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PLEISTOCENE FORAMINIFERS OF THE AREA OF THE LOWER VISTULA RIVER (NORTHERN POLAND)

Contents

Abstract. — Descriptions of 49 benthic foraminiferal species (including three new species: *Elphidium halickii, E. hyalinum* and *Protelphidium rozkowskae*), belonging to 16 genera found in the Pleistocene of the Lower Vistula River area are given. Neither planktonic nor agglutinated foraminifers are represented here. Three assemblages are distinguished: warm-water foraminifer assemblage with contribu-

tion of Lusitanian species, found at Brachlewo and related to the Eemian Interglacial, boreal assemblage with contribution of both Lusitanian and Arctic species, found at Elbląg, and Arctic assemblage from Nadbrzeże. Foraminiferal fauna from Nadbrzeże shows cyclic alternation of cold-water and warmer-water assemblages corresponding to changes in pollen-spectra. According to pollen analysis, deposits of the Eemian, Amersfoort and Brørup Interglacials are represented at Nadbrzeże.

INTRODUCTION

The present paper constitutes the successive part of a monograph on Pleistocene faunas of the southern Baltic Sea studied by the author. Previously, molluscan assemblages from the borehole at Brachlewo (Brodniewicz, 1960) and from Elbląg clays exposed at Elbląg and its vicinity were described (Brodniewicz, 1960 and 1969a, respectively). The present paper deals with foraminifers found in Quaternary deposits of Brachlewo, Elbląg, Nadbrzeże, Bogdaniec and Suchacz (Text-fig. 1). Ostracods from the same materials and localities will be discussed in a subsequent paper, now in preparation. In turn, general conclusions and problems of development of southern Baltic faunas during the Quaternary will be dealt with in a separate paper.

On behalf of the Museum of the Earth, Warsaw, the present author collected samples of Quaternary clays from the Elbląg vicinity in 1952. In literature, these clays are known under various names as "Elbląg clays", "Elbląg *Yoldia* clays", "*Yoldia* clays", "Elbląg *Cyprina* clays". Core material from Brachlewo was obtained from the Geological Institute of Poland, Warsaw.

Descriptions of 49 benthic foraminifer species (including 3 new ones), belonging to 16 genera and 8 families are given. Neither planktonic nor agglutinated foraminifers are represented in the foraminifer-bearing deposits. The systematic is accepted after Loeblich & Tappan (1964), except for the case of the family Elphidiidae, which is of a tentative character. The present author together with Prof. Lutze and Dr. Haake of the Universität Kiel began detailed studies on representatives of this family by means of stereoscan electron microscope (SEM).

The material described herein is housed in the Palaeozoological Institute of the Polish Academy of Sciences — Poznań Branch and the numbers of specimens on the plates refer to the collection of this Institute.

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Thanks to the efforts of the Polish Academy of Sciences, the author was granted a 4-month research grant from the Government of Holland and had the possibility of studying foraminifer collection of the Geologische Dienst at Haarlem, Geologisch Institut — afdeling Micropaleontologie — der Rijks Universiteit at Utrecht, Rijksmuseum van Naturlijke Histories at Leiden and Geologische Institut Rijks Universiteit at Groningen.

Thanks to the efforts of Prof. E. Seibold (Kiel), the author was granted two monthly research grants from the Deutscher Akademischer Austauschdienst for studying at the Geologisch-Paläontologisches Institut und Museum der Universität at Kiel, where she had the possibility of studying rich foraminifer collections from the whole world and of studying and making 250 photos of foraminifers by means of SEM.

The author would like to express her thanks for the kindness and aid of many persons at the Geologisch-Paläontologisches Institut und Museum der Universität at Kiel, and especially to Prof. E. Seibold, Dr. I. Seibold, Prof. G. Lutze, Dr. F.-W. Haake, Dr. Ch. Samtleben.

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GENERAL PART

HISTORY OF RESEARCH

Palaeontological literature dealing with deposits of the Eemian Interglacial, yielding Lusitanian faunas is very scarce in the case of the region in question. Only two short notes on Eemian foraminifers accompanying Lusitanian molluscan faunas have been hitherto published. Pożaryski (1951) described 9 foraminifer species: *Nonion orbiculare* (Brady), *N. depressulus* (Walker & Jacob), *Elphidium lidoense* Cushman, *E. incertum* (Williamson), *E. incertum clavatum* (Cushman), *E. excavatum* (Terquem), *E.* (*Elphidiella*) aff. *asklundi* Brotzen, *Eponides frigidus calidus* Cushman & Cole, and *Rotalia beccarii* (Linné) from the borehole at Tychnowy. Subsequently, Brodniewicz (1965) published a short preliminary note on foraminifer assemblage comprising *Rotalia beccarii* (L.), *Nonion*, *Eponides* and *Quinqueloculina*, accompanying Lusitanian molluscan faunas from the contemporaneous deposits pierced out by borehole at Brachlewo, near Tychnowy.

Younger deposits, Elbląg clays, yielding Boreal and Arctic faunas, were the subject of a number of studies, but mainly geological in character. In turn, among faunas of these deposits, molluscan faunas were most often studied, but primarily from the geological-stratigraphic point of view (e. g., Jentzsch, 1876; Linstow, 1922; Galon, 1934, 1952; Halicki, 1950, 1951a; Woldstedt, 1955; Halicki & Brodniewicz, 1961; a. o.). Just a few short notes on Quaternary foraminifers of this region were hitherto published. Madsen (1896) described 9 foraminifer species: *Miliolina seminulum* L., *M. subrotunda* Mts., *Haplophragmoides pseudospiralis* Williamson, *Truncatulina lobatula* Walker & Jacob, *Rotalia beccarii* L., *R. beccarii lucida* Madsen, *Nonionina depressula* Walker & Jacob, *N. depressula orbicularis* Brady, and *Polystomella striatopunctata* Fichtel & Moll. Subsequently, Halicki and Brodniewicz (1961) published progress report on studies on Elbląg and Nadbrzeże areas, where the following foraminifer species were cited:

from Elbląg:	Revised names:
Elphidium aff. *pseudolessoni* Ten Dam	= *E. umbilicatulum* (Williamson)
E. excavatum Terquem	= *E. umbilicatulum* (Williamson)
E. orbiculare Brady	= *Protelphidium orbiculare* (Brady)
E. incertum Williamson	= *E. incertum* (Williamson)
E. incertum clavatum Cushman	= *E. clavatum* Cushman

from Elbląg:	Revised names:
E. articulatum d'Orbigny	= *E. bartletti* Cushman
Eponides frigidus calida Cushman & Cole	= *Buccella frigida* Cushman
Rotalia beccarii L.	= *Ammonia beccarii* (L.) var.
Quinqueloculina seminulum L.	= *Q.* sp. *1* (cf. *Q.* from the *seminulum* group)
from Nadbrzeże:	
Cornuspira involvens Reuss	= *Cyclogyra* sp. *2*
Quinqueloculina seminulum L.	= *Q.* sp. *1* (cf. *Q.* from the *seminulum* group)
Eponides frigidus calida Cushman & Cole	= *Buccella frigida* Cushman
Nonion pauciloculus albiumbilicatum Weiss	= *E. albiumbilicatum* (Weiss)
Elphidium incertum (Williamson)	= *E. incertum* (Williamson)
E. articulatum (d'Orbigny)	= *E. bartletti* Cushman
E. orbiculare (Brady)	= *Protelphidium orbiculare* (Brady)

Some remarks concerning the occurrence of foraminifers of the families Elphidiidae and Polymorphinidae were given by Piotrowicz (1961) and Brodniewicz (1969a). Elbląg foraminifers were somewhat more widely discussed by Brodniewicz (1969b), where 13 species were listed:

	Revised names:
Quinqueloculina seminulum (Linné)	= *Q. seminulum* (Linnaeus)
Buccella frigida (Cushman)	= *B. frigida* (Cushman)
Ammonia batava Hofker	= *A. beccarii* var.
Nonion granosum (d'Orbigny)	= *Protelphidium granosum* (d'Orbigny)
N. depressulus (Walker & Jacob)	= *P. umbilicatulum* (Walker & Jacob)
Protelphidium orbiculare (Brady)	= P. orbiculare (Brady)
Elphidium poeyanum (d'Orbigny)	= *E. poeyanum* (d'Orbigny)
E. excavatum (Terquem)	= *E. umbilicatulum* (Williamson)
E. gunteri Cole	= *E. gunteri* Cole
E. clavatum Cushman	= *E. clavatum* Cushman
E. incertum (Williamson)	= *E. incertum* (Williamson)
E. subarcticum Cushman	= *E. albiumbilicatum* (Weiss)
E. bartletti Cushman	= *E. bartletti* Cushman

The studies carried out by the present author represent the first more complete elaboration of faunas occurring in the region; however, they should be treated as an introduction to further, complex studies.

MATERIALS AND METHODS

Faunal material obtained from Brachlewo represents a mixture of microfossils occurring in layer 2.3 m thick. Foraminifer fauna is very well-preserevd; foraminifer tests are undamaged, and generally not infilled with

sediment. In this rich material all developmental stages of some species may be found.

From the Elbląg profile, monolith samples were taken in the ratio of 1 kg per 10 cm of layer. Foraminifers were not found until bed 3 — the so-called "*Cardium* layer". Preservation of foraminifer tests, initially very good, becomes gradually poorer towards the top of the profile. Tests become opaque and damaged. This is particularly the case in tests of *Protelphidium orbiculare*, found in bed 5.

At Nadbrzeże, 64 monolith samples were taken from the profile of wall, 25 m high, at intervals given in Table 3. The profile was extended by a section pierced by manual borehole, which gave a further 25 samples. In Table 3, level of outcrop was marked with 0, and samples numbered −1, −2, etc. were taken from the borehole. In the material obtained, tests of some species are quite well-preserved, whereas others are somewhat damaged. The majority of tests are opaque, last chambers are usually broken-off. In the case of *Protelphidium orbiculare,* granular material initially covering umbilical area and sutures is usually eroded or obliterated. It is worth noting that preservation of tests markedly differs in various parts of the profile, or even in particular samples — in some places tests are markedly better preserved than in others. In numerous places tests filled with pyrite were found.

Single samples collected at Elbląg, Nadbrzeże, Suchacz, or Bogdaniec profile generally contain well-preserved material, except for damaged ultimate chambers and granular material eroded from umbilicus and sutures.

In the material studied, only benthic foraminifers were found. Even a single representative of the agglutinated species was not found; this is presumably a secondary phenomenon, connected with destruction of organic cement of these tender tests during fossilization and handling. This suggestion is supported by observations of Baltic Holocene and Recent foraminifers carried out by both the present author and others. Although agglutinated foraminifers occur in great number in the contemporaneous Baltic sea, no such forms were found in Holocene deposits (Brodniewicz, 1965). Direct interdependence between the degree of fossilization and impoverishment of material in agglutinated forms in the course of the handling process was traced by the author in laboratory conditions.

Samples were soaked for 24-hours and then filtred through sieve with meshes 0.06 mm in diameter. Greasy clays, which did not disintegrate during soaking were boiled for 20 min. in water with some addition of soda and then filtered. Micro- and megalospheric generations were studied in polished sections. Data given in Tables 2 and 3 are based on specimens picked up on 10 picking trays. In turn, Text-fig. 3 presents data obtained by means of test tube used as a container of quantitative measurements, which results in general contributions of particular species in assemblage studied.

DESCRIPTIONS OF EXPOSURES

Brachlewo. (Text-figs 1, 2)

Foraminiferal assemblage was obtained from marl layer, 2.3 m thick pierced out by borehole at Brachlewo (Text-fig. 2) at depth of 50.4 m. The

Fig. 1. Map of the Lower Vistula area.

layer yields numerous foraminifers as well as molluscans, ostracods, crustaceans (fragments of plates of *Balanus* sp. and Decapoda chelae) and echinoderm fragments (spikes, skeletal and madreporoid plates of Asteroidea, spikes and plates of Echinoidea).

The Lusitanian molluscan assemblage is represented by *Cardium paucicostatum* Sow., *Gastrana fragilis* (L.), *Brachyodontes lineatus* (Gmelin), *Eulimella nitidissima* (Mont), and characteristic fossil of the Eemian, *Venerupis aurea senescens* (Cocconi). Among foraminifer assemblage, *Ammonia beccarii* var. and *Protelphidium granosum* predominate; moreover, some species of the family Elphidiidae, namely *Elphidium umbilicatulum*, *E. clavatum*, *E. incertum*, *Protelphidium orbiculare* and *P. umbilicatulum*, appear to be quite common.

Elbląg and vicinities.

Interglacial Elbląg clays occur to the east of Vistula River outlet, in the Elbląg area, and spread along southern coast of Zalew Wiślany as far as Braniewo. Over the northern part of Elbląg Upland and at Elbląg, these

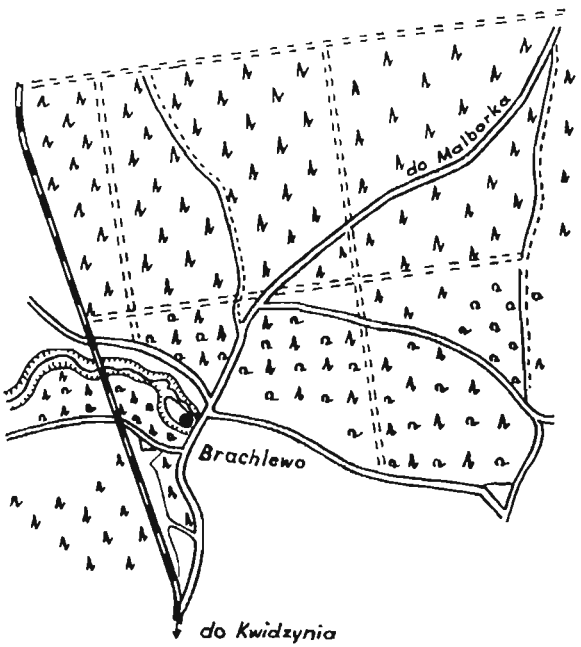


Fig. 2. Location sketch of the Brachlewo borehole.

clays were found in boreholes and, occasionally, outcrop in gullies and stream valleys, as e. g. at Bażantarnia at Elbląg. To the north, along the Zalew Wiślany coast, Elbląg clays are exposed in numerous claypits. Jentzsch (1876), Piotrowski (1961) and others noted that bedding of the Elbląg clays is highly glacitectonically disturbed. In places, the clays are strongly heaped or even broken, forming large floes separated by glacial material. Such deformations are widely distributed over the area studied, hence arrangement and sequence of particular beds are difficult to evaluate.

Samples were taken by the author from the so-called "*Cardium*-layer" of the undisturbed profile from Bażantarnia at Elbląg and randomly, from the so-called "Krystyna crag". Some samples were also taken from profile of the NE wall of upper clay-pit at Nadbrzeże and from a waste heap and various parts of clay-pit abandoned at present. At Suchacz, single samples were taken from the waste heap and in various parts of clay-pit, abandoned at present. Monolith samples were taken at Bogdaniec, where excavation was dug out in red clays.

Profile of Bażantarnia. — The material studied comprises samples

of the Elbląg clays forming a steep wall, a few meters high, along the left bank of Srebrny stream; here, the so-called "*Cardium* layer" ("Cardium-bank" of Woldstedt, 1955) was sampled. That name was given to layer, 5 to 10 cm thick and yielding numerous pelecypods, among which *Cardium* (*Cerastoderma*) *lamarcki* (Reeve) predominates. In this profile the succession is as follows:

1. At the bottom there are exposed green, fresh-water muds, 0.30 m thick, observable just above the water level in Srebrny stream; these muds yield great amounts of plant detritus and numerous opercles of *Bithynia tentaculata* (L.) and ostracod tests.

2. Gray fresh-water muds, 0.7 m thick, yielding rich fauna of fresh-water molluscans, Unionidae glochidia and ostracod tests.

3. So-called *Cardium* layer, 0.05—0.10 m thick, filled with broken shells of brackish and marine molluscans, mainly *Cardium* (*Cerastoderma*) *lamarcki* (Reeve). Also some foraminifer and ostracod tests were found here. In the foraminifer assemblage, *Ammonia beccarii* var., *Elphidium umbilicatulum* predominate; representatives of the species *Protelphidium granosum* occur in subordinate amounts.

4. Dark-gray clays passing to black clays, 1.20 m thick. Here, both marine molluscans, accompanied by chitons, and foraminifer-ostracod assemblage are represented; also remains of other faunal groups, such as plates of *Balanus* sp., chelae of Decapoda, Polychaeta jaws and skeletal fragments of echinoderms (spikes and madreporoid plates of star-fishes, and fragments of echinoid spikes and plate fragments) and, occasionally, otoliths and Arthropoda carapace fragments were found. The fauna, quite common at the base of these clays, becomes more and more scarce towards the top. Foraminifer assemblages, quite numerous in that bottom part, change their specific composition, decrease in number of individuals. *Ammonia beccarii* var., *Protelphidium umbilicatum*, *P. granosum* and *Elphidium umbilicatulum*, occurring in masses in the basal part, become progressively scarcer and ultimately disappear close to the top of that layer. In turn, *E. clavatum* (morphotype 2) conversely, becomes more frequent in the upper part.

5. Sandy intercalations, 0.25 m thick, with clayey bands. No molluscans were found here; foraminifers are represented by small-sized individuals of the species *Protelphidium orbiculare*, *Buccella frigida* and Polymorphinidae; moreover, plant detritus, oogonia of *Characea*, *Nereis* jaws and beetle elytra were found.

6. Greasy gray clays, 1.80 m thick and yielding unnumerous fragments of marine pelecypod shells and tests of *Protelphidium orbiculare*.

7. Greasy clays with sandy bands, 2.20 m thick. No macrofauna was found; microfauna represented by occasional tests of *Protelphidium orbiculare*, *Nereis* jaws, beetle elytra and plant detritus.

8. Sandy clays, 1.0 m thick; no fauna found.

"*Krystyna crag*". — Upstream of the exposure of "*Cardium* layer", at picturesque place known as "Krystyna crag", gray clays outcrop in stream bed. These clays yield small admixture of very fine-grained sand, fine, pink-violet fragments of shell of pelecypod, *Mytilus edulis*, as well as foraminifers, among which those belonging to *Protelphidium orbiculare* and *Elphidium clavatum* (morphotype 2) predominate. Moreover, *Nereis* and *Mesidotea* jaws and large amount of plant detritus were found.

Nadbrzeże. — Profile of upper part of NE wall of clay-pit was sampled. No macrofossils were found. In the rather numerous micro-faunal assemblage, foraminifers prevail on ostracods both in number of individuals and species.

Moreover, single samples were taken at various places in the clay-pit:

a — "*Portlandia arctica* clays" — samples of deposits newly exposed in exploitation wall were taken. Shell fragments of *Portlandia arctica*, numerous foraminifers and occasional ostracod valves were found.

b — "*Arctica islandica* clays" — samples taken from exploitation wall yielded shell fragments of pelecypods, *Arctica islandica* (= *Cyprina islandica*) and *Astarte borealis*, numerous foraminifers and single ostracod valves.

c — clay samples from waste heaps — these samples were taken at various places in the clay-pit. Some of them yielded macrofossils; whereas, as a rule, numerous foraminifers and single ostracod valves were found everywhere.

Suchacz. — Single samples were taken at different places in clay-pit II; some of them yielded macrofossils; foraminifers, among which tests of *Protelphidium orbiculare* predominate, were found in all samples.

Bogdaniec. — Monolit samples were taken from profile exposed. Clays outcropping here yield numerous foraminifer and ostracod assemblages, whereas macrofauna is represented only by fine pelecypod detritus.

CHARACTERISTICS OF SEDIMENTARY ENVIRONMENTS OF THE PROFILES STUDIED

The complete lack of planktonic forms is a striking feature of assemblages found both in materials from profiles and random samples. This indicates sedimentation in isolated basins poorly connected with open sea. In turn, the lack of agglutinated forms seems to be a secondary effect (see p. 428).

The foraminifers reflect distinct climatic changes in particular profiles. It should be emphasized that these changes in foraminifer assemblages support and supplement observations made on molluscan faunas (Brodniewicz, 1960, 1965, 1969).

Brachlewo. — In general large numbers of representatives of a relatively few (18) species are found in marine marls occurring here (Text-fig. 3; Table 1). The species identified characterize the sedimentary environment

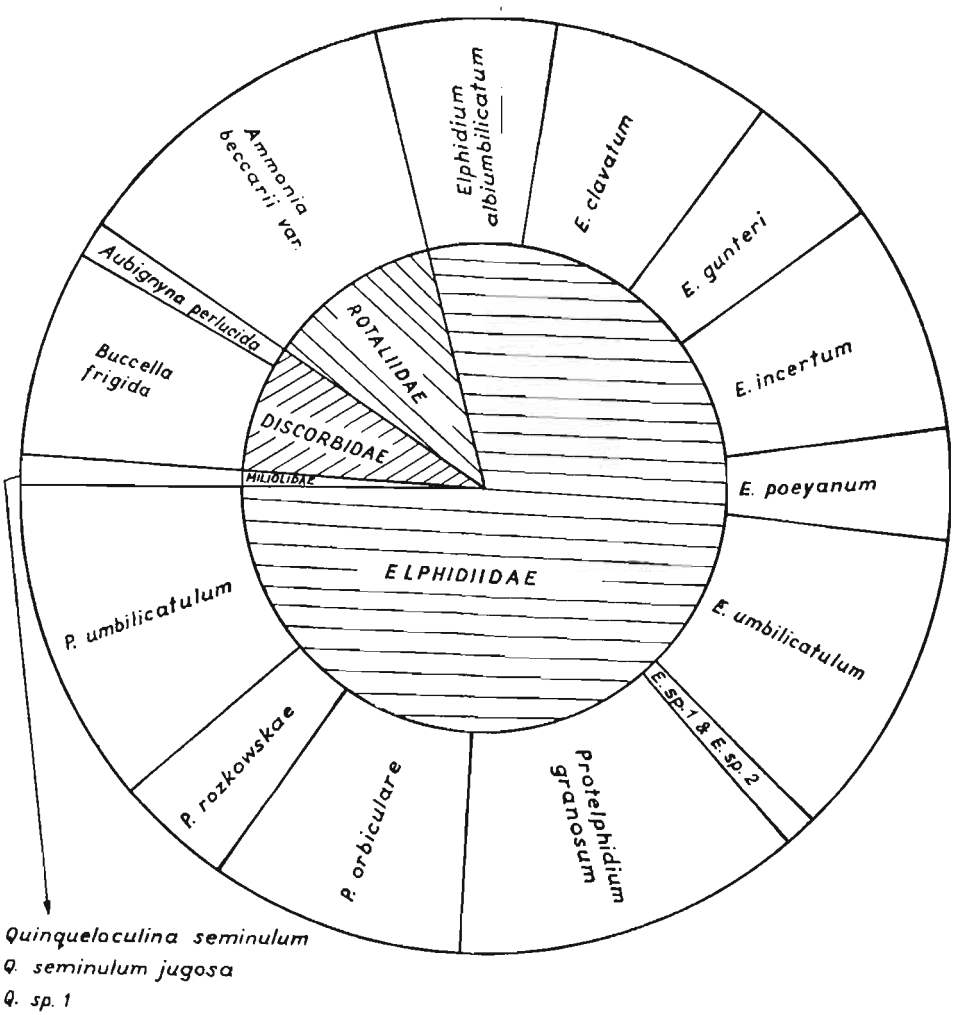
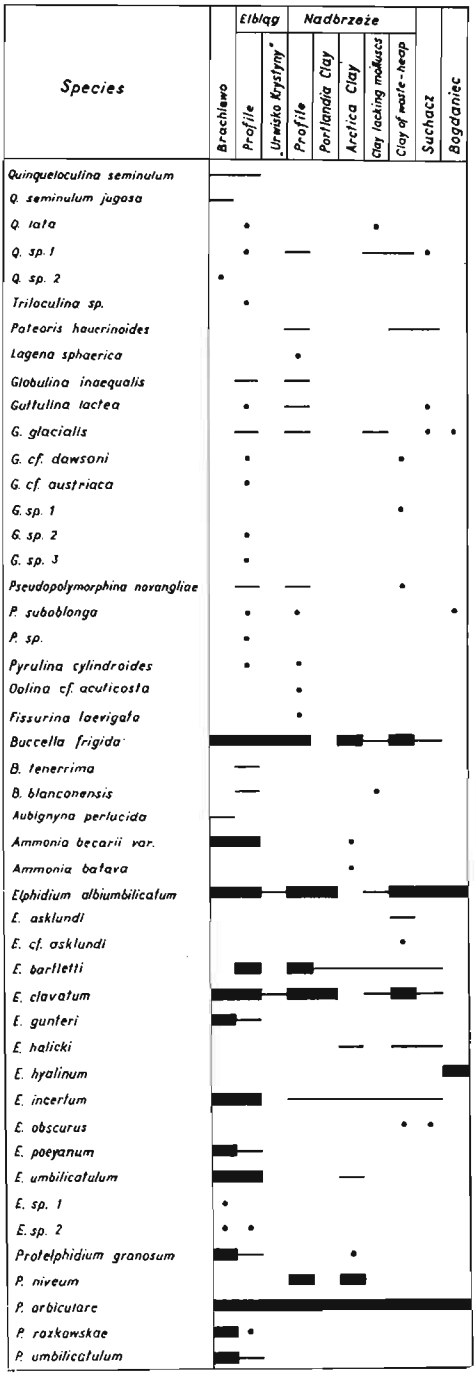


Fig. 3. Percentage contribution of particular species in the assemblage from Brachlewo.

well. The assemblage may be generally termed as *Ammonia-Elphidium* assemblage of shallow, warm waters with slightly decreased salinity, which fact is evidenced by occurrence of species inhabiting contemporaneous lagoons, pools and brackish coastal waters of Lusitanian province. These species include *Protelphidium granosum, Elphidium poeyanum, E. gunteri*; also *Protelphidium umbilicatulum*, known from Boreal zone, may be included here. The remaining species are characterized by wide geograp-

Table 1



Distribution of foraminifers in the materials studied. Explanation as in Text-fig. 2.

hical distribution and are known to occur from Boreal to Arctic province at present.

Hence, the above analysis of foraminifer assemblage supports the results of studies on molluscan fauna, which assemblage, Lusitanian in character, indicates sedimentation in shallow parts of warm sea (Brodniewicz, 1960).

Elbląg. — Profile of "*Cardium* bed" (Table 2). The analysis of foraminifer assemblage also supports and supplements results of studies on molluscans (Brodniewicz, 1969). Fresh-water deposits of first two beds are overlayed by marine sediments. In bed 3, marine transgression is evidenced by appearance of marine micro- and macrofauna. The faunal assemblage of this bed is tanatocoenotic, typical of waving zone of shallow sea, where shells, and particularly pelecypod shells are broken, diminuted, transported and finally deposited by waves. Here, for the first time, still innumerous, representatives of *Ammonia beccarii* var., *Elphidium umbilicatulum* and *Quinqueloculina seminulum*, as well as marine pelecypods, *Cardium* (*Cerastoderma*) *lamarcki* (Reeve), *Macoma balthica* (Linnaeus) and *Mytilus edulis* Linnaeus appear.

The overlaying bed (bed 4) is characterized by an increase in number of both species and individuals, but temporarily, as a subsequent decrease is marked towards the top of this bed. In that bed, there is a gradual transition from Lusitanian — Boreal assemblage of the climatic optimum of the profile to Boreal, poorer assemblage, related to cool climate. It seems that materials sampled from the Srebrny stream bed and from "Krystyna crag" may be considered as corresponding to prolongation of the upper part of bed 4, which is indicated by foraminifers occurring here.

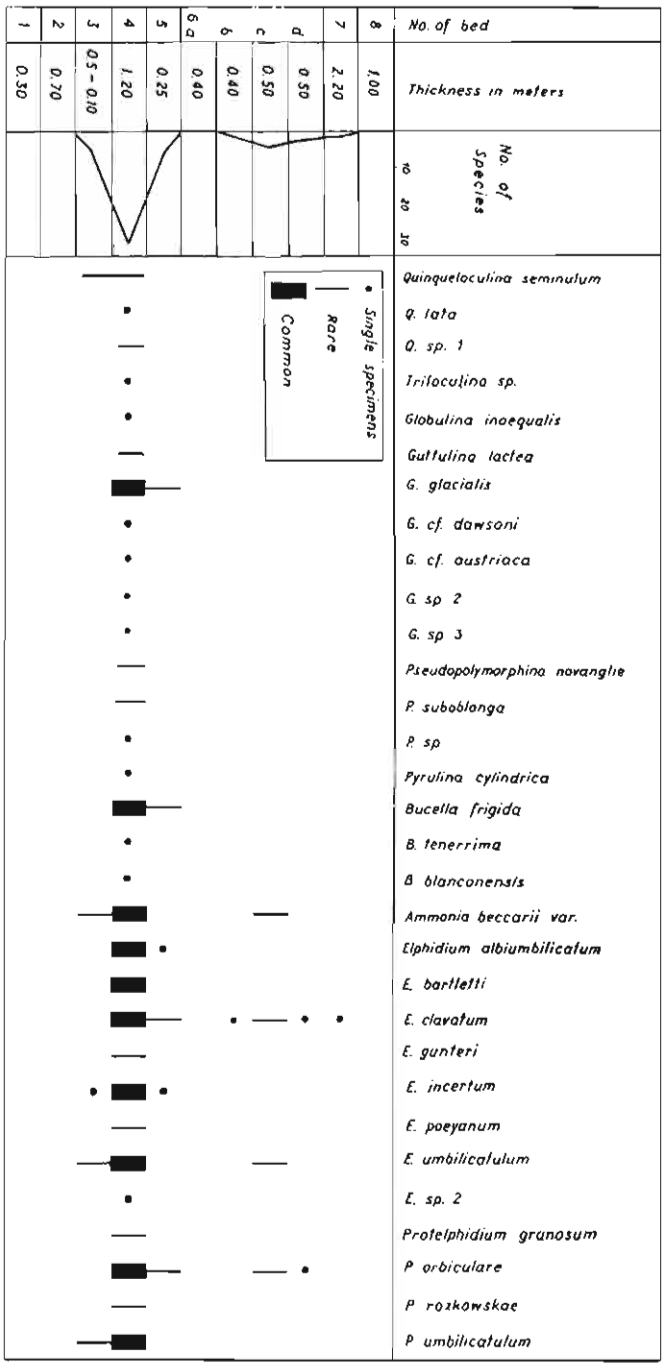
The next bed (5th), yields innumerous foraminifers indicating cool climate prevailing during its deposition.

Bed 6, divided into four sections because of its great thickness, appears to be poor in foraminifers. Single tests of *Ammonia beccari* var., *Elphidium clavatum* (morphotype 2) and *E. umbilicatulum* indicate both some melioration of climate and shallowing of the boreal basin.

Nadbrzeże. — Cyclical changes in foraminifer assemblages may be noted in Table 3. Three changes in assemblage of foraminifer species found correspond well to climatic changes shown by pollen spectrum changes (Przybylski, in: Halicki & Brodniewicz, 1961).

In the lower part of the profile (Zone 6, see Table 3) only two species, *Elphidium clavatum* (morphotype) and *E. albiumbilicatum*, were found. Increase in number of individuals of one species is accompanied by corresponding decrease in number of individuals of the other species, which indicates that conditions favourable for these species were markedly different. This assemblage, poor in species but rich in individuals, presumably develops in specific conditions under Arctic climatic conditions, as only fo-

Table 2



Distribution of foraminifers in the Elbląg profile.

raminifers and ostracods are represented in some samples. In such conditions, a form, occasionally attaining "giant" size developed within *Elphidium clavatum* population. *Elphidium albiumbilicatum* also appears highly variable. Among individuals of this species, typical forms as well as others, listen in its synonymy, may be distinguished.

Climatic optimum is marked in samples 2—15 (Zone 5), by both foraminifer faunas and pollen spectrum. Here, an assemblage markedly richer in species and individuals and diametrically different from the preceding one, is found. From the preceding assemblage, only small, not numerous forms of *Elphidium albiumbilicatum*, typical of this species, survived. Although no typical Lusitanian species, such as those from Elbląg, are found here, the whole assemblage indicates melioration of climate in comparison with that of the preceding zone. The assemblage may be termed Boreal-Arctic assemblage with predominance of *Protelphidium orbiculare*. In samples 2 to 6, *P. niveum*, the species known exclusively from Eemian deposits of Schleswig-Holstein (Lafrenz, 1963) and Denmark from Older *Yoldia* Clay deposits from Vendsyssel (Feyling-Hanssen et al., 1971) becomes quite common. The maximal number of species was recorded along this section, which fact, together with the occurrence of *Protelphidium niveum*, indicates that this section reflects the optimum not only of this part but of the whole profile.

Contributions of particular species in assemblages from subsequent samples (Zone 4) generally resemble those from the oldest assemblage found in the profile in question (Zone 6), but some decrease in the number of species is marked.

A new cycle begins with sample nr. 31, where an increase in the number of species is marked. Here, singular tests of *Protelphidium niveum* and *Buccella frigida* appear (Zone 3). The change is also reflected in the pollen spectrum by the appearance of stenothermal species.

Beginning with sample no. 37, assemblage of *Elphidium clavatum* (morphotype 3) and *E. albiumbilicatum* similar to those typical of Zones 6 and 4, return (Zone 2). This specific assemblage vanishes in sample no. 44. From sample no. 48, boreal cycle similar to that of climatic optimum (Zone 5) but differing in much smaller and poorer content of foraminifer species and numer, is repeated (Zone 1). Occurrence of microfauna in the profile ends with sample no. 51.

A supplementary sample, taken outside the profile from overlaying sands yields thin-walled, translucent, very well-preserved representatives of *Elphidium clavatum* (morphotype 2).

The above analysis shows that alternation of two foraminifer assemblages is distinctly marked in this profile, generally poor in species. The first of these assemblages comprises cold, Boreal-Arctic assemblage, *Elphidium clavatum* (morphotype 3) — *E. albiumbilicatum* (Zones 2, 4, 6),

whereas the second, warmer, is characterized by *Protelphidium orbiculare* and *P. niveum* (Zones 1, 3, and 5), and is accompanied by increase of contribution of stenothermal elements in pollen spectrum. Single samples randomly taken cannot be correlated with the profile.

Samples with *Arctica islandica* yield very interesting assemblage, which differs from those of the profile and appears close to those of the Elbląg profile. Here, Lusitanian species such as *Protelphidium granosum*, *Ammonia beccarii* var., as well as Lusitanian-Boreal species such as *Protelphidium umbilicatulum* and *Elphidium umbilicatulum*, were found. The remaining samples, representing *Portlandia arctica* clays, clays without fauna, clays from waste heaps or clays from clay pit II at Suchacz (Table 1) contained foraminifers typical of Boreal-Arctic Zone.

Bogdaniec. — Profile of red clays is highly glacitectonically disturbed, which results in contamination of the material. Foraminifer assemblage found in these clays is poor in species (Table 1) and no faunal zones may be distinguished. A new species, *Elphidium hyalinum*, is described from this locality. *Elphidium albiumbilicatum* occurring here appears to be highly variable; in its large population it would be possible to distinguish typical forms, as well as others, listed in the synonymy, which include intermediate forms. The species represented in the red clays are typical of Boreal-Arctic type of basin in which deposition took place.

AGE OF THE DEPOSITS STUDIED

Foraminifers, just as molluscans, may be used as indices for stratigraphic correlation of the deposits studied. It is difficult to talk about guide fossils for the Quaternary, but it is possible to distinguish characteristic assemblages, making it possible to support and supplement results of faunistic-palynologic studies. In the case of Lusitanian fauna, typical of sea from the Eemian Interglacial, foraminifer assemblage may even be used to determine age of sediments deposited during that time interval. The species common to Eemian deposits of Poland, Schleswig-Holstein and Holland include: *Quinqueloculina seminulum*, *Q. seminulum jugosa*, *Aubignyna perlucida*, *Ammonia beccarii* var., *Elphidium poeyanum*, *E. gunteri*, *E. umbilicatulum*, *E. clavatum* (morphotype 1), *Protelphidium granosum* and *P. umbilicatulum*.

The age of deposits from Brachlewo has already been very accurately determined (Brodniewicz, 1960). Lusitanian molluscan fauna with the guide fossil of the Eemian, *Venerupis aurea senescens* (Cocc.) indicate the Eemian age of these deposits. This is confirmed by the occurrence of such Lusitanian species as *Protelphidium granosum*, *Elphidium gunteri*, *E. umbilicatulum*, *Ammonia beccarii* var. and *Protelphidium umbilicatulum*. The

assemblage appears to be identical with that described by Pożaryski (1951) from a borehole at Tychnowy, near Brachlewo.

The assemblage from Brachlewo is close to that described by Lafrenz (1963) from the upper beds of Eemian Interglacial from the Baltic region. Fauna of Schleswig-Holstein is somewhat richer in species than the Polish assemblage, differing in higher contribution of Lusitanian and Lusitanian-Boreal forms including the new species, *Protelphidium niveum*. The latter element seems typical of Eemian fauna from deposits of Baltic region (Lafrenz, 1963), but it was not recorded from Brachlewo.

Comparison of Brachlewo assemblage with typical Eemian foraminifers described by Voorthuysen (1958) from the borehole Amersfoort I, shows their remarkable similarity. However, cold-water form, *Protelphidium orbiculare*, occurring in great numbers in Brachlewo assemblage, was not recorded from Holland; moreover, Brachlewo assemblages appears much poorer than the latter one, which results from weaker connection of embayment of Eemian sea from the area in question with open sea and thus lower salinity than in the case of Holland.

The age of younger deposits, to which Elbląg clays should be assigned, is more difficult to establish on the basis of foraminifer faunas. Halicki (1951) and others related Elbląg clays with Baltic of the Skaerumhede time, and thus considered them as younger than deposits of the Eemian Interglacial. Deposits of the Skaerumhede series are regarded by some authors as corresponding to the second half of the Last Interglacial, and the Eemian they correlate with the first half of this interglacial; some authors related Skaerumhede to the interstage, others (Halicki 1951; Borówko-Dłużakowa 1964, and others) assume interglacial rank of deposits of this time.

Pollen analyses serve as the basis for age determination of deposits from Elbląg and Nadbrzeże profiles (Halicki & Brodniewicz, 1961). According to these determinations, these sediments were formed during the Eemian Interglacial times (Elbląg and Zone 5 of Nadbrzeże profile). Borówko-Dłużakowa (1964) related later melioration of climate, marked in Nadbrzeże profile (Zone 1), with the Brørup (= Skaerumhede) Interglacial.

Some Lusitanian foraminifers are represented in bed 3 and at the base of bed 4 of the Elbląg profile. These innumerous warm-water elements occurring in the lowermost part of the profile seem to suggest a cooler phase of the Eemian Interglacial, during which a small number of Lusitanian species developed.

Recently, Feyling-Hanssen et al. (1971) described a number of profiles from Denmark and Norway. Foraminifer assemblages of these profiles are much richer and hence the number of species in common with faunas from the Elbląg area is low and comparisons difficult to make. Generally,

Nadbrzeże assemblage is somewhat similar to some foraminifer spectra of Sandes Clay and Older *Yoldia* Clay from Vendsyssel (Feyling-Hanssen et al., 1971), but not identical, as it is much poorer than the latter.

No Lusitanian elements were found at Nadbrzeże. Particular zones distinguished in the Nadbrzeże profile are characterized by foraminifer assemblages difficult to correlate with zones distinguished in other profiles. *Protelephidium niveum* appears three times in the Nadbrzeże profile (Zones 1, 3, 5). The species is known from the Eemian of Baltic regions of Jutland and Schleswig-Holstein, where it occurs together with warm-water species, and from Older *Yoldia* Clay (Feyling-Hanssen et al., *l.c.*). Two distinct warm periods marked in pollen spectrum of the Nadbrzeże profile confirm two changes in foraminiferal assemblages in which *Protelphidium niveum* contributes (Zones 1 and 5). Increase in contribution of oak, spruce and alder marked in Zone 3 is also accompanied by small change in foraminifer assemblage, related to appearance of not numerous individuals of the species *Protelphidium niveum*. Zone 3 may correspond to the Amersfoot age.

SYSTEMATIC PART

Family **Fischerinidae** Millet, 1898
Genus *Cyclogyra* Wood, 1842
Cyclogyra sp. 1
(Pl. XVII, Figs 5, 6)

Material. — Six partly damaged specimens and numerous fragments.

Remarks. — Poor preservation permits only general characterization of the specimens. Calcareous, porcelain, plano-spiral test; peripheral margin rounded; chamber long, progressively evolute; wall unperforated, milky white tinted, smooth, except for transversal growth-lines unclearly marked; suture distinct. Earliest chambers, similarly as terminal part of the test with peristome are lacking in all specimens.

The tests under discussion are most similar to *Cyclogyra foliacea* (Philippi).

Occurrence. — Quaternary: Poland (Nadbrzeże).

Cyclogyra sp. 2
(Pl. XXII, Fig. 4)

Material. — Single pyritized, incomplete specimen.

Remarks. — Test most similar to *Cyclogyra involvens* (Reuss).

Occurrence. — Quaternary: Poland (Nadbrzeże).

Family **Miliolidae** Ehrenberg, 1839
Genus *Quinqueloculina* d'Orbigny, 1826
Quinqueloculina seminulum (Linnaeus, 1758)
(Pl. XVIII, Figs 1, 2; Text-fig. 4)

1758. *Serpula seminulum* Linnaeus; C. Linnaeus, Systema naturae ..., p. 786.
1929. *Quinqueloculina seminulum* (Linné); J. A. Cushman; On Quinqueloculina seminula (Linné), p. 59—60, Pl. 9, Figs 17, 18.
1967. *Quinqueloculina seminulum* (Linné); M. Moulinier, Repartition des foraminifères..., p. 479, Figs 2—1, 5, 8.
1971b. *Quinqueloculina seminulum* (Linné); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 194, Pl. 1, Figs 18, 20 (cum synon.).

Material. — Approximately 30 specimens, mostly damaged.
Dimensions (in mm):

	F. XV/4	F. XV/5	F. XV/6
Length	0.36	0.60	0.56
Width	0.22	0.34	0.38

Remarks. — The present species is pandemic being widely reported. However, it is doubtful whether or not all specimens illustrated or cited under this name belong, in fact, to this species.

Occurrence. — *Quinqueloculina seminulum* (Lin.) is characterized by a wide stratigraphical and geographical distribution, being known from the Tertiary to the present day from Europe, Asia and America. Quater-

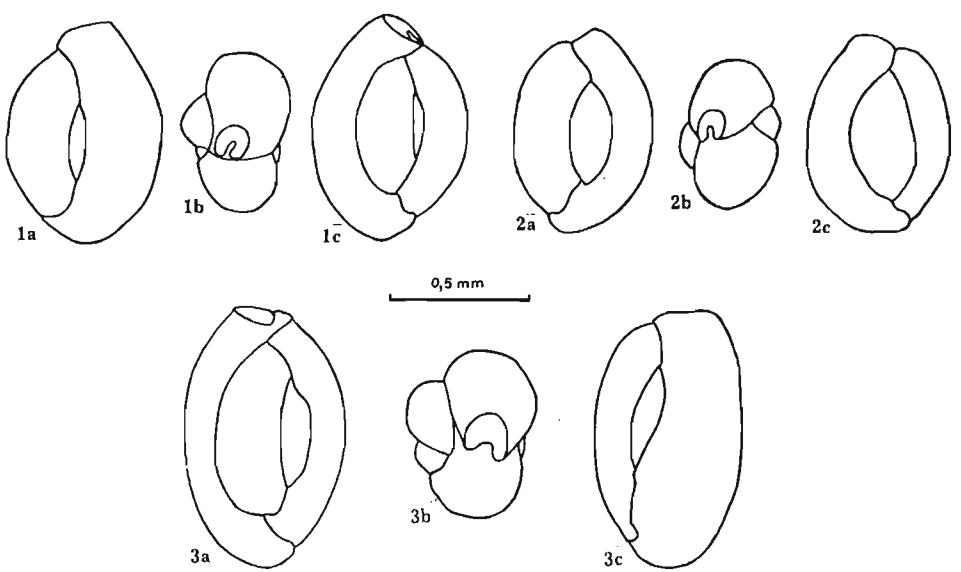


Fig. 4. *Quinqueloculina seminulum* (Linnaeus); outlines of tests from Brachlewo: *a* and *c* side views, *b* apertural views.

nary: Poland (Brachlewo, Elbląg), Denmark, Sweden, Germany, Norway, Holland, France, Italy, England. Recent: pandemic species.

Quinqueloculina seminulum jugosa Cushman, 1944
(Text-fig. 5)

1944. *Quinequeloculina seminula* (Linnaeus) var. *jugosa* Cushman; J. A. Cushman, Foraminifera from the shallow..., p. 13, Pl. 2, Fig. 15.
1952b. *Quinqueloculina seminula* (Linnaeus) var. *jugosa* Cushman; L. Parker, Foraminiferal distribution..., p. 456, Pl. 2, Fig. 8.
1953. *Quinqueloculina seminulum* (Linnaeus) var. *jugosa* Cushman; D. N. Miller, Ecological study..., p. 52, Pl. 8, Fig. 5.
1957. *Quinqueloculina seminulum* (Linnaeus) var. *jugosa* Cushman; J. H. van Voorthuysen, Foraminiferen aus dem Eemien..., p. 37, Pl. 26, Fig. 47.
1963. *Quinqueloculina seminulum* (Linnaeus) var. *jugosa* Cushman; A. Ayala-Castanares, Sistematica y distribucion..., p. 65, Pl. 4, Fig. 3.
1963. *Quinqueloculina seminula* (Linnaeus) var. *jugosa* Cushman; H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 16, Pl. 1, Fig. 1.

Material. — Five well-preserved and five fragmentary specimens. Dimensions (in mm):

	F. XV/7	F. XV/8	F. XV/9
Length	0.70	0.58	0.74
Width	0.45	0.36	0.49

Remarks. — Tests identical to those described by Cushman (1944). The species was reported by van Voorthuysen (1957) from borehole Amers-

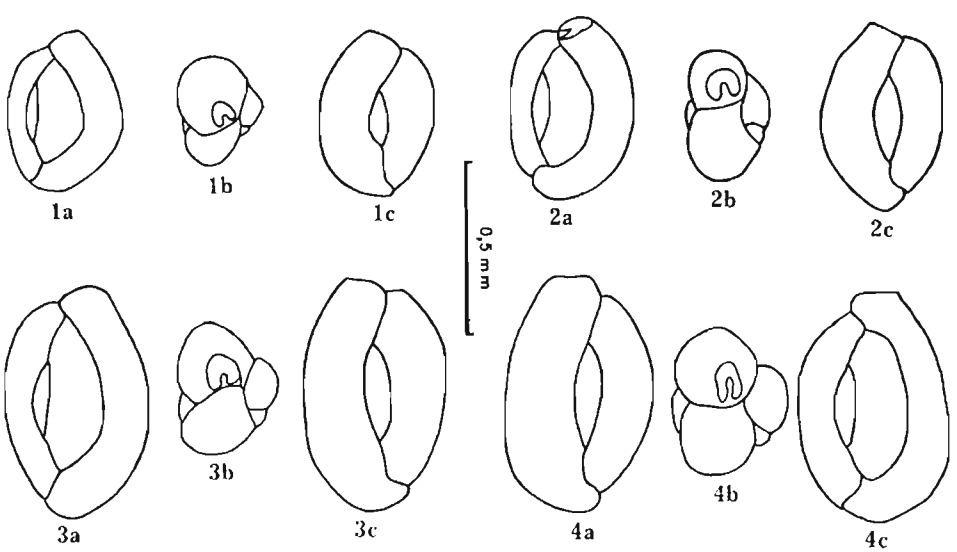


Fig. 5. *Quinqueloculina seminulum jugosa* Cushman; outlines of tests from Brachlewo: *a* and *c* side views, *b* apertural views.

foort I, who considered it typical of interior, neritic facies of the Eemian transgression.

Occurrence. — Quaternary: Poland (Brachlewo), Germany, Holland, USA. Recent: eastern coasts of North America and Laguna de Terminas (Mexican Gulf).

Quinqueloculina lata Terquem, 1876
(Pl. XXII, Fig. 3)

1958. *Quinqueloculina lata* Terquem; Y. Le Calvez, Les foraminifères..., p. 158.
1964. *Quinqueloculina lata* Terquem; P.-A. Dupeuble, Contribution à l'étude..., p. 94, Pl. 3, Fig. 29.

Material. — Two somewhat damaged tests.
Dimensions (in mm):

	F. XV/10
Length	0.40
Width	0.34
Thickness	0.22

Remarks. — Rare forms, well-matching morphological description of the holotype.

Occurrence. — Quaternary: Poland (Elbląg, Nadbrzeże). Recent: Northern Sea, English Channel.

Quinqueloculina sp. 1
(Pl. XVIII, Figs 3—5; Text-figs 6, 7)

Material. — Approximately 29 specimens, mostly damaged.
Dimensions (in mm):

	F. XV/12	F. XV/13
Length	0.72	0.83
Width	0.54	0.58

Remarks. — Tests ovate, thick-walled, with broadly rounded peripheral margin; aperture wide, semicircular, without or with tooth variable in shape. The specimens may be attributed to the group of *Q. seminulum*. They are similar to the representatives of *Q. ovalis* Gudina (Gudina 1969, p. 10, Pl. 3, Figs 1—3) from the Quaternary series of NW part of Western Siberia, differing in unswollen apertural margin.

Variability. — Shape of tooth is subjected to greatest changes which was observed in apertures of numerous chambers (cf. Text-fig. 7). The shape of teeth in the chambers of the same test may be greatly variable or tooth may even be lacking in some chambers; e.g. one of the specimens (A), the third chamber counting from the end has a single, rod-

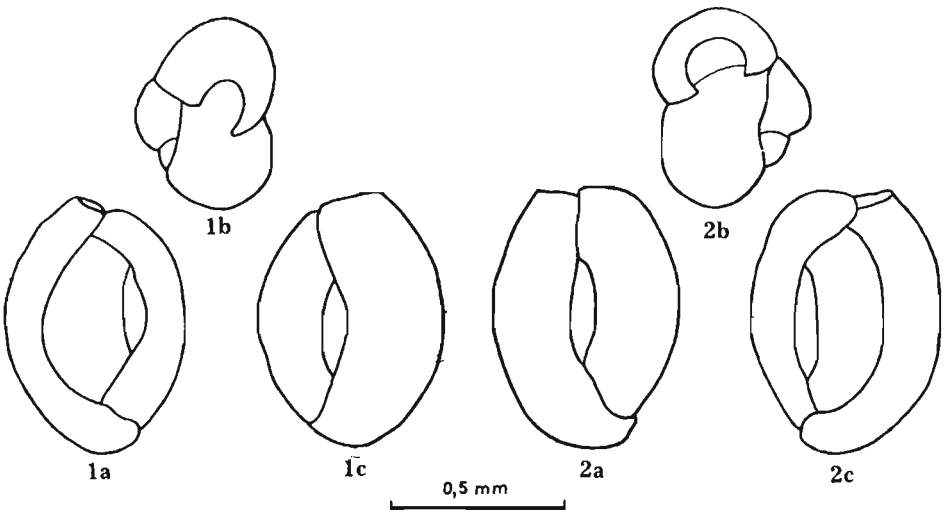


Fig. 6. *Quinqueloculina* sp. *1.*; outlines of tests from Nadbrzeże: *a* and *c* side views, *b*, apertural views.

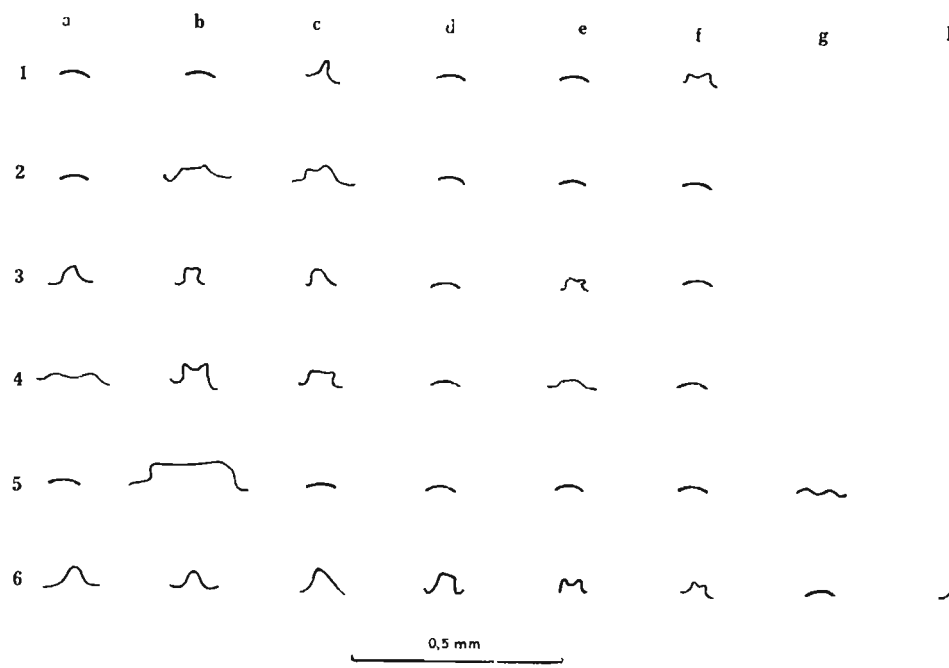


Fig. 7. Mode of development of tooth in *Quinqueloculina* sp. *1* observed in 6 specimens in the following chambers: *a* ultimate chamber, *b* penultimate chamber, *c*, *d*, *e*, *f*, *g*, and *h* successively older chambers.

shaped tooth, chamber sixth counting from the end, has wide, inflatted tooth, whereas in the remaining ones teeth are not developed at all.

Occurrence. — Quaternary: Poland (Elbląg, Nadbrzeże, Suchacz).

Quinqueloculina sp. 2
(Text-fig. 8)

Material. — Four well-preserved tests.
Dimensions (in mm):

	F. XV/14	F. XV/15	F. XV/16
Length	0.58	0.65	0.65
Width	0.38	0.42	0.47

Remarks. — Tests smooth-walled, porcelain; aperture wide, semicircular, with single, wide tooth, bifurcating at the end.

Occurrence. — Quaternary: Poland (Brachlewo).

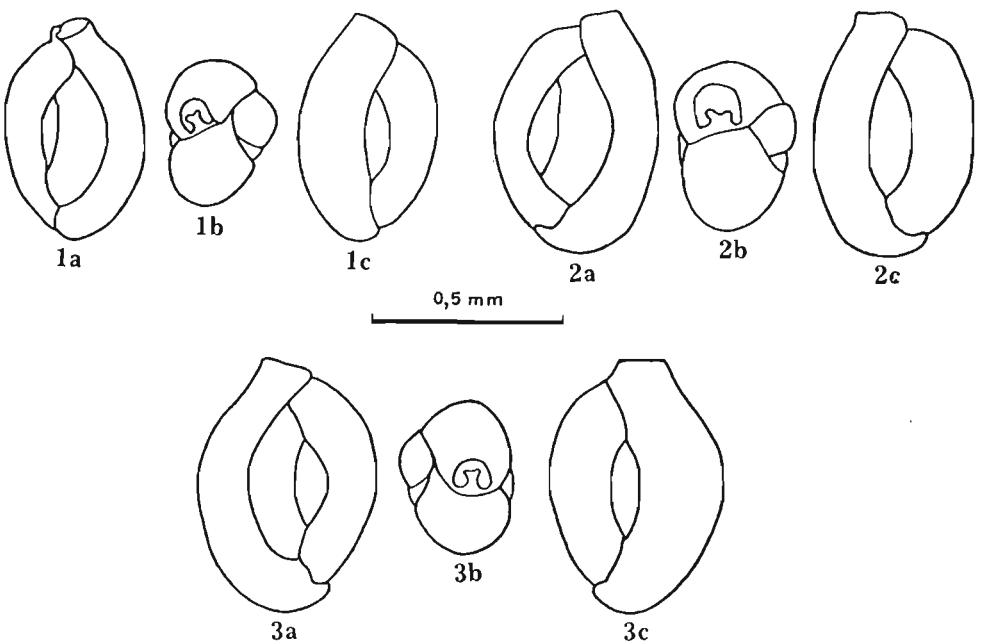


Fig. 8. *Quinqueloculina* sp. 2.; outlines of tests from Brachlewo: *a* and *c* side views, *b* apertural views.

Genus *Triloculina* d'Orbigny, 1826
Triloculina sp.

Material. — One well-preserved and one fragmentary test.
Dimensions (in mm):

	F. XV/17
Length	0.31
Width	0.22

Remarks. — These extremely rare forms, found at Elbląg, most resemble a specimen identified as *Triloculina rotunda* d'Orbigny by Cushman (1930, Pl. 13, Fig. 3).

Occurrence. — Quaternary: Poland (Elbląg).

Genus *Pateoris* Loeblich & Tappan, 1953
Pateoris hauerinoides (Rhumbler, 1936)
(Pl. XVII, Figs. 3, 4)

1936. *Quinqueloculina subrotunda* (Montagu) forma *hauerinoides* Rhumbler; L. Rhumbler, Foraminifera der..., p. 226, Figs 208—212.
1953. *Pateoris hauerinoides* (Rhumbler); A. R. Leoblich & H. Tappan, Studies of Arctic..., p. 42, Pl. 6, Figs 8—12; Text-fig. 1A, B (cum synon.).
1964. *Pateoris hauerinoides* (Rhumbler); R. W. Feyling-Hanssen, Foraminifera in Late..., p. 256, Pl. 6, Fig. 5.
1965a. *Pateoris hauerinoides* (Rhumbler); M. A. Buzas, Foraminifera from Late..., p. 17, Pl. 1, Fig. 5.
1965a. *Pateoris hauerinoides* (Rhumbler); I. Brodniewicz, Recent and some..., p. 197, Pl. 6, Figs 1—6; Pl. 11, Figs 5—7, Text-fig. 26.
1967. *Pateoris hauerinoides* (Rhumbler); O. Michelsen, Foraminifera of the Late..., p. 216.
1970. *Pateoris hauerinoides* (Rhumbler); F. J. E. Wagner, Faunas Pleistocene..., p. 17, Pl. 1, Fig. 5.
1971b. *Pateoris hauerinoides* (Rhumbler); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 198, Pl. 2, Figs 13—15.

Material. — Eight tests, mostly damaged.

Dimensions (in mm):

	F. XV/18	F. XV/19	F. XV/19a
Longest diameter	0.31	0.38	0.40
Shortest diameter	0.42	0.36	0.34

Variability. — Author's collection is too small to characterize the variability in detail. Shape of test and outline of aperture appear the most variable.

Occurrence. — Quaternary: Poland (Nadbrzeże, Suchacz), Denmark, Norway, Canada, USA. Recent: southern Baltic Sea, Kiel Bay, coasts of Alaska and Greenland, Spitsbergen.

Family **Nodosariidae** Ehrenberg, 1838
Genus *Lagena* Walker & Boys, 1784
Lagena sphaerica Marie, 1941
(Text-fig. 9)

1941. *Lagena sphaerica* Marie; P. Marie, Foraminifères de la Craie..., p. 81, Pl. 9, Fig. 100.
1957. *Lagena sphaerica* Marie; K. Pożaryska, Lagenidae du Crétacé..., p. 52, Pl. 5, Fig. 4, Text-fig. 2.

Material. — Two well-preserved tests.

Dimensions (in mm):

	F. XV/20	F. XV/21
Length	0.20	0.19
Width	0.16	0.15

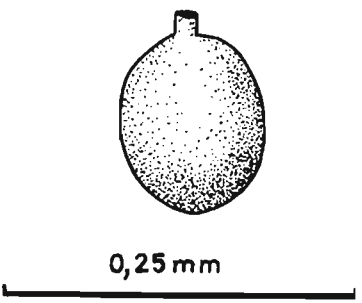


Fig. 9. *Lagena sphaerica* Marie.

Remarks. — The author's specimens match the diagnosis of the species well.

Occurrence. — Cretaceous: Poland, France. Quaternary: Poland (Nadbrzeże).

Family **Polymorphinidae** d'Orbigny, 1839

Genus *Globulina* d'Orbigny, 1839

Globulina inaequalis Reuss, 1850

(Pl. XVII, Fig. 1)

1850. *Globulina inaequalis* Reuss; A. E. von Reuss, Neue Foraminiferen..., p. 377, Pl. 48, Fig. 9.

1930. *Globulina inaequalis* Reuss; J. A. Cushman & Y. Ozawa, A monograph of the foraminiferal..., p. 73, Pl. 18, Figs 2—4 (cum synon.).

1964. *Globulina inaequalis* Reuss; R. W. Feyling-Hanssen, Foraminifera in Late Quaternary..., p. 298, Pl. 12, Fig. 17; Pl. 13, Figs 1, 2, Text-figs 42—44.

1971b. *Globulina inaequalis* Reuss; K. L. Knudsen. Systematic part *in*: R. W. Feyling-Hansen et al., p. 216, Pl. 5, Fig. 3.

Material. — Seven well-preserved tests.

Dimensions (in mm):

	F. XV/22	F. XV/23	F. XV/24
Length	0.38	0.37	0.45
Maximal width	0.28	0.26	0.32

Variability. — Some differences in size of specimens, as well as in sutures, more or less deeply incised, were found.

Occurrence. — Known to occur from the Eocene to the present (Cushman & Ozawa, 1930, pp. 74—75). Quaternary: Poland (Elbląg, Nadbrzeże), Denmark, Norway.

Genus *Guttulina* d'Orbigny, 1839 (in de la Sagra)

Guttulina lactea (Walker & Jacob, 1798)

(Pl. XIX, Fig. 4)

1798. *Serpula lactea* Walker & Jacob; G. Walker & E. Jacob, in: G. Adams, Essays on the..., p. 634, Pl. 14, Fig. 4.
1930. *Guttulina lactea* (Walker & Jacob); J. A. Cushman & Y. Ozawa, A monograph of the foraminiferal..., p. 43, Pl. 10, Figs 1—4 (cum. synon.).
1949. *Guttulina lactea* (Walker & Jacob); J. A. van Voorthuysen, Foraminifera of the Icenian..., p. 66, Pl. 1, Fig. 6.
1962. *Guttulina lactea* (Walker & Jacob); H. Woszidlo, Foraminiferen und Ostracoden..., p. 69, Pl. 1, Fig. 9.
1964. *Guttulina lactea* (Walker & Jacob); R. W. Feyling-Hanssen, Foraminifera in Late..., p. 297, Pl. 12, Figs 12—14.
1967. *Guttulina lactea* (Walker & Jacob); O. Michelsen, Foraminifera of the Late..., p. 219, Pl. 1, Fig. 10.
1971b. *Guttulina lactea* (Walker & Jacob); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 214, Pl. 4, Figs 14—18.

Material: Fourteen well-preserved specimens.

Dimensions (in mm):

	F. XV/25	F. XV/26	F. XV/27
Length	0.48	0.36	0.46
Maximal width	0.25	0.18	0.23

Remarks. — The species is characterized by high individual variability. Along with adding subsequent chambers, tests strongly change in outlines.

Occurrence. — Known from the Eocene to the present. Quaternary: Poland (Elbląg, Nadbrzeże, Suchacz), Germany, Denmark, Holland, Norway. Recent: pandemic species.

Guttulina glacialis (Cushman & Ozawa, 1930)

Pl. IX, Figs 5—7)

1930. *Globulina glacialis* Cushman & Ozawa; J. A. Cushman & Y. Ozawa, A monograph of the foraminiferal..., p. 71, Pl. 15, Figs 6, 7.
1948. *Globulina glacialis* Cushman & Ozawa; J. A. Cushman, Arctic Foraminifera, p. 50, Pl. 5, Figs 15, 16.
1965a. *Globulina glacialis* Cushman & Ozawa; M. A. Buzas, Foraminifera from Late..., p. 19, Pl. 2, Fig. 5.
1969. *Globulina glacialis* Cushman & Ozawa; W. I. Gudina, Morskoj Plejstocen..., p. 19, Pl. 7, Figs 2—4.

1970. *Globulina glacialis* Cushman & Ozawa; F. J. E. Wagner, Faunas of the Pleistocene..., p. 19, Pl. 1, Fig. 9.

1971b. *Guttulina glacialis* (Cushman & Ozawa); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 213, Pl. 4, Figs 11—13.

Material. — Thirty-six well-preserved specimens.

Dimensions (in mm):

	F. XV/28	F. XV/29	F. XV/30
Length	0.54	0.58	0.57
Maximal width	0.29	0.35	0.31

Variability. — The species is characterized by high variability, primarily expressed in differences in size of the whole specimens and particular chambers. This may result from occurrence of micro- and megalosphaeric forms, but the number of specimens is too small for unequivocal solution of the problem.

Remarks. — Some young individuals of this species are somewhat similar to *Globulina inaequalis* (Reuss) and *Guttulina lactea* (Walker & Jacob).

Occurrence. — Quaternary: Poland (Elbląg, Nadbrzeże, Suchacz, Bogdaniec), Denmark, Germany, Norway, Spitsbergen, USSR (Siberia), Canada, USA. Recent: Canada coasts.

Guttulina cf. *dawsoni* Cushman & Ozawa, 1930
(Pl. XXIII, Fig. 12)

Material. — Six well-preserved specimens.

Dimensions (in mm):

	F. XV/32	F. XV/33
Length	0.67	0.65
Maximal width	0.36	0.33

Remarks. — The author's specimens are most similar to *G. dawsoni* Cushman & Ozawa; however, they differ from the latter species in more convex and less numerous chambers and in deeper incised sutures, hence they are assigned to this species with reservation.

Occurrence. — Quaternary: Poland (Elbląg, Nadbrzeże).

Guttulina cf. *austriaca* d'Orbigny, 1846
(Pl. XIX, Fig. 2; Pl. XXIII, Fig. 9)

Material. — Four specimens, two somewhat damaged.

Dimensions (in mm):

	F. XV/34	F. XV/35
Length	0.54	0.65
Maximal width	0.33	0.38

Remarks. — The specimens are most closely comparable to typical juvenile forms of this species. However, no typical mature forms were found.

Occurrence. — Quaternary: Poland (Elbląg).

Guttulina sp. 1
(Pl. XIX, Fig. 8)

Material. — Single well-preserved specimen.
Dimensions (in mm):

	F. XV/36
Length	0.72
Maximal width	0.36

Remarks. — A specific affinity of this single test, found in blue clays at Nadbrzeże is unclear.

Guttulina sp. 2
(Pl. XIX, Fig. 3)

Material. — Single well-preserved specimen.
Dimensions (in mm):

	F. XV/37
Length	0.41
Maximal width	0.21

Remarks. — A specific affinity of this single specimen found at Elbląg is unclear.

Guttulina sp. 3
(Pl. XVII, Fig. 2)

Material. — Four well-preserved specimens.
Dimensions (in mm):

	F. XV/243
Length	0.43
Maximal width	0.18

Remarks. — A specific affinity of these four specimens found at Elbląg is unclear.

Genus *Pseudopolymorphina* Cushman & Ozawa, 1928
Pseudopolymorphina novangliae (Cushman, 1923)
(Pl. XXIII, Fig. 11)

1930. *Pseudopolymorphina novangliae* (Cushman); J. A. Cushman & Y. Ozawa, A monograph of the foraminiferal..., p. 90, Pl. 23, Figs 1, 2.
1952a. *Pseudopolymorphina novangliae* (Cushman); F. L. Parker, Foraminifera species..., p. 410, Pl. 5, Fig. 1.
1952b. *Pseudopolymorphina novangliae* (Cushman); F. L. Parker, Foraminiferal distribution..., p. 455, Pl. 3, Figs 11, 12.
1961. *Pseudopolymorphina novangliae* (Cushman); Ch. M. Saidova, Ekologija Foraminifer..., p. 59, Pl. 17, Fig. 120.
1964. *Pseudopolymorphina novangliae* (Cushman); R. W. Feyling-Hanssen, Foraminifera in Late..., p. 300, Pl. 13, Fig. 3.
1967. *Pseudopolymorphina novangliae* (Cushman); O. Michelsen, Foraminifera of the Late..., p. 219, Pl. 1, Fig. 11.
1969. *Pseudopolymorphina novangliae* (Cushman); W. I. Gudina, Morskoj Plejstocen..., p. 20, Pl. 7, Figs. 5, 6.
1970. *Pseudopolymorphina novangliae* (Cushman); F. J. E. Wagner, Faunas of the Pleistocene..., p. 19, Pl. 1, Figs 11, 12.
1971b. *Pseudopolymorphina novangliae* (Cushman); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 217, Pl. 5, Figs 5, 6.

Material. — Fifteen well-preserved specimens.

Dimension (in mm):

	F. XV/38	F. XV/39	F. XV/40
Length	0.81	0.78	0.80
Maximal width	0.34	0.30	0.33

Remarks. — The specimens fall within the limits of specific variability of this species.

Occurrence. — Quaternary: Poland (Elbląg, Nadbrzeże), Denmark, Norway, Spitsbergen, USSR (Siberia), Canada. Recent: North America coasts, NW Pacific.

Pseudopolymorphina suboblonga Cushman & Ozawa, 1930

1930. *Pseudopolymorphina suboblonga* Cushman & Ozawa; J. A. Cushman & Y. Ozawa, A Monograph of the foraminiferal..., p. 91, Pl. 23, Fig. 3.
1964. *Pseudopolymorphina suboblonga* Cushman & Ozawa; R. W. Feyling-Hanssen, Foraminifera in Late..., p. 300, Pl. 13, Fig. 4.
1970. *Pseudopolymorphina suboblonga* Cushman & Ozawa; F. J. E. Wagner, Faunas of the Pleistocene..., p. 20, Pl. 1, Fig. 13.
1971b. Pseudopolymorphina suboblonga Cushman & Ozawa; K. L. Knudsen, Systematic part in: R. W. Feyling-Hanssen et al., p. 218, Pl. 5, Figs 8 and 9.

Material. — Fourteen specimens, 10 of which are well-preserved.

Dimensions (in mm):

	F. XV/41	F. XV/42	F. XV/43
Length	0.22	0.24	0.28
Maximal width	0.12	0.14	0.16

Remarks. — The author's specimens generally correspond to descriptions and figures given by Cushman & Ozawa (*l. c.*) and other authors listed in the synonymy.

Occurrence. — Pliocene: Japan. Quaternary: Poland (Elbląg, Nadbrzeże, Bogdaniec), Denmark, Norway, Canada. Recent: Japan coasts.

Pseudopolymorhpina sp.
(Pl. XIX, Fig. 1)

Material. — Single well-preserved specimen.
Dimensions (in mm):

	F. XV/44
Length	0.56
Maximal width	0.31

Occurrence. — Poland (Elbląg).

Genus *Pyrulina* d'Orbigny, 1839 in de la Sagra
Pyrulina cylindroides (Roemer, 1838)

1838. *Polymorphina cylindroides* Roemer; F. A. Roemer, Die Cephalopoden..., p. 385, Pl. 3, Fig. 26.
1930. *Pyrulina cylindroides* (Roemer); J. A. Cushman & Y. Ozawa, A monograph of the foraminiferal..., p. 56, Pl. 14, Figs 1—5.
1948. *Pyrulina cylindroides* (Roemer); J. A. Cushman, Arctic Foraminifera, p. 50, Pl. 5, Fig. 14.
1971b. *Pyrulina cylindroides* (Roemer); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 219, Pl. 5, Figs 10, 11.

Material. — Eight specimens, some of which are slightly damaged.
Dimensions (in mm):

	F. XV/45	F. XV/46	F. XV/47
Length	0.33	0.35	0.38
Maximal width	0.12	0.12	0.14

Remarks. — The specimens are most closely comparable to tests figured by Cushman (1948) and Knudsen (1971).

Occurrence. — Oligocene: Germany. Quaternary: Poland (Elbląg, Nadbrzeże), Denmark. Recent: north-western coasts of Greenland.

Family **Glandulinidae** Reuss, 1860
Genus *Oolina* d'Orbigny, 1839
Oolina cf. *acuticosta* (Reuss, 1862)
(Pl. XXIII, Fig. 8)

Material. — Single well-preserved specimen.
Dimensions (in mm):

	F. XV/48
Length	0.28
Maximal width	0.20

Occurrence. — Quaternary: Poland (Nadbrzeże).

Genus *Fissurina* Reuss, 1850
Fissurina laevigata Reuss, 1850
(Pl. XXII, Figs 1, 2)

1850. *Fissurina laevigata* Reuss; A. E. Reuss, Neue Foraminiferen..., p. 226, Pl. 46, Fig. 1.

1895. *Lagena laevigata* Reuss; V. Madsen, Istidens foraminiferer..., p. 195, Pl. Fig. 3.

1944. *Entosolenia laevigata* (Reuss); J. A. Cushman, Foraminifera from the shallow..., p. 28, Pl. 4, Fig. 12.

1957. *Fissurina laevigata* Reuss; K. Pożaryska, Lagenidae du Crétacé..., p. 60, Pl. 5, Fig. 2 (cum synon.).

1962. *Fissurina laevigata* Reuss; H. Woszidlo, Foraminiferen und Ostracoden..., p. 70, Pl. 2, Figs 1, 2.

1966b. *Fissurina laevigata* Reuss; M. A. Buzas, The distribution..., p. 58, Pl. 2, Fig. 3.

Material. — Six well-preserved specimens.

Dimensions (in mm):

	F. XV/50	F. XV/51
Length	0.22	0.22
Maximal width	0.16	0.14

Remarks. — The author's specimens match the diagnosis of this species.

Occurrence. — Cretaceous: Europe, North America. Quaternary: Poland (Nadbrzeże), Denmark, Norway. Recent: Atlantic and Pacific.

Family **Discorbidae** Ehrenberg, 1838
Genus *Buccella* Anderson, 1952
Buccella frigida (Cushman, 1922)
(Pl. XV, Figs 1, 2; Pl. XX, Figs 1—3, 6—18, 20)

1930. *Eponides frigida* (Cushman) var. *calida* Cushman & Cole; J. A. Cushman & W. S. Cole, Pleistocene Foraminifera..., p. 98, Pl. 13, Fig. 13.

1948. *Eponides frigida* (Cushman) var. *calida* Cushman & Cole; F. L. Parker, Foraminifera of the continental..., p. 238, Pl. 5, Fig. 25.

1949. *Eponides frigida* (Cushman) var. *calida* Cushman & Cole; J. A. Cushman, Recent Belgian..., p. 46, Pl. 9, Fig. 1.

1949. *Eponides frigidus* (Cushman); J. H. van Voorthuysen, Foraminifera of the Icenian..., p. 66, Pl. 1, Fig. 3.

1952. *Buccella frigida* (Cushman); H. V. Andersen, Buccella, a new genus..., p. 144, Figs 4—6.

1952a. *Eponides frigidus* (Cushman); F. L. Parker, Foraminifera species..., p. 419, Pl. 6, Fig. 12.

1952b. *Eponides frigidus* (Cushman); F. L. Parker, Foraminiferal distribution..., p. 449, Pl. 5, Fig. 2.

1952b. *Eponides frigidus* (Cushman) var. *calidus* Cushman & Cole; F. L. Parker, Ibidem, p. 450, Pl. 5, Fig. 3.

1953. *Buccella frigida* (Cushman); A. R. Loeblich & H. Tappan, Studies of arctic..., p. 115, Pl. 22, Figs 2, 3.
1954. *Eponides frigidus calidus* Cushman & Cole; L. Weiss, Foraminifera and origin..., p. 160, Pl. 33, Fig. 2.
1957. *Buccella frigida* (Cushman); J. H. van Voorthuysen, Foraminiferen aus dem Eemien..., p. 33, Pl. 24, Fig. 15.
1961. *Buccella frigida* (Cushman); R. Todd & D. Low, Near-shore Foraminifera..., p. 18, Pl. 1, Figs 24, 25.
1961. *Eponides frigidus* (Cushman); Ch. M. Saidova, Ekologija foraminifer..., p. 64, Pl. 19, Fig. 131.
1962. *Buccella frigida* (Cushman); F.-W. Haake, Untersuchungen an der Foraminiferen-Fauna..., p. 44, Pl. 4, Figs 3—6.
1962. *Buccella frigida* (Cushman); H. Woszidlo, Foraminiferen und Ostracoden..., p. 73, Pl. 2, Figs 25, 26.
1963. *Buccella frigida* (Cushman); H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 25, Pl. 2, Figs 10—14.
1964. *Buccella frigida* (Cushman); R. W. Feyling-Hanssen, Foraminifera in Late..., p. 337, Pl. 18, Figs 15—18.
1966. *Buccella frigida* (Cushman); W. I. Gudina, Foraminifery i stratygrafia..., p. 31, Pl. 5, Fig. 7; Pl. 12, Fig. 4.
1967. *Buccella frigida* (Cushman); Y. Matoba, Younger Cenozoic..., p. 252, p. 26, Figs 8, 9.
1967. *Buccella frigida* (Cushman); O. Michelsen, Foraminifera of the Late..., p. 228, Pl. 3, Fig. 1.
1969. *Buccella frigida* (Cushman); W. I. Gudina, Morskoj Plejstocen..., p. 24, Pl. 8, Fig. 4.
1970. *Buccella frigida* (Cushman); Y. Matoba, Distribution of recent..., p. 49, Pl. 4, Fig. 1.
1970. *Buccella frigida* (Cushman); F. J. E. Wagner, Faunas of the Pleistocene..., p. 23, Pl. 1, Figs 20, 21.
1971b. *Buccella frigida* (Cushman); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 253, Pl. 8, Figs 12—14; Pl. 19, Fig. 1.

Material. — Approximately 2000 specimens.

Dimensions (in mm):

	F. XV/60	F. XV/64	F. XV/65
Maximal diameter	0.30	0.31	0.36
Height	0.18	0.16	0.18

Variability. — Individual variability high. Test outline, number of chambers in ultimate whorl as well as appearace of granulated surface of the ventral side are highly variable. Marked differences in convexity of ventral and dorsal parts of the test were also noted.

Remarks. — *Buccella frigida* occurs in masses in Eemian deposits at Brachlewo. It was also cited from similar Eemian deposits pierced by a borehole at Tychnowy (Pożaryski, 1954). It is also a common fossil at Elbląg, Nadbrzeże and Suchacz.

Knudsen (1971) placed the subspecies *Rotalia beccarii lucida* Madsen (1895) into the synonymy of *Buccella frigida* with some reservation. Such allocation seems quite probable according to the present author.

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg, Nadbrzeże, Suchacz, Tychnowy), Germany, Denmark, Norway, Holland, Great Britain, USSR (Siberia), Canada, USA. Recent: North Sea, English Channel, coasts of Great Britain, Argentina, Greenland, USSR, Japan, South-western Pacific.

Buccella tenerrima (Bandy, 1950)
(Pl. XX, Figs 4, 5, 19, 21; Pl. XXII, Fig. 5)

1950. *Rotalia tenerrima* Bandy; O. L. Bandy, Some later Foraminifera..., p. 278, Pl. 42, Fig. 3.
1960. *Buccella inusitata* Andersen; N. A. Voloschinova, Rod Buccella Andersen..., p. 287, Pl. 7, Fig. 1.
1965. *Buccella tenerrima* (Bandy); J. Nagy, Foraminifera in some..., p. 123, Pl. 2, Fig. 11.
1971b. *Buccella tenerrima* Bandy; K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 254, Pl. 8, Figs 15—17 (cum synon.).

Material. — Sixteen specimens, mostly well-preserved.
Dimensions (in mm):

	F. XV/69	F. XV/70	F. XV/73
Maximal diameter	0.40	0.42	0.36
Height	0.24	0.24	0.20

Remarks. — In Poland representatives of this rare species were found at profile of Nadbrzeże, exclusively.

Occurrence. — Quaternary: Poland (Elbląg), Denmark, Norway, Spitsbergen, USSR (Siberia), USA. Recent: Hudson Bay, Arctic islands of Canada and Greenland.

Buccella blanconensis (Bandy, 1950)
(Pl. XXII, Figs 6, 7)

1950. *Eponides blanconensis* Bandy; O. L. Bandy, Some later Cenozoic..., p. 278, Pl. 42, Fig. 1.

Material. — Twenty-five well-preserved specimens.
Dimensions (in mm):

	F. XV/74	F. XV/76	F. XV/75
Maximal diameter	0.36	0.42	0.43
Height	0.25	0.30	0.32

Remarks. — The author's specimens match the diagnosis of the holotype (Bandy, 1950) from the Pleistocene of Cape Blanco, Oregon, USA.

Occurrence. — Quaternary: Poland (Nadbrzeże, Elbląg), USA.

Genus *Aubignyna* Margerel, 1970
Aubignyna perlucida (Heron-Allen & Earland, 1913)
(Text-fig. 10)

1913. *Rotalia perlucida* Heron-Allen & Earland; E. Heron-Allen & A. Earland, Foraminifera..., p. 139, Pl. 13, Figs 7—9.
1950. *Streblus? perlucidus* (Heron-Allen & Earland); J. H. van Voorthuysen, The quantitative distribution..., p. 45, Pl. 4, Fig. 7.
1953. *Rotalia perlucida* Heron-Allen & Earland; A. Gionotti, Microfauna del Pliocene..., Pl. 2, Fig. 20.
1957. *Rotalia perlucida* Heron-Allen & Earland; Foraminiferi Padani..., Pl. 41, Fig. 7.
1962. *Streblus? perlucidus* (Heron-Allen & Earland); H. Woszidlo, Foraminiferen und Ostracoden..., p. 78, Pl. 13, Figs 21, 22.
1962. *Ammonia perlucida* (Heron-Allen & Earland); M. B. Cita & M. A. Chierici, Crociera talassografica..., p. 352, Pl. 5, Fig. 1.
1966—67. *Ammonia perlucida* (Heron-Allen & Earland); M. B. Cita & I. Premoli Silva, Sui foramiferi incontrati..., Pl. 1, Figs 8—10.
1967. *Ammonia perlucida* (Heron-Allen & Earland); S. Jaccarino, Ricerche sui foraminiferi..., Table 1.
1970. *Aubignyana* cf. *mariei* Margerel; C. H. v. Daniels, Quantitative ökologische..., p. 85, Pl. 7, Fig. 6, Text-fig. 60.

Material. — Nineteen specimens, some of which are partly damaged. Dimensions (in mm):

	F. XV/78	F. XV/79
Maximal diameter	0.36	0.29
Height	0.18	0.13

Variability. — The number of specimens is too small to permit characterization of individual variability. Generally, specimens from Brachlewo are characterized by quite uniform test outline.

The number of chambers of the ultimate whorl is constant in the case if megalosphaeric forms and equals 6 to 7. Microspheric forms are characterized by number of chambers higher both in the ultimate whorl (up to 10 chambers) and in the case of the whole test (up to 20 chambers). Tests from Brachlewo are smaller than recent individuals from the Adriatic Sea, Black Sea and forms from the Quaternary of Holstein Interglacial series figured by Woszidlo (1962).

Remarks. — Outlines of tests of specimens representing micro- and megalospheric generations of *Aubignyna perlucida* are illustrated in Text-fig. 10. In the innumerous population gathered by the present author, tests of the latter generation predominate. Aperture of the ultimate chamber is not visible. It may be observed in specimens with destroyed ultimate chambers where it is crescent, slit-like, located at the base of last chamber preserved, situated close to the middle, somewhat shifted towards umbilical side of test. Umbilical side evolute, with small umbilicus filled with granular material. Dorsal side involute, with narrow sutures and without granular material.

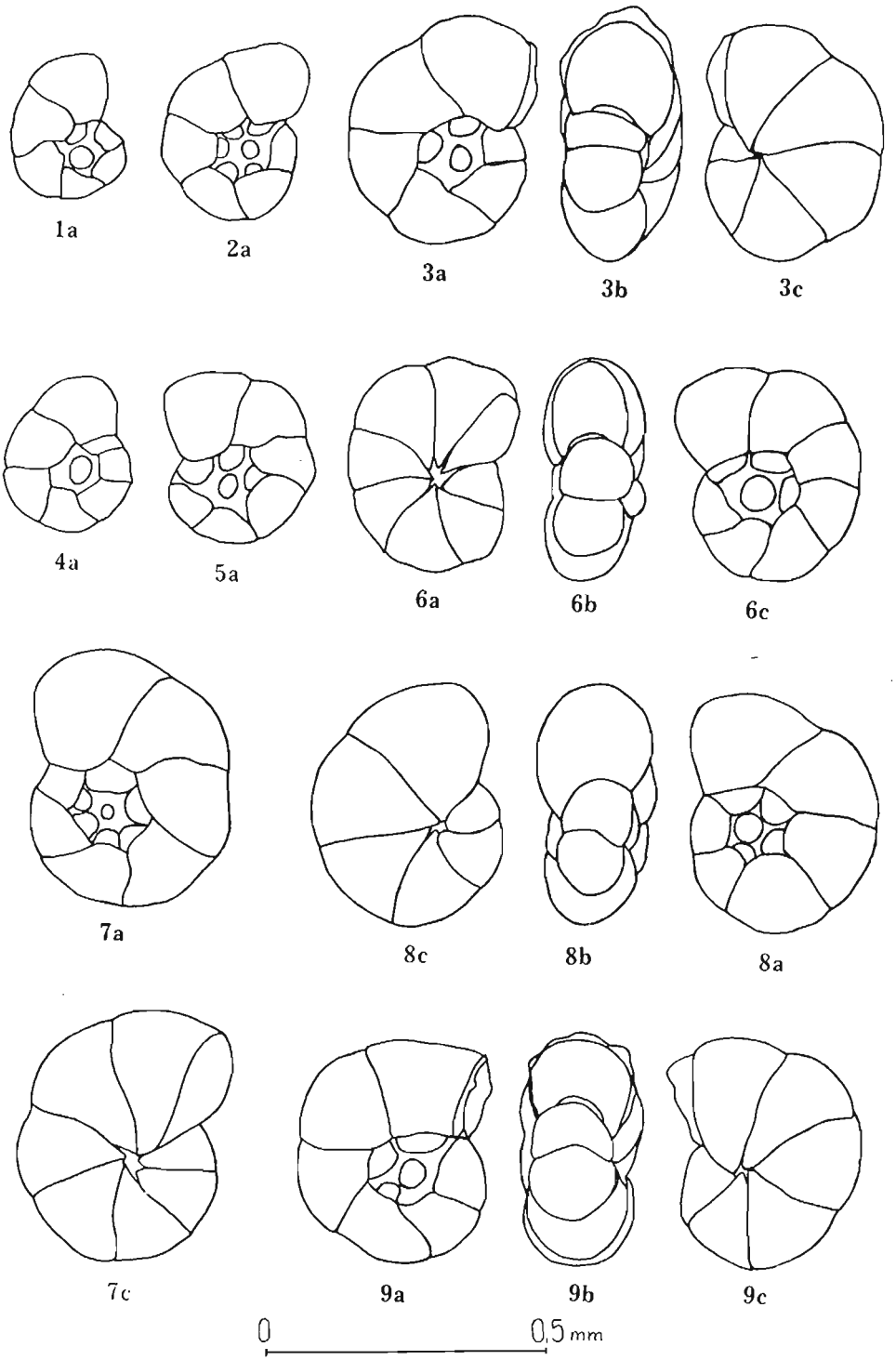


Fig. 10. *Aubignyna perlucida* (Heron-Allen & Arland); outlines of tests from Brachlewo: *a* dorsal views, *b* peripheral views, *c* ventral views.

Occurrence. — Quaternary: Poland (Brachlewo), Germany, Holland, Italy. Recent: Mediterranean, Adriatic and Black Seas.

Family **Rotaliidae** Ehrenberg, 1839
Genus *Ammonia* Brünnich, 1772
Ammonia beccarii (Linnaeus) var.
(Pl. XX)

1758. *Nautilus beccarii* Linnaeus; C. von Linnaeus, Systema naturae, p. 710.

Material. — Approximately 2000 well-preserved specimens.
Dimensions (in mm):

	F. XV/80	F. XV/81	F. XV/82
Maximal diameter	0.36	0.51	0.60
Height	0.18	0.27	0.29

Remarks. — *Ammonia beccarii* var. is one of the most common foraminifers of the Brachlewo assemblage. The holotype of this species, from Rimini, Adriatic Sea, is insufficiently known and yet controversial as a few species of the genus *Ammonia* occur at present beside one another in the Adriatic Sea.

A detailed description of representatives of this species, from the Quaternary deposits of Poland will be published in a separate paper dealing exclusively with this species.

The author's specimens from Brachlewo and Elbląg are identical with those figured as *Ammonia beccarii* (Linnaeus) by Voorthuysen (1957, Pl. 23, Fig. 1). They are also similar to one of the forms assigned to *Ammonia beccarii* occurring in the Adriatic Sea, which is devoid of knob in umblicus and has prominent umbilical lips. They are similar to *A. batava* (Hofker), particularly to forms without distinct knob in umbilicus, differing in flat sutures, less convex test and less walled chambers; thus they resemble *A. batavus* Hofker var. as figured by Woszidlo (Woszidlo, 1963, Pl. 3, Figs 18—20).

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg, Nadbrzeże), Holland. Recent: Adriatic Sea.

Ammonia batava (Hofker, 1951)

1951. *Streblus batavus* Hofker: J. Hofker, The foraminifera..., p. 498, Figs 340, 341.
1957. *Streblus batavus* Hofker: J. H. van Voorthuysen, Foraminiferen aus dem Eemien..., Text-fig. 1d.
1962. *Streblus batavus* Hofker; F. -W. Haake, Untersuchungen an der Foraminiferen-Fauna..., p. 52, Pl. 6, Figs 6—12.
1962. *Streblus batavus* Hofker; H. Woszidlo, Foraminiferen und Ostracoden..., p. 77, Pl. 3, Figs 12—17.
1963. *Streblus batavus* Hofker; H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 34.
1964. *Ammonia batavus* (Hofker); R. W. Feyling-Hanssen, Foraminifera in Late..., p. 349, Pl. 21, Figs 4—13.

1965a. *Ammonia beccarii batavus* Hofker; J. W. Murray, On the Foraminiferida..., p. 502, Pl. 1, Figs 1, 2.

1971b. *Ammonia batavus* (Hofker); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 290, Pl. 14, Figs 12, 13.

Material. — Two somewhat damaged specimens.

Remarks. — The specimens are closely comparable with the holotype of *Ammonia batava* (Hofker) and other forms found over the area of North Sea and assigned to this species.

Occurrence. — Quaternary: Poland (Nadbrzeże), Germany, Denmark, Norway, Holland, Great Britain. Recent: Kiel Bay, North Sea.

Family **Elphidiidae** Galloway, 1933

Diagnoses of particular genera of the family Elphidiidae are as yet controversial. According to the present author, no adequate morphological criteria for performing more accurate subdivision have hitherto been distinguished. Therefore, the elphides species described herein are artificially grouped into two genera tentatively accepted, *Elphidium* and *Protelphidium*. It is hard to consider as just the allocation of such different species as e. g. *Elphidium poyeanum* (d'Orbigny) and *E. albiumbilicatum* (Weiss) or *Protelphidium granosum* and *P. umbilicatulum* into a single. However, according to the present author, introduction of any new genera seems inadvisable until knowledge of different elphides is sufficient, as it would result in further complication of the taxonomical subdivision of this family. At present, when electronic microscope reveals new details of test morphology, which were not taken into account in taxa hitherto proposed, a general generic name, *Elphidium*, is used by the majority of authors. That general name comprises morphologically similar species, which, however, undoubtedly belong to various genera.

The generic name, *Elphidium*, is used here in a very wide sense and, therefore, particular species are alphabetically arranged.

Genus *Elphidium* Montfort, 1808

Elphidium albiumbilicatum Weiss, 1954

(Pl. I, Figs 1—6; Pl. XXIX, Figs 1—14; Text-figs 11, 12)

1954. *Nonion pauciloculum albiumbilicatum* Weiss; L. Weiss, Foraminifera and origin..., p. 157, Pl. 32, Figs 1, 2.

1965. *Elphidium subarcticum* Cushman; I. Brodniewicz, Recent and some..., p. 201, Pl. 9, Figs 7—14; Pl. 11, Fig. 3; Text-fig. 28 (cum synon.).

1971b. *Elphidium albiumbilicatum* (Weiss); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen, et al., p. 268, Pl. 10, Figs 15—19; Pl. 19, Figs 4—8 (cum synon.).

Material. — Approximately 1500 well-preserved specimens.

Dimensions (in mm):

	F. XV/94	F. XV/102	F. XV/106
Maximal diameter	0.36	0.43	0.52
Thickness	0.16	0.18	0.18

Remarks. — This species was previously described under the name of E. *subarticum* Cushman by the present author (Brodniewicz, 1965). However, in the author's material the tests with appearance typical of *E. al-*

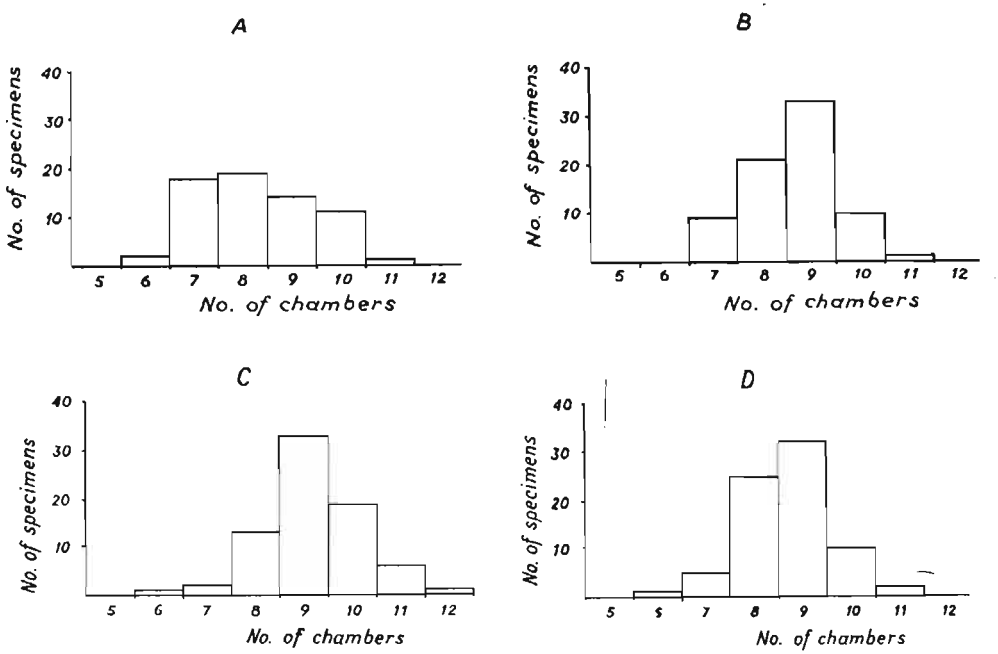


Fig. 11. Histogram of number of chambers per ultimate whorl of *Elphidium albiumbilicatum* (Weiss); *A* for 65 tests from Brachlewo, *B*, for 74 tests from Elbląg, *C* for 77 tests from Nadbrzeże, *D* for 75 tests from Bogdaniec.

biumbilicatum Weiss prevail, hence they are assigned to the latter species. The variability within this population appears higher than it was previously assumed (Brodniewicz, *l. c.*). Besides specimens identical to those described by Weiss (1954), some forms with supplementary openings above slit-like aperture were found (cf. Pl. XXIX, Figs 10, 12, 13; Text-fig. 12—1b). The variability in this species was widely discussed in the previous paper (Brodniewicz, *l. c.*), so only some additional remarks will be given below.

Stereoscan electron microscope photos have shown differentiation of granular material from umbilical and apertural surfaces and from sutures, irregular concentrations of circular pores, and arrangement of calcite crystals forming the test. Typical tests of the species *E. albiumbilicatum* were found in all materials studied. Moreover, some opaque forms, similar to those reported by Knudsen (1971, Pl. 10. Figs. 16 and 17) and somewhat

resembling a form described as *E. granatum* Gudina by Gudina (1966, p. 53, Pl. 4, Figs 10, 11) were found at Elbląg, Nadbrzeże, Suchacz and Bogdaniec. Opaque appearance of specimens (even when due to spraying before making a photo) is quite different from the usual, non-opaque ones.

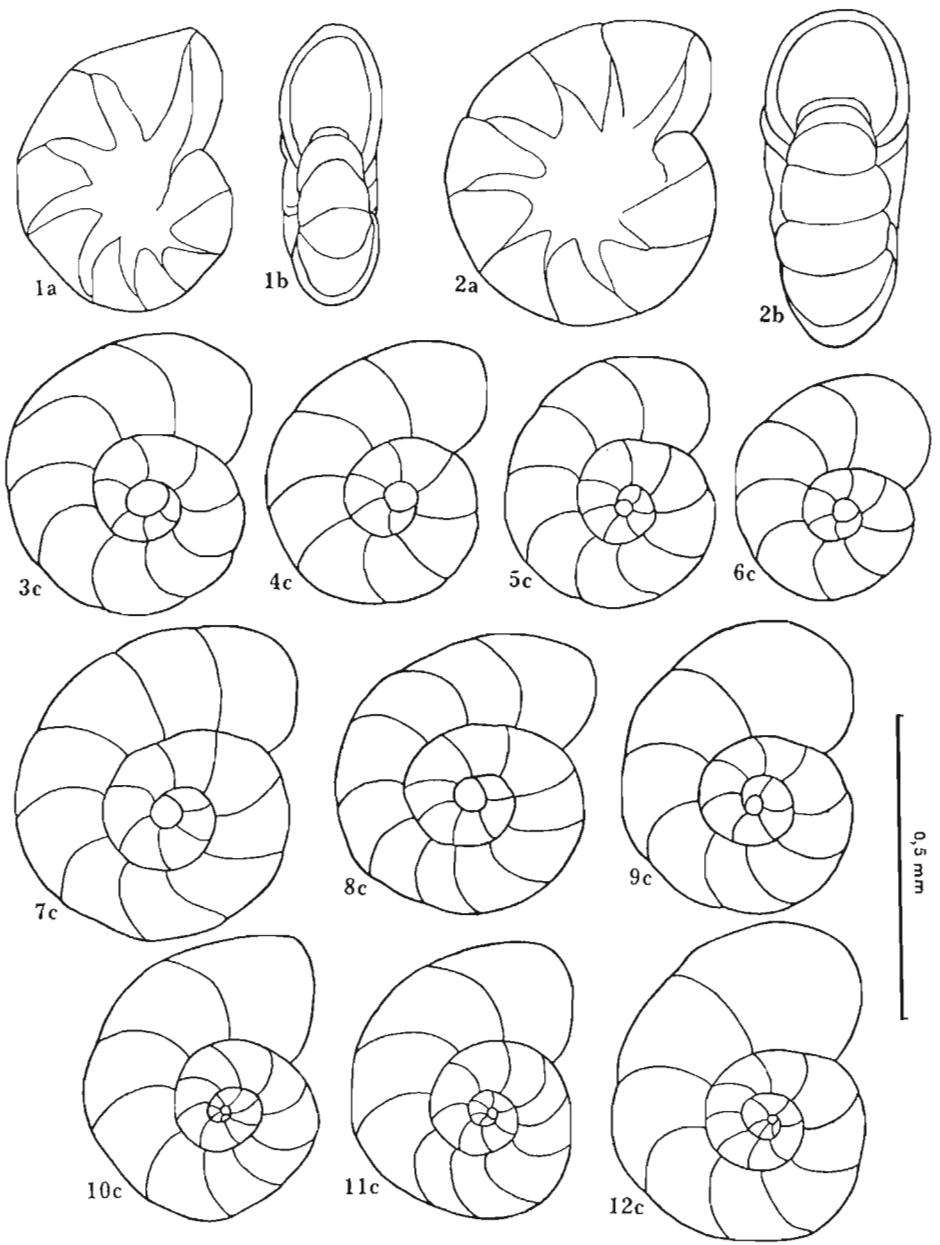


Fig. 12. *Elphidium albiumbilicatum* Cushman; *a* and *b* outlines of tests, *c* outlines of cross-sections of tests belonging to micro- and megalospheric generations; *3c—9c* megalospheric tests, *10c—12c* microspheric tests.

Some changes in test appearance resulting from environmental conditions may be supposed. In Quaternary deposits of this area, forms resembling *E. frigidum* Cushman, characterized by slit-like aperture figured by Todd & Low (1967) were occasionally found.

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg, Nadbrzeże, Suchacz, Bogdaniec, Tychnowy), Denmark, Germany, Norway, Holland, Great Britain, USA, Canada. Recent: Baltic and North Seas, Atlantic — boreal and arctic zones.

Elphidium asklundi Brotzen, 1943
(Pl. XXVII, Fig. 9)

1943. *Elphidium (Elphidiella) asklundi* Brotzen; F. Brotzen *in*: I. Hessland, Marine Schalenablagerungen..., p. 267, Fig. 109—1.
1966. *Elphidium asklundi* Brotzen; R. W. Feyling-Hanssen, Geologiske observasjoner..., Fig. 11.
1971b. *Elphidium asklundi* Brotzen; K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 270, Pl. 10, Figs 20, 21; Pl. 11, Figs 1—5.

Material. — Four specimens.

Dimensions (in mm):

	F. XV/107	F. XV/108	F. XV/109
Maximal diameter	0.72	0.74	0.79
Thickness	0.44	0.39	0.39

Remarks. — The species and its occurrence has been exhaustively discussed by Knudsen (1971). It is closely related to *E. incertum* (Williamson), which fact was also noted by the above author. Some affinity between this species and *Cribrononion obscurus* Gudina, a cold-water species according to Gudina (1969, p. 28), may also be inferred.

Knudsen (1971) noted on some specimens two irregular rows of elongated outlet openings of sutural channels, similar to those from Brotzen's Sweden specimens. Taking this feature into account, Brotzen (1946) clearly stressed the similarity between this species and *Elphidiella arctica* (Parker & Jones), but did not assign it to the genus *Elphidiella* because of incompletely developed double sutural openings.

Occurrence. — Quaternary: Poland (Nadbrzeże), Sweden, Denmark, Norway.

Elphidium cf. *asklundi* Brotzen
(Pl. II, Figs. 1—6)

Material. — Three specimens with ultimate chambers damaged.

Description. — Test almost involute, circular in side view. Margin of the last chamber initially complete, later wavy and flaky. Peripheral margin broadly rounded. Umbilicus depressed, filled with granular test

material; the granular material also covers base of the ultimate chamber. Sutures slightly incurved, depressed and filled with granular material in subumbilical part, becoming smooth and merely slightly depressed in peripheral part. Grains variable in size, quite uniformly distributed. Outlet openings of sutural channels occasionally marked. Aperture formed by row of openings at the base of apertural face. Wall thick, opaque; pores irregular in shape, randomly distributed, not concentrated.

Remarks. — Thick-walled specimens from the "Elbląg-clays" mostly resemble tests of *Elphidium asklundi* Brotzen, somewhat differing from the typical representatives of this species. The comparative material available is insufficient to determine whether or not the author's specimens fall within the variability of the latter species.

Occurrence. — Quaternary: Poland (Nadbrzeże, Suchacz).

Elphidium bartletti Cushman, 1933

(Pl. III, figs 1—8; Pl. IV, Figs 1—7; Pl. XXVI, Figs 1—14; Text-figs 13, 14)

1933. *Elphidium bartletti* Cushman; J. A. Cushman, New Arctic foraminifera..., p. 4, Pl. 1, Fig. 9.
1939. *Elphidium bartletti* Cushman; J. A. Cushman, A monograph of the foraminiferal..., p. 64, Pl. 18, Fig. 10.
1946. *Elphidium goësi* Stschedrina; Z. G. Stschedrina, Novye formy..., p. 144, Pl. 4, Fig. 20.
1953. *Elphidium bartletti* Cushman; A. R. Loeblich & H. Tappan, Studies of arctic..., p. 96, Pl. 2, Figs 21—23.
1958. *Cribroelphidium goësi* (Stschedrina); N. A. Voloshinova, O nowoj systematike..., p. 172, Pl. 6, Figs 4—6.
1958. *Cribroelphidium vulgare* Voloshinova; N. A. Voloshinova, ibid. p. 174, Pl. 7, Figs 2—10.
1961. *Cribroelphidium goësi* (Stschedrina); Ch. M. Saidova, Ekologija foraminifer..., p. 80, Pl. 24, Fig. 166.
1964. *Elphidium bartletti* Cushman; R. W. Feyling-Hanssen, Foraminifera in Late..., p. 343, Pl. 21, Figs 1, 2.
1966. *Cribroelphidium goësi* (Stschedrina); W. I. Gudina, Foraminifery i stratygrafia..., p. 58, Pl. 3, Figs 1—6; Pl. 10, Fig. 4; Pl. 11, Fig. 5.
1967. *Elphidium bartletti* Cushman; R. Todd & D. Low, Recent foraminifera..., p. A 33, Pl. 4, Fig. 19.
1971b. *Elphidium bartletti* Cushman; K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 271, Pl. 11, Figs 6—9; Pl. 20, Figs 1—4.

Material. — Approximately 60 specimens, mostly damaged.

Dimensions (in mm):

	F. XV/117	F. XV/116	F. XV/118
Maximal diameter	0.51	0.57	0.58
Maximal thickness	0.27	0.27	0.21

Variability. — Variability high. Number of chambers varies from 7 to 12, usually equalling 9 (Text-fig. 13). Test outline circular-ovate to ovate-elongated; margin smooth at the beginning of the ultimate whorl, be-

coming smooth to more or less lobulate towards the end of the whorl. Peripheral margin, broadly rounded, particularly in ultimate or penultimate chambers. Test thick-walled, whereas walls of particular chambers

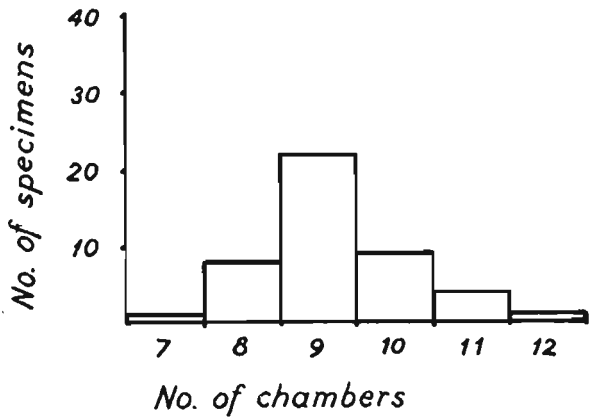


Fig. 13. Histogram of number of chambers per ultimate whorl of *Elphidium bartletti* Cushman for 45 specimens from Elbląg and Nadbrzeże.

vary in thickness. Chambers quite uniform in outline, slightly convex, differing in width. Umbilicus variable in diameter and degree of depression, filled up with granular test material (Pl. III, Figs 1—3). Sutures more or less depressed, filled with granular material; openings of sutural channels obscured or only visible close to the umbilicus; in other case, well-marked in all sutures. Granular material extends from suture and umbilical areas over apertural face of the ultimate chamber and over first visible chamber of the ultimate whorl, which results in the fact that aperture of the ultimate chamber is obscured (Pl. IV, Figs 2, 3; Text-figs 14—16). Foramen of preceding chambers is developed in the form of crescent slit situated in the middle of the base of apertural face; supplementary openings are randomly scattered over apertural face, or, occasionally, arranged in two or three rows. Number and size of pores in particular parts of test and chamber surfaces also markedly vary (Pl. III, Figs 7, 8).

Remarks. — Granular test material infilling depressed umbilicus, sutures and covering apertural face of the ultimate chamber and first chambers of the ultimate whorl was observed by means of Stereoscan. It consists of high projections and acute, angular-ended rods, set close to one another over the apertural face (Pl. IV, Figs 3, 4), decreasing in height and becoming more widely-spaced and ultimately disappearing towards the periphery (Pl. IV, Figs 5, 7). Wall of apertural chamber face is unperforated (Pl. IV, Figs 5 and 6). When surface of projections is abraded, their compact, solid structure may be observed (Pl. III, Figs 3, 4, 6).

The author's specimens differ from those described by Cushman (1933, 1948), Loeblich & Tappan (1953), Wagner (1970) and others in the type of aperture. Aperture of specimens of the latter authors consists of a number of openings situated along the base of apertural face and of some sup-

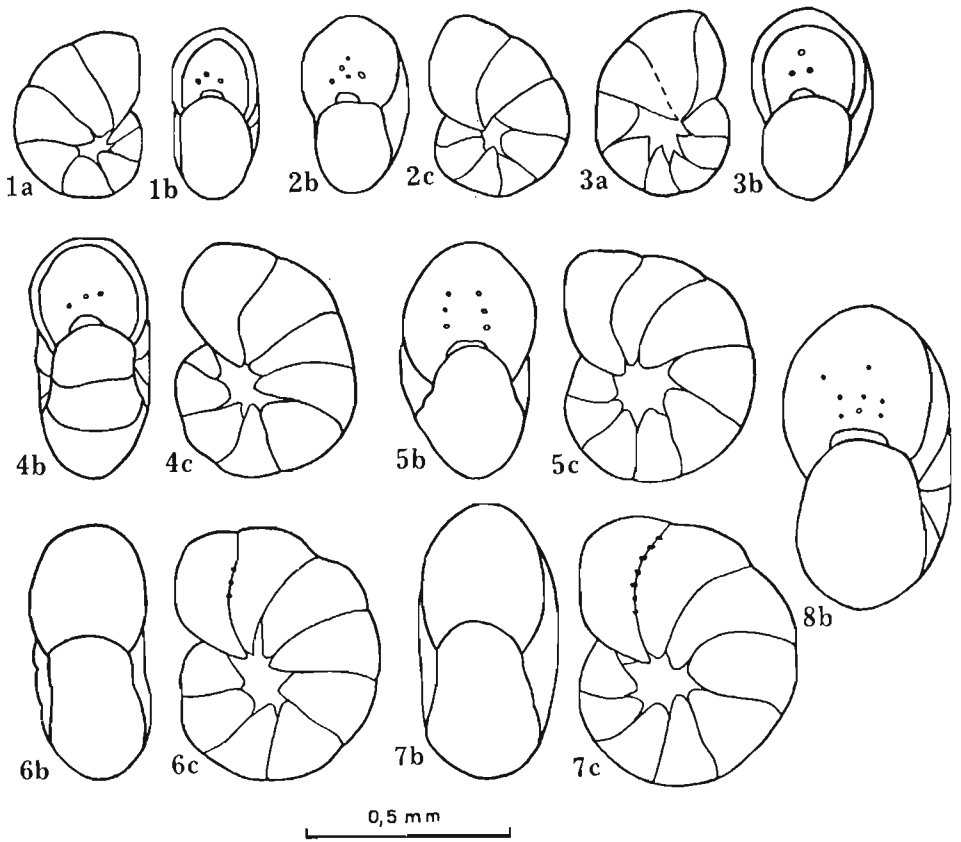


Fig. 14. *Elphidium bartletti* Cushman; outlines of tests: *a* and *c* side views, *b* apertural views.

plementary openings scattered over the apertural face. Therefore, the present author allocates her specimens to the species *E. bartletti* with reservation.

According to the present author, *Cribroelphidium yabei* Asano described from the Miocene of Japan by Kikuchi (1964, Pl. 4, Figs 32 and 33) should be placed into the synonymy of *E. bartletti*.

Occurrence. — Tertiary: Miocene of USSR (Sachalin). Quaternary: Poland (Nadbrzeże, Elbląg, Suchacz), Germany, Denmark, Norway, Spitsbergen, Great Britain, USSR (Siberia), USA (Alaska). Recent: Coasts of Alaska, Greenland and Arctic coasts of North America, Bering, Ochotsk and Japan Seas and north-western Pacific.

Elphidium clavatum Cushman *sensu lato*

(Pl. V, Figs. 1—6; Pl. X, Figs. 1, 2; Pl. XXIII, Fig. 4; Pl. XXIV, Figs. 1—5; Pl. XXVII, Figs. 2—8; Text-figs. 15—18)

1875. *Polystomella excavata* var. Terquem; O. Terquem, Essai sur le classement..., p. 25, Pl. 2, Fig. 2a—f.
1930. *Elphidium incertum* (Williamson); J. A. Cushman, The Foraminifera of the Atlantic..., p. 18, Pl. 7, Figs 8, 9.
1930. *Elphidium incertum* (Williamson); J. A. Cushman & W. S. Cole, Pleistocene Foraminifera..., p. , Pl. 13, Figs 6, 7.
1944. *Elphidium incertum* (Williamson); J. A. Cushman, Foraminifera from the shallow..., p. 25, Pl. 3, Figs 28—31.
1946. *Elphidium incertum* (Williamson) var. *clavatum*; I. Hessland, Marine Schalenablagerungen..., Pl. 3, Fig. 4.
1950. *Elphidium incertum* (Williamson); F. B. Phleger & W. R. Walton, Ecology of marsh..., p. , Pl. 2, Figs 17, 18.
1952a. *Elphidium incertum* (Williamson) var. *clavatum* Cushman; F. B. Phleger, Foraminifera distribution..., Pl. 14, Fig. 10.
1955. *Elphidium clavatum* Cushman; P. H. Ronai, Brackish-water foraminifera..., p. 146, Pl. 21, Figs 7, 8.
1955. *Elphidium clavatum* Cushman var. *broklynense* Shupack; P. H. Ronai, Ibid., p. 146, Pl. 21, Fig. 9.
1955. *Elphidium incertum* (Williamson); P. H. Ronai, Ibid., p. 148, Pl. 21, Fig. 14.
1961. *Elphidium clavatum* Cushman; R. Todd & D. Low, Near-shore Foraminifera..., p. 18, Pl. 2, Fig. 1.
1961. *Elphidium clavatum* Cushman; Ch. M. Saidova, Ekologija foraminifer..., p. 78, Pl. 23, Fig. 162.
1961. *Elphidium incertum* (Williamson); Ch. M. Saidova, Ibidem, p. 79, Pl. 23, Fig. 163.
1962. *Elphidium selseyense* (Heron-Allen & Earland); H. Woszidlo, Foraminiferen und Ostracoden..., p. 75, Pl. 3, Fig. 10.
1964. *Elphidium clavatum* Cushman; Y. Kikuchi, Biostratigraphy of the Neogene..., Pl. 4, Figs 20—22.
1964. *Elphidium incertum incertum* (Williamson); R. W. Feyling-Hanssen, Foraminifera in Late..., p. 344, Pl. 19, Figs. 16, 17; Pl. 20, Figs 9, 10.
1964. *Elphidium incertum clavatum* Cushman; R. W. Feyling-Hanssen, Ibidem, p. 345, Pl. 20, Figs 11—15.
1965a. *Elphidium clavatum* Cushman; M. A. Buzas, Foraminifera from Late..., p. 23, Pl. 3, Figs. 3, 4.
1965. *Elphidium clavatum* Cushman *sensu lato*; I. Brodniewicz, Recent and some..., p. 210, Pl. 10, Figs 1—8; Text-fig. 32 (cum synon.).
1965. *Elphidium excavatum* (Terquem); G. Lutze, Zur Foraminiferen-Fauna..., p. 96, Pl. 15, Figs. 39—41 (cum synon.).
1965. *Elphidium clavatum* Cushman; J. Nagy, Foraminifera in some..., p. 124, Pl. 2, Figs 21, 22.
1966. *Elphidium clavatum* Cushman; M. A. Buzas, The discrimination of morphological..., p. 591, Pl. 71, Figs 1—8.
1967. *Elphidium clavatum* Cushman; Y. Matoba, Younger Cenozoic..., p. 254, Pl. 27, Fig. 8.
1967. *Elphidium clavatum* Cushman; O. Michelsen, Foraminifera of the Late..., p. 236, Pl. 4, Fig. 6.

1967. *Elphidium broklynense* Schupack; S. Grossman & R. H. Benson, Ecology of Rhizopodes..., p. 58, Pl. 6, Figs 15, 16.
1967. *Elphidium clavatum* Cushman; S. Grossman & R. H. Benson, Ibid., p. 58, Pl. 8, Figs 13, 14.
1968. *Elphidium incertum clavatum* Cushman; F. J. E. Wagner, Illustrated checklist..., p. 1411, Pl. 1, Fig. 8.
1969. *Elphidium boreale Nuzhdina*; W. I. Gudina, Morskoj Pleistocen..., p. 31, Pl. 10, Figs. 4, 5; Pl. 11, Figs 1—4.
1969. *Elphidium selseyense* (Heron-Allen & Earland); W. I. Gudina, Ibid., p. 34, Pl. 12, Figs. 1—5; Pl. 14, Fig. 3.
1970. *Elphidium clavatum* Cushman; Y. Matoba, Distribution of Recent..., p. 51, Pl. 6, Fig. 11.
1970. *Elphidium incertum* (Williamson) and forma *clavatum* Cushman; F. J. E. Wagner, Faunas of the Pleistocene..., p. 24, Pl. 2, Figs. 3—6.
1971b. *Elphidium clavatum* Cushman; K. L. Knudsen. Systematic part *in*: R. W. Feyling-Hanssen et al., p. 273, Pl. 11, Figs 10—13; Pl. 20, Figs 5—8.

Material. — Approximately 1800 specimens.

Dimensions (in mm):

	F. XV/134	F. XV/133	F. XV/142
Maximal diameter	0.33	0.40	0.65
Thickness	0.18	0.34	0.29

Remarks. — Very rich material collected from all localities under discusssion is here tentatively assigned to *E. clavatum*. The specific name, *E. clavatum*, is used here in a very broad sense, as the name for a group of species. The variability of the species so interpreted is extremely great;

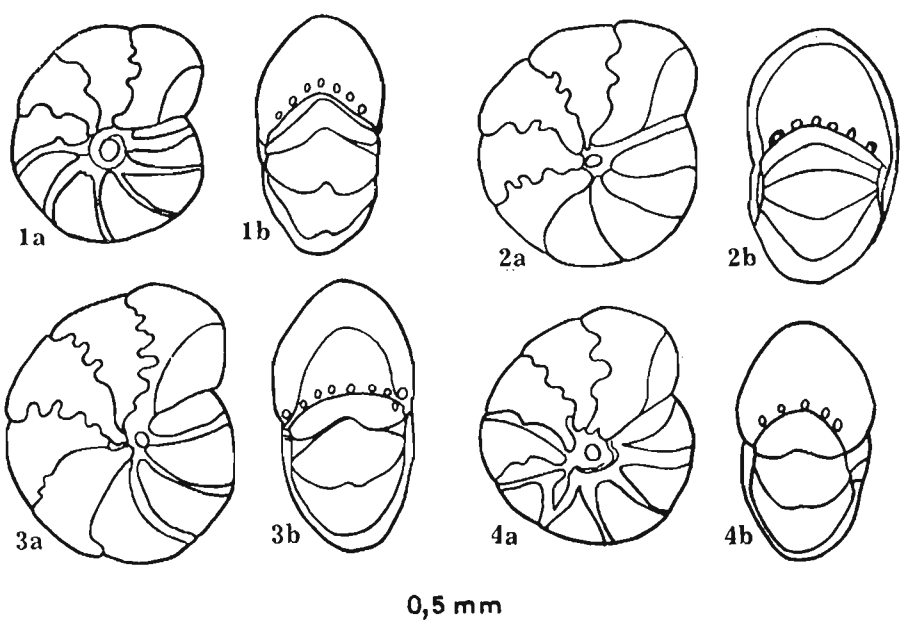


Fig. 15. *Elphidium clavatum* Cushman; outlines of tests from Brachlewo, having 1 tubercle in umbilicus: *a* side views, *b* apertural views.

however, present knowledge of this group is insufficient for dividing it into species or subspecies. It seems that this "species", *E. clavatum*, is euryhaline, eurythermal, eurybathial, etc., and its morphology changes depending on environmental conditions, being less variable when environmental conditions are more stable. Presumably it will be possible

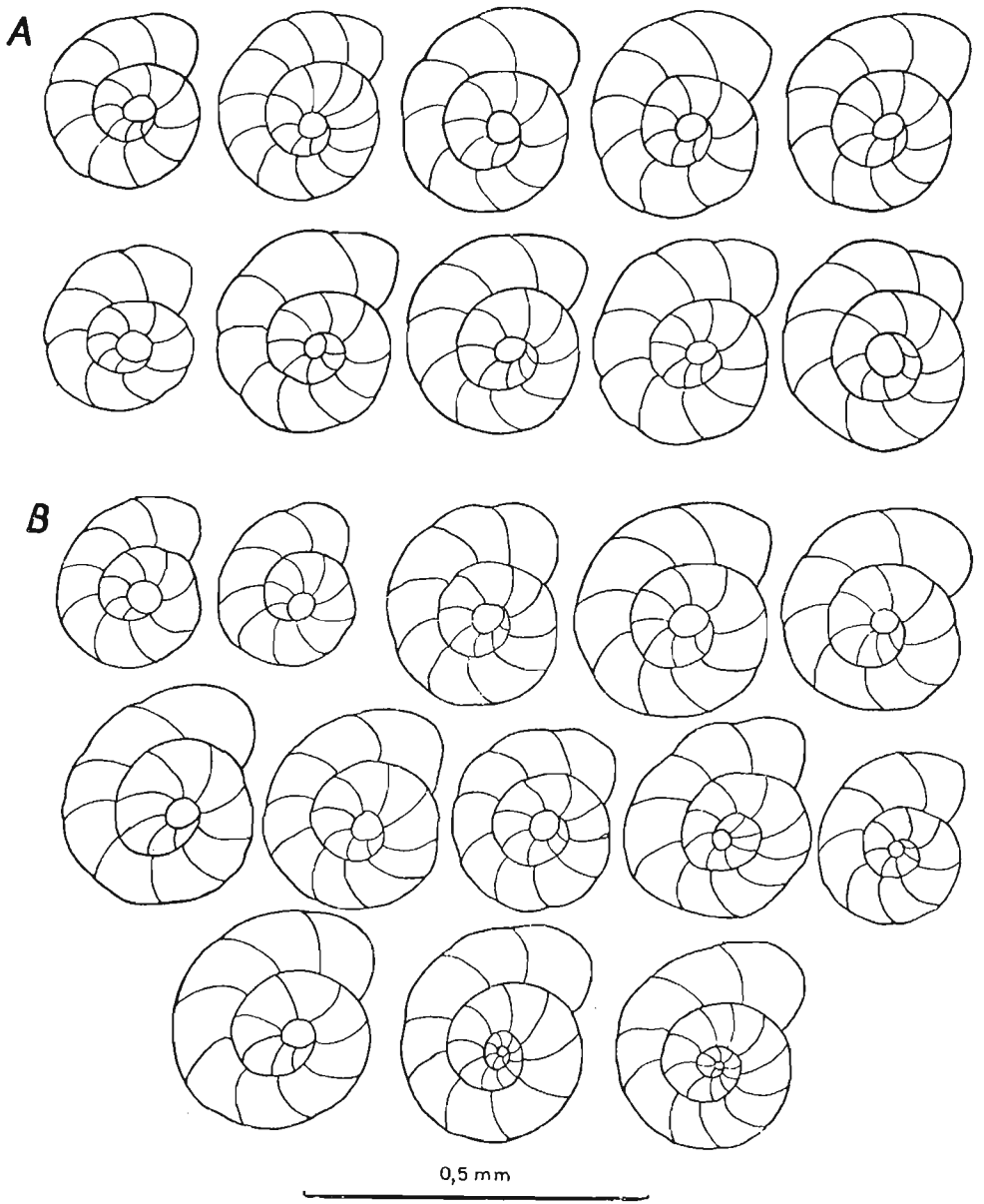


Fig. 16. *Elphidium clavatum* Cushman; outlines of cross-sections of tests from Brachlewo: *A* megalospheric generation tests with 1 tubercle in umbilicus, *B* megalo- and microspheric generation tests with a few tubercles in umbilicus.

to split this group into separate species and subspecies or ecotypes in the future. Probably some morphological details will be revealed by electron microscope studies. However, cultivation of the "species" in laboratory conditions would be the most effective method for solving this problem.

The views of particular authors on the taxonomic position of this "species" are remarkably diversified, hence its extensive synonymy. In her studies on recent form of this group inhabiting Baltic Sea, Brodniewicz (1965) allocated them to *E. clavatum* Cushman *sensu lato*, because of the great variability of this group. Buzas (1966) has suggested allocating *E. incertum* (Williamson) sensu Cushman to *E. clavatum* Cushman. Unfortunately, the synonymy of the latter species from North America, given by Buzes (*l.c.*) is incomplete. Grossman & Benson (1967) have described some interesting forms from North Carolina; the forms appear similar to the species under discussion, so specific identity is inferred. Gudina (1966, 1969) has described *E. subclavatum* and *E. obesum* from Quaternary deposits of Siberia, which forms fall within the limits of variability of the *E. clavatum* group, according to the present author. Specimens described as *E. obesum* in successive papers by Gudina (1966 and 1969), respectively differ from one another to the same degree as particular representatives of *E. clavatum* of the author's collection. More-

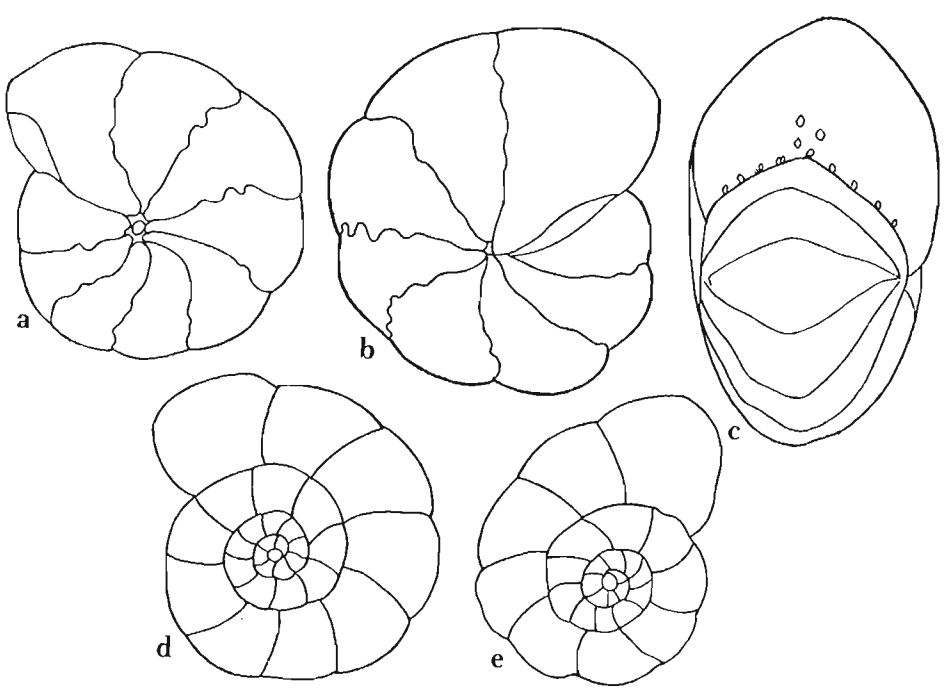


Fig. 17. *Elphidium clavatum* Cushman; *a* and *b* outlines of tests without tubercles in umbilicus — side views, *c* apertural views, *d* and *e* outlines of cross-sections of tests belonging to microspheric generation, without tubercles in umbilicus.

over, it appears practically impossible to separate these forms, described as *E. boreale* and *E. obesum* by Gudina (1969), from the Elbląg population of *E. clavatum*. In the Elbląg material the whole range of variability is found to which Gudina's forms correspond.

Troickaja (1970a, 1970b) has described some forms very similar to those under discussion as *E. subgranulosum* Asano, and she has found that tests with a knob in the umbilicus belong to the megalospheric generation and those without the knob — to the microspheric generation.

A number of forms described under a different specific name are herein assigned to the species *E. clavatum* Cushman *sensu lato*. Some groups of most closely morphologically related forms are distinguished below. However, no subgeneric names are proposed, as it would result in greater complication of the taxonomy.

Morphotype 1 (Pl. XXIV, Figs. 1—5) sensu *E. clavatum* Cushman (Cushman, 1930, Pl. 7, Fig. 10) and corresponding to specimens figured by Loeblich & Tappan (1953, Pl. 19, Figs 8—10), Buzas (1965, Pl. 3, Figs 3, 4; 1966, Pl. 71, Figs 1, 2) and others. Homogeneous and typical population of small, yellow-brownish and translucent tests occurring at Brachlewo and, occasionally, at Elbląg. The tests from Brachlewo and their cross-sections illustrated in Text-figs 15 and 16 indicate that the forms exclusively belong to the megalospheric generation. On the other hand, tests with a few knobs in the umbilicus (Pl. XXIV, Figs 3—5), found at Brachlewo, belong to micro- or megalospheric generations (Text-fig. 16B). Also some larger specimens from the Brachlewo assemblage, characterized by translucent yellow-brownish tests devoid of knobs in the umbilicus and by opaque sutures have cross-sections typical of the microspheric generation (Text-fig. 17).

Morphotype 2, *E. incertum* sensu Cushman illustrated in several papers and considered conspecific with *E. clavatum* by Buzas (1966). Here, large forms of *E. clavatum*, with or without knobs in the umbilicus, which were figured by Buzas (1965, Pl. 2, Figs 7, 8; Pl. 3, Figs 1, 2) and forms identified as *E. boreale* Nuzhdina and *E. obesum* Gudina by Gudina (1969), as well as forms described by Parker (1952), Shupack (1934), Grossman & Benson (1967) and others.

Morphotype 3 (Pl. XXVII, Figs 2—7) comprises large and some, extremely rare, "giant" tests (Pl. XXVII, Figs 4, 5). The number of chambers per ultimate whorl varies from 8 to 13, commonly attaining 10, in the case of Nadbrzeże assemblages, samples No. — 19 to — 25 and 42, or 9 in Nadbrzeże, samples No. 40 to — 12. The giants were usually found among the latter (Text-fig. 18). Specimens of this group are characterized by sutures with retral processes markedly curved backward, and correspondingly backward projected chambers. Extremely large but very rare specimens are characterized by a peripheral outline angular in side view and

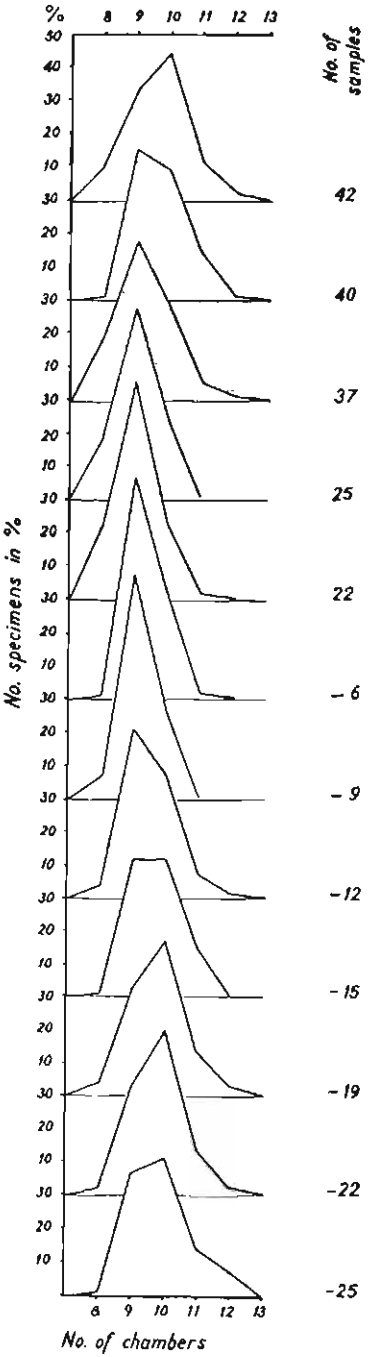


Fig. 18. Histogram of number of chambers per ultimate whorl of *Elphidium clavatum* Cushman for particular samples from the profile at Nadbrzeże.

differ diametrally from typical forms of this group. It would be difficult to allocate them to this "species" unless (quite numerous) transitional forms were known. This form was found at Nadbrzeże in profile and in clays with *Portlandia arctica* and at Bogdaniec. Forms somewhat similar to specimens of this group were figured as *E. obesum* by Gudina (Gudina 1966, Pl. 4, Figs 12 and 13).

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg, Nadbrzeże, Suchacz, Bogdaniec, Tychnowy), Sweden, Denmark, Germany, Norway, Holland, France, Great Britain, USSR, Canada, USA, Japan. Recent: Baltic, North, Bering and White Seas, Atlantic (Boreal and Arctic Zones), Arctic seas of USSR and Canada, Pacific (Boreal and Arctic Zones).

Elphidium gunteri Cole, 1931
(Pl. XXIV, Figs 9, 10, 13—15)

1931. *Elphidium gunteri* Cole; W. S. Cole, The Pliocene and Pleistocene..., p. 34, Pl. 4, Figs 9, 10.
1939. *Elphidium gunteri* Cole; J. A. Cushman, A monograph of the foraminiferal..., p. 49, Pl. 13, Fig. 10.
1951. *Elphidium littorale* Le Calvez & Le Calvez; J. Le Calvez & Y. Le Calvez, Contribution à l'étude..., p. 251, Text-fig. 5.
1956. *Elphidium gunteri* Cole; O. L. Bandy, Ecology of Foraminifera..., p. 194, Pl. 30, Fig. 19.
1957. *Elphidium gunteri* Cole; J. H. van Voorthuysen, Foraminiferen aus dem Eemien..., p. 32, Pl. 23, Fig. 11.
1959. *Elphidium gunteri* Cole; F. L. Parker & W. D. Athearn, Ecology of marsh..., p. 342, Pl. 50, Fig. 36.
1960. *Elphidium gunteri* Cole; J. H. van Voorthuysen, Die Foraminiferen des Dollart..., p. 115.
1962. *Elphidium gunteri* Cole; F.-W. Haake, Untersuchungen..., p. 48, Pl. 5, Figs 3, 4.
1963. *Elphidium gunteri* Cole; H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 29, Pl. 3, Figs 7, 8.
1963. *Elphidium gunteri* Cole; E. Boltovskoy, The littoral foraminiferal..., p. 61, Pl. 6, Figs 13, 14.
1963. *Elphidium gunteri* Cole; A. Ayala-Castanares, Systematica y distribucion..., p. 93, Pl. 8, Fig. 5.
1964a. *Elphidium gunteri* Cole; G. Richter, Zur Ökologie..., Fig. 7.
1966—67. *Elphidium gunteri* Cole; M. B. Cita & I. Premoli Silva, Sui foraminiferi incentrati..., p. 35.
1967. *Elphidium gunteri* Cole; F. B. Phleger, Marsh foraminiferal..., p. 27.
1971b. *Elphidium gunteri* Cole; K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 277, Pl. 12, Figs 9, 10; Pl. 21, Figs 4—7.

Material. — Approximately 200 specimens, mostly damaged.
Dimensions (in mm):

	F. XV/147	F. XV/148	F. XV/150
Diameter	0.37	0.49	0.49
Thickness	0.25	0.25	0.27

Variability. — Wide variability, primarily expressed in differences in size and thickness of test and in number of chambers in the ultimate whorl. This variability is presumably related both to the occurrence of micro- and megalospheric generations and to changes proceeding in the environment inhabited by every population.

Remarks. — Some authors e. g. Parker (1954) and Bandy (1956) hold that some specimens assigned to the subspecies *E. gunteri galvestonense* Kornfeld belong, in fact, to *E. gunteri* Cole. It is valid in the case of the larger part of tests figured or described as *E. qunteri galvestonense* Kornfeld, because of the very high individual variability of *E. gunteri* primarily resulting from environmental conditions. In the author's material, numerous aberrant tests with irregularly spaced or deformed chambers were found.

Occurrence. — Miocene: Mexico. Pliocene: USA (Florida). Quaternary: Poland (Brachlewo, Elbląg), Denmark, Germany, Holland. Recent: brackish waters of watts and embayments of the North Sea in Germany and Holland, Mediterranean Canet and Salses pools with salty waters, lagoon of Venice, Atlantic — brackish and littoral waters along North American coasts, South American coasts, western African coasts, Pacific — lagoons of California coast.

Elphidium halickii n.sp.

(Pl. VI, Figs 1—6; Pl. XXIII, Figs 7, 10; Text-fig. 19)

Holotype: Specimen No. F. XV/152; Pl. XXIII, Fig. 10.
Paratype: Specimen No. F. XV/153; Pl. XXIII, Fig. 7.
Type horizon: Quaternary beds.
Type locality: Poland, Nadbrzeże, Elbląg clays.
Derivation of the name: Named in honour of the late Professor B. Halicki, the outstanding Polish geologist.

Material: Approximately 56 specimens with ultimate chamber partly damaged.

Dimensions (in mm):

	F. XV/153	F. XV/154	F. XV/152
Maximal diameter	0.49	0.67	0.70
Thickness	0.24	0.36	0.33

Diagnosis. — Test circular in side view, thick-walled, somewhat evolute; chambers short; umbilical plane wide; sutures straight, slightly depressed, with large outlet openings of sutural channels and not numerous, fine grains of test material. Aperture consisting of circular small openings arranged in row along the base of apertural face. Number of chambers in the ultimate whorl varies from 9 to 12.

Description. — Test laterally inflatted, thick-walled. Side view quite regular, circular, occasionally lightly lobulated, particularly towards the end of ultimate whorl. Peripheral margin rounded. Chambers initially flat, and then gradually increasing in size and becoming somewhat convex. The test is slightly evolute, hence chambers are relatively short and umbilical plane — markedly wide. Umbilicus undepressed, filled with test

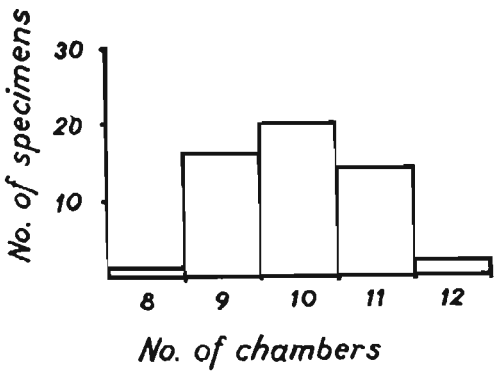


Fig. 19. Histogram of numbers of chambers per ultimate whorl of *Elphidium halickii* n. sp. for 53 specimens.

material. Sutures slightly depressed, with markedly large, occasionally elongated outlet openings of sutural channels; moreover, small grains of test material are occasionally found in the sutures. Pores are irregular, sometimes elongated on the inner chambers, becoming regularly circular on the outer chambers; arrangement of pores is given in Pl. VI, Fig. 4. Test white-coloured. Aperture formed by circular openings arranged in a row along the base of apertural face.

Variability. — *Elphidium halickii* n. sp. shows distinct and rather constant features; some slight differences in size of test, number of chambers, number of outlet openings of sutural channels, area of umbilical plane and shape of pores on chamber walls were found.

Remarks. — *Elphidium halickii* n. sp. is somewhat similar to *E. incertum* in arrangement of pores, differing in thicker and more circular test, less depressed sutures and large, flat umbilical plane; moreover, grains of test material found in the umbilicus and sutures appear scarcer and finer. *Elphidium halickii* n. sp. is also somewhat similar to boreal *Cibrononion obscurus* Gudina, differing in wide umbilicus of glittering test material, with granular material occurring in small amounts along narrow sutures and along margins of umbilical plane, close to the sutures. Outlet openings of sutural channels usually number 5 to 6 in the case of adult specimens, being smaller in smaller or younger ones.

Occurrence. — Quaternary: Poland (Nadbrzeże, Suchacz).

Elphidium hyalinum n. sp.
(Pl. IX, Figs 1—6; Pl. X, Figs 3—7; Pl. XI, Figs. 1—3; Text-fig. 20)

Holotype: Specimen No. F. XV/155; Pl. IX, Fig. 1.
Paratype: Specimen No. F. XV/156; Pl. IX, Fig. 3.
Type horizon: Quaternary beds.
Type locality: Bogdaniec, North Poland.
Derivation of the name: *Lat.* from translucent, colourless test.

Diagnosis. — Test planospiral, somewhat evolute, flat, circular in side view; peripheral margin lobulated. Umbilicus wide, with translucent, imporous knob in the center. Sutures wide, arcuate, with 1 to 2 retral processes. Umbilicus and sutures filled with opaque, granulated test material. Wall thin, translucent, colourless, markedly perforated. Aperture formed by circular openings arranged in row along the base of apertural face.

Material. — Approximately 148 well-preserved specimens.

Dimensions (in mm):

	F. XV/159	F. XV/158	F. XV/160
Maximal diameter	0.36	0.40	0.42
Thickness	0.11	0.18	0.15

Description. — Test planospiral, symmetrical, somewhat evolute, circular to circular-ovate in side-view. Peripheral margin somewhat wavy; ultimate chambers lobulated. Chambers 7 do 10 in number per ultimate whorl (Text-fig. 20) initially flat, later becoming slightly convex, narrow and projected backward. Sutures quite wide, arcuate, rapidly twisted backward in the peripheral area; ultimate sutures have 1 to 2 retral processes. Umbilicus wide, flat, occasionally somewhat depressed, with central knob formed of glossy, nonporous material and variable in size; sometimes outlet pores of spiral umbilical channel are found. Umbilicus, sutures and base of the ultimate chamber are covered with opaque granular test material. Umbilical margins of chambers are built of nonporous, glossy test material and bent backward or connected with one another in the form of a continuous circum-umbilical ring, markedly separated from umbilical surface. Wall thin, markedly perforated, except for central part of apertural face above aperture. Pores circular, irregularly distributed over test surface. Calcite grains forming the wall fine, regularly arranged. Test in apertural view thin, with ultimate chamber somewhat widened. Apertural face narrow, ovate, convex. Aperture formed of circular openings arranged in row and obscured by granulated test material in the case of ultimate chamber. In penultimate chamber, supplementary openings were occasionally found near aperture of apertural face.

Remarks. — *Elphidium hyalinum* n. sp. was only found in red clays outcropping at Bogdaniec and even there it was represented by a relatively small number of individuals. The species is somewhat similar to the spe-

cimen illustrated as *E. clavatum* by Knudsen (1972, Pl. 20, Figs 7 and 8) in having circum-umbilical ring formed of imperforated material of sub-umbilical margins of chambers, differing in wider umbilicus, more arcuate sutures and chambers more projected backward, and in less even peripheral margin of test; moreover, its test in apertural view is markedly thinner and flatter than that of *E. clavatum* in Knudsen (1972).

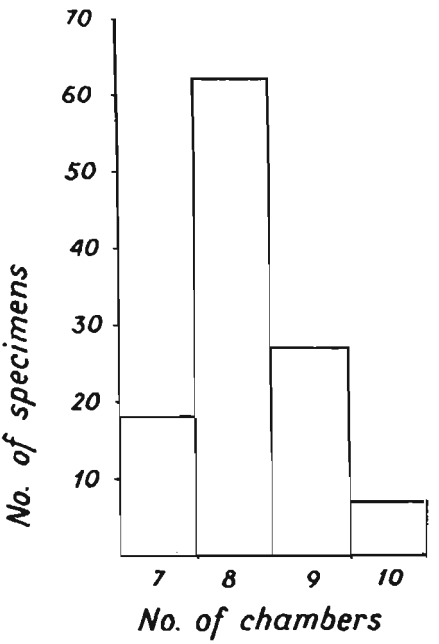


Fig. 20. Histogram of number of chambers per ultimate whorl of *Elphidium hyalinum* n. sp. for 114 tests from Bogdaniec.

The number of specimens was too small to study generations of the species, or to make thin sections and cross-sections.

The new species has a number of features in common with *E. clavatum s. lato,* differing from the latter species in more evolute test, umbilicus with marked central knob, small number of retral processes, flatter and thinner test, arcuate sutures, and particularly ultimate chamber more lobulated.

Occurrence. — Quaternary, Poland (Bogdaniec).

Elphidium incertum (Williamson, 1858)

(Pl. VII, Figs 1—7; Pl. XXVIII, Figs 6—11; Text-figs 21, 22)

1858. *Polystomella umbilicatula* var. *incerta* Williamson; C. W. Williamson, On the recent..., p. 44, Pl. 3, Fig. 82a.

1951. *Elphidium incertum* (Williamson); J. W. van Voorthuysen, Recent (and derived...), Pl. 2, Fig. 15.

1963. *Elphidium incertum* (Williamson); H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 29, Pl. 3, Figs 9—12.
1964. *Elphidium incertum* (Williamson); O. Michelsen, Foraminifera of the Late..., p. 239, Pl. 5, Fig. 4.
1965a. *Elphidium varium* Buzas; M. A. Buzas, Foraminifera from Late..., p. 21, Pl. 2, Fig. 7; Pl. 3, Figs 1, 2.
1965. *Elphidium incertum* (Williamson); I. Brodniewicz, Recent and some..., p. 207, Pl. 10, Figs 9—11; Text-figs 30, 31.
1965. *Cribrononion incertum* (Williamson); G. Lutze, Zur Foraminiferen-Fauna..., p. 103, Pl. 21, Figs 43, 44.
1966. *Elphidium incertum* (Williamson); M. A. Buzas, The discrimination of morphological..., p. 592, Pl. 72, Figs 1—6.
1969. *Cribrononion incertum* (Williamson); W. I. Gudina, Morskoj Plejstocen..., p. 28, Pl. 9, Figs 4—7.
1970. *Elphidium incertum* (Williamson); F. J. E. Wagner, Faunas of the Pleistocene..., p. 24, Pl. 2, Figs 5, 6.
1971b. *Elphidium incertum* (Williamson); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 277, Pl. 12, Figs 11, 12; Pl. 21, Figs 8, 9.

Material. — Approximately 500 specimens, commonly damaged.
Dimensions (in mm):

	F. XV/165	F. XV/167	F. XV/169
Maximal diameter	0.49	0.54	0.58
Thickness	0.22	0.24	0.25

Variability. — The variability of this species is quite high. Outline of test changes from circular to circular-ovate; margin usually more or less

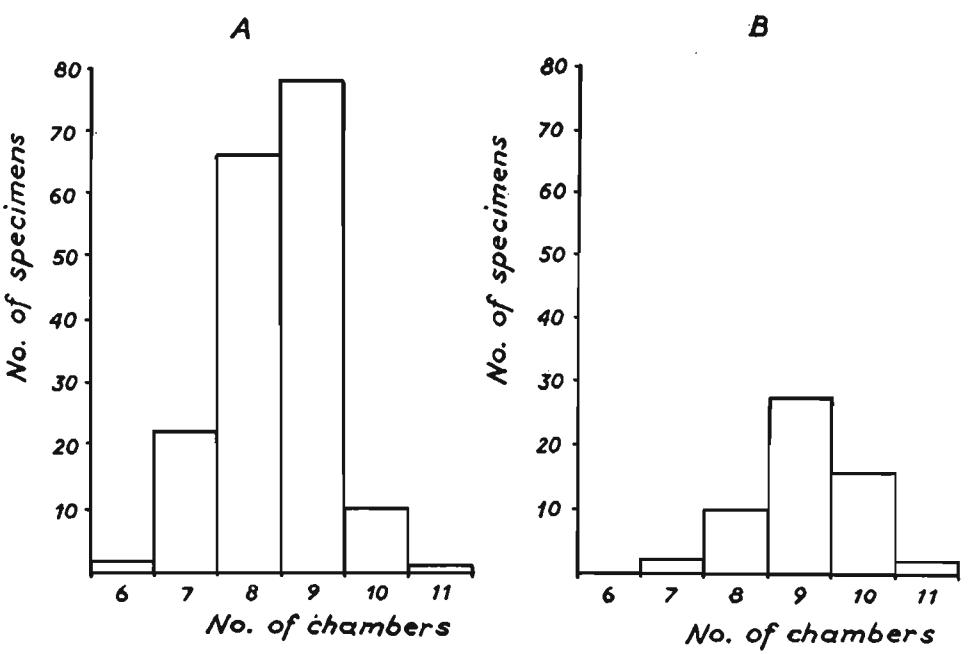


Fig. 21. Histograms of number of chambers per ultimate whorl of *Elphidium incertum* (Williamson); *A* for 178 tests from Brachlewo, *B* for 57 tests from Elbląg.

lobulated, sometimes margin of the initial part of ultimate whorl is smooth. Chambers somewhat convex, numbering 6 to 11 per ultimate whorl, commonly 9 (Text-fig. 21). Sutures distinct, more or less arched backward, filled with granular material varying in size; retral processes sometimes obscured; when distinct, up to 6 may be found on every side of the test. Outlet openings of sutural channels circular to elongated, slit-like, occasionally obscured with granulated test material. Forms with slits radially elongated and markedly symmetrically distributed over sub-umbilical part are quite common. There are also some specimens with retral processes and outlet openings of sutural channels completely obscured with granulated material; this results in distinct similarity to representatives of the genus *Protelphidium*. Umbilicus flat to slightly depressed, filled with granulated test material. Grains filling up sutures, umbilicus and partly covering base of the ultimate chamber are massive and vary in size. Aperture consisting of circular, uniform openings arranged in line along base of apertural face, occasionally obscured with granulated material, almost invariable in character. Size of specimens from Brachlewo is variable, but generally larger than that of specimens from Elbląg or Nadbrzeże. This presumably results both from occurrence of micro- and megalospheric forms (Text-fig. 22) and various environmental factors.

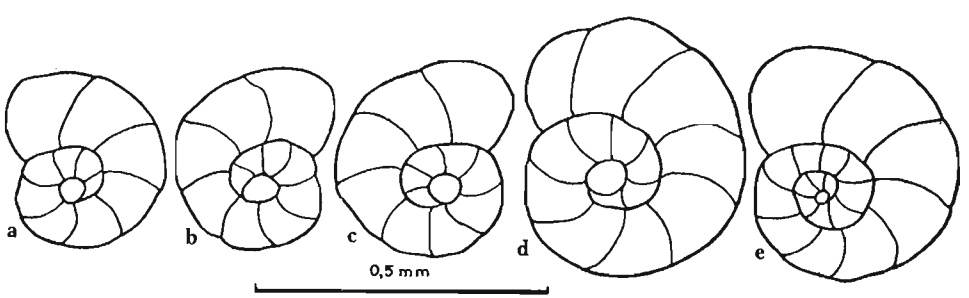


Fig. 22. *Elphidium incertum* (Williamson); outlines of tests from Brachlewo: *a—d* megalospheric forms, *e* microspheric form.

Remarks. — The author has presented her observations and remarks concerning *E. incertum* in a previous paper (Brodniewicz 1965, p. 208). Since that time, a number of other authors have provided more adequate descriptions and figures of this species, and the problem of *Elphidium incertum* (Williamson, 1858) now appears to be solved.

According both to Knudsen (1971) and the present author, large forms of *E. incertum* are similar to *E. asklundi*. In turn, Gudina (1969) holds that *E. obscurus*, described by her from the Quaternary series of Siberia, is closest to the species in question. There is also some similarity between *E. halickii* n. sp. and the species under discussion.

Cushman (1949) has allocated some forms recently inhabiting Belgian coast waters to *E. incertum* (Cushman, 1949, Pl. 5, Fig. 9); however, these forms seem to belong to *E. clavatum* Cushman, occurring in masses in this area at present; hence, it is not included in the synonymy of the species in question.

Specimens figured by Buzas (165, 1966) from the Pleistocene and Recent coasts of the eastern USA are identical with forms from Recent and Pleistocene populations of Europe.

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg, Nadbrzeże, Suchacz, Tychnowy), Sweden, Denmark, Germany, Norway, Holland, USSR, USA, Canada. Recent: Baltic Sea, Kiel Bay, coasts of Great Britain, Holland, Canada and Greenland, Atlantic coasts of USA, Arctic coasts of USSR and Canada.

Elphidium obscurus (Gudina, 1966)

1966. *Cribrononion obscurus* Gudina; W. I. Gudina, Foraminifery i stratygrafja..., p. 36, Pl. 2, Figs 4, 5; Pl. 11, Fig. 4.

1969. *Cribrononion obscurus* Gudina; W. I. Gudina, Morskoj Pleistocen..., p. 29, Pl. 10, Figs 1, 2; Pl. 16, Fig. 2.

Material. — Five well-preserved specimens.

Dimensions (in mm):

	F. XV/176	F. XV/177	F. XV/178
Maximal diameter	0.51	0.54	0.64
Thickness	0.24	0.24	0.30

Remarks. — This species is very rare in the material studied. Single specimen was found at Nadbrzeże, profile, sample No. 14; moreover, 4 tests were found at Suchacz, in the blue clays with *Portlandia arctica* (Gray) exposed in the claypit II.

Gudina (1966, 1969) described *E. obscurus* from the Quaternary deposits of the northern parts of western Siberia and European areas of the USSR, as well as from contemporaneous Arctic seas of the USSR. The present species is close to *E. incertum*, which fact has been noted by Gudina (1969, p. 28) as well as to *E. halickii* n. sp.

Occurrence. — Quaternary: Poland (Nadbrzeże, Suchacz), USSR (N part of European areas of USSR and N parts of the western Siberia). Recent: Arctic seas of the USSR.

Elphidium poeyanum (d'Orbigny, 1839)

(Pl. VIII, Figs 1—7; Text-fig. 23)

1839a. *Polystomella poeyana* d'Orbigny; A. d'Orbigny, Foraminifères, *in*: M. R. de la Sagra, p. 55, Pl. 6, Figs 25, 26.

1922. *Polystomella poeyana* d'Orbigny; J. A. Cushman, Shallow-water Foraminifera..., p. 55, Pl. 9, Figs 9, 10.
1931. *Elphidium poeyanum* (d'Orbigny); M. Dolgopolskaja & W. Pauli, Foraminifery..., Pl. 2, Fig. 11.
1939. *Elphidium poeyanum* (d'Orbigny); H. A. Cushman, A monograph of the foraminiferal..., p. 54, Pl. 14, Figs 25, 26.
1954. *Elphidium poeyanum* (d'Orbigny); F. L. Parker, Distribution of the foraminifera..., p. 509, Pl. 6, Fig. 17.
1957. *Elphidium* sp. *A*; J. H. van Voorthuysen, Foraminiferen aus dem Eemien..., p. 31, Pl. 23, Fig. 10.
1963. *Elphidium* sp. *A* van Voorthuysen; H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 33, Pl. 4, Figs 12—14.
1963. *Elphidium poeyanum* (d'Orbigny); A. Ayala-Castanares, Sistematica y distribucion..., p. 95, Pl. 9, Fig. 1.
1966. *Elphidium poeyanum* (d'Orbigny); E. Boltovskoy & H. Lena, Foraminiferos recientes..., p. 301, Pl. 3, Fig. 13.
1966—67. *Elphidium excavatum* (Terquem); M. B. Cita & I. Premoli Silva, Sui foraminiferi incontrati..., p. 34, Text-fig. 3a.

Material. — 220 specimens, generally well-preserved.

Dimensions (in mm):

	F. XV/173	F. XV/174	F. XV/175
Maximal diameter	0.29	0.40	0.42
Thickness	0.13	0.18	0.22

Variability. — The species is characterized by a high variability. The ultimate whorl has 7 to 14 chambers, usually 9 chambers (Text-fig. 23).

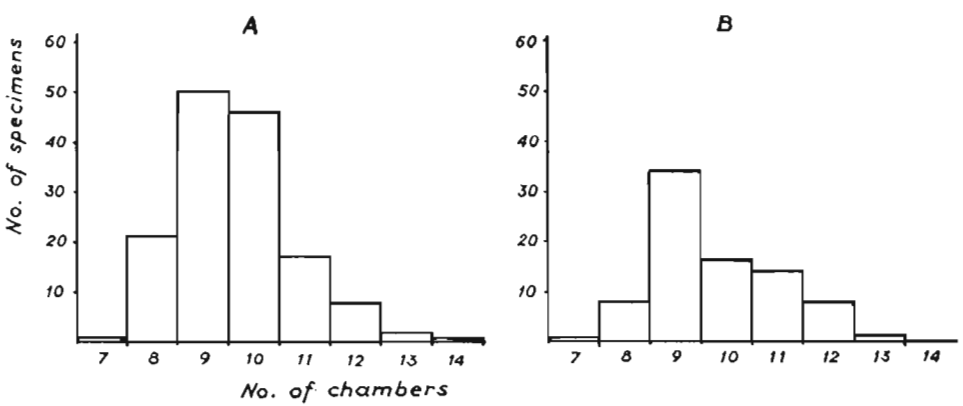


Fig. 23. Histograms of number of chambers per ultimate whorl of *Elphidium poeyanum* (d'Orbigny) for: *A* 146 tests from Brachlewo, *B* 81 tests from Elbląg.

The most common or most typical forms are figured in Pl. VIII, Figs 1 and 2. Tests similar to those described as *Elphidium cuvillieri* Lévy (1966) and those figured as *E. decipiens* (Costa) in Foraminiferi Padani (1957, Pl. 22, Fig. 2) and by Gianotti (1953, Pl. 2, Fig. 4). There are, however, transitory forms between the latter ones and typical *E. poeyanum*. The typical

forms have a smaller number of chambers and lobe-like periphery in side view, whereas transitory forms have a greater number of chambers and smoother periphery. Wall thin, translucent, and with pores uniformly distributed over the whole chamber surface, except for sutures and apertural surface. Sutures more or less depressed, with circular outlet openings of sutural channels. Umbilical area quite large, filled with glossy, nonporous test material with circular or elongated outlet pores of umbilical channel. The lack of granular test material in umbilicus, sutures and on surface of the ultimate chamber appears characteristic of this species. Aperture consists of circular openings at the base of apertural surface.

Remarks. — The author's specimens seem to be identical to the holotype of this species. Specimens from Brachlewo and Elbląg exhibit the same variability as the topotypes in Paris.

The morphological features of *E. cuvillieri* Lévy (1966) seem to fall within the limits of variability of *E. poeyanum*, but allocation of the former species into the synonymy of the latter should be preceded by further detailed study.

Occurrence. — Miocene: USA (Florida). Pliocene: Italy, USA (Florida). Quaternary: Poland (Brachlewo, Elbląg), Germany, Holland, Italy. Recent: Mediterranean, Adriatic and Black Seas, Atlantic coasts of America (USA — Massachussetts, Brazil, Argentina, Carribean, Cuba, Mexican Gulf).

Elphidium umbilicatulum (Williamson, 1858)

(Pl. XXIII, Figs 1—2; Pl. XXV, Figs 1—8; Text-fig. 24)

1858. *Polystomella umbilicatula* (Walker); W. C. Williamson, On the Recent..., p. 42, Figs 81, 82 (not 82a).
1938. *Elphidium excavatum* (Terquem); H. Bartenstein, Die Foraminiferen-Fauna..., p. 389, Fig. 3.
1944. *Elphidium excavatum* (Terquem); J. A. Cushman, Foraminifera from the shallow..., p. 26, Pl. 3, Fig. 40.
1946. *Elphidium excavatum* (Terquem); I. Hessland, Marine Schalenablagerungen..., Pl. 3, Fig. 42.
1951. *Elphidium excavatum* (Terquem); W. Pożaryski, Les Foraminifères eémiens..., p. 311.
1957. *Elphidium excavatum* (Terquem); J. H. van Voorthuysen, Foraminifera aus dem Eemien..., p. 31, Pl. 23, Fig. 8.
1962. *Elphidium excavatum* (Terquem); F.-W. Haake, Untersuchungen..., p. 47, Pl. 5, Fig. 5.
1963. *Elphidium excavatum* (Terquem); H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 28.
1965a. *Elphidium excavatum* (Terquem); I. Brodniewicz, Recent and some..., p. 214, Pl. 7, Fig. 5; Pl. 11, Fig. 4.
1965a. *Elphidium excavatum* (Terquem); J. W. Murray, On the Foraminiferida..., p. 503, Pl. 1, Fig. 6.

1965. *Elphidium* cf. *alvarezianum* (d'Orbigny); G. Lutze, Zur Foraminiferen-Fauna..., p. 101, Pl. 15, Fig. 46.
1967. *Elphidium excavatum* (Terquem); O. Michelsen, Foraminifera of the Late..., p. 238, Pl. 5, Fig. 2.
1968. *Cribrononion articulatum* (d'Orbigny); G. Lutze, Jahresgang der Foraminiferen-Fauna..., p. 27, Pl. 1, Figs 1, 2.
1969. *Elphidium umbilicatulum* (Williamson); A. Lévy et al., Les réprésentants..., p. 96, Pl. 1, Fig. 6; Pl. 2, Figs 1, 2.
1971b. *Elphidium umbilicatulum* (Williamson); K. L. Knudsen, Systematic part *in*: R. W. Feyling-Hanssen et al., p. 281, Pl. 13, Figs 8—11; Pl. 23, Figs 1—4.

Material. — Approximately 2000 specimens with ultimate chambers slightly damaged or other minor damages.

Dimensions (in mm):

	F. XV/180	F. XV/181	F. XV/188
Maximal diameter	0.38	0.52	0.81
Thickness	0.18	0.22	0.38

Description. — Test symmetrical, planospiral, with compressed sides, circular in side view. Peripheral margin smooth to slightly lobulated. Umbilicus depressed, sometimes slightly convex. Chambers narrow, initially quite flat, later slightly convex, numbering 9 to 17, commonly 12 per ultimate whorl (Text-fig. 24). Sutures distinct, somewhat depressed, with

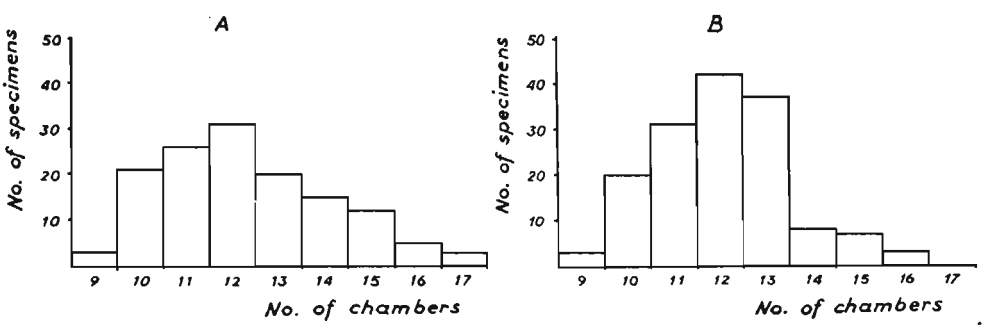


Fig. 24. Histograms of number of chambers per ultimate whorl of *Elphidium umbilicatulum* (Williamson) for: *A* 136 tests from Brachlewo, *B* 152 tests from Elbląg.

regular retral processes numbering 7 to 14 along every side of suture and transversal grooves between them. Both retral process and grooves are regularly spaced and uniformly pass through peripheral margin, which shows that sutural channel continues along peripheral margin of every chamber.

Wall finely perforated, smooth, colourless, thin, translucent, to white, thick, glittering, occasionally opaque. Umbilicus and sutural transversal grooves filled with granular test material. Aperture consisting of circular pores arranged in line along base of apertural face; supplementary open-

ings forming second, parallel row above aperture or irregularly spaced above proper aperture are occasionally found. Aperture is sometimes obscured by granulated test material.

Variability. — The specimens from the author's collection are quite uniform in shape. The number of chambers per ultimate whorl, size and thickness of tests and related changes in test periphery outline and number of retral processes along sutures are variable characters. Young forms are characterized by convex chambers, whereas chambers of adult individuals are only somewhat convex or almost flat.

Remarks. — The species has commonly been described under the name of *E. excavatum* (Terquem) so long as the range of the latter species was not well delimited (Lutze, 1965; Haake, 1967; Lévy et al. 1969). However, the question of a proper specific name for this species still remains. There is no doubt that it is identical with that described and figured by Williamson (1858, p. 42, Figs 81, 82, *not* 82*a*) under the name of *P. umbilicatula,* but tests of this species were regarded by Lutze (1965) as close to *E.* cf. *alvarezianum* (d'Orbigny). They were subsequently assigned by the latter author (Lutze, 1968) to *E. articulatum* (d'Orbigny) on the basis of comparison with topotypes supplied to Lutze by Boltovskoy. The topotypes are small, translucent tests resembling *E. articulatum,* except for the aperture; their aperture is represented by a single row of openings continuing along apertural base, whereas aperture of d'Orbigny's specimen (d'Orbigny, 1839, Pl. 3, Fig. 10) has besides a single row of openings along apertural base also supplementary openings irregularly spaced over triangular apertural face. Some small, presumably young specimens of *E. umbilicatulum* found at Brachlewo and Elbląg appear similar to the topotypes in question; however, they are subordinate in the population, in which 12-chamber tests typical of *E. umbilicatulum* population from the coasts of Great Britain (Williamson, 1858; Murray, 1961, 1969), distinctly prevail.

The present author took into consideration the similarity of her material to the elphidia described from South America by d'Orbigny (1839) as well as from the Falkand Islands by Heron-Allen & Earland (1932). There is some similarity between specimens described by latter author (1932, Pl. 16, Figs 24 and 25) under the name of *E. alvarezianum* (d'Orbigny) and some specimens from Brachlewo and Elbląg, and between 16-chamber test of *E. lessoni* (d'Orbigny) figured by Heron-Allen Earland (1932, Pl. 16, Figs 29 and 30) and 16-chamber test from Elbląg (Pl. XXV, Fig. 8 in the present paper). There are also in the author's collection some forms transitional in morphology between those discussed above.

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg, Nadbrzeże, Tychnowy), Sweden, Denmark, Germany, Norway, Holland, Great Britain. Recent: Kiel Bay, North Sea, coasts of Great Britain, White Sea, Atlantic coasts of North America.

Elphidium sp. *1*
(Pl. XXVII, Fig. 1)

Material. — One well-preserved specimen.
Dimensions (in mm):

	F. XV/189
Diameter	0.44
Thickness	0.18

Remarks. — A single form of the genus Elphidium found in the Eemian deposits at Brachlewo, the specific identification of which appears difficult.

Elphidium sp. *2*
(Pl. XXIII, Figs 5, 6)

Material. — Three well-preserved specimens.
Dimensions (in mm):

	F. XV/190	F. XV/191
Maximal diameter	0.24	0.26

Remarks. — These small tests are somewhat similar to specimens figured by Knudsen (1971, Pl. 12, Figs 15 and 16) under the name of *E. magelanicum* Heron-Allen & Earland.

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg).

Genus *Protelphidium* Haynes, 1936
Protelphidium granosum (d'Orbigny, 1846)

(Pl. XI, Figs 4—8; Pl. XII, Figs 1—6; Pl. XXIV, Figs 6—8, 11, 12; Text-figs 25—27)

1846. *Nonionina granosa* d'Orbigny; A. d'Orbigny, Foraminifères fossiles..., p. 110, Pl. 5, Figs 19, 20.
1857. *Nonionina subgranosa* Egger; J. G. Egger, Die Foraminiferen..., p. 299, Pl. 14, Figs 16—18.
1939. *Nonion granosum* (d'Orbigny); J. A. Cushman, A monograph of the foraminiferal..., p. 11, Pl. 2, Figs 17, 18 (cum synon.).
1953. *Nonion granosum* (d'Orbigny); P. Marks, A revision of the smaller..., p. 48.
1953. *Nonion tuberculatum* (d'Orbigny); P. Marks, Ibidem, p. 50, Pl. 5, Fig. 15.
1957. *Nonion granosum* (d'Orbigny); Foraminiferi Padani, Pl. 21, Fig. 2.
1957. *Elphidium selseyensis* (Heron-Allen & Earland); J. A. van Voorthuysen, Foraminiferen aus dem Eemien..., p. 31, Pl. 23, Fig. 9.
1960. *Porosononion subgranosus* (Egger); N. N. Subbotina, L. S. Pischvanova & L. V. Ivanova, Stratigrafja oligocenovych..., p. 48, Pl. 3, Figs 5, 6 (cum synon.).
1962. *Nonion granosum* (d'Orbigny); M. B. Cita & M. A. Chierici, Crociera talassografica..., p. 347, Pl. 4, Fig. 2; Pl. 5, Fig. 12; Pl. 6, Fig. 14.
1963. *Elphidium dittmeri* Lafrenz; H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 33, Pl. 4, Figs 15—18.
1964. *Nonion granosum* (d'Orbigny); E. Th. A. Bik, An aberrant Nonionid..., p. 70, Pl. 5, Fig. 1, Text-figs 3a, b.
1966—67. *Nonion granosum* (d'Orbigny); M. B. Cita & I. Premoli Silva, Sui Foraminiferi incontrati..., Pl. 2, Figs 27—29.

1970. *Cribrononion excavatum* (Terquem); C. H. v. Daniels, Quantitative ökologische..., p. 87, Pl. 7, Fig. 11.

Material. — Approximately 800 well-preserved specimens.

Diameters (in mm):

	F. XV/197	F. XV/198	F. XV/200
Maximal diameter	0.36	0.43	0.45
Thickness	0.18	0.20	0.18

Description. — Slightly evolute test, circular to ovate in side view; peripheral margin rounded. Chambers well-differentiated, flat to convex-spherical, numbering 6 to 13, usually 8 per ultimate whorl (Text-fig. 25). Sutures distinct, ledge-like, flat in the initial stages of development, becoming sometimes very deeply cut and widened towards umbilicus in the latest developmental stage. Wall usually translucent, occasionally opaque, markedly coarsely-perforated. Umbilicus filled with opaque granular test material, often with knobs formed of translucent, imperforated test material (Text-fig. 26). Umbilical knobs, observable when chambers are broken-off, appear to be formed of material accumulated in the form of umbilical "pillars", increasing in height along with test growth (Text-fig. 26—*11b*). Apertural face of the ultimate chamber rounded, spherically-convex (Text-figs 26—*1b*, and *6b*; 27 — *1b*, *4*, *5b*). Aperture formed by a row of circular

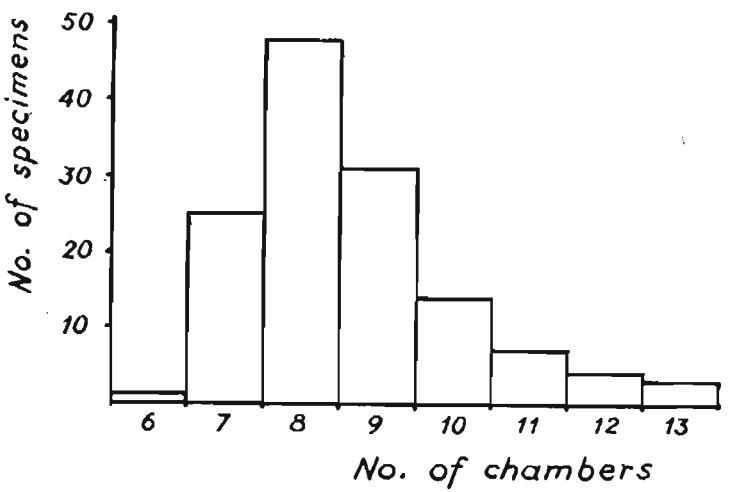


Fig. 25. Histogram of number of chambers per ultimate whorl of *Protelphidium granosum* (d'Orbigny) for 135 tests from Brachlewo.

openings continuing along base of apertural face and one or more rows of supplementary openings situated above the former one (Text-fig. 27 — *6b*). Sometimes the supplementary openings are randomly spaced over the apertural face (Text-fig. 27 — *3b*, and *5b*). Particular openings are surrounded by distinct, wide, flat lip (Pl. XII, Fig. 1). Translucent tests are yellow-brown coloured, the opaque tests — white — coloured.

Variability. — The variability of this species is very high. Three generations A1, A2 and B, are distinguished, hence it seems reasonable to analyse variability within each of these generations separately. Generations A1 and B do not differ from each other (specimens of B generation are very rare). In turn, tests of generation A2 markedly differ from the former ones; however, some morphological transitions between these generations make it possible to allocate tests of generation A2 to the species in question.

Variability involves a number of morphological features such as: number of chambers per ultimate whorl, shape and convexity of chambers and resulting outline of test in side view, which is rounded-ovate with even peripheral margin in the case of generation A1, and circular with lobulated peripheral margin in the case of generation A2 and particularly in terminal part of tests of the latter generation. Sutures, their outline, and particularly their depth and widening in subumbilical part, appear to be closely correlated with the above changes. In the microspheric generation, B, sutures are flat and ledge-like and chambers are also flat. In the megalosphaeric generation A1 both sutures and chambers are flat in the initial part of whorl, while in the terminal part of the tests sutures become slightly depressed and chambers — slightly concave. Forms of the megalospheric generation A2 are characterized by sutures slightly depressed in the initial part of ultimate whorl, becoming very deeply cut in the terminal part of the whorl, which results from change in shape of chambers from spherical to lobulated. Umbilical plane quite large, filled with granulated test material in the case of all these generations. In tests of generations A1 and B, besides the granulated material, knobs formed of translucent test material and varying in size may be noted. Umbilical plane in tests of megalospheric generation A2 is wider, more depressed, and filled with fine-grained test material; occasionally there is a free space at the center and initial chamber may be noted. Only in a few specimens of this generation innumerous knobs formed of translucent, imperforated test material were found (Pl. XXIV, Fig. 8). Sometimes, in a single test of generation A2 knobs may be found on one side of undepressed umbilical plane, whereas the opposite side of the umbilical plane is wider and markedly more depressed, and filled with fine-grained test material. Such specimens form transitions among different tests of generations A2, A1 (Text-fig. 27—1). Chambers of tests of generations A1 and B are narrower than those of generation A2. Tests of the megalospheric generation A2 have well-developed umbilical lips at chamber margins within the umbilical plane. These lips are formed of fine-grained, imperforated, opaque test material, and are usually well-marked, particularly on last chambers of the ultimate whorl (Text-fig. 27—*1*, and *5b*). Below these lips, outlets of spiral umbilical channel are situated (Text-fig. 27—*9b* and *9h*). The channel is open down to lateral, subumbilical part of chamber (Text-fig. 27—

10b). On the last chambers it may be noted that the lips protecting channel outlets are directed backward, towards older part of the test (Text-fig. 27—7). Occasionally even pair of outlet openings of spiral umbilical channels may be found (Text-fig. 27—*9h*). In the case of tests of generations A1, lips are seldom developed and when they are, only on the last chambers. Spiral umbilical channel was not found in initial parts of tests. In terminal chambers of the ultimate whorl in tests of these generations well-developed lips protecting the umbilical channel were found only in a few instances.

Although remarkable differences in morphology marked between forms belonging to generation A2 on one hand, and generation A1 and B on the other hand, these forms may be allocated to a single species, which assumption is supported by the existence of transitional forms.

Remarks. — This species, demonstrating marked variability, was described by d'Orbigny from the Vienna Basin. Also some other species described by this author (d'Orbigny, 1846) such as *Nonionina tuberculata* (d'Orbigny, *l.c.*, p. 108, Pl. 5, Figs 13 and 14) characterized by granular material covering umbilical plane, *Nonionina perforata* (*l.c.*, p. 110, Pl. 5, Figs 17 and 18) with depressed umbilical plane filled with grains and knobs, may in fact belong to the species in question. The last two chambers of Cushman topotype of *N. perforata* (Cushman, 1939, Pl. 3, Fig. 3) exhibit distinct umbilical lips.

Nonionina subgranosa Egger (Egger, 1857, p. 209, Pl. 14, Figs 16—18) should be assigned to *Protelphidium granosum*. A number of authors have described this species as *Nonion subgranosus* Egger (e.g. Bogdanowich, 1947; Voloschinova, 1952; Venglinsky, 1958; and others) or as *Porosononion subgranosus* (Egger) (Subbotina, Pischvanova & Ivanova, 1960).

Tests with wide umbilical plane filled with fine-grained test material, allocated here to the megalospheric generation A2 of *Protelphidium granosum* (d'Orbigny) presumably also correspond to the diagnosis of the following species: *Nonion demens* Bik (Bik, 1964, Pl. 5, Figs 3—8, Text-fig. 3c, d), *Nonion stelligerum* Sidebottom (Dolgopolskaja & Pauli, 1931, Pl. 3, Fig. 12), *Nonion martkobi* Bogdanowich (Bogdanowich, 1947, Pl. 4, Fig. 4) and *Cribrononion martkobi* (Bogdanowich) (*in*: F. D. Morduchaj-Boltovskoj (ed.), 1968, Pl. 7, Fig. 1).

Comparisons with Lafrenz's collection show that *Elphidium dittmeri* Lafrenz (Lafrenz, 1963, p. 33, Pl. 4, Figs 15—18) appears identical to *Protelphidium granosum* (d'Orbigny). Specimens from the Miocene of Poland (Łuczkowska, 1958) and Austria (Marks, 1953) as well as from the Adriatic (Cita & Premoli Silva, 1966—1967; Cita & Chierici, 1962) assigned to *Nonion granosum*, appear to be identical to Polish specimens from the Quaternary of Brachlewo.

Cribroelphidium excavatum (Terquem) from the Adriatic, well figur-

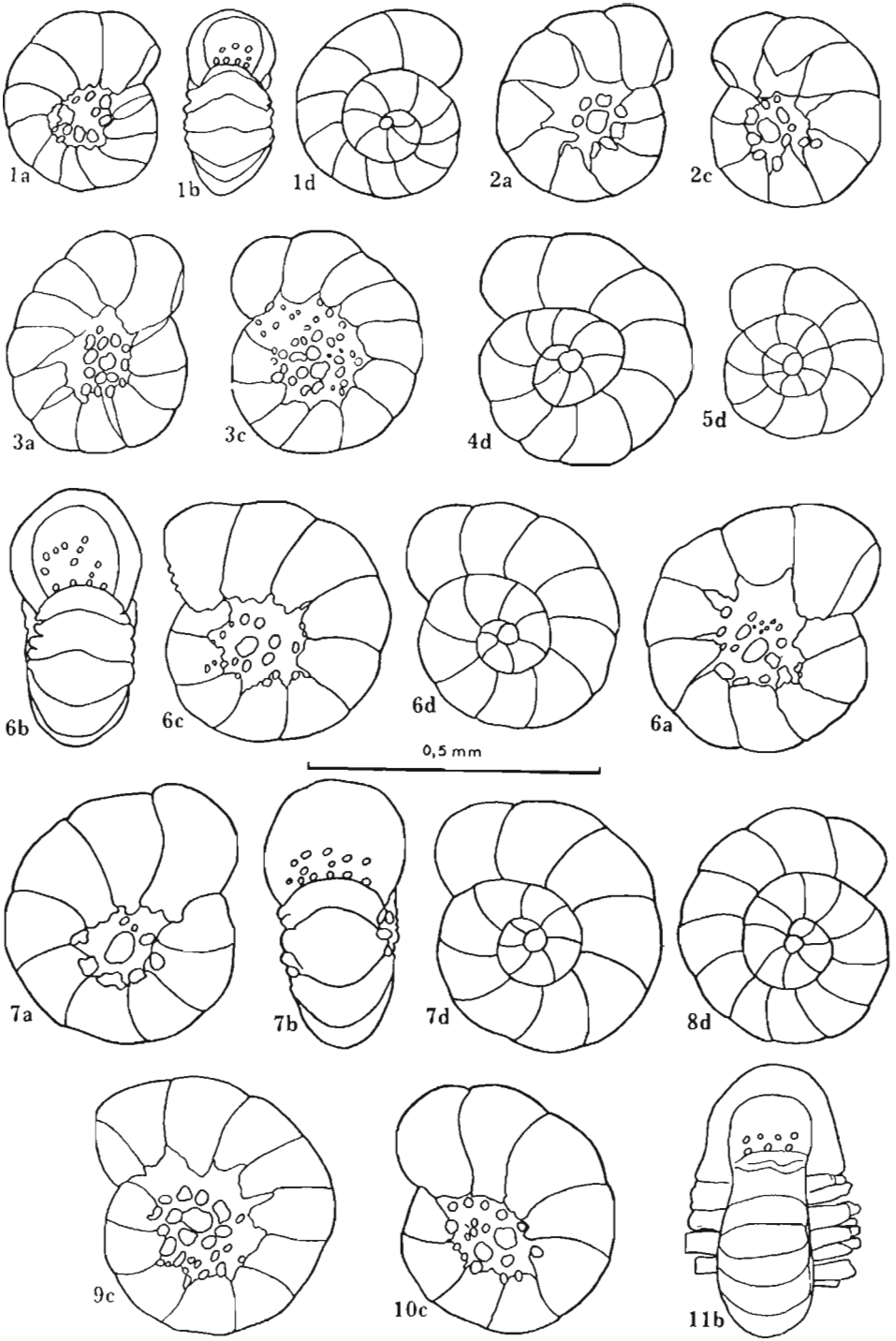


Fig. 26. *Protelphidium granosum* (d'Orbigny); outlines of tests from Brachlewo: *a* and *c* side views, *b* apertural views, *d* cross-section of test.

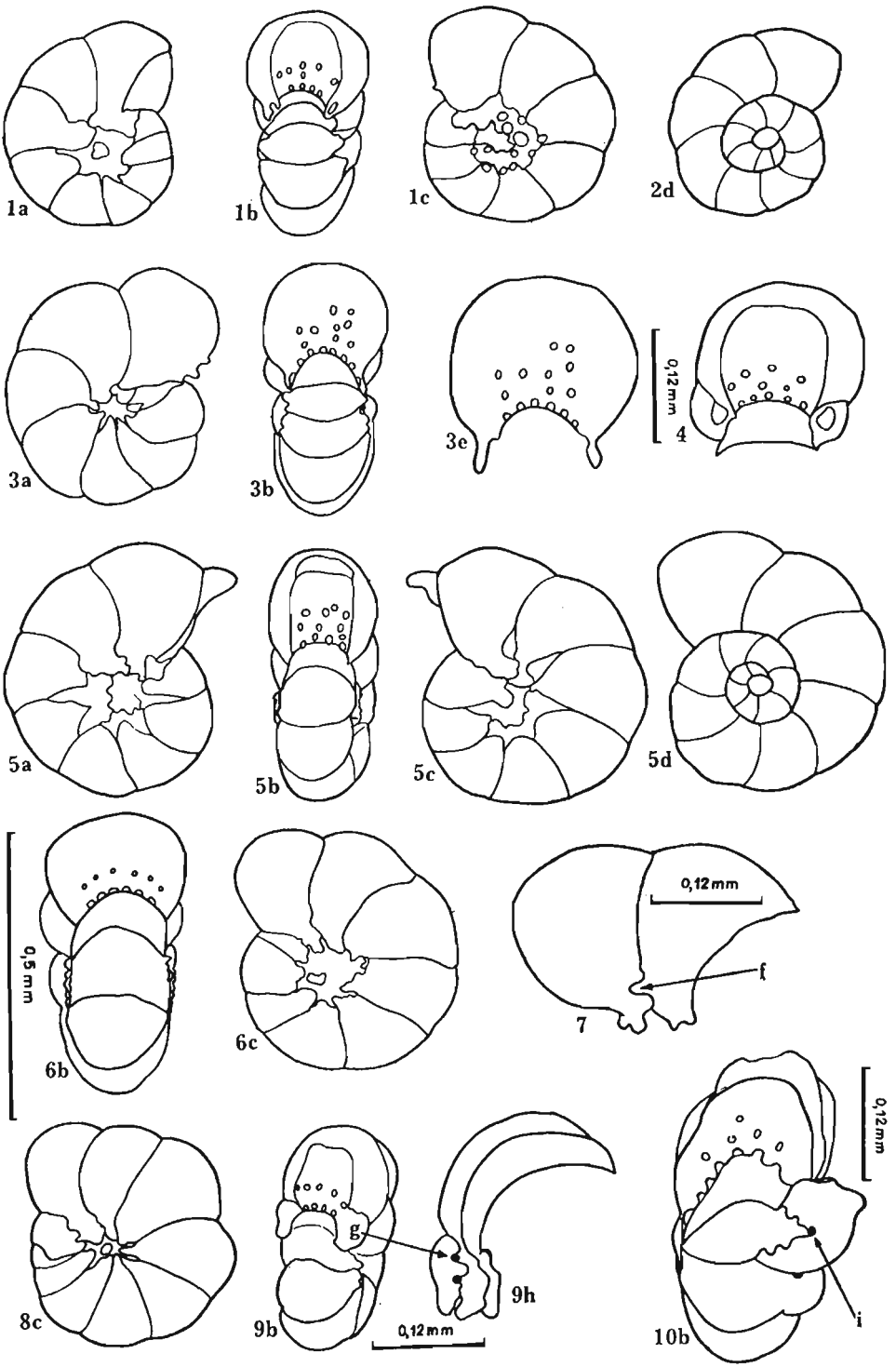


Fig. 27. *Protelphidium granosum* (d'Orbigny); outlines of tests from Brachlewo: *a* and *c* side views, *b* apertural views, *d* cross-section of test, *e* apertural face of penultimate chamber with projected downward lips and depression of umbilical channel situated beneath these lips, *g* lip of penultimate chamber, *h* sinus-like lip with outlet of umbilical channel, *i* outlet of umbilical channel out of chamber, located beneath lip, *f* sinuslike lip above outlet of umbilical channel.

ed by Danielsen (1970, p. 87, Pl. 7, Fig. 11), corresponds well to *Protelphidium granosum* (d'Orbigny) described from the Venezian lagoon by Cita and Premoli Silva (1966—1967).

Cushman described *Elphidium lidoense* (Cushman, 1936, Pl. 15, Fig. 6) on the basis of material from sands of the Lido coast at Venezia which also belongs to *P. granosum* (d'Orbigny); forms identical to Cushman's may be found among the Brachlewo population; these include thin-walled, coarsely-perforated tests with ledge-like sutures widening towards umbilicus, which belong to generation A1. Some of these forms are characterized by coarse pores which, when visible through translucent ledge-like sutures, refract light in such a way that they look like short retral processes. Forms described as *Elphidium lidoense* Cushman by Pożaryski (1951) from the Eemian series pierced by borehole at Tychnowy also belong to the species in question, as they appear to be identical to Cushman's.

Occurrence. — Tertiary: Poland, Rumania, Bulgaria, USSR, Jugoslavia, Hungary. Quaternary: Poland (Brachlewo, Elbląg, Nadbrzeże), Germany, Holland, Italy. Recent: Black Sea, Adriatic, Mediterranean Sea.

Protelphidium niveum (Lafrenz, 1963)
(Pl. XIII, Figs 1—8; Pl. XIV, Fig. 6; Text-figs 28, 29)

1963. *Nonion? niveum* Lafrenz; H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 24, Pl. 2, Figs 1—4.

1971. *Protelphidium niveum* (Lafrenz); K. L. Knudsen, systematic part in: R. W. Feyling-Hanssen et al., p. 288, Pl. 14, Figs 6, 7.

Material. — Approximately 130 well-preserved specimens.

Dimensions (in mm):

	F. XV/207	F. XV/208
Maximal diameter	0.23	0.17
Thickness	0.01	0.07

Description. — Peripheral margin rounded, even; ultimate chambers sometimes somewhat lobulated. Sutures almost rectilinear, smooth, somewhat depressed, becoming slightly deeper in subumbilical part. Umbilicus depressed and filled with grains; grains spread also over apertural face of the ultimate chamber. Aperture situated at the base of apertural face of the ultimate chamber and consisting of two circular openings. Ultimate whorl consisting of 8 to 11, usually 9 chambers (Text-fig. 28). Pores irregularly distributed, single or spaced in two or three (Pl. XIII, Fig. 4). Test formed of a few layers, (Pl. XIII, Fig. 6, and Pl. IV, Fig. 6). Structure of grains occurring in umbilicus differs from that in e.g. *E. bartletti* and shows layered structure. Every test layer also covers granulation, which results both in thickening of test walls and increase in grain height (Pl. XIII, Figs 7 and 8).

Variability. — Variability relatively small, primarily expressed in dif-

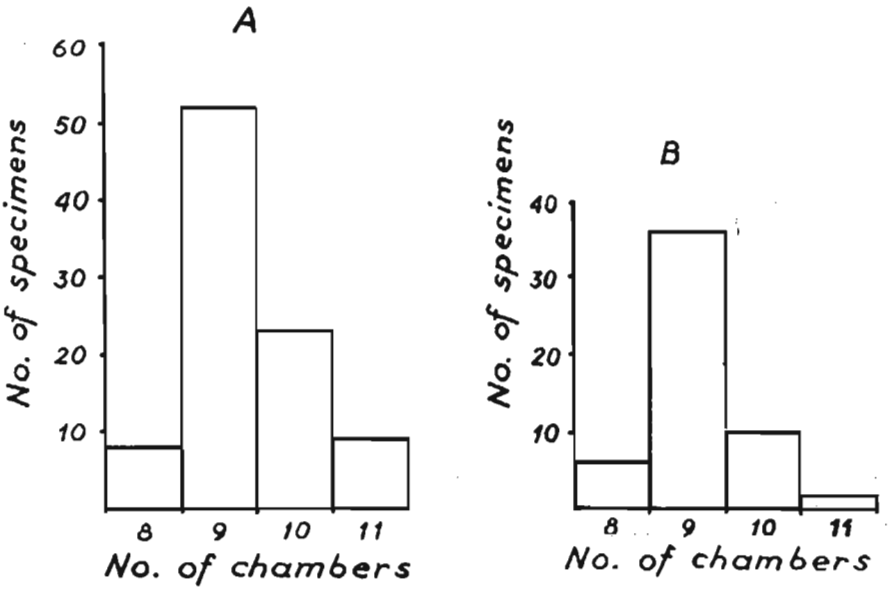


Fig. 28. Histogram of number of chambers per ultimate whorl of *Protelphidium niveum* Lafrenz from Nadbrzeże: *A* for 92 tests from sample No. 1 taken from profile, *B* for 52 tests from clays with *Arctica islandica*.

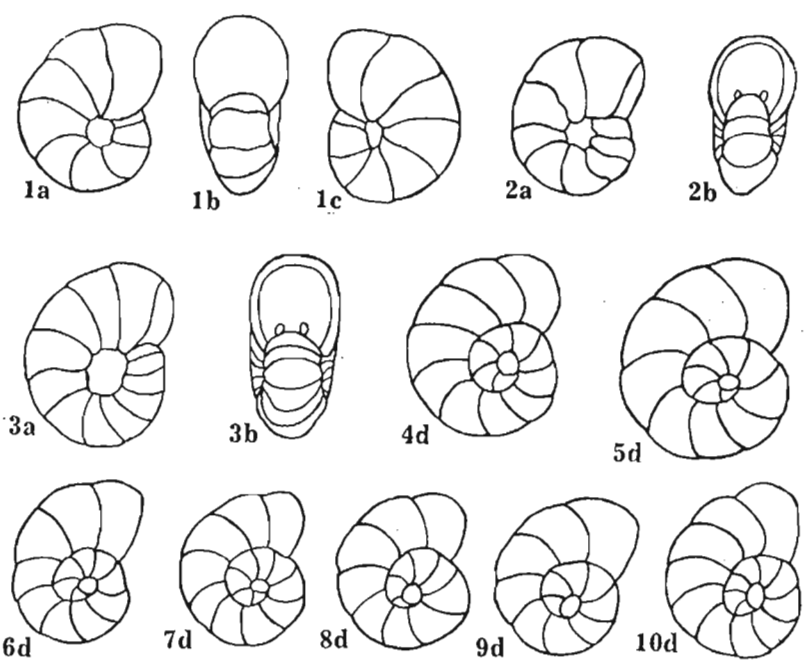


Fig. 29. *Protelphidium niveum* Lafrenz from Nadbrzeże: *a* and *c* side views, *b* apertural views, *d* horizontal section of megalospheric specimens.

ferences in test size and thickness, and in number of chambers per the ultimate whorl and diameter of umbilical plane covered with granulated material. Lateral outline of tests even, or, occasionally, with slightly lobulated peripheral margin of ultimate chambers.

Remarks. — Specimens from Nadbrzeże, belonging to the megalosphaeric generation (Text-fig. 29), are identical with typical tests described by Lafrenz (1963). They are also similar to those figured by Knudsen (1971, Pl. 14, Figs 6 and 7), differing in somewhat less convex ultimate chambers.

Occurrence. — Quaternary: Poland (Nadbrzeże), Denmark, Germany.

Protelphidium orbiculare (Brady, 1881)

(Pl. XV, Figs 3—6; Pl. XXIII, Fig. 3; Pl. XXX, Figs 1—13; Text-figs 30—33)

1881. *Nonionina orbiculare* Brady; H. B. Brady, On some Arctic..., p. 415, Pl. 21, Fig. 5.
1894. *Nonionina depressula* var. *orbicularis* Brady; V. Madsen, Istidens Foraminiferer..., p. 217, Pl. Fig. 7.
1932. *Nonion orbiculare* (Brady); W. A. MacFadyen, Foraminifera from some Late..., Pl. 34, Fig. 14.
1939. *Nonionina orbiculare* (Brady); J. A. Cushman, A monograph of the foraminiferal..., p. 23, Pl. 6, Figs 17—19.
1948. *Nonion orbiculare* (Brady); J. A. Cushman, Arctic Foraminifera, p. 53, Pl. 6, Fig. 3.
1950. *Nonion orbiculare* (Brady); J. H. van Voorthuysen, The quantitative distribution..., p. 41, Pl. 3, Fig. 5.
1953. *Elphidium orbiculare* (Brady); A. R. Loeblich & H. Tappan, Studies of arctic..., p. 102, Pl. 19, Figs 1—4.
1958. *Nonion orbiculare* (Brady); Z. G. Stschedrina, Fauna foraminifer..., p. 16.
1961. *Protelphidium orbiculare* (Brady); R. Todd & D. Low, Foraminifera of Martha's..., p. 20, Pl. 2, Fig. 11.
1961. *Elphidium orbiculare* Brady; Ch. M. Saidova, Ekologija foraminifer..., p. 79, Pl. 24, Fig. 165.
1962. *Nonion orbiculare* (Brady); H. Woszidlo, Foraminiferen und Ostracoden..., p. 72, Pl. 2, Fig. 15.
1963. *Elphidium orbiculare* (Brady); H. R. Lafrenz, Foraminiferen aus dem marinen..., p. 30, Pl. 4, Figs 3—7.
1964. *Protelphidium orbiculare* (Brady); R. W. Feyling-Hanssen, Foraminifera in Late..., p. 349, Pl. 21, Fig. 3.
1965. *Elphidium orbiculare* (Brady); J. Nagy, Foraminifera in some..., p. 124, Pl. 2, Fig. 15.
1965. *Protelphidium orbiculare* (Brady); M. A. Buzas, Foraminifera from Late..., p. 23, Pl. 3, Fig. 5; Pl. 4. Fig. 1.
1966. *Protelphidium orbiculare* (Brady); W. I. Gudina, Foraminifery i stratigrafja..., p. 56, Pl. 4, Figs 1—3.
1967. *Elphidium orbiculare* (Brady); O. Michelsen, Foraminifera of the Late..., p. 242, Pl. 6, Fig. 3.
1968. *Protelphidium orbiculare* (Brady); F. J. E. Wagner, Illustrated check-list..., p. 1411, Pl. 1, Fig. 10.
1969. *Protelphidium orbiculare* (Brady); G. Vilks, Recent foraminifera..., p. 50, Pl. 3, Fig. 14.

1970. *Protelphidium orbiculare* (Brady); F. J. E. Wagner, Faunas of the Pleistocene..., p. 26, Pl. 2, Figs 10, 11.

1971b. *Protelphidium orbiculare* (Brady); K. L. Knudsen, systematic part *in*: R. W. Feyling-Hanssen et al., p. 289, Pl. 14, Figs 8—11; Pl. 24, Figs 6—8.

Material. — Over 2000 well preserved specimens; ultimate chamber sometimes damaged.

Dimensions (in mm):

	F. XV/213	F. XV/219	F. XV/224
Maximal diameter	0.40	0.46	0.56
Thickness	0.24	0.27	0.25

Variability. — Individual variability of this species is high both in the case of particular samples from Elbląg and Nadbrzeże profiles and among populations from particular localities. Number of chambers per ultimate whorl varies from 7 to 12 (Text-fig. 30). However, 8-chamber individuals predominate at Brachlewo, Elbląg or Bogdaniec (Text-fig. 30A, B and D), whereas among Nadbrzeże specimens, 9-chamber individuals are the most numerous (Text-fig. 30C). Nine-chamber specimens prevail at Nadbrzeże in all samples, except for two, where 8-chamber specimens appear in great numbers (Text-fig. 31, No. of samples 14 and 15).

Also size of test, diameter of umbilical plane, shape of chambers appear variable. In turn, sutures are more or less depressed and their width vary, particulary close to the umbilicus (Text-fig. 32). Depressions of sutures and umbilicus are filled with granulated test material, which occasionally undergoes destruction. This is the case of specimens from a few samples from Elbląg and almost all samples from Nadbrzeże (Pl. XXX, Figs 3, 5—7, 10, 12), in which granular material from sutural depressions and, partly, from umbilical area was destroyed. In turn, thin-walled Brachlewo tests are never destroyed in this way (Pl. XXX, Figs 1, 2, 4, 8, 9, 13). Tests from Bogdaniec are damaged in other way — here, mainly granulated material is mainly removed from the umbilicus, and only small part of the material is removed from sutural depressions.

Thickness of tests vary to a marked extent and it is the feature most differentiating particular populations. Specimens from Brachlewo are commonly compressed; the degree of compression or convexity of tests differs from one specimen to another. The thickest forms, most similar to typical specimens of Brady (1881, Pl. 2, Fig. 5) were found at Nadbrzeże as well as at Elbląg. Moreover, both at Elbląg and Nadbrzeże, specimens generally corresponding to the diagnosis of this species in morphology, but attaining much larger, giant size (up to 0.62 mm in diameter) were found, but in subordinate amounts.

It seems that the high variability in test shape results from various environmental factors such as temperature, depth, salinity, and is also related to occurrence of micro- and megalospheric populations (Text-fig. 33).

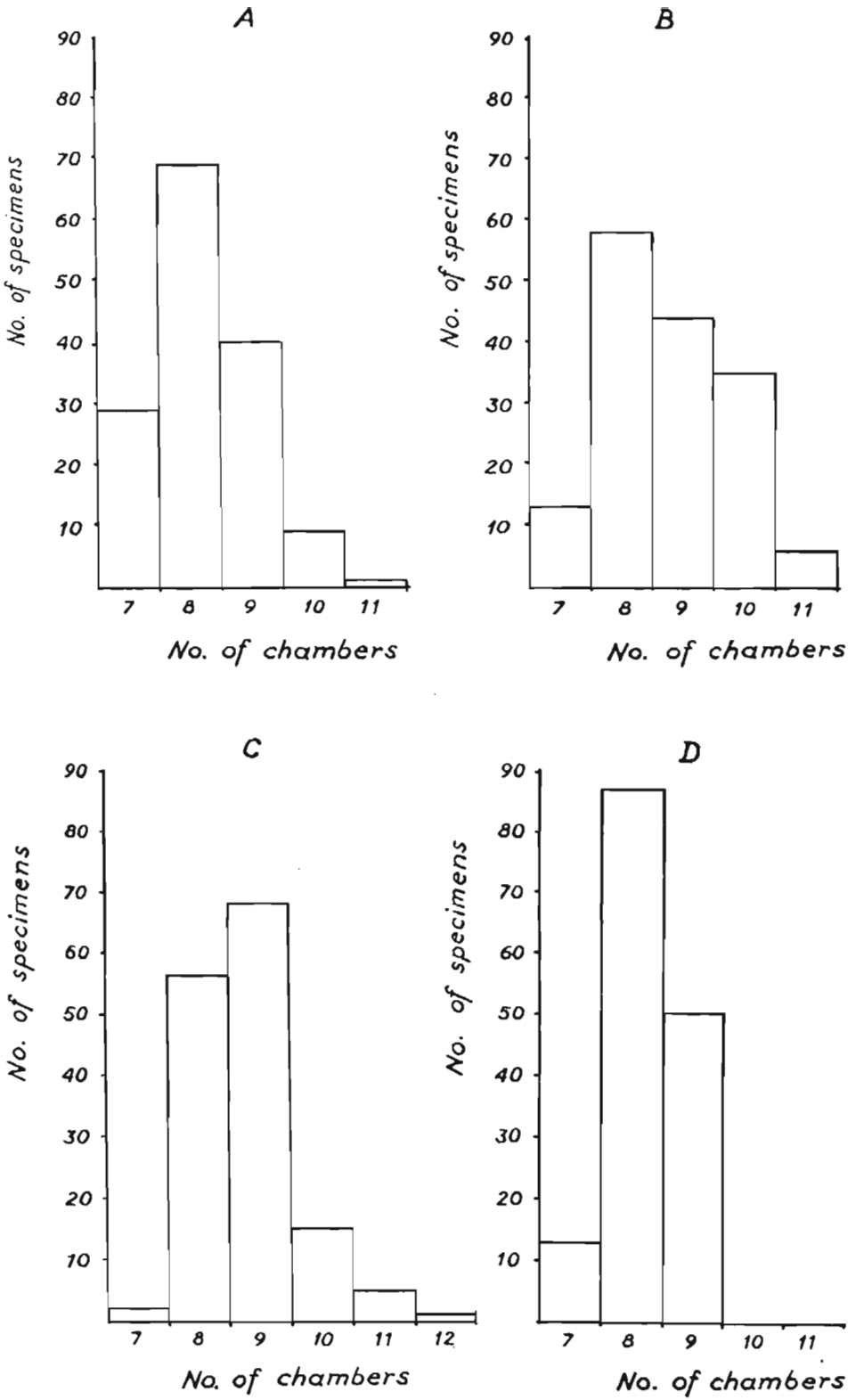


Fig. 30. Histograms of number of chambers per ultimate whorl of *Protelphidium orbiculare* (Brady): *A* for 148 specimens from Brachlewo, *B* for 152 specimens from Elbląg, *C* for 146 specimens from Nadbrzeże, *D* for 150 specimens from Bogdaniec.

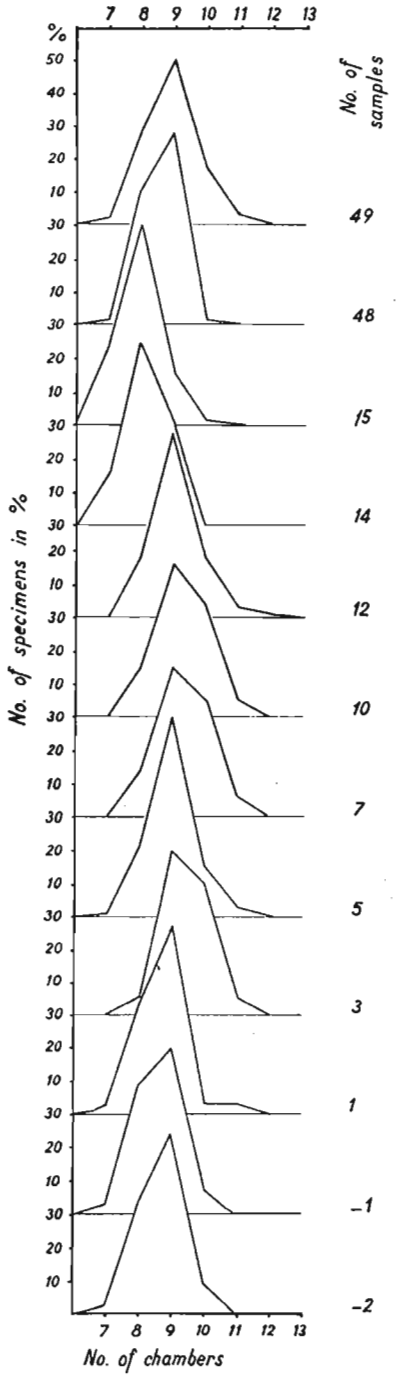


Fig. 31. Histogram of number of chambers per ultimate whorl of *Protelphidium orbiculare* (Brady) from particular samples taken from the profile at Nadbrzeże.

The present author distinguished, besides typical forms of *P. orbiculare*, morphotypes occurring in the material studied:

Morphotype 1 — typical tests, meeting the description of the holotype, which has spherical test with convex sides, broadly rounded peripheral

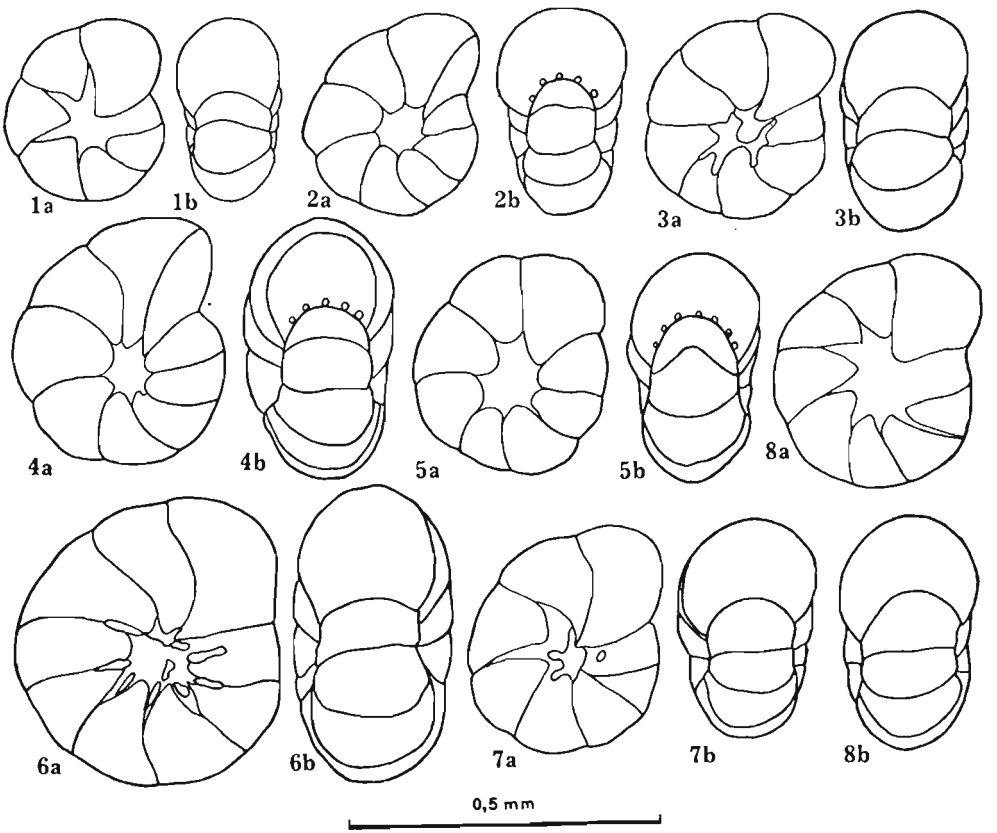


Fig. 32. *Protelphidium orbiculare* (Brady); outlines of tests from Brachlewo: *a* side views, *b* apertural views.

margin; number of chambers per ultimate whorl varies from 7 to 12, commonly equalling 9.

Morphotype 2 — with compressed test sides and somewhat depressed umbilicus, thin and translucent walls and number of chambers per ultimate whorl varying from 7 to 11, commonly equalling 8. These forms are mainly found at Brachlewo.

Morphotype 3 — with compressed test sides, sutures twisted backward and chambers correspondingly incurved and extended backward; number of chambers per ultimate whorl varies from 7 to 9, commonly equalling 8. This form predominates at Bogdaniec and Nadbrzeże (profile, samples No. 14 and 15).

Morphotype 4 — with large, opaque tests; umbilical area regularly circular. This morphotype was recorded at Elbląg, Nadbrzeże and Suchacz.

Remarks. — Tests of *P. orbiculare* from the author's collection exhibit high variability. Descriptions and figures given by other authors show that the variability of this species recorded elsewhere corresponds to the

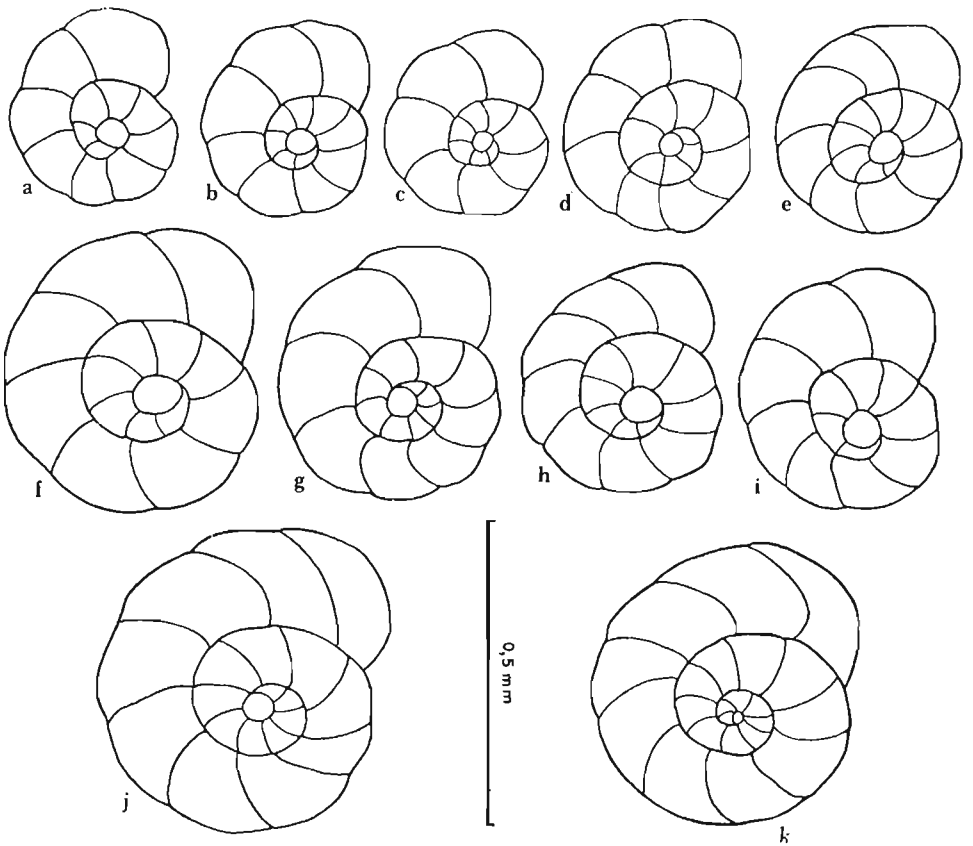


Fig. 33. *Protelphidium orbiculare* (Brady); cross-sections of tests from Brachlewo: *a*—*j* megalospheric generation tests, *k* microspheric generation test.

variability found in Polish populations. Typical spherical specimens corresponding to the holotype were cited from the Quaternary of Denmark (Madsen, 1894, Fig. 7), England (MacFadyen, 1932, Pl. 34, Fig. 14), Arctic seas of America (Leoblich & Tappan, 1953, Pl. 19, Fig. 4), Denmark (Knudsen, 1971, Pl. 13, Figs 8—11), and Sea of Ohotsk (Saidova, 1961, Pl. 24, Fig. 165). Specimens with less convex, almost flat and parallel sides were figured from the Quaternary deposits of England (MacFadyen, 1932, Pl. 3, Fig. 14), Schleswig-Holstein (Woszidlo, 1963, Pl. 2, Figs 15 and 16), USA, Maine (Buzas, 1965, Pl. 3, Fig. 5; Pl. 4, Fig. 1), New York Bight area (Ronai, 1955, Pl. 21, Fig. 1), Spitsbergen (Nagy, 1965, Pl. 2, Fig. 15) and Arctic seas of America (Cushman, 1948, Pl. 6, Fig. 3; Loeblich & Tap-

pan, 1953, Pl. 19, Fig. 1). Tests with the flattened sides, with depressed umbilical area, being the most slender in apertural view, were figured by Grossman & Benson (1967, Pl. 7, Figs 7 and 8) from North Carolina, corresponding to the population from the warm Eemian deposits of Brachlewo. Vilks figured specimen from the Recent Arctic waters of Canada (Vilks, 1969, Pl. 3, Fig. 14) which corresponds to the morphotype 3 of the present author, characterized by chambers and sutures twisted backwards, found at Bogdaniec and Nadbrzeże.

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg, Nadbrzeże, Suchacz, Bogdaniec, Tychnowy), Sweden. Recent: Spitsbergen, Arctic seas of USSR and USA, USA (New York, North Carolina).

Protelphidium rozkowskae n. sp.
(Pl. XIV, Figs 1—5; Pl. XXVIII, Figs 1—4; Text-figs 34—36)

Holotype: Specimen No. F. XV/229; Pl. XXVIII, Fig. 3.
Paratype: Specimen No. F. XV/227; Pl. XXVIII, Fig. 1.
Type horizon: Quaternary beds, Eemian Interglacial.
Type locality: Brachlewo, northern Poland.
Derivation of the name: Named in honour of Professor M. Różkowska, an eminent Polish palaeontologist.

Diagnosis. — Test circular-ovate in side view, with slightly lobulated peripheral margin. Suture slightly bent backwards, gradually widening towards umbilicus. Number of chambers per ultimate whorl varies from 5 to 9, commonly equalling 7 (Text-fig. 34). Peripheral margin broadly rounded. Wall translucent. Umbilical area and sutures opaque, filled with granular test material. Aperture formed by circular openings arranged in a row along the base of apertural face.

Material. — Approximately 170 specimens.

Dimensions (in mm):

	F. XV/232	F. XV/233	F. XV/231
Maximal diameter	0.33	0.40	0.47
Thickness	0.22	0.24	0.27

Description. — Test ovate, calcareous, planospiral, evolute, circular-ovate in side-view; peripheral margin slightly lobulated. Chambers somewhat convex, triangular, quickly increasing in size along with growth; ultimate chamber usually the most swollen. Periphery of test broadly rounded. Umbilical area large, flush, with the test surface somewhat depressed, filled with quite homogeneous granular test material. Sutures slightly bent backwards, wide in subumbilical part, becoming progressively narrow towards peripheral margin. Sutures, along with test growth, increase in width and become delineated by band of granular material narrowing towards test periphery.

Irregular outlet openings of septal channel are occasionally found on sutures (Pl. XIV, Fig. 3). Granular test material fills sutures and partially

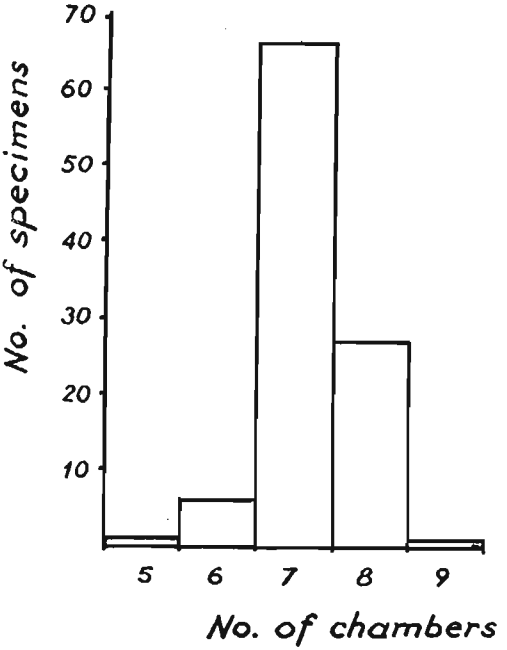


Fig. 34. Histogram of number of chambers per ultimate whorl for *Protelphidium rozkowskae* n. sp. for 100 specimens from Brachlewo.

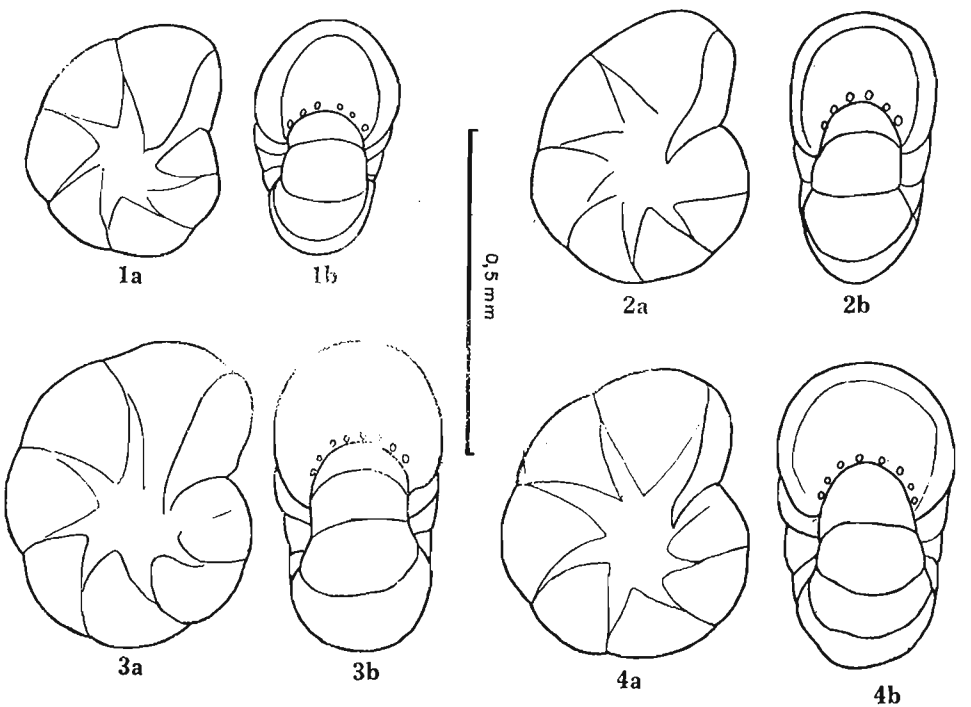


Fig. 35. *Protelphidium rozkowskae* n. sp.; outlines of tests from Brachlewo: *a* side views, *b* apertural views.

covers subsutural and subumbilical parts of chambers. Granular material also covers lower part of apertural face of ultimate chamber and first chamber of ultimate whorl. Pores fine, randomly scattered, often in pairs one close to another. Test wall colourless, almost translucent, except for white and opaque granular areas. Aperture, sometimes obscured by granular material, formed by circular openings arranged in a row along the base of apertural face.

Variability. — Variability in this species is quite small (cf. Text-fig. 35). Number of chambers per ultimate whorl usually varies from 6 to 8; however, 7-chamber individuals remarkably predominate. Individuals with extremal numbers of chambers, i.e. 5 or 9 chambers, are occasionally found. The size of test and thickness of its walls is subjected to slight changes, similarly as area of umbilicus and width of sutures filled with granular material. Tests of micro- and megalospheric generations do not differ from one another in morphology, as they form homogeneous population (cf. Text-figs 35 and 36).

Remarks. — *Protelphidium rozkowskae* n. sp. is characterized by quite uniform features and the typical specimens of this species are easy to

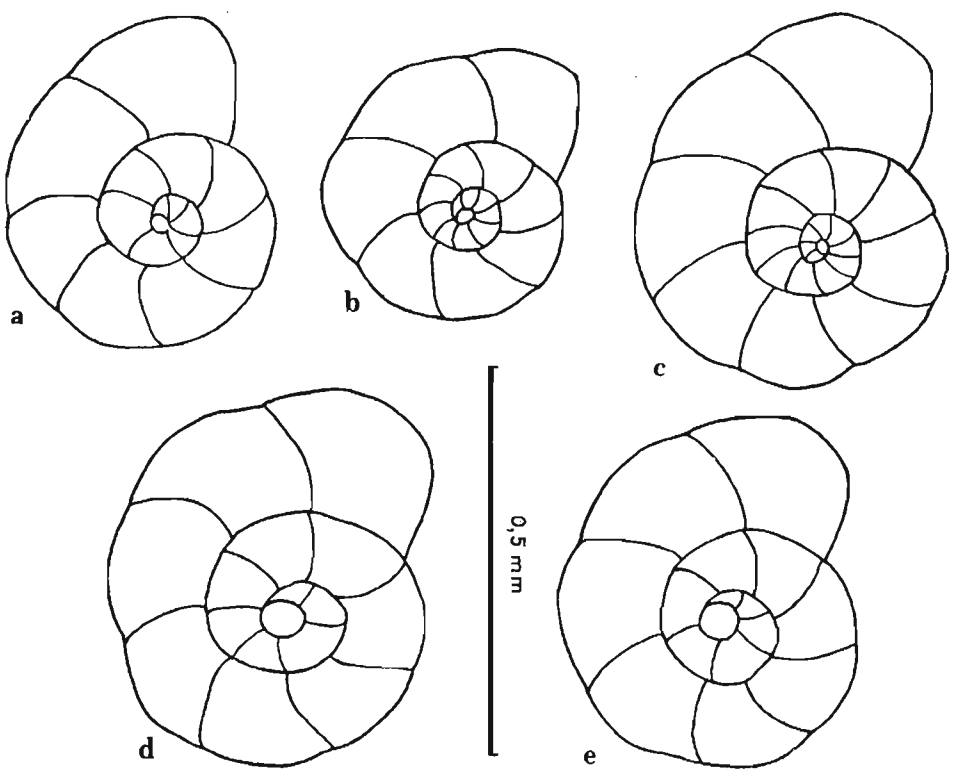


Fig. 36. *Protelphidium rozkowskae* n. sp.; cross-sections of tests of micro- and megalospheric generations from Brachlewo.

distinguish from the representatives of a closely affined species, *P. orbiculare* (Brady), from which they differ in smaller number of chambers, more swollen, spherical test and sutures wider close to the umbilicus, and star-like, opaque body formed by the umbilicus and sutures. Moreover, sutures of *P. rozkowskae* n. sp. are less depressed and less incurved backward, and outline of its test is more uniform than those of *P. orbiculare* (Brady).

P. rozkowskae n. sp. is also somewhat similar to *Nonion pauciloculum* Cushman, differing in form of aperture. Aperture of the latter species is slit-like, whereas aperture of *P. rozkowskae* is formed by a row of circular openings. Moreover, test of *P. rozkowskae* is more spherical than that of *N. pauciloculum*, which is flat.

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg).

Protelphidium umbilicatulum Walker & Jacob, 1798
(Pl. XVI, Figs 1—6; Pl. XXXI, Figs 1—9; Text-figs 37—41)

1798. *Nautilus umbilicatulus* Walker & Jacob; G. Walker & E. Jacob, *in*: F. Kanmacher, Adam's essays..., p. 64, Pl. 14, Fig. 34.
1858. *Nonionina crassula* (Walker); W. C. Williamson, On the Recent Foraminifera..., p. 33, Figs 70, 71.
1916. *Nonionina depressula* (Walker & Jacob); E. Heron-Allen & A. Earland, The Foraminifera..., p. 279, Pl. 43, Figs 4—7.
1939. *Nonion? umbilicatulum* (Walker & Jacob); J. A. Cushman, A monograph of the foraminiferal..., p. 21, Pl. 5, Fig. 27.
1940. *Nonion depressulus* (Walker & Jacob); W. A. MacFadyen, Foraminifera in Boulder..., Text-fig. 2.
1946. *Nonion gemanicum* (Ehrenberg); I. Hessland, Marine Schalenablagerungen..., Pl. 3, Fig. 39.
1957. *Nonion depressulus* (Walker & Jacob); J. H. van Voorthuysen, Foraminiferen aus dem Eemien..., p. 28, Pl. 23, Fig. 2.
1962. *Nonion* aff. *pauciloculus* Cushman; M. B. Cita & M. A. Chierici, Crociera talassografica..., p. 347, Pl. 1; Pl. 6, Fig. 15.
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1965b. *Protelphidium anglicum* Murray; J. W. Murray, Two species..., p. 149, Pl. 25, Figs 1—5; Pl. 26, Figs 1—6.
1966—67. *Nonion* aff. *pauciloculum* Cushman; M. B. Cita & I. Premoli Silva, Sui foraminiferi..., Pl. 2, Figs 16—18.
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1970. *Protelphidium anglicum* Murray; J. W. Murray & C. A. Wright, Surface texture of..., Pl. 37, Figs 1—5.
1971. *Protelphidium anglicum* Murray; K. L. Knudsen, systematic part in: R. W. Feyling-Hanssen et al., p. 286, Pl. 14, Figs 2—5; Pl. 24, Figs 2—5.

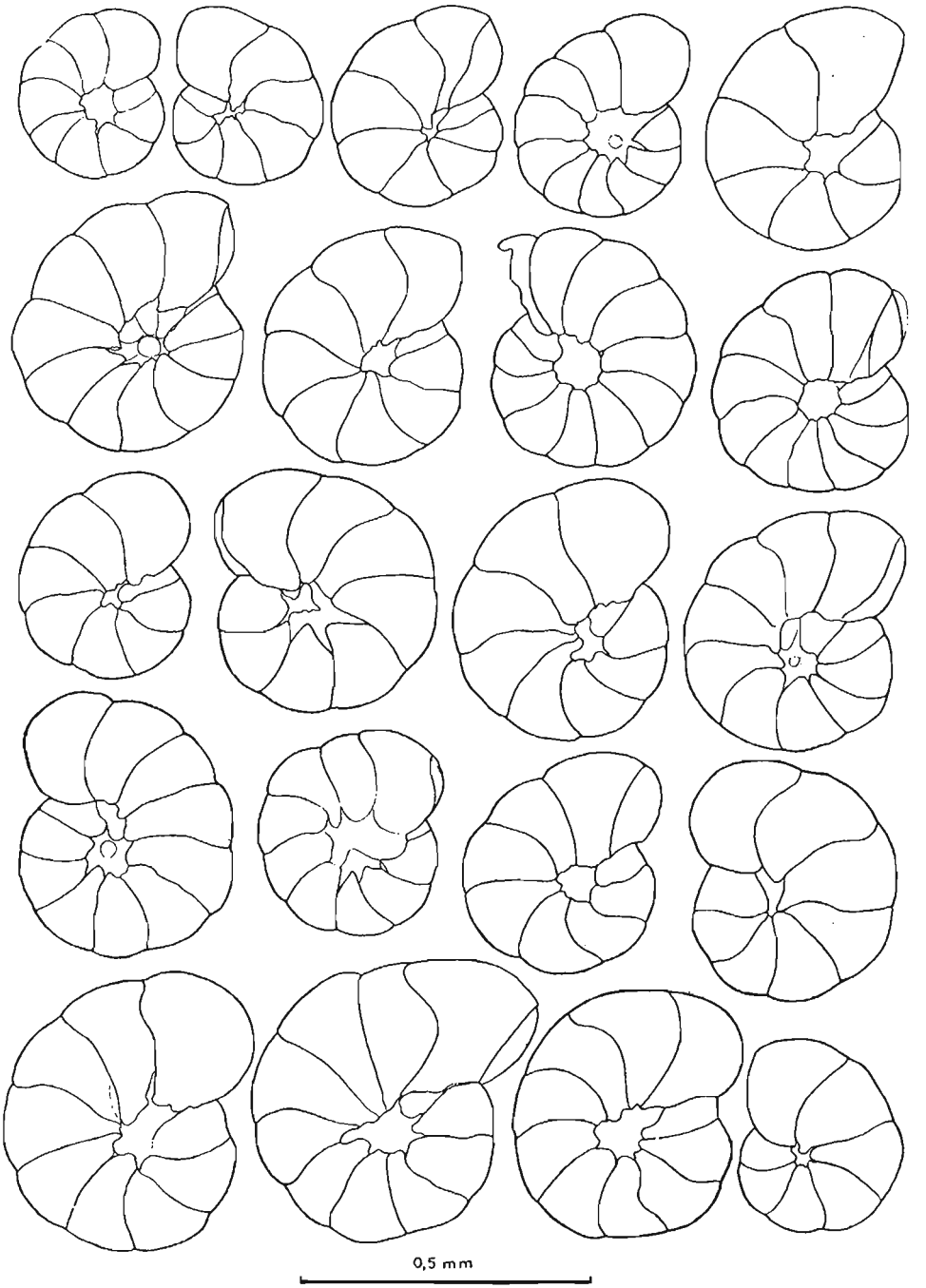

Fig. 37. *Protelphidium umbilicatulum* (Walker & Jacob); outlines of tests from Brachlewo.

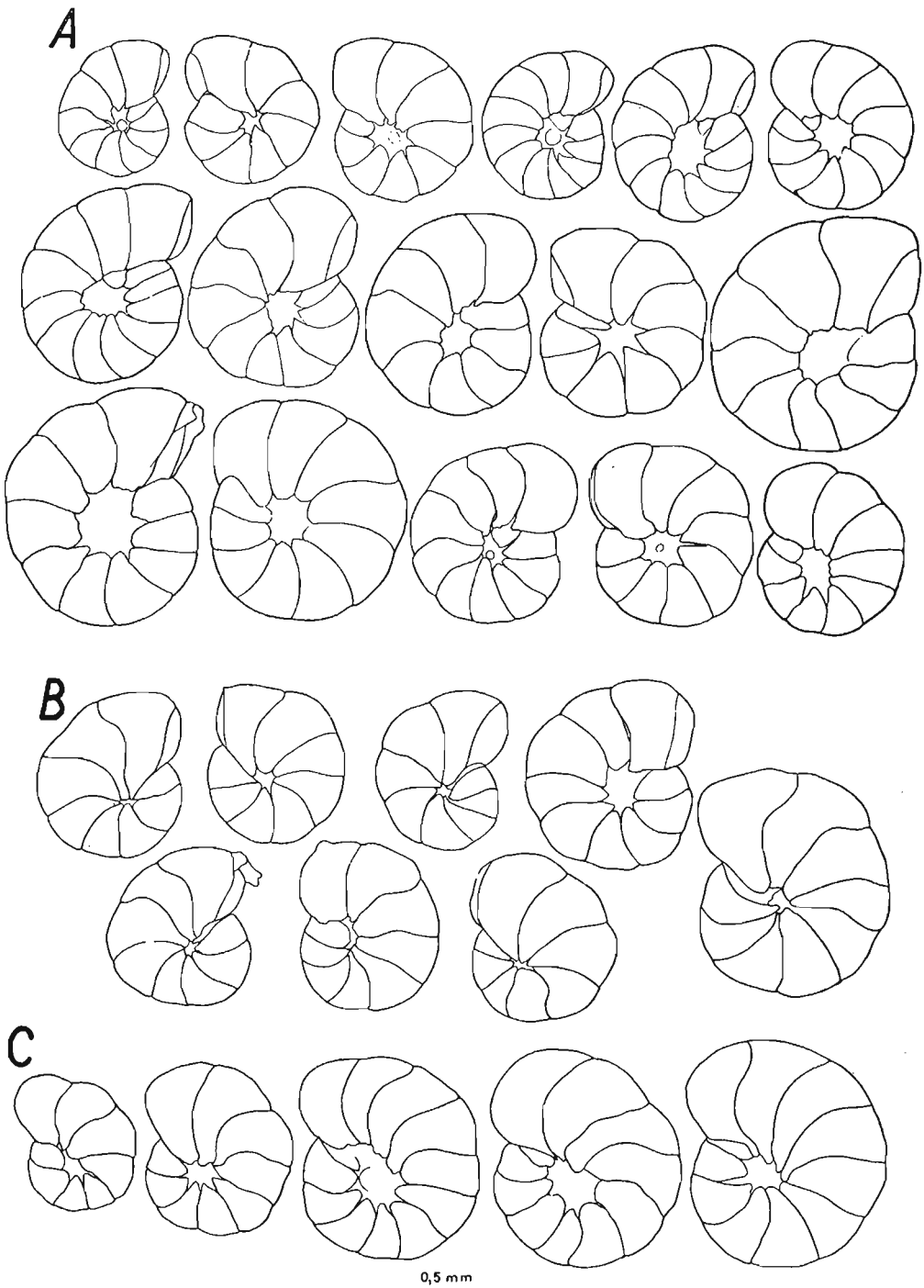

Fig. 38. *Protelphidium umbilicatulum* (Walker & Jacob); outlines of tests from: *A* Eemian Interglacial of Holland, borehole Amersfoort I; *B* Selses Bill, Sussex, England, leg. Heron-Allen & Earland, Recent; *C* Langeoog Watt, leg. Haake, Recent.

Material. — Approximately 2.500 well-preserved specimens.

Dimensions (in mm):

	F. XV/235	F. XV/242	F. XV/243
Maximal diameter	0.43	0.49	0.58
Thickness	0.22	0.22	0.26

Variability. — The present author had an opportunity to study the variability of Quaternary and Recent representatives of this species from Germany, Denmark, Holland, France, Great Britain and Italy. The results of these studies on individual variability are illustrated in Text-figs 37 and 38.

Test outline and size are highly variable. The test size is primarily related to test growth (only megalospheric forms were found in the populations studied — see Text-fig. 39). Test outline in side view is commonly circular to circular-ovate; peripheral margin wavy, becoming usually lobulated close to aperture; occasionally margin and ultimate whorl is complete. Sutures depressed, particularly close to the aperture; occasionally, sutures are ledge-like, glittering, at the beginning of ultimate whorl. Number of chambers per ultimate whorl varies from 7 to 12, usually equalling 9 (Text-fig. 40). Chambers quickly increase in size along with growth. Degree of evolutness varies from one specimen to another. Umbilical area moderate in size, depressed, commonly filled with granular test material.

Amount of granular test material is variable; sometimes the umbilicus is filled with the material, whereas in other case chambers of penultimate whorl are exposed. Sutures depressed and somewhat widened close to the umbilicus, becoming shallower and narrower towards periphery. Base of apertural face covered with granular material.

Aperture, sometimes obscured, formed by crescent slit at the middle of base of apertural face. Wall consisting of a few layers. Test finely perforated; pores are also marked on upper half of apertural face.

The majority of specimens shows symmetrical, planospiral coiling; but about 20 per cent of specimens appear to be asymmetrically coiled (Pl. XXXI, Figs 4 and 9; Text-Fig. 41). In the latter case, umbilical area on one side is wider than that from the opposite side. Especially asymmetrical individual is figured (Pl. XXXI, Fig. 9); such specimens are extremely rare in the collection. These aberrant forms are characterized both by asymmetrical coiling and shift of apertural opening on one side (Text-fig. 41). Such specimens look like mutants of the species in question, and at the same time being close to Anomalinidae.

Remarks. — The species in question was often misidentified with *Nonion depressulus* (Walker & Jacob). According to Murray (1965b), the latter species comprises smaller, symmetrical forms with more numerous, narrower chambers; this viewpoint is accepted by the present author.

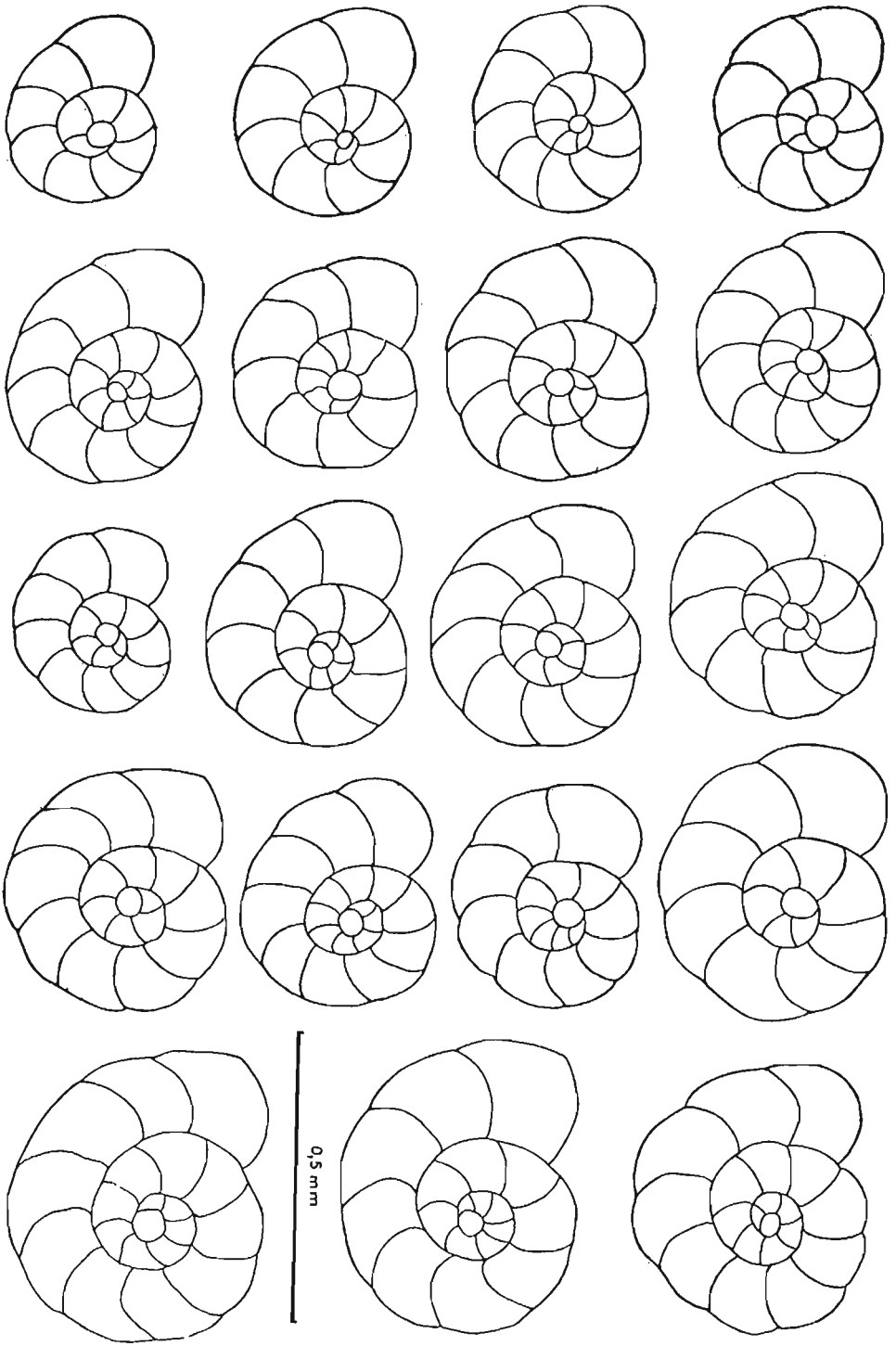

Fig. 39. *Protelphidium umbilicatulum* (Walker & Jacob); outlines of cross-sections of tests of homogenous megalospheric generation from Brachlewo.

The problem of *Protelphidium umbilicatum* (Walker & Jacob), described in 1798 under the generic name of *Nautilus*, was widely discussed, and critical review of literature on this subject is given by Langer (1967, pp.

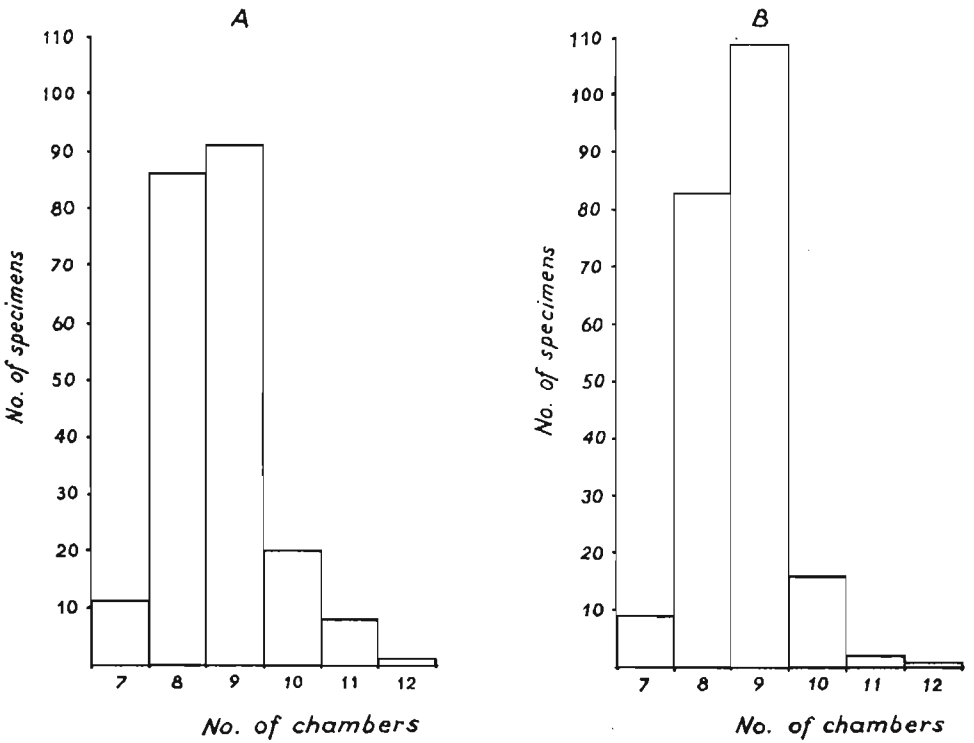

Fig. 40. Histogram of number of chambers per ultimate whorl of *Protelphidium umbilicatulum* (Walker & Jacob) for: *A* 218 specimens from Brachlewo, *B* 220 specimens from Elbląg.

723—725). The point of view of the present author on specific affinity of forms hitherto allocated in the species in question is given in the synonymy.

Polish specimens are characterized by not numerous, somewhat evolutely-coiled chambers and quite often by asymmetry of tests, which is in accordance with schematic drawing of Walker & Jacob (1798, Pl. 14, Fig. 34). The asymmetry of tests of this species has already been noted by Cushman (1939). Although symmetric tests prevail in populations of this species, the asymmetric forms are quite common both in fossil and Recent assemblages.

Specimens described from the Helgoland region by Rhumbler (1938), Text-fig. 64) under the name of *Nonion depressulum granosum* (d'Orbigny) and characterized by somewhat asymmetric test, with umbilical area filled with a small amount of granular material (chambers of penultimate whorl are observable), seems to belong to the species in question.

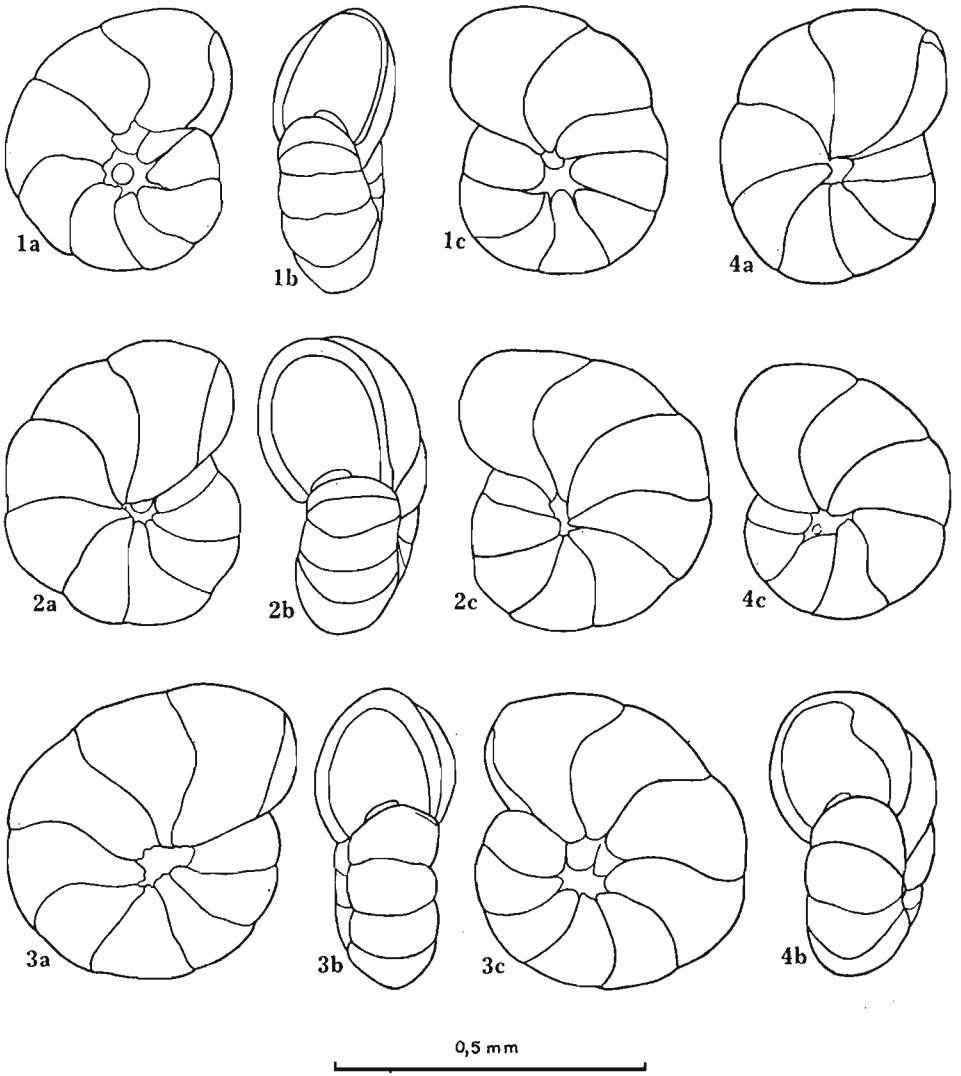

Fig. 41. *Protelphidium umbilicatulum* (Walker & Jacob); outlines of asymmetric tests from Brachlewo; umbilicus is markedly wider on one side and aperture is shifted onto the opposite side; *a* and *c* side views, *b* apertural views.

Occurrence. — Quaternary: Poland (Brachlewo, Elbląg, Tychnowy), Sweden, Denmark, Italy, Great Britain. Recent: North Sea, coasts of Germany, Holland, Great Britain, Mediterranean Sea.

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IRENA BRODNIEWICZ

PLEJSTOCEŃSKIE OTWORNICE REGIONU DOLNEJ WISŁY (POLSKA)

Streszczenie

Opracowano 49 gatunków otwornic bentonicznych z plejstocenu Dolnej Wisły (Tabela 1). Do badań posłużyły materiały z wiercenia w Brachlewie oraz z odkrywek Elbląga i okolicy (Text-fig. 1, 2). Otwornice potwierdzają i uzupełniają poprzednie badania makrofaunistyczne autorki (Brodniewicz, 1960). Wiekowo najstarsze margle morskie z Brachlewa zawierają zespół 18 gatunków z dużym udziałem ciepłolubnych otwornic luzytańskich (Text-fig. 3). Zespół ten dobrze określa wiek eemski tych osadów i pozwala stwierdzić, że margle morskie z Brachlewa z bogatą mikro- i makrofauną luzytańską są równowiekowe z marglami z wiercenia w pobliskich Tychnowach.

Zespół mikrofauny z profilu w Elblągu (Tabela 2) wykazuje duże podobieństwo zarówno do ciepłowodnego eemskiego z Brachlewa jak i do zimnowodnego z Nadbrzeża. Ma on charakter borealny z elementami mikro- i makrofauny zarówno luzytańskiej z interglacjału eemskiego jak i arktycznej z iłów elbląskich (iły yoldiowe, iły cyprinowe). U dołu profilu w warstwie 4 występują formy luzytańskie, które mogą wskazywać na zimniejszą fazę interglacjału eemskiego. I tutaj analiza otwornic zgodna jest z wynikami badań nad mięczakami (Brodniewicz, 1969).

Materiały z Nadbrzeża z tzw. iłów elbląskich, pochodzą z różnych prób (Tabela 1). Iły elbląskie przez różnych autorów były paralelizowane z morską serią Skaerumhede w Danii (Halicki, 1951; i inni). W iłach tych został wykonany profil w Nadbrzeżu. Zespoły fauny w profilu w Nadbrzeżu zmieniają się na przemian (Tabela 3). Wyróżniono trzy strefy, gdzie występują zimnowodne gatunki (Zona 2, 4, 6) i trzy strefy cieplejszych zespołów (Zona 1, 3, 5). Podstawą do określenia wieku profilów w Elblągu i w Nadbrzeżu są badania palynologiczne (Ołtuszewski i Przybylski in: Halicki & Brodniewicz, 1961). Analiza pyłkowa określiła zarówno osady w Elblągu jak i dolną część profilu w Nadbrzeżu (Zona 5) jako interglacjał eemski. Borówko-Dłużakowa (1964) zaliczyła górne ocieplenie w Nadbrzeżu (Zona 1) do interglacjału Brørup (osady morskie serii Skaerumhede niektórzy autorzy odnoszą do Brørup). Szczegółowe badania obecnej autorki wykazały w profilu w Nadbrzeżu (Tabela 3) jeszcze jedno pośrednie małe wachnięcie klimatyczne w Zonie 3. Odznacza się ono tylko małą zmianą zespołu *Protelphidium orbiculare* — *P. niveum*. Towarzyszy jej również niewielki wzrost ilości dębu, świerka i olchy. Być może, że zona 3 jest odpowiednikiem wieku Amersfoort.

Otwornice z pojedynczych prób z Nadbrzeża, Suchacza i czerwonych iłów z Bogdańca wykazują borealno-arktyczny charakter. Natomiast iły *Arctica islandica* z Nadbrzeża zawierają również gatunki luzytańskie i tym samym można by je korelować z warstwą 4 z profilu w Elblągu.

W pracy scharakteryzowano środowisko sedymentacyjne w badanych profilach i przedyskutowano zagadnienie wieku i korelacji zespołów.

W części systematycznej u bogatych w osobniki gatunków badano zmienność osobniczą oraz generacje mikro- i megalosferyczne. Opisano 3 nowe gatunki *Elphidium halickii, E. hyalinum, Protelphidium rozkowskae*. W badanych materiałach nie stwierdzono form zlepieńcowatych ani planktonicznych.

ИРЕНА БРОДНЕВИЧ

ПЛЕЙСТОЦЕНОВЫЕ ФОРАМИНИФЕРЫ РАЙОНА НИЖНЕЙ ВИСЛЫ (ПОЛЬША)

Резюме

Автор исследовал 49 видов бентонных фораминифер из плестоцена в районе Нижней Вислы (табл. 1). Материалом для исследований послужили фораминиферы из буровой скважины Брахлево и обнажений окрестностей г. Эльблёнг (фиг. 1, 2). Фораминиферы подтверждают и дополняют предыдущие макрофаунистические исследования автора (Бродневич, 1960). Самые древние морские мергели в разрезе Брахлево содержат сообщество 18 видов с большим количеством теплолюбивых люзитанских фораминифер (фиг. 3). Это сообщество достоверно датирует ээмский возраст отложений и позволяет констратировать, что морские мергели разреза Брахлево с обильной макрофауной и микрофауной люзитанского типа одновозрастны с мергелями в разрезе скважины в близлежащей местности Тыхновы.

Микрофаунистическое сообщество в разрезе Эльблёнг (табл. 2) характеризуется сходными чертами как с теплолюбивым сообществом ээмского возраста в разрезе Брахлево, так и с холодолюбивым сообществом из Надбжеже. Оно обладает бореальным характером с элементами микро- и макрофауны как люзитанской, из ээмского межледниковья, так и арктической, из эльблёнгских глин (иольдиевые, циприновые глины). В низах разреза, в слое 4, распространены люзитанские формы, которые могут определять фазу похолодания во время ээмского межледниковья. В данном случае результаты анализа фораминифер совпадают с показаниями изучения моллюсков (Бродневич, 1969).

Данные по эльблёнгским глинам профиля Надбжеже основываются на разных образцах (табл. 1). Эльблёнгские глины рассматриваются разными авторами в качестве эквивалента морской серии Скёрумхеде в Дании (Галицки, 1951 и др.). В профиле этих глин в местности Надбжеже наблюдается чередование фаунистических сообществ (табл. 3). Определены три зоны распространения холодолюбивых видов (зоны 2, 4, 6) и три зоны теплолюбивых сообществ (зоны 1, 3, 5). Основой для определения возраста отложений в профилях Эльблёнг и Надбжеже были палинологические исследования (Олтошевски и Пшибыльски в: Галицки, Бродневич, 1961). По данным пыльцевого анализа, отложения профиля Эльблёнг и нижний интервал (зона 5) профиля Надбжеже относится к ээмскому

межледниковью. Борувко-Длужакова (1964) зачислила осадки верхнего потепления в профиле Надбжеже (зона 1) к межледниковью брёруп (морские осадки серии Скёрумхеде относятся некоторыми авторами к брёруп). Детальные исследования, проведенные автором настоящей работы, выявили в профиле Надбжеже (табл. 3) еще одно промежточное климатическое колебание в зоне 3. Оно характеризуется небольшим изменением сообщества *Protelphidium orbiculare — P. niveum*. Это изменение сопровождается также небольшим увеличением количества дуба, ели и ольхи. Возможно, что зона 3 является эквивалентом межстадии амерсфорт.

Фораминиферы из отдельных образцов профиля Надбжеже, профиля Сухач и из красных глин в местности Богданец проявляют бореально-арктический характер. Глины же, содержащие *Arctica islandica* в профиле Надбжеже, включают также люзитанские виды и, таким образом, их можно коррелировать со слоем 4 в разрезе Эльблёнг.

В работе рассматриваются условия седиментационной среды по данным изученных профилей, а также обсуждаются проблемы возраста и корреляции фаунистических сообществ.

В систематической части описываются индивидуальные особенности, микросферические и мегасферические генерации у представителей некоторых богатых особями видов. Представлено описание трех новых видов: *Elphidium halickii, E. hyalinum, Protelphidium rozkowskae*. В исследованном материале не наблюдались агглютинированные и планктонные формы.

EXPLANATIONS OF PLATES

Plate I

Elphidium albiumbilicatum (Weiss), Elbląg (F. XV/92)

Fig. 1. Side view, ×190.
Fig. 2. Umbilical area covered with granular test material, ×1900.
Fig. 3. Differentiated granular material covering first chamber of the ultimate whorl; ×4750.
Fig. 4. Surface of the second chamber of the ultimate whorl; note gradual disappearance of granular test material and pores in test wall; ×1900.
Fig. 5. Pattern of distribution of pores on surface of test wall, arranged in twos or threes.
Fig. 6. Pores and structure of calcite; ×19000.
Figs 2—5 — enlarged fragments of the test figured in Fig. 1,

Plate II

Elphidium cf. *asklundi* Brotzen, Nadbrzeże

Fig. 1. Apertural view; note apertural face with aperture formed of openings arranged in a single row, outlet openings of sutural channels on chambers and slit-like opening of sutural channels, ×140 (F. XV/110).

Fig. 2. Fragment of last chamber with remnant of destroyed aperture; enlarged fragment of the test figured on Fig. 1, ×1400.
Fig. 3. Side view; granular umbilical area and sutures, ×140 (F. XV/111).
Fig. 4. Enlarged fragment of specimen figured on Fig. 3, ×700.
Fig. 5. Granulation of umbilical area; enlarged fragment figured on Fig. 3, ×2800.
Fig. 6. Pores randomly distributed over the surface of penultimate chamber of specimen in Fig. 3, ×2800.

Plate III

Elphidium bartletti Cushman, Elbląg

Fig. 1. Side view, ×100 (F. XV/112).
Fig. 2. Side view, ×100 (F. XV/113).
Fig. 3. Umbilical area with obliterated tubercles formed of granular test material and with openings of sutural channels, ×1040.
Fig. 4. Fragment of second chamber of ultimate whorl of specimen figured in Fig. 2: transition from obliterated tubercles to outlines of tubercles dissolved by protoplasma; note pores in test wall, ×1040.
Fig. 5. Enlarged fragment figured on Fig. 4: pores in test wall arranged among circular outlines of bases of tubercles dissolved by protoplasma, ×5250.
Fig. 6. Enlarged fragment figured on Fig 4: obliterated tubercles, ×5200.
Fig. 7. Pores in wall of ultimate chamber, ×5200.
Fig. 8. Pores in wall of the fourth chamber (counting from the end of test), ×5200.

Plate IV

Elphidium bartletti Cushman, Elbląg

Fig. 1. Apertural view, penultimate chamber, ×105 (F. XV/114).
Fig. 2. Apertural view, ultimate chamber, ×100 (F. XV/115).
Fig. 3. Enlarged fragment of the test figured on Fig. 2; distinct sharp tubercles, ×525.
Fig. 4. Enlarged fragment figured on Fig. 3: sharp, high test tubercles, ×5250.
Fig. 5. Enlarged fragment figured on Fig. 1: apertural face of penultimate chamber with slit-like aperture at the base and supplementary openings above. Apertural face smooth, except for traces after tubercles dissolved by protoplasma, ×520.
Fig. 6. Fragment of the second chamber of ultimate whorl figured on Fig. 1; very tiny tubercles gradually disappearing over the perforated part of chamber, ×2050.
Fig. 7. Enlarged fragment of Fig. 5; distinct outlines of bases of tubercles dissolved by protoplasma, ×5250.

Plate V

Elphidium clavatum Cushman, Nadbrzeże

Fig. 1. Side view, ×190 (F. XV/130).
Fig. 2. Side view, ×136 (F. XV/131).
Fig. 3. Depressed suture filled with granular material, ×1900.

Fig. 4. Enlarged fragment of suture filled with sharp-pointed, conical granular material, ×9400.
Fig. 5. Enlarged fragment of test with large pores in wall and imperforated retral processes.
Fig. 6. Enlarged fragment of imperforated extension of chambers onto umbilical part of test with observable calcite structure of wall layer, ×1900.

Plate VI

Elphidium halickii n. sp., Nadbrzeże

Fig. 1. Side view, ×105 (F. XV/151).
Fig. 2. Pores in penultimate chamber, ×2100.
Fig. 3. Fragment of umbilical area and sutures with openings of sutural channels and destroyed tubercles formed of granular material, ×1050.
Fig. 4. Pores in ultimate chamber, ×5250.
Fig. 5. Fragment of suture between fourth and fifth chambers with a very small amount of destroyed tubercles formed of granular material, pores elongated, ×1050.
Fig. 6. Fragment of fourth chamber of the ultimate whorl with irregular and elongated pores, ×5250.

Plate VII

Elphidium incertum (Williamson), Brachlewo

Fig. 1. Apertural view, ×105 (F. XV/161).
Fig. 2. Side view, ×105 (F. XV/162).
Fig. 3. Apertural view, ×210 (F. XV/163).
Fig. 4. Enlarged fragment of the test figured on Fig. 1: umbilical part of test, ×525.
Fig. 5. Fragment of the test figured on Fig. 2: umbilical part with obliterated granular material, ×1050.
Fig. 6. Fragment of the same test: suture with marked outlet opening of sutural channel: obliterated granular material, ×2100.
Fig. 7. Fragment from Fig. 2: pores in the ultimate chamber, ×5025.

Plate VIII

Elphidium poeyanum (d'Orbigny), Brachlewo

Fig. 1. Side view, ×200 (F. XV/170).
Fig. 2. Side view, ×200 (F. XV/171).
Fig. 3. Apertural view. ×500 (F. XV/172).
Fig. 4. Imperforated umbilicus with outlet openings of umbilical channel; enlarged fragment of test figured on Fig. 1, ×500.
Fig. 5. Imperforated apertural face of penultimate chamber with small apertural openings and distinct trace of sutural channel; enlarged fragment of test figured on Fig. 3, ×500.
Fig. 6. Enlarged fragment of test figured on Fig. 2: ultimate and penultimate

sutures; note imperforated wall along suture and distinct outlet openings of sutural channels, ×1000.

Fig. 7. Pores in ultimate chambers; enlarged fragments of test figured on Fig. 2, ×5000.

Plate IX

Elphidium hyalinum n. sp., Bogdaniec

Fig. 1. Side view, ×190. Holotype (F. XV/155).

Fig. 2. Enlarged fragment of paratype figured on Fig. 3: umbilicus with knob and outlet openings of umbilical channel, umbilicus filled with granular material, ×4800.

Fig. 3. Side view, ×194. Paratype (F. XV/156).

Fig. 4. Part of umbilicus devoid of pores, note structure of calcite forming test wall, ×9600.

Fig. 5. Pores in the ultimate chamber, ×4800.

Fig. 6. Pores in the second chamber (counting from the beginning of ultimate whorl), ×4800.

Plate X

Elphidium clavatum Cushman, Nadbrzeże.

Figs 1—2. Fragments of last chambers of test; note outlet openings on the bottom surface of retral process, opening to sutural channel and elongated slits of this channel, ×190.

Fig. 3. Fragment of test with pore and structure of calcite, ×19000.

Elphidium hyalinum n. sp., Bogdaniec.

Fig. 4. Side view, ×196 (F. XV/157).

Fig. 5. Pores in penultimate chamber of test figured on Fig. 4, ×995.

Fig. 6. Umbilical part of test figured on Fig. 4: slightly perforated or imperforated terminal parts of chambers unite, forming circum-umbilical circle; in the center of umbilicus, umbilical knob surrounded by granular material, ×490.

Fig. 7. Enlarged fragment figured on Fig. 5: open and closed pores, ×4900.

Plate XI

Elphidium hyalinum n. sp., Bogdaniec

Fig. 1. Apertural view; test with ultimate chamber preserved, aperture obscured, ×195 (F. XV/158).

Figs 2 and 3. Apertural views; penultimate and preceding chambers, ×195 (F. XV/159, 160).

Protelphidium granosum (d'Orbigny), Brachlewo

Fig. 4. Appertural view; penultimate chamber with aperture formed of three rows of circular openings and with large opening of umbilical channel continuing under lip, X 190 (F. XV/192).

Fig. 5. Side view; umbilicus with tubercles and filled with granular material, which also spreads over sutural depressions, X 205 (F. XV/193).

Fig. 6. Large pores in ultimate chamber of test from Fig. 5, X 2050.
Fig 7. Pores in second chamber from the beginning of ultimate whorl of test figured on Fig. 5, X 5100.
Fig. 8. Fragment of umbilical wall with partly damaged layers of test wall and with granular material, X 5100.

Plate XII

Protelphidium granosum (d'Orbigny), Brachlewo

Fig. 1. Enlarged fragment of specimen figured on Fig. 3: aperture in the form of two rows of openings, each of which is surrounded by thick lip, ×1050.
Fig. 2. Side view; umbilicus infilled with granular material and devoid of tubercles, ×210 (F. XV/194).
Fig. 3. Apertural view, ×210 (F. XV/195).
Fig. 4. Suture between penultimate and ultimate chambers, covered with granular material; enlarged fragment figured on Fig. 2, ×2100.
Fig. 5. Apertural view; distinct opening of umbilical channel at the base of chamber, ×210 (F. XV/196).
Fig. 6. Large circular pores in ultimate chamber, ×5100.

Plate XIII

Protelphidium niveum (Lafrenz), Nadbrzeże

Fig. 1. Side view, ×210 (F. XV/202).
Fig. 2. Apertural view, ×210 (F. XV/203).
Fig. 3. Apertural view, ×525 (F. XV/204).
Fig. 4. Pores in ultimate chamber of test figured on Fig. 1, ×5025.
Fig. 5. Enlarged fragment of test figured on Fig. 2: test destroyed in the umbilical area; noticeable chambers and septum, ×2100.
Fig. 6. Side view, ×525 (F. XV/205).
Fig. 7. Enlarged fragment figured on Fig. 6: Outer test layer destroyed, layered grains at the umbilicus visible, ×2100.
Fig. 8. Enlarged fragment figured on Fig. 7: grains at the umbilicus, surrounded by two layers of test wall, ×10500.

Plate XIV

Protelphidium rozkowskae n. sp., Brachlewo

Fig. 1. Side view, ×200 (F. XV/226).
Fig. 2. Fragment of test figured on Fig. 1, ×500.
Fig. 3. Fragment of test figured on Fig. 1: suture filled with granular material, ×1000.
Fig. 4. Pores in fourth chamber (counting from the aperture) of test from Fig. 1, ×5000.
Fig. 5. Pores in ultimate chamber of test from Fig. 1, ×5000.

Protelphidium niveum (Lafrenz), Nadbrzeże

Fig. 6. Side view. ×525 (F. XV/206).

Plate XV

Buccella frigida Cushman, Brachlewo

Fig. 1. Peripheral view, ×210 (F. XV/52).
Fig. 2. Ventral view, ×210 (F. XV/53).

Protelphidium orbiculare (Brady), Elbląg.

Fig. 3. Apertural view; test with ultimate chamber preserved, ×200 (F. XV/210).
Fig. 4. Fragment of test figured on Fig. 3, ×100.
Fig. 5. Apertural view; penultimate chamber with single apertural opening pore, ×200 (F. XV/211).
Fig. 6. Fragment of test figured on Fig. 5, ×2000.

Plate XVI

Protelphidium umbilicatulum (Walker & Jacob), Brachlewo

Fig. 1. Apertural view; penultimate test chamber, ×200 (F. XV/234).
Fig. 2. Fragment of test figured on Fig. 1, ×1000.
Fig. 3. Destroyed chambers at the umbilicus, revealing septum, ×1000.
Fig. 4. Suture on the beginning of the whorl, with obliterated granular material, ×2000.
Fig. 5. Upper layer of test wall; fragment of test figured on Fig. 1, ×2000.
Fig. 6. Pores in penultimate chamber, ×5000.

Plate XVII

Fig. 1. *Globulina inaequalis* Reuss, Elbląg, ×80 (F. XV/22).
Fig. 2. *Guttulina* sp. 3, Nadbrzeże, ×80 (F. XV/243).
Figs 3 and 4. *Pateoris hauerionoides* (Rhumbler), Nadbrzeże, ×85 (F. XV/18, 19).
Figs 5 and 6. *Cyclogyra* sp. 1, Nadbrzeże; side view, ×52 (F. XV/1, 2).

Plate XVIII

Figs 1 and 2. *Quinqueloculina seminulum* (Linnaeus), Nadbrzeże, ×80 (F. XV/4, 5).
Figs 3, 4 and 5. *Quinqueloculina* sp. 1, Nadbrzeże, ×80 (F. XV/11, 13).

Plate XIX

Fig. 1. *Pseudopolymorphina* sp. 1, Elbląg, ×80 (F. XV/44).
Fig. 2. *Guttulina* cf. *austriaca*, Elbląg, ×80 (F. XV/34).
Fig. 3. *Guttulina* sp. 2, Nadbrzeże, ×80 (F. XV/37).
Fig. 4. *Guttulina lactea* (Walker & Jacob), Elbląg, ×80 (F. XV/25).
Figs 5, 6 and 7. *Guttulina glacialis* (Cushman & Ozawa), Nadbrzeże, ×80 (F. XV/28—30).
Fig. 8. *Guttulina sp.* 1, Nadbrzeże, ×80 (F. XV/36).

Plate XX

Figs 1—3, 6—18, 20. *Buccella frigida* Cushman, Nadbrzeże, ×80 (F. XV/52—68).
Figs 3, 4, 19, 21. *Buccella tenerrima* (Brandy), Elbląg ×80 (F. XV/69—72).

Plate XXI

Ammonia beccarii (Linnaeus) var., Brachlewo, ×60 (F. XV/80—91).

Plate XXII

Fig. 1. *Fissurina laevigata* Reuss, Nadbrzeże: *a* side view, *b* apertural view; ×160 (F. XV/49).
Fig. 2. *Fissurina laevigata* Reuss, Nadbrzeże; side view, ×160 (FmXV/50).
Fig. 3. *Quinqueloculina lata* Elbląg: *a* apertural view, *b* side view; ×80 (F. XV/10).
Fig. 4. *Cyclogyra* sp. 2, Nadbrzeże; side view, ×100 (F. XV/3).
Fig. 5. *Buccella tenerrima* (Bandy), Elbląg: *a* dorsal view, *b* peripheral view, *c* ventral view; ×90 (F. XV/65a).
Fig. 6. *Buccella blanconensis* (Bandy), Elbląg: *a* dorsal view, *b* peripheral view, *c* ventral view; ×90 (F. XV/74).
Fig. 7. *Buccella blanconensis* (Bandy), Elbląg: *a* dorsal view, *b* peripheral view, *c* ventral view; ×85 (F. XV/75).

Plate XXIII

Fig. 1. *Elphidium umbilicatulum* (Williamson), Elbląg; side view, ×80 (F. XV/179).
Fig. 2. *Elphidium umbilicatulum* (Williamson), Elbląg: *a* apertural view, *b* side view; ×70 (F. XV/180).
Fig. 3. *Protelphidium orbiculare* (Brandy), Bogdaniec: side view, ×90 (F. XV/225).
Fig. 4. *Elphidium clavatum* Cushman, Nadbrzeże: *a* apertural view, *b* side view; ×70 (F. XV/133).
Figs 5, 6. *Elphidium* sp. 2, Brachlewo: side views, ×120 (F. XV/190, 191).
Fig. 7. *Elphidium halickii* n. sp. Nadbrzeże: *a* apertural view, *b* side view; ×60. Paratype (F. XV/152).
Fig. 8. *Oolina* cf. *acuticosta* (Reuss), Nadbrzeże, ×100 (F. XV/48).
Fig. 9. *Guttulina* cf. *austriaca*, Elbląg, ×65 (F. XV/35).
Fig. 10. *Elphidium halickii* n. sp. Nadbrzeże: *a* side view, *b* apertural view; ×70. Holotype (F. XV/153).
Fig. 11. *Pseudopolymorphina novangliae* (Cushman), Bogdaniec, ×65 (F. XV/38).
Fig. 12. *Guttulina* cf. *dawsoni*, Bogdaniec, ×65 (F. XV/31).

Plate XXIV

Figs 1—5. *Elphidium clavatum* Cushman, Brachlewo; side views, ×80 (F. XV/134—138).
Figs 6—8, 11, 12. *Protelphidium granosum* (d'Orbigny), Brachlewo: side views, ×80 (F. XV/197—201).
Figs 9, 10, 13—15. *Elphidium gunteri* Cole, Brachlewo: side views, ×80 (F. XV/146—150).

Plate XXV

Figs 1—8. *Elphidium umbilicatulum* (Williamson), Brachlewo: side views, ×80 (F. XV/ /181—188).

Plate XXVI

Figs 1—14. *Elphidium bartletti* Cushman, Nadbrzeże: *a* apertural views, *b* side views; ×50 (F. XV/116—129).

Plate XXVII

Fig. 1. *Elphidium* sp. 1, Brachlewo: side view, ×80 (F. XV/189).
Figs. 2—7. *Elphidium clavatum* Cushman (morphotype 3), Nadbrzeże: side views, ×80 (F. XV/139—144).
Fig. 8. *Elphidium clavatum* (morphotype 3), Nadbrzeże: side view, ×80, (F. XV/145).
Fig. 9. *Elphidium asklundi* Brotzen, Nadbrzeże: side view, ×80 (F. XV/107).

Plate XXVIII

Protelphidium różkowskae n. sp., Brachlewo

Fig. 1. Side view, ×85. Paratype (F. XV/227).
Fig. 2. Side view, ×85 (F. XV/228).
Fig. 3. Side view, ×85. Holotype (F. XV/229).
Fig. 4. Side view, ×85 (F. XV/230).
Figs 5—11. *Elphidium incertum* (Williamson), Brachlewo: side views, ×80 (F. XV/164—170).

Plate XXIX

Elphidium albiumbilicatum (Weiss): side views, ×80 (F. XV/93—106)

Figs 1, 4—8, 14: Nadbrzeże. Figs 2, 3, 11: Brachlewo; Figs 9, 10, 12—14: Elbląg.

Plate XXX

Protelphidium orbiculre (Brady): side views, ×80 (F. XV/212—224)

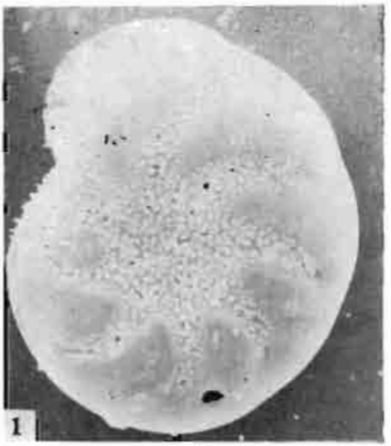
Figs 1, 2, 4, 8, 9, 13; Brachlewo; Figs 3, 6, 7: Elbląg, Figs 5, 10, 11, 12: Nadbrzeże.

Plate XXXI

Figs 1—9. *Protelphidium umbilicatulum* (Walker & Jacob) Brachlewo: side views, ×80 (F. XV/235—243).

Plate XXXII

Fig. 1. Foraminiferal assemblage from Brachlewo.
Fig. 2. Foraminiferal assemblage from Bogdaniec.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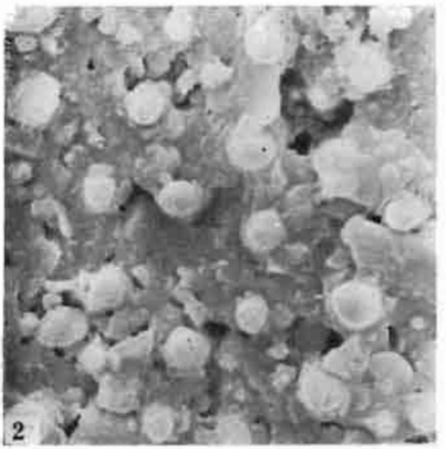
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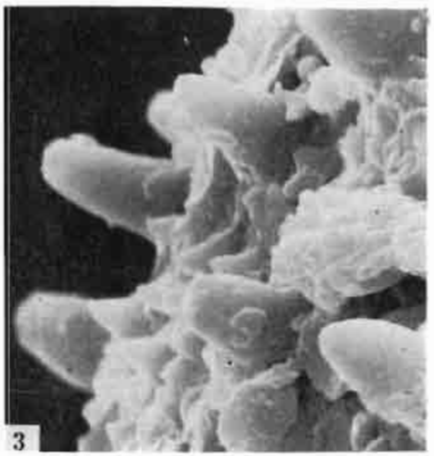
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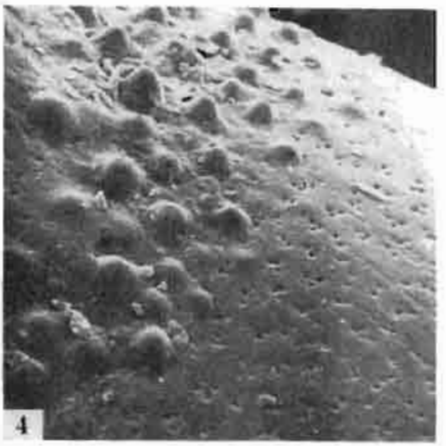
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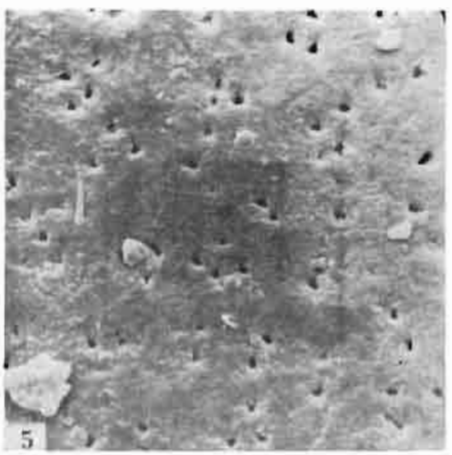
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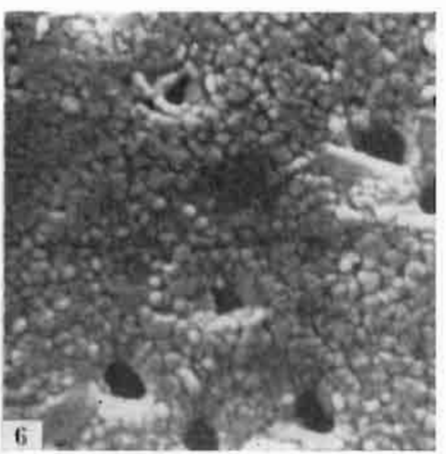
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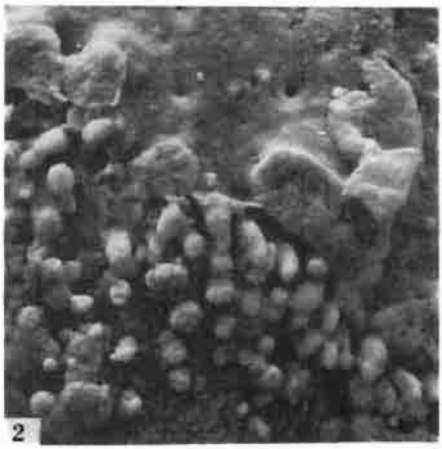
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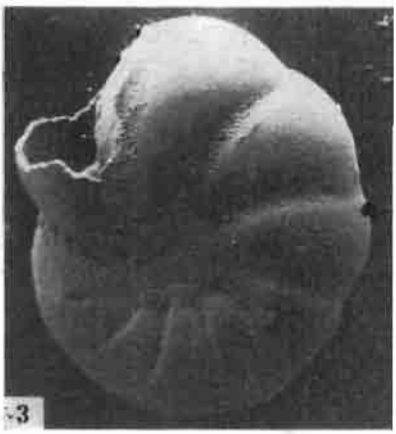
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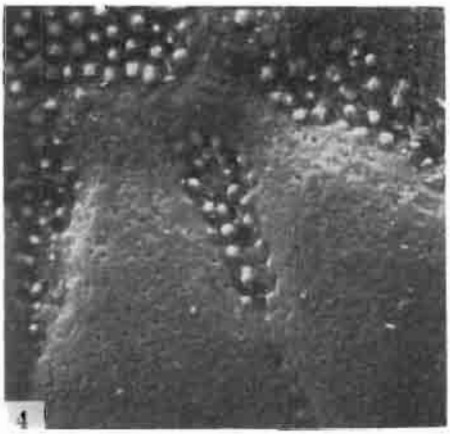
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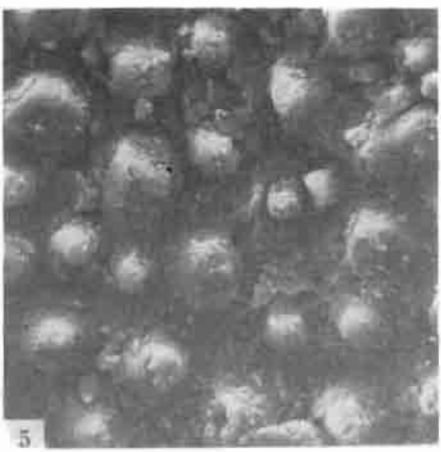
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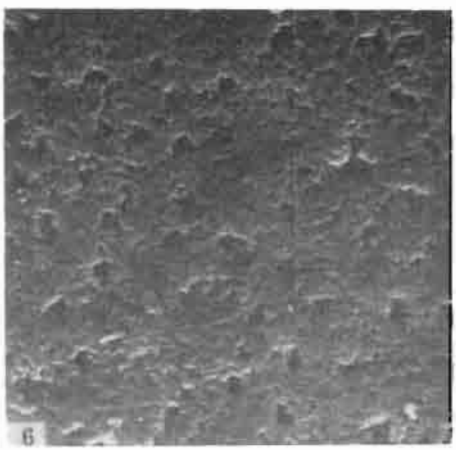
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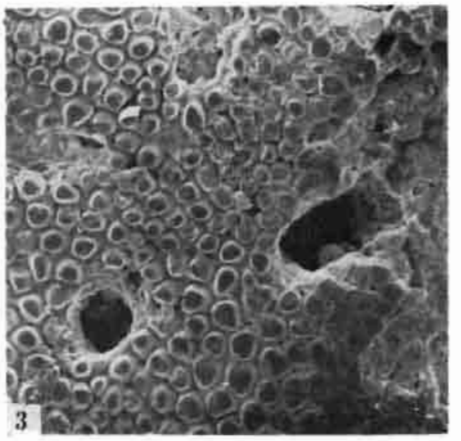
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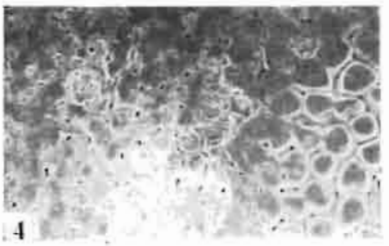
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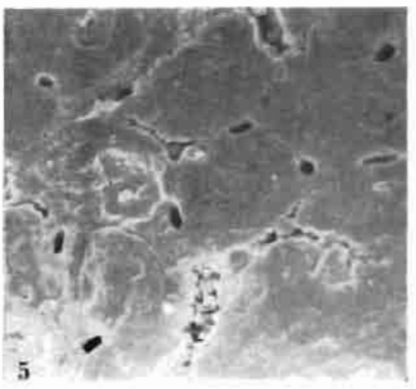
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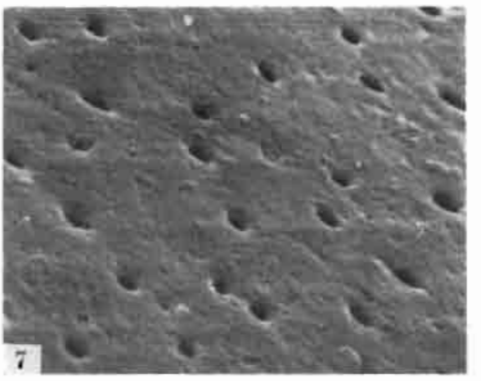
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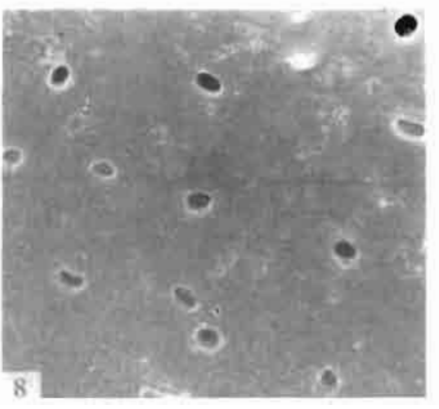
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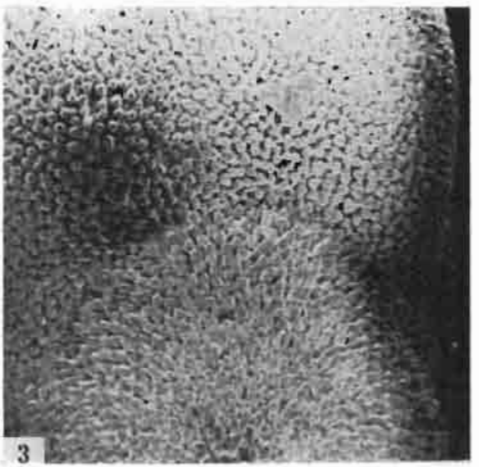
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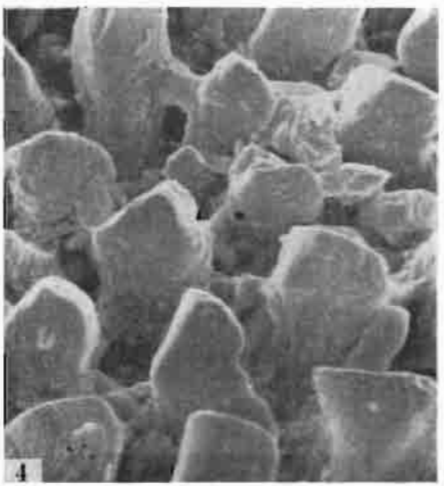
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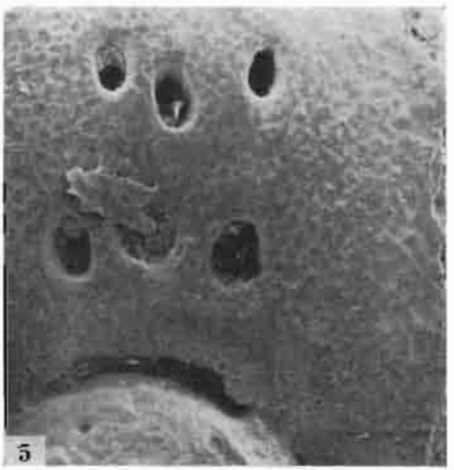
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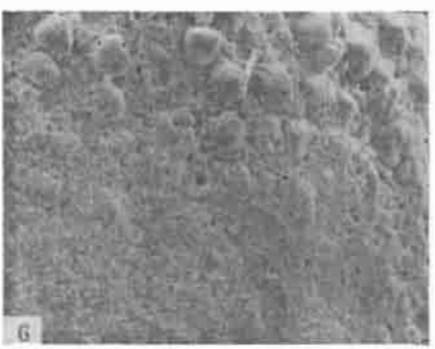
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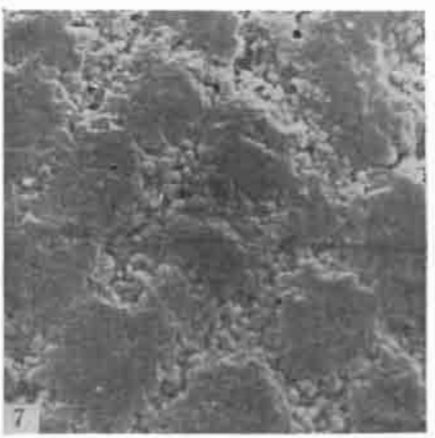
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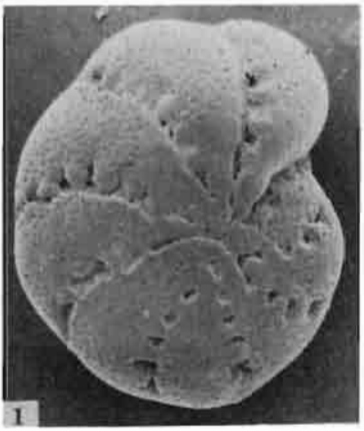
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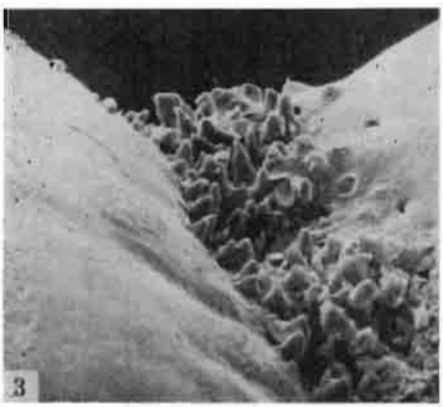
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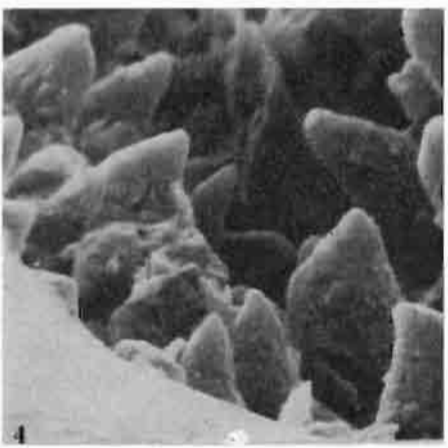
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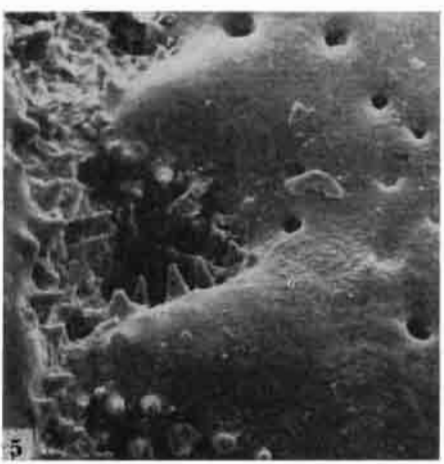
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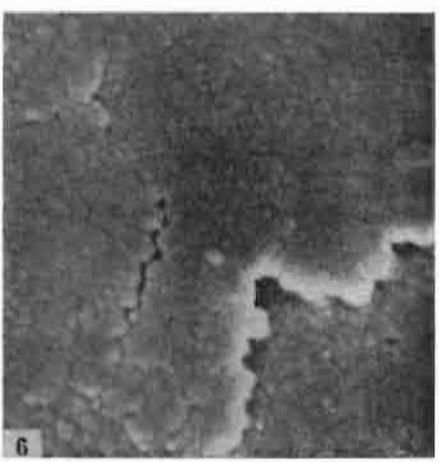
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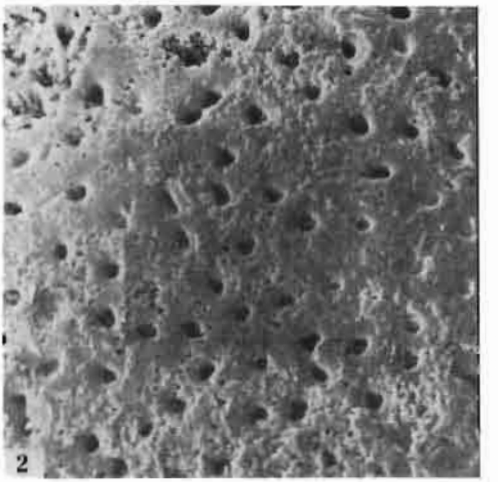
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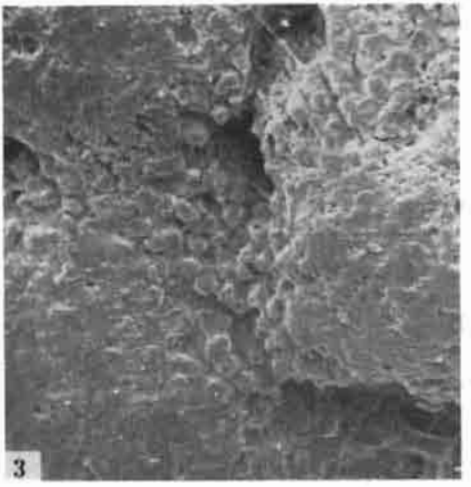
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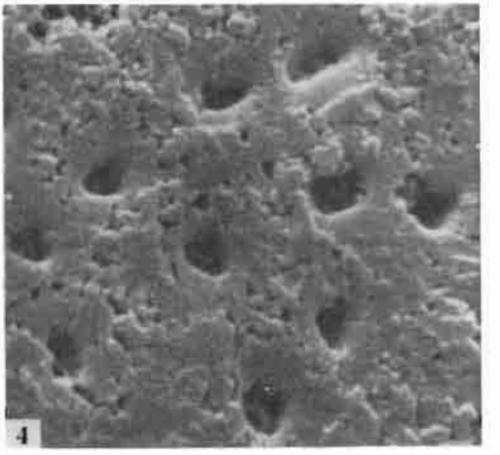
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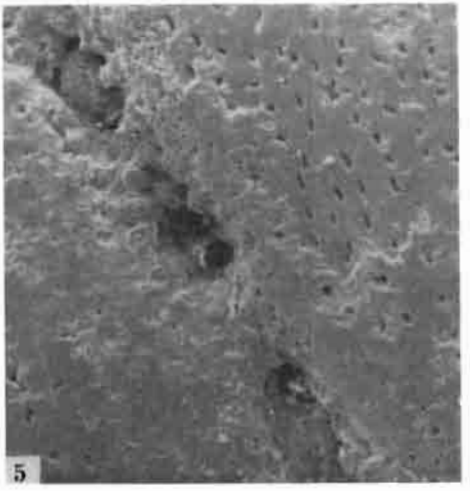
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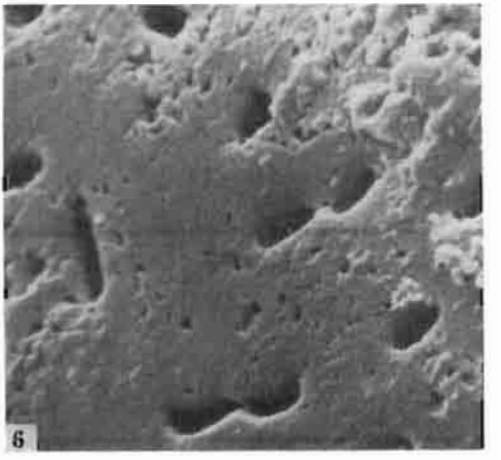
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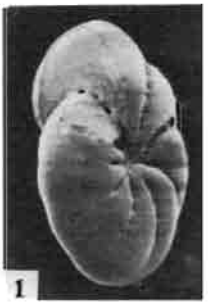
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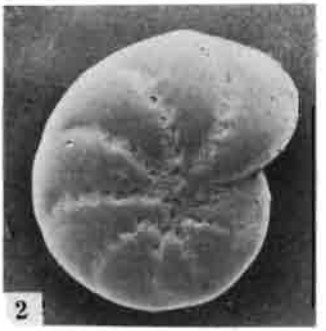
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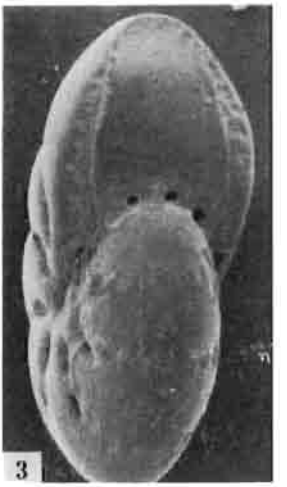
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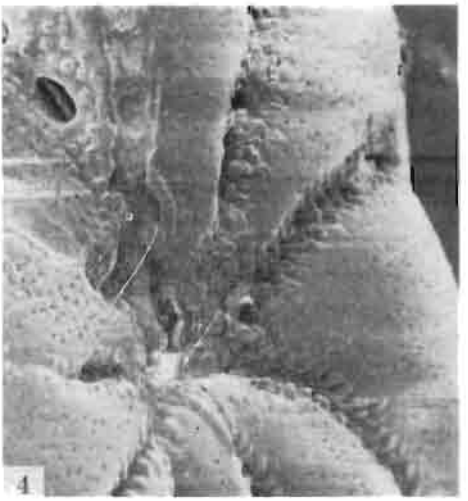
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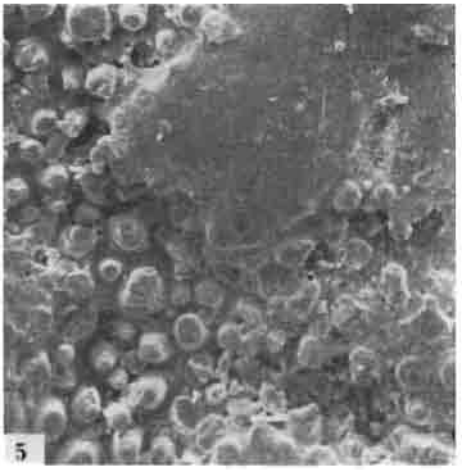
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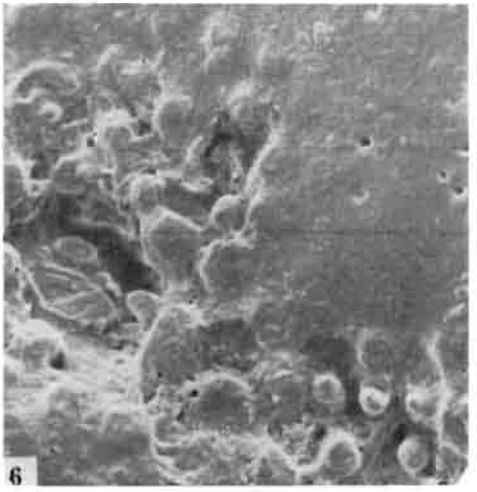
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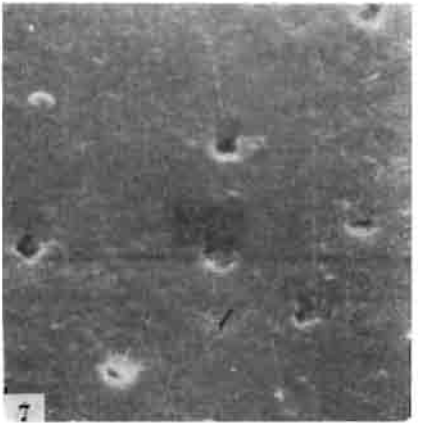
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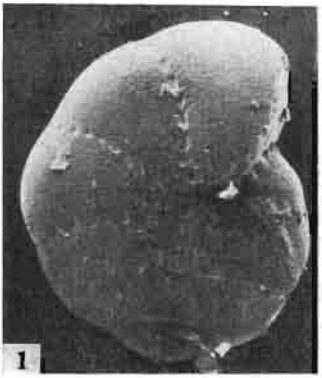
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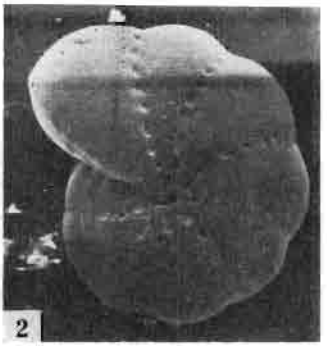
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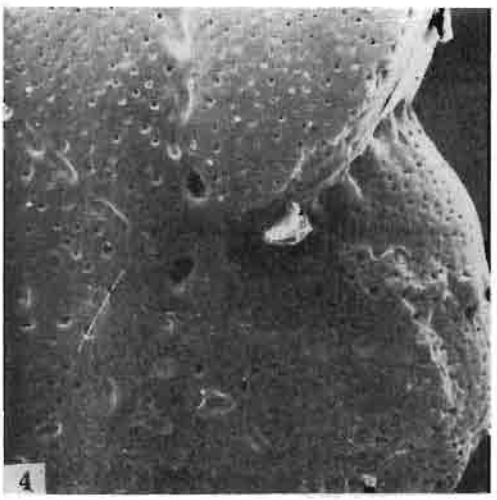
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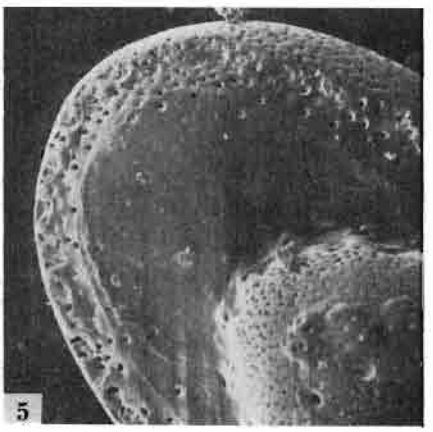
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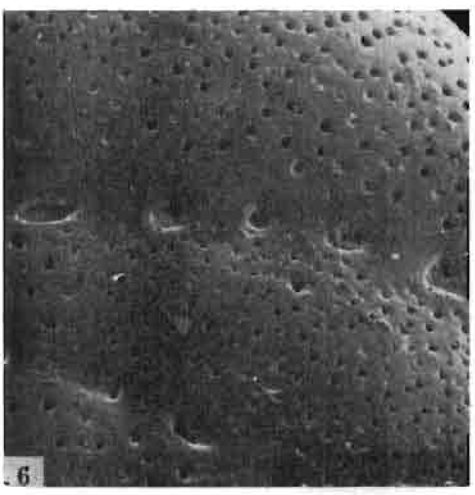
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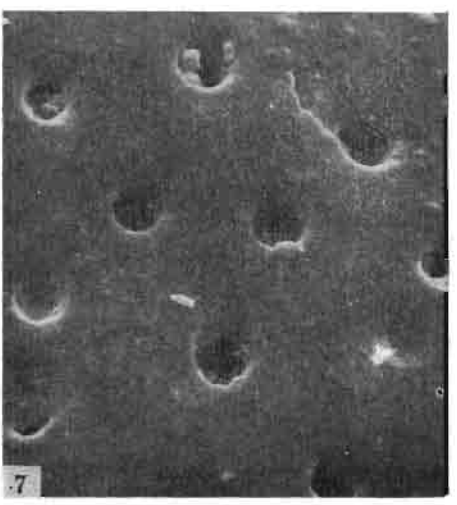
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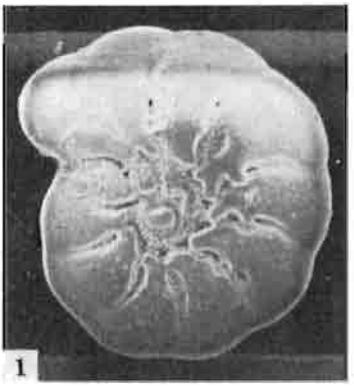
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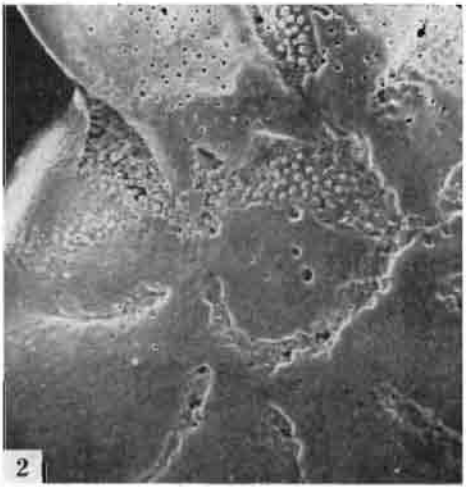
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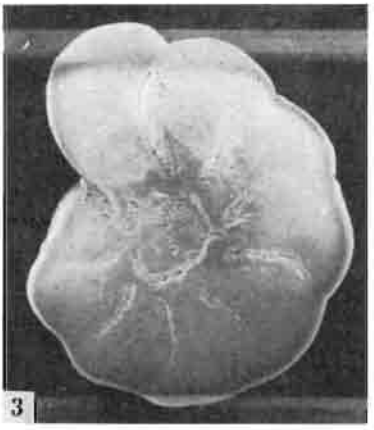
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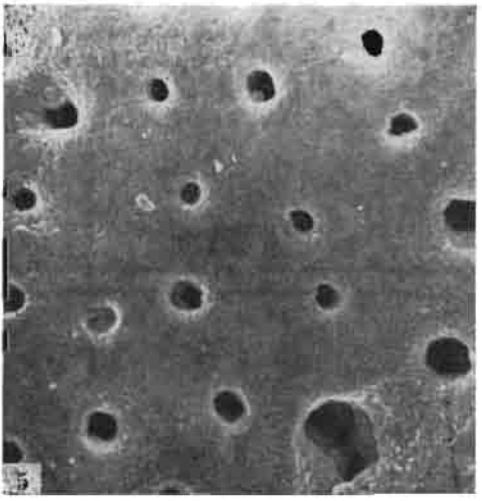
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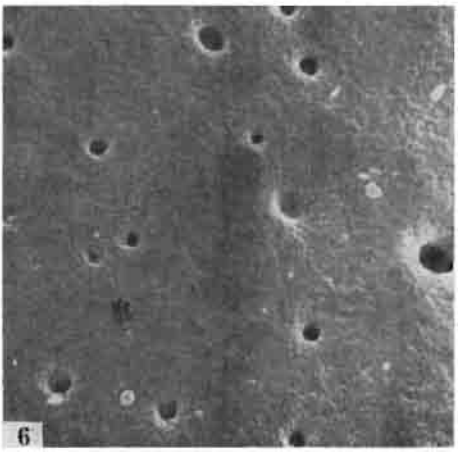
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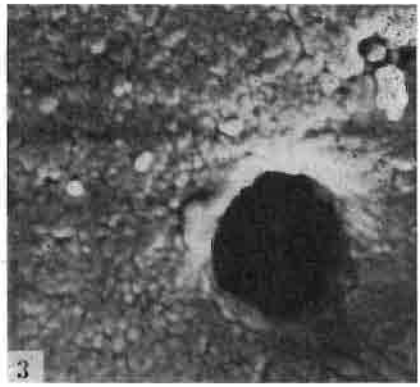
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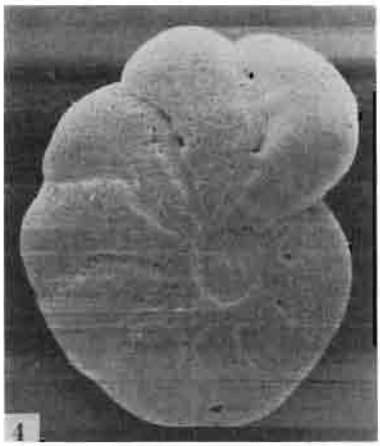
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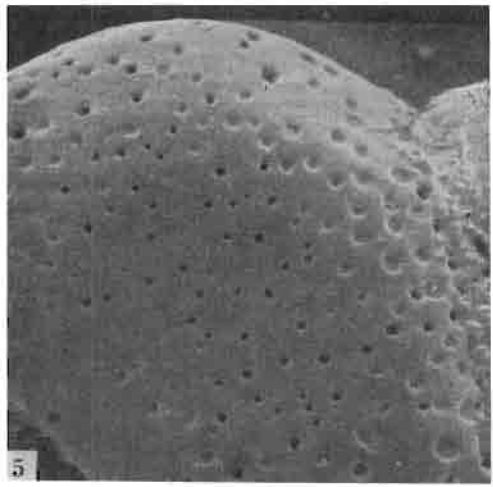
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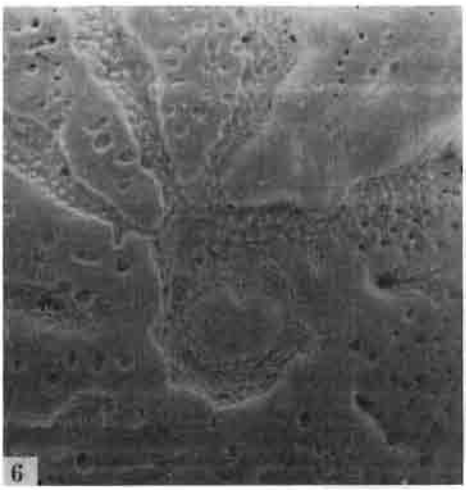
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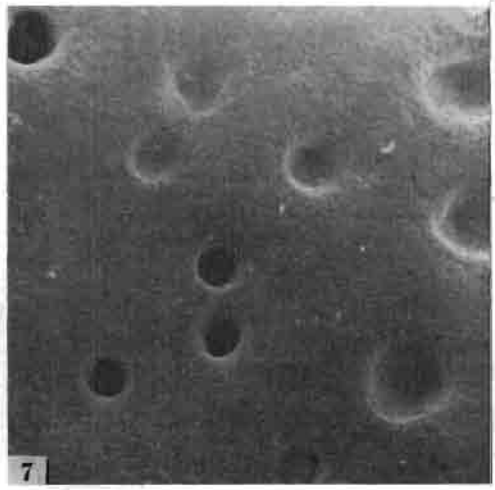
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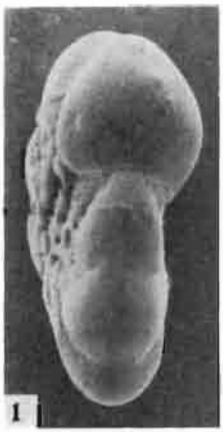
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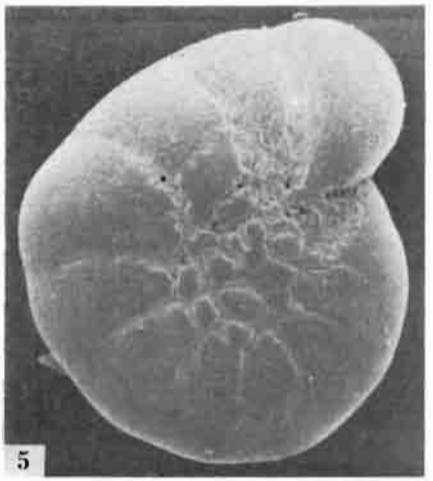
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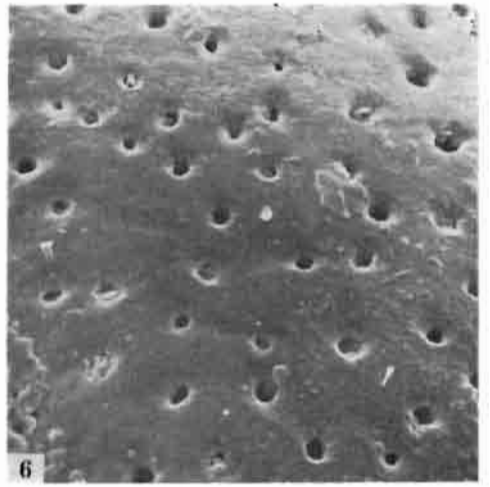
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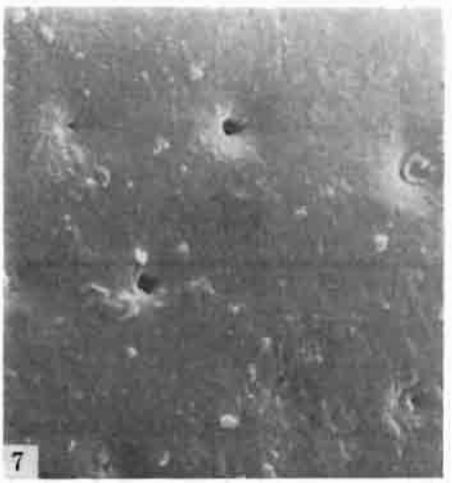
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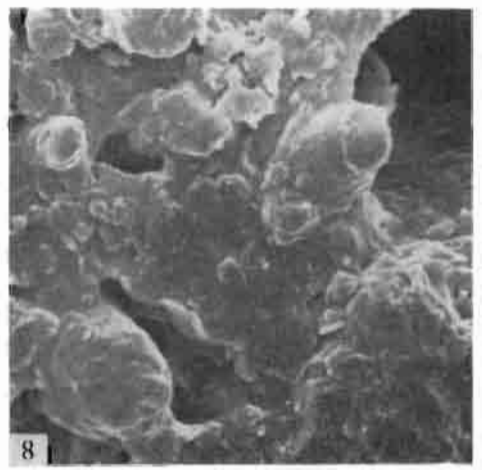
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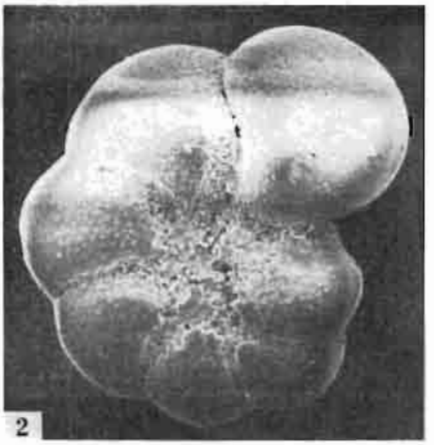
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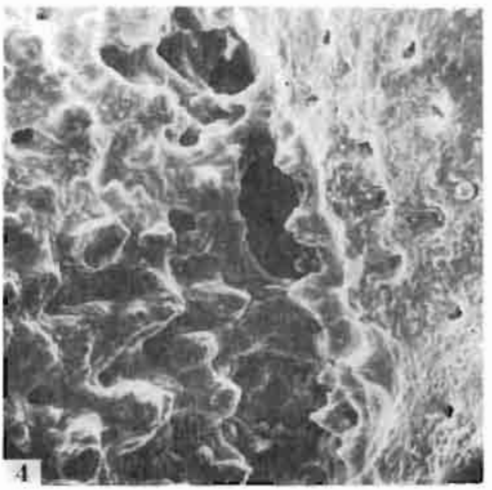
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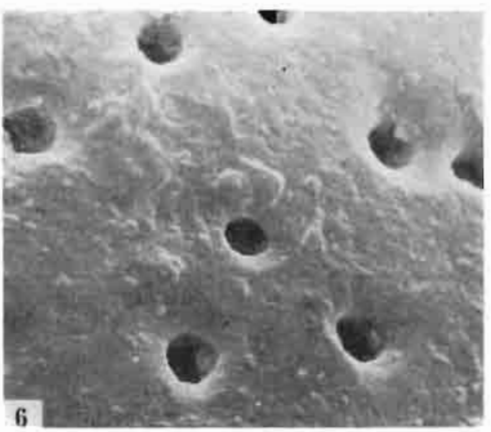
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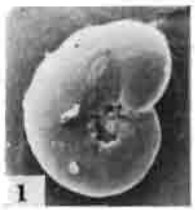
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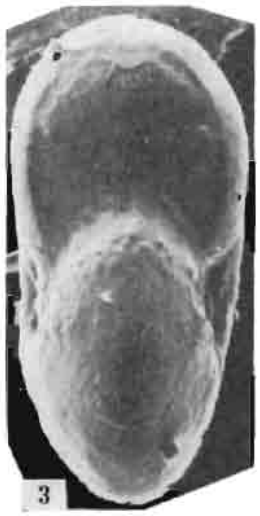
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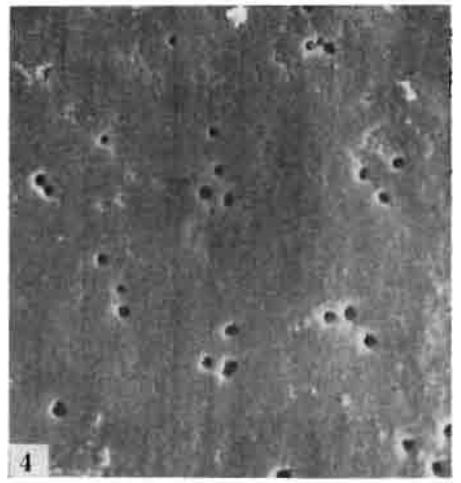
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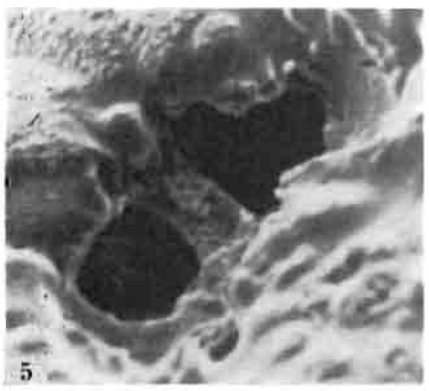
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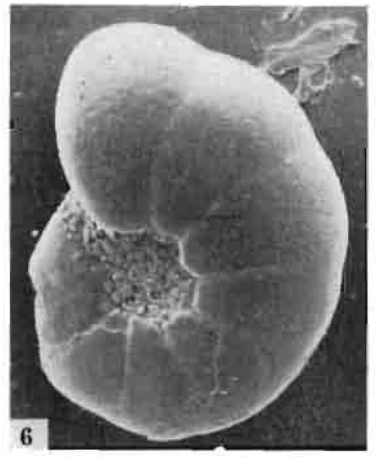
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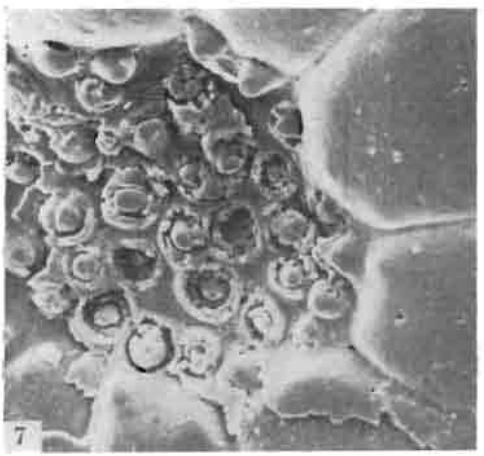
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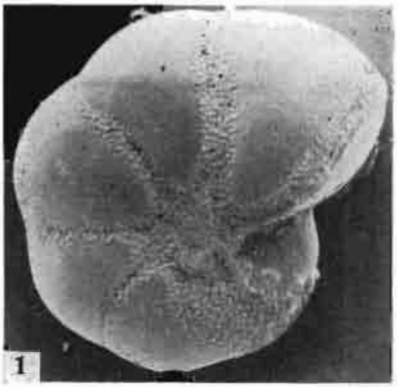
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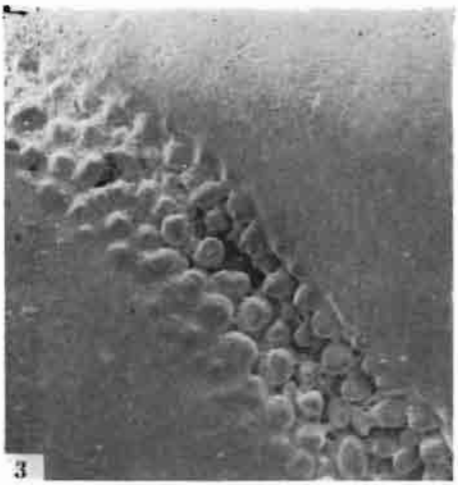
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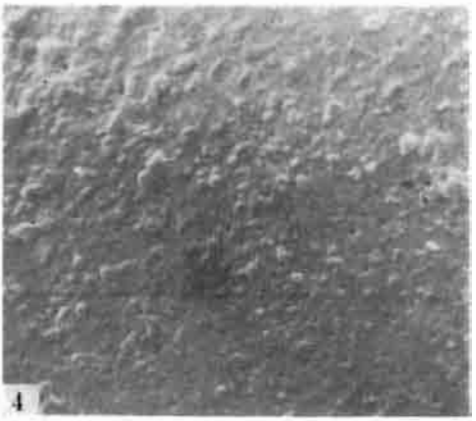
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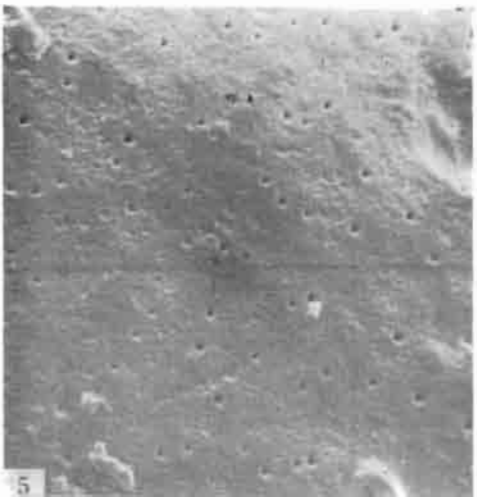
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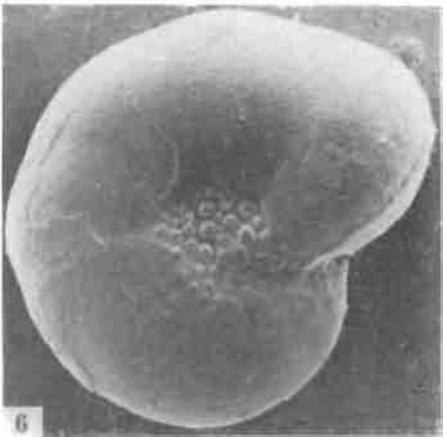
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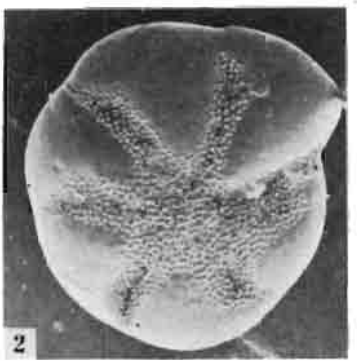
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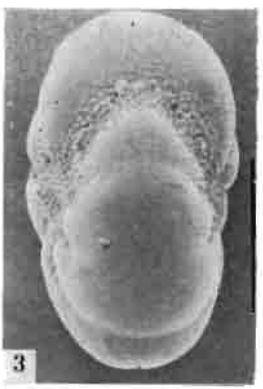
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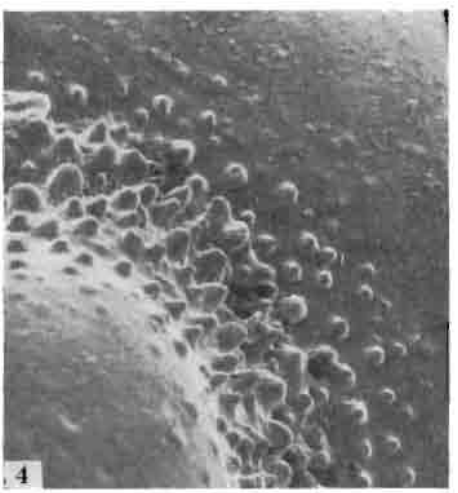
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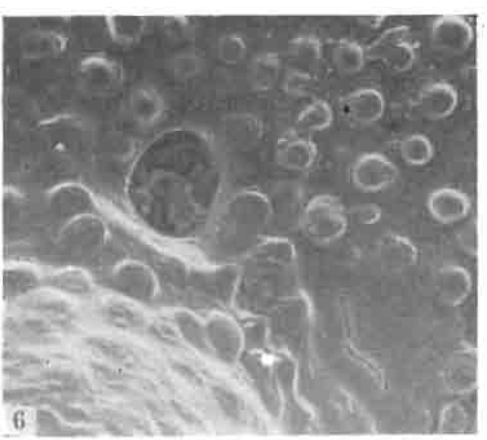
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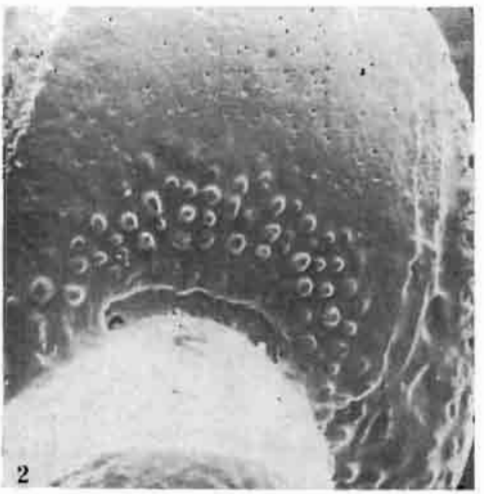
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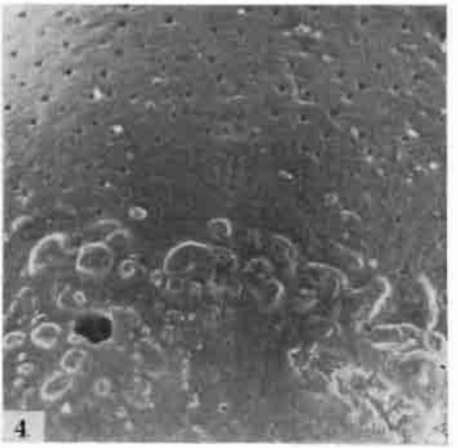
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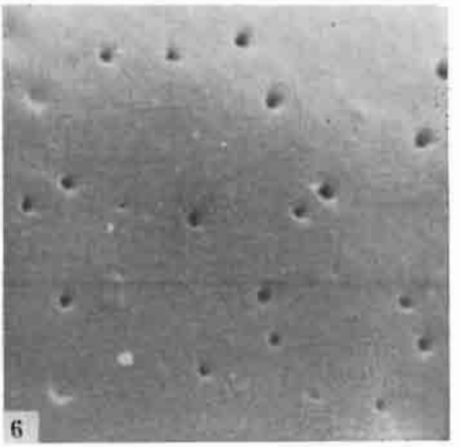
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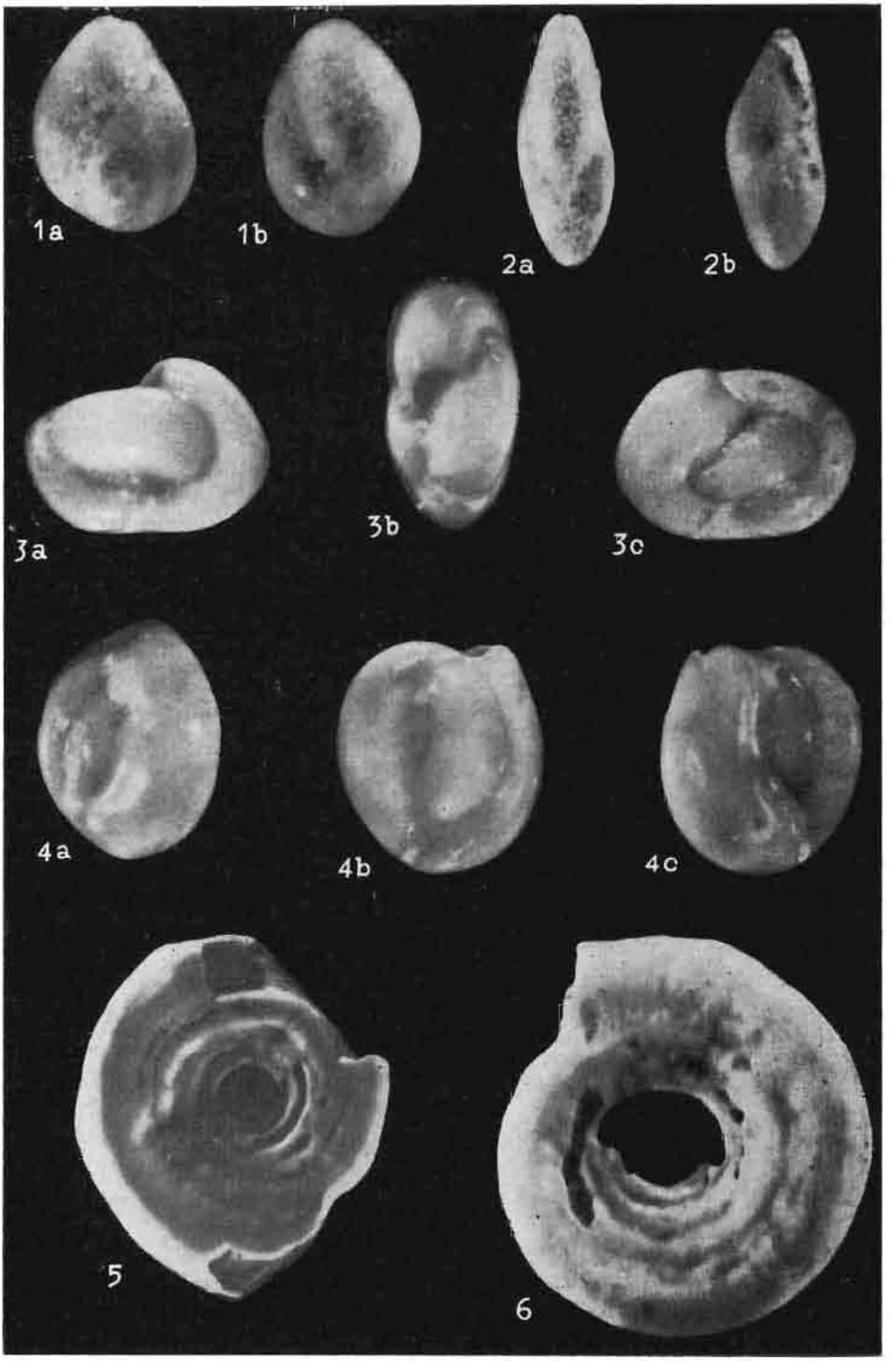
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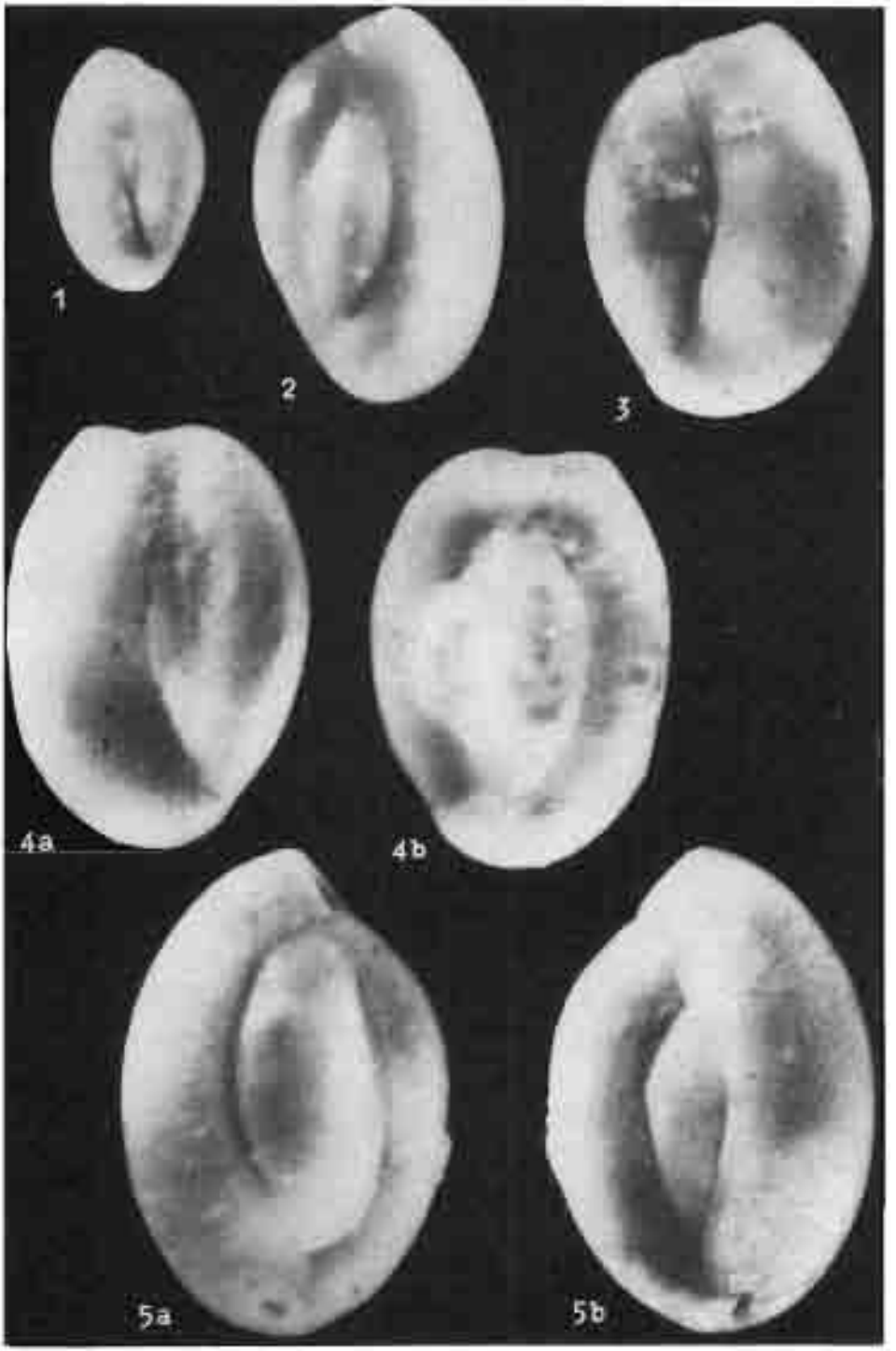
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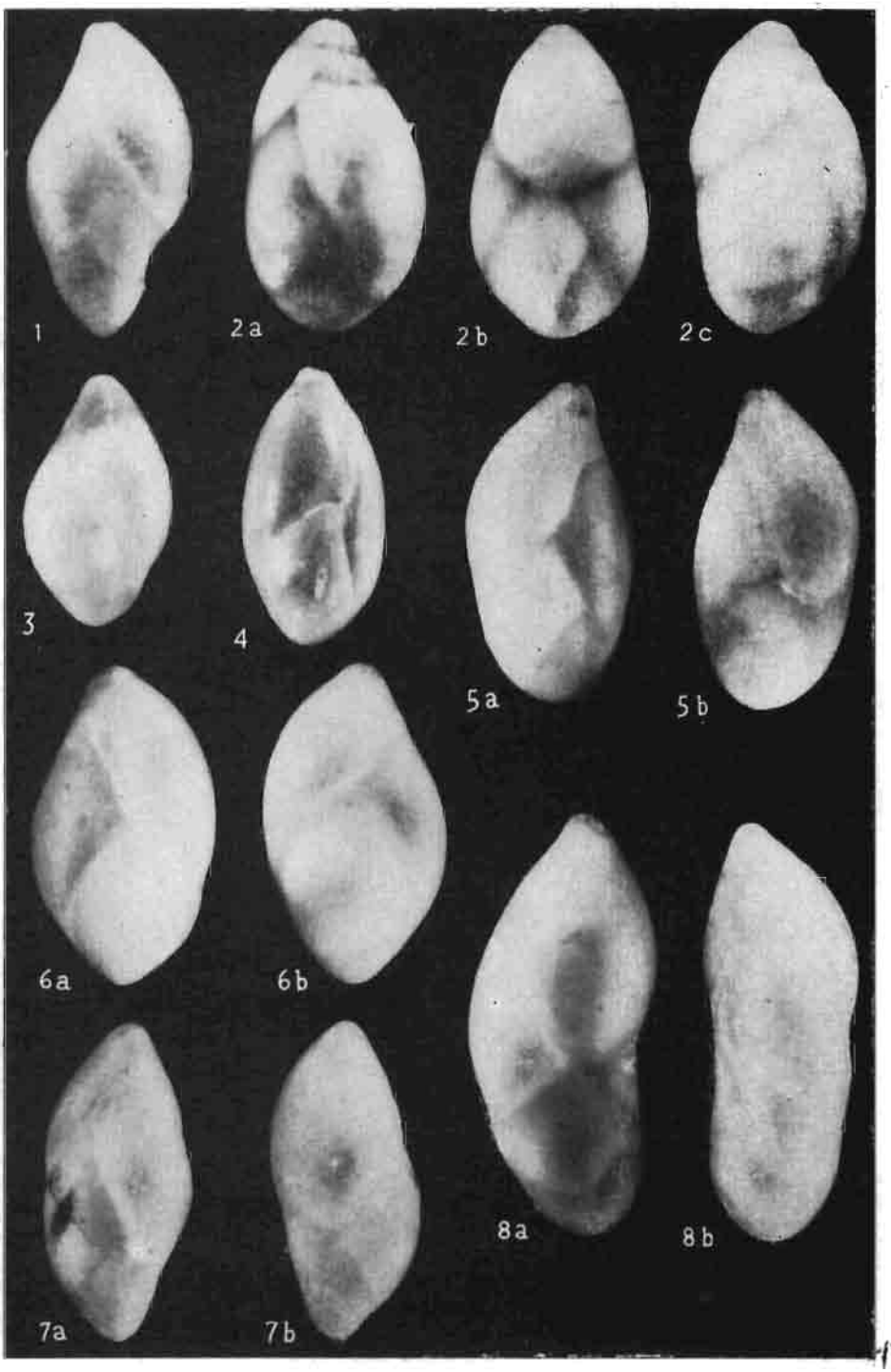
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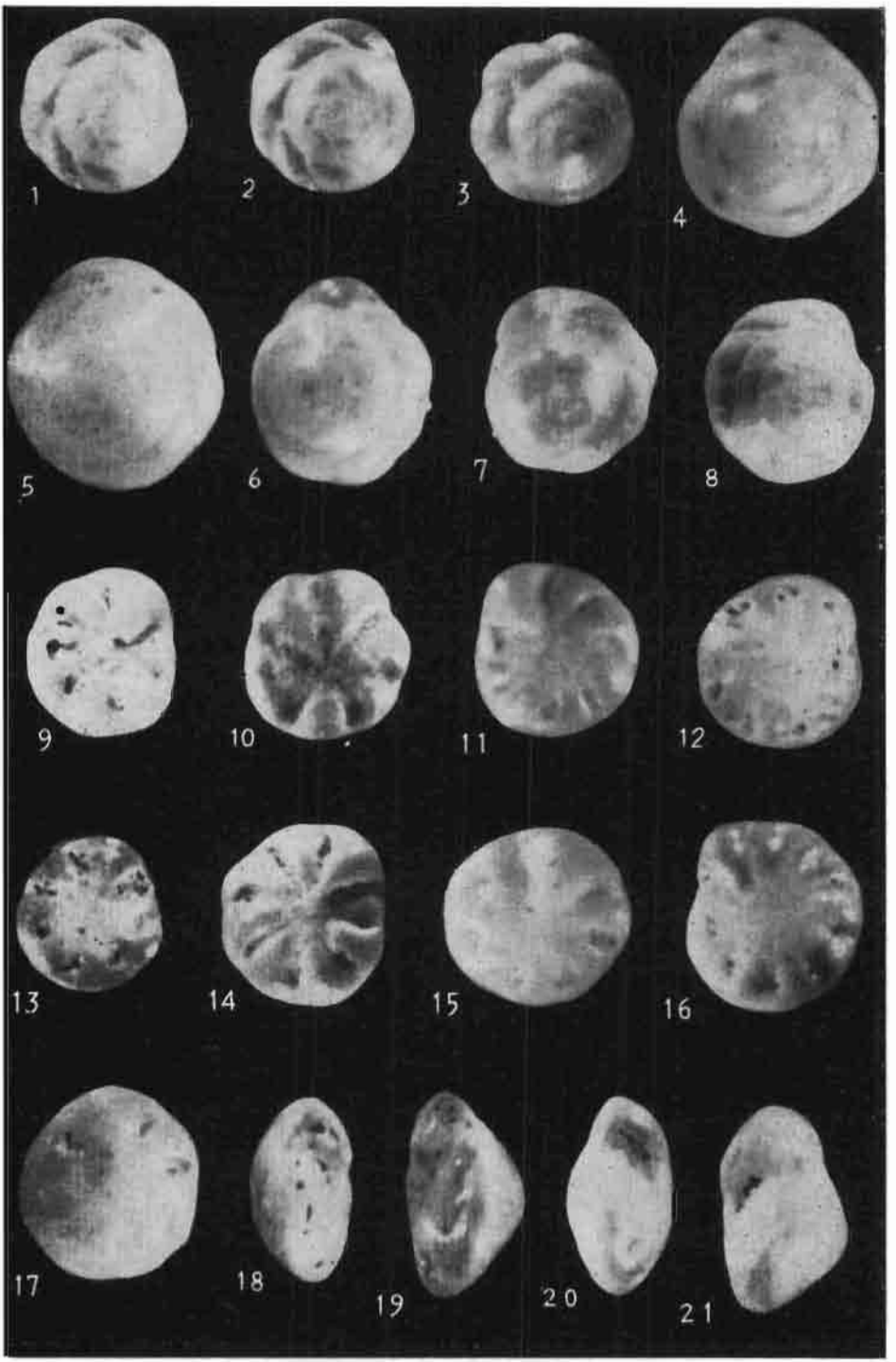
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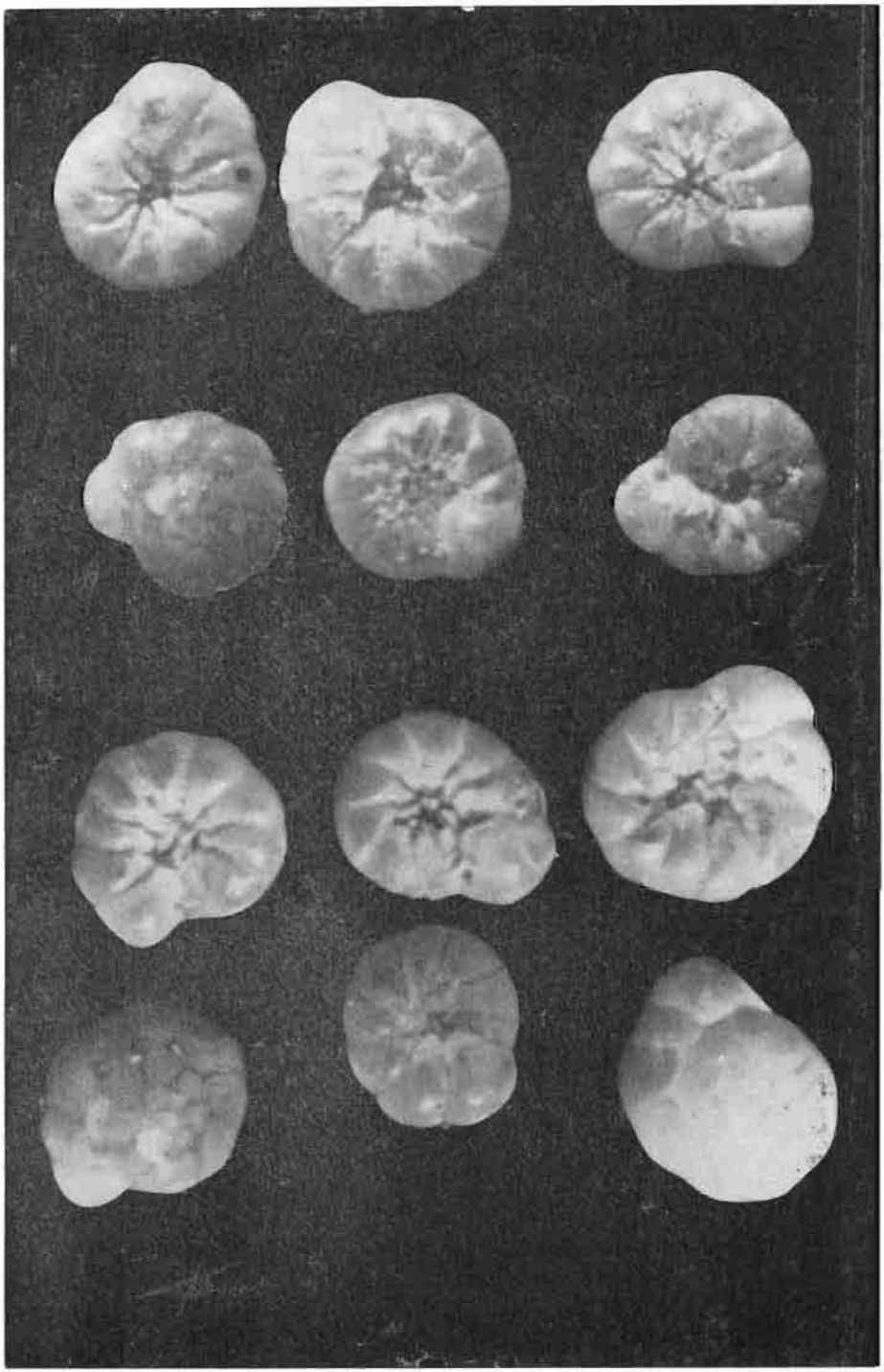

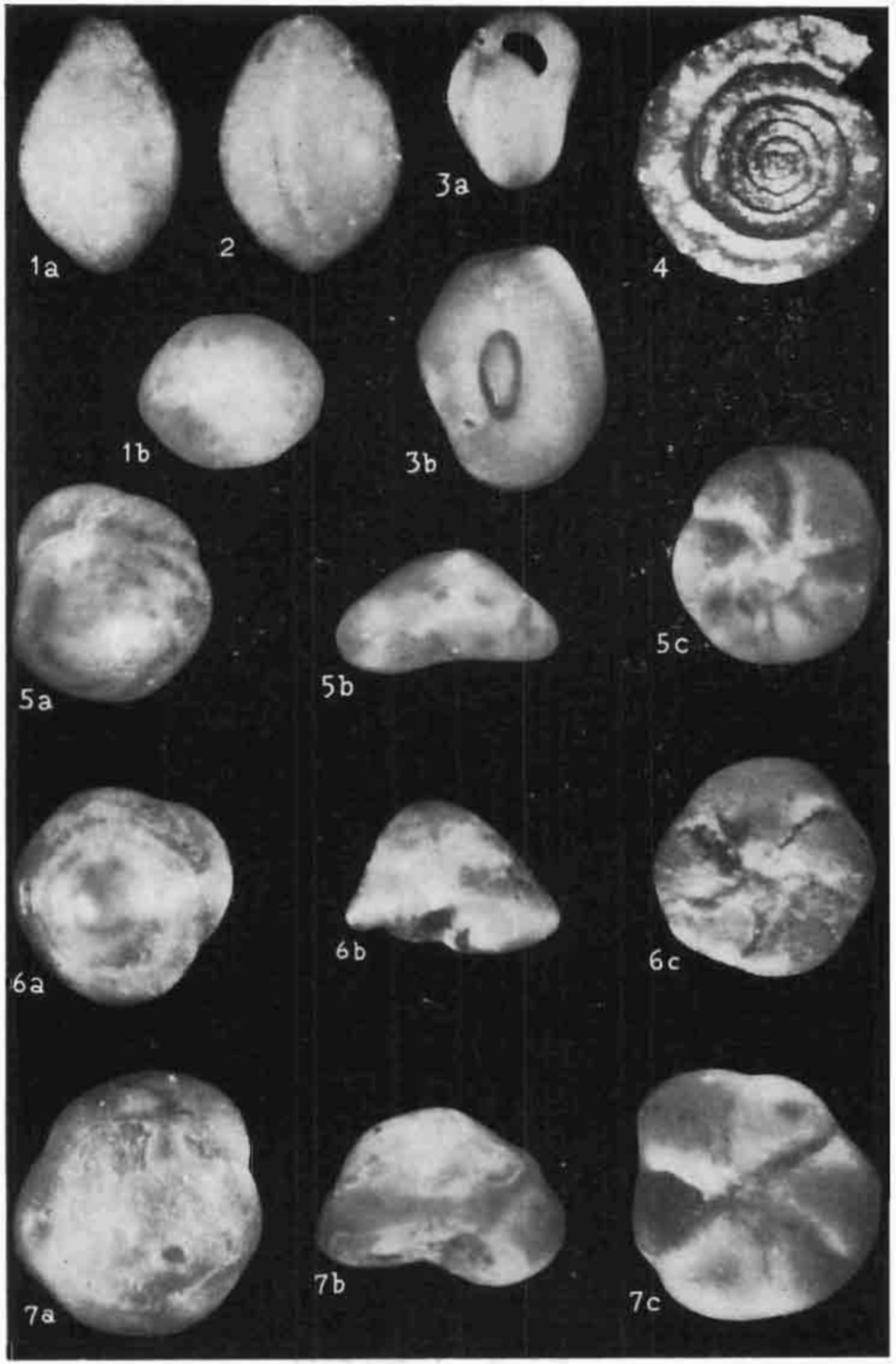
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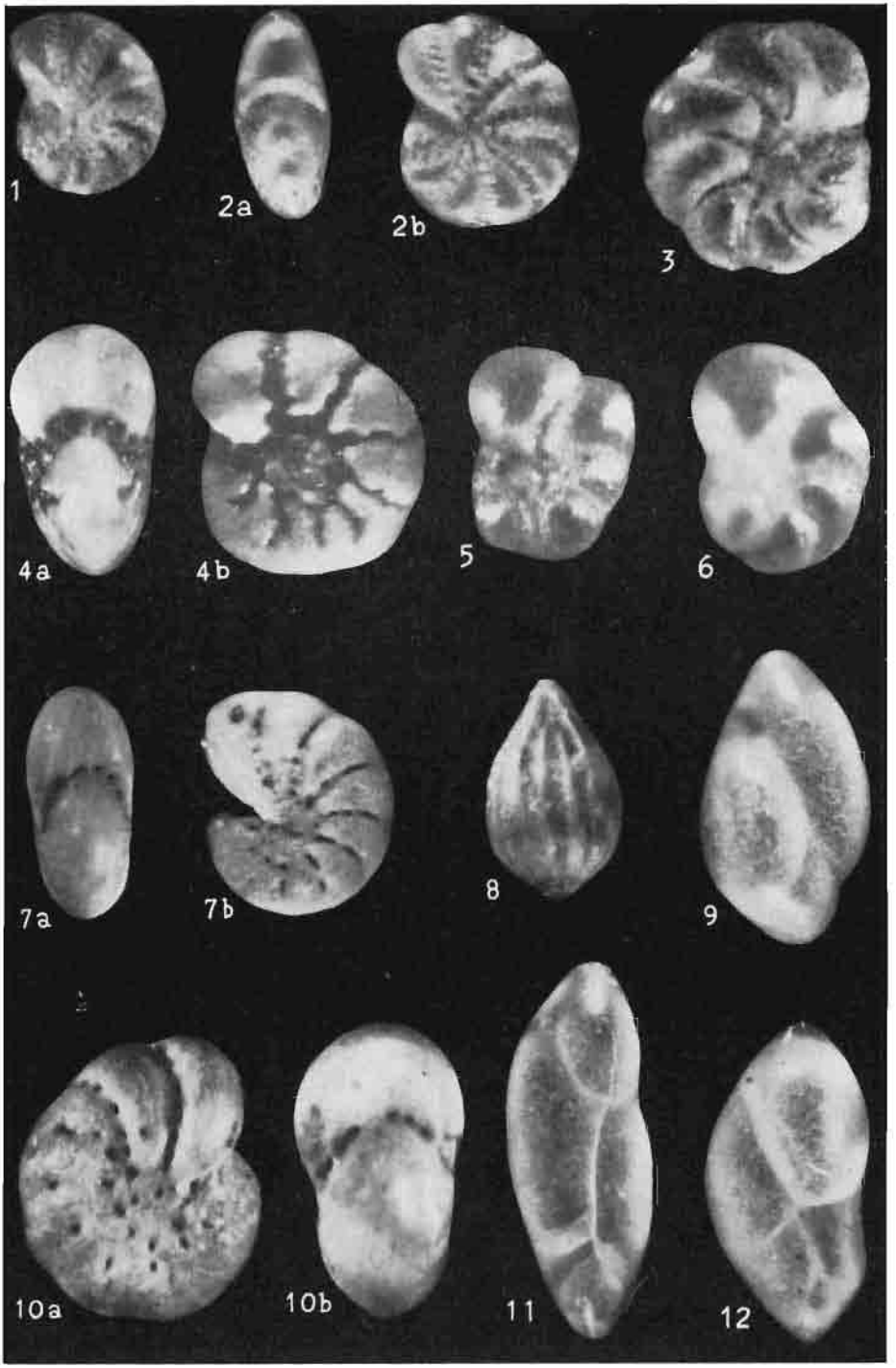
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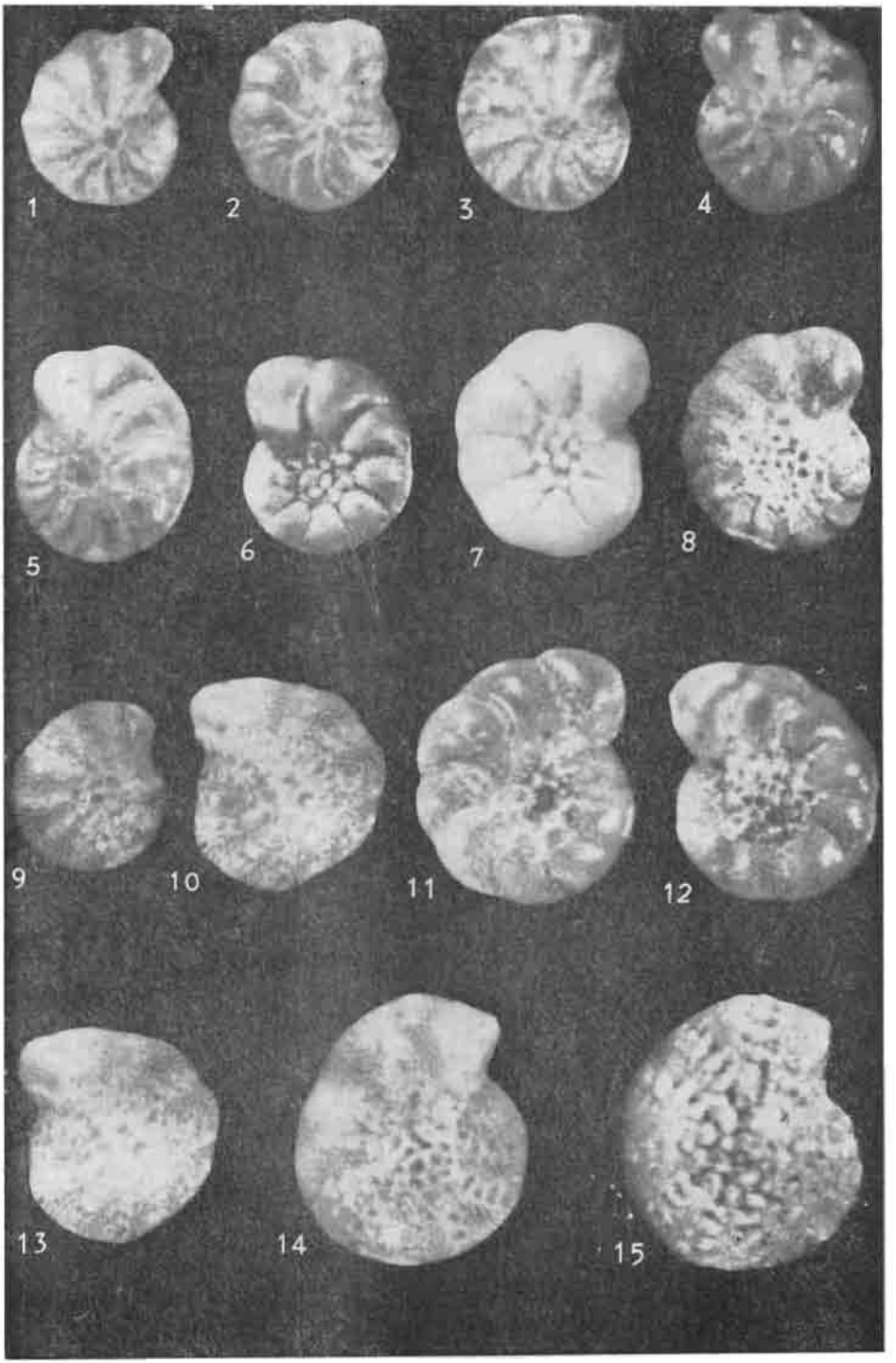
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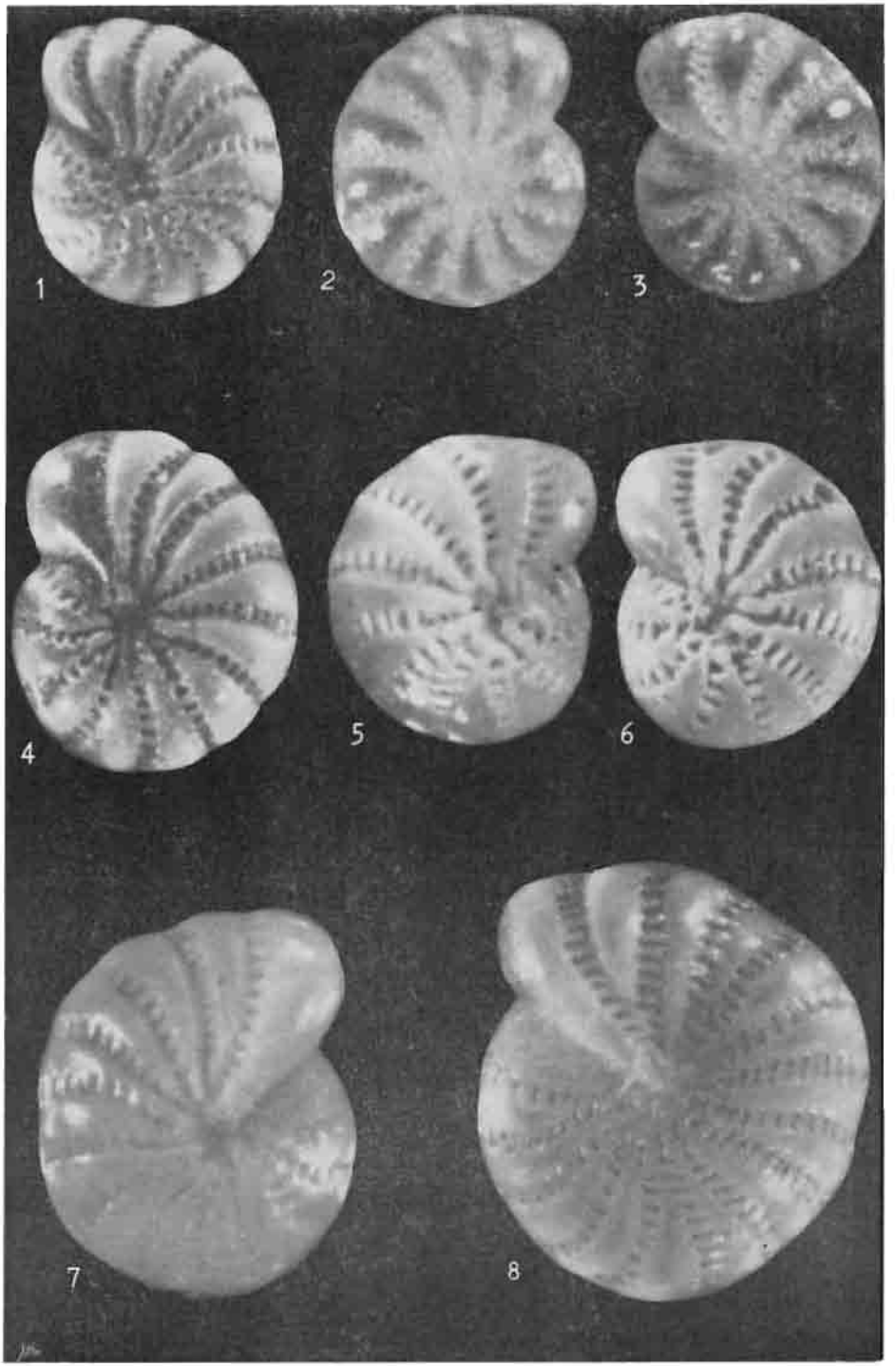
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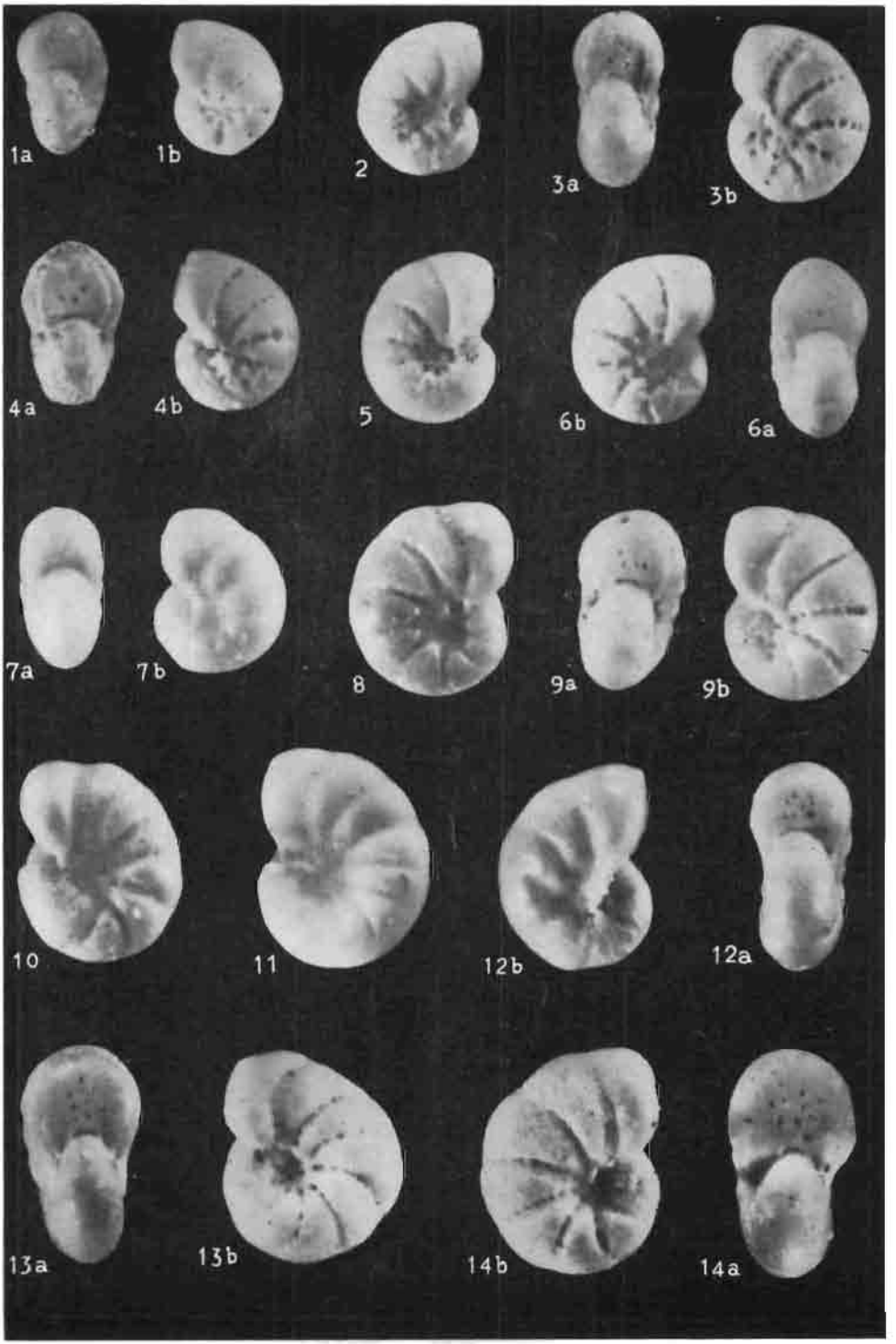
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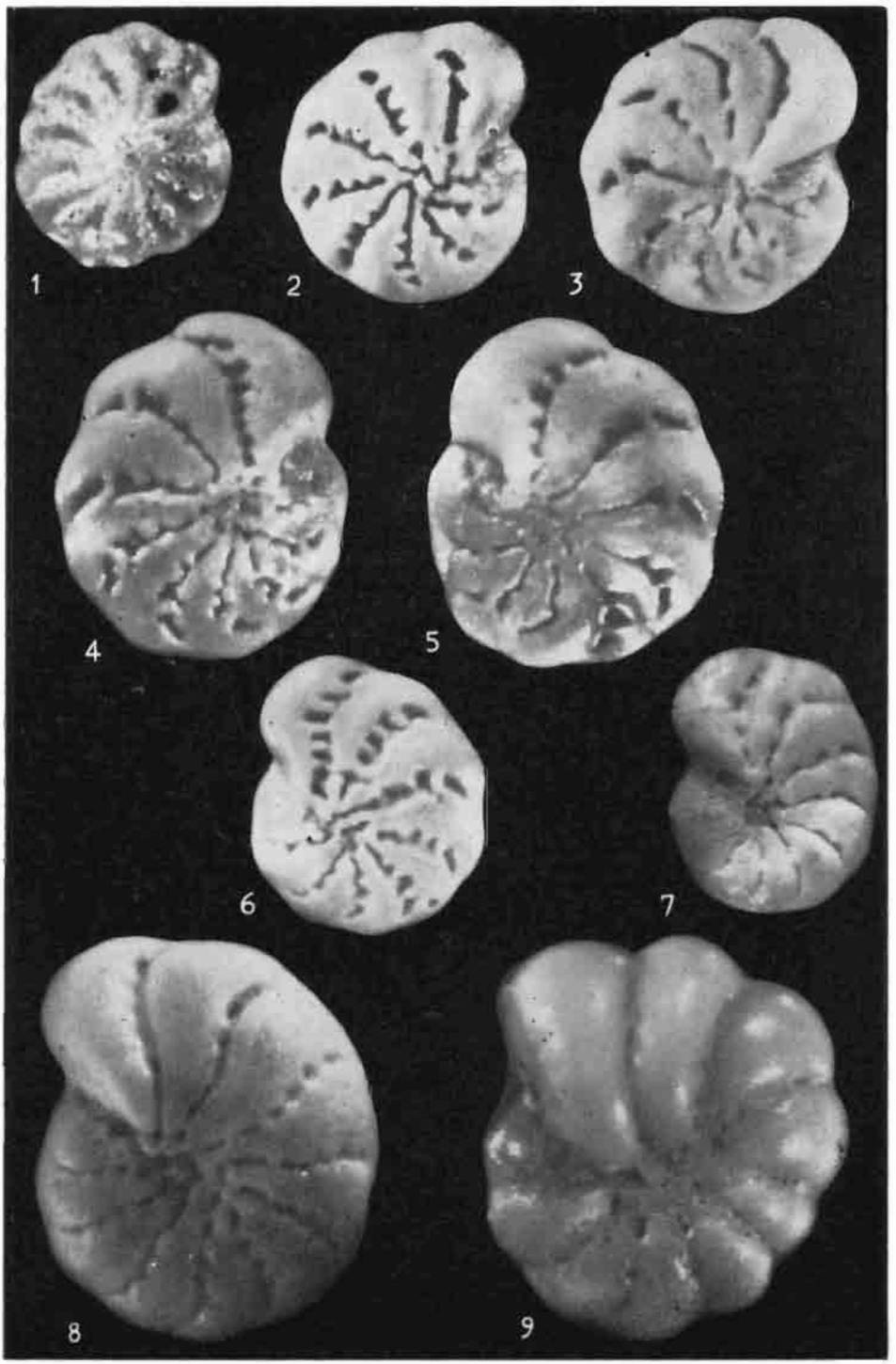
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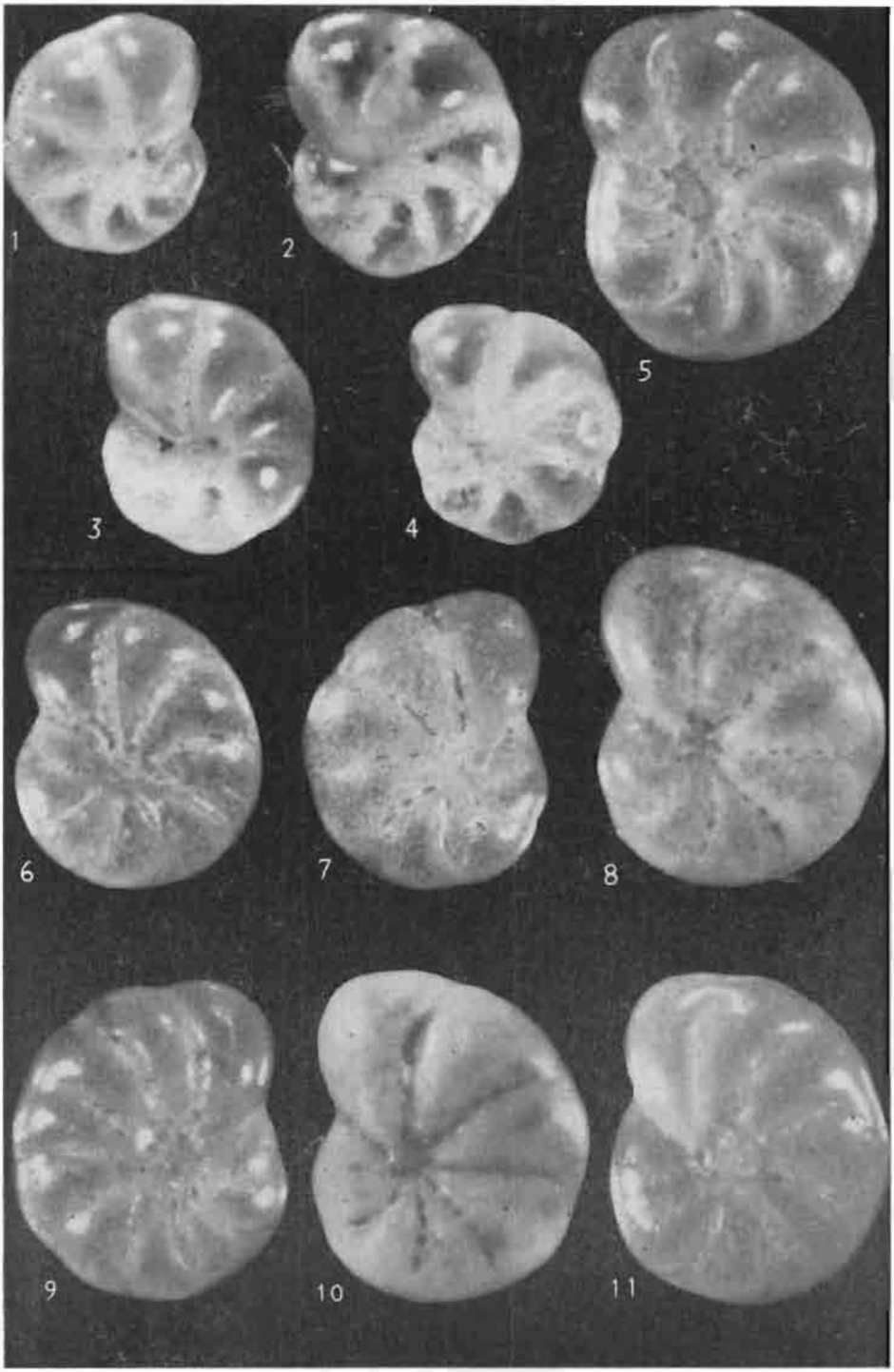
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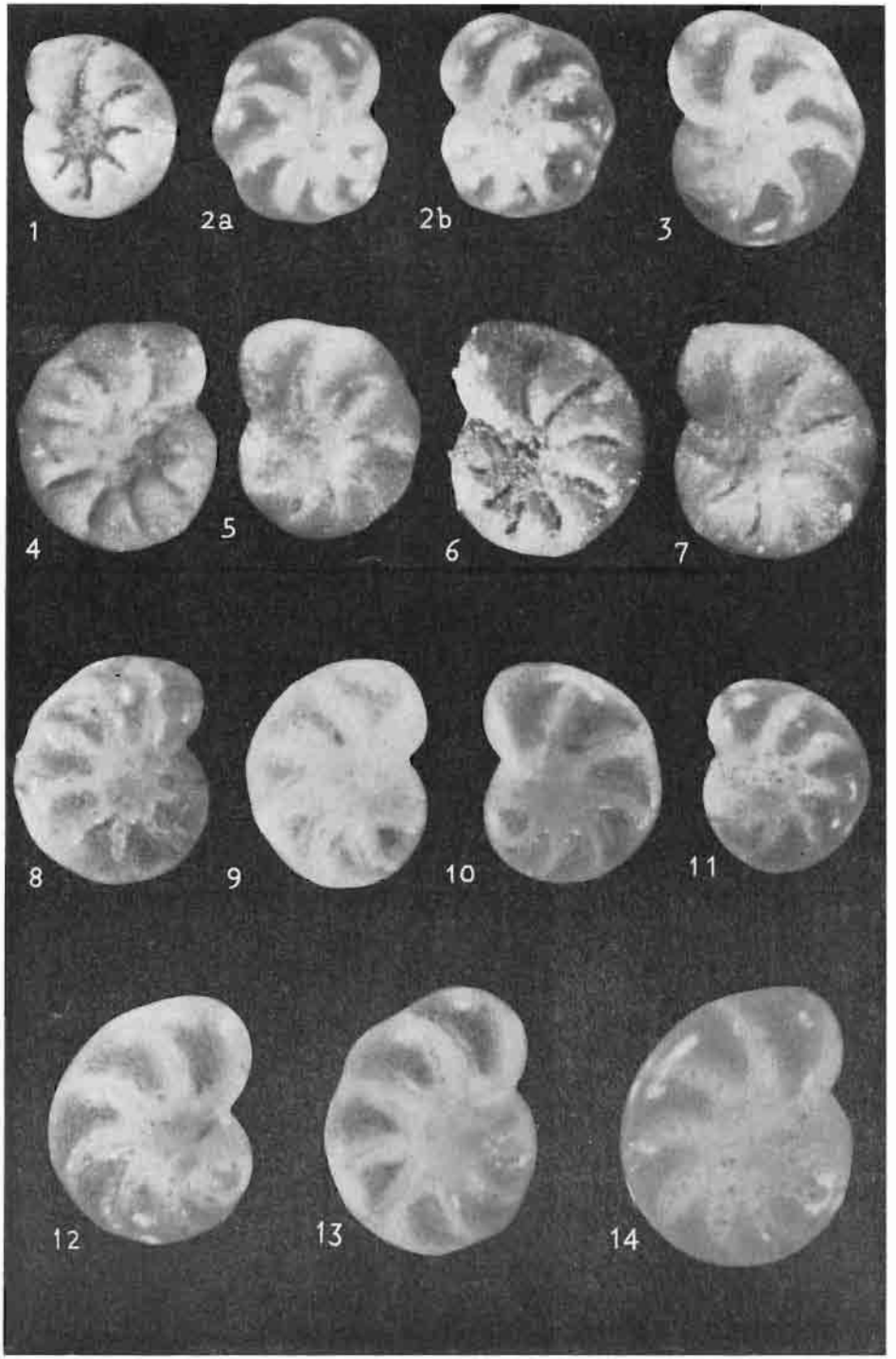
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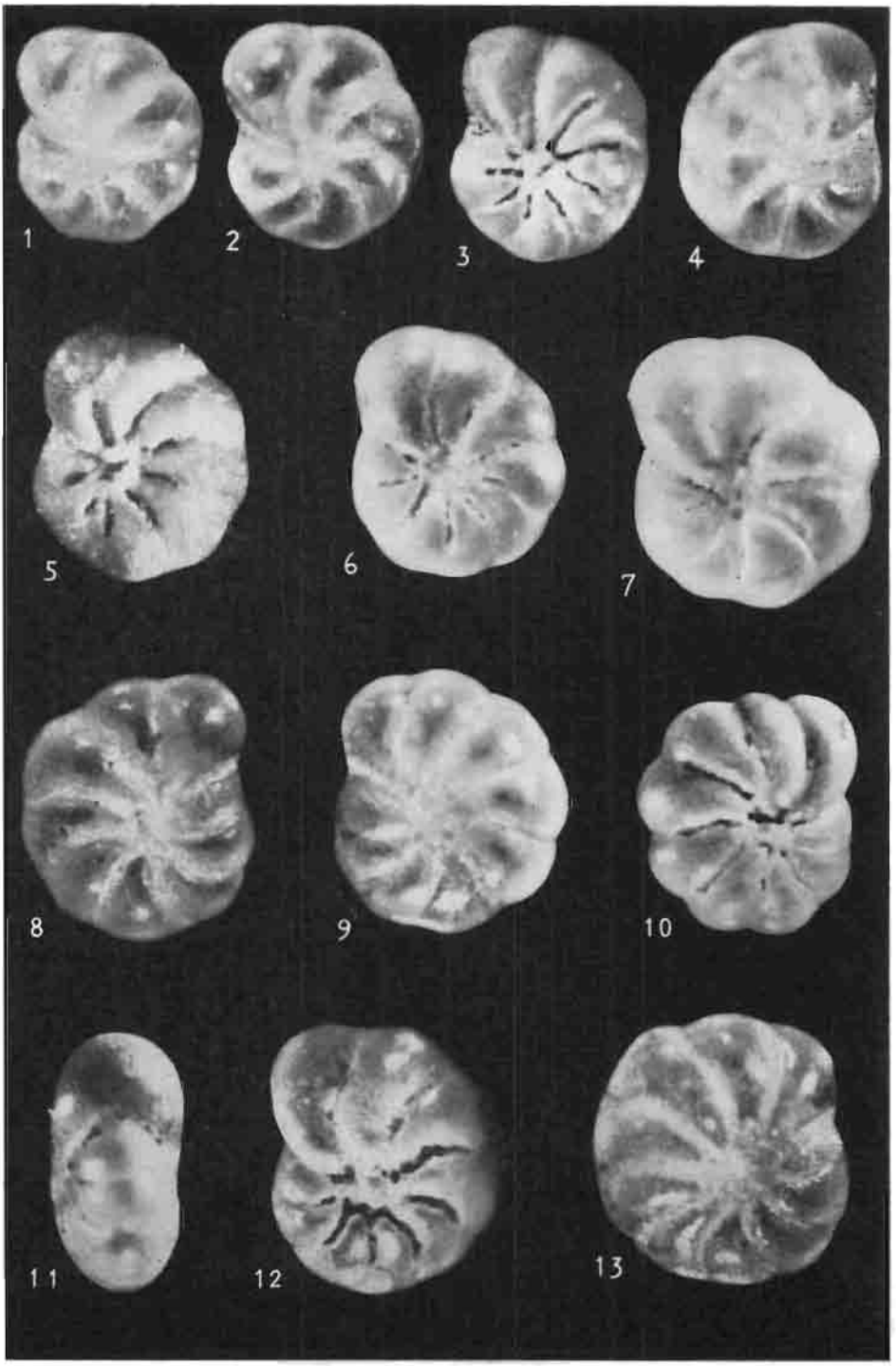
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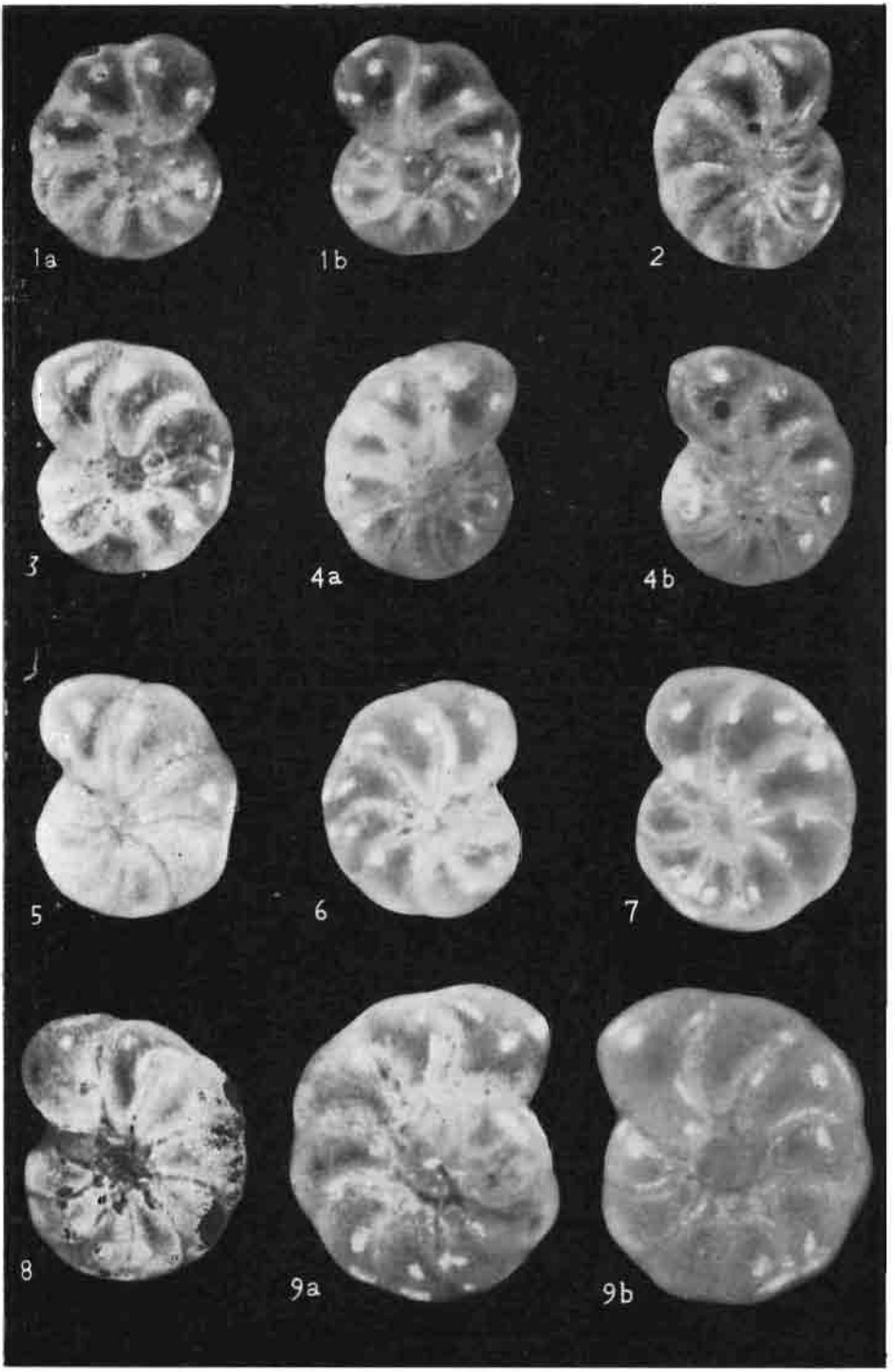
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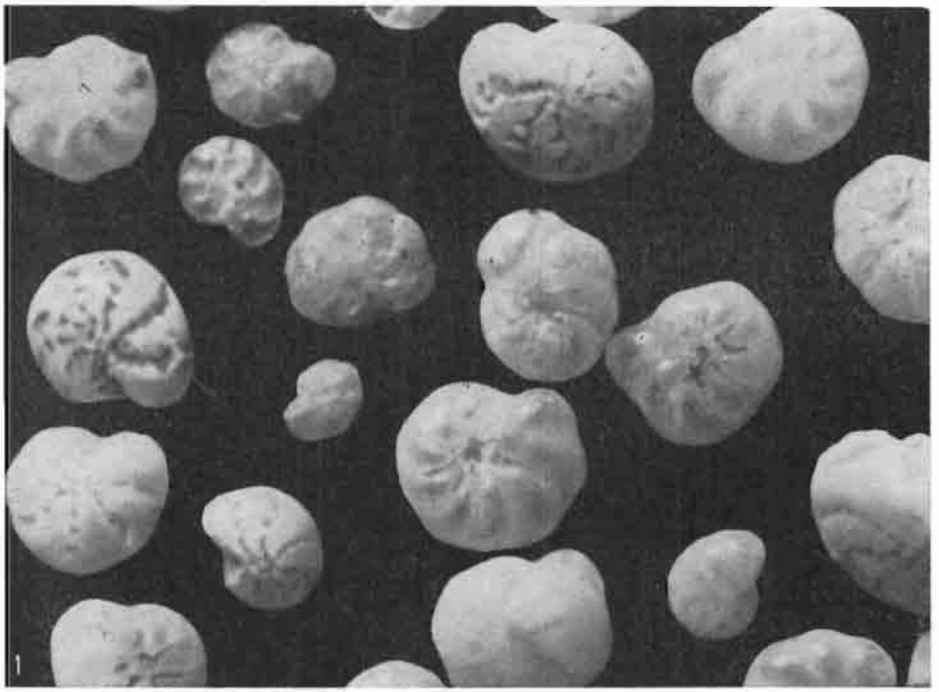
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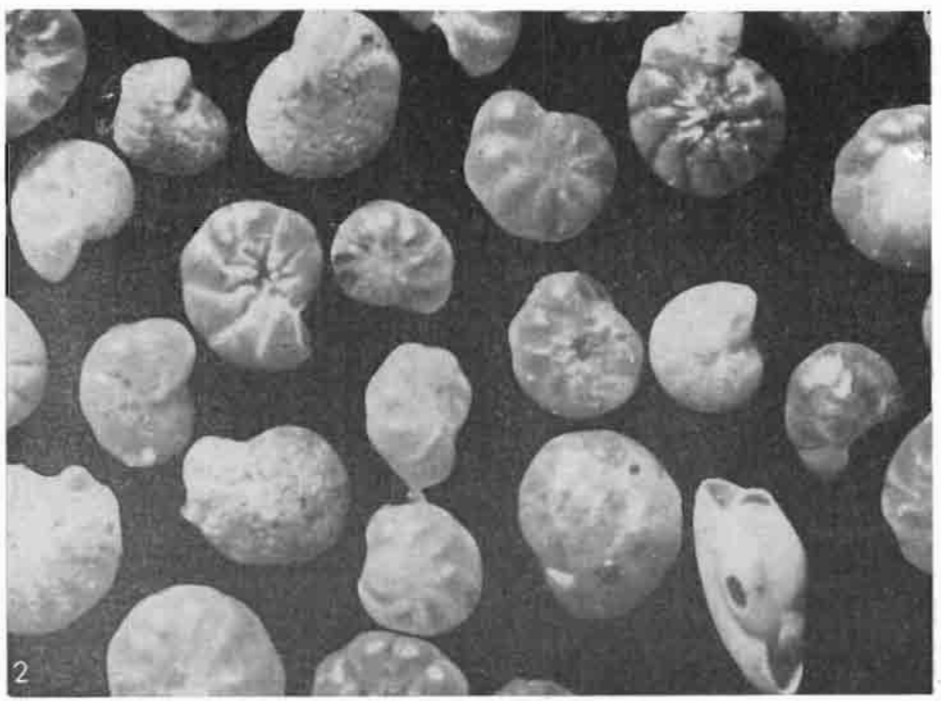
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Errata do No 4/72

Table 3

Distribution of foraminifers in the Nadbrzeże profile Explanation as in Fig.2

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