucze (Fig. 5).

In the WB-137 (depth 253.0–561.0 m), WB-139 (depth 342.0–646.5 m), and WB-141 (depth 251.6–527.1 m) boreholes (Fig. 1), C. Harańczyk (C. Harańczyk, 1982; C. Harańczyk, A. Wala, 1982) has distinguished rock complexes occurring under the Triassic and Lower Devonian (Fig. 5); he has given them the name of the Kwaśniów Arcosic Sandstones. They consist of light grey or pink fine- to medium-grained arcosic or greywacke sandstones, interbedded or laminated with grey-green claystones and siltstones. Dominant in the lower part of the WB-141 profile are sandy siltstones interbedded with fine-grained greywacke sandstones.

Fig. 5. Profiles of the Lower Cambrian in the region of Mogilany – Grabowa
For explanations see Figs. 2–4
Profile kambru dolnego z rejonu Mogilan – Grabowej
Objaśnienia jak na fig. 2–4

Referring to results of M. Linczowska's study of acritarchs, C. Harańczyk (1982) has included these rocks in the Lower Cambrian. Examination of acritarchs carried out by M. Jachowicz (1995) on 3 samples of Cambrian rocks from the depth of 456.0–518.0 m in the WB-141 borehole has resulted in identification of acritarch assemblages characteristic of the Lower Cambrian (Sub-Holmia Zone); they are similar to those identified in the following boreholes: Borzęta IG 1, Rajbrot 1 and 2, Trojanowice, Wiśniowa 3 and 6.

Taking into account the lithological features of the Lower Cambrian rocks from the Sub-Holmia Zone in the WB-141 borehole they should be classified as the equivalent of Rajbrot Sandstone and Osieczany Mudstone Members of the Borzęta Formation (Fig. 5).

Stratigraphic position of rocks encountered under carbonates of Lower Devonian age, at the depth of 713.6–1000.0 m in the P-8 borehole (in the Krzywopłoty area, approx. 4 km north-eastwards of Kwaśniów; Fig. 1) is questionable. These rocks have been classified by F. Ekiert (1971) as Middle and Upper Cambrian basing up on the comparison with the Cambrian rocks of similar development in the Holy Cross Mts. They are composed of: quartz sandstones grading into quartzites; light grey or grey-green arcosic and greywacke sandstones, in places laminated with light green claystones; green or black and green siltstones or black claystones. Badly preserved traces of brachiopods *Lingulella* sp. were found in the black claystones. W. Ryka (1974) found there the inserts of bentonites. The rocks were subject to silicification and carbonatization (F. Ekiert, 1971; W. Ryka, 1974); they were also frequently dissected by intrusions of porphyres. Considering the presence of some analogous lithotypes in the Cambrian profiles at Kwaśniów and Krzywopłoty, one can conditionally accept that rocks in the P-8 borehole represent the Lower Cambrian (Sub-Holmia Zone).

Complexes of rocks of similar development and variable thickness (from 21.0 to 199.0 m) were encountered under the Jurassic in boreholes: Kurdwanów, Zabierzów-Bolechowice D-3, Karniowice 2a and 6 (Fig. 1) situated close to each other, in the outskirts of Kraków (S. Z. Różycki, 1953; H. Roszek, S. Siedlecki, 1963; S. Bukowy *et al.*, 1965; J. Ślósarz, 1969). These rocks are represented by fine-, rarely medium- and coarse-grained sandstones with admixture of fine gravel, pink or cherry-red, or light yellow, in places light grey, sometimes with intraclasts of red siltstones. They are interbedded with red and red-brown ferruginous, hematite-rich siltstones. The sub-Jurassic rocks encountered here have been included in the Lower Devonian (S. Z. Różycki, 1953; H. Roszek, S. Siedlecki, 1963; J. Znosko, 1963), or have been considered to be Late Silurian in age (S. Bukowy *et al.*, 1965; J. Znosko, 1965; J. Ślósarz, 1969; C. Harańczyk, 1994*b*).

Comparison of results of lithologic and petrographic study by S. Cebulak on rocks of the Karniowice 2a borehole (S. Bukowy *et al.*, 1965), by J. Ślósarz (1969) on rocks of the Karniowice 6 borehole, by H. Roszek and S. Siedlecki (1963) on rocks of the Zabierzów-Bolechowice D-3 borehole, and by A. Pelczar (1973, 1975) on rocks of the Borzęta IG 1 and Głogoczów IG 1 boreholes indicates that genetic connections exist between rocks in the first three profiles and that assigned to the *Scolithos* Sandstone Member in the Głogoczów IG 1 and Borzęta IG 1 boreholes. Common and characteristic features of rocks are as follows: (1) dominant fine-, medium-, and coarse-grained sandstones poorly sorted, in places with admixture of fine gravel; (2) similar mineral composition of sandstones with feldspars and micas non-resistant to transport and weathering along with quartzite and metamorphic schist fragments; (3) predominance of clayey-hematite cement over other

cement types; (4) participation of hematite-rich siltstones as interbeds in sandstones; (5) the presence of intraclasts of red and cherry-brown siltstones in sandstones.

Accordingly, sandstones interbedded with ferrigenous siltstones in the Karniowice 2a and 6, Zabierzów-Bolechowice D-3, and Kurdwanów boreholes have been considered to be Lower Cambrian. It is likely that the boreholes cited penetrated fragments of the profile of the *Scolithos* Sandstone Member of the Goczałkowice Formation (Fig. 5).

Lithologically similar rocks were encountered under the Jurassic at the depth of 290.3–322.8 m in the WB-76 borehole located northwards of Sułoszowa (Fig. 1).

Then, lithologically different sections of the Lower Cambrian profile were recognized in individual boreholes within the entire area between Mogilany and Grabowa. More complete profiles of the Lower Cambrian sediments, lithologically and facially similar to those recognized in this region, of total thickness reaching 3000 m are known in the Głogoczów – Borzęta region (Fig. 5).

THE MIDDLE CAMBRIAN IN THE SOSNOWIEC IG 1 BOREHOLE

A complex of clastic rocks was encountered under the Lower Devonian sediments, at the depth of 3156.0–3442.6 m, in the Sosnowiec IG 1 borehole situated in the northeastern sector of the Upper Silesian Coal Basin (Fig. 1); this complex was described by A. Kotas (1973*a*). Its upper part, down to the depth of 3425 m, is composed of alternating layers of fine- and medium-grained quartz and quartzitic sandstones, silicified, grey and grey-green, and of sandy siltstones, grey-green, with horizontal lamination. Trace fossils and scorce inarticulate brachiopods belonging to families Lingulidae, and Acrotrotidae,were found in siltstones (G. Biernat, A. Baliński, 1973). The lower part of the profile, below the depth of 3444.0 m, is composed of dominant medium-grained and unequigranular sandstones with admixture of fine gravel, with laminae and thin layers of sandy siltstones. Intrusions of gabbro-diorites, diorites, and diabases are noted in the middle part of the profile (at the depth of 3244.0–3326.0 m).

Sub-Devonian rocks in the Sosnowiec IG 1 borehole were assigned by A. Kotas (1973*a*) to Lower Cambrian. Examination of Cambrian rocks from this borehole was repeated by Z. Kowalczewski *et al.* (1984, 1985). Results of the study on acritarchs by M. Moczydłowska enabled to put the sub-Devonian rocks from Sosnowiec into Lower, Middle and Upper Cambrian, and Ordovician (Tremadoc). It has been accepted that in the upper part of the profile, above the intrusion of magmatic rocks, they occur in a reversed tectonic position (Z. Kowalczewski *et al.*, 1984, 1985; Z. Kowalczewski, 1990). In 1993, M. Moczydłowska discussed again the results of her study on acritarchs and presented the opinion that the Lower Cambrian sediments passed upwards in sedimentary continuity into the Middle Cambrian. The recent study by M. Jachowicz on microscopic organic remains, resulted in finding of the Middle Cambrian acritarch assemblages in five rock samples from the depth of 3211.0–3351.0 m; *Adara alea* Martin dominates here (sometimes in 60%) and *Cristallinium cambriense* (Slavikova) Vanguestaine, *Micrhystridium notatum* Volkova and *Eliasum llaniscum* Fombella also occur.

THE ORDOVICIAN IN THE BM-152 BOREHOLE AT BIBIELA

The Lower Palaeozoic deposits younger than Cambrian were encountered in the BM-152 borehole located in the Bibiela area (Fig. 1). Clastic rocks with variable degree of

silicification, with inserts of carbonate rocks, occur at the depth of 255.3–375.6 m under the Devonian sediments. As defined by J. Gładysz (J. Gładysz, 1982; J. Gładysz *et al.*, 1990), they are clayey-siliceous rocks, light green, interbedded with fine-grained quartz sandstones, compact, light grey or grey-green, in places with brown-red spots. The middle part of the profile contains thin inserts of compact, light grey clayey dolomites. The acritarchs in sub-Devonian rocks samples were examined by M. Linczowska-Makowska (1978); the study has later been carried out again by M. Jachowicz (J. Gładysz *et al.*, 1990). Studies of conodonts have also been carried out (A. Siewniak-Madej, M. Jeziorowska, 1978). All these investigations led to determination of Ordovician age of rocks. Their lithology and facial development are different from those in Zawiercie (M. Nehring-Lefeld *et al.*, 1992) and Mrzygłód (K. Piekarski, A. Siewniak-Witruk, 1978). Z. Buła (1994) expressed the opinion that fragment of the Ordovician rocks profile, found here "...constituted a part of so far unrecognized complex of the Lower Palaeozoic rocks being younger than Cambrian, occurring in the northern part of the Upper Silesian massif".

DISTRIBUTION, THICKNESS, AND TECTONICS OF THE LOWER PALAEOZOIC SEDIMENTS

The Lower Cambrian in the region of Rajbrot, Myślenice, Kraków, and Olkusz as well as the Ordovician in the region of Bibiela considerably differ with respect to their tectono-stratigraphic equivalents that were recognized in the area of Lubliniec – Myszków – Zawiercie – Dolina Będkowska – Bochnia. The Lower Palaeozoic and Vendian rocks in the latter area have been found in about 300 boreholes. More than 90% out of the total number of boreholes are groupped within a small area between Żarki – Myszków – Wolbrom. Locations shown in Figure 1 concern more important boreholes only. The Lower Palaeozoic sediments are represented here by the probable Lower Cambrian-Vendian clastic rocks, Ordovician and Lower Silurian carbonates, and Silurian clastic rocks (Z. Buła, 1994). These rocks are metamorphosed at variable degree. The results of studies of these rocks have been presented in numerous published and archival studies.

Proximity of the Lower Palaeozoic and Vendian sediments of different tectono-stratigraphic development, recognized in both the Upper Silesian and the Małopolska Blocks (Fig. 1), indicates that a tectonic contact along a narrow (approx. 0.5 km) tectonic zone exists between them. Its course between Lubliniec and Kraków is irregular; further south-eastwards of Kraków, the zone continues in the Palaeozoic basement of the Carpathians (Fig. 1) — Z. Buła (1994).

The Lower Palaeozoic sediments in the area of the Upper Silesian Block are represented by the Lower Cambrian sediments, and — in the northern part — also by Middle Cambrian and Ordovician. The Sub-Holmia deposits (the Borzęta Formation) were so far recognized in the marginal, eastern part of the block (Fig. 3). They are preserved in places in the Rzeszotary horst zone (Fig. 4). No equivalent of this formation was found in the region of Goczałkowice – Piotrowice (Fig. 3) and Bielsko-Biała – Potrójna (Fig. 2). Thickness of the Borzęta Formation exceeds 670 m (the longest section in the Borzęta IG 1 borehole).

The Lower Cambrian sediments belonging to the Holmia Zone of the Goczałkowice Formation overlie the Borzęta Formation in a transgressive way. They were not found

neither in the zone of the Rzeszotary Horst nor in the Rajbrot region. Their thickness increases from the Bielsko-Biała – Potrójna region towards the north and east (A. Ślączka, 1982); the thickness of the lower member — the *Scolithos* Sandstone — increases at much higher rate than of other members. This formation (the Bioturbated Sandstone and the *Scolithos* Sandstone Members) in the Głogoczów – Mogilany region reach a total thickness of 2000 m (Fig. 5). Taking into consideration the trends of thickness distribution the similar thickness of the Goczałkowice Formation can be expected in the Olkusz region (Fig. 5) and in the northern part of the Upper Silesian Block, i.e. in the Siewierz – Kalety region.

Thickness of the Middle Cambrian in the Sosnowiec IG 1 borehole is approx. 280 m, and of the Ordovician in the BM-152 borehole — approx. 120 m.

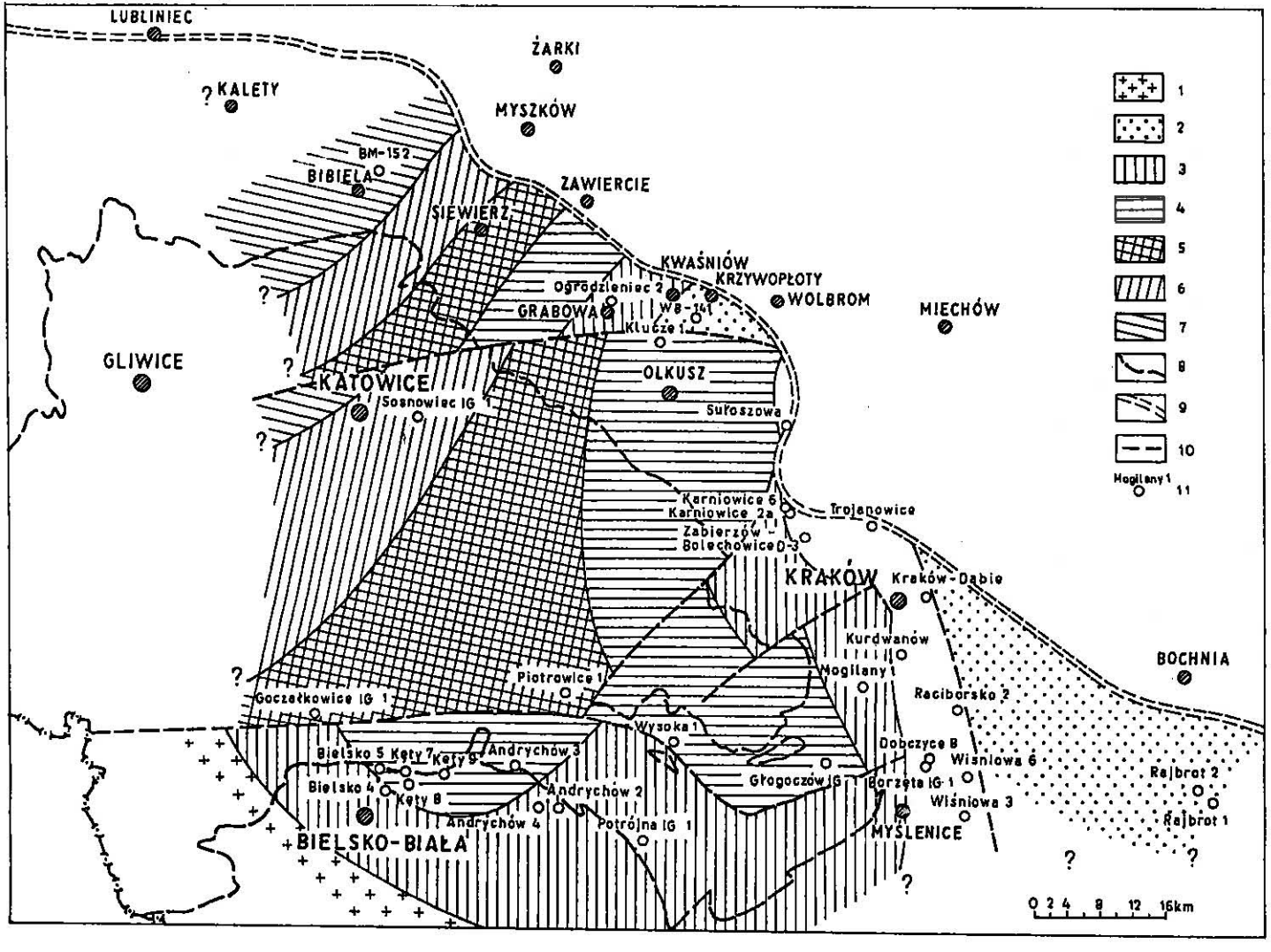
An Ordovician section in the BM-152 borehole constitutes only a part of the profile of unrecognized Lower Palaeozoic rocks in the northern part of the Upper Silesian Block. The regularity in distribution of the Cambrian sediments on the sub-Devonian surface speaks in favour of this opinion (Fig. 6). When moving from the south-east (the Rajbrot region) to the north and north-west, one can find that younger and younger lithostratigraphic members of the Lower Cambrian are met under the Devonian sediments and in Sosnowiec — also of the Middle Cambrian. Thus, the presence of sediments younger than Cambrian in the northern part of the Upper Silesian Block — Ordovician in this case — is, to considerable extent, well-founded.

The Cambrian rocks in the region of Bielsko-Biała – Potrójna, Goczałkowice – Rajbrot, and in Sosnowiec lie subhorizontally; they are inclined at an angle commonly not more than 25°. In spite of significant sedimentary hiatus which separates the Cambrian from the Devonian, a difference in dip angles in these complexes is minor, up to 10° at most. Considerably larger and more differentiated dip angles occur in the Cambrian rocks recognized between Zabierzów and Grabowa. Dips range here from 10 to 70°. Distinct angular unconformities were found between the Lower Cambrian and Upper Palaeozoic sediments within the region of Grabowa – Klucze. Dip angles of the Lower Devonian rocks in the Ogrodzieniec 2 borehole are of the range of 31–39°, in the Klucze 1 borehole — 25–30°, and of the Lower Cambrian beds — 46–58 and 45–60°, respectively.

A discordance on contact of the Lower Devonian with the Lower Cambrian in the region of Grabowa – Klucze provides an evidence that the Cambrian and younger rocks in the marginal eastern part of the Upper Silesian Massif were subject to tectonic deformations after the Early Cambrian and before the Early Devonian. However, the scale and character of these deformations remain unknown since they became obliterated by later, more intensive deformations during the polyphase Variscan movements.

DEVELOPMENT OF SEDIMENTATION OF THE LOWER PALAEOZOIC ROCKS — A GENERAL OUTLINE

As concluded from studies carried out earlier and at present (A. Kotas, 1973*a*, *b*, 1982*b*; A. Ślączka, 1976, 1982), the sedimentation of the Lower Cambrian sediments within the Upper Silesian Block was of cyclic character. Clastic sedimentation in the Lower Cambrian Sub-Holmia Zone took place only in the marginal part of the Upper Silesian Block, presently adjacent to the Małopolska Block (Fig. 1). Lithological and sedimentological features along


LUBLINIEC
ŻARKI
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BM-152
BIBIELA
ZAWIERCIE
SIEWIERZ
KWAŚNIÓW
KRZYWOPŁOTY
Ogrodzieniec 2
WOLBROM
GRABOWA
WB-141
Kluczе 1
MIECHÓW
GLIWICE
KATOWICE
Sosnowiec IG 1
OLKUSZ
Sułoszowa
Karniowice 6
Karniowice 2a
Trojanowice
Zabierzów
Bolechowice D-3
KRAKÓW
Kraków-Dabie
Kurdwanów
Mogilany 1
BOCHNIA
Piotrowice 1
Raciborsko 2
Goczałkowice IG 1
Wysoka 1
Dobczyce 8
Wisniowa 6
Bielsko 5
Kęty 7
Kęty 9
Andrychów 3
Głogoczów IG
Borzęta IG 1
Rajbrot 2
Bielsko 4
Kęty 8
Andrychów 2
Wiśniowa 3
Andrychów 4
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with characteristic sequence of sediments of the Borzęta Formation indicate that they were deposited in deeper parts of the marine basin first; then, the basin was gradually shallowing. At present, it is impossible to univocally conclude whether the complete regression of the sea followed by the end of the Lower Cambrian Sub-Holmia Zone or whether the sedimentation of the Borzęta Formation was going on in continuity with the sediments of consecutive, Lower Cambrian (Holmia) transgressive cycle of the Goczałkowice Formation (A. Kotas, 1982*b*). So far, the deposits of the Lower Cambrian sedimentary cycles were encountered only in the Borzęta IG 1 borehole but no core was recovered from the contact zone. Sediments of the Goczałkowice Formation, as mentioned before, overlie transgressively the sediments of the Borzęta Formation. An intensified subsidence continuously sustained in the initial stage of sedimentary development within the marginal eastern, and possibly in the northern part, of the Upper Silesian Block. This is evidenced by very distinct differentiation of thickness especially of the increase of the *Scolithos* Sandstone Member (up to more than 1400 m in the Mogilany – Głogoczów region; Fig. 5). Missing sediments of the Goczałkowice Formation in the zone of Rzeszotary Horst and further to the east (the Rajbrot region) may indicate that uplifting of these parts of the Upper Silesian Block was taking place already in the Lower Cambrian. However, it is not excluded that the sediments of the Goczałkowice Formation — the *Scolithos* Sandstone Member — could be initially deposited within this area, and that later — after the Lower Cambrian and before the Middle Devonian — eroded. Sedimentation of the *Scolithos* Sandstone Member was going on in the littoral zone (A. Kotas, 1973*b*, 1982*b*; A. Ślączka, 1976, 1982). Despite significant differentiation in thickness, no distinct facial changes are observed in the profile of this member. In the region of Głogoczów – Mogilany, where sediments of the *Scolithos* Sandstone Member reaches maximum thickness, the facial changes are evidenced by alternating beds of sandstones with *Scolithos* and barren sandstones (A. Ślączka, 1982) — Figures 3, 5.

Sedimentation of deposits representing the upper members of the Goczałkowice Formation took place in the deeper zones of the marine basin.

Regularity in distribution of the Cambrian sediments on the sub-Devonian surface (Fig. 6), may testify to the development of a marine transgression in the western and northwestern parts of the Upper Silesian Block in the late Early Cambrian, Middle Cambrian, and

Fig. 6. Map of distribution of the Lower Palaeozoic sediments on the sub-Devonian surface within the Upper Silesian Block

1 — Precambrian; 2 — Lower Cambrian, Sub-Holmia Zone (the Borzęta Formation); 3–5 — Lower Cambrian, Holmia Zone (the Goczałkowice Formation): 3 — the Mogilany *Scolithos* Sandstone Member, 4 — the Głogoczów Bioturbated Sandstone Member, 5 — the Pszczyna Trilobite Siltstone Member; 6 — Middle Cambrian; 7 — Ordovician; 8 — boundary of the Upper Silesian Coal Basin (after Z. Buła, A. Kotas, 1994); 9 — tectonic zone separating the Upper Silesian Block from the Małopolska Block; 10 — faults; 11 — boreholes in which the Lower Palaeozoic rocks were encountered

Mapa rozmieszczenia osadów dolnopaleozoicznych na powierzchni poddewońskiej na bloku górnośląskim

1 — prekambr; 2 — kambr dolny subholmiowy (formacja z Borzęt); 3–5 — kambr dolny holmiowy (formacja z Goczałkowic): 3 — ogniwo piaskowców skolitusowych z Mogilan, 4 — ogniwo piaskowców bioturbacyjnych z Głogoczowa, 5 — ogniwo mułowców z trylobitami z Pszczyny; 6 — kambr środkowy; 7 — ordowik; 8 — granica Górnośląskiego Zagłębia Węglowego (według Z. Buły, A. Kotasa, 1994); 9 — strefa tektoniczna oddzielająca bloki górnośląski i małopolski; 10 — uskoki; 11 — otwory wiertnicze, w których stwierdzono skały dolnopaleozoiczne

Ordovician. Fragmentary recognition of the Middle Cambrian and Ordovician in the northern part, combined with complete lack of data about the Lower Palaeozoic rocks in the western part of the Upper Silesian Block do not allow the reconstruction of development of sedimentation in the discussed period.

CONCLUSIONS

As a result of this study, a new data was acquired on spatial distribution, development, and stratigraphy of the Cambrian and younger (Ordovician) deposits within the Upper Silesian Block. It has been shown:

1. The lithologically and facially similar sediments of the Lower Cambrian (Holmia Zone) of the Goczałkowice Formation, till present known in the regions of Bielsko-Biała – Andrychów and Goczałkowice – Myślenice also occur in the Olkusz region (Klucze, Grabowa, and Sułoszowa).

2. The older sediments of the Lower Cambrian (Sub-Holmia Zone) were found in the southeastern part of the Upper Silesian Block (Rajbrot, Wiśniowa – Trojanowice, Kwaśniów); they were defined as the Borzęta Formation.

3. Thickness of the Lower Cambrian sediments in the Upper Silesian Block increases from the south to the east and north and in the region of Głogoczów – Borzęta (Fig. 5) reaches 3000 m.

4. Fragments of the Middle Cambrian and Ordovician were recognized in the northern part of the Upper Silesian Block.

5. Studies of microscopic organic remains (acritarchs) resulted in documenting the Lower and Middle Cambrian as well as Ordovician. Assemblages of genera and species yielded by the rocks of the Cambrian and Ordovician are different with respect to their taxonomy; based on this, one can make a detailed correlation of particular members.

The oldest known assemblages of microfossils characteristic of the Lower Cambrian Sub-Holmia Zone have been found in the following boreholes: Borzęta IG 1, Rajbrot 1 and 2, Wiśniowa 3 and 6, Trojanowice, and WB-141 (Fig. 1). Except for individual barren samples, the remaining samples (more than one hundred) contained abundant and well preserved assemblages; the *Leiosphaeridia* species ranging in size from 10 μ to more than 200 μ is dominant here. It is accompanied by such more diagnostic microfossils as: *Leiovalia, Granomarginata, Tasmanites,* and *Tyrasotaenia.* Very abundant cyanobacteria and ribbon-like algae belonging to species *Tyrasotaenia* are other characteristic constituents. Assemblages of organic microfossils of similar composition have been described in the East-European Platform (T. Jankauskas, K. Lendzion, 1992) as well as in the Lower Cambrian of the Barrandian (O. Fatka, M. Konzalova, 1995). In these areas they are correlated with the sediments of the Sub-Holmia Zone.

The acritarch assemblages characteristic of the Lower Cambrian Holmia Zone have been documented in boreholes: Goczałkowice IG 1, Piotrowice 1, Głogoczów IG 1, Sułoszowa, and Klucze 1 (Fig. 1). Very abundant index fossils include: genus *Skiagia* represented by several species, *Alliumela baltica* Fanderflit, *Estiastria minima* Volkova, *Archaeodiscina umbonulata* Volkova, *Multiplicisphaeridium dendroideum* (Jankauskas) Jankauskas et Kirjanov, *Heliosphaeridium dissimilare* (Volkova) Moczydłowska, *Granomarginata, Pte-*

rospermella and *Asteridium*. Similar assemblages have been described, among others, in the Lower Cambrian of the East-European Platform (T. V. Jankauskas, K. Lendzion, 1992; M. Moczydłowska, 1991) as well as in Scotland, Norway, Greenland, and Canada (C. Downie, 1982).

Middle Cambrian acritarchs have been identified only in samples from the Sosnowiec IG 1 borehole. Among them, dominant is the species *Adara alea* Martin, the first description of which is connected with the Middle Cambrian in Newfoundland (F. Martin, W. T. Dean, 1981, 1984, 1988); it is also known in the Middle Cambrian sediments of Belgium and of the East-European Platform (N. A. Volkova, 1990). Similar assemblages were also described in the Middle Cambrian of the Barrandian area (O. Fatka, 1989).

Ordovician acritarchs have been found in samples from the BM-152 borehole (J. Gładysz *et al.*, 1990).

The state of preservation of microfossils in the Lower Palaeozoic sediments is very good. Neither important damage nor high degree of carbonization could be found in their structures.

6. The described Lower Palaeozoic sediments differ fundamentally, with respect to their tectono-stratigraphic development, from the Lower Palaeozoic and Vendian sediments in the marginal part of the Małopolska Block. Proximity of the Lower Palaeozoic and Vendian sediments of variable tectono-stratigraphic development indicates that the tectonic contact exists between both the Upper Silesian and Małopolska Blocks (Fig. 1) along a narrow (approx. 0.5 km) tectonic zone.

7. The determination of reliable model of the geological structure of the Palaeozoic within the contact zone between both the Upper Silesian and Małopolska Blocks, as well as between both the Upper Silesian and Fore-Sudetic Blocks could only be possible if more complete profiles of the Lower Palaeozoic and their basement are recognized in their marginal parts.

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UTWORY DOLNOPALEOZOICZNE NA BLOKU GÓRNOŚLĄSKIM

Streszczenie

W wyniku badań litologicznych i stratygraficznych rdzeni i próbek archiwalnych skał, wykonanych w Państwowym Instytucie Geologicznym w latach 1990–1995, uzyskano nowe dane o stratygrafii, wykształceniu, przestrzennym rozmieszczeniu i miąższości osadów dolnopaleozoicznych bloku górnośląskiego. Dla określenia

wieku skał przebadano mikroszczątki akritarch. Ustalono bądź zweryfikowano pozycję stratygraficzną skał paleozoicznych stwierdzonych w kilkunastu otworach. Wykorzystując wyniki badań obecnych i wcześniejszych, porównano profile dolnego paleozoiku (fig. 2–5). Na tym tle przedstawiono propozycje nowego podziału litostratygraficznego osadów dolnokambryjskich występujących w obrębie bloku górnośląskiego, nawiązując do podziału wcześniejszego (A. Kotas, 1982*b*).

Jak wynika z wcześniejszych i obecnych badań, osady dolnokambryjskie poziomu holmiowego, rozpoznane w otworze wiertniczym Goczałkowice IG 1 i wyróżnione w randze formacji z Goczałkowic przez A. Kotasa (1982*b*), znajdują odpowiedniki litologiczno-facjalne w profilach otworów w rejonach Bielska-Białej – Potrójnej, Goczałkowic – Myślenic (fig. 2, 3) oraz Mogilan – Grabowej (fig. 5). Dolnokambryjski wiek skał poziomu holmiowego został potwierdzony badaniami akritarch w otworach Andrychów 3, Piotrowice 1, Głogoczów IG 1, Sułoszowa i Klucze 1 (G. Vidal *fide* W. Brochwicz-Lewiński i in., 1986; M. Jachowicz, 1984, 1985). Skały kambru dolnego, reprezentujące poziom subholmiowy, rozpoznano w otworze Borzęta IG 1 (fig. 3). Zostały one wyróżnione w randze formacji z Borzęt. Odpowiedniki litologiczno-facjalne tej formacji stwierdzono w rejonie Rajbrota (fig. 3), w strefie horstu Rzeszotar (fig. 4) kontynuującego się na N od Krakowa (fig. 1) oraz w rejonie Kwaśniowa (fig. 5). Dolnokambryjskie zespoły mikroskamieniałości poziomu subholmiowego zostały stwierdzone w skałach nawierconych otworami: Borzęta IG 1, Rajbrot 1 i 2, Wiśniowa 3 i 6, Trojanowice oraz WB-141 w Kwaśniowie (M. Jachowicz, 1994, 1995; M. Jachowicz, W. Moryc, 1995).

W północnej części bloku górnośląskiego rozpoznano dotychczas tylko fragmenty profili skał środkowokambryjskich (otwór Sosnowiec IG 1; fig.1; M. Moczydłowska, 1983) oraz ordowiku (otwór BM-152 w Bibieli; fig.1; J. Gładysz i in., 1992). Na obecność skał ordowiku w tej części bloku górnośląskiego wskazuje zarysowująca się prawidłowość rozmieszczenia osadów kambryjskich na powierzchni poddewońskiej (fig. 6).

Skały kambru i ordowiku, rozpoznane na bloku górnośląskim, różnią się pod względem rozwoju tektonostratygraficznego od skał dolnopaleozoicznych i wendyjskich w różnym stopniu zmetamorfizowanych z brzeżnej części bloku małopolskiego (między Lublińcem – Myszkowem – Zawierciem – Doliną Będkowską – Bochnią). Bliskie sąsiedztwo osadów dolnopaleozoicznych i wendyjskich o różnym rozwoju tektonostratygraficznym wskazuje na kontakt tektoniczny bloków górnośląskiego i małopolskiego (fig. 1; Z. Buła, 1994) wzdłuż wąskiej strefy tektonicznej o szerokości ok. 0,5 km.

Osady kambru dolnego subholmiowego formacji z Borzęt występują tylko we wschodniej i prawdopodobnie północnej części bloku górnośląskiego. Miąższość najdłuższego odcinka profilu tej formacji nawierconego otworem Borzęta IG 1 wynosi 670 m.

Osady dolnokambryjskie poziomu holmiowego formacji z Goczałkowic leżą przekraczająco na skałach formacji z Borzęt. Nie stwierdzono ich w strefie horstu Rzeszotar i w rejonie Rajbrota (fig. 1, 3, 4). Miąższość ich rośnie od rejonu Bielska-Białej – Potrójnej ku E i N, przy czym w tym kierunku wzrasta głównie miąższość piaskowców skolitusowych (fig. 3) — spągowego ogniwa formacji z Goczałkowic. W rejonie Głogoczowa – Mogilan osady tej formacji osiągają (sumarycznie) miąższość rzędu 2000 m (fig. 4). Podobnych miąższości osadów formacji z Goczałkowic należy się spodziewać w rejonie Olkusza i w północnej części bloku górnośląskiego w rejonie Siewierza – Kalet.

Miąższość odcinka profilu osadów środkowokambryjskich nawierconego w Sosnowcu wynosi ok. 280 m, a osadów ordowiku w otworze BM-152 — ok. 120 m.

Sedymentacja osadów dolnokambryjskich na bloku górnośląskim rozwijała się cyklicznie, początkowo w brzeżnej, wschodniej i północnej części bloku (formacja z Borzęt). W dolnym kambrze holmiowym (formacja z Goczałkowic) sedymentacją został objęty już znacznie większy obszar bloku górnośląskiego. Zaznaczające się prawidłowości rozmieszczenia osadów kambryjskich na powierzchni poddewońskiej (fig. 6) mogą świadczyć o transgresji morza w zachodniej i północno-zachodniej części bloku górnośląskiego, rozwijającej się w późnym kambrze dolnym, środkowym i w ordowiku. Fragmentaryczne rozpoznanie osadów środkowokambryjskich i ordowickich w północnej części i całkowity brak rozpoznania utworów dolnopaleozoicznych w zachodniej części bloku górnośląskiego nie pozwalają na odtworzenie rozwoju sedymentacji od kambru środkowego do ordowiku i wcześniej.

Skały kambru w rejonie Sosnowca i południowej części bloku górnośląskiego leżą subhoryzontalnie; najczęściej nachylone są pod kątem nie większym niż 25°. Znacznie większe i zróżnicowane kąty upadu warstw kambryjskich (10–70°) odnotowano w brzeżnej, wschodniej części bloku górnośląskiego.

PLATE I

Lower Cambrian Sub-Holmia Zone acritarch assemblages
Zespoły akritarch dolnego kambru poziomu subholmiowego

Figs. 1, 2. *Leiosphaeridia* sp.
Borzęta IG 1 borehole, depth 3352.0 m

Fig. 3. *Ceratophyton vernicosum* Kirjanov
Rajbrot 2 borehole, depth 3968.8 m

Figs. 4, 8. *Leiovalia tenera* Kirjanov
Trojanowice borehole, depth 219.0–220.0 m

Figs. 5, 6, 11. *Ceratophyton vernicosum* Kirjanov
Rajbrot 1 borehole, depth 4884.0–4889.0 m

Fig. 7. *Leiosphaeridia* sp.
Trojanowice borehole, depth 219.0–220.0 m

Fig. 9. *Tasmanites baltanavensis* Volkova et Piskun
Borzęta IG 1 borehole, depth 3352.0 m

Fig. 10. *Cyanophyta*
Borzęta IG 1 borehole, depth 3352.0 m

Figs. 12, 13. *Tasmanites* sp.
Borzęta IG 1 borehole, depth 3352.0 m

Figs. 1, 4, 5, 8 — x 1000; Figs. 2, 3, 6, 7, 9–13 — x 300

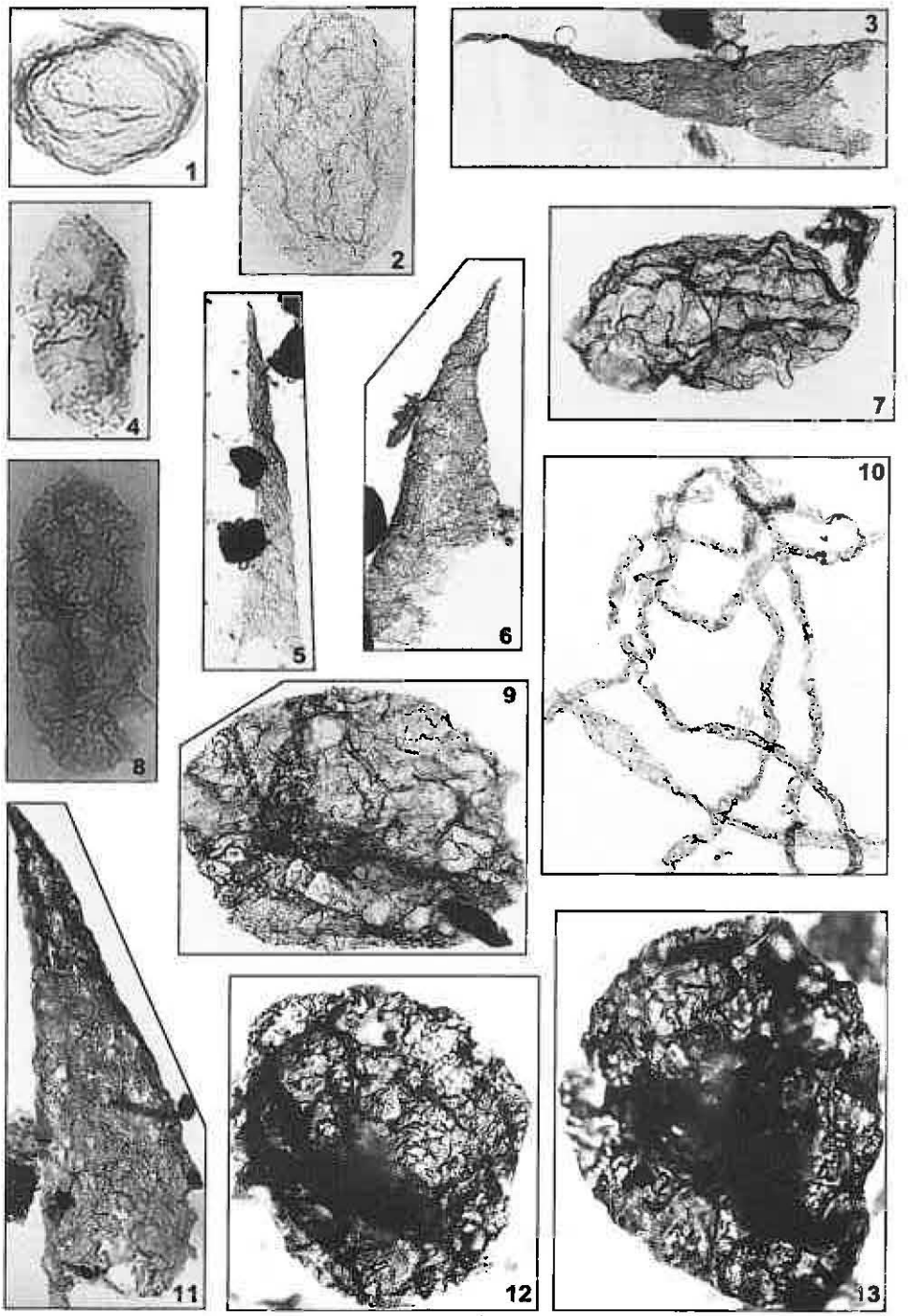

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PLATE II

Lower Cambrian Holmia Zone acritarch assemblages
Zespoły akritarch kambru dolnego poziomu holmiowego
Figs. 1–4. *Estiastra minima* Volkova
Figs. 5, 7. *Granomarginata squamacea* Volkova
Fig. 6. *Comasphaeridium* sp.
Fig. 8. *Multiplicisphaeridium* sp.
Fig. 9. *Heliosphaeridium dissimilare* (Volkova) Moczydłowska
Figs. 10, 11. *Multiplicisphaeridium dendroideum* (Jankauskas) Jankauskas et Kirjanov
Fig. 12. *Archaeodiscina umbonulata* Volkova

Sułoszowa borehole, depth 198.1–200.0 m; x 1000

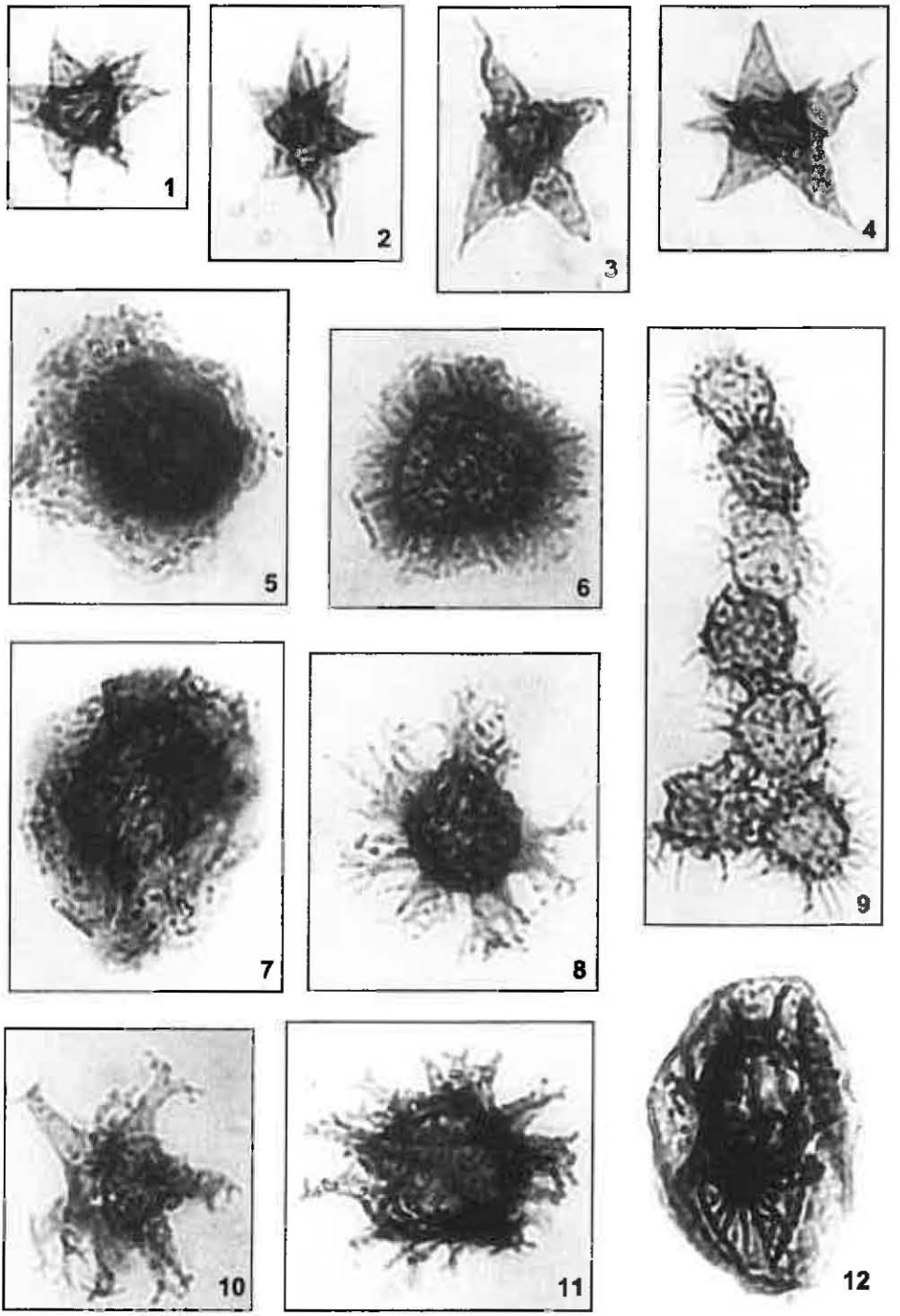

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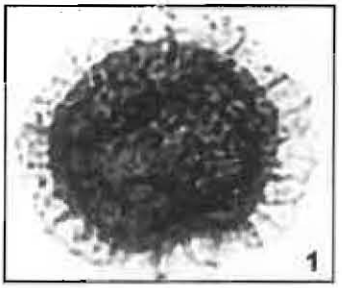
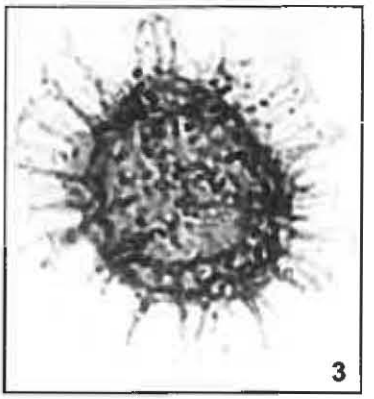
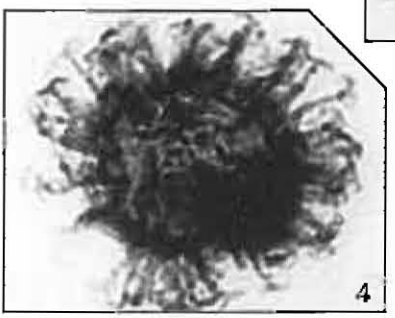
PLATE III

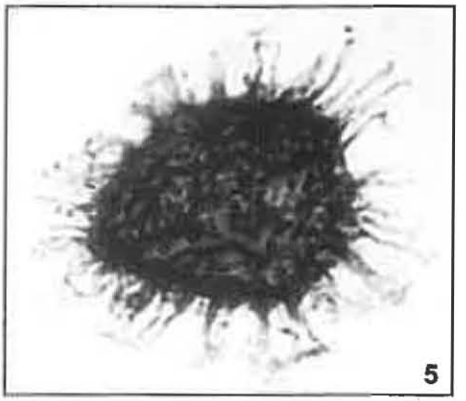
Lower Cambrian Holmia Zone acritarch assemblages
Zespoły akritarch dolnego kambru poziomu holmiowego
Fig. 1. *Skiagia scottica* Downie
Fig. 2. *Heliosphaeridium dissimilare* (Volkova) Moczydłowska
Figs. 3, 5, 7, 8. *Skiagia compressa* (Volkova) Downie
Fig. 4. *Skiagia* sp.
Fig. 6. *Skiagia orbiculare* (Volkova) Downie

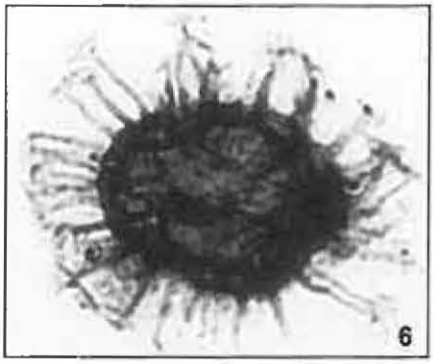
Sułoszowa borehole, depth 198.1–200.0 m; x 1000

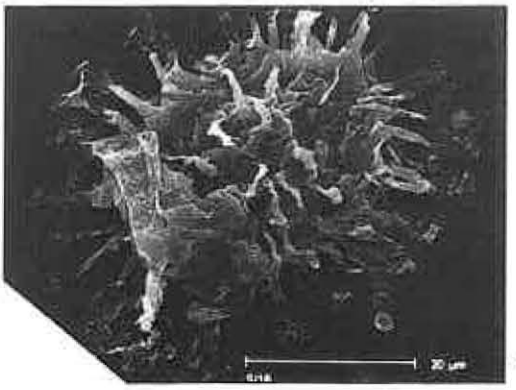












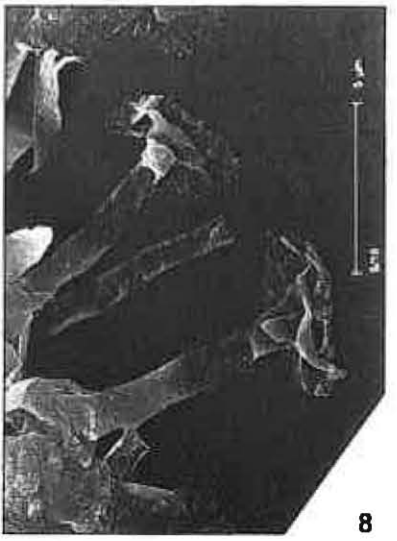


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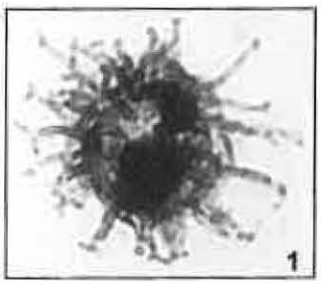
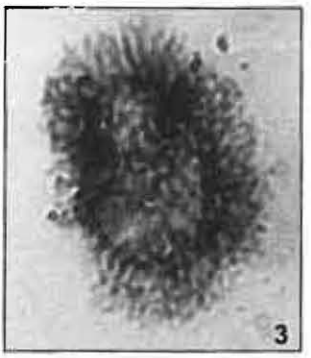
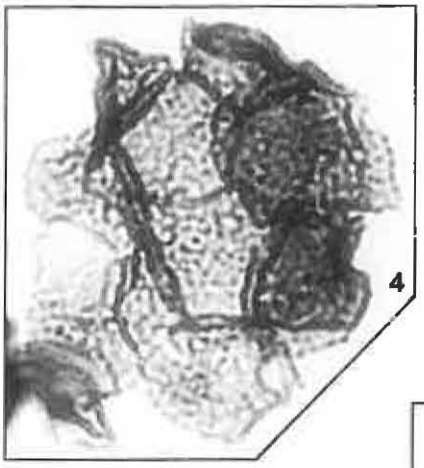
PLATE IV

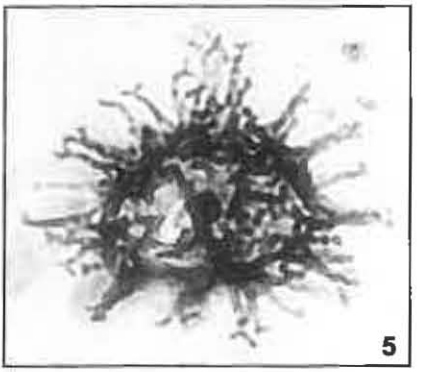
Middle Cambrian acritarch assemblages
Środkowokambryjskie zespoły acritarch
Figs. 1, 5. *Micrhystridium notatum* Volkova
Figs. 2, 6. *Adara alea* Martin
Fig. 3. *Comasphaeridium* sp.
Fig. 4. *Cristallinium cambriense* (Slavikova) Vanguestaine
Figs. 7, 8. *Eliasum llaniscum* Fombella

Sosnowiec IG 1 borehole, depth 3211.0 m; x 1000









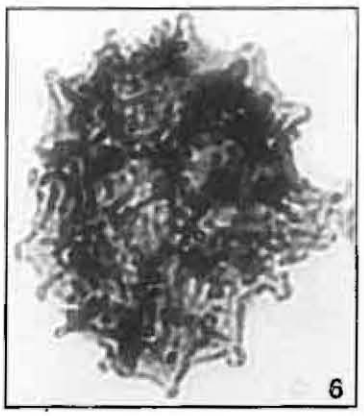


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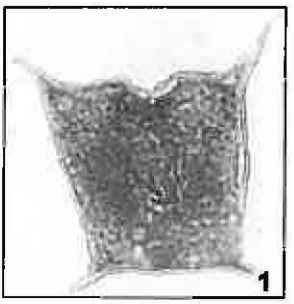
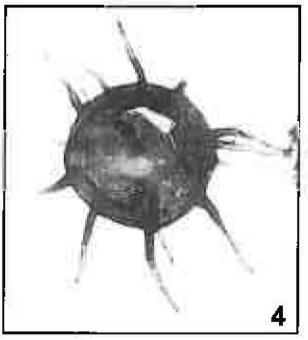
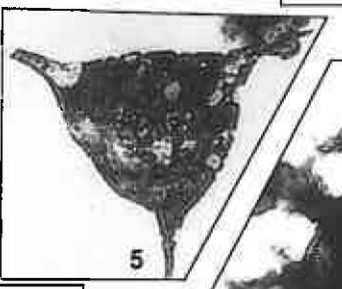
PLATE V

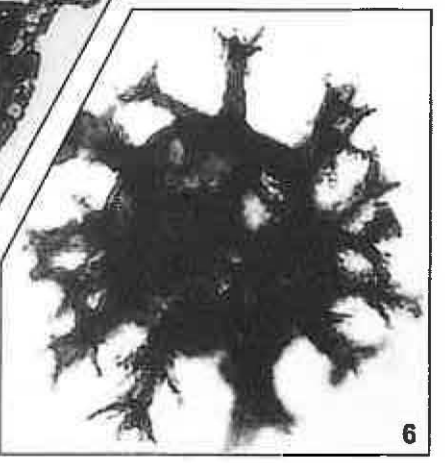
Ordovician acritach assemblages
Ordowickie zespoły akritarch
Fig. 1, 5. *Veryhachium* sp.
Fig. 2. *Pirea* sp.
Fig. 3. *Peteinosphaeridium* sp.
Fig. 4. *Baltisphaeridium calcispinae* Górka
Fig. 6. *Peteinosphaeridium trifurcatum* Eisenack
Fig. 7. *Baltisphaeridium brevifilicum* Kjellström
Fig. 8. *Ordovicidium heteromorphicum* Kjellström
Fig. 9. *Ordovicidium elegantulum* Tappan et Loeblich Jr.

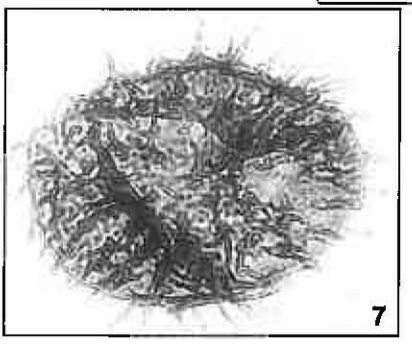
BM-152 borehole, depth 340.1–343.0 m; Figs. 1, 2 — x 1000, Figs. 3–9 — x 400

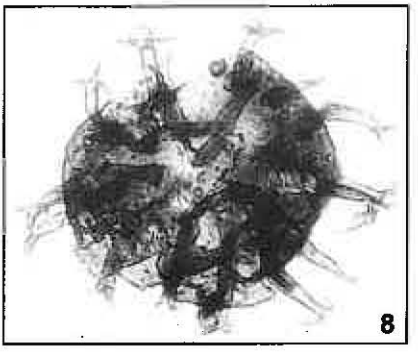


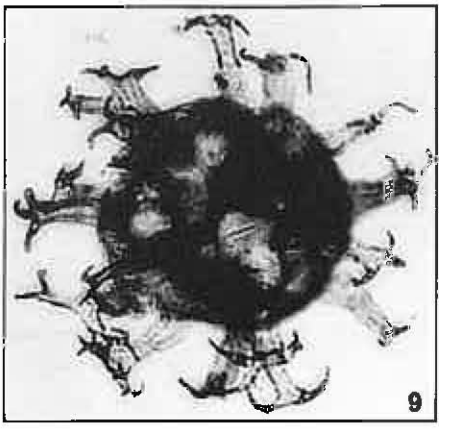












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