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Stratigraphy of the Upper Precambrian and lowest Cambrian strata in southern Poland

ABSTRACT: The sequence of the Vendian system in southern Poland overlies that of the Upper Riphaean sedimentary cycle, and it is overlain by the Cambrian system. The Vendian system is bound by the Wieliczka phase at the bottom, and by the Małopolska phase at the top. The investigated sequence comprises 7 formations, the five of which (the Rzeszów Group) belong to the Vendian system. The two upper formations are included into the Holy Cross Group. The Upper Vendian deposits contain primitive Acritarcha and the trace fossils, whilst the lowest Cambrian sediments (Sabellidites Zone) yield an assamblage of body fossils and trace fossils.

INTRODUCTION

The Vendian strata in the substrate of southern Poland has been hitherto assigned (Table 1), to the Riphaean (Samsonowicz 1955, 1956, 1960; Moryc 1961), Algonkian (Łydka & Siedlecki 1963), Sinian (Jaworowski & *al.* 1967), or Vendian (Kowalczewski 1979, Jurkiewicz 1980).

The areas of the Holy Cross Mts and of the Carpathian Foredeep in southern Poland (Text-fig. 1) comprise a full sequence of Upper Precambrian and Lower Cambrian strata. It seems that it will be a possibility to define the boundary between Vendian and Cambrian systems on biostratigraphic data (*cf. e. g.* Michniak 1973, Cloud 1973, Cowie & Rozanov 1974). An analysis of such a problem needed the studies over the bottom Cambrian sediments and the underlying rocks.

Unfortunately, the boundary between the Vendian and Cambrian systems is here covered by the Miocene deposits (Samsonowicz 1960, Pawłowski 1965, Michniak 1969, Orłowski 1975b). It was possible to recognize the stratigraphic succession when the borehole profiles from Kotuszów, Osiek and Gwoździec areas (Text-fig. 2) had been analyzed (Kowalski 1979).

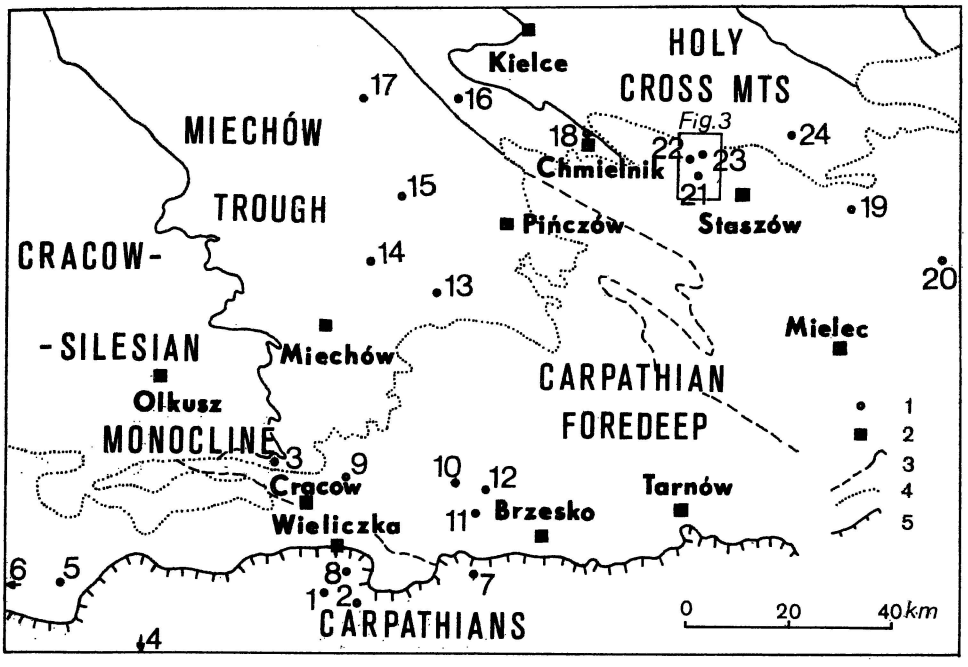

Fig. 1. Location of analyzed boreholes and exposures in southern Poland
1 boreholes and exposures, *2* referenced towns, *3* limits of tectonic units, *4* extent of Miocene sediments in the Carpathian Foredeep, *5* border of the Carpathian flysch zone

Boreholes cited in the text: 1 — Rzeszotary *2*, 2 — Dobczyce *1*, 3 — Bębło, 4 — Potrójna *IG-1*, 5 — Piotrowice *1*, 6 — Goczałkowice *IG-1*, 7 — Łapczyca *2*, 8 — Raciborsko *2*, 9 — Batowice *1*, 10 — Puszcza *2*, 11 — Puszcza *3*, 12 — Opatkowice *1*, 13 — Mikluszowice *1*, 14 — Książ Wielki *IG-1*, 15 — Potok Mały *IG-1*, 16 — Węgleszyn *IG-1*, 17 — Brzegi *IG-1*, 18 — exposure at Słońce Hill, 19 — Osiek *141*, 20 — Gwoździec *1*, 21 — Kotuszów *1*, 22 — Korytnica *1*, 23 — Korytnica *2*, 24 — Bazów *IG-1*

Recently, Kowalczewski (1981) presented an entirely different stratigraphic scheme of the Upper Precambrian and Lower Cambrian sequence, ignoring all biostratigraphic data. On the other hand, Pożaryski & *al.* (1981) extended enormously, on the basis of finds of Acritarcha, the range of the Holmia horizon and include in it also the sediments univocally documented by the index *Sabellidites* and *Platysolenites*.

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LITHOSTRATIGRAPHY OF THE RZESZÓW GROUP

NAME OF THE GROUP

The name comes from Rzeszów town in the area of subsurface occurrence of Precambrian rocks in the Carpathian Foredeep. The group is composed of five formations (Text-fig. 2) developed in terrigenic facies, and belonging to one diastrophic cycle.

Pożaryski & Tomczyk (1968) when studing the Precambrian rocks of south-eastern Poland, introduced the term "Rzeszów Beds" for the whole complex between the metamorphic basement ("Rzeszotary Beds") and the Cambrian strata ("Kotuszów Beds"). Such meaning of the term corresponds now to a group.

BASEMENT OF THE GROUP

The rocks of the Rzeszów Group are underlain by the crystalline basement (Burtan 1962; Heflik & Konior 1967, 1970, 1971, 1972a, 1974b) or by the oldest sedimentary complex that have been found at the border of the Upper Silesian Coal Basin and the Carpathians as well as near Cracow. This sequence is well known from the boreholes Bębło, Potrójna *IG-1* and Piotrowice *1* (Bukowy & Ślósarz 1968, Heflik & Konior 1974a, Ślączka 1976). None of the boreholes reached the boundary between the oldest sedimentary series and the crystalline basement. At the lowest known part of the sequence there are mainly arkosic sandstones (Ślączka 1976). Towards the top, the arkoses pass into clayey shales ("Bębło Shales") of dark or even black colors, with inserts of lydites, quartzitic siltstones and sandstones (Heflik & Piekarski 1978). These rocks are intersect by diabases. A top part of the sequence is usually featured by the weathering processes (Bukowy & Ślósarz 1968, Ślączka 1976).

Similar deposits occurring near Zawiercie and Mrzygłód have been conventionally considered to be of Silurian age (Ekiert 1971, Ciemniewska 1978).

The discussed sequence is isochronous with the Upper Riphaean sedimentary cycle well known from the Ukraine (Shulga 1969) and Moldavia (Bukatchuk 1969).

TECTONIC FEATURES

The tectonic re-modelled basement (Wieliczka phase) is overlain, with an angular unconformity (about 15°—35°), by the Łapczyca Conglomerate that begins the Rzeszów Group. At the top, this group is distinctly separated by another angular unconformity (*Małopolska phase* of Pożaryski & Tomczyk 1968) from the overlying Holy Cross Group.

The rocks of the Rzeszów Group, in comparison with the underlying rocks of older sedimentary cycle in the Cracow und Upper Silesian regions, are much less diagenized and they are do not contain diabases. The rock sequence of this Group are cleavaged, and commonly contain slickensides and mineral veins, and differ thereby from the Holy Cross Group.

ISOTOPIC AGE

Determination of isotopic age of the crystalline basement in southern Poland by the potassium-argon method (Borucki & Sałdan 1965) resulted in an interval age of 307—533 million years what proved it to be "an apparent age" (Burchart 1971). The only dating of hornblende from amphibolite by potassium-argon method, which resulted in an age of 837 million years (Siedlecki 1962, Burchart 1971), seems to be reliable. This dating defines the age of the metamorphosis processes at the middle part of the Upper Riphaean.

Isotopic age determinations of the top formation (Brzegi Shales) of the Group are: 634, 653, and 673 million years (Burchart 1971, *after* Semenenko 1962).

"COLD CLIMATE SEDIMENTS"

In the Group there are two conglomerate sequences (Text-fig. 2). They are treated as the isochronic equivalents of tillites of two Lapland glaciations (*cf.* Chumakov 1974, 1978). The Łapczyca Conglomerates would then correspond to the first glaciation and to the "tillites" of eastern Poland (*cf.* Areń 1968). Instead, the Potok Mały Conglomerates could represented the second glaciation.

ORGANIC REMAINS

In three of the formations (Opatkowice Shales, Książ Wielki Greywacke, and Brzegi Shales) there occur primitive assamblages of Acritarcha (*Leiosphaeridia, Orygmatosphaeridium*). The top part of the Group contains traces of worm-shaped organisms, which have never been reported from sediments earlier than Lower Vendian (*cf.* Reading 1965).

STRATIGRAPHIC AFFILIATION

On the ground of absolute dating of the metamorphic basement, and of the age of "cold" events of the Lowest Vendian, the oldest sedimentary complex ("Bębło Shales") must belong to the upper part of the Upper Riphaean.

The sedimentation of the Rzeszów Group have begun not earlier than at the begining of the Vendian. The uppermost part of the Vendian is represented by a hiatus. Possibly, in the easthern part of Carpathian Foredeep this hiatus is shorter.

The overlying sediments contain the body fossils and trace fossils which document their affiliation to the first biostratigraphic zone of the Cambrian.

EXTENT OF THE GROUP

In the Upper Silesia area, there occurs only the lowest unit (Łapczyca Conglomerates) of the Group. It overlies the metamorphic basement or the "Bębło Shales". In the boreholes Potrójna *IG-1* and Piotrowice *1* these conglomerates are overlain by Lower Cambrian sandy sediments (Kotas 1973, Orłowski 1975a).

In north-eastern and eastern directions, the higher units successively appear in the basement of Paleozoic and younger sediments.

THICKNESS OF THE GROUP

The thickness of the Group, recognizable in the boreholes Łapczyca *2*, Opatkowice *1*, Książ Wielki *IG-1*, Potok Mały *IG-1*, Brzegi *IG-1* (Łydka & *al.* 1963, Jurkiewicz 1975) equals about 3000 m after a reduction of the strata dips. These boreholes do not provide with the whole sequence, and thus the real thickness of the Rzeszów Group must be greater (?4000 m).

ŁAPCZYCA CONGLOMERATE FORMATION

NAME OF THE FORMATION

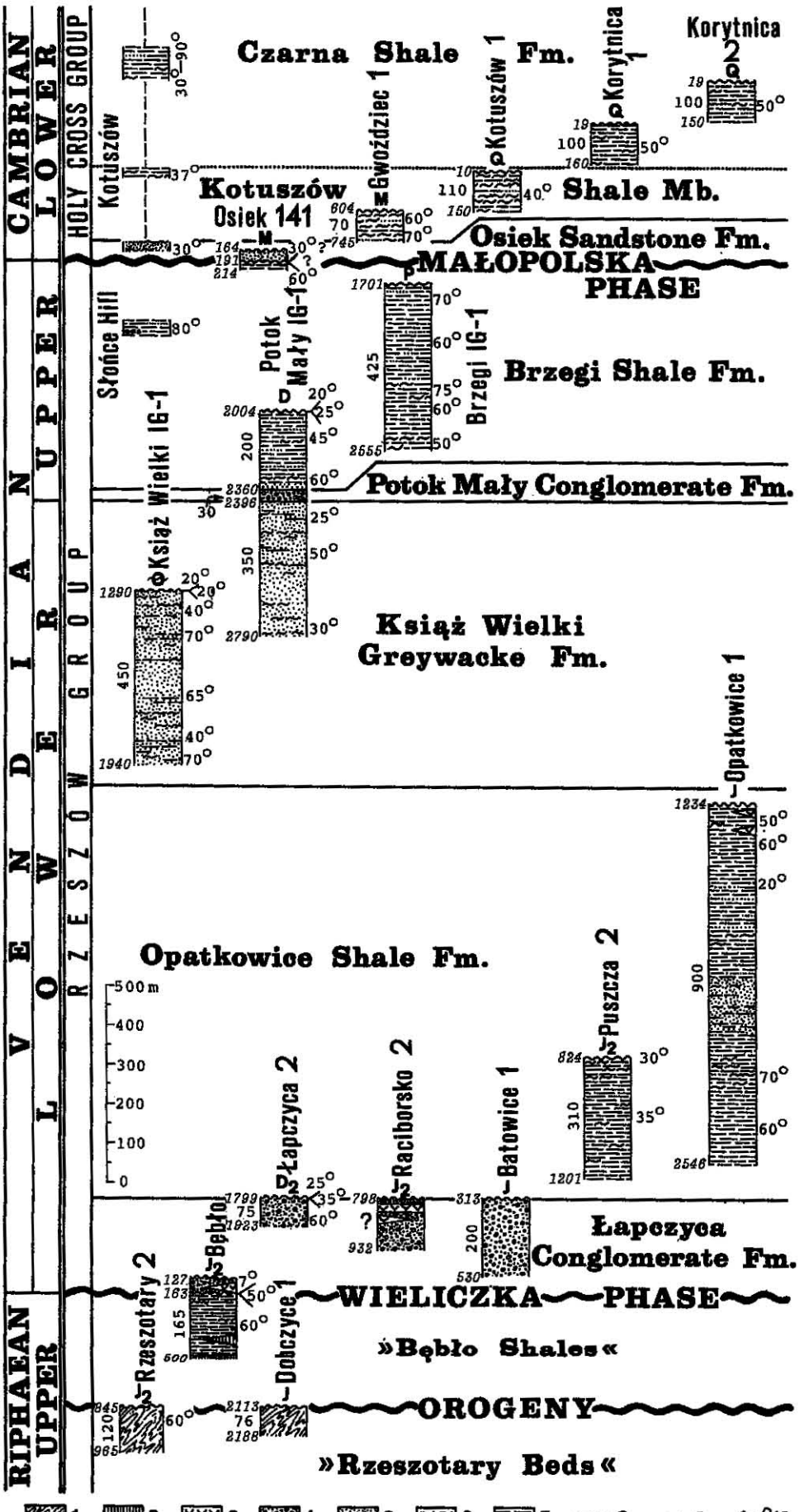
The name comes from the locality Łapczyca (borehole Łapczyca *2*), south-west of Wieliczka, Cracow region.

TYPE SECTION

The hypostratotype sections are established in the two boreholes: Łapczyca *2* (depth 1795.0—1923.6 m; Turnau-Morawska 1957, Łydka & *al.* 1963) and Batowice *1* (depth 313.0—530.1 m; Myszka & Parachoniak 1958, Łydka & Siedlecki 1963). The type area for the proposed formation extends between Cracow, Wieliczka and Bochnia. The sediments ascribed to this formation have been drilled close to Cracow in about 20 boreholes (Konior 1974, Ślączka 1976), and they overlie the metamorphosed basement complex ("Rzeszotary Beds"; Pożaryski & Tomczyk 1968; Burtan 1962; Heflik & Konior 1972a, 1974b).

The formation is composed of conglomerates and breccias of red-brown color, and diversified petrographic composition (Turnau-Morawska 1957, Myszka & Parachoniak 1958, Łydka & *al.* 1963, Bukowy & Ślósarz 1968, Heflik & Konior 1972b).

Lithostratigraphic subdivision of the investigated sections



Based on the data presented by: Woiński & Karnkowski (1954), Turnau-Morawska (1957), Myszka & Parachoniak (1958), Butran (1962), Łydka & Siedlecki (1963), Łydka & *al.* (1963), Stemulak & Jawor (1963), Jaworowski & *al.* (1967), Bukowy & Ślósarz (1968), Pożaryski & Tomczyk (1968), Kicuła & Wieser (1970), Heflik & Konior (1972a, b), Jurkiewicz (1975, 1980), Orłowski (1975b), and Ślączka (1976)

1 metamorphic rocks, *2* diabases, *3* porphyries, *4* conglomerates and breccias, *5* greywackes, arkoses and quartzitic sandstones, *6* siltstones, *7* clayey and siltstone shales, *8* phases of tectonic movements, *9* hiatuses, *10* angular unconformities

Volcanic and metamorphic rocks predominate in pebbles, whereas sedimentary rocks are subordinate, and plutonic rocks are sporadic. The volcanic rocks are several types of basalts, rhyolites, dacites, andesites as well as various tuffs. Metamorphic rocks are represented by quartz-muscovitic, quartzitic, chloritic, and sericitic shales, associated with quartzites, keratophyres, and greenstones, locally also with gneissic and mylonities.

Sedimentary rocks comprise: greywacke and arkosic sandstones, claystones and siltstones, fine-grained siliceous sandstones, black clayey-siliceous shales as well as lydites. The grains of minerals, derived probably from granite-gneisses, include primarily potash feldspars, plagioclases, and numerous vein quartz (Turnau-Morawska 1957, Heflik & Konior 1972b).

Matrix of the conglomerates and breccias is composed of quartz, feldspars, chlorite, and haematite, locally it is also siliceous with an admixture of calcium carbonate.

All the pebbles (up to 8 cm in diameter) are usually subrounded or sharp-edged, badly sorted. Locally, the conglomerates pass into conglomeratic sandstones (*e.g.* in borehole Bębło; Bukowy & Ślósarz 1968).

Within the conglomerates there are, in the boreholes Raciborsko *2* and Bębło, inserts of quartz porphyries (Heflik & Konior 1972b).

Thickness of the formation is varied. On the ground of data from boreholes (Turnau-Morawska 1957, Łydka & *al.* 1963, Konior 1974) the thickness in the type area (Text-figs 1, 2) does not probably exceed 200 m.

The conglomerates have been erroneously included to the Upper Silurian or Lower Devonian (Konior 1974). Lately, a necessity for an age revision of these conglomerates has appeared (Kotas 1973, Orłowski 1975a, Ślączka 1976).

BOUNDARIES OF THE FORMATION

The lower boundary of the formation has been nowhere drilled in the type area; toward the west, similar conglomerates have been drilled in the boreholes Potrójna *IG-1*, Piotrowice *1* and Bębło where they overlie metaargillites of an older cycle and their thickness is reduced; they are overlain by the Cambrian basal conglomerates (Ślączka 1976). The upper boundary of the formation has not been evidenced in boreholes. In many boreholes these conglomerates are overlain by Lower Cambrian sandstones (Kotas 1973; *cf. also* Konior 1968, 1969; Konior & Ślączka 1972).

The conglomerates are overlain by the Devonian, Carboniferous, Permian and Jurassic deposits. A transition of the Łapczyca Conglomerates into the overlying Opatkowice Shales is suggested by an occurrence of arkoses in the borehole Bębło (Bukowy & Ślósarz 1968) and of greywackes in the borehole Batowice *1* (Łydka & Siedlecki 1963). The continuity is also supported by the same petrographic composition of pebbles in the both formations.

OPATKOWICE SHALE FORMATION

NAME OF THE FORMATION

The name comes from the locality Opatkowice in the southern part of the Miechów Upland.

TYPE SECTION

The type section is established in the borehole Opatkowice *1* (depth 1235.0—2546.5 m). Real thickness of this sequence is about 900 m (Kicuła & Wieser 1970). Similar sediments are known from the boreholes Puszcza *2* (Łydka & Sied-

lecki 1963) and Puszcza *3* (Stemulak & Jawor 1963). The anticline of Książ Wielki — Opatkowice is proposed as the type area, distinguished in the Precambrian substrate of the southern part of the Miechów Upland (Jurkiewicz 1975).

This formation comprises a monotonous sequence of red-versus green colored siltstone-clayey shales with inserts of arkoses and arkosic sandstones, especially in the middle part of the profile (Kicuła & Wieser 1970). The clayey-siltstone rocks are composed mainly of hydromicas and hydrochlorite with a changeable content of quartz and feldspars, and all are slightly metamorphosed, being enriched *i. a.* in albite, chlorite, and sericite.

Within these shales there are frequent intercalations of arkosic sandstones, usually less metamorphosed. Among the principal components there are: quartz and feldspars making the rocks a "granite-like" appearance, associated with plutonic (granites, micropegmatites, aplites), and metamorphic rocks (gneisses). There are also numerous pieces of acid volcanites and particularly, of various kinds of porphyries and tuffs. Pieces of basalts are quite rare. The volcanic rocks are usually modified by metamorphism and weathering. Among the pieces of sedimentary rocks there are clayey shales and siltstones. The cement of sandstones is composed of siltstone-clayey matter with chlorite or haematite. At the depth of 1974.5 m, in the type section, a calcareous arkose was found, which contains a great quantity of calcite in the matrix.

Clayey-siltstone sediments are usually fine-laminated, locally graded. More coarse-grained sediments are usually badly sorted, and their detrital components are usually sharp-edged. Diameters of arkosic grains reach sporadically 4 mm (depth 1860.0 m). In the type section there are also (depth 1575.0 m) the mud balls attaining 7 cm in diameter, indicating a redeposition within the sedimentary basin.

The sequence proves a considerable influence of later tectonic processes. Cleavage is quite common, and there appear numerous mineral veins of several generations, and in the type section also lamprophyric dikes.

Within the Opatkowice Shales a primitive assemblage of Acritarcha has been found (Jagielska *in*: Kicuła & Wieser 1970): *Protosphaeridium acis* Timofeev, *P. flexuosum* Timofeev, and *Protosphaeridium* sp., *Leiosphaeridia* sp., and *Orygmatosphaeridium* sp. The taxonomical composition of the assemblage suggests Upper Proterozoic age of the formation.

BOUNDARIES OF THE FORMATION

Boundaries of the formation are unknown.

KSIĄŻ WIELKI GREYWACKE FORMATION

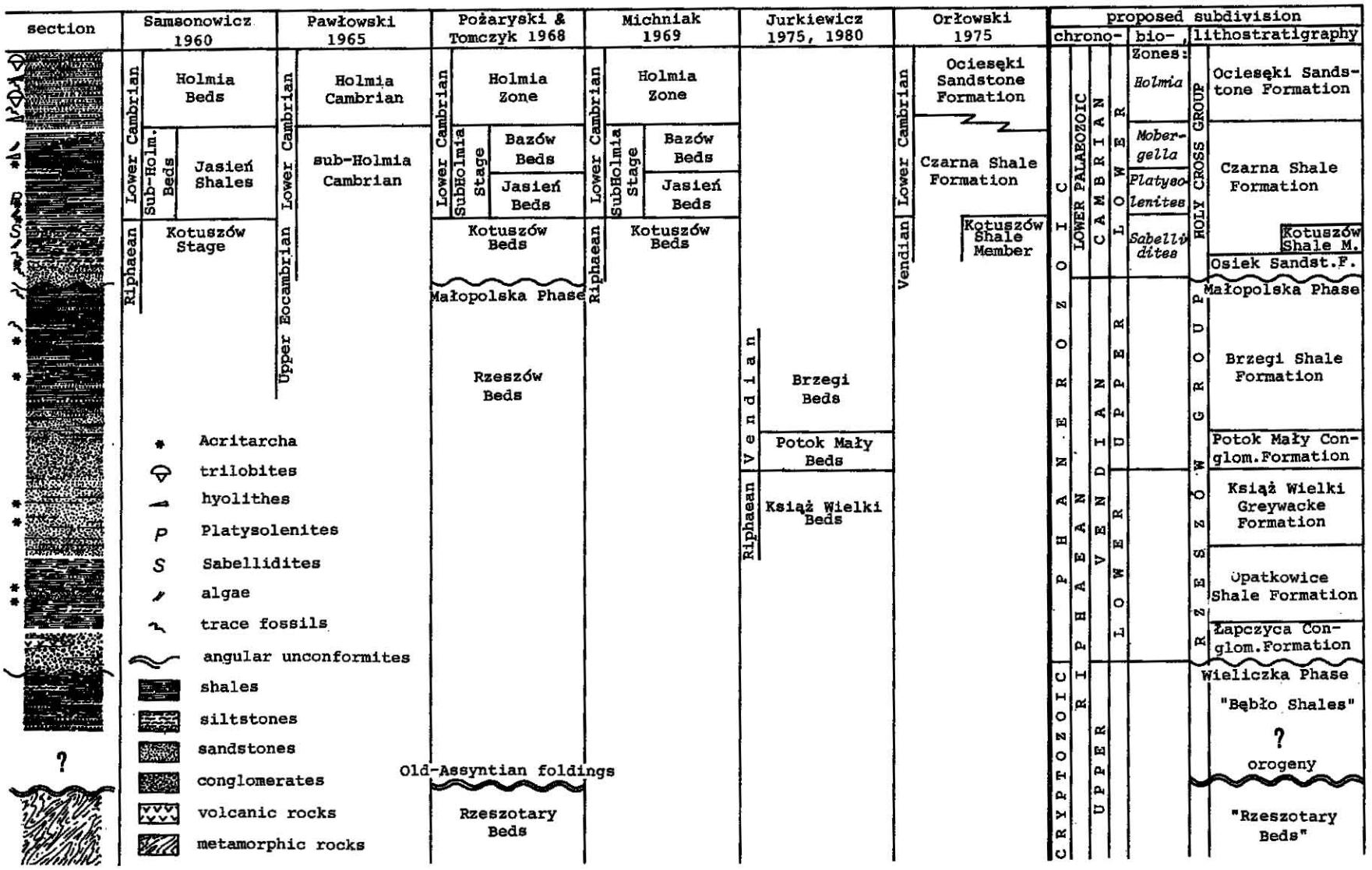
NAME OF THE FORMATION

The name is derived from the Książ Wielki village located about 15 km to north-east of Miechów.

TYPE SECTION

The section of the borehole Mikluszowice *1* (depth 1132.0—1202.0 m, thickness about 75 m; Łydka & Siedlecki 1963) is proved, as the hypostratotype section for the bottom part of the formation. For the hypostratotype section for the middle part of the formation a sequence of the borehole Książ Wielki *IG-1* (depth 1290.0—1940.0 m, thickness about 450 m; Jurkiewicz 1975) can be considered,

Stratigraphic subdivision of the Upper Precambrian and the lowest Cambrian in southern Poland



whereas for the upper part — the bottom part of the sequence of Precambrian sediments in the borehole Potok Mały *IG-1* (depth 2396.0—2790.0 m, thickness about 350 m, Jurkiewicz 1975).

In the sequence there are mainly greenish-grey greywackes with rare intercalations of clayey and marly shales of a greenish, locally reddish colors.

The greywackes contain many fragments of rocks, mainly clayey and siliceous-clayey ones, and associated with those of acid and neutral volcanic, and some granite-gneisses.

Quartz is the main component of the greywackes. Among other mineral components there are numerous feldspars but in the vertical section there is no regularity in mutual quantitative relation between the potash feldspars and plagioclases. These rocks always contain chlorite; there are also micas among which muscovite is definitely predominating.

Locally, there are transitions of greywackes into arkosic sandstones.

Shales contain tuffogenic matter with quartz, frequently with corrosive notches and relicts of volcanic glass. Within the clayey-sandy sediments there is also the same detrital matter as within the greywackes.

The clayey shales contain great quantity of quartz pelite, and albite, accompanied by chlorite and illite.

The shales are slightly metamorphosed what is expressed macroscopically by a weak silky polish and by the abundance of chlorite and albite (anchimetamorphism).

Similar sediments are known from the basement of the north-eastern margin of the Upper Silesian Coal Basin (Ekiert 1971) and from the southern part of the Miechów Upland (Jurkiewicz 1975).

The thickness of the formation is not easy to evaluate. The summing up the thicknesses of the hypostratotype sections gives a value of at least 1000 m.

Recorded fossils are *Orygmatosphaeridium* sp. *1* and *Leiosphaeridia* sp.

BOUNDARY OF THE FORMATION

The lower boundary is unknown. The upper boundary is defined at a depth of 2396.0 m in the borehole Potok Mały *IG-1*. The contact of the Książ Wielki Greywackes with the Potok Mały Conglomerates has not been cored and the depth was defined by geophysic methods.

PREVIOUS SYNONYMS

The unit was introduced by Jurkiewicz (1975) as the "Beds from Książ Wielki".

POTOK MAŁY CONGLOMERATE FORMATION

NAME OF THE FORMATION

The name comes from locality Potok Mały situated in the south-eastern part of the Miechów Upland, between Miechów and Jędrzejów.

TYPE SECTION

The type section of the formation is established in a part of the sequence from the borehole Potok Mały *IG-1* (depth 2336.0—2396.0 m). The real thickness of the formation equals about 30 m (Jurkiewicz 1975, p. 95).

The formation is composed of red-brown conglomerates which include pebbles of sedimentary, metamorphic and magmatic rocks, all of similar composition as

those from the Łapczyca Conglomerate Formation, but of the smaller size (usually to 0.5 cm diameter, maximum up to 1 cm). They are also subrounded and angular, without sorting.

BOUNDARIES OF THE FORMATION

The boundaries of the formation have sedimentary character. The upper boundary is featured with a quartz vein which was formed in result of different tectonic competency of the rock sequences.

PREVIOUS SYNONYMS

The described unit was introduced by Jurkiewicz (1975) as the "Beds from Potok Mały".

BRZEGI SHALE FORMATION

NAME OF THE FORMATION

The name comes from the Brzegi village situated about 10 km to north-east of Jędrzejów, at the border of the Miechów Upland and the Holy Cross Mts.

TYPE SECTION

The upper part of the section of Precambrian sediments in the borehole Potok Mały *IG-1* (depth 2004.0—2360.0 m; thickness about 200 m) and a section of the borehole Brzegi *IG-1* (depth 1701.2—2555.0 m; thickness about 425 m) are proposed as the hypostratotype sections of the formation. The total thickness of the formation increases towards the eastern part of the Carpathian Foredeep and it is probably greater than in both hypostratotype sections.

Within the formation, grey-greenish clayey-siltstone, clayey and marly shales predominate. Amid the shales there are interbeds of greywacke sandstones and siltstones.

Clayey shales are composed mainly of illite and chlorite with an admixture of quartz pelite, and albite.

In the bottom part of the borehole Potok Mały *IG-1* sequence (*vide* Jurkiewicz 1975, Fig. 2), there are greywacke intercalations with fragments of sedimentary, metamorphic and magmatic rocks similar to those in older formations.

Intercalations of polymictic sandstones in the upper parts of the formation (*e. g.* the borehole Osiek *1*, depth 134.7 m) contain usually smaller variability of minerals in relation to the rocks of the bottom part of the formation. The sandstones are usually fine-grained and frequently pass into siltstones.

Rock pieces are rare and usually represented by clayey and siliceous-clayey shales and by single fragments of quartzites and granite gneisses. The cement of polymictic sandstones and siltstones is usually of chloritic-illitic type.

Within the formation there are also rare inserts (5—15 cm thick) of breccia (exposure at the Słońce Hill, Filonowicz 1961). These rocks have a composition similar to polymictic sandstones and siltstones described. They consist mainly sharp-edged fragments of vein quartz, quartzites, cataclasites, mylonites and sandstones with calcareous cement. There are also trace quantities of volcanites of felsitic matrix, micro-crystalline siliceous rocks and quartzitic-muscovitic shales.

In comparison to the Potok Mały Conglomerates the rocks contain smaller quantity of less stable components; instead, their roundness degree is still smaller. Rock pieces of breccias are up to 5 mm in diameter.

The sediments contain poor assemblage of Acritarcha: *Leiosphaeridia* sp. and *Orygmatosphaeridium* sp. *1*, and trace fossils represented by exichnial burrow casts (*Gordia* sp.) and epichnial grooves.

An isotopic age for the samples of the Brzegi Shale Formation (673, 653 and 634 million years) prove the middle and upper parts of the Vendian.

BOUNDARIES OF THE FORMATION

The lower boundary was distinguished in the borehole Potok Mały *IG-1* at a depth of 2360.0 m. In the section of the borehole Osiek *141* there is the stratotype of the upper boundary of the formation; there, the upper layers of the unit show a color change, probably of weathering nature. Starting from the bottom of this borehole (215.0 m up to a depth of 211.5 m), the shales are grey-greenish (typical color in the whole formation), and there are only rare cherry-red laminae. At depth interval 204.5—211.5 m there is quantitative balance of the beds of a primary color and of the cherry-red ones. At depth 194.0—204.5 m the cherry color already predominates whereas greenish laminae are sporadic. The top beds (185.0—194.0 m) are greenish-grey, and upwards they become more and more weathered. They are overlain by variously-grained and fine-grained sandstones of a clayey matrix with fine rock fragments (about 2 mm diameter) of shales, the latter redeposited from the underlying formation. At the contact there is also a considerable angular unconformity between the Brzegi Shales and the Osiek Sandstones. Unfortunately, the core is not good enough for proper measurements. But beneath, at a depth of 194—215 m there are dips of about 60° within the shales whereas above, at a depth of about 168 m, the dip within the sandstones may be estimated as 20—30°.

PREVIOUS SYNONYMS

The sediments of this formation have been distinguished as the "Rzeszów Beds" (Pożaryski & Tomczyk 1968) in the Upper San Anticlinorium and as the "Beds from Brzegi" in the Miechów Upland (Jurkiewicz 1975). Probably, this formation includes, some of the beds considered as the Upper Eocambrian at the border of the Carpathian Foredeep and the Holy Cross Mts (Pawłowski 1965).

LITHOSTRATIGRAPHY OF THE HOLY CROSS GROUP

The unit was introduced by Orłowski (1975b). The two lowest formations of the Holy Cross Group are described here, the lower one for the first time. The definition of the upper unit (Czarna Shale Formation) is supplemented basing on boreholes from the type area (Text-fig. 4).

OSIEK SANDSTONE FORMATION

NAME OF THE FORMATION

The name is derived from the locality Osiek, south-southwest from Sandomierz.

TYPE SECTION

The section of the borehole Osiek *141* at a depth interval of 164.4—185.0 m (Text-fig. 2) and an exposure sequence close to Kurozwęki (Pl. 1, Fig. 2; Text-fig. 3) are proposed for the hypostratotype areas of the Formation.

The formation is represented by yellow and light-grey quartz sandstones passing upwards into dark-grey quartzitic sandstones.

In the type sequence the weathered clayey shales and sandstones of the Brzegi Shale Formation are overlain (depth 183.0—185.0 m) by siliceous-kaolinitic quartzitic sandstones of yellow and grey colors, with numerous fragments of illitic claystones, locally of clayey-siltstone shales, with chlorite. These rock fragments (in 1—2 mm diameter) are elongated and rounded. Larger sand grains are oval whereas the smaller ones are sharp-edged. Locally there also appears detrital glauconite. At a depth of 175.0—183.0 m the core recovery was small and the fragments proved an occurrence of quartz and quartzitic sandstones. Higher up (depth 164.4—167.5 m) there are siliceous-kaolinitic and chloritic-ferruginous quartzitic sandstones. These sediments contain abundant chlorites, both in the matrix as well as in the fragments. In the matrix, there is also kaolinite, heavy minerals and detrital glauconite. Ferruginization of these rocks and sporadic carbonates are of secondary origin. In the type borehole the sequence is terminated by the Tertiary erosion surface. Quartzitic sandstones and siltstones of the upper part of the formation contain mainly quartz grains of varying diameter and changeable roundness. Larger grains are usually better rounded although it is frequently difficult to define the roundness degree due to recrystallization. The micas are sporadic and fine, with predominance of muscovite. At the bottom part of the sequence the rock fragments redeposited from the Brzegi Shales are the most abundant. Instead, in the whole sequence there are small amounts of fragments of siliceous rocks and fine-crystalline quartzitic rocks, very resistant to destructive factors. In contradistinction to the sediments of the Rzeszów Group the rocks contain abundant heavy minerals among which zircone and tourmaline dominate locally, and are associated with apatite, rutile, epidote and detrital glauconite.

The formation thickness is not to be evaluated precisely but it does not probably exceed 30 m.

The higher part of the formation in the exposure at Kurozwęki (Text-fig. 3; Pl. 1, Fig. 2) is composed of ferruginous quartzitic sandstones and siltstones with inserts of clayey-siltstone shales. The beds of sandstones and siltstones are usually 4—7 cm thick, rarely up to 27 cm. At the bed surfaces there are flute marks and abundant mica plates. There are also trace fossils: *Planolites montanus* Richter, *P. nematus* Kowalski, and *Phycodes* sp.

The clayey-siltstone shales that form interbeds contain abundant chlorite, and they make up regular laminae 0.1—0.3 mm thick.

BOUNDARIES OF THE FORMATION

The lower boundary has been defined in the borehole Osiek *141* (depth 183.0 m), but the upper boundary was not accessible.

PREVIOUS SYNONYMS

The described lithostratigraphic unit probably corresponds to some of the sediments described by Pawłowski (1965) as the Upper Eocambrian.

CZARNA SHALE FORMATION

NAME OF THE FORMATION

The name comes from the Czarna River (Orłowski 1975b).

TYPE SECTION

For the partial type sections the exposures along the Czarna River (Walczowski 1965), along the southern edge of the Koprzywianka stream, between Bazów and Koprzywnica, and in the Chęciny anticline have been considered.

The formation consists (Text-fig. 4) of siltstone and clayey-siltstone and clayey--siltstone shales with single inserts of quartzitic and quartz siltstones and fine--grained sandstones, locally also of limestones (Żak 1968, Łydka 1979, Łydka & Orłowski 1978).

In the lower part of the formation there are also, amidst shales, inserts of fine-grained quartzic grey or greenish-grey sandstones with micas (boreholes (Gwoździec *1* and Kotuszów *1*). These sandstones have calcareous matrix of poikilitic type. In the lower part of the formation there are quite abundant feldspars among which acid plagioclases predominate but there are also some

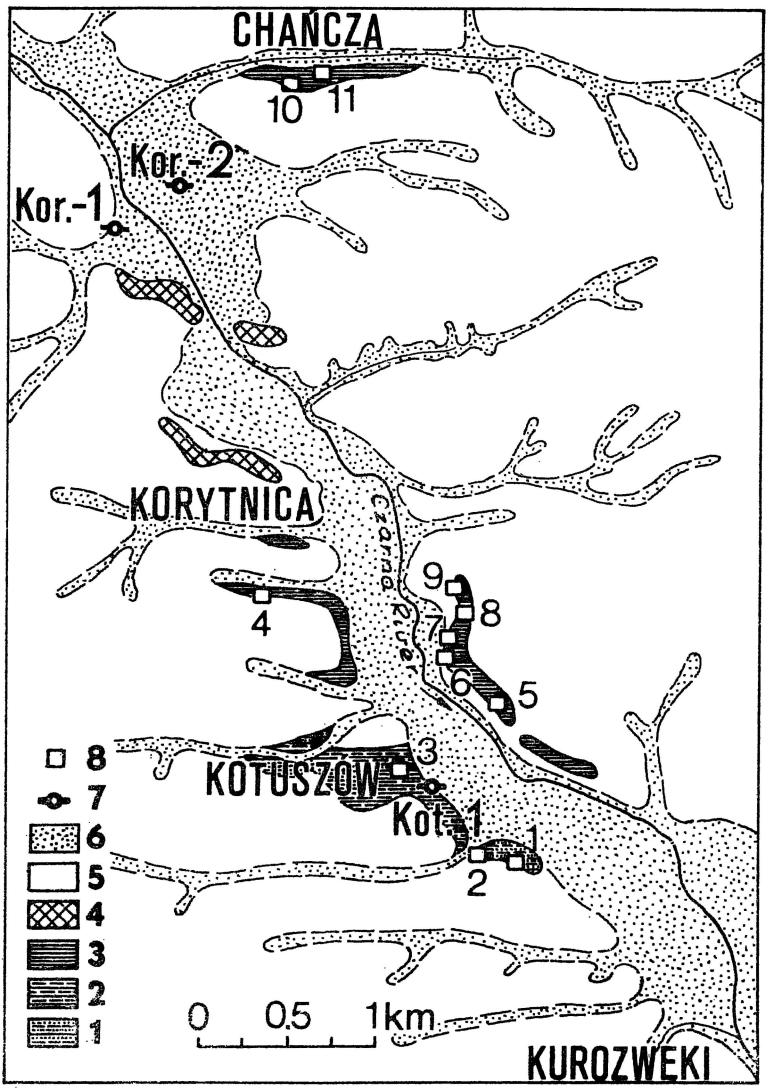


Fig. 3. Location of boreholes and exposures in the Kotuszów area

1—3: Lower Cambrian: *1* Osiek Sandstone Fm.; *2* Czarna Shale Fm., Kotuszów Shale Mem.; *3* upper part of the Czarna Shale Fm.; *4* Lower Devonian; *5* Miocene; *6* alluvia; *7* boreholes; *8* exposures

sericitized potash feldspars. Beside the predominating quartz, the micas are also an important rock component. Usually there are similar amounts of muscovite and biotite but locally, muscovite prevails. Among the clay minerals there occur illite and chlorite. The latter is detrital as well as intergranular.

In the sequence of the formation there are also horizons enriched in tuffogenic matter with feldspars. Towards the top of the sequence a gradual decrease of grain sizes and a passing into clayey shales are noted. There is also an increase in carbonate content and there are even silt-containing limestones with micas (borehole Korytnica *1*, depth 30.0 m).

In the lower part of the formation (Kotuszów Shale Member), Acritarcha and trace fossils, whereas in the upper part also macrofauna and algae have been found. The fossils recorded are: *Sabellidites cambriensis* Yanischevsky, cf. *Parasabellidites yanischevskyi* Sokolov, *Platysolenites antiquissimus* Eichwald (*see* Michniak & Rozanov 1969), *Coleoloides* sp. (Samsonowicz 1960, 1962), Merostomoidea

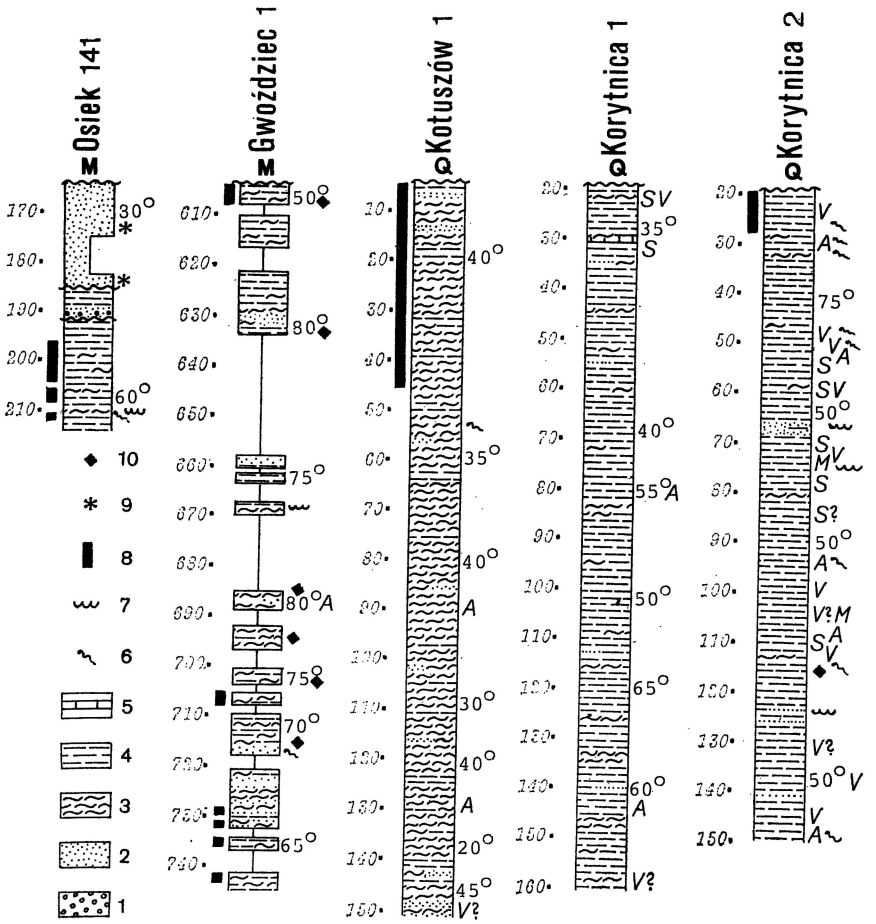


Fig. 4. Lowest Cambrian sequences in southern Poland (*cf.* Text-figs 1 and 3)
1 conglomerates, *2* sandstones, *3* siltstones, *4* clayey and siltstone shales, *5* limestones, *6* trace fossils, *7* sedimentary structures, *8* red-colored rocks, *9* glauconite, *10* pyrite
S — Sabellilditidae, **M** — Merostomoidea, **V** — Vendotaenides, **A** — Acritarcha

indet., and in the uppermost part of the formation: *Sabellidites* sp., *Pelagiella* sp., *Linevitus* sp., *Trapezovitus* sp., *Hyolithellus* sp. (Żakowa & Jagielska 1970). There are also algae of the genera: *Vendotaenia, Tyrasotaenia, Pilitela,* and *Thallulus.*

The Acritarcha are represented by genera *Baltisphaeridium, Leiosphaeridia, Leiomarginata, Asperatopsophosphaera, Granularia, Orygmatosphaeridium, Asteriscus, Cymatiosphaera,* and *Tasmanites* (*vide also* Michniak 1959, 1969; Żakowa & Jagielska 1970).

The trace fossils are represented mainly by *Planolites.* In the studied part of the section (Sabellidites Zone) there are also problematic forms: *?Bunyerichnus, ?Monocraterion* and *?Palaeophycus.*

The rocks of the formation have been dated by K/Ar method (*vide* Burchart 1971). The obtained values of 489—557 million years (the borehole Bazów) and 479 million years (the borehole Kotuszów *1*) seem to be too low as apparent from analyses of the whole rock samples.

Orłowski (1975b) evaluated the thickness of the formation for 500—700 m.

BOUNDARIES OF THE FORMATION

The lower boundary of the formation is defined by a lithologic change from predominating quartzitic and quartzitic sandstones and siltstones (Osiek Sandstone Formation) into clayey and clayey-silty shales with some inserts of fine-detrital rocks. A type section of the lower boundary has not been defined due to lack of exposures and boreholes.

The upper boundary of the formation is defined (Orłowski 197b) by a lithologic change of the clay sequence into sandstones and siltstones (Ociesęki Sandstone Formation). The type section of the upper boundary occurs near Gieraszowice (Holy Cross Mts).

PREVIOUS SYNONYMS

The Czarna Shale Formation comprises several lithostratigraphic units distinguished informally, such as: the Kotuszów Stage (Samsonowicz 1960), the Kotuszów Beds (Michniak & Orłowski 1963), the Jasień Shales (Samsonowicz 1960), as well as the Jasień Beds and the Bazów Beds (Michniak & Orłowski 1963).

KOTUSZÓW SHALE MEMBER

The Kotuszów Shale Member has been distinguished by Orłowski (1975b). The rocks of this member are exposed at Kotuszów (Text-fig. 3 and Pl. 12, Fig. 1). They consist of clayey-siltstone shales with a considerable content of illite and chlorite. The rocks contain greater quantity of quartz grains of siltstone fraction than the rocks of the upper part of the member. Besides the quartz pelite there are abundant muscovite and biotite. Feldspars occur usually in smaller quantities, and they are mainly represented by albite. Chlorite as well as some albite probably originated due to weak metamorphosis (anchimetamorphism). The shales contain rare intercalations of quartz and quartzitic sandstones and silstones. If non weathered, the rocks are greenish, whereas in exposures the original color is rare and they become greenish-cherry and greenish-rusty. The content of the fossils comprises *Oldhamia antiqua* Kinahan (borehole Gwoździec *1*), *Planolites nematus* Kowalski, and *P. ballandus* Webby. The Acritarcha are represented by *Cymatiosphaera, Orygmatosphaeridium* and *Leiosphaeridia* (*see* Michniak 1959).

Considerations over thickness of the member are based on the data from the boreholes Gwoździec *1* (Woiński & Karnkowski 1954) and Kotuszów *1*. In the

borehole Gwoździec *1* (depth 603.6—744.8 m, thickness about 70 m) there are, in the bottom part, numerous sandstone beds what suggests that these sediments represent the contact with the Osiek Sandstone Formation. Instead, in the borehole Kotuszów *1* (depth 10.0—150.0 m, thickness about 115 m) the sequence is monotonous and there are only rare sandy interbeds. Therefore, the borehole section represents the upper part of the member. On the ground of these premises the thickness of the member can be evaluated as about 150 m.

PREVIOUS SYNONYMS

The Kotuszów Shale Member has been distinguished as the Kotuszów Stage (Samsonowicz 1960) or as the Kotuszów Beds (Michniak & Orłowski 1963, Michniak 1969). As a formal unit it was introduced by Orłowski (1975b).

SEDIMENTARY ENVIRONMENT OF THE RZESZÓW GROUP

ŁAPCZYCA CONGLOMERATE FM.

At the decline of the Upper Riphaean the sea retreated from the Cracow region, and then, in the earliest Vendian in result of the Wieliczka phase, the substratal blocks were uplifted. These phenomena were accompanied by volcanic activity. Considerable morphological differentiation under cold climatic conditions (first Vendian glaciation; *comp.* Chumakov 1974, 1978; Khomentovskii 1976) caused intensive erosion on elevations and deposition of coarse clastics in depressions (Text-fig. 5).

An analysis of the occurrence of conglomerates, their thickness and petrographic composition proves varying sedimentary conditions. In the area from Bębło to Bochnia, the conglomerates pass frequently into breccias composed of badly rounded and angular fragments (Turnau-Morawska 1957). Thickness of these sediments is over 200 m (Myszka & Parachoniak 1958, Heflik & Konior 1972b). These sediments, due to their fraction and lack of sorting, resemble fanglomerates deposited during a violent transport and from the surroundings. The conglomerates occur along the north-eastern margin of the Rzeszotary elevation (Fig. 6 *in* Konior 1974).

Contrary to these rocks, the conglomerates in the Upper Silesian region possess a considerably greater structural maturity. The sequence consists almost entirely of pebbles of sedimentary rocks of the older sedimentary cycle; towards the top it passes into typical polymictic conglomerates. The conglomerates are only 23 m thick (Ślączka 1976). The pebbles are rounded in the whole sequence. Usually they are discoidal, and then they are imbricated what suggests their water transport.

OPATKOWICE SHALE FM.

Sediments of this unit may partly be isochronic with the Łapczyca Conglomerate Fm. Their sedimentation occurred in terrestial or in subaqual environments but the action of flowing water was not strong enough to differentiate the components coarser than clay and silt. Occurrence of arkosic sandstones in the middle part of the section proves periodical, more intensive water flows. Marine influence during sedimentation is proved by the presence of Acritarcha. No traces of chemical weathering are noted what can be explained by severe climatic conditions (Kicuła & Wieser 1970).

KSIĄŻ WIELKI GREYWACKE FM.

Sediments of this formation were deposited in a water environment what is suggested by the occurrence of fine-graded series within some greywacke beds. Occurrence of Acritarcha suggests marine features of the sedimentary basin. Thick beds of the Książ Wielki Greywackes do not usually present any regular arrangement of the components. They were formed in result of rapid deposition during which no differentiation of the components occurred ("fluxoturbidites"). A lack of redeposition within the sedimentary basin caused slight structural and mineral maturity of the sediments. Within the greywackes there are similar mineral and rock fragments as within the previously described formations. The alimentary area was the same as in the case of the conglomerates and shales. The difference is in the fraction of sediment and in the type of sedimentation.

POTOK MAŁY CONGLOMERATE FM.

Sediments of this formation were deposited in an inland environment or in a littoral part of a larger water reservoir. The conglomerates are neither tillites nor tillite-like rocks. It seems more probable that they originated in result of

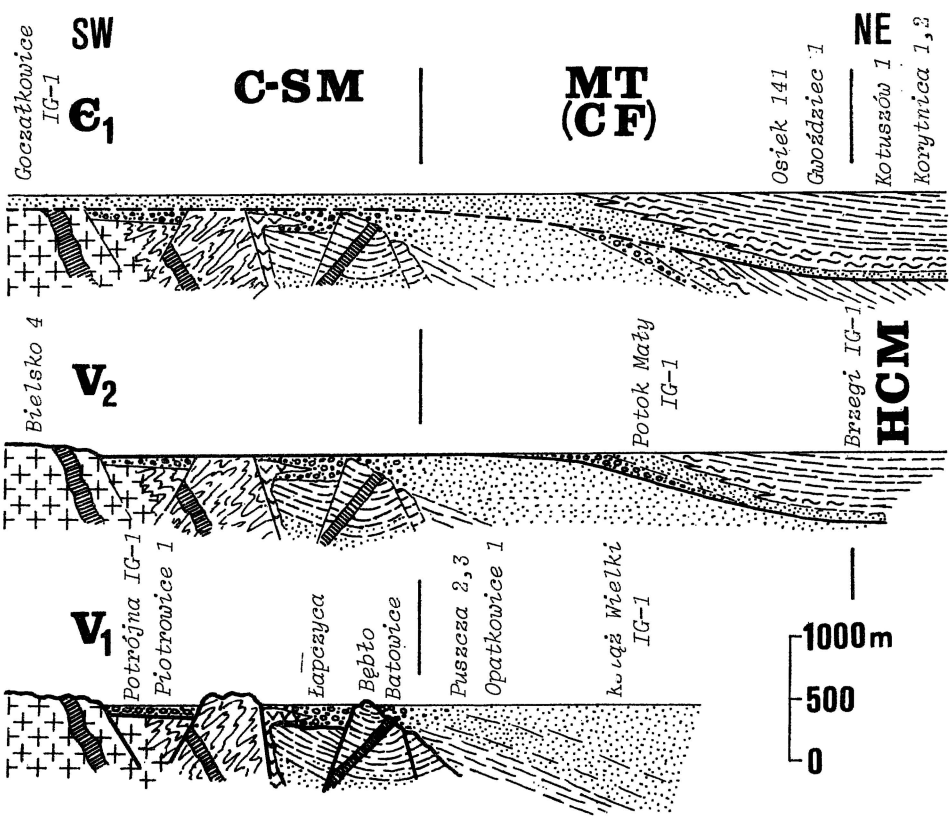


Fig. 5. Sedimentary evolution of southern Poland; lithology the same as in Text-fig. 2

C-SM — Cracow-Silesian Monocline, **MT** — Miechów Trough, **CF** — Carpathian Foredeep, **HCM** — Holy Cross Mts

activating the bedrock erosion. An increased denudation rate could have been caused by marine regression and by lowering of the erosion base during the second Vendian glaciation.

BRZEGI SHALE FM.

At the beginning of sedimentation of this formation there must have been a transgression onto the previous alimentary area. The marine origin of the deposit is proved by the presence of Acritarcha and trace fossils. The material was transported from a greater distance. Probably the lowermost sedimentary sequence (Upper Riphaean one) as well as the bedrock composed of granites were eroded.

Concluding from the sediment features, the sedimentation occurred during a diastrophic stagnation, slow denudation with a probable great participation of chemical weathering.

A considerable part of the sediments is laminated, but locally fine graded-bedded interbeds occur. Organic structures did not take any important part in the sediment features. In the upper part of the formation there appear fine, current ripplemarks. Most sedimentary structures have been probably blurred due to diagenesis and dynamic metamorphosis.

The sporadically noted breccia beds (*see* Filonowicz 1961, 1969) are of fluxo-turbidite type.

At the end of Vendian, a marine regression and a break in sedimentation took place. This regression resulted from climatic oscillations by the end of the Upper Precambrian (*e. g.* Chumakov 1978). The lowering of sea level was connected with sediment transport across the previous depositional area to the areas situated at lower altitudes.

Some tectonic phenomena prove the presence of a tectonic phase (Małopolska Phase; *vide* Pożaryski & Tomczyk 1968) of a block-faulting character. They have not however resulted in an uplift of southern Poland and in the development of any coarse-detrital sequence.

SEDIMENTARY ENVIRONMENT OF THE HOLY CROSS GROUP

OSIEK SANDSTONE FM.

The violent Lower Cambrian transgression inundated weakly differentiated vast areas, and all sediments were deposited in a shallow, sublittoral environments.

As the transgression developed, a supply of sandy matter decreased and interbeds of siltstone and clayey-siltstone shales appeared. Numerous sedimentary structures such as diagonal bedding and ripplemarks prove the activity of bottom currents. At some levels there appear many traces of organic activity, the concentrations of which suggest periodical breaks in accumulation.

CZARNA SHALE FM.

The sediments of this formation were deposited in a zone far-distant from the influence of littoral processes. Primarily, a clay-silty sediment dominated. Periodically, a supply of silts was greater and the ripplemarks have formed. All these deposits are locally disturbed due to unstable density bedding and fine faults caused by draining of the sediment. A lithologic contrast between the siltstone-clayey sediments and siltstones as well as sandstones enabled to preserve such sedimentary structures as flute casts or fine flow structures suggesting local

turbulent flow. Traces of organic activity are quite numerous, but their concentration is not great enough to influence the sediment structure. Above the Kotuszów Shale Member, an increase of clay content enabled preservation of organic remains. The remains of the thallophytic algae (*see* Gnilovskaja 1971, 1975; Aseeva 1976) of typical marine habitats indicate sedimentation within the photic zone.

BIOSTRATIGRAPHY

The sediments of Upper Precambrian and Lower Cambrian age contain a limited assemblage of organic remains which allow to precise the biostratigraphic position of the studied sequences.

The macrofauna occurs only in the boreholes Korytnica *1* and *2*, within the Czarna Shale Fm., namely *Sabellidites cambriensis* Yanischevski, *Sabellidites* sp. (cf. *Parasabellidite[illegible]skyi* Sokolov), and Merostomoidea indet. (Text-fig. 6). The occurrence of *S. cambriensis* proves that the sediments of the lower part of the formation belong to the Sabellidites Zone (*see* Kiryanov 1969, Sokolov 1972b, Lendzion 1972, Areń 1978). The upper part of the formation belongs (Michniak & Razanov 1969) to the second zone of the Cambrian with *Platysolenites antiquissimus* Eichwald.

Within the sediments of the Sabellidites Zone there appear algae of the Vendotaenides group, represented by *Tyrasotaenia podolica* Gnilovskaja, *Pilitela composita* Aseeva, *Vendotaenia major* sp. n., and *Thallulus carnosus gen.* & sp. n. The genera of macroalgae *Vendotaenia* and *Tyrasotaenia* are known both from the Upper Vendian (Gnilovskaja 1971, 1975, 1976) and from Lower Cambrian (Areń & Lendzion 1974, Areń & *al.* 1977). Instead, *Pilitela* had been noted within the sediments of Upper Vendian age (Aseeva 1976). The stratigraphic extents of *Tyrasotaenia podolica* Gnilovskaja and *Pilitela composita* Aseeva include the Upper Vendian and the lower part of the "Sub-Holmia" Cambrian, and thus they are of no stratigraphic significance for the recognization of the Vendian/Cambrian boundary.

All the investigated deposits contain also Acritarcha (Jagielska 1966). Within the Precambrian sediments only the primitive forms of *Leiosphaeridia* and *Orygmatosphaeridium* were found. A more differentiated assemblage within the sediments of the Sabellidites Zone comprises *Baltisphaeridium ornatum* Volkova, *Asperatopsophosphaera bavlensis* Schepeleva, *Tasmanites bobrowskii* Ważyńska, *Granularia saccoformis* gen. & sp. n., *Asteriscus irregularis* gen. & sp. n., *Cymatiosphaera* sp. div., *Leiosphaeridia* sp., *Orygmatosphaeridium* sp. *1*, *Orygmatosphaeridium* sp. *2*, and *Leiomarginata* sp. The occurrence of *Baltisphaeridium, Tasmanites, Cymatiosphaera* and *Leiomarginata* proves the Cambrian age of these sediments.

The earliest trace fossils from the sediments of the uppermost Vendian (Brzegi Shale Fm.) are represented by exichnial burrow casts (*Gordia* sp.) and epichnial grooves.

A more differentiated trace assemblage was found within the sediments of the lower part of the Cambrian. It contains among others *Phycodes* sp. that proves the Cambrian age of the Osiek Sandstone Fm., and *Oldhamia antiqua* Kinahan, which does the same for the lower part of the Czarna Shale Fm. (*see* Dhonau & Holland 1974, Alpert 1977).

Within the sediments documented by *Sabellidites* there appears *?Bunyerichnus* sp. which shows a similarity to *Bunyerichnus dalgarnoi* Glaessner, known from the Precambrian sediments of Australia (Glaessner 1969) and considered for a stratigraphic key for the Upper Precambrian (Alpert 1977).

The sediments that underlie the Cambrian ones possess a much poorer biostratigraphic documentation (Text-fig. 6), and all the microfossils are here represented by the taxa typical of the Vendian.

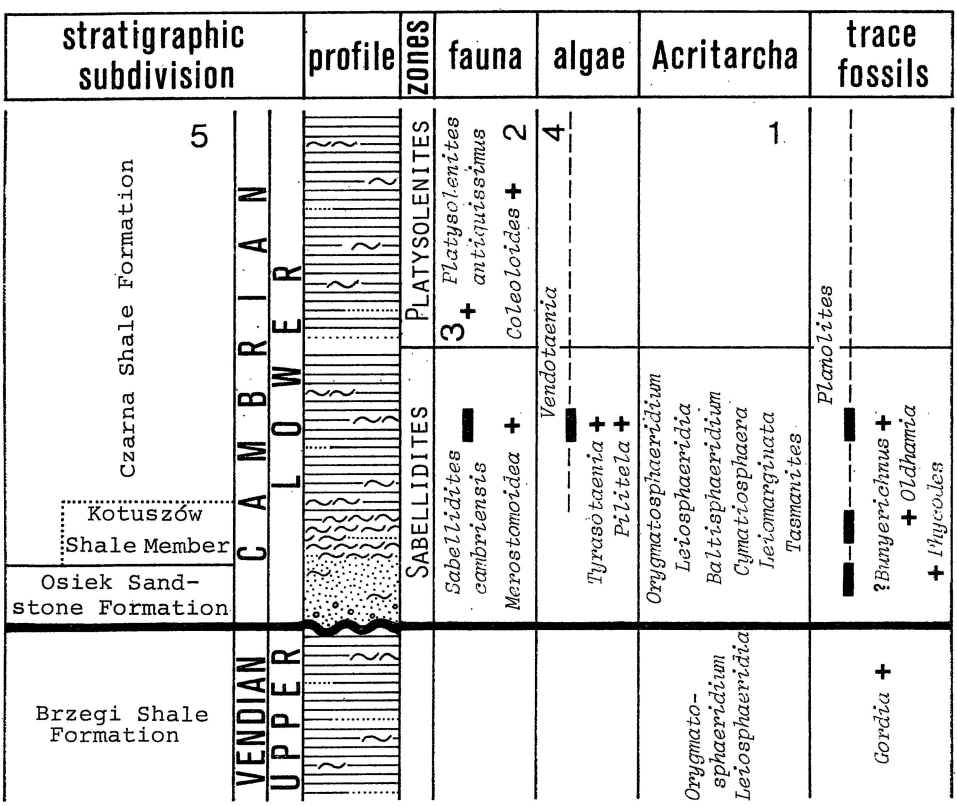


Fig. 6. Biostratigraphy of the Upper Vendian and the lowest Cambrian in the Holy Cross Mts; lithology the same as in Text-fig. 4

Based partly on the data presented by: *1* Michniak (1959), *2* Samsonowicz (1960), *3* Michniak & Rozanov (1969), *4* Żakowa & Jagielska (1970), *5* Orłowski (1975b)

CHRONOSTRATIGRAPHY

The Vendian is the latest in the systems distinguished within the Upper Precambrian and more precisely, within the Riphaean (Sokolov 1952 *fide* Keller & Sokolov 1962, Sokolov 1972b, Chumakov 1974, Keller & Semikhatov 1976, Aksjenov & *al.* 1978).

In a classical approach, the Vendian was lithologically bipartite. The Lower Vendian comprised tillite-like and volcanic rocks (Volhyn Group) whereas the Upper displayed clastic, marine sediments (Valdai Group). They were separated by a considerable gap. But, in the complete sections located at the edge of the European Platform (*comp.* Znosko 1961) besides tillites at the bottom of the system, there also occur the sediments isochronic with the second glacial epoch. Each glacial series is overlain by a huge complex of fine-detrital rocks. According to the conventional idea, the boundary between the two Vendian sequences was placed (Khomentovskii 1976) at the top of tillites of the second glaciation.

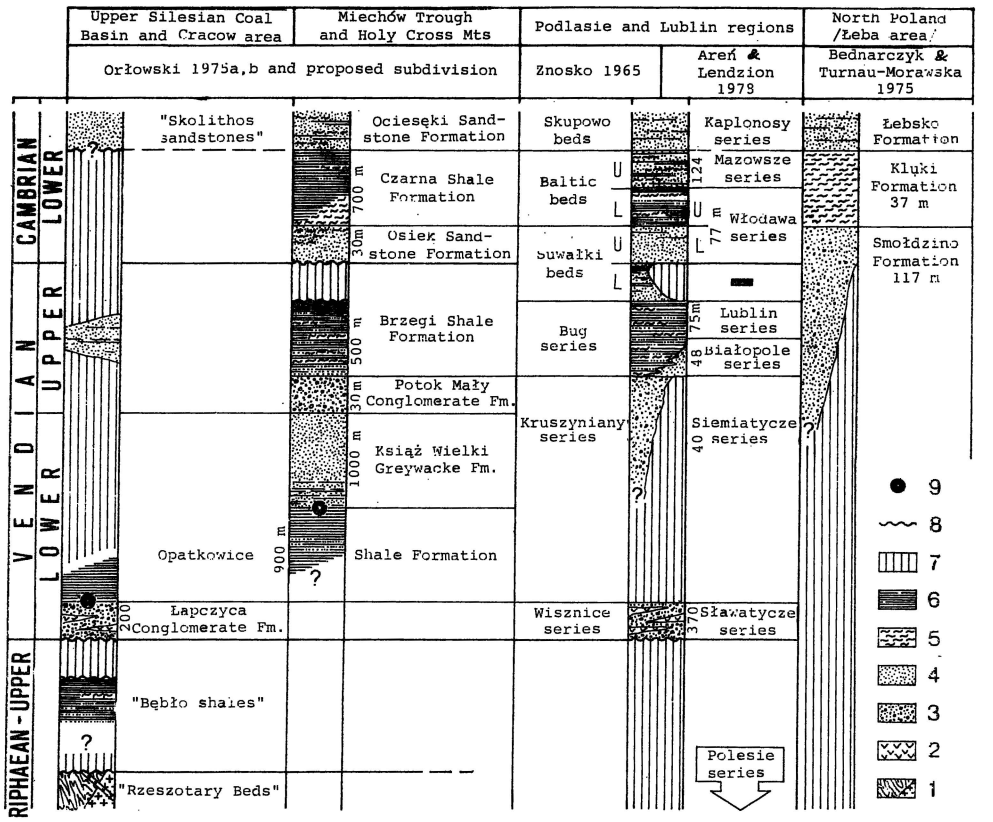


Fig. 7. Correlation of the Upper Precambrian and the lowest Cambrian lithostratigraphic columns in Poland

1 basement, *2* volcanic rocks, *3* conglomerates, *4* sandstones, *5* siltstones, *6* shales, *7* stratigraphic hiatuses, *8* angular unconformites, *9* non-defined boundaries of lithostratigraphic units

L — Lower, and **U** — Upper parts of some lithostratigraphic units

The comparison of the Vendian sequences from various areas proves that a new definition of the Lower/Upper Vendian boundary is highly requested. For practical purposes the boundary should be located at the bottom of tillites of the second glacial epoch. In such an approach, the both parts of many European sections comprise the sedimentary cycles of similar lithologic successions.

The Rzeszów Group, distinguished in the Precambrian section of southern Poland, was considered in a chronostratigraphic scheme as an equivalent of the Vendian System. A section of the Rzeszów Group presents a great sedimentary and diastrophic similarity to typical sections of the Vendian from the border zone of the European Platform (*sensu* Baily 1929 *fide* Holms 1965, Zhuravlev 1972).

The profiles which comprise the boundary zone of the Vendian and the Cambrian, have a sedimentary break at the contact of both systems. The only European profiles in which no breaks have been noted occur in eastern Poland (Text-fig. 7; Areń & Lendzion 1978 — opposite *comp.* Kiryanov 1979) and in the Oslo Trough (Skjeseth 1963).

The boundary of the Rzeszów and the Holy Cross groups is concordant with the boundary of the Vendian and the Cambrian systems. The Cambrian System starts with the transgressive Osiek Sandstone Formation.

The sediments of the lowest Cambrian, devoid of any trilobites, are usually distinguished as the Sub-Holmia Stage (Sub-Holmia Cambrian, Sub-Holmia zone, Sub-Holmia Beds; Samsonowicz 1960, Lendzion 1972) and comprise three biostratigraphic zones (*comp.* Areń 1978, Fig. 10). In Poland the term "Klimontów Stage" was introduced as the synonym of the "Sub-Holmia" Stage (Areń & Lendzion 1974). The sediments of two lower zones are distinguished in the Soviet Union as the Baltian Stage (Salop 1968).

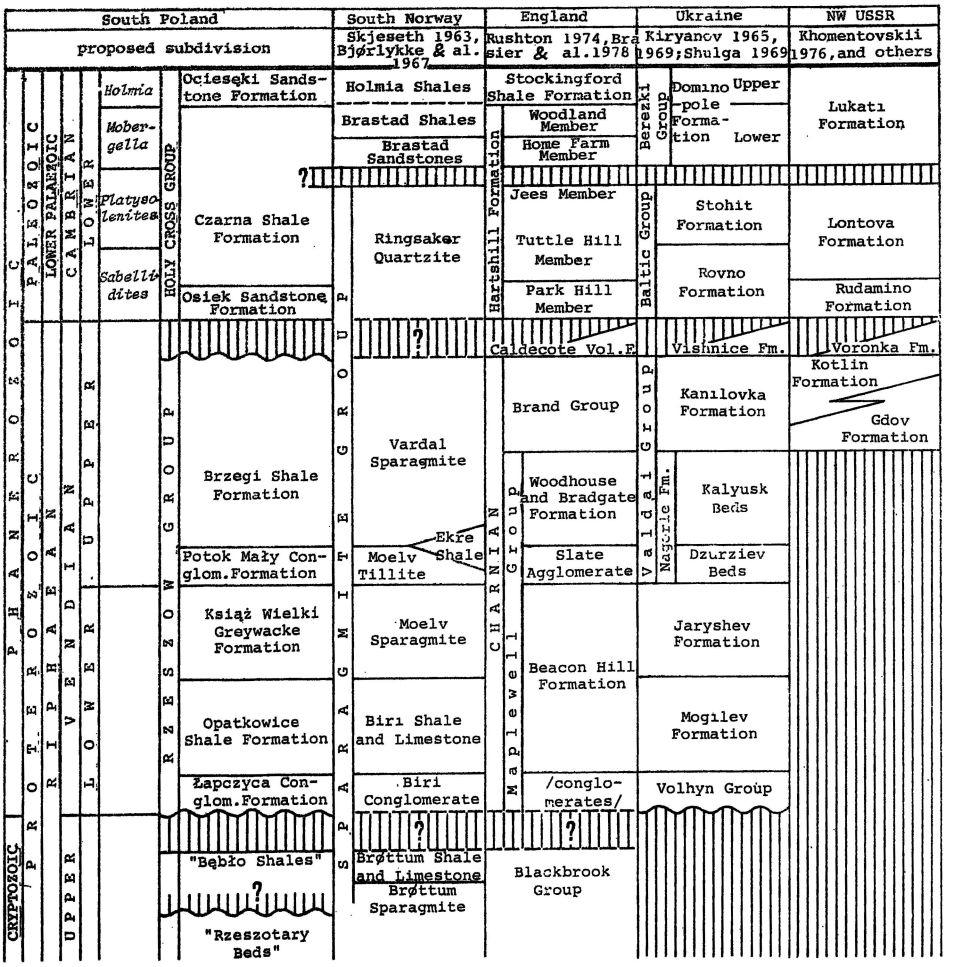
STRATIGRAPHIC CONCLUSIONS

Within the analyzed sequence several lithostratigraphic units were distinguished; five of them form the Rzeszów Group whereas the sixth one was proposed as the lowermost formation of the Holy Cross Group. At the bottom of the Rzeszów Group, the older sedimentary cycle ("Bębło Shales") was recognized in some boreholes, and it probably overlies a consolidated basement ("Rzeszotary Beds").

The Rzeszów Group is limited at the top and at the bottom by sedimentary breaks and tectonic phases: the Wieliczka and the Małopolska phase (*comp.* Pożaryski & Tomczyk 1968). The group is recognized as an equivalent of the Vendian system.

The lower boundary of the Upper Vendian is placed at the bottom of the sediments corresponding to the second glacial epoch (the bottom of the Potok Mały Conglomerate Formation).

Correlation of Upper Precambrian and lowest Cambrian sediments in Europe



The formation of the Osiek Sandstones, introduced into the Holy Cross Group (*cf.* Orłowski 1975b), is included into the Cambrian on the ground of typical Cambrian trace fossils. Also, a lower boundary of the Czarna Shale Formation can be precisely defined, as the presence of *Sabellidites cambriensis* Yanischevsky indicates the first biostratigraphic zone of the Cambrian. The Cambrian age of this formation is also proved by the occurrence of Trilobitomorpha, and of diversified assemblage of Acritarcha, algae and trace fossils.

A sedimentologic analysis of the sequences proves a terrigenic origin of the Łapczyca Conglomerates. The sediments of this formation, similarly as of the Potok Mały Conglomerate Formation, suggest a periglacial environment of deposition. The sediments of the Opatkowice Shale Formation were probably deposited in inshore environments. The sequences of the Książ Wielki Greywacke Formation, the Brzegi Shale Formation, the Osiek Sandstone Formation, and the Czarna Shale Formation have been deposited in aquatic, presumably marine environments.

PALEONTOLOGIC PART

Incertae sedis
Order **Sabelliditida** Sokolov, 1965
Family **Sabelliditidae** Sokolov, 1965
Genus *SABELLIDITES* Yanischevsky, 1926; emend. Sokolov, 1972a
Sabellidites cambriensis Yanischevsky, 1926
(Pl. 2, Figs 1, 3 and 7)

1926. *Sabellidites cambriensis* Yanischevsky; Yanischevsky, p. 102, Figs 1—5, 8, 9a,b, 10.
1940. *Sabellidites cambriensis* Janischevsky; Yanischevsky, p. 104, Fig. 91, Pl. 35, Fig. 13.
1966. *Sabellidites cambriensis* Yanischevsky; Korkutis, pp. 11—15, Figs 5—6; Pl. 1, Figs 1a—c, 2a—b; Pl. 2, Figs 1—3; Pl. 3, Figs 1a—c, 2.
1967. *Sabellidites cambriensis* Yan.; Sokolov, p. 202, Figs 1a—g, 2a—b.
1968. *Sabellidites cambriensis* Yanischevsky; Kiryanov, pp. 21—22, Pl. 3, Figs 1—2.
1971. *Sabellidites cambriensis* Yanischevsky; Korkutis, pp. 50—53, Figs 29—30, Pls 1—13.
1972a. *Sabellidites cambriensis* Yanischevsky; Sokolov, p. 81, Pl. 1, Fig. 1a—d.
1972. *Sabellidites cambriensis* Yanischevsky; Lendzion, p. 560, Pl. 1, Figs 2—4.
1974. *Sabellidites cambriensis* Ianisevski; Patrulius & Iordan, pp. 12—13, Pl. 1, Fig. 4; Pls 2—3; Pl. 4, Figs 1—2.

Material: Several badly preserved specimens from boreholes Korytnica *1* and *2* (*see* Text-fig. 4).

Description. — Flattened fragments of black tubes forming narrow bands of constant width about 0.9 mm, length up to 40 mm, composed of organic matter.

At the surface of best preserved specimens there occur fine ripples. Specimens are straight and recurvated.

Remarks. — In the investigated specimens, two assemblages of different width of flattened tubes were noted; the first one about 0.9 mm wide (*Sabellidites cambriensis* Yan.), and the other about 1.2 mm wide (cf. *Parasabellidites yanischevskyi* Sok.). The wider specimens are badly preserved. Narrow specimens are preserved much better what suggests that they had more solid walls. The possible affiliation of wider forms to *Parasabellidites yanischevskyi* is indicated by a greater width of bands and by a more subtle structure in comparison with *Sabellidites cambriensis.*

Occurrence. — Lower part of the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian. The species is known from the lowest Cambrian of the Soviet Union in the Baltic area, in the Moscow Syneclise (Lontova Fm.), in the western Ukraine (Rovno Beds), in Podolia (Chmielnik Beds), in Moldavia, and in the Siberian Platform where it occurs in the Nemakit-Daldin Fm. (Luchinina & *al.* 1978). It is also reported from north-eastern Romania (Patrulius & Iordan 1974). In Poland the species is known from the Podlasie (Lendzion 1972) and Lublin regions (Areń & *al.* 1977).

Trilobitomorpha
Group Trilobitoidea Størmer, 1959
Subgroup Merostomoidea Størmer, 1944
Merostomoidea indet.
(Pl. 4, Figs 1—4 and Pl. 5, Figs 1—3)

Material: One well preserved specimen, and possibly two other fragments from borehole Korytnica 2 (depth 74.2 m and 104.5 m).

Description. — Cephalon triangular, strongly bulged. Marginal part flattened and separated by a trough from the bulged central part. At the back there is a notch passing across the flat marginal part at the trough. It reaches the base of the bulged cephalon centre; its edges are rounded (Text-fig. 8). Flattened cephalon edge is of varying width. At the head shield there is an elongated bulge ("glabella") reaching the trough at the front and the notch at the back. This "glabella" is the widest at the front and gets narrow backwards. It has the steepest edges at the back and at the frontal end. Cephalon has strongly tucked lateral patches. The tucking seems to be of secondary origin. Probably, the primary lateral cephalon patches were steep, similarly as in *Leanchoilia superlata* Walcott, 1912 (*vide* Størmer 1959, Fig. 20, 2).

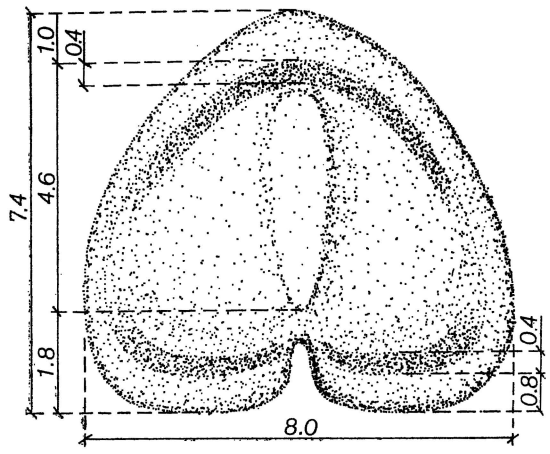


Fig. 8
Cephalon of Merostomoidea indet.; dimensions in millimeters

Preserved dorsal part of the head shield is composed of organic matter. The carapace is built of two layers of varying thickness and appearance (Pl. 4, Fig. 4a). Its surface is fine-ornamented with nods, locally arranged in parallel strips.

Remarks. — The investigated specimens are similar to those described from the Burgess Shales (Middle Cambrian) of Canada (Walcott 1912). A slight similarity

is revealed in the structure of the head part to the genera *Emeraldella* Walcott and *Leanchoilia* Walcott, the cephalons of which are strongly bulged and of triangular shape.

Occurrence. — Sabellidites Zone, Lower Cambrian.

Group **Vendotaenides** Gnilovskaja, 1971

Genus *VENDOTAENIA* Gnilovskaja, 1971

Vendotaenia major sp. n.

(Pl. 3, Figs 3—5)

Holotype: The specimen illustrated in Pl. 3, Fig. 3.
Stratigraphic position: Lower part of the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian.
Type locality: Korytnica near Raków (borehole Korytnica 2: depth 48.00 m).
Derivation of the name: After Latin *major* — large.
Material: Over 10 specimens.
Diagnosis: Fossils of strip shape, 5—8 mm wide, several centimetres long.

Description. — Thallus is straight or slightly curved, up to 8 mm wide, with distinct and parallel edges. Black or brown in color. On the surface there are darker, thread-like strips, mainly of longitudinal course.

Remarks. — The investigated specimens differ from *Vendotaenia antiqua* Gnilovskaja by a considerably greater width of thallus and by the presence of thread-like elements on the wall surface.

Occurrence. — Czarna Shale Fm., Sabellidites Zone, Lower Cambrian. Remains of similar algae have been found in sediments of the "Sub-Holmia zone" (borehole Bazów *IG-1*) of the southern Holy Cross Mts (Żakowa & Jagielska 1970). Similar forms have also been noted in the Upper Yudomian of the Siberian Platform (Sokolov 1975).

Genus *TYRASOTAENIA* Gnilovskaja, 1971

Tyrasotaenia podolica Gnilovskaja, 1971

(Pl. 3, Fig. 1a—b)

1971. *Tyrasotaenia podolica* Gnilovskaja, sp. nov.; Gnilovskaja, pp. 106—107, Pl. 11, Figs 1—5.
Material: 10 specimens.

Description. — Thallus forms thin straight or curved strips up to several centimetres long, about 0.5 mm wide, black or brown in color.

Occurrence. — Uppermost Vendian and probably lowest Cambrian of the Ukraine and Moldavia (Gnilovskaja 1971, 1976); in Poland — "Sub-Holmia zone", Lower Cambrian (borehole Radzyń, Lendzion 1972, Areń & Lendzion 1974), and lower part of the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, southern Holy Cross Mts, Kotuszów area.

Genus *PILITELA* Aseeva, 1976

Pilitela composita Aseeva, 1976

(Pl. 3, Fig. 2a—b)

1976. *Pilitela composita* Aseeva, sp. nov.; Aseeva, p. 58, Pl. 20, Figs 3—5.
Material: One specimen well preserved and a number of fragments.

Description. — Shaggy bunch formed of thalluses starting at a common base Thalluses about 15 mm long, 0.2 mm wide, black in color, alternating one another.

Occurrence. — Upper Vendian of Podolia (Aseeva 1976) and the lower part of the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, south-eastern Holy Cross Mts (borehole Korytnica 2).

Genus *THALLULUS* gen. n.
Type species *Thallulus carnosus* sp. n.

Derivation of the name: After Latin *thallus.*
Diagnosis: Thallus flat, leaf-shaped, 40—50 mm long, more narrow at the bottom (5 mm) and widened towards the top (14 mm) where it is oval-ended; basal part (probably a basal discus) slightly widened.

Remarks. — The new genus *Thallulus* differs from the other genera of Vendotaenides by a thallus habit and its considerable thickness.

Occurrence. — Sabellidites Zone, Lower Cambrian.

Thallulus carnosus sp. n.
(Pl. 3, Figs 6—7)

Holotype: The specimen presented in Pl. 3, Fig. 6.
Stratigraphic position: Lower part of the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian.
Type locality: Korytnica near Raków (borehole Korytnica 2: depth 24.90 m).
Derivation of the name: After Latin *carnosus* — obese.
Material: Two well preserved specimens.
Diagnosis: As for the genus.

Remarks. — One of thalluses is curved in its lower part, at the narrowing (Pl. 3, Fig. 7).

Incertae sedis
Group **Acritarcha** Evitt, 1963
Subgroup **Acanthomorphitae** Downie, Evitt & Sarjeant, 1963
Genus *BALTISPHAERIDIUM* Eisenack, 1958; emend. Downie & Sarjeant, 1963
Baltisphaeridium ornatum Volkova, 1968
(Pl. 7, Fig. 1a—b)

1968. *Baltisphaeridium ornatum* Volkova, sp. nov.; Volkova, pp. 18—19, Pl. 1, Figs 10—14; Pl. 11, Fig. 1.
?1971. *Baltisphaeridium* cf. *ornatum* Volkova; Fridrichsone, p. 10, Pl. 1, Fig. 7.
1974a. *Baltisphaeridium ornatum* Volk.; Volkova, Pl. 1, Fig. 3,.
Material: Six specimens.

Description. — The investigated specimens are oval, yellowish in color, flattened, about 60 μm diameter, with indistinct crumplings. The central body contains numerous outgrowths composed of a very thin, colorless membrane. The outgrowths are slightly widened towards their ends creating a flocculosus coat around the central body. At the body surface there are fine rolls, 1 to 3 μm long, about 0.2 μm wide, chaotically arranged and of straight or wavy course (Pl. 7, Fig. 1b).

Remarks. — The investigated specimens differ from those described by Volkova (1968) by the irregular arrangement of rolls on the central body surface.

Occurrence. — Upper part of the Lontova Fm., Lower Cambrian (Volkova 1968, Fridrichsone 1971) and the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, southern Holy Cross Mts (borehole Korytnica 2).

Subgroup **Sphaeromorphitae** Downie, Evitt & Sarjeant, 1963
Genus *LEIOSPHAERIDIA* Eisenack, 1958
Leiosphaeridia sp. div.

Material: Several hundred specimens.

Description. — The investigated specimens are devoid of the inner body. They are completely or partially flattened, yellow, red or brown in color, 40—125 μm diameter. The walls, 1 to 2 μm thick, are sculptured by folds, the number of which is dependent on the wall thickness.

Remarks. — Within the genus *Leiosphaeridia* the species are usually distinguished basing on two features: specimen diameter and wall thickness. In result there are many taxa of similar definitions. A subdivision into types *A*, *B* and *C* by Volkova (1964, 1973) is also charged with subjectivism.

Occurrence. — Single specimens occur in the Brzegi Shale Fm. (Upper Vendian) and numerous in the Czarna Shale Fm. (Sabellidites Zone, Lower Cambrian).

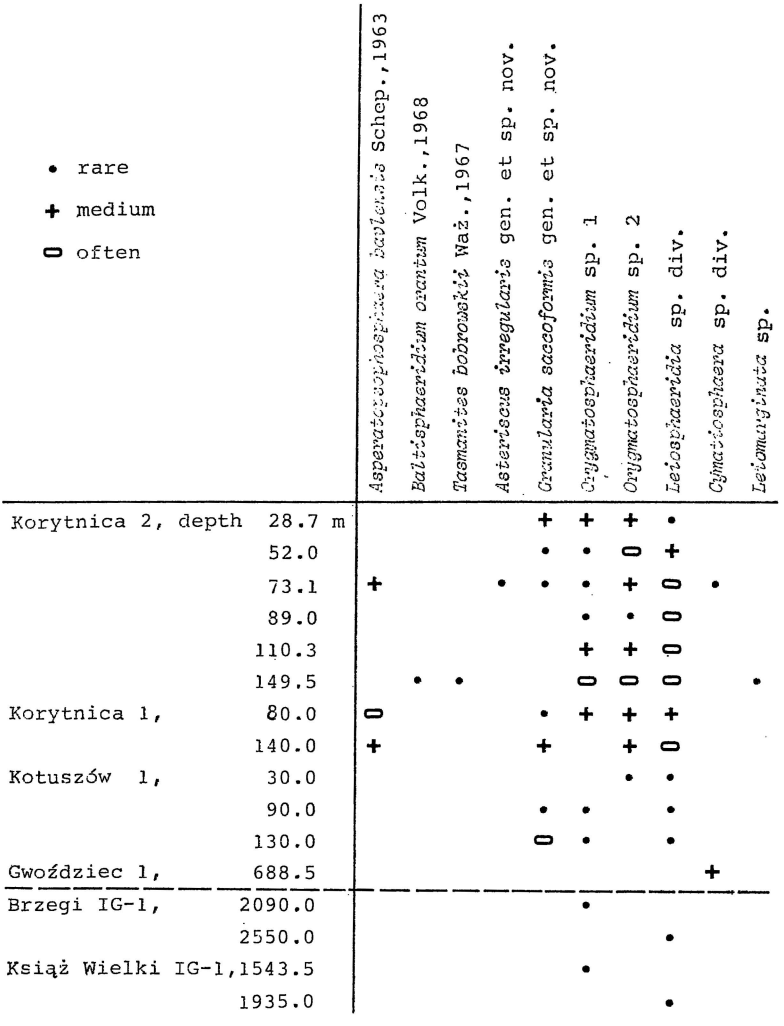


Fig. 9. Occurrence of Acritarcha in samples

Genus *LEIOMARGINATA* Naumova, 1960
Leiomarginata sp.
(Pl. 9, Fig. 5)

Material: About 25 specimens.

Description. — The investigated specimens are oval or elongated, 37—70 μm (usually about 50 μm in diameter), light-yellow in color, with a darker narrow (4 μm wide) swell without ornamentation. Crumpled forms have irregular swells accompanied by numerous fine folds. Central part is composed of thin membrane without ornamentation.

Remarks. — The specimens *Leiomarginata* sp. differ from *L. simplex* by their larger dimensions. Similar forms are also presented by Khizhniakov & Shepeleva (1964, Table 4, Figs 5—6).

Occurrence. — Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, south-eastern Holy Cross Mts, Kotuszów area.

Genus *ASPERATOPSOPHOSPHAERA* Shepeleva, 1963; emend.
Type species *Asperatopsophosphaera bavlensis* Shepeleva, 1963

Emended diagnosis: Specimens ovally elongated, yellow to dark-brown in color; the surface featured with numerous holes and depressions, usually of irregular contours; dimensions vary from 30 to 220 μm.

Remarks. — The genus *Archaeopsophosphaera* Naumova, 1968, is a synonym of *Asperatopsophosphaera* Shepeleva, 1963. Problems concerning mutual relations between genera *Asperatopsophosphaera* and *Orygmatosphaeridium* are discussed by Aseeva (1976; *comp. also* Chepikova 1971, Rudavskaja 1974, Piatiletov 1977).

Occurrence. — Upper Riphaean till Lower Cambrian (Shepeleva 1963, 1973; Naumova 1968, 1974; Chepikova 1971; Iltchenko 1972; Bogomjagkova 1973; Aseeva 1976).

Asperatopsophosphaera bavlensis Shepeleva, 1963; emend.
(Pl. 11, Fig. 2)

1963. *Asperatopsophosphaera bavlensis* sp. nov.; Shepeleva, p. 15, Pl. 2, Figs 7—8.
1963. *Asperatopsophosphaera partialis* sp. n.; Shepeleva, p. 15, Pl. 2, Fig. 9.
1964. *Asperatopsophosphaera partialis* Shep.; Khizhniakov & Shepeleva, Pl. 2, Fig. 3; Pl. 3, Figs 3—5.
1968. *Archaeopsophosphaera asperata* Naum.; Naumova, p: 37, Pl. 2, Fig. 14.
1971. *Archaeopsophosphaera sinuosa* Chepikova, sp. nov.; Chepikova, pp. 61—62, Pl. 1, Figs. 1—3.
1972. *Asperatopsophosphaera bavlensis* Shep.; Iltchenko, Pl. 2, Fig. 16.
1972. *Asperatopsophosphaera partialis* Shep.; Iltchenko, Pl. 2, Fig. 21.
1972. *Asperatopsophosphaera magna* Shep.; Iltchenko, Pl. 2, Figs 22 and 27.
1976. *Asperatopsophosphaera partialis* Shepeleva; Aseeva, p. 51, Pl. 7, Figs 1—6.
1976. *Asperatopsophosphaera bavlensis* Shepeleva; Aseeva, p. 51, Pl. 8, Fig. 1; Pl. 9, Fig. 1.

Material: Several dozen specimens.
Emended diagnosis: As for the genus.

Description. — In the optical microscope, investigated specimens display a porous-spongy structure, but in the scanning electron microscope they exhibit a distinct wall with numerous depressions and irregular holes of oval shape and variable size. Specimen thickness is about 5 μm. The color depends on oxidation degree of organic matter, and it changes from yellow to black.

Remarks. — The other species of the genus (Shepeleva 1963, Khizhniakov & Shepeleva 1964, Chepikova 1971) were distinguished on the specimen diameter and

degree of translucency through the walls. The present studies have revealed continuous size varieties of specimens and a unified wall structure of specimens of varying diameter (*cf.* Aseeva 1976).

Occurrence. — Upper Riphaean (Pachelma Group, Naumova 1968, 1974; Khizhniakov & Shepeleva 1964), Vendian (Aseeva 1976) and lowest Cambrian (Baltic Group, Rovno Fm.; Naumova 1968, 1974); very numerous in the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, south-eastern Holy Cross Mts, Kotuszów area.

Genus *GRANULARIA* gen. n.

Type species *Granularia saccoformis* sp. n.

Derivation of the name: After Latin *granula* — grain.
Diagnosis: Specimens oval, opaque, 120 μm diameter, from yellow to black in colors; the swells at the surface create a granulated ornamentation resulting from coverage of fine globules (diameter of 7.5 μm) by a wall membrane.

Remarks. — The genus *Granularia* differs from *Zonosphaeridium* and *Lophoritidodiacrodium* by its ornamentation. A certain similarity, although limited to the studies with an optical microscope, is displayed to *Asperatopsophosphaera*; in an electron microscope these genera differ distinctly.

Occurrence. — Sabellidites Zone, Lower Cambrian.

Granularia saccoformis sp. n.
(Pl. 6, Fig. 1a—b)

Holotype: The specimen presented in Pl. 6, Fig. 1a—b.
Stratigraphic position: Czarna Shale Fm., Sabellidites Zone, Lower Cambrian.
Type locality: Korytnica near Raków (borehole Korytnica 2; depth 73.1 m).
Derivation of the name: After Latin *saccus* — sack, and *forma* — shape.
Material: About 30 specimens.
Diagnosis: As for the genus.

Description. — The investigated specimens are oval (diameter from 100 to 130 μm), opaque and brown in color. The edge zone is most flattened what results in numerous, narrow ripples parallel to the edge. In the central part, under the membrane, there are the globules resistant to smashing.

Subgroup **Herkomorphitae** Downie, Evitt & Sarjeant, 1963
Genus *ORYGMATOSPHAERIDIUM* Timofeev, 1959

Type species *Orygmatosphaeridium ruminatum* Timofeev, 1959

Supplemented diagnosis: Microfossils from yellow to dark-brown color, oval (diameter from 20 to 250 μm), lenticularly flattened and of a spongy, uniform structure; the surface sculptured by numerous, irregular holes, depressions, and short outgrowths; contours irregular, tattered.

Remarks. — The genus *Orygmatosphaeridium* differs from *Asperatopsophosphaera* by its surface structure and lenticular flattening of specimens.

The wall structure makes a difference between the genera *Orygmatosphaeridium* and *Bavlinella* (Vidal 1976; *comp. also* Shepeleva 1962, Timofeev 1969). The genera *Spumiosa* and *Spumosina* introduced by Naumova (1968) are probably the synonyms of *Orygmatosphaeridium* (see Chepikova 1971). Rudavskaja (1974) considered *Spumiosa* for a later synonym of *Orygmatosphaeridium*, and *Spumosina* for a taxon without sufficient documentation.

Occurrence. — Riphaean till Silurian (Timofeev 1973).

Orygmatosphaeridium sp. *1*
(Pl. 9, Fig. 4 and Pl. 10, Figs 1—2)

Material: Several dozen specimens.

Description. — The investigated specimens are oval-shaped, seldom slightly irregular, with irregular, tattered contours, yellow, 20 to 100 (?) μm in diameter. The structure is sponge-like. The outgrowths at the specimen surface are from 1 to about 3 μm long.

Remarks. — Similar specimens have been presented as *Orygmatosphaeridium* by Medvedeva & Kusovleva (1974) from the Bavlin Group, Upper Vendian.

Occurrence. — Książ Wielki Greywacke Fm. and the Brzegi Shale Fm., Vendian, basement of the Carpathian Foredeep, and the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, south-eastern Holy Cross Mts.

Orygmatosphaeridium sp. *2*
(Pl. 9, Fig. 2 and Pl. 11, Fig. 1)

Material: Several dozen specimens.

Description. — The investigated specimens are oval-shaped, yellow to brown in color, 40 to 200 μm in diameter. The structure is sponge-like with irregular depressions (2—5 μm) separated by tattered, irregular walls. Specimen contours are uneven and tattered.

Remarks. — The taxon differs from *Orygmatosphaeridium* sp. *1* by larger elements of the structure.

Occurrence. — Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, south-eastern Holy Cross Mts, Kotuszów area.

Genus *ASTERISCUS* gen. n.
Type species *Asteriscus irregularis* sp. n.

Derivation of the name: After Latin *aster* — star.
Diagnosis: Specimens of irregular oval shape, about 60 μm in diameter; radial swells spread from the centre, connected with a thin membrane in which there are oblong holes between the swells; whole surface covered with numerous fine nodules.

Occurrence. — Sabellidites Zone, Lower Cambrian.

Asteriscus irregularis sp. n.
(Pl. 6, Fig. 2a—b)

Holotype: The specimen presented in Pl. 6, Fig. 2a.
Stratigraphic position: Czarna Shale Fm., Sabellidites Zone, Lower Cambrian.
Type locality: Korytnica near Raków (borehole Korytnica 2: depth 73.1 m).
Derivation of the name: After Latin *irregularis* — irregular.
Material: Four specimens.
Diagnosis: As for the genus.

Description. — The investigated specimens of irregular oval shape, with distinct swells spreading from their central part, 60 μm in diameter. Central part of specimens as well as the radii are dark-yellow. Swells are connected with a subtle, yellow membrane. Patches of membrane connect several neighboring swells each. In the membrane between the swells there are oblong holes, up to 5—6 μm long and to 2—3 μm wide. Specimen surface is covered with small nodules about 2 μm in diameter.

Remarks. — Numerous radial swells are similar (in the optical microscope, at low magnification) to those of *Baltisphaeridium compressum* Volkova and *B. ornatum* Volkova.

Genus *CYMATIOSPHAERA* O. Wetzel, 1933; emend. Deflandre, 1954

Cymatiosphaera sp. div.

(Pl. 7, Figs 2—3)

Material: About 15 specimens.

Description. — The specimens are oval-shaped, with outgrowths forming slats that divide the specimen surface into polygonal fields; membrane surface in these fields is smooth. Specimen color is dark-yellow to brown.

Occurrence. — Czarna Shale Fm., Sabellidites Zone, Lower Cambrian.

Subgroup **Tasmanititae** Staplin, Jansonius & Pocock, 1965

Genus *TASMANITES* Newton, 1875

Tasmanites bobrowskii Ważyńska, 1967

(Pl. 8, Fig. 1a—b)

1967. *Tasmanites bobrowskii* n. sp.; Ważyńska, pp. 14—15, Pl. 3, Figs 23—27, Pl. 4, Fig. 28.
1968. *Tasmanites variabilis* Volkova, sp. nov.; Volkova, p. 29, Pl. 5, Figs 9—12, Pl. 11, Fig. 9.
1974b. *Tasmanites variabilis* Volkova; Volkova, Pl. 9, Fig. 13.
Material: About 15 specimens.

Description. — The investigated specimens are oval-shaped, from yellow to brown in color, flattened, about 120 μm diameter. At the surface there are large folds formed in result of crumpling and numerous fine pores (0.8 μm in diameter), located at a distance of about 5 μm one from the other.

Remarks. — The species differs from the other taxa of the genus by distribution of pores and thicknes of walls.

Occurrence. — Platysolenites and Holmia Zones, Lower Cambrian, eastern Poland (Ważyńska 1967), Baltic region of the Soviet Union (Volkova 1968, 1973; Jankauskas & Posti 1976; Bogomjagkova 1973), and lower part of the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian in southern Poland.

Problematicum

(Pl. 10, Fig. 1a—c)

Material: Many specimens.

Description. — Spherical forms of varying diameter (10—100 μm), black in color. On their surface there appear holes and furrows of varying dimensions. Specimens composed of fragile matter, but resistant to hydrofluoric acid.

Occurrence. — Brzegi Shale Fm., Upper Vendian and lower part of the Czarna Shale Fm., Sabellidites Zone, Lower Cambrian.

TRACE FOSSILS

In the analyzed sequence, the trace fossils were found (*see* Text-fig. 6) within three formations (Kowalski, *in prep.*).

Within the Brzegi Shale Fm., the exichnial burrow casts (*Gordia* sp.) and epichnial grooves occur occasionally, mainly in the upper part of

the sequence. A trace-fossil assemblage was formed by the animals of primitive mode of moving and feeding.

The more diversified ichnocoenoses were noted within the Cambrian sediments. Within the Osiek Sandstone Fm., there occur such hypichnia as: *Phycodes* sp., *Planolites ballandus* Webby, and *P. nematus* Kowalski. Within the overlying Czarna Shale Fm. there appear both the hypichnia and epichnia, as follows: *Oldhamia antiqua* Kinahan (in the Kotuszów Shale Member), *Planolites ballandus* Webby, *P. montanus* Richter, ?*Palaeophycus* sp., ?*Bunyerichnus* sp., and ?*Monocraterion* sp. The presence of *Phycodes* and *Oldhamia* within the Osiek and Czarna formations proves their Cambrian age (*cf.* Glaessner 1969, Cowie & Spencer 1970, Orłowski 1975b, Alpert 1977, Fedonkin 1977).

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W. R. KOWALSKI

STRATYGRAFIA OSADÓW GÓRNEGO PREKAMBRU I NAJNIŻSZEGO KAMBRU POLSKI POŁUDNIOWEJ

(Streszczenie)

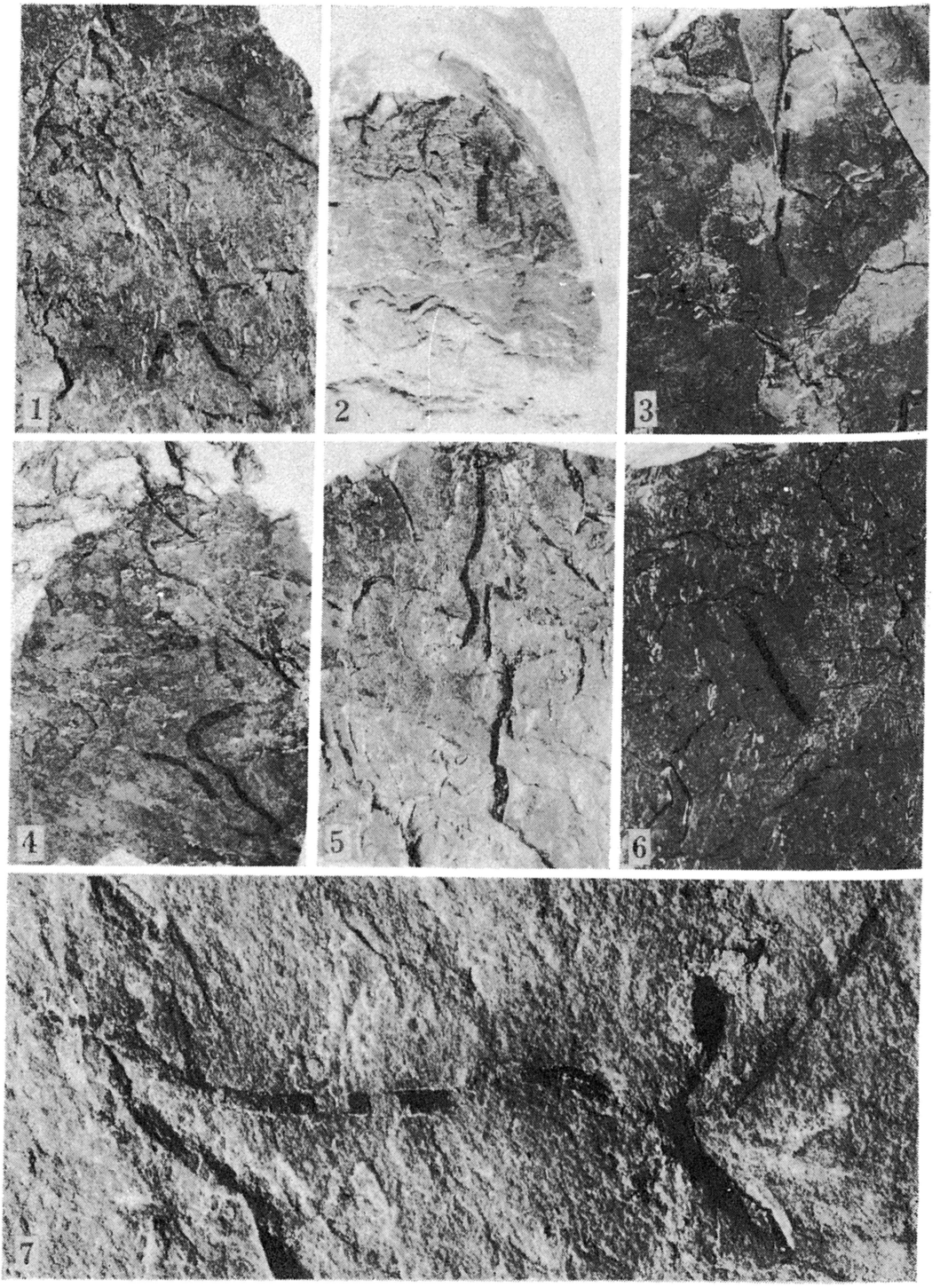
Utwory wendu występujące w podłożu Polski południowej (*patrz* fig. 1—2 oraz tab. 1) przykrywają niezgodnie (faza wielicka) podłoże zbudowane ze skał zmetamorfizowanych („warstwy rzeszotarskie", Pożaryski & Tomczyk 1968) i osadowych („łupki z Bębła"). System wendyjski reprezentowany jest przez urozmaiconą sekwencję skalną należącą do jednego cyklu sedymentacyjnego (fig. 5). W obrębie tej sekwencji wyróżniono 5 formacji tworzących grupę rzeszowską. Dwie z nich, reprezentowane przez zlepieńce, uznano za równowiekowe ze zlodowaceniami wendyjskimi (*por.* Chumakov 1974, 1978). W stropie sekwencji znaleziono ślady żerowania prymitywnych organizmów, a w niektórych formacjach tej grupy również nieliczne Acritarcha (*patrz* fig. 6 oraz 9).

Skały grupy rzeszowskiej przykryte są z niezgodnością tektoniczną (faza małopolska, Pożaryski & Tomczyk 1968) przez skały grupy świętokrzyskiej (*por.* Orłowski 1975b). Grupa ta uzupełniona została o formację piaskowców z Osieka (fig. 4), której kambryjski wiek dokumentują ślady działalności życiowej organizmów (*patrz* fig. 6). Obecność skamieniałości w obrębie spągowej części formacji łupków Czarnej (*patrz* fig. 3 oraz pl. 1 i 12) dokumentuje jej przynależność również do najniższego poziomu biostratygraficznego dolnego kambru (fig. 8 oraz pl. 2—11).

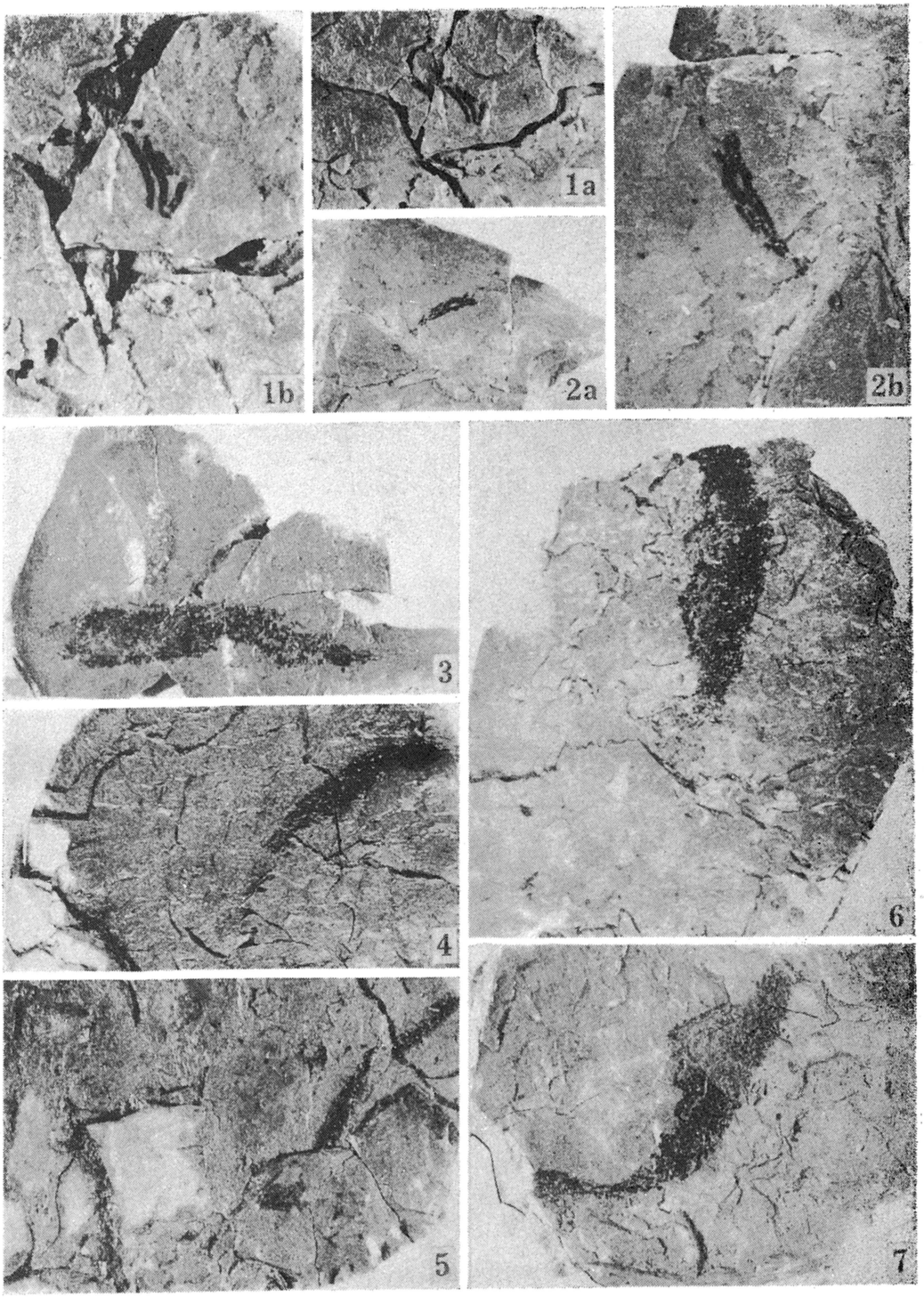
Opisaną sekwencję wendu i najniższego kambru porównano z profilami izochronicznych osadów innych obszarów Polski (fig. 7) oraz Europy (tab. 2).

1 — Heap of silty shales and sandstones (Brzegi Shale Fm., Upper Vendian) around an old pit at Słońce Hill, near Chmielnik

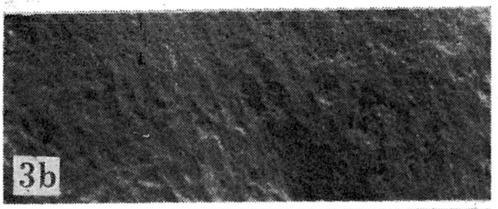
2 — Exposure of sandstones and silty shales near Kurozwęki, Osiek Sandstone Fm., Lower Cambrian

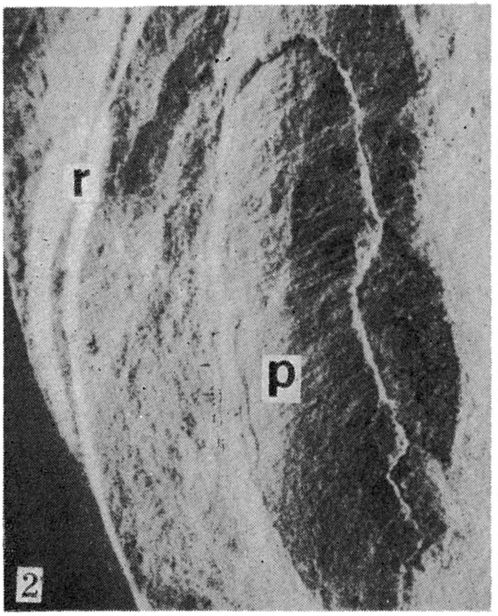


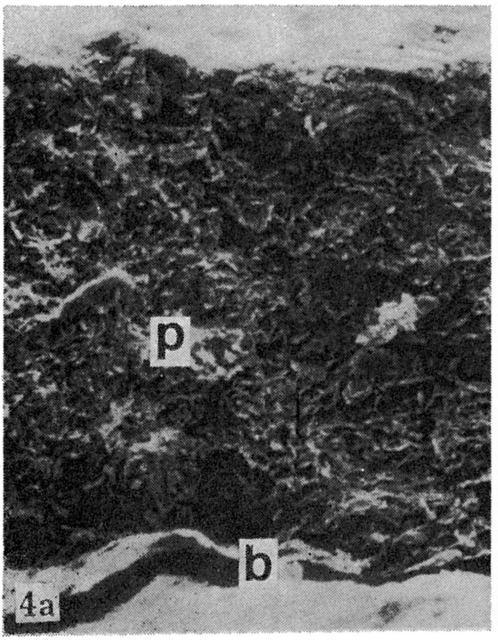
1 — *Sabellidites cambriensis* Yan., and cf. *Parasabellidites yanischevskyi* Sok.; Korytnica *2:* 56.3 m; **2** and **4—6** — cf. *P. yanischevskyi* Sok.; Korytnica *2*: *2* — 61.2 m, *4* — 56.3 m, *5* — 60.3 m, *6* — 73.1 m; **3** — *S. cambriensis* Yan., Korytnica *2*: 78.9 m; **7** — *S. cambriensis* Yan., Korytnica *1*: 20.0 m; Czarna Shale Fm., Sabellidites Zone, Lower Combrian; All nat. size, except Fig. 7 taken × 4

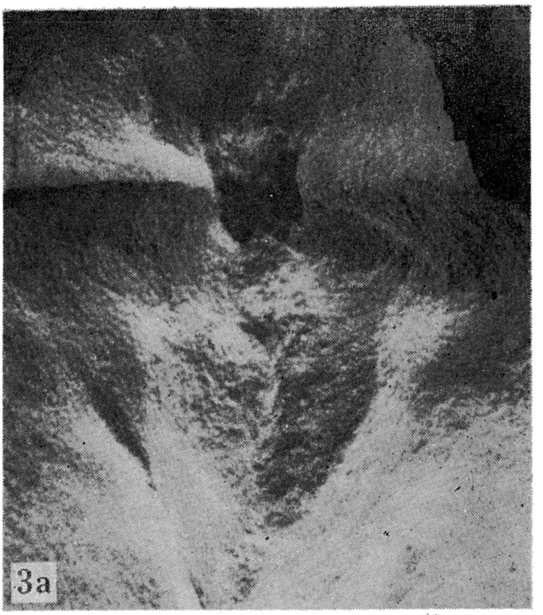


1 — *Tyrasotaenia podolica* Gnil., **2** — *Pilitela composita* Aseeva, **3—5** — *Vendotaenia major* sp. n. (*3* — holotype), **6—7** — *Thallulus carnosus* gen. & sp. n.; Czarna Shale Fm., Sabellidites Zone, Lower Cambrian; Korytnica *2*: *1* — 110.3 m, *2* — 52.1 m, *3* — 48.0 m, *4* — 58.4 m, *5* — 137.1 m, *6* — 24.9 m, *7* — 110.6 m; All nat. size, except 1b, 2b taken × 2

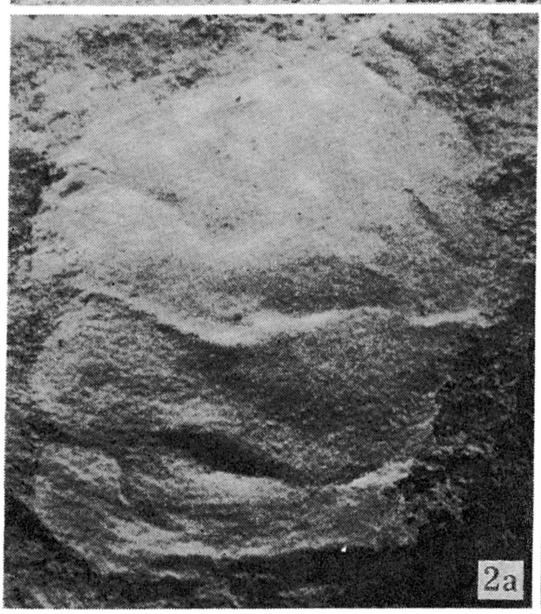


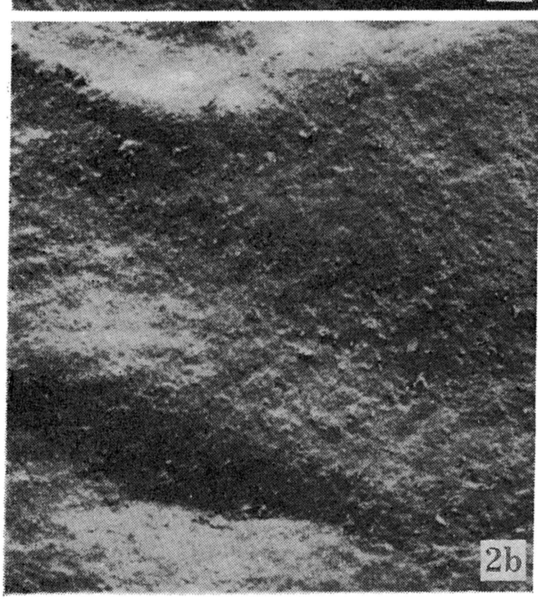




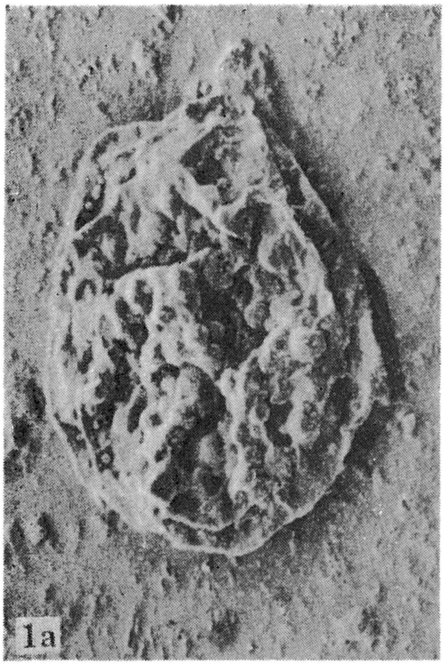


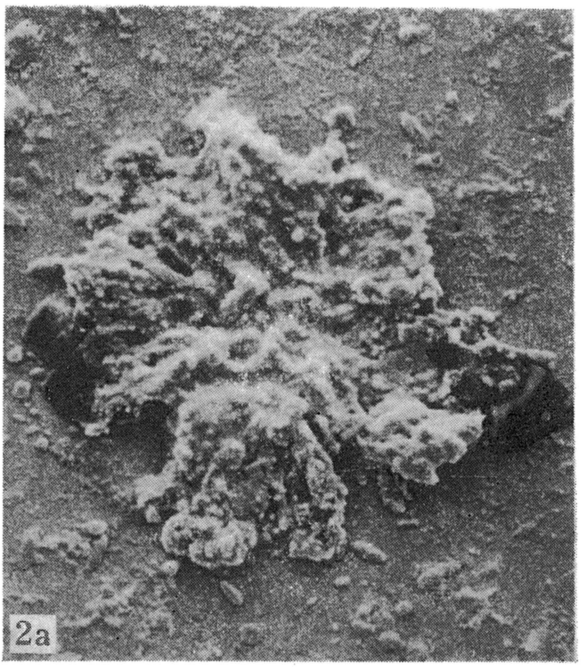
Merostomoidea indet.: 1 — cephalon with tucked lateral lobes; × 10, refl. light; 2 — view from underneath (*p* — print of inner ornamentation, *r* — right lobe), × 30; 3a — frontal part of the cephalon, × 30; 3b — ornamentation of carapace, × 100; 4a — carapace section, × 1000, bottom (*b*) and principal (*p*) layers; 4b — × 3000; Czarna Shale Fm., Sabellidites Zone, Lower Cambrian; Korytnica 2: 74.2 m; Figs 2—4 are SEM

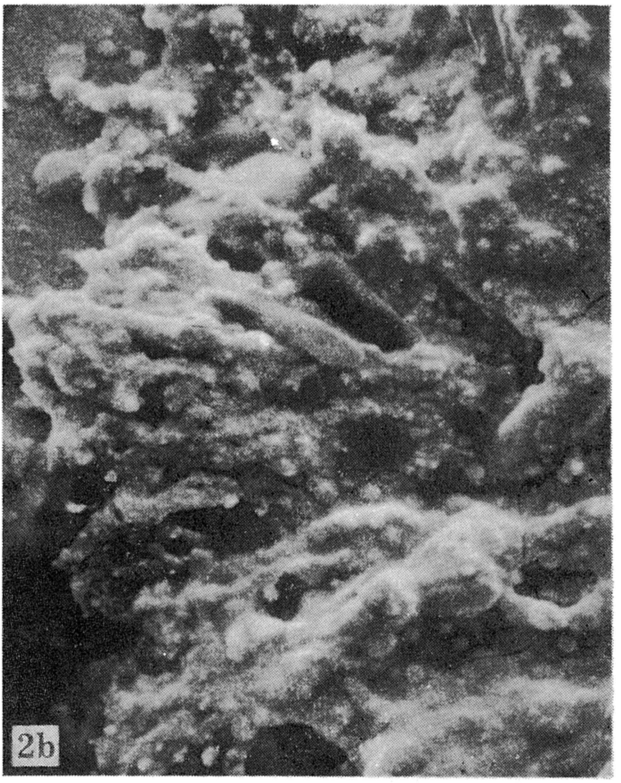




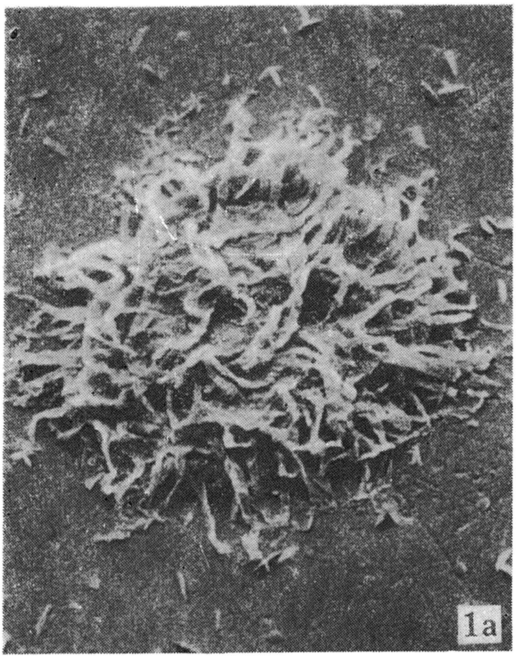
Carapace fragments of Merostomoidea indet.: **1** — × 6, refl. light; **2a, 3a** — × 30, SEM; **2b, 3b** — ornamentation, × 1000, SEM; Czarna Shale Fm., Sabellidites Zone Lower Cambrian; Korytnica 2: 104.5 m

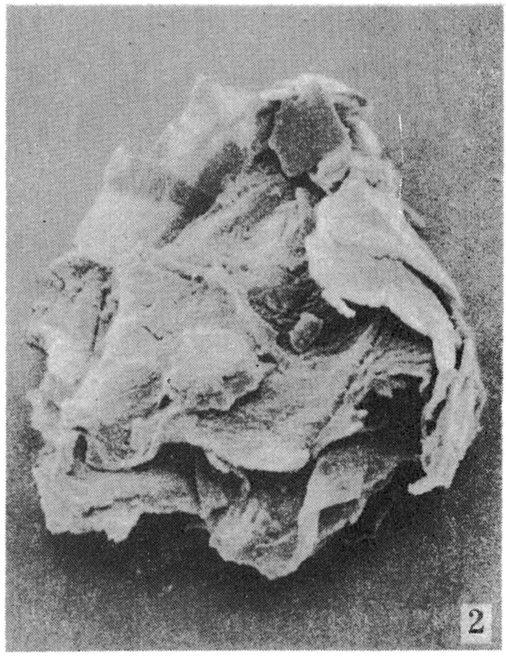


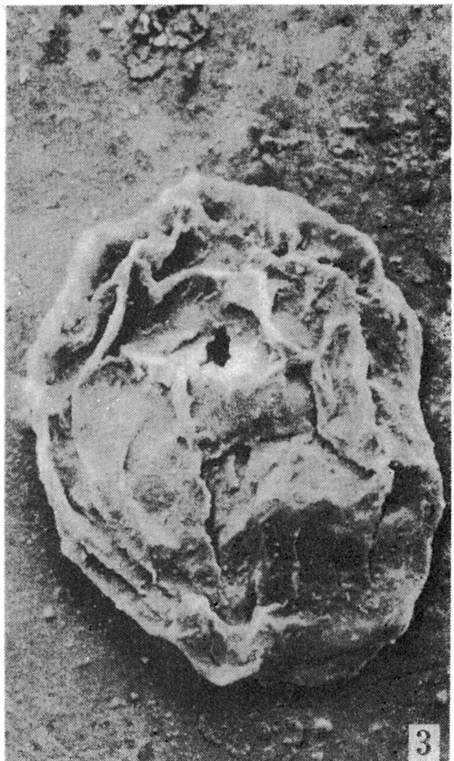




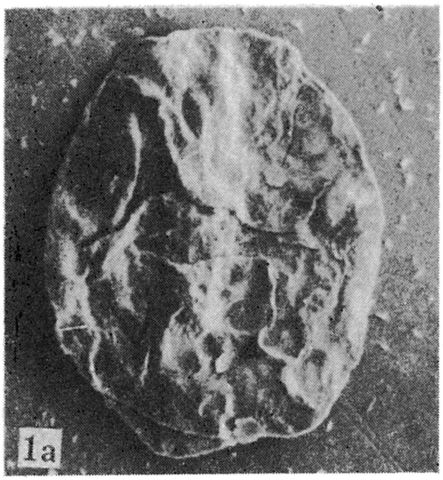
1 — *Granularia saccoformis* gen. & sp. n.; *1a* — × 450, *1b* — × 2000. **2** — *Asteriscus irregularis* gen. & sp. n.; *2a* × 1000, *2b* — × 3000;
Czarna Shale Fm., Sabellidites Zone, Lower Cambrian; Korytnica *2*: 73.1 m; All SEM

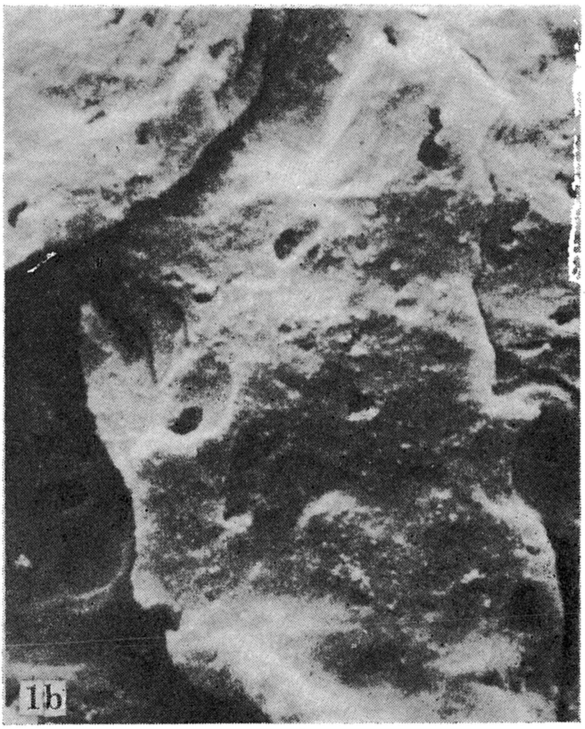


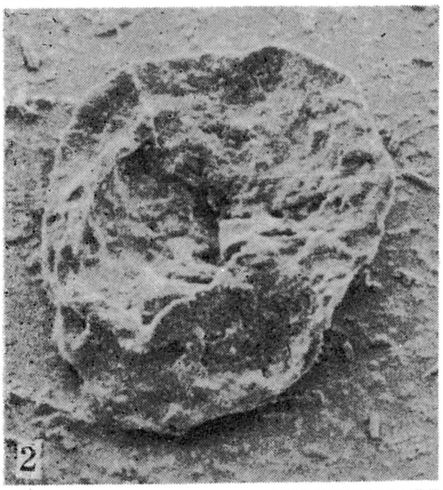


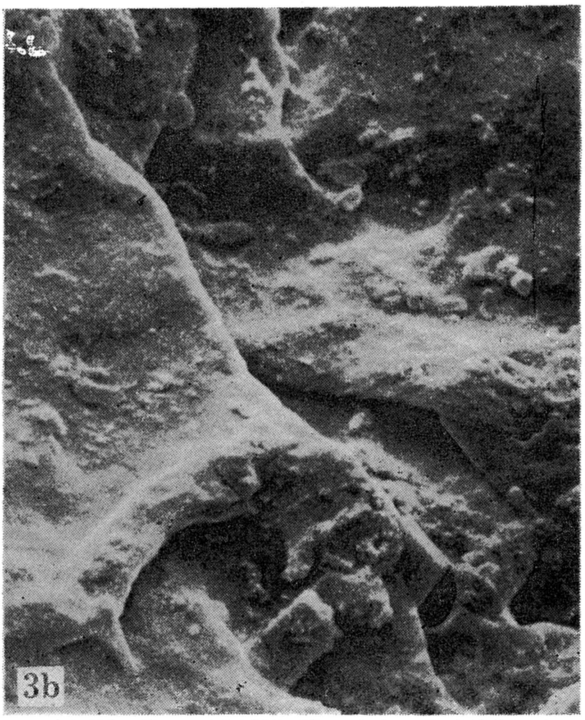


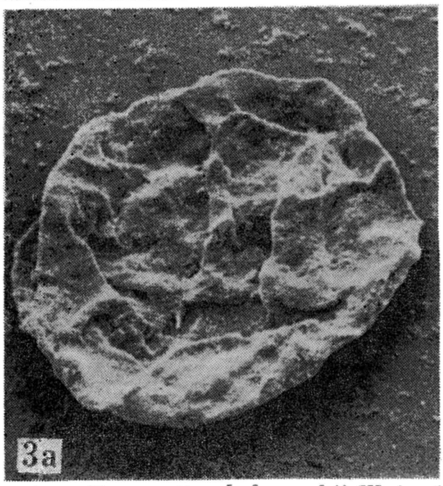
1 — *Baltisphaeridium ornatum* Volk., Korytnica 2: 149.5 m. **2** — *Cymatiosphaera* sp., Korytnica *2*: 73.1 m. **3** — *Cymatiosphaera* sp., Gwoździec *1*: 672.5—697.0 m; Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, *3* — Kotuszów Shale Mem.; All × 1000, except 1b — × 3000; SEM



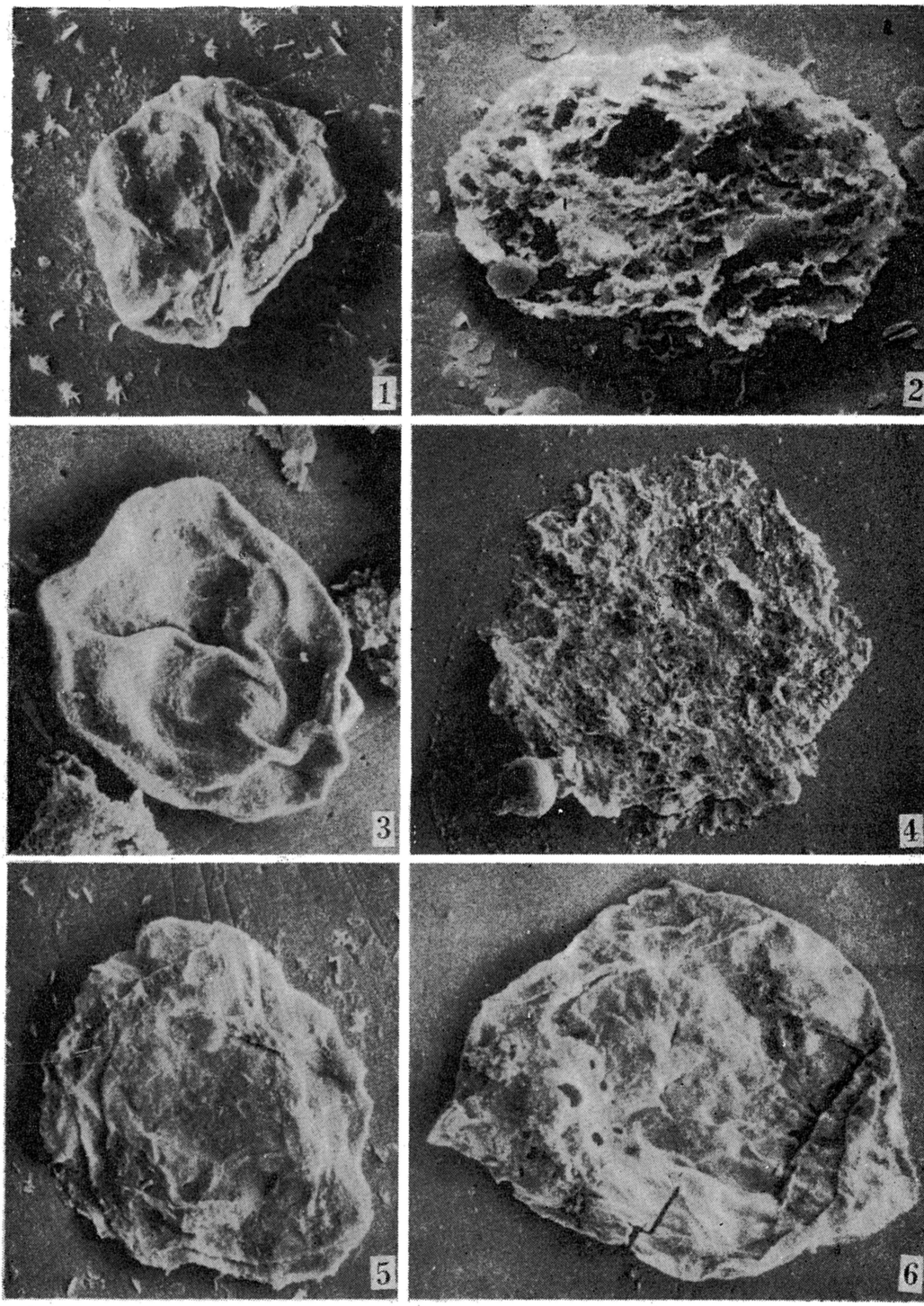




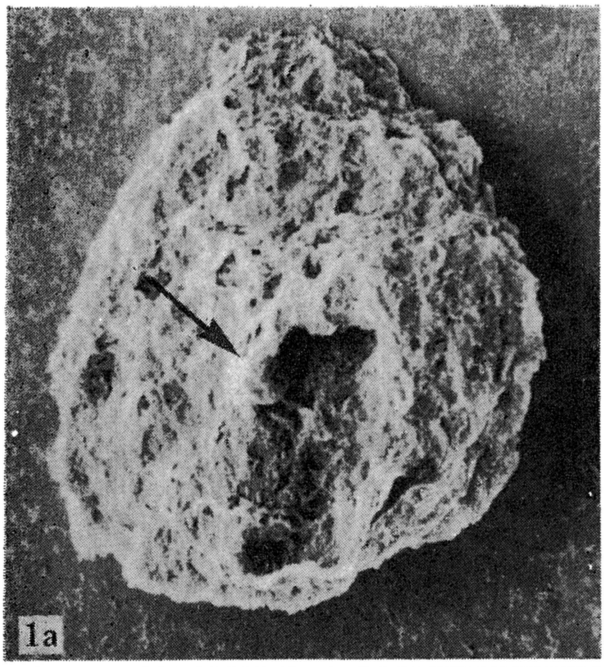


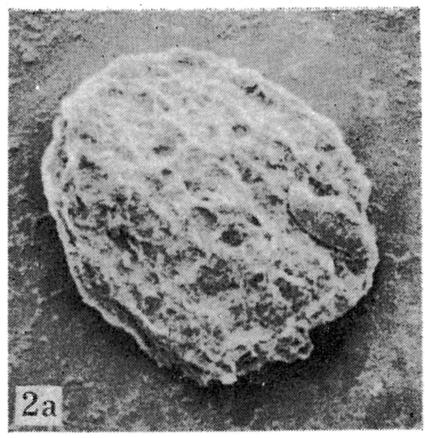


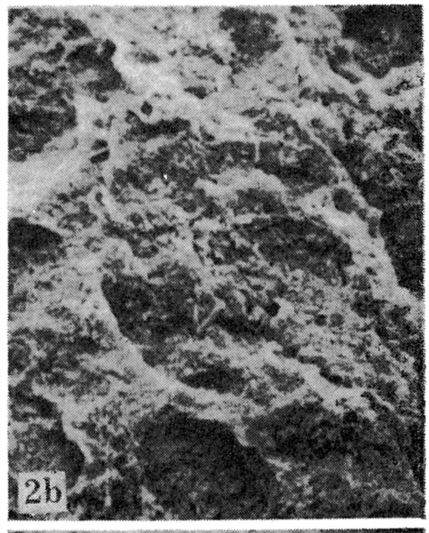
1 — *Tasmanites bobrowskii* Waż.; *1a* — × 450, *1b* — × 4500; Korytnica *2*: 149.5 m.
2 — *Leiosphaeridia* sp. (type *A*); × 450, Korytnica *1*: 140.0 m. 3 — *Leiosphaeridia* sp. (type *A*); *3a* × 450, *3b* × 2000; Korytnica *2*: 73.1 m;
Czarna Shale Fm., Sabellidites Zone, Lower Cambrian; All SEM

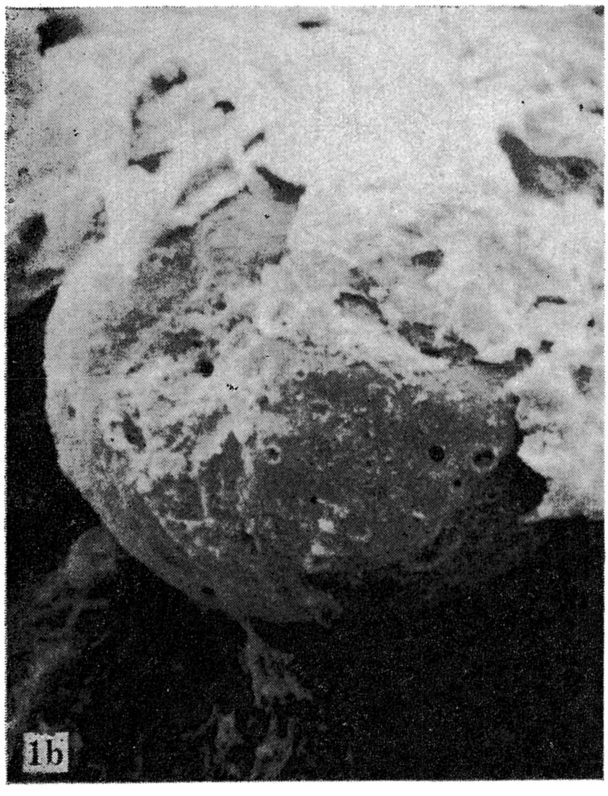


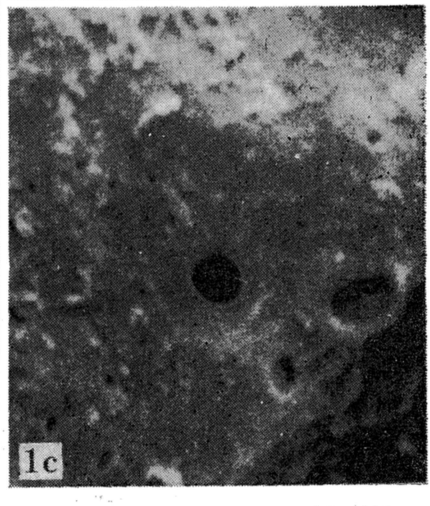
1 — *Leiosphaeridia* sp. (type *B*), Korytnica *2*: 149.5 m. 2 — *Orygmatosphaeridium* sp. *2*, Korytnica *1*: 149.5 m. 3 — *Leiosphaeridia* sp. (type *C*), Korytnica *1*: 140.0 m. 4 — *Orygmatosphaeridium* sp. *1*, Kotuszów *1*: 90.0 m. 5 — *Leiomarginata* sp., Korytnica 2: 149.5 m. 6 — *Leiosphaeridia* sp. [cf. *L. pellucidum* (Tim.)], Kotuszów *1*: 90.0 m; Czarna Shale Fm., Sabellidites Zone, Lower Cambrian, *4*, *6* — Kotuszów Shale Mem.; All × 1000, SEM



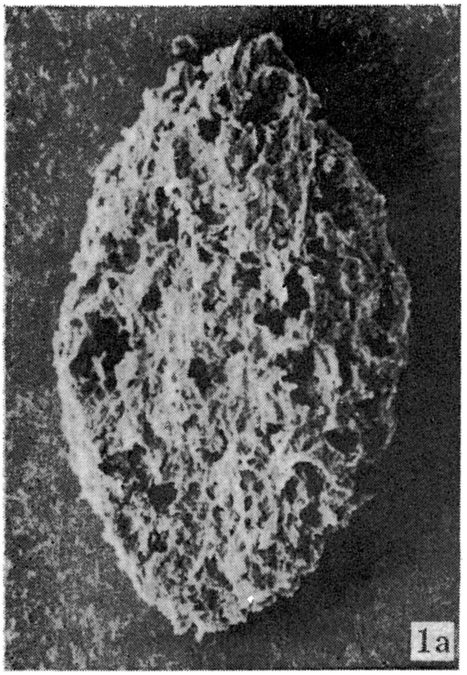


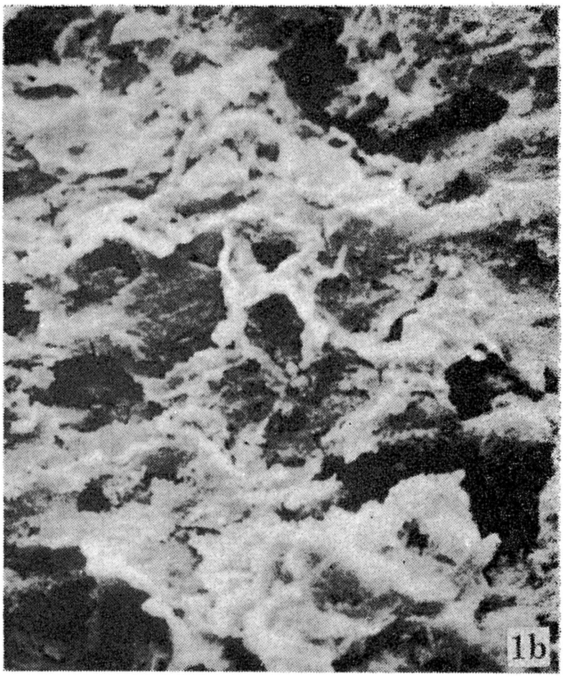


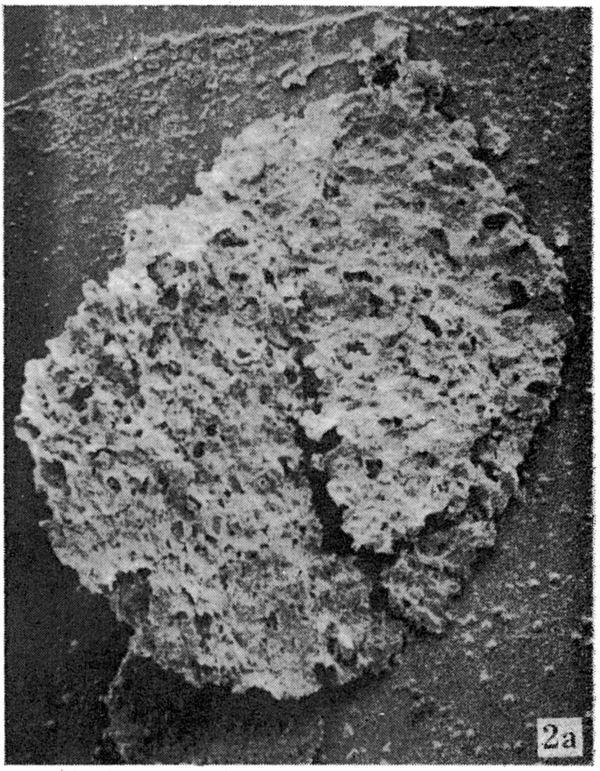




1 — *Orygmatosphaeridium* sp. *1* and Problematicum; *1a* — × 300, *1b* — × 3000, *1c* — × 10,000; SEM; Korytnica *2*: 73.1 m; Czarna Shale Fm., Sabellidites Zone, Lower Cambrian. 2 — *Orygmatosphaeridium* sp. *1*; *2a* — × 450, *2b* — × 2000; SEM; Brzegi *IG-1*: 2090.0 m; Brzegi Shale Fm., Upper Vendian







1 — *Orygmatosphaeridium* sp. 2; *1a* — × 300, *1b* — × 3000, 2 — *Asperatopsophosphaera bavlensis* Shep.; *2a* — × 250, *2b* — × 900;
Czarna Shale Fm.; Sabellidites Zone, Lower Cambrian; Korytnica 2: 73.1 m;
All SEM

1 — Exposure of silty shales at Kotuszów; Czarna Shale Fm., Kotuszów Shale Mem., Sabellidites Zone, Lower Cambrian; 2 — Sandstones beds among clayey shales, exposure on eastern side of the Czarna River valley near Kotuszów; Czarna Shale Fm., Platysolenites Zone, Lower Cambrian