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Microfossils from the high-grade metamorphic rocks in the Góry Sowie Mts. (Sudetes area) and their stratigraphical importance

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Unconventional micropalaeontological methods have been employed in order to examine calcareous-silicic rocks and intercalations of crystalline limestones from 7 localities of "diabasic amphibolites"* in the gneissic Góry Sowie Block. Very poorly preserved microflora and relicts of skeletal fauna, i.e. fragments of radiolarians, calcareous shells of Hyolithes, problematic conoidal forms and minut ?brachiopod shells have been found for the first time in the investigated rocks. A few specimens belonging to Archaeogastropoda, Ostracoda and ?Vermes have been identified, too. The microfossil assemblage contains also problematic taxa. The discovery of microfossils including skeletal fauna in crystalline limestones (marbles) enclosed in "schistose diabasic amphibolites" of the Góry Sowie Block has an outstanding stratigraphical importance. It is possible now to accept that the rocks are undoubtedly younger than Precambrian. The most probable age would be Cambrian. There have been over 10 isotopic datings reported for the Góry Sowie Mts. Various methods have been used and different minerals examined. Most of the ages fall within the Ordovician. There are also rather extreme results pointing to the Proterozoic and Devonian, and even to the Early Carboniferous.

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INTRODUCTION

One of the difficult problems of geology of the Sudetes and their foreland is the age of metamorphic series. Lithological, petrological and tectonic criteria previously used have proved to be ambiguous. In course of time there arose a need to revise these criteria.

This required arduous and time-consuming studies. The author has finally managed to work out new unconventional methods which enabled a discovery of organic origin relicts of a stratigraphical importance in over 20 localities with the so-called "parametamorphites". Such studies were also conducted earlier in the gneissic Góry Sowie area.

Acritarchs and filamentous microflora indicative of the Late Riphean age of the primary marine deposits which were metamorphosed later to form paragneisses were discovered by T. Gunia (1981*a*, *b*, 1984) in 2 paragneisses localities (Fig. 1, black squares).

The two localities with documented age appeared to be insufficient for a vast area occupied by the Góry Sowie paragneisses showing both a considerable thickness (a few thousand metres) and highly complex tectonics.

When looking for new fossil localities in metamorphic rocks a particular attention was paid to calcareous-silicic rocks and scarce carbonate intercalations accompanying "schistose diabasic amphibolites" marked in old geological maps of the Góry Sowie Block.

* The name "diabasic amphibolites" and its synonyms such as diabasic amphibolites with crystalline limestones intercalations, schistose diabasic amphibolites, calcareous-silicic rocks exist in some older geological maps of the Góry Sowie Block published by E. Dathe (1902), L. Finckh (1925) and others (scale 1:25 000). Carbonate intercalations from these amphibolites have yielded palaeontological material cited in this paper. The name "diabasic amphibolites" is a traditional one. It has been accepted after earlier authors. In more recent literature the name diabase refers to a basic subvolcanic rock, whereas surface eruptions may result in a basalt rock. Tuffs and tuffites may be related to such eruptions (A. Philpotts, 1990).

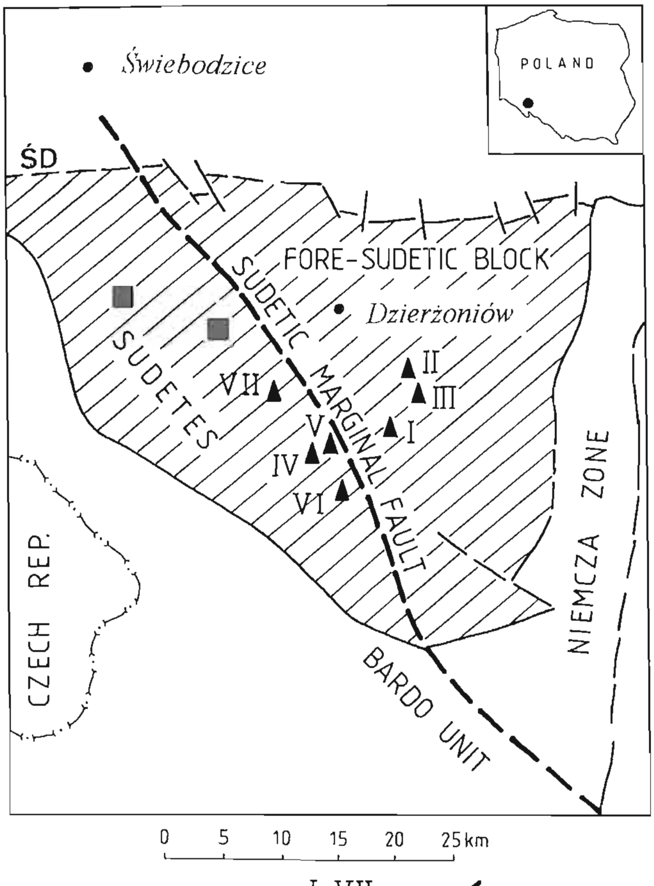

Fig. 1. Schematic map of Góry Sowie gneissic block

1 — metamorphic rocks; 2 — outcrops of Upper Riphean paragneisses; 3 — outcrops (I–VII) of calc-silicate rocks and "diabase amphibolite" with microfossils; 4 — faults; ŚD — Świebodzice Depression

An additional impulse to undertake these studies was the information found in L. Finckh's papers (1923, 1925) that the calcareous-silicic rocks and crystalline limestones accompanying "schistose diabasic amphibolites" were formed out of "diabasic tuffites and calcareous tuffites", whereas gneisses of the Góry Sowie Block (according to that author) are a product of metamorphism of Cambro-Silurian sedimentary rocks.

Taking into account also this data, samples collected from carbonate rocks of paraamphibolites located in both the Fore-Sudetic (3 localities) and Sudetic (4 localities) parts of the Góry Sowie Block (Fig. 1) have been studied using traditional micropalaeontological-stratigraphical methods. Both high degree of metamorphism (amphibolite facies) and intense tectonic deformations have made it impossible to obtain well preserved specimens enabling precise identifications according to palaeontological rules.

The author realizes all these difficulties. These are, so far unknown from carbonate intercalations in paraamphibolites of the Sudetes and its foreland, organic origin forms of a great stratigraphic importance, whose localities were described (Fig. 1) and specimens labelled using modern methods (Tab. 1). Better preserved ones were photographed (Pl. II–VIII). Maybe in the future some others, more perfect research methods will be worked out and it will be possible to find in these carbonate intercalations better preserved specimens. So far, there have been found no reports in the available literature on organic microfossils in analogous rocks.

GEOLOGICAL POSITION OF MICROFOSSIL LOCALITIES

The autcrops which for the first time have yielded the microfossils are natural and artificial exposures and weathered *in situ* blocks. They have been found in places where E. Dathe (1902), L. Finckh (1925) and others marked in old detailed geological maps (1:25 000) a "small rock bodies" within paragneisses, calling them "schistose" or "bedded" diabasic amphibolites or "paraamphibolites" (black triangles in this paper — Fig. 1, labelled with Roman numerals: I–III in the Fore-Sudetic part and IV–VII in Sudetic part of the Góry Sowie Block).

The Góry Sowie Block, in which the "schistose diabasic amphibolites" occur, has a triangle-like shape and area of about 650 km^2 (Fig. 1). It is divided by the Marginal Sudetic Fault into the smaller Sudetic part and larger Fore-Sudetic one. This unit, sometimes being considered a part of the Bohemian Massif, is largely composed of gneisses and migmatites, within which very abundant "small metamorphic bodies" occur, including amphibolites of a different origin, granulites, hyperites, serpentinites and extremely rare crystalline limestones. Locally occurring unmetamorphosed rocks in this area include the Lower Carboniferous sedimentary series, gabbros, porphyries, porphyrites and kersantites (H. Żakowa, 1963; W. Grocholski, 1967).

This block, being one of major tectonic units in the Middle Sudetes, played the important role in the Palaeozoic tectonics and palaeogeography (T. Gunia, 1985).

Relatively greatest amount of publications have dealt with problems of its tectonics and tectono-metamorphic evolution. Only a few synthetic paper can be mentioned here, some synthetic ones should be including the aerlie ones by E. Kalkowsky (1878) and E. Bederke (1929, 1934) and more recent by H. Teisseyre (1957), J. Oberc (1966), W. Grocholski (1967) and A. Żelaźniewicz (1987).

Stages of alterations of rocks in the Góry Sowie Block have been believed to depend on tectonics and in particular on tectono-metamorphic evolution. There were relatively few exclusively petrological works showing these complex problems synthetically. Of older ones a monograph by H. Hentschel (1943), devoted to petrology of calcareous-silicic rocks, should be mentioned. Of more recent works, that by K. Smulikowski (1952) on metamorphic complexes of the Sudetes including the Góry Sowie Block, and monographs by A. Polański (1955) and R. Kryza (1981) must be quoted. The latter explains petrology of gneisses and migmatites together with a reconstruction of premetamorphic series. The mono-

Table 1

Microfossils from carbonate enclosures in "diabase amphibolites" of the Góry Sowie Mts.

	Microfossils	Outcrops							Precambrian	Cambrian
		I Owiesno	II Gilów	III Piława	IV Błyszcz	V Czyżyk	VI Bielawa	VII Kamionki		
Flora	*Baltisphaeridium* sp.	x							•	
Flora	*Micrhystridium lanatum*	x								•
Flora	*Micrhystridium* cf. *brevicornatum*	x								•
Flora	*Micrhystridium* sp.	x							•	
Flora	*Aranidium* sp.	x								•
Flora	*Asteridium* cf. *spinosum*	x								•
Flora	Filamentous forms	x							•	
Flora	Algae indet.		x	x		x	x	x	•	
Fauna	**Radiolaria**									
Fauna	Liosphaeridae	x	x	x		x		x		•
Fauna	*Ulcundia* sp.	x								•
Fauna	?Radiolaria indet.	x			x	x	x	x		•
Fauna	**Hyolitha**	x	x	x	x	x	x	x		•
Fauna	Circothecidae	x	x	x	x	x	x	x		•
Fauna	?*Laratheca* sp.					x	x	x		•
Fauna	*Turcutheca* sp.		x			x	x	x		•
Fauna	Allathecidae		x	x	x	x	x	x		•
Fauna	*Allatheca* sp.		x	x	x	x		x		•
Fauna	Anabaritidae		x	x		x	x	x		•
Fauna	*Cambrotubulus* sp.			x			x	x		•
Fauna	*Longiochrea* sp.	x	x	x	x		x	x		•
Fauna	**Hyolitha indet.**	x	x	x	x	x	x	x		•
Fauna	**Operculum** from **Hyolitha**	x	x	x	x	x	x	x		•
Fauna	**Hyolithelminthes**	x	x	x	x	x	x	x		•
Fauna	Hyolithellidae		x	x		x	x	x		•
Fauna	*Hyolithellus* cf. *rectus*	x				x	x	x		•
Fauna	*Pseudortheca* cf. *filosa*					x	x	x		•
Fauna	*Pseudortheca* cf. *perornata*		x	x	x	x	x	x		•
Fauna	*Pseudortheca* cf. *rotundicincta*		x		x	x	x			•
Fauna	*Pseudortheca* sp.	x	x		x	x	x	x		•
Fauna	Lapworthellidae		x	x	x			x		•
Fauna	?*Tetratheca* sp.		x				x			•
Fauna	Cambroclavitidae				x		x	x		•
Fauna	?*Cambroclavus* sp.			x				x		•
Fauna	?*Pseudoclavus* sp.			x			x			•
Fauna	**?Polychaeta**	x		x		x	x			•
Fauna	*Coleoloides* sp.	x			x			x		•
Fauna	**?Protoconodonts**		x		x		x	x		•
Fauna	?*Fomitchella* sp.			x				x		•
Fauna	**?Brachiopoda**									•
Fauna	?Obolidae et Kutorginidae			x	x	x	x	x		•
Fauna	Brachiopoda indet.		x	x	x	x	x	x		•
Fauna	**Archaeogastropoda indet.**	x	x			x		x		•
Fauna	**Ostracoda**		x	x	x	x	x	x		•
Fauna	?*Bradoria* sp.			x		x	x			•
Fauna	**?Vermes indet.**			x			x			•
Fauna	Microproblematica	x	x	x	x	x	x	x		•

graph concerning petrology of serpentinites has been given by T. Gunia (1997*a*, *b*).

DESCRIPTION OF LOCALITIES

LOCALITY I: OWIESNO

This is a natural exposure in Owiesno village (Fore-Sudetic part of the Góry Sowie Block). The calcareous-silicic rocks are exposed in the western slope of the (unnamed) hill marked in the old geological map by an altitude of 375.5 m. Dimensions of this exposure are 5 x 3 m. The exposed rocks are dark steel-grey in colour with abundant light grey calcareous beds or laminae within dark-coloured amphibolite mass. Schistosity and tectonic deformations are distinct. Locally, the rock passes into a massive amphibolite.

In the old geological map (scale 1:25 000) by E. Meister (1925), sheet Gnadenfrei (= Piława Górna), the Owiesno exposure was marked within "schistose amphibolites" forming a small lense in sillimanite gneisses, stretching almost N–S and cut by a fault. These gneisses were petrologically studied by C. August and R. Kryza (1979). They estimated the palaeotemperature of their formation to be over 600°C.

A total amount of 35 samples have been collected from the calcareous-silicic rock exposed in Owiesno, out of which 15 petrographical sections and 220 powdered preparations have been prepared. These revealed fairly abundant but poorly preserved faunal relicts, mainly of radiolarians, as well as a few specimens of microflora, among others acritarchs and filamentous forms (Tab. 1). Preliminary results of micropalaeontological and stratigraphical studies of the rocks have been published separately (T. Gunia, 1997*a, b*).

LOCALITY II: GILÓW

It is also located in the Fore-Sudetic part of the gneiss Góry Sowie Block, and comprises a crystalline limestone lense occurring between diabasic amphibolites and paragneisses. It is situated about 1 km south of Gilów village, on the southern slope of an unnamed hill. The limestone is not exposed at the surface. Basing on investigations conducted by P. Raczyński (pers. comm.) in a shaft, a photograph of wall fragment, and megascopic studies in cross-cut samples, it may be assumed that the rocks are represented by fine- and middle-grained crystalline limestones with numerous amphibolitic laminae, dark in colour. According to P. Raczyński (pers. comm.) there is a tectonic breccia composed of angular blocks of amphibolites and limestones in the lower part of the pit.

The shaft is located within the above-mentioned crystalline limestone lense marked on a detailed geological map (scale 1:25 000), sheet Lauterbach (= Sieniawka), compiled by O. Barsch and L. Finckh (1921). Text explanations to this map were written by L. Finckh (1925). 25 samples have been collected from the shaft wall. 10 thin sections and 90 microscopic preparations have been prepared. Poorly preserved microflora, small fragments of fauna and microproblematics have been found (Tab. 1).

LOCALITY III: PIŁAWA

This locality comprises weathered *in situ* blocks. It is located at the place where an exposure of "diabasic para-amphibolites" is marked on the old geological map by a letter "a". This is a small unnamed hill, marked on the E. Meister's map (1925) by an altitude of 334.5 m, situated near Piława Dolna (sheet Gnadenfrei = Piława Górna) in the Fore-Sudetic Block. 6 samples of white and brown-grey crystalline limestones have been collected from the blocks. Very fine, light in colour carbonate laminae and dark amphibolitic ones are visible on weathered surfaces. 4 petrographical sections and 40 microscopic preparations have been prepared. Relicts of microflora and fauna have been found (Tab. 1).

LOCALITY IV: BŁYSZCZ–KAMIONKI HILL

This locality consists of weathered blocks *in situ* situated on a steep slope of the Błyszcz Hill with altitude 637 m at the place where a branching amphibolite lense with enclosed two smaller crystalline limestone lenses is marked within biotitic paragneisses on the old geological map on scale 1:25 000 (E. Dathe, 1902, sheet Langenbielau = Bielawa). Isolated small rocks and outcrops marked on that map do not exist at present. Their remains are weathered blocks in which small fragments of crystalline limestones and amphibolites can be recognized. The limestones are light in colour, most frequently coarsely and medium crystalline with numerous intergrowths and lenticular laminae of amphibolite. 20 samples have been collected from here. 7 thin sections and 110 microscopic preparations have been prepared. Scarce and very small fragments of fauna and microproblematics have been found (mainly in preparations) (Tab. 1).

LOCALITY V: CZYŻYK–KAMIONKI HILL

It is situated 1 km east of the previous one, on the slope of the Czyżyk Hill with marked altitude of 555 m. Here, amongst numerous amphibolite lenses marked by letters "ag", and enclosed in biotitic paragneisses as shown on the E. Dathe's map (1902), there is one slightly larger lense of "diabasic amphibolites" with three small intercalations of crystalline limestones within it.

The outcrops do not exist any more and there are only weathered blocks at that site. 15 samples have been collected from the blocks for laboratory analyses.

A total amount of 80 preparations have been prepared. Cut sections of particular samples have shown laminae of white coarsely and medium crystalline limestones within amphibolites. In some samples laminae of dark-coloured amphibolite pass into light-coloured limestone.

LOCALITY VI: BIELAWA–KAMIONKI

This is a small quarry, marked on the old detailed geological map by E. Dathe (1902), as comprising "diabasic para-amphibolites" with intercalations of crystalline limestones. It is located close to a topographic edge of the Góry Sowie Mts. in the outskirts of the town of Bielawa called "Kamieniczki". The limestone has been completely mined out here. In one of the quarry walls, in the area of a few square metres, numerous laminae and lenses (up to 5 cm thick) of light-coloured crystalline limestones can be seen on the background of darker amphibolite. From 15 samples collected from the locality. 5 petrographical sections and 80 microscopic preparations have been prepared. Relicts of microfauna have been found in the limestones.

LOCALITY VII: KAMIONKI–SMOCZA JAMA

This is a former adit in Kamionki (probably after limestone exploitation) situated on the western slope of the unnamed hill, at the place where E. Dathe (1902) marked an intercalation of crystalline limestones within one of diabasic amphibolite lenses. This adit is now called "Smocza Jama". Inside, very numerous, fine and irregular carbonate laminae within amphibolites are visible on the walls. 25 samples have been collected from the rock out of which 7 sections (4 petrographical and 4 palaeontological) as well as 120 microscopic preparations have been prepared.

METHODS OF STUDY

Some unconventional micropalaeontological methods have been employed in order to examine carbonate rocks, i.e. crystalline limestones and dolomites forming a single larger "rock body", as well as irregular, fine laminae, intergrowths and lenses within the so-called "schistose diabasic amphibolites" (*sensu* E. Dathe, 1902; L. Finckh, 1925).

There were no previous attempts to investigate microfossils in such highly metamorphosed (amphibolite facies) and tectonically deformed rocks. Thus it has been difficult to apply methods worked out earlier. The present micropalaeontological and stratigraphical studies were conducted during several stages.

At the first stage some of the old detailed geological maps (70 or even 100 years old) of the gneissic Góry Sowie Block were analysed. Basing on the maps (and taking into account also text explanations), larger exposures of the above-mentioned "schistose diabasic amphibolites" with intercalations and lenses of crystalline limestones were selected.

The second stage started with field work in order to find the exposures and collect samples for laboratory analyses. This appeared to be a difficult task as both topography and state of preservation of rocks have changed after such a long time between the recent studies and cartographic works completed tens of years ago. Only some of the natural and artificial exposures, that existed at those times and were marked on geological maps, have been preserved. Unfortunately, in many places, instead of isolated rocks or natural exposures, weathered blocks are now present. Samples for further investigations were collected from both exposures and blocks.

During the third stage the samples were cut into thin slabs (3 cm thick). Weathered coatings were removed from them. Surfaces of the thin-sections were macerated cold and heated in 10% HCl in order to recognize larger biogenic structures as well as carbonate intergrowths, irregular laminae and lenses within the amphibolitic background. No fossils have been found using this method in both megascopic and binocular studies.

Slightly better results were archived when studying the so-called "palaeontological sections", i.e. large (5 x 7 cm) and uncovered thin-sections, thicker than petrographical ones. Some of them revealed fragments of extremely strongly recrystallized algal structures.

As it was mentioned above, petrographical thin-sections have also been prepared to find better preserved specimens. These sections were analysed using a polarizing microscope without analyser and with crossed nicols. In a few cases siliceous (Radiolaria) and carbonate (relicts of algae) structures have been recognized.

The studied rocks were probably subjected to a repeated and complex metamorphic alterations. This is, however, a separate petrological problem beyond the scope of this work.

The next stage of experimental researches was to prepare microscopic powdered preparations. Limestones and calcareous-silicic rocks containing numerous carbonate intergrowths, laminae and lenses, collected from each exposure were crushed separately.

Samples were mechanically crushed into two fractions: finer-grained (< 0.10 mm) and coarser-grained (0.10–0.50 mm). Both fractions were separately treated with cold HCl for 5–10 minutes. The powder residue, washed with distilled water and then dried up, was a material for microscopic preparations impregnated with Canada balm. 10 preparations for each grain fraction were preliminarily studied, separately for each stand. It has appeared that the relicts of microflora, and in particular of fauna, are the most abundant among very fine grains, i.e. within the fraction less than 0.10 mm, whereas among coarser-grains (i.e. 0.10–0.50 mm) they are very rare or lacking. Basing upon these preliminary results next preparations were prepared, from 40 to 220 for each stand. A total amount of 730 preparations have been prepared and examined. Microfossil specimens were analysed and photographed in transmitted light, without analyser and with crossed nicols using a polarizing mineralogical microscope, as well as in reflected light using the fibre optics. The obtained palaeontological "material" is exceptionally poorly preserved and extremely difficult to identify.

Acritarchs and filamentous microflora are usually carbonized, whereas calcareous algae show a strongly recrystallized structure. Fauna is also poorly preserved. These are very small, deformed or strongly recrystallized, siliceous and calcareous relicts. In many cases it was possible to determine their affiliation only to a family, subfamily or genus, rare instances and with reservations to a species. The microfossil assemblage also contains forms whose identification is impossible. These were ascribed to "Problematica".

GENERAL CHARACTERISTICS OF MICROFOSSILS

Microfossils are carbonized relicts of microflora, fragments of carbonate algal structures of microscopic sizes as well as siliceous and carbonate relicts of various faunal groups exhibiting very poor state of preservation. This work presents only their tabulated determinations (Tab. 1) with age of appearance given for a particular group, as well as localities in which they have been found. Literature used for identifications is also cited.

Among microflora there are some genera of Acritarcha, carbonized filamentous structures (Pl. II) and relicts of carbonate algal structures labelled as Algae indet. They have been recognized using the following literature: N. Wołkowa (1969), T. Jankauskas (1979), T. Gunia (1981*a*, *b*), C. Downie (1982) and M. Moczydłowska (1991).

Microscopic faunal relicts are represented by very poorly preserved siliceous specimens, belonging to Radiolaria. The external sculpture makes some of them alike to Liosphaeridae (Pl. III), others to ?Polyentactiniinae (Pl. IV), ?Plegmosphaerinae or to the genus ?*Astroentactinia*. This assemblage also contains forms similar to the genus ?*Ulcundia* or to spicules of undefined radiolarians. Forms difficult to identify are described as ?Radiolaria indet. Radiolaria are identified basing on A. Campbell (1964) and B. Nazarov (1974, 1975). The above-mentioned siliceous specimens are most common in calcareous-silicic rocks in Owiesno (locality I), whereas in other localities only small fragments, difficult for identification, have been encountered.

Abundant and more diversified with respect to both sculpture and mineral composition (calcium carbonate or magnesium carbonate) are other faunal relicts belonging to Hyolitha. They show a characteristic sculpture, different sections and variable width of angle in apical part of shells. A similarity to some of genera of Circothecidae, Allathecidae and Anabaritidae (Pl. V) is apparent amongst them. They are accompanied by similar carbonate specimens, resembling some of the genera (Tab. 1) of Hyolithellidae (Pl. V) (order Hyolithelminthes) and Lapworthellidae (order Tommotiida).

Within this group there are also fairly abundant small fragments of shells resembling Hyolitha in shape and sculpture. Their closer identification has been impossible. They are distinguished separately as Hyolitha indet. Oval and subtrigonal carbonate forms are also impossible to identify. They are similar to operculum of some hyolithes genera.

Small tube-shaped forms of Cambroclavitidae and other specimens possibly belonging to ?Polychaeta and ?Protoconodonts have also been difficult to identify. They are recognized basing on: E. Cobbold, W. Pocock (1934), W. Missazhevski (1969*a–c*, 1989), S. Matthews (1973), N. Meshkova (1974), A. Valkov (1975), W. Missazhevski, A. Mambetov (1981), M. Brasier, P. Singh (1987) and M. Kerber (1988).

Apart from the small tube-shaped forms, small oval or subtrigonal specimens being a single unsculptured shells of "?microbrachiopods", have also been found. Some of them resemble specimens of ?Obolidae, others — ?Kutorginidae (Pl. VII).

There are also unidentifiable specimens most probably belonging to "?microbrachiopods" as well. They are separately distinguished as Brachiopoda indet. (Pl. VIII, Figs. 1–12) basing on: Ch. Walcott (1889), Ch. Poulsen (1932), W. Goryanski (1969) and A. Williams, A. Roweli (1965).

Carbonate specimens are also represented by those which may be comparable with Archaeogastropoda (Pl. VIII, Figs. 13–15), some of the genera belonging to Ostracoda and ?Vermes. Microproblematics are present here, too.

DISCUSSION AND CONCLUSIONS

The discovery of organic origin relicts in crystalline limestones (marbles) occurring as a larger "rock body" (*vide* Gilów-locality II) or in a form of irregular laminae (2–5 cm thick), intergrowths or lenses within calcareous-silicic rocks and "diabasic amphibolites" (*sensu* L. Finckh, 1925) has an outstanding stratigraphical importance.

In the former literature (E. Kalkowsky, 1878; E. Dathe, 1902; L. Finckh, 1923; K. Smulikowski, 1952; H. Teisseyre, 1957; W. Grocholski, 1967 and others) the Góry Sowie Block was believed to be composed of gneisses and migmatites of the Archaean age.

Later on, it appeared that some of the paragneisses contain Late Riphean microflora (T. Gunia, 1981*a*, *b*, 1984). Therefore, their age determination changed from the Archaean to Late Proterozoic.

However, the problem of biostratigraphical data in the Góry Sowie Mts. has not been ultimately solved this way. Still unsolved among others is the problem of age of the "small paraamphibolite bodies" occurring within the gneisses and migmatites. There is a comprehensive petrological literature on orthoamphibolites (J. A. Winchester *et al.*, 1998), while paraamphibolites did not receive similar attention so far. Their origin is merely a matter of suppositions. On the older geological maps and in text explanations (E. Dathe, 1902; L. Finckh, 1925) paraamphibolites were generally distinguished as "diabasic amphibolites with limestone lenses" or as "calcareous-silicic rocks" whose praecursors were "diabasic tuffites rich in calcium carbonate or calcareous tuffites". In more recent papers the paraamphibolites are also supposed to have originated from dolomitic-marly intercalations occurring within the primary sedimentary sequence (K. Smulikowski, 1952; A. Polański, 1955; T. Morawski, 1973).

According to A. Żelaźniewicz (1995) who gave an incomplete description of lithologies of "...the Fore-Sudetic part of the Góry Sowie Block...", "...quartz-bearing amphibolites forming concordant interbeds in gneisses..." are probably of a volcanic origin, i.e. secondary after tuffites (compare earlier opinion of L. Finckh, 1925). A part of them, according to A. Żelaźniewicz (*op. cit.*), "...is of a sedimentary origin..." (compare earlier views of K. Smulikowski, 1952; A. Polański, 1955 and T. Morawski, 1973). Although I object to the lack of references to earlier literature and concepts in the paper by A. Żelaźniewicz (*op. cit.*), but I share his opinion of that the paraamphibolites "...are not quite well studied yet..." with respect to their petrology. Detailed and modern petrological investigations of gneisses and migmatites of the Góry Sowie Block conducted by R. Kryza (1981) have shown that the primary sediments (protolith) were marine flysch-like series. It may be assumed that they probably contained tuffs of effusive basic rocks rich in calcium carbonate, calcareous tuffites (*sensu* L. Finckh, 1925) or intercalations of marly-calcareous rocks (*sensu* K. Smulikowski, 1952 and others). Such on origin of the paraamphibolites will remain hypothetical until detailed petrological investigations are made.

The analysis of old geological maps mentioned in the above chapter describing the localities indicates that all the studied finds of paraamphibolites with carbonate intercalations occur within paragneisses, both in the Sudetic and Fore-Sudetic parts of the Góry Sowie Block. It may be presumed that they are coeval. The presence of microfossils, in particular skeletal fauna in carbonates enclosed in paraamphibolites, shows that these rocks cannot be older than Cambrian.

The present-day state of knowledge on biostratigraphy of the Góry Sowie Block with regard to the paragneisses and paraamphibolites can be summarized as follows: a thick (estimated at several thousand metres) primary sedimentary series, i.e. marine flysch-like series and related carbonate-rich tuffs or tuffites of basic rocks (basalt type) or containing marly-dolomitic interbeds, were deposited in the Late Riphean–Cambrian. They might have been metamorphosed after the Cambrian and before Late Devonian.

Lowermost Upper Devonian (Lower and Middle Frasnian) sediments were partly deposited already upon a metamorphosed basement of an undefined and unknown pre-Góry Sowie area. Limestone pebbles containing fauna of the lowermost Upper Devonian (T. Gunia, 1962) occurring together with pebbles of metamorphic rocks, among others the Góry Sowie gneisses (T. Gunia, 1962; Porębski, 1981), and known from the Lower Famennian conglomerates of the neighbouring Świebodzice Depression area (Fig. 1), are indicative of sediment transport from that area.

A separate problem for further studies is a similarity in terms of biostratigraphy between the Cambrian age of the carbonates in paraamphibolites of the Góry Sowie Block and the same age of marbles connected with amphibolites and amphibolitic shales in another part of the Sudetes, i.e. within the Lądek–Śnieżnik metamorphic complex.

The attempts to determine an isotopic age of metamorphic rocks in the Góry Sowie Block were undertaken many times. They have brought very different results leading to various interpretations. Recently, they have been summarized by Z. Cymerman (1998). That author (pers. comm.) is preparing a paper containing geochronological interpretation of these results. Here, only selected results are presented basing on the IUGS geochronological table compiled by J. Cowie and M. Basset (1989). According to O. van Breemen *et al.* (1988) the datings fall between 381 and 369 Ma, i.e. Middle and Late Devonian. Other authors, among others A. Kröner and E. Hegner (1998) have obtained the age of 482–472 Ma, i.e. Early Ordovician. The same authors have determined the age of detrital zircons to span younger Archean to Proterozoic. Single datings (G. Olivier, S. Kelley, 1993) even point to the Early Carboniferous.

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MIKROSKAMIENIAŁOŚCI Z SILNIE ZMETAMORFIZOWANYCH UTWORÓW GÓR SOWICH I ICH ZNACZENIE STRATYGRAFICZNE

Streszczenie

Przy zastosowaniu nowych, niekonwencjonalnych metod mikropaleontologicznych udało się znaleźć relikty organiczne dokumentujące nowe „repery" stratygraficzne. Korzystając z nabytego doświadczenia, zbadano wtrącenia węglanowe w niektórych „amfibolitach diabazowych"*. Według L. Flinckha (1925) protolitem dla nich były tufy diabazowe bogate w węglany oraz tufity wapienne. W późniejszej literaturze (K. Smulikowski, 1952; A. Polański, 1955; T. Morawski, 1973) nie neguje się wulkanicznego pochodze-

* Oznaczenie „amfibolity diabazowe" przyjęto jako dawną nazwę „tradycyjną". We współczesnych podręcznikach (A. Philpotts, 1990) diabaz uznawany jest za subwulkaniczną skałę zasadową. Erupcje powierzchniowe mogą tworzyć bazalty i z nimi mogą być związane tufy i tufity.

nia, lecz wyraża się prawdopodobieństwo, że protolitem tych amfibolitów mogły być wkładki dolomityczno-margliste w pierwotnym osadzie.

W wyniku przeprowadzonych badań udało się w siedmiu miejscach (fig. 1) znaleźć we wtrąceniach węglanowych tkwiących w „amfibolitach diabazowych" mikroskopowej wielkości fragmenty flory i fauny, którą zestawiono tabelarycznie (tab. 1) i udokumentowano fotograficznie (tabl. II–VIII), podając „czas geologiczny" pojawienia się poszczególnych grup. Zacytowano również literaturę, na podstawie której dokonano oznaczeń. Do mikroflory należą niektóre rodzaje akritarch, uwęglone formy nitkowate (tabl. II) oraz relikty glonowych struktur węglanowych, które oznaczono jako Algae indet.

Wśród mikroskopowych reliktów fauny widoczne są okazy krzemionkowe, należące do radiolarii. Rzeźba zewnętrzna zbliża niektóre z nich do Liosphaeridae (tabl. III), inne do ?Polyentactiniinae (tabl. IV) czy ?Plegmosphaerinae, lub do rodzaju ?*Astroentactinia*. Są też w tym zespole formy podobne do rodzaju ?*Ulcundia* lub do igieł bliżej nieokreślonych rodzajów radiolarii. Trudne do oznaczenia formy wydzielono jako ?Radiolaria indet.

Liczne i bardziej zróżnicowane są hiolity. Można było wśród nich dostrzec podobieństwo do niektórych rodzajów z Circothecidae, Allathecidae i Anabaritidae (tabl. V). Razem z nimi występują podobne okazy węglanowe, zbliżone do niektórych rodzajów z Hyolithellidae (tab. 1; tabl. VI) (rząd Hyolithelminthes) oraz z Lapworthellidae (rząd Tommotiida). Małe okruchy muszli wydzielono jako Hyolitha indet. Są tu również owalne lub subtrygonalne formy węglanowe, zbliżone do wieczek niektórych hiolitów.

Trudne do oznaczenia były również rureczkowate formy Cambroclavitidae, a także okazy należące, być może, do ?Polychaeta oraz do protokonodontów.

Znaleziono też bardzo małe okazy owalne lub subtrygonalne „?mikroramienionogów" zbliżonych do ?Obolidae, a inne do ?Kutorginidae (tabl. VII). Niektóre oznaczono jako Brachiopoda indet. (tabl. VIII, fig. 1–12). Są też okazy porównywalne z Archaeogastropoda (tabl. VIII, fig. 13–15), z niektórymi rodzajami Ostracoda i ?Vermes. Nie brak tu również mikroproblematyków.

W dawniejszej literaturze (E. Kalkowsky, 1878; E. Dathe, 1902), a także i w powojennej (K. Smulikowski, 1952; H. Teisseyre, 1957; W. Grocholski, 1967 i in.) sądzono, że blok Gór Sowich jest zbudowany z gnejsów i migmatytów archaicznych. Później okazało się, że niektóre paragnejsy zawierają mikroflorę górnego ryfeju (T. Gunia, 1981*a*, *b*, 1984).

Na temat ortoamfibolitów istnieje obecnie obszerna literatura petrologiczna (J. A. Winchester i in., 1998), natomiast paraamfibolity takiego opracowania jeszcze nie mają.

Z dotychczasowych badań petrologicznych gnejsów i migmatytów bloku sowiogórskiego (R. Kryza, 1981) wynika, że ich protolitem były morskie serie fliszowate. Można przyjąć, że w nich występowały najprawdopodobniej tufy skał wylewnych (zasadowych) bogate w węglan wapnia lub tufity wapienne (*sensu* L. Finckh, 1925), lub też wkładki skał marglisto-dolomitycznych (*sensu* K. Smulikowski, 1952 i in.).

Stan badań biostratygraficznych na bloku sowiogórskim można by przedstawić następująco: miąższe (oceniane na kilka tysięcy metrów) morskie osady fliszowate i związane z nimi tufy czy tufity (bogate w węglany) skał zasadowych (typu bazaltów) lub zawierające wkładki dolomityczno-margliste powstawały w przedziale wieku górny ryfej–kambr. Ich metamorfoza mogła nastąpić po kambrze, a zakończyć się przed górnym dewonem.

Sedymentacja osadów najniższego górnego dewonu (dolny i środkowy fran) w części odbywała się już na zmetamorfizowanym podłożu jakiegoś ówczesnego, bliżej nieznanego, obszaru „prasowiogórskiego". O transporcie z tego obszaru świadczą m.in. otoczaki wapieni z fauną najniższych ogniw górnego dewonu (T. Gunia, 1962), występujące razem z otoczakami skał metamorficznych, w tym gnejsów sowiogórskich (T. Gunia, 1962; S. Porębski, 1981) znane z dolnofameńskich zlepieńców sąsiedniego obszaru depresji Świebodzic (fig. 1).

Porównawczym zagadnieniem jest „czasowa" (w sensie biostratygraficznym) zbieżność między kambryjskim wiekiem wapieni krystalicznych w „amfibolitach diabazowych" na bloku sowiogórskim a takim samym wiekiem większych wystąpień marmurów związanych z amfibolitami i łupkami amfibolitowymi innej części Sudetów, a mianowicie metamorfiku Lądka–Śnieżnika (T. Gunia, 1997*a*, *b*).

Dotychczasowe datowania wieku izotopowego Gór Sowich w zależności od autorów, metody badań i wybranych minerałów nie przyniosły roztrzygających wyjaśnień. Oznaczony wiek waha się od górnego proterozoiku, poprzez starszy paleozoik i obejmuje też dewon środkowy i górny, a nawet dolny karbon (patrz tabela w pracy Z. Cymermana, 1998).

EXPLANATIONS OF PLATES

PLATE I

Fig. 1. Outcrop of calc-silicate rocks with microfossils (Owiesno); photo J. Stachowiak

PLATE II

Figs. 1–7. *Baltisphaeridium* sp.
Owiesno 31 and 87; powder samples

Figs. 8–10. *Micrhystridium lanatum*
Owiesno 20 and 30; powder samples

Figs. 11–14. *Micrhystridium* cf. *brevicornatum*
Owiesno 22–24; powder samples

Figs. 15–17. *Micrhystridium* sp.
Owiesno 60; powder samples

Figs. 18, 19. *Aranidium* sp.
Owiesno 80; powder samples

Fig. 20. *Aranidium* cf. *spinosum*
Owiesno 22; powder samples

Figs. 21–24. Filamenous forms
Owiesno 27–36; powder samples

PLATE III

Figs. 1–7. Siliceous, oval, elliptic and polygonal forms with sculpture resembling ?Liosphaeridae (radiolarian); Owiesno 35–95; powder samples

PLATE IV

Figs. 1–6. Siliceous forms with spongy-like sculpture resembling radiolarian (subfam. ?Polyentactiniinae); Owiesno 35–95; thin-section

PLATE V

Hyolita (Anabaritidae)
Figs. 8, 9. *Cambrotubulus* sp.
Piława 21/1, 66/1, 27/1; powder samples

Figs. 4–7. *Longiochrea* sp.
Gilów 56/1, Piława 8/1, Błyszcz Hill 82/4, 73/1; powder samples

Hyolithelminthes (Hyolithellidae)
Figs. 8, 9. *Hyolithellus* cf. *rectus*
Owiesno 158/2, 191/1; powder samples

Figs. 10–12. *Pseudortheca* cf. *filosa*
Czyżyk Hill 39/1, 45/1, 38/1; powder samples

PLATE VI

Figs. 1–3. *Pseudortheca* cf. *perornata*
Gilów 1/4, Czyżyk Hill 32/3, Piława 33/1; powder samples

Figs. 4–9. *Pseudortheca* cf. *rotundicincta*
Czyżyk Hill 34/3, Gilów 82/2, 1/3, 76/2, 18/2; powder samples

PLATE VII

Figs. 1–11. Kutorginidae like forms
Piława 4/2, 45/2, 64/2, Błyszcz Hill 46/1, 106/1, 105/2, 39/1, 40/2, Gilów Hill 1/2, Czyżyk Hill 25/1, 32/1; powder samples

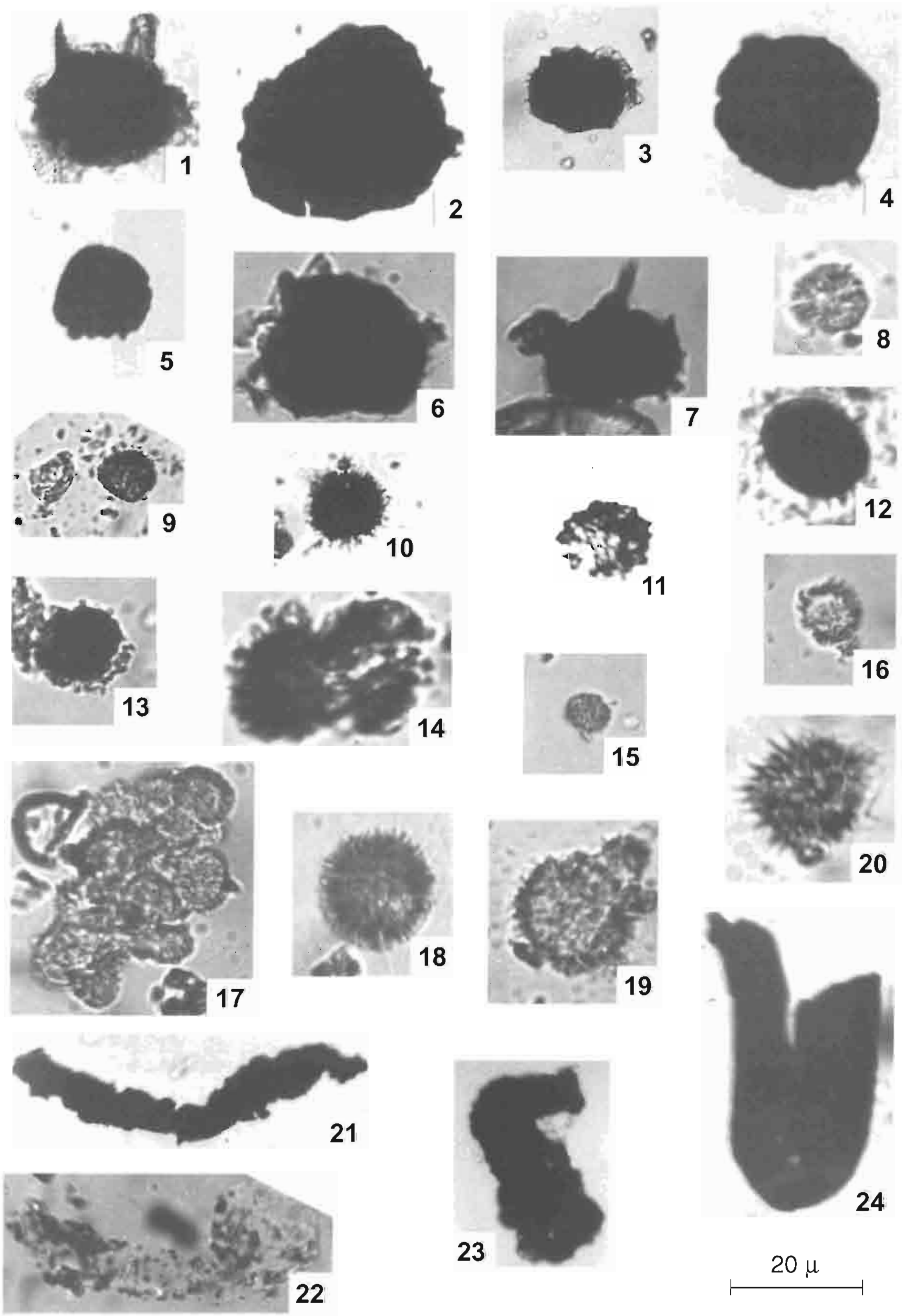
PLATE VIII

Figs. 1–12. Brachiopoda indet.
Piława 21/1, 41/2, 61/3, 47/2, 42/1, 61/2, Błyszcz Hill 45/1, 106/2, 15/1, 109/6, Czyżyk Hill 28/4; powder samples

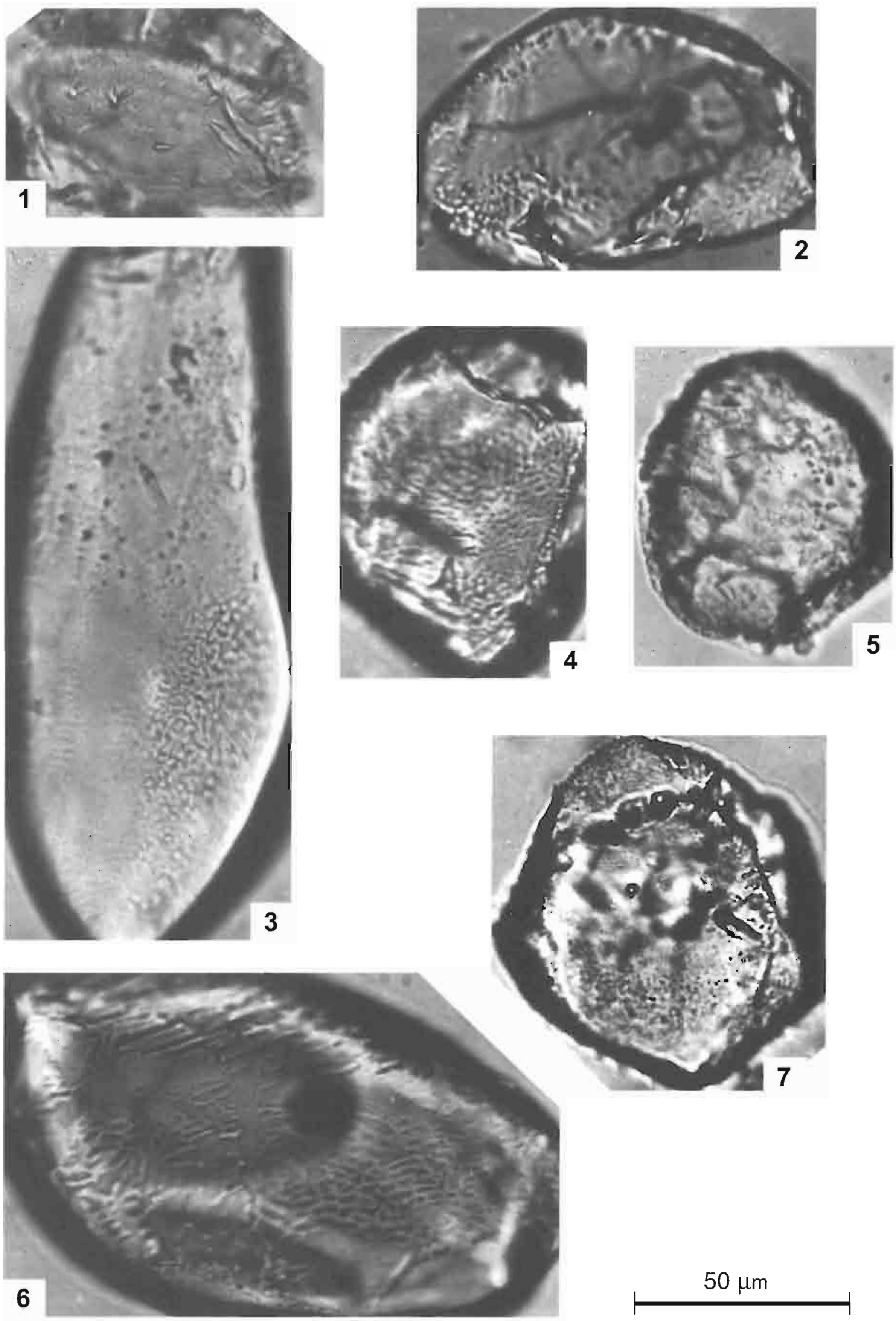
Figs. 13–15. Archaeogastropoda indet.
Piława 13/1, Czyżyk Hill 24/2, Qwiesno 18/2; powder samples

Tadeusz GUNIA — Microfossils from the high-grade metamorphic rocks in the Góry Sowie Mts. (Sudetes area) and their stratigraphical importance

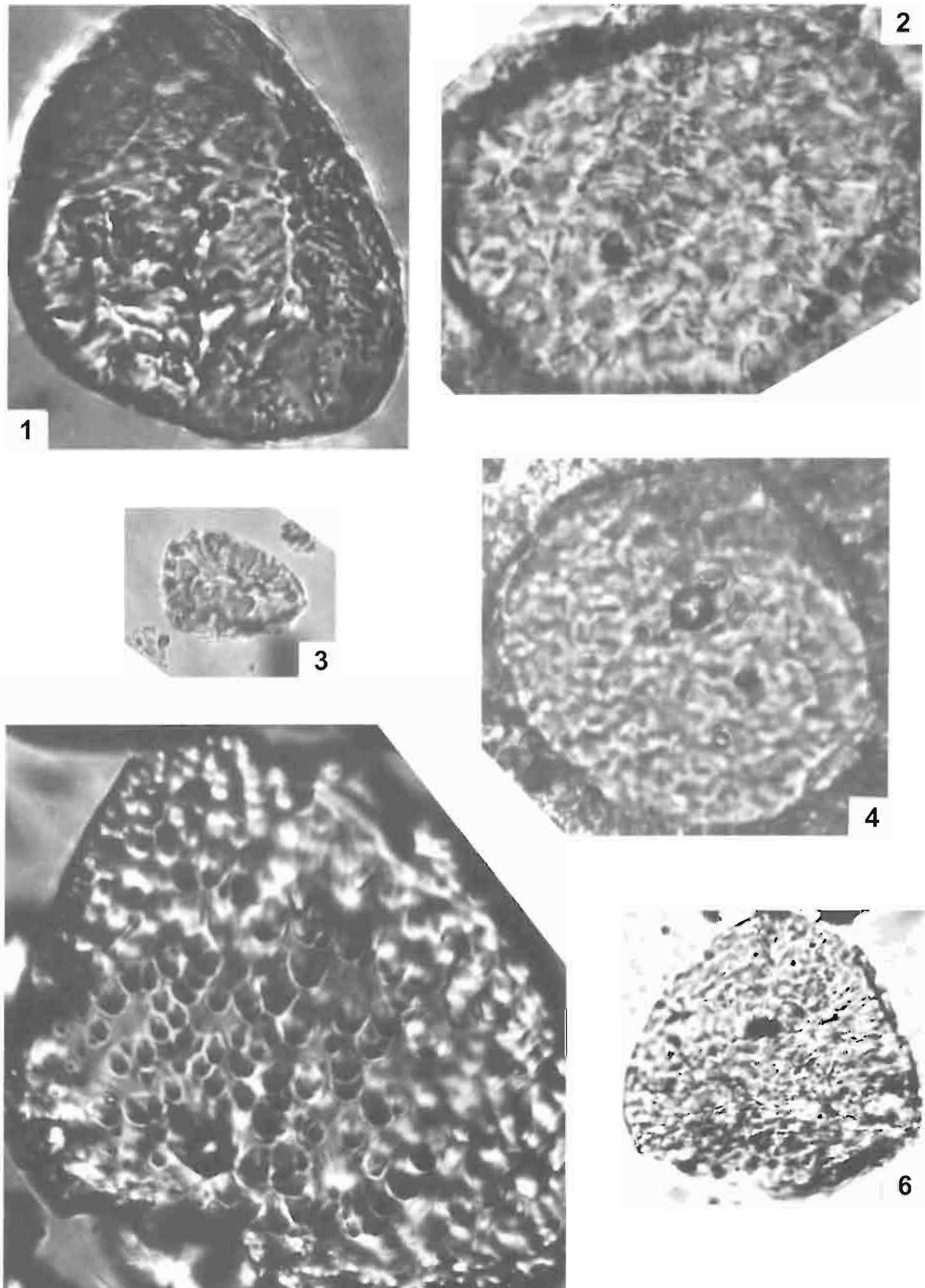
Geol. Quart., 1999, **43** (4)



Tadeusz GUNIA — Microfossils from the high-grade metamorphic rocks in the Góry Sowie Mts. (Sudetes area) and their stratigraphical importance



Tadeusz GUNIA — Microfossils from the high-grade metamorphic rocks in the Góry Sowie Mts. (Sudetes area) and their stratigraphical importance



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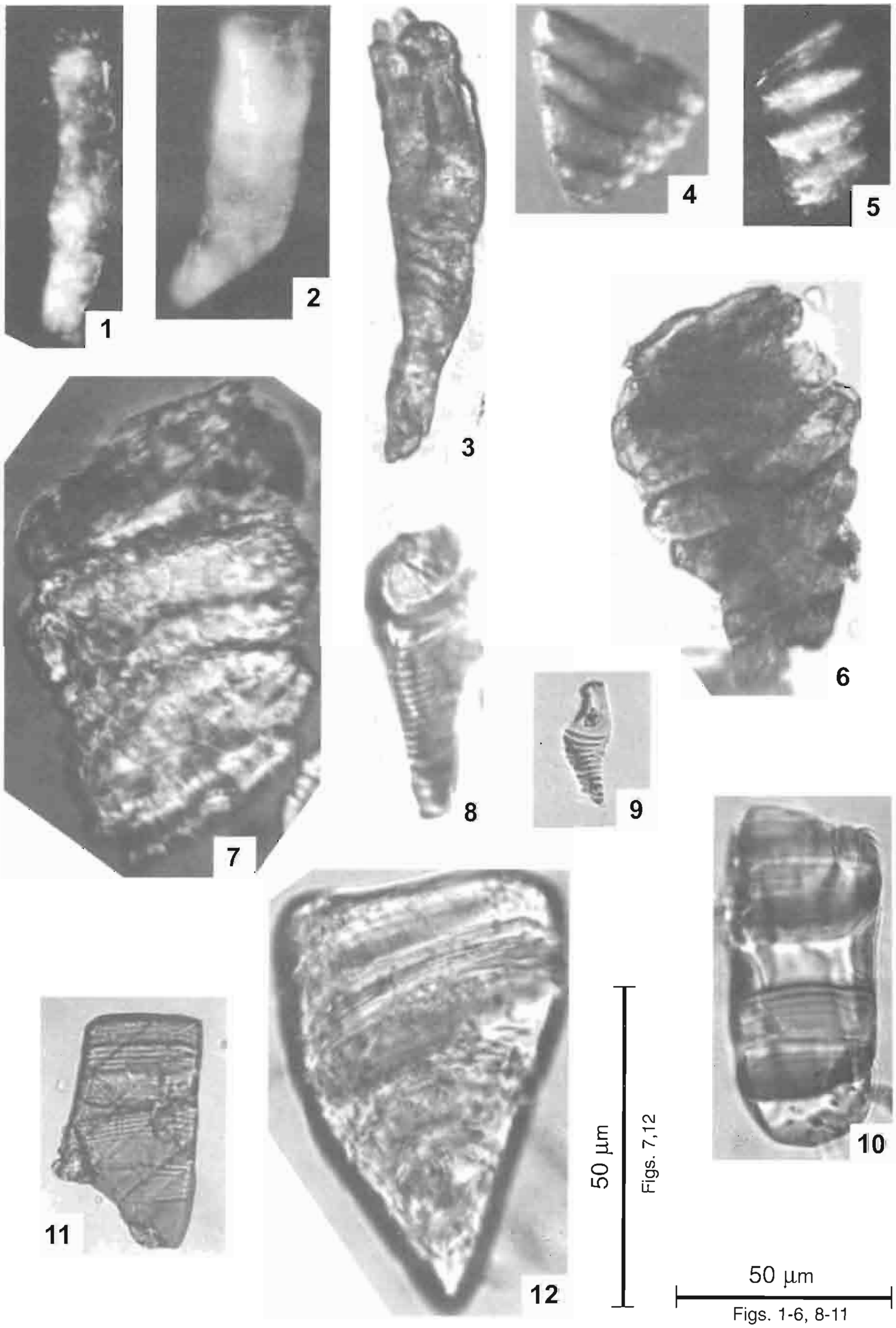

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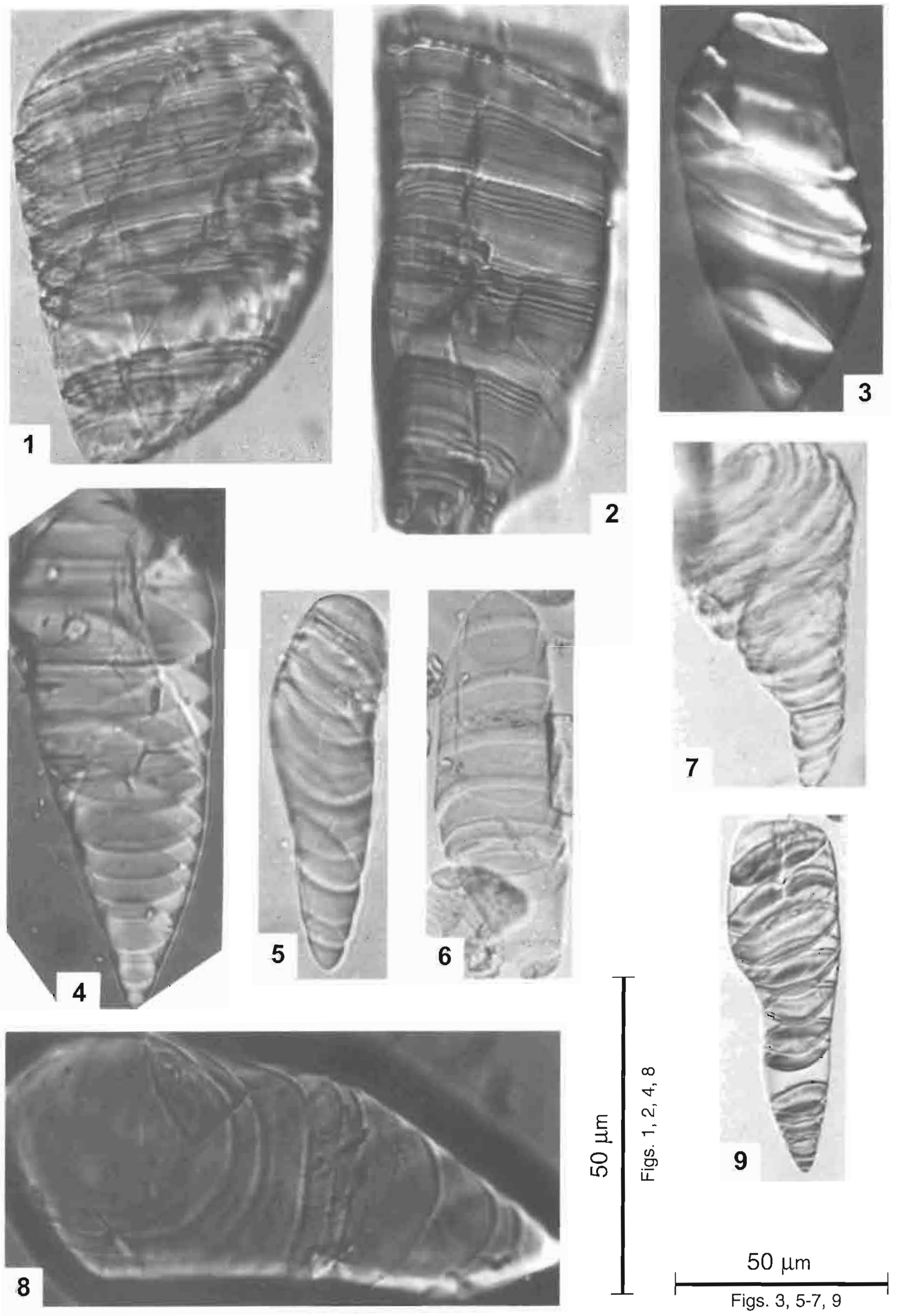

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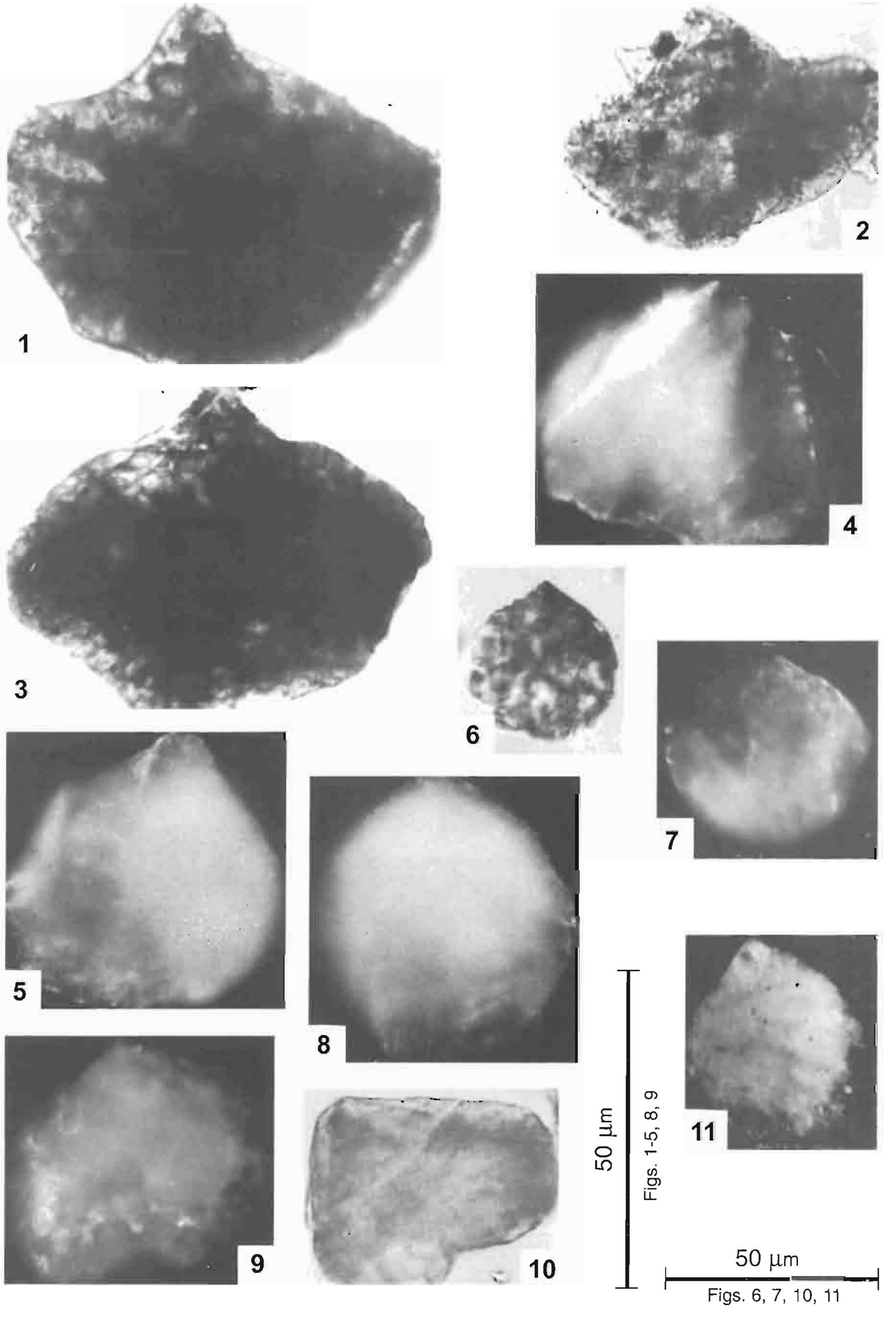

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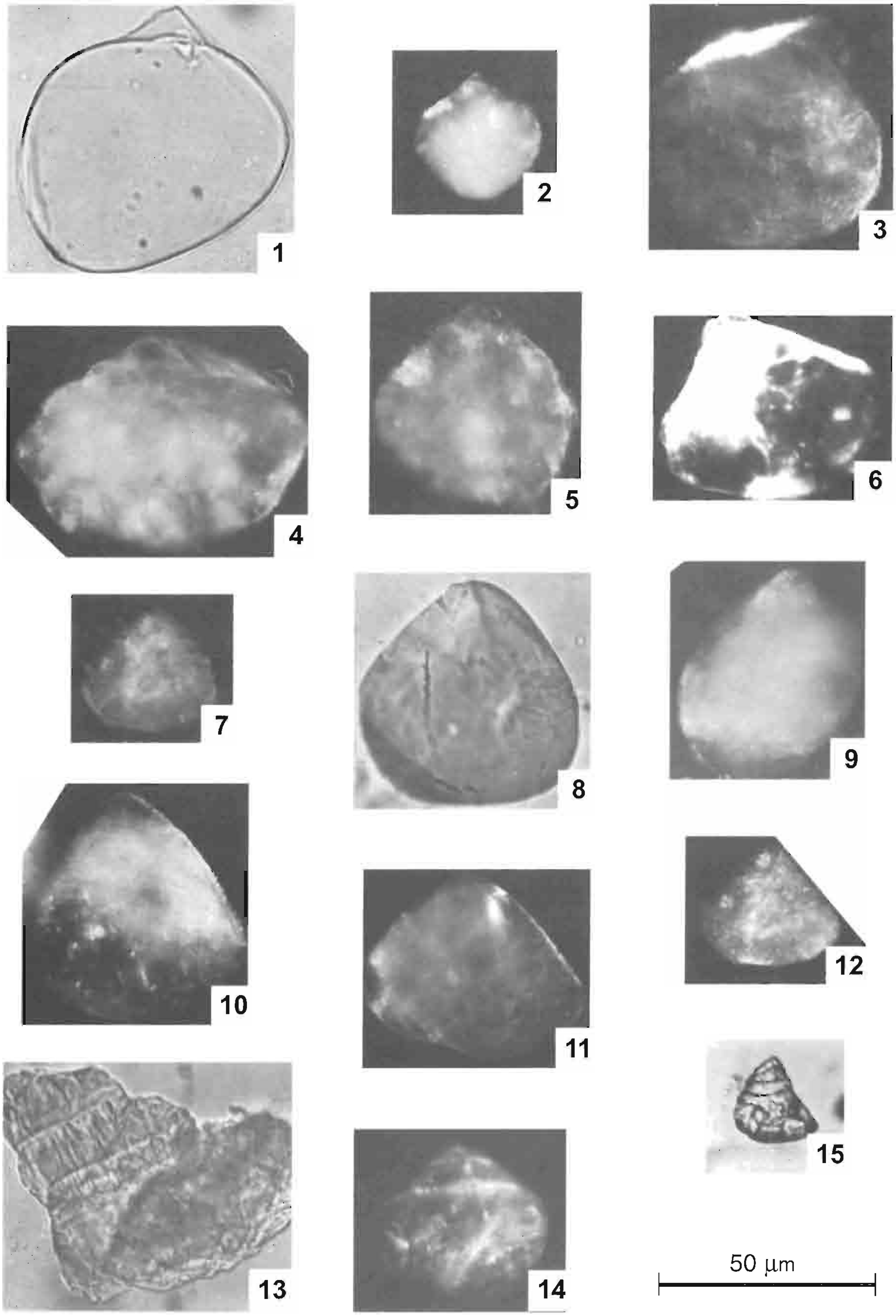

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