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ELŻBIETA GAŻDZICKA

COCCOLITHS AND INDEX FORAMINIFERA FROM THE UPPER CRETACEOUS CHALK OF MIELNIK REGION, EASTERN POLAND

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The abundant but weakly diversified calcareous nannoplankton has been stated in the chalk of the Mielnik region. Large forms of massive structure dominate: *Kamptnerius magnificus* Deflandre, *Broinsonia parca* (Stradner), *Reinhardtites anthophorus* (Deflandre), *Lucianorhabdus cayeuxi* Deflandre. Two biostratigraphic zones: *Broinsonia parca* and *Quadrum trifidum* have heen distinguished. Foraminifera were examined in order to make a correlation with the coccolith zones.

Key words: Coccoliths, foraminifera, Campanian, stratigraphy, Poland.

Elżbieta Gaździcka, Instytut Geologii Podstawowej, Uniwersytet Warszawski, Al. Żwirki i Wigury 93, 02-089 Warszawa, Poland. *Received: September 1980.*

INTRODUCTION

The chalk deposits at Mielnik on the Bug River (Eastern Poland) were the subject of several geological and palaeontological papers. The first petrographic characteristic of those sediments and descriptions of the micro- and macrofossils contained have been given by Sujkowski (1930). Basing on the foraminifer assemblages Bieda (1958) has divided the chalk complex into the Upper Campanian and Lower Maastrichtian. Pożaryski (1960) regarded the hard-ground level as Campanian — Maastrichtian boundary. On the basis of brachiopods Bitner and Pisera (1979) correlated those sediments with the zones 2 and 3 of the chalk in Denmark (the lowermost Maastrichtian) established by Surlyk (1970).

The present analysis of calcareous nannoplankton assemblages has been done aiming at their stratigraphic values. For comparative reason, in addition to the samples from Mielnik two chalk samples from Kornica have been examined, a locality situated 18 km SW of Mielnik. Several species of foraminifera have been determined as well, in order to make a comparison with the coccolith zonation.

The calcareous nannoplankton has been studied under the light microscope and the scanning electron microscope. All the SEM micrographs were taken at the Laboratory of Electronic Microscopy, the Nencki Institute of Experimental Biology in Warsaw.

The material studied and SEM micrographs are housed in the Institute of Geology of the Warsaw University.

Acknowledgements. — The author thanks Mrs. M. Bitner and Mr A. Pisera for making available for examination the material from the Mielnik section and for discussion. Thanks are also due to Dr. R. Marcinowski for valuable remarks and information concerning the belemnoids occurring in the Mielnik chalk.

CALCAREOUS NANNOPLANKTON

Abundant and well preserved calcareous nannoplankton occurs commonly in the chalk at Mielnik (fig. 1), except for the hard-ground horizon. There, the coccoliths are less numerous (both in taxa and individuals) and difficult to separate from the hard rock. Complete lack of nannoplankton has been stated in the grey marls overlying the chalk complex. Inspite of the coccolith abundance in the chalk, the species diversity is relatively low and ranges from 20 to 30 species in most samples. Other authors (e.g. Verbeek 1977, Manivit 1971, Gartner 1968) stated 40—60 species in different Campanian sediments. Similar number of taxa as that found at Mielnik has been reported from the Maastrichtian chalk in Denmark (Hakanson, Bromley and Perch-Nielsen, 1974).

The frequency of species in not uniform. In some samples only several species (sometimes dozen or so) occur abundantly while the remaining species are rare. Larger, massive forms dominate: *Kamptnerius magnificus* Deflandre, *Reinhardtites anthophorus* (Deflandre), *Broinsonia parca* (Stradner), *Lucianorhabdus cayeuxi* Deflandre. Some coccoliths attain enormous size due to the overgrowth of some structural elements (e.g. *Prediscosphaera cretacea* (Arkhangelsky), *Kamptnerius magnificus* Deflandre, *Tranolithus orionatus* (Reinhardt), *Micula decussata* Vekshina, *Tetralithus obscurus* Deflandre.

In two samples taken at Kornica altogether 38 coccolith species have been found. This assemblage is more diversified than these at Mielnik and small forms are more abundant: *Biscutum ignotum* (Górka) and the representatives of genera *Vekshinella* and *Zygodiscus.* Most of them are present at Mielnik but there are some different species: *Broinsonia bevieri* Bukry, *B. furtiva* Bukry, *Corollithion rhombicum* (Stradner and Adamiker), *Vekshinella elliptica* Gartner, *Lithraphidites quadratus* Bramlette et Martini.

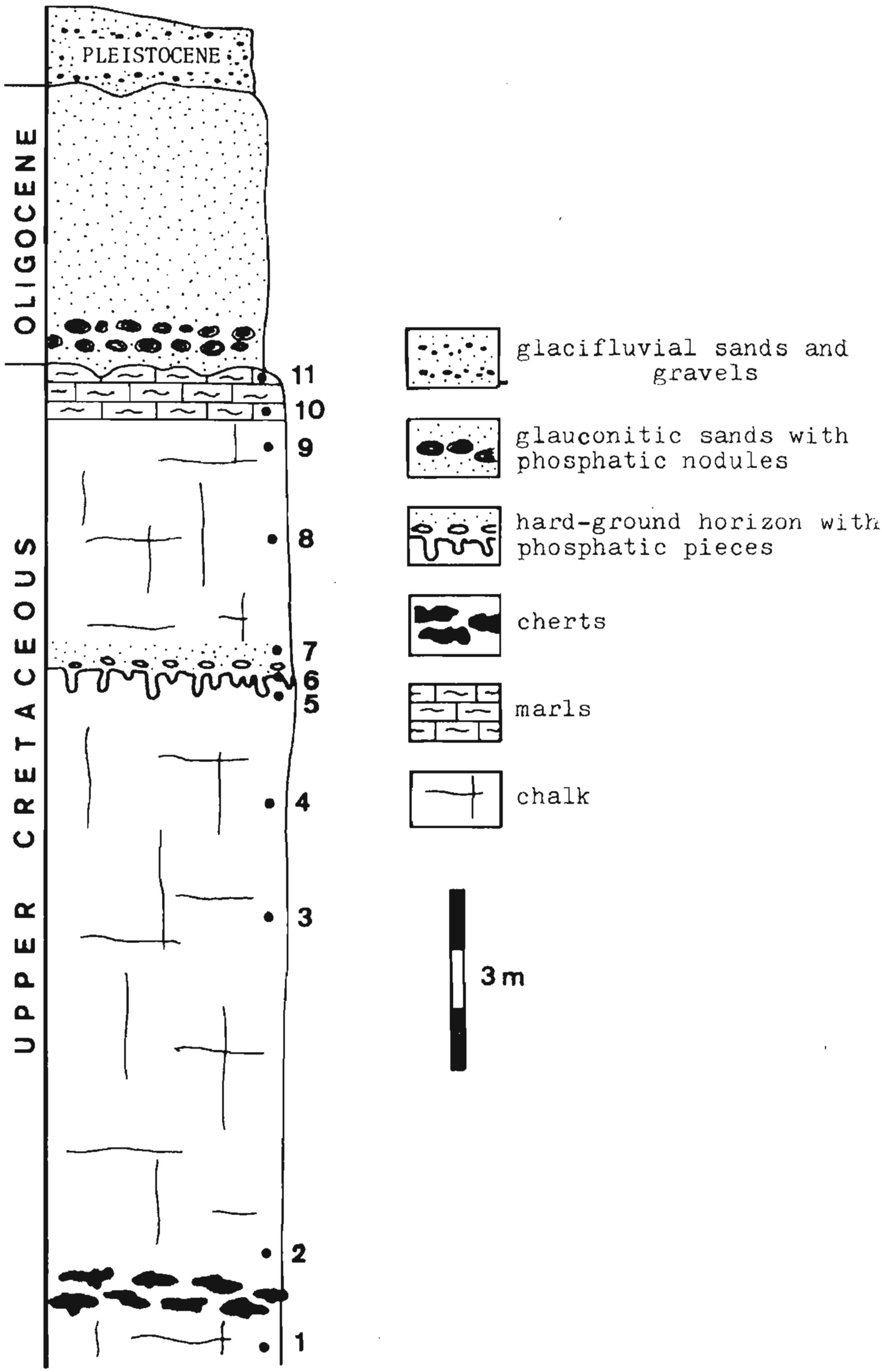
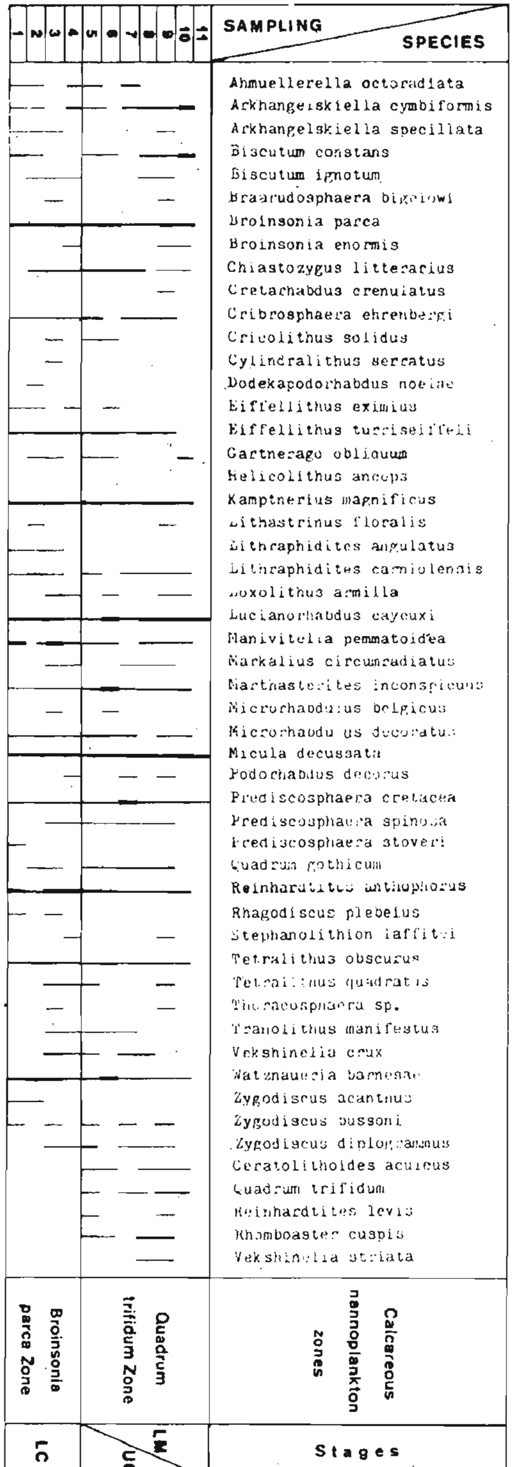


Fig. 1. Columnar section of deposits exposed at Mielnik (after Bitner and Pisera 1979; modified), and sampling sites (1—11) for the coccoliths.

Table 1

Stratigraphic ranges of the calcareous nannoplankton species in the chalk of Mielnik



All the here identified species were described many times in the literature and for this reason only the list is given here (Table 1) as well as the occurrence in the section. The most common species are illustrated on plates 15—21.

STRATIGRAPHIC REMARKS

A typical Campanian assemblage occurs in the lower part of the section (samples 1—4, fig. 1). It contains *Broinsonia parca* (Stradner). *Ceratolithoides aculeus* (Stradner) is absent here, at least in its typical form concordant with the holotype (Stradner 1961). But some forms were observed which were determind by Verbeek (1977) as *Ceratolithoides aculeus* type I, II and regarded by this author as early evolutionary stages of the species. This part of the section can be determined as the *Broinsonia parca* coccolith Zone. According to Thierstein (1976) this biozone embraces the Lower Campanian. The occurence of *Reinhardtites anthophorus* (Deflandre) and *Arkhangelskiella specillata* Vekshina, with the simultaneous lack of *Marthasterites furcatus* (Deflandre) points to the upper part of Lower Campanian. The presence of belemnoids *Belemnellocamax mamillatus* (Nilsson), *Belemnitella mucronata mucronata* (Link) and *Gonioteuthis gracilis* (Stolley) determined by Prof. D. P. Naidin of the Moscow University (Dr. R. Marcinowski — oral information) points also to the uppermost part of the Lower Campanian.

The following foraminifera species have been found in the part of the section in question: *Globotruncana fornicata* Plummer, *G. arca* (Cushman), *G. lapparenti* Brotzen, *G. bulloides* Vogler, *Heterohelix globulosa* (Ehrenberg), *Globorotalites michelinianus* (Orbigny), *Bolivinoides decoratus decoratus* (Jones), *Gavelinella clementiana* (Orbigny), *Stensiöina exculpta gracilis* Brotzen, *Stensiöina pommerana* Brotzen, *Neoflabellina rugosa* (Orbigny). (See pl. 22).

Identical assemblage occurs in the sediments regarded as the uppermost Lower Campanian in NW part of the Federal Republic of Germany (Koch 1977) and defined as the *Bolivinoides decoratus decoratus* Zone which is a counterpart of the cephalopod *gracilis/mucronata* Zone.

Starting from the sample 5 (0,5 m below the hard-ground) there appear in the coccolith assemblage: *Ceratolithoides aculeus* (Stradner), *Quadrum trifidum* (Stradner) and *Reinhardtites levis* Prins and Sissingh. Beside that, no other quantitative nor qualitative changes were noted in the nannoplankton. *Broinsonia parca* (Stradner) is still very common. Only in the uppermost part of the section (sample 10) there is a notable increase of *Arkhangelskiella cymbiformis* Vekshina as compared to other components of the assemblage. Hence the part of the section from about 0,5 m below the hard-ground up to the grey marls inclusively has been defined as the *Quadrum trifidum* coccolith Zone. It covers an interval between the first occurrence of *Quadrum trifidum* (Stradner) and the first occurrence of *Lithraphidites quadratus* Bramlette et Martini and it comprises the Upper Campanian and lowermost part of the Maastrichtian (Thierstein 1976, Verbeek 1977).

Simultaneous appearance of *Ceratolithoides aculeus* and *Quadrum trifidum* in the Mielnik chalk does not allow to separate two different biozones here, as it has been done by many authors. Nor is it possible to distinguish the *Ceratolithoides* (= *Tetralithus*) *aculeus* Zone (Čepek and Hay, 1969 emend. Martini, 1976) as an interval between the first appearance of *Ceratolithoides aculeus* and the first appearance of *Quadrum gothicum* (Deflandre) because the latter species occurs in the section in question earlier than the former. Analogous situation has been observed by Barrier (1980) in the Upper Cretaceous in Texas.

According to Salaj and Gašparikova (1979) the lower boundary of the *Quadrum* (= *Tetralithus*) *trifidum* Zone corresponds to that of Campanian — Maastrichtian. In the section considered this cannot be accepted because *Quadrum trifidum* appears there below the hard-ground just above the sediments containing a nannoplankton assemblage characteristic of the Lower Campanian. Thus the Upper Campanian age has been accepted here after Thierstein (1976).

Reinhardtites levis Prins and Sissingh stated only in samples 5, 8, 9, is limited to the Uppermost Campanian — Lower Maastrichtian interval (Sissingh 1977, Perch-Nielsen 1979).

No changes occur in the coccolith assemblage above the hard-ground as compared to this derived from samples taken just below that horizon. Thus, basing only on the calcareous nannoplankton, it is impossible to find out whether these sediments represent the Upper Campanian or Lower Maastrichtian. Taking for granted Pożaryski's (1960) point of view, according to which there is a sedimentary hiatus in the hard-ground horizon, it can be accepted that the sediments lying just above that horizon are of the Lower Maastrichtian age.

Appearance of some new coccolith species just below the hard-ground is accompanied by changes in the foraminifera composition; the following foraminifera appear: *Neoflabellina numismalis* (Wedekind), *N. buticula* (Hiltermann), *Bolivina incrassata incrassata* (Reiss) and rare *Bolivinoides draco miliaris* Hiltermann and Koch. Among the planktic foraminifera, the quantity of representatives of *Globotruncana* rapidly decreases but *Heterohelix globulosa* (Ehrenberg), *Globigerina cretacea* (Orbigny) and *Globigerinelloides asper* (Ehrenberg) dominate. The presence of the above species points to the Upper Campanian age (Koch 1977).

Above the hard-ground, there appear more stratigraphically younger forms. In samples 7, 8, 9 the following foraminifera has been stated: *Globigerinelloides asper* (Ehrenberg), *Heterohelix striata* (Ehrenberg), *Bolivina decurrens* (Ehrenberg), *B. incrassata incrassata* (Reiss), *Bolivinoides draco miliaris* Hiltermann et Koch, *B. delicatulus regularis* (Reiss), *Stensiöina pommerana* Brotzen and in sample 10 (grey marls): *Neoflabellina prereticulata* Hiltermann, *Bolivina incrassata crassa* Vasilenko et Myatliuk. (See pl. 22).

Most of the above mentioned species are known both from the Upper Campanian and from the Lower Maastrichtian. Only *Heterohelix striata* (Ehrenberg) is known entirely from the Lower Maastrichtian (Masters 1980).

In two samples of the chalk from Kornica, only the calcareous nannoplankton has been studied. In both, the presence of *Lithraphidites quadratus* Bramlette et Martini has been stated on the basis of which the age of these sediments can be defined as the higher part of the Lower Maastrichtian or the Middle Maastrichtian (Manivit 1971, Thierstein 1976, Verbeek 1977, Gaździcka 1978). Hence these sediments are younger than those cropping out at Mielnik. There are also the Upper Campanian and Lowermost Maastrichtian sediments in the Kornica area (Alexandrowicz 1965) which, however, were not accessible in the outcrop from which derives the material studied by the present author.

FINAL REMARKS

The calcareous nannoplankton assemblages which occur in the Mielnik chalk are typical for the Upper Cretaceous epicontinental seas of the boreal province (Thierstein 1976). Mass occurence of coccoliths points to exceptionally favourable physico-chemical conditions for the phytoplankton (abundance of light, CO_2, P, N). The abundance of nannoplankton is associated here with that of foraminifera and predominance of the filter feeders among the macrofossils (Bitner and Pisera 1979). A definite prevalence of benthic foraminifera over the planktic ones (the latter make about 25 per cent of the assemblage in the Kornica chalk: Alexandrowicz 1965) suggests a depth of the basin of about 100 meters. There are, however, some horizons at Mielnik in which the quantity of planktic foraminifera increases greatly. This phenomenon suggests periodical coming of currents from the open sea that brought the planktic forms rather than changes in bathymetry.

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ELŻBIETA GAŻDZICKA

KOKKOLITY I PRZEWODNIE OTWORNICE Z KREDY PISZĄCEJ MIELNIKA NAD BUGIEM

Streszczenie

Przedmiotem pracy jest analiza zespołów nannoplanktonu wapiennego z osadów kredy piszącej z Mielnika nad Bugiem. W badanym profilu (fig. 1) kokkolity występują masowo, z wyjątkiem poziomu twardego dna oraz szarych margli występujących w stropie kompleksu kredy piszącej. Zróżnicowanie gatunkowe w zespołach kokkolitów jest stosunkowo małe; w poszczególnych próbach zidentyfikowano od 20 do 30 gatunków. Dominują formy duże, o masywnej budowie: *Kamptnerius magnificus* Deflandre, *Broinsonia parca* (Stradner), *Reinhardtites anthophorus* (Deflandre), *Lucianorhabdus cayeuxi* Deflandre (pls 15—21).

Analiza składu zespołów nannoplanktonu wapiennego (tabela 1) pozwoliła na wyróżnienie 2 poziomów biostratygraficznych: *Broinsonia parca* (dolny kampan) oraz *Quadrum trifidum* (górny kampan-dolny mastrycht) (por. Thierstein 1976). Dla celów porównawczych oznaczono także niektóre gatunki otwornic (pl. 22). W najniższej części profilu skład zespołu otwornic wskazuje na wyższą część dolnego kampanu — poziom *Bolivinoides decoratus decoratus* (por. Koch 1977), co potwierdza wnioski wyciągnięte na podstawie kokkolitów. Natomiast obecność gatunku *Heterohelix striata* (Ehrenberg) w najwyższej części profilu sugeruje dolnomastrychcki wiek osadów. Potwierdza to sugestie Pożaryskiego (1960) o istnieniu luki stratygraficznej w badanym profilu. W zespołach otwornic zaobserwowano także zdecydowaną przewagę form bentonicznych nad planktonicznymi, co świadczy o niedużej głębokości zbiornika, rzędu 100 m.

Osady kredy piszącej z Kornicy są młodsze niż osady z Mielnika — reprezentują wyższą część dolnego mastrychtu, poziom kokkolitowy *Lithraphidites quadratus*.

EXPLANATION OF THE PLATES 15—22

All specimens from the chalk of Mielnik

Plate 15

1. *Zygodiscus bussoni* (Noël), proximal view, electron micrograph M I/4 N, ×6000.
2. *Vekshinella crux* (Deflandre and Fert), distal view, electron micrograph M II/1 N, ×6000.
3. *Ahmuellerella octoradiata* (Górka), distal view, electron micrograph M I/6 N, ×5000.

4. Same species, distal view, electron micrograph M II/2 N, ×6000.
5. *Helicolithus anceps* (Górka), distal view, electron micrograph M I/5 N, ×5000.
6. *Rhagodiscus plebeius* Perch-Nielsen, proximal view, electron micrograph M I/8 N, ×5000.
7. *Eiffellithus turriseiffeli* (Deflandre), distal view, electron micrograph M I/7 N, ×5000.

1, 3, 5—7 Broinsonia parca Zone *2, 4 Quadrum trifidum* Zone

Plate 16

1. *Zygodiscus acanthus* (Reinhardt), distal view, electron micrograph M I/3 N, ×5000.
2. *Tranolithus orionatus* (Reinhardt) proximal view, electron micrograph M II/10 N, ×10 000.
3. *Reinhardtites levis* Prins and Sissingh, distal view, electron micrograph M III/3 N, ×5000.
4. Same species, distal view, electron micrograph M II/3 N, ×5000.
5. *Reinhardtites anthophorus* (Deflandre), distal view, electron micrograph M III/1 N, ×6000.

1 Broinsonia parca Zone *2—5 Quadrum trifidum* Zone

Plate 17

1. *Arkhangelskiella cymbiformis* Vekshina, proximal view, electron micrograph M II/5 N, ×6000.
2. *Arkhangelskiella specillata* Vekshina, distal view, electron micrograph M III/8 N, ×6000.
3. *Broinsonia parca* (Stradner), proximal view, electron micrograph M II/4 N, ×6000
4. Same species, distal view, electron micrograph M I/14 N, ×6000.
5. Same species, distal view, electron micrograph M I/13 N, ×5000.
6. Same species, proximal view, electron micrograph M III/7 N, ×6000.

1—3, 6 Quadrum trifidum Zone *4, 5 Broinsonia parca* Zone

Plate 18

1. *a Kamptnerius magnificus* Deflandre, proximal view, electron micrograph M I/17 N, ×5000; *b Biscutum constans* (Górka), proximal view.
2. *a Kamptnerius magnificus* Deflandre, distal view, electron micrograph M I/8 N, ×5000; *b Watznaueria barnesae* (Black), distal view.
3. *Kamptnerius magnificus* Deflandre, distal view, electron micrograph M II/6 N, ×6000.
4. Central process of *Parhabdolithus* sp., electron micrograph M I/22 N, ×3000.

1, 2, 4 Broinsonia parca Zone *3 Quadrum trifidum* Zone

Plate 19

1. *Prediscosphaera cretacea* (Arkhangelsky), distal view, electron micrograph M I/11 N, ×6000.
2. *Prediscosphaera stoveri* (Perch-Nielsen), distal view, electron micrograph M I/12 N, ×6000.
3. *a Prediscosphaera cretacea* (Arkhangelsky), proximal view, electron micrograph M I/10 N, ×6000; *b Zygodiscus diplogrammus* (Deflandre), distal view.

4. *Prediscosphaera cretacea* (Arkhangelsky), side view, electron micrograph M III/4 N, ×5500.
5. *Watznaueria barnesae* (Black), distal view, electron micrograph M I/20 N, ×5000.
6. *Manivitella pemmatoidea* (Deflandre), proximal view, electron micrograph M I/19 N, ×6000.

1—3, 5, 6 Broinsonia parca Zone *4 Quadrum trifidum* Zone

Plate 20

1. *Biscutum constans* (Górka), distal view, electron micrograph M II/7 N, ×10 000.
2. *a, b Watznaueria barnesae* (Black) proximal view, electron micrograph M I/21 N, ×6000; *c Watznaueria barnesae* (Black) distal view; *d Zygodiscus diplogrammus* (Deflandre), proximal view.
3. *a Watznaueria barnesae* (Black), proximal view, electron micrograph M II/9 N, ×6000; *b Prediscosphaera cretacea* (Arkhangelsky), distal view.
4. *a Watznaueria barnesae* (Black), coccosphaere, electron micrograph M II/8 N, ×6000; *b Prediscosphaera cretacea* (Arkhangelsky), distal view; *c Tetralithus quadratus* (Stradner); *d* Zygodiscus sp.

1, 3, 4 Quadrum trifidum Zone *2 Broinsonia parca* Zone

Plate 21

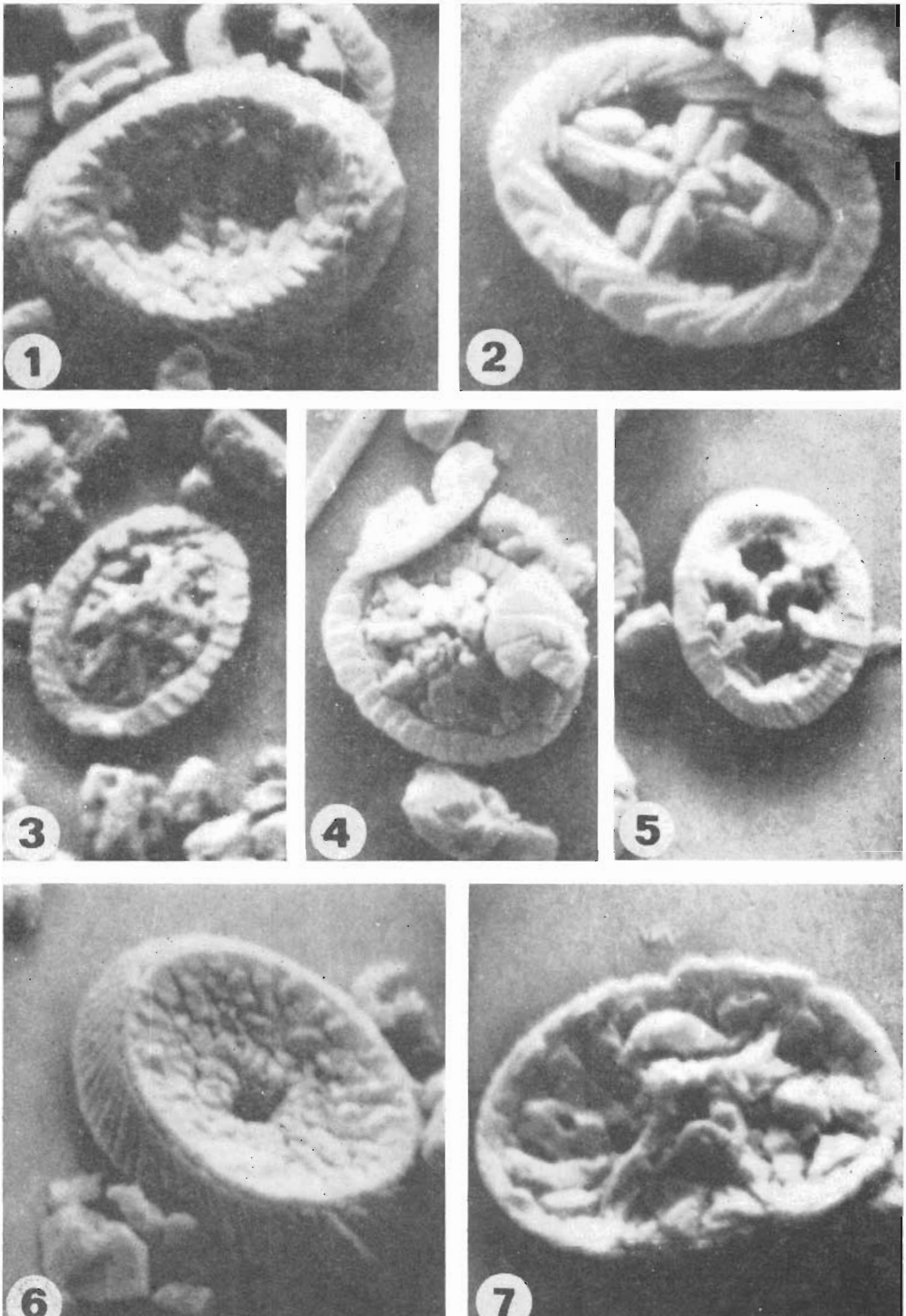
1. *a Micula decussata* Vekshina, electron micrograph M III/10 N, ×6000.
2. *a, b* Same species, electron micrograph M I/23 N, ×5000; *c Lucianorhabdus cayeuxi* Deflandre.
3. *Thoracosphaera* sp., electron micrograph M III/11 N, ×4000.
4. Typical assemblage of coccoliths from Mielnik, electron micrograph M I/1 N, ×2000.

1, 3 Quadrum trifidum Zone *2, 4 Broinsonia parca* Zone

Plate 22

1. *Globotruncana arca* (Cushman), dorsal view, IGP M4S/1 F, ×80.
2. *Globotruncana lapparenti* Brotzen, dorsal view, IGP M4S/2 F, ×100.
3. *Globigerinelloides asper* (Ehrenberg), side view, IGP M5S/2 F, ×200.
4. *Globotruncana fornicata* Plummer, dorsal view, IGP M4S/4 F, ×90.
5. Same species, ventral view, IGP M4S/5 F, ×100.
6. *Heterohelix globulosa* (Ehrenberg), side view, IGP M5S/3 F, ×200.
7. *Heterohelix striata* (Ehrenberg), side view, IGP M8S/2 F, ×200.
8. *Bolivinoides decoratus decoratus* (Jones), side view, IGP M3S/5 F, ×70.
9. *Stensiöina exculpta gracilis* Brotzen, dorsal view, IGP M3S/10 F, ×80.
10. *Gavelinella clementiana* (Orbigny), dorsal view, IGP M3S/8 F, ×70.
11. Same species, ventral view, IGP M3S/9 F, ×70.
12. *Neoflabellina rugosa* (Orbigny), side view, IGP M3S/16 F, ×80.

1, 2, 4, 5, 8—12 Broinsonia parca Zone *3, 6, 7 Quadrum trifidum* Zone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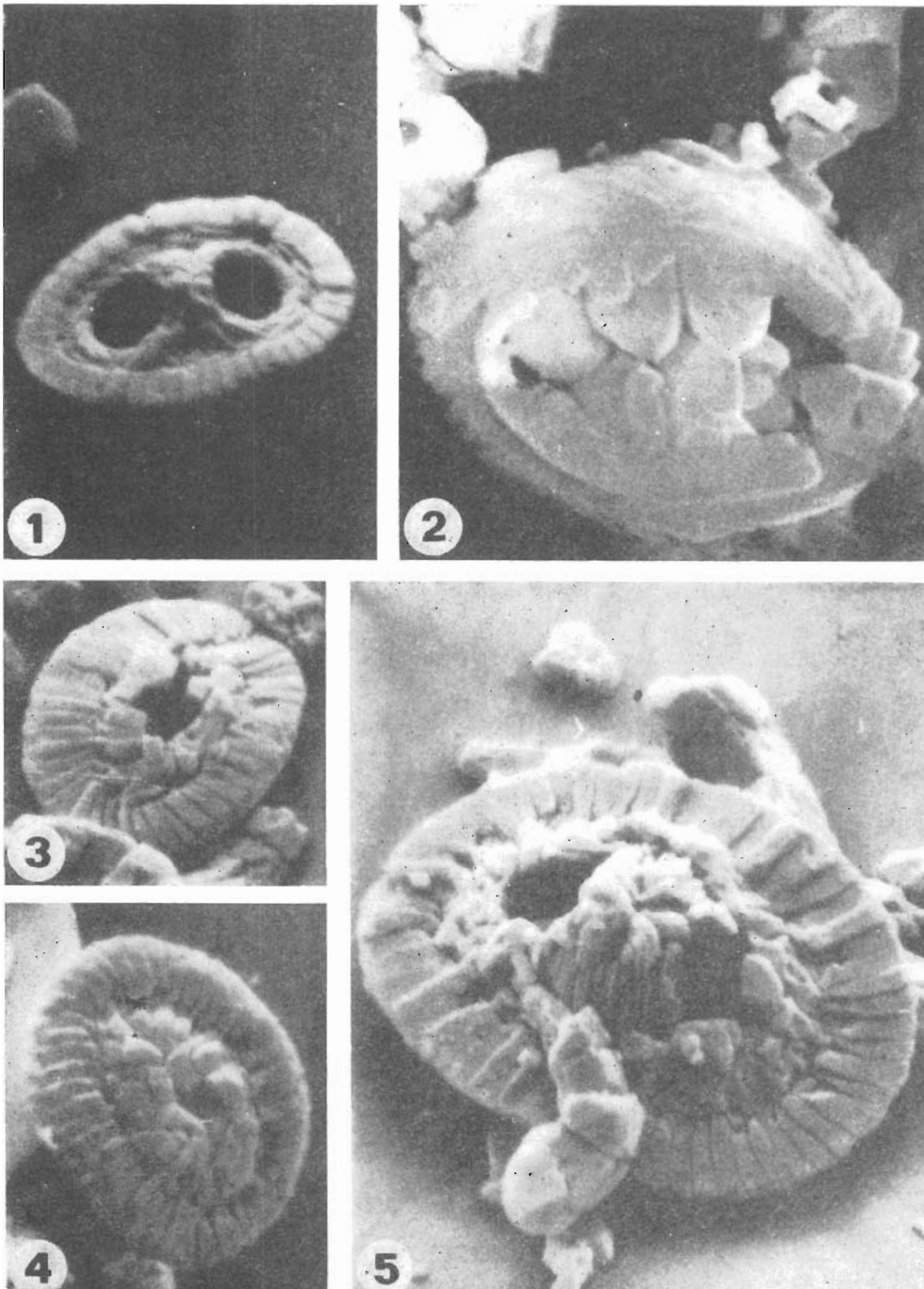
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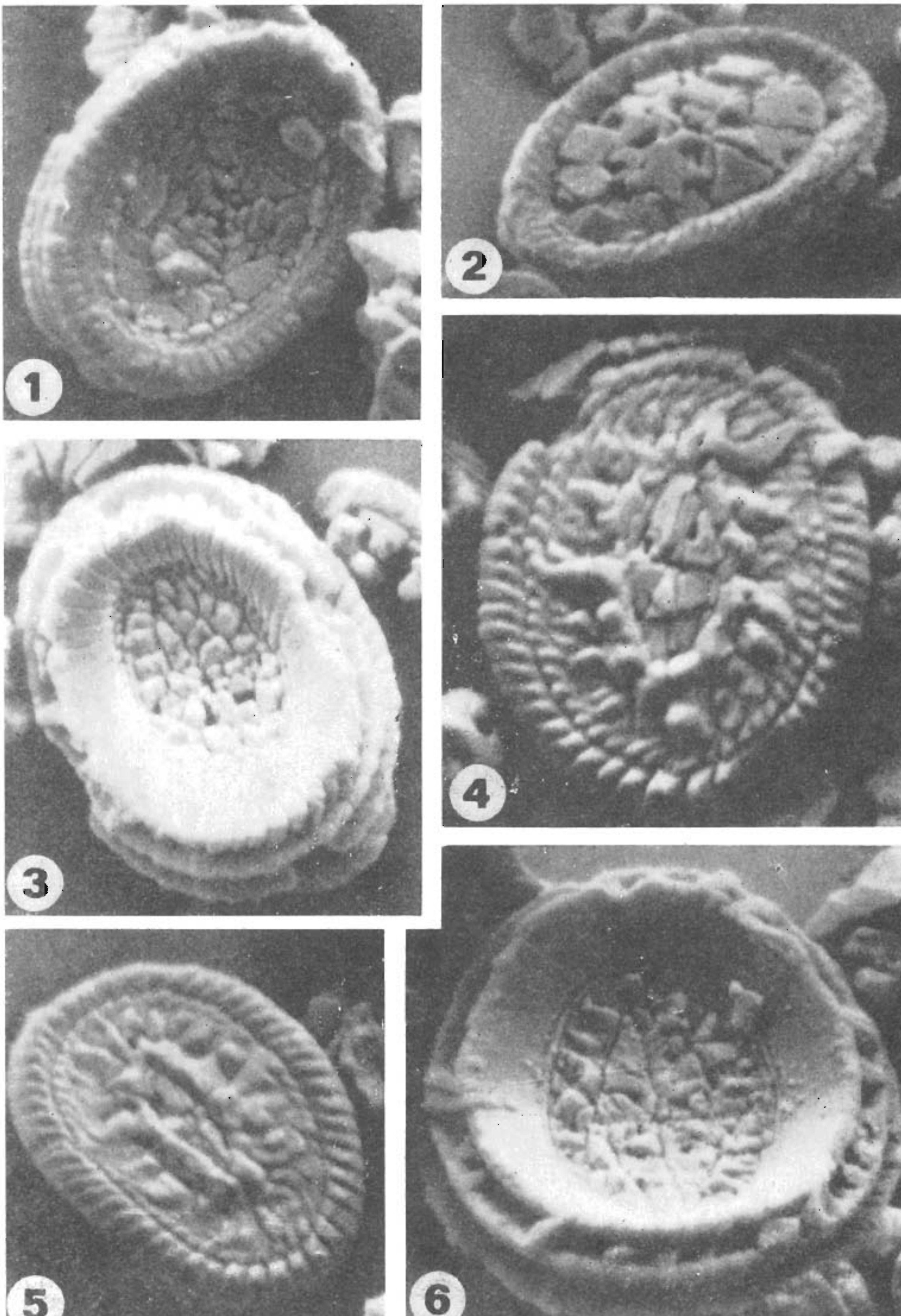
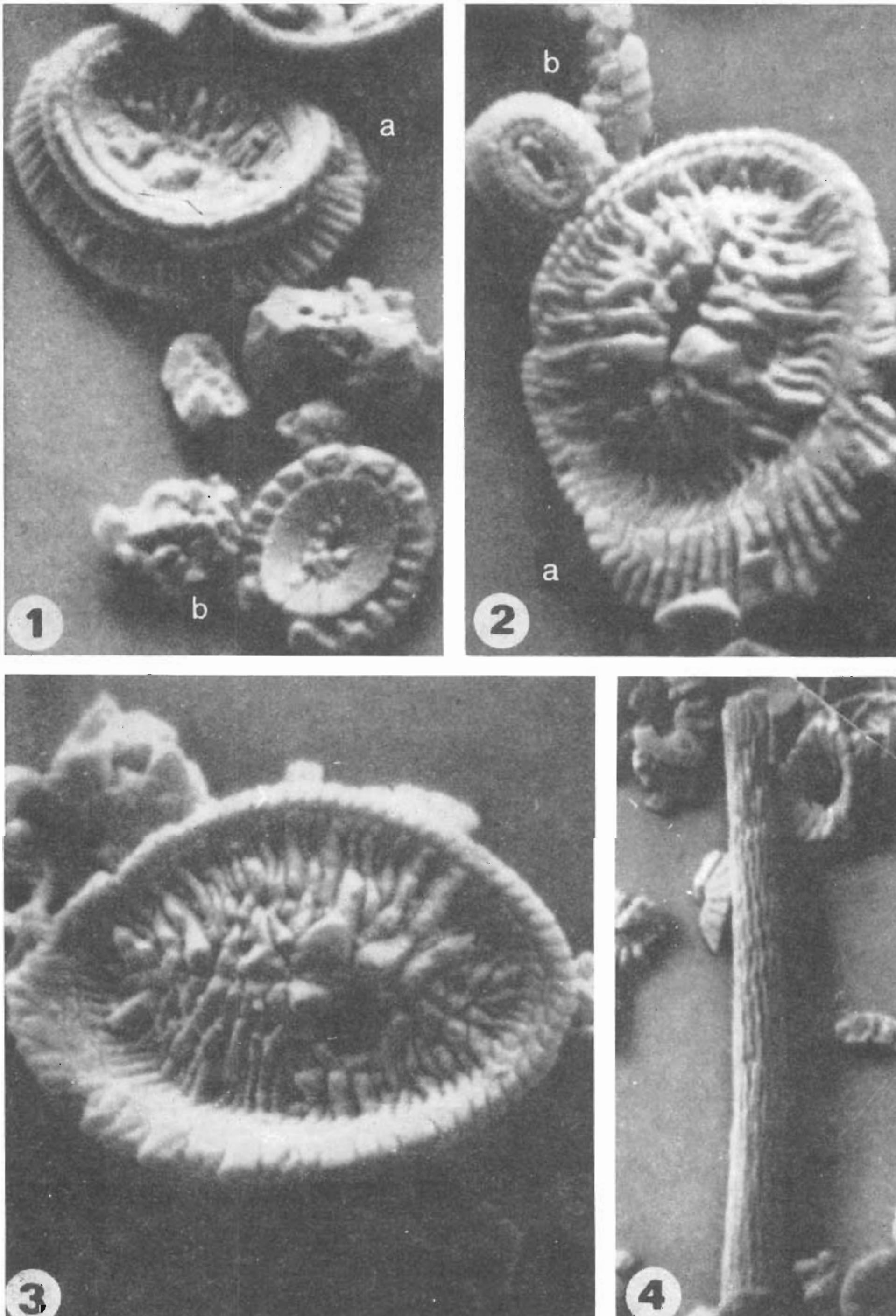
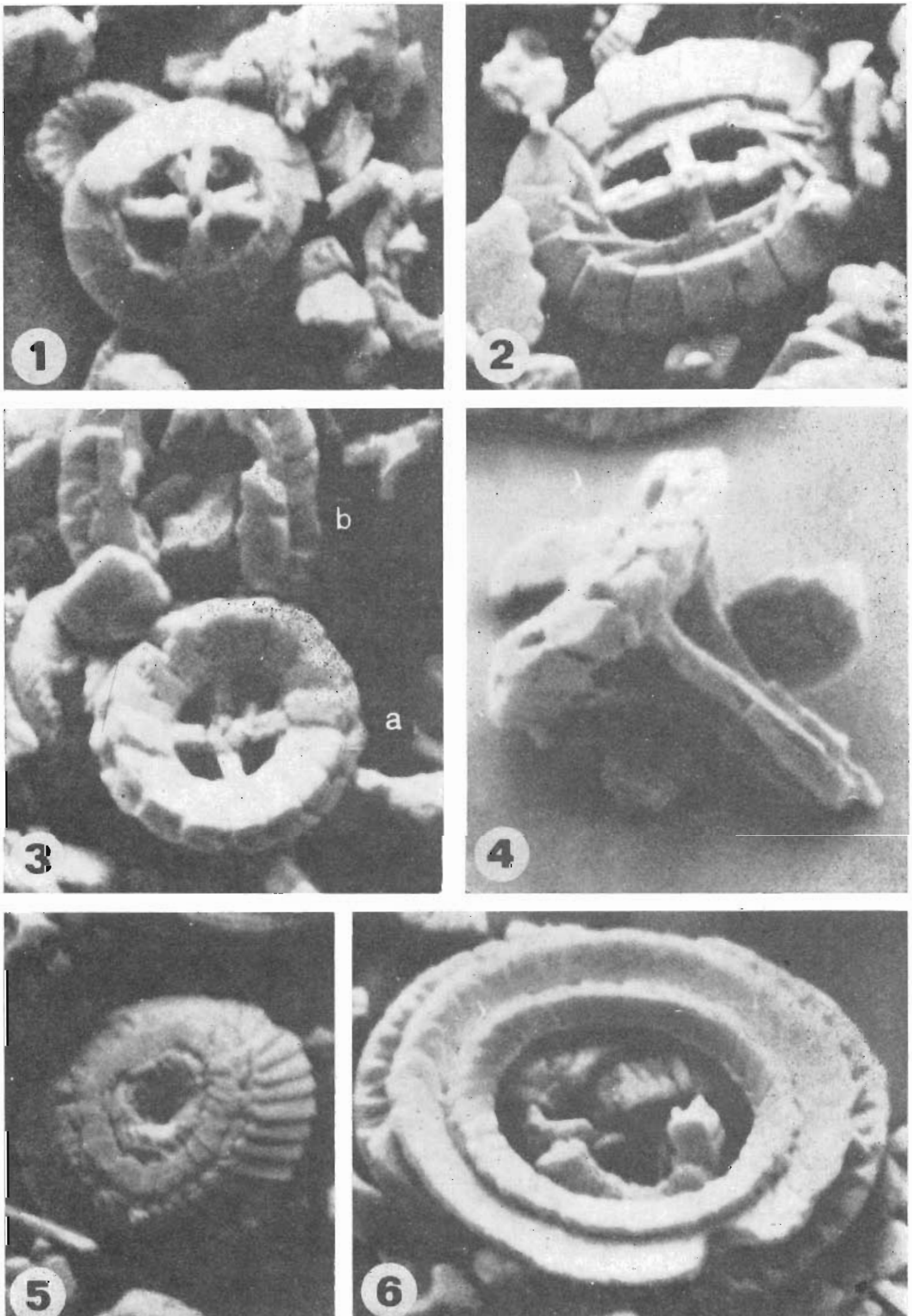



a
b
1
b
a
2
3
4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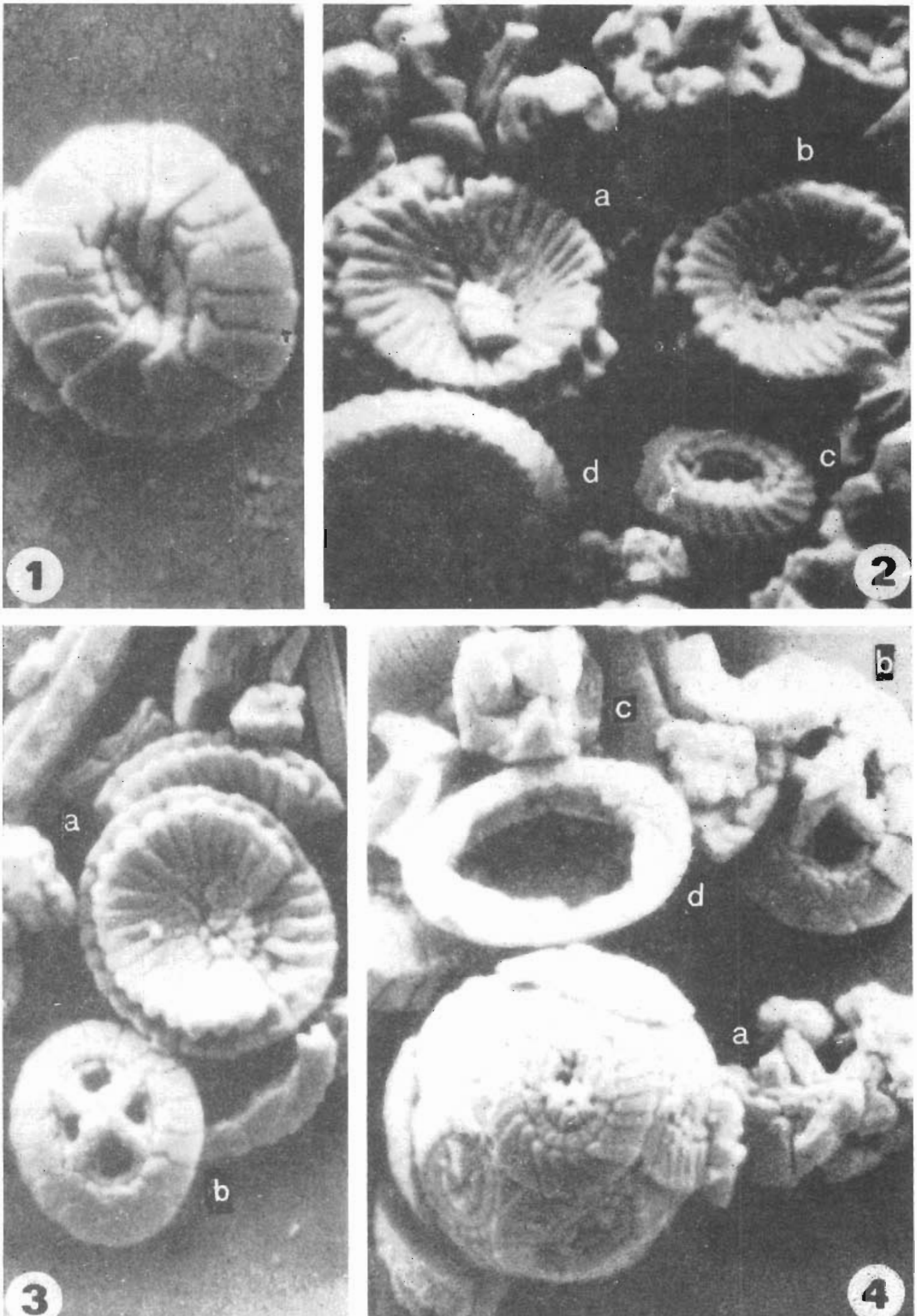
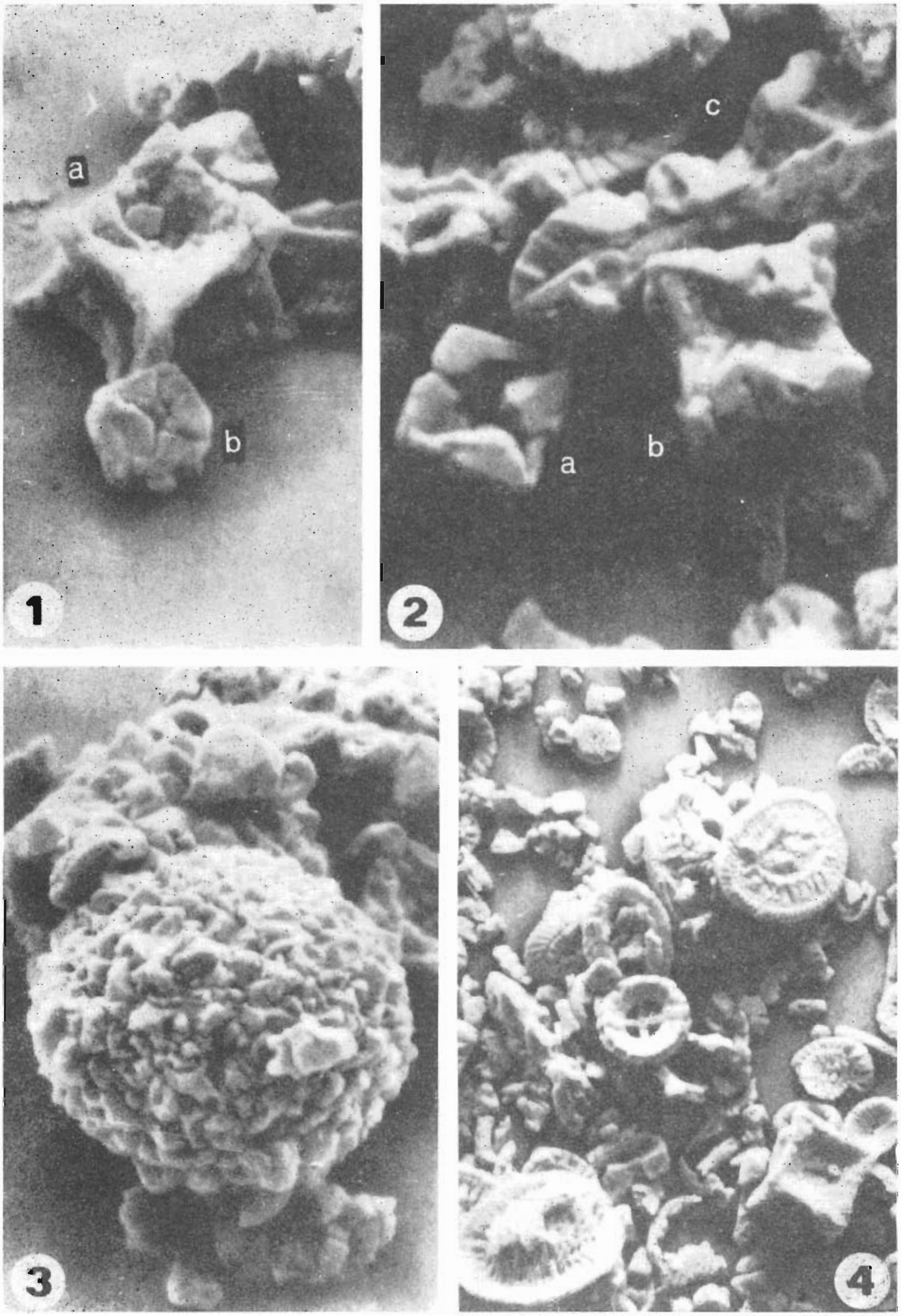
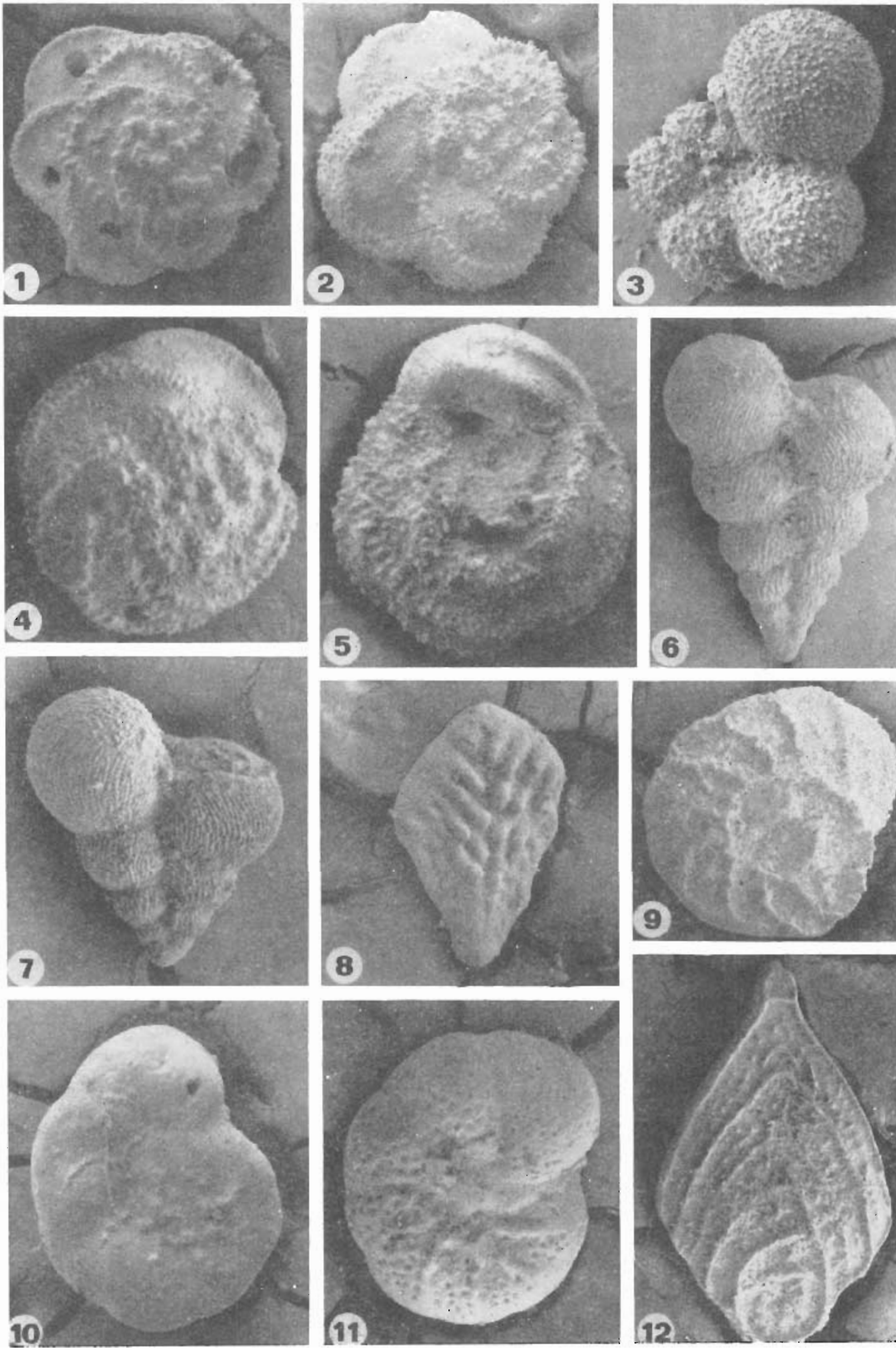
b
a
3
4
5
6


1
a
b
d
c
2
a
b
3
b
c
d
a
4


a
b
1
c
a
b
2
3
4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11
12