EWA ŁUCZKOWSKA

MILIOLIDAE (FORAMINIFERIDA) FROM THE MIOCENE OF POLAND PART II. BIOSTRATIGRAPHY, PALAEOECOLOGY AND SYSTEMATICS

CONTENTS

Abstract. — Descriptions are given of 103 species and subspecies of the Miliolidae from the Miocene of Poland, including 9 new species and 1 new name. A new genus, *Articularia*, and a new subfamily, Sigmoilinitinae, comprising species which show a sigmoiline initial stage and not a quinqueloculine or cryptoquinqueloculine one, have also been separated. The distribution and stratigraphic range of the species under study in the Tortonian and Sarmatian of Poland have been discussed and the hypothetical palaeoecologic conditions prevailing in the coastal facies of the Miocene sea reconstructed.

GENERAL PART

INTRODUCTION

In Poland the Miliolidae occur chiefly in the coastal facies of the Miocene of the Precarpathian Foredeep, i.e. at its northern border — in Upper Silesia, the Miechów region, Holy-Cross Mts. and Roztocze Mts. —

and in a few places at the southern border, e.g. in the regions of Wadowice, Rzeszów and Nowy Sącz. In smaller numbers they also occur in the facies of the central part of the Foredeep (Text-fig. 1). As regards stratigraphy, these Miocene deposits of Poland represent the Lower and Upper

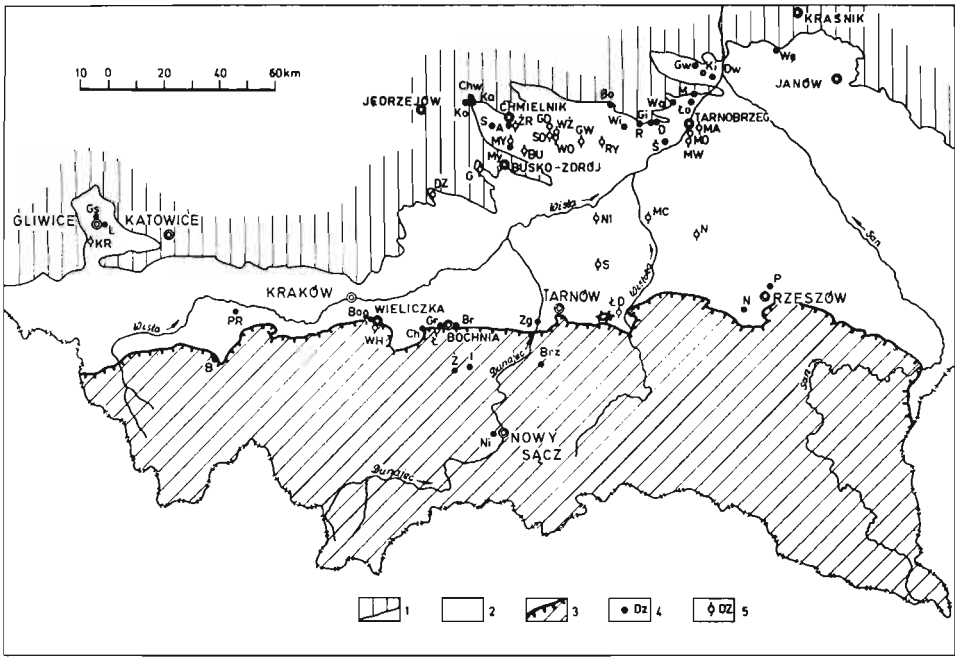

Fig. 1. Distribution of localities and boreholes in which Miliolidae have been found in the Miocene of Poland: *1* — Northern border of the occurrence of Miocene deposits; *2* — Northern border of the Carpathian overthrust *3* — localities: *A* — Andrzejówka, *B* — Benczyn, *Bo* — Bogoria, *Bog.* — Bogucice, *Br* — Brzeźnica, *Brz* — Brzozowa, *Ch* — Chełm n/Rabą, *Cw* — Chomentów, *D* — Dmosice, *Dw* — Dwikozy, *G* — Gacki, *Gd* — Gieraszowice, *Gs* — Gliwice Stare, *Gw* — Góry Wysokie, *Gr* — Grabowiec, *Gd* — Grudna Dolna, *I* — Iwkowa, *Ka* — Karsy, *Ki* — Kichary, *Ko* — Korytnica, *L* — Ligota Zabrska, *Ło* — Łojowice, *M* — Milczany, *My* — Młyny, *N* — Niechobrz, *Ni* — Niskowa, *P* — Pobitno, *R* — Rybnica, *S* — Samostrzałów, *Ś* — Świniary, *Wę* — Węglinek, *Wi* — Wiązownica, *Wl* — Wieliczka, *Wa* — Wielogóra, *Z* — Zabawa, *Zg* — Zgłobice, *Ż.* — Żegocina; *4* — boreholes: *BU* — Budy-1, *CZ* — Czechowice, *DZ* — Działoszyce, *G* — Gacki-1 and Gacki-4, *GD* — Grabki Duże N-8, *GW* — Grzybów x4 and Grzybów x5, *KR* — Krywałd, *Ł* — Łapczyca-1, 2 and 3, *ŁD* — Łęki Dolne-1, *MW* — Machów, *MO* — Miechocin O-3, *MC* — Mielec-6, *MY* — Młyny-1, *MA* — Mokrzyszów A-3, *N* — Niwiska-2, *NI* — Niwka-1, *PR* — Przeciszów, *RY* — Rytwiany-1, *S* — Sieradza-1, *SO* — Solec, *WH* — Wieliczka H-1, *WŻ* — Wola Żyzna, *WO* — Wolica, *ZR* — Zrecze-3.

Tortonian (Badenian — acc. to the suggestion of the Committee on Mediterranean Neogene Stratigraphy, Papp *et al.*, 1968) and the Lower Sarmatian.

The proposals concerning the classification of the Miliolidae on the basis of their internal structure and the shape of aperture have been presented in Part I (Łuczkowska, 1972). Part II comprises data about the distribution and stratigraphic range of the Miliolidae in the Miocene of

Poland, the discussion of the rich material studied, and the descriptions of 103 species and subspecies. Specimens are stored in the Department of Palaeontology and Stratigraphy, Academy of Mining and Metallurgy in Cracow.

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MATERIAL

The material for study was obtained from outcrops and drill cores. Its collection and preparation was carried out partly during the author's regular work and was partly enabled by a commission she received from the Institute of Geology in Warsaw and grants from the Committee for Geology, Polish Academy of Sciences in Cracow. The comparative material coming from the Miocene of other countries and recent seas was rendered accessible or delivered to the author by the micropalaeontologists mentioned in the acknowledgments. The list of localities and the sorts of materials used in this investigation are presented below.

Poland.

Outcrops. Lower Tortonian: Benczyn, Brzozowa, Chomentów, Gacki, Grudna Dolna, Iwkowa, Karsy, Korytnica, Wieliczka, Żegocina.

Upper Tortonian: Bogucice, Brzeźnica, Chełm n/Rabą, Gliwice Stare, Grabowiec, Ligota Zabrska, Niskowa, Pobitno, Rybnica, Świniary, Węglinek, Zabawa, Zgłobice. Sarmatian: Andrzejówka, Bogoria, Dmosice, Dwikozy, Gieraszowice, Góry Wysokie, Kichary, Łojowice, Milczany, Młyny, Rybnica, Samostrzałów, Świniary, Wiązownica, Wielogóra.

Bore holes. Tortonian and Sarmatian: Budy 1, Czechowice 1, Działoszyce, Gacki 1 and 2, Grabki Duże N-8, Grzybów x4 and x5, Krywałd, Łapczyca 1, 2 and 3, Łęki Dolne 1, Miechocin 03, Mielec 6, Młyny 1, Mokrzyszów A3, Niwiska 2, Niwka 1, Przeciszów, Rytwiany 1, Sieradza 1, Solec 103, 105—108, Wieliczka H1, Wola Żyzna 104, Wolica 101, Zrecze 3.

Other countries

Eocene: France. — Grignon. Oligocene: Berlin (Hermsdorf). Miocene (Tortonian and Sarmatian): Austria. — Baden (Sooss), Eisenstadt, Frättingsdorf, Nexing, Nussdorf, Ritzing, Siebenhürten, Steinabrunn, Wiesen, Vöslau. Czechoslovakia. — Devinska Nova Ves, Židlochovice. Hungary. — Hidas, Samsonhaza, Varpalota, Tekeres. Italy. — Tortona (S. Agata Fossili), Sicily. Romania. — Buitur, Lapugiu. Pliocene: Castell Arquato (Emilia, Italy), Palermo (Sicily).

Recent: Adriatic Sea (Sibenic, Grado, Val Muggia, Rovinj, Punta Grossa near Trieste); Mediterranean Sea (Haifa, Villefranche); Aegean Sea, from depths of 150 and 250 m; Tyrrhenian Sea, 23 m; Black Sea (Bosphorus region, 95 m; region bordering on Bosphorus, 15, 87, 93 and 98 m; Tuapse region, 47 m; Skadovsk region, 0.5 and 6.0 m); Gulf of Aden, 86 m; Arabian Sea, Omanian coast, 60 m; Indian Ocean, S of Bombay, 80 m, W of Bombay, 120 m; England (Bognor, Sussex, English Channel); Helgoland; Bergen Fiord.

METHODS

Two characters were used as main taxonomic criteria in determining genera: the internal structure of the test and the type of the aperture, because the number of chambers seen from the outside appeared to be a secondary character, as it is often the same in different genera (Part I, Łuczkowska, 1972). In the diagnoses and descriptions of species the author confined herself to the discussion of the front side of the test, in which the number of visible chambers is larger, and the apertural view, which is very important in identifying species. The back or small-chambered side adds no new features to the description. The terminology used in the descriptions is elucidated in Text-fig. 2.

In the descriptions of species of the genus *Quinqueloculina* two stages have been indicated, the quinqueloculine stage (QS) and the massiline stage (MS) [1], because a single stage does not cover the morphological data of the species. The dimensions are given for the smallest and the largest specimen of a given species and in the case of the genus *Quinqueloculina* also separately for the quinqueloculine and massiline forms.

[1] The abbreviations QS and MS have been introduced in Part I (1972) for the designation of the ontogenetic stages in determining the species of *Quinqueloculina*.

Attempts were made to base the identification of species on materials from the type localities, from which they had been described originally or on materials obtained from the deposits of the same age in the neighbouring area. This is especially true of the species erected by earlier authors, like d'Orbigny, Reuss or Karrer, whose orginal materials were

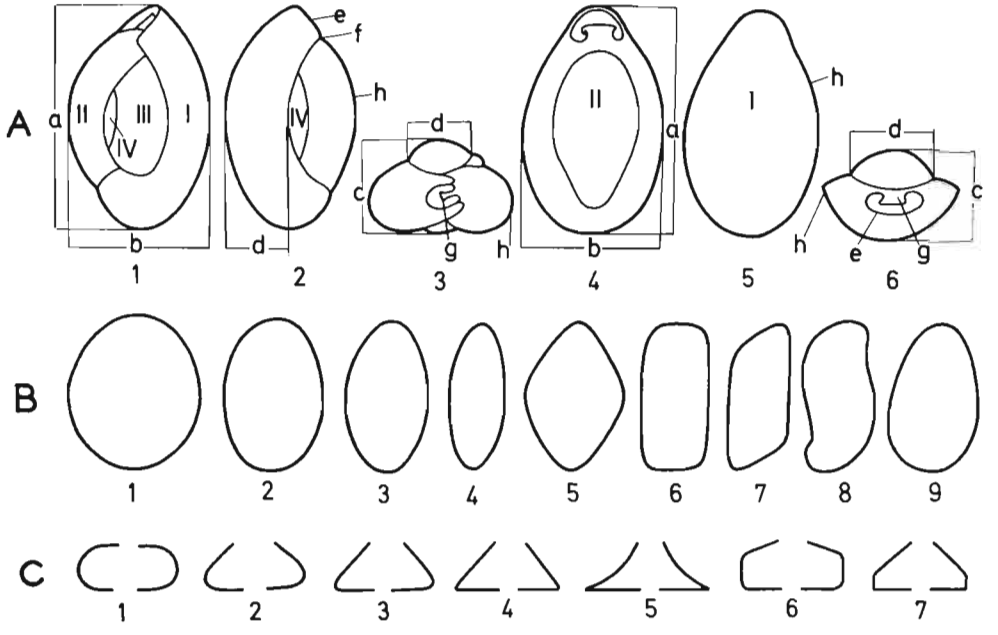


Fig. 2. Test morphology of Miliolidae: A. Chamber arrangement and dimensions. *1-3* — *Quinqueloculina*, *4-6* — *Pyrgo*; 1, 4 — front side, 2, 5 — back side, 3, 6 — apertural view; I, II — last chambers, III, V — central chambers (or middle chambers) of the front side, IV — central chamber of the opposite side (succession of chambers beginning at the last one); *a* length, *b* breadth, *c* thicknes, *d* width of the chamber, *e* aperture edge, *f* basis of the aperture, *g* tooth, *h* periphery or edge. B. Shapes of tests. 1 — broadly oval, 2 — oval, 3 — elongate oval, 4 — elongate or slender, 5 — rhomboid, 6 — rectangular or quadrangular, 7 — equilateral, 8 — sigmoid, 9 — ovoid. C. Periphery outline. 1 — rounded, 2 — subrounded, 3 — subacute, 4 — acute, 5 — keeled or carinate, 6 — quadrate, or angular, 7 — truncate, or subangular.

inaccessible to the author. She was in a position to see the holotypes and paratypes of some newer species personally, e.g. those described by Bogdanowich, Serova, Pishvanova, Didkovsky and Venglinsky. In this connection, the following symbols are placed beside the names of species:

* — species identified on the basis of comparison with the holotype (homeotype),

× — species identified on the basis of comparison with specimens from the locality and horizon in which the holotype was found (topotype),

\+ — species identified on the basis of materials of the same age as the holotype and from the same horizon, but from another locality of the same region, and

= — species identified after a consultation with its author.

Studies of morphological variation in some species, their ontogeny, differentiation of generations, etc. were carried out on transverse sections showing the proloculus and successive developmental stages. For example, the juvenile form of the genus *Quinqueloculina* generally occurs in a normal quinueloculine form, whereas the mature stage has a massiline form and is usually included in the genus *Massilina*. The sections of these massiline specimens exhibit the form of the quinqueloculine stage characteristic of each species.

The most time-consuming job was the grinding of specimens in order to obtain transverse sections. This was, as a rule, done by the modified method described by Bogdanowich (1952, p. 49). The consecutive manipulations were as follows:

1) A drop of liquid Canada balsam was placed on a slide, there being usually 10 slides in a series.

2) The slides with balsam on them were put in a thermostat for the balsam to attain the desired density.

3) After the removal and cooling of the slides up to the complete hardening of the balsam, one specimen was placed on each drop.

4) The balsam was melted in the place where the specimen was positioned by means of an electrically heated needle and the specimen stuck to it immediately. The specimen was set in the desired position by suitable manipulations of the heated needle, attached by its base only, and covered all over with a thin envelope of balsam. Mounted in this way, it projected above the surface of the hardened drop and could be ground down easily and quickly, there being no need to grind off the whole surface of the balsam, which takes very much time.

5) Grinding was done under a binocular microscope, which afforded possibilities for constant visual check-up. The slide with a specimen was placed on a glass support, equal to it in area and at least 5 mm thick (e.g. three slides put together) to keep the specimen at a certain distance from the stage of the microscope and thus to facilitate the movements of the hand at the time of grinding. Next a drop of water or glycerol and a little abrasive dust were placed on a slide of frosted glass, the slide was turned its frosted side down and the specimen, watched under the microscope, was ground with circular movements, from the top down to the proloculus. Frosted glass wetted from below is transparent and makes it possible to watch the procedure all the time. The nicety of movements and some skill are indispensable, since an excessive pressure exerted on the specimen may cause its destruction; as a result, however, we obtain a transverse section of the specimen unfilled with balsam and therefore more distinct and easier to draw or to take a photograph of. Nevertheless, with respect to very small and fragile specimens, it is advisable to fill the chambers with balsam, which can be accomplished by nearing the electrically heated needle to the specimen, partly ground

down, and melting the surrounding balsam slightly. Then the balsam enters the chambers, but the specimen needs resetting in the upright position. The method of filling specimens with balsam by boiling them in it after their being dipped in xylol, recommended by Pokorny (1958), was not effective, for balsam in the chambers was softer than that surrounding the specimen. The method described here is superior to the method of grinding specimens embedded entirely e.g. in polymers and to that of cutting them with a razor, as proposed by some investigators (Haake 1964), in that it enables the worker to check his work constantly, to stop grinding at suitable moments, and to handle the specimen and correct its position by melting the balsam in the course of operation. This method also allows the filling of the chambers with balsam when they are all open after initial grinding. In whole, unground, fossil foraminifera the filling of the interior with balsam or any other hardening compound is rarely effective, since it is enough that a grain of sand sticks in the last chamber for the inflow of liquid to be stopped. The preparation of sections by the present method is successful in at least 90 per cent of specimens.

The electrically heated needle used for handling specimens in balsam was manufactured according to the description given by Triebel (1958, p. 115, Text-fig. 16). All manipulations were performed with the switch in the hand so that the current could be switched on or off at any moment without interrupting observation through the microscope and without putting the needle aside.

Diagrammatic drawings of whole specimens were made before and those of their sections after the specimens were ground down. The photographs of sections taken by means of available equipment were not accurate enough because of big differences in size between the proloculus (values of the order of a few microns) and the whole specimen (values of the order of several millimetres). A total of 437 sections and as many drawings were made.

All the drawings in text and in plates have been made by the author.

HISTORY OF STUDIES ON THE MILIOLIDAE

The classification of the Miliolidae has been giving trouble to micropalaeontologists for more than 150 years, i.e. since the first attempts were made to include the foraminifera in Linnaeus's system. At first they were numbered in various genera containing also other foraminiferal groups, like *Serpula* and *Vermiculum*. It was only in 1826 that d'Orbigny grouped the miliolid species known at that time into six new genera: *Biloculina*, *Spiroloculina*, *Triloculina*, *Articulina*, *Quinqueloculina* and *Adelosina*. Later, in 1839, he separated another new genus, *Hauerina*. The definitions of these genera were based on the number and shape of the chambers visible from the outside and we cannot refrain from admiring

d'Orbigny for his discerning observation, since though these definitions lack detailed data concerning the internal structure of the tests, they have not lost their validity up to now and are used all over the world. Soon, however, there arose difficulties in the classification of some forms which could not be included in any of these genera, and further studies were continued in two directions: some workers supplemented d'Orbigny's classification by adding new genera, others concelled them and synonymized them with other old or new taxonomic units that had a wider range of classificatory criteria.

The first trial of overcoming these difficulties, going in the latter direction, was made by Williamson in 1858, who integrated the forms having their chambers coiled, two in a whorl, round the vertical axis, together with the genera *Quinqueloculina*, *Triloculina* and *Adelosina*, established by d'Orbigny, into a new genus, *Miliolina*. This seemingly simplified many problems of classification and, thanks to the facility with which the genus *Miliolina* could be applied for forms that differ much from each other both morphologically and in their internal structure, it persisted in literature for nearly 100 years. In the last century the main followers of this trend were Carpenter, Parker, Jones, Brady, Rhumbler and Goes. This last investigator tried even to unite all d'Orbigny's genera in one genus, *Miliola* Lamarck. More detailed data concerning this page of the Miliolidae are presented in a paper by Cushman (1917).

In the present century the direction established by Williamson was continued chiefly by Wiesner (1912, 1918 and 1931) and Bogdanowich (1947 and 1952). Studying the recent foraminifera of the Adriatic Sea, Wiesner (1931) consistently used the genus *Miliolina* Williamson, with which he synonymized *Triloculina* d'Orbigny, *Quinqueloculina* d'Orbigny, *Massilina* Schlumberger and *Sigmoilina* Schlumberger. He attached great importance to the characters of the test and grouped them according to their significance for the determination of forms (1912). He regarded the arrangement of chambers as the criterion of the division into larger groups, "Formenkreise", the material of test walls, the shape of apperture and, partly, the proloculus as the basis for the division into subgroups, and the surface ornamentation and the presence of an arenaceous layer as the basis for the division into "Nebenformen", of minor importace. Using these criteria, he distinguished 4 larger groups, "Formenkreise", from among the forms with two-chambered whorls: I. *Nubecularia* Defrance, II. *Spiroloculina* d'Orbigny, III. *Miliolina* Williamson and IV. *Biloculina* d'Orbigny. Later, he (1918) somewhat changed this division, distinguishing one larger group, Spiroloculininae, in which he included the genera belonging to the groups separated previously: *Spiroloculina* d'Orbigny, *Miliolina* Williamson, *Articulina* d'Orbigny, *Adelosina* d'Orbigny, *Nodobacularia* Rhumbler, *Biloculina* d'Orbigny, *Nummoloculina* Steinmann, *Hauerina* d'Orbigny and *Ceratina* Goes. In his last paper (1931) he raised

the group Spiroloculininae to the rank of subfamily, in which, in addition to the above-mentioned genera, he placed also *Tubinellina* gen.n., *Flintina* Cushman, *Ptychomiliola* Eimer et Fickert, *Nubeculina* Cushman and *Flintia* Schubert, and separated two new genera on the basis of their having a plate-like tooth in the aperture; these are *Miliolinella* and *Biloculinella*. In this concection the genus *Miliolina* was split into three genera: *Miliolina* Williamson proper, with a simple tooth, *Miliolinella* gen.n., with a plate-like tooth, and *Miliola* Lamarck, with a trematophore aperture, and the genus *Biloculina* into two genera: *Biloculina* proper (now *Pyrgo*), with a bifid tooth, and *Biloculinella* gen.n., with a plate-like tooth.

Wiesner (1918) was, therefore, one of the first writers who acknowledged the taxonomic value of such characters, hardly taken into consideration up to then, as the shape of the aperture, the mode of its narrowing, the type of the apertural tooth and the material of the test walls. He even paid attention to the differences between the surfaces of tests in the Miliolidae, distinguishing there degrees of lustre, dull, oily, and porcellaneous or brilliant, and applying this differentiation in his division into "Formenkreise". Unfortunately, the series of forms established by him so meticulously are only of practical significance, they facilitate the identification of species, rather than of systematic import, because they do not include the internal structure of tests nor do they utilize the criterion of apertural structure fully, although they show first steps taken in this direction.

Bogdanowich (1947 and 1952), who in his studies based himself chiefly on the classification of Brady (1884) and, partly, that of Wiesner (1932), did not go any further. In his monograph of the Miliolidae of the USSR (1952) he acknowledged the genus *Miliolina* Williamson together with its synonyms, among which he also numbered *Miliolinella* Wiesner. Later, Bogdanowich (*in* Rauzer-Chernousova & Fursenko, 1959) gave up the genus *Miliolina* and recognized the genera *Quinqueloculina* and *Triloculina*. He considered most of the former synonyms of *Miliolina*, e.g. *Adelosina* d'Orbigny, *Massilina* Schlumberger and *Miliolinella* Wiesner to be synonymous with the genus *Quinqueloculina*. However, he did not recognize the genus *Biloculinella* Wiesner in the paper referred to and treated it as a synonym of *Pyrgo*. As can be seen, in this classification the significance of apertural characters diminished compared with Wiesner's views and Bogdanowich laid stress on the internal structure and genetic relationships instead.

The investigators who assented to and supplemented d'Orbigny's division of the Miliolidae into genera were, in the first place, Reuss, active in the middle of the nineteenth century, Schlumberger towards the end of the nineteenth century, and Cushman at the beginning of the present century. Reuss (1862) grouped the porcellaneous calcareous foraminifera

in four larger units: Squamulinidea (?), Miliolidea, Peneroplidea and Orbitulitidea. He next divided the Miliolidea into three groups: 1) Cornuspiridea, comprising the genus *Cornuspira* Schultze, 2) Miliolidea proper, including d'Orbigny's genera *Uniloculina*, *Biloculina*, *Spiroloculina*, *Triloculina* and *Quinqueloculina*, and 3) Fabularidea, having only one genus, *Fabularia* Defrance. Studying the internal structure of tests on sections, Schlumberger was the first to pay attention to the occurrence of micro- and megalospheric forms in many species and to the generic characters present at the juvenile stage. Sections of miliolids, exhibiting their internal structure, were known also to other investigators, like Parker (1958), Brady (1884) and Goes (1896), who, however, did not utilize them in classification. A great many such sections, figured in the papers by Schlumberger & Munier-Chalmas (1885) and Schlumberger (1886, 1891 and 1893 *a*, *b*), especially in his monographic paper on the Miliolidae of the Gulf of Marseilles (1893 *a*), prompted the separation of a number of genera on the basis of their developmental characters and became the foundation of the later classifications based on genetic relationships. The new genera erected by Schlumberger are *Sigmoilina* and *Massilina* and a number of others containing forms with a trematophore aperture and separated by him in collaboration with Munier-Chalmas.

In working out the Miliolidae of the Gulf of Marseilles, Schlumberger used the drawings gathered in d'Orbigny's unpublished plates (1826) and sections prepared by himself. He distinguished 6 groups differing in the arrangement of succeeding chambers: 1) group *Biloculina* — 2 planes of symmetry (*Biloculina*, *Spiroloculina*, *Sigmoilina*), 2) group *Triloculina* — 3 planes of symmetry (*Triloculina*), 3) group *Quinqueloculina* — 5 planes of symmetry (*Quinqueloculina*, *Massilina*), 4) group *Adelosina* — special arrangement of two initial chambers, 5) group *Planispirina* — one plane of symmetry (*Cornuspira*, *Planispirina*, *Ophthalmidium*), and 6) group *Vertebralina* — early chambers quinqueloculine, later ones arranged rectilinearly (*Vertebralina*, *Articulina*).

Cushman (1917) made use of Schlumberger's sections in his monograph of the Miliolidae of the North Pacific Ocean, in which he discussed their phylogenetic development, the characters of the initial stage and the evolution of particular groups, from the most primitive groups to the most specialized ones: *Cornuspira* — *Ophthalmidium* — *Planispirina* — *Spiroloculina* and derived forms — *Quinqueloculina* and derived forms — *Triloculina* — *Biloculina* — *Idalina* and *Peneroplis*. So far as systematics is concerned, he grouped them in the family Miliolidae and two subfamilies, Cornuspirininae and Quinqueloculininae.

In 1927 Cushman published his outline of classification of the Foraminifera, later revised and complemented several times, at that time the first and only synthetic elaboration of the Foraminifera on genetic relationships. As regards the miliolids, in the first draft their classification

did not differ from that presented in 1917. In the next editions (1928, 1933, 1940 and 1948) there are already three families: Miliolidae, Ophthalmidiidae (including, among other groups, the subfamily Cornuspirininae) and Fischerinidae. The Miliolidae were not divided into subfamilies, instead they comprised all d'Orbigny's genera, Wiesner's two genera (*Miliolinella* and *Biloculinella*), Schlumberger's two genera (*Massilina* and *Sigmoilina*), single genera introduced by other authors, e.g. *Nummoloculina* Steinmann, *Tubinella* Rhumbler, *Miliola* Lamarck, and several new genera described by Cushman himself: *Nubeculina*, *Ammomassilina* and *Flintina*.

Cushman initiated a period of keen interest in the genetic classification of the Foraminifera, which found its reflection in new elaborations appearing every several years. At first the authors grouped the known miliolid genera in one family, Miliolidae, after the fashion of earlier writers (Galloway, 1933), and in three families, after the fashion of Cushman (Chapman & Parr, 1936). Glaessner (1945) introduced a higher taxonomic unit, i.e. the super-family Miliolidea divided into four families, with two of which, the Miliolidae and Ophthalmidiidae, we are concerned. Sigal (1952) and Pokorny (1958) applied the same division, in which they made only small changes within the subfamilies. The classification proposed by Bogdanowich and Voloshinova (*in* Rauser-Chernousova & Fursenko, 1959) was characterized by the introduction of a still higher rank, i.e. the order Miliolida comprising the superfamily Miliolidea and the families Cornuspiridae, Ophthalmidiidae, Miliolidae and Familiae incertae. In the more recent classification of Loeblich & Tappan (1964) the taxonomic unit of the highest rank is the suborder Miliolina, which contains the superfamily Miliolacea and the families Squamulinidae, Fischerinidae, Nubeculariidae and Miliolidae. The families except the first one, split into subfamilies, e.g. the Miliolidae into the Quinqueloculininae, Miliolinellinae, Miliolinae, Fabulariinae and Tubinellinae, which differ from each other in aperture type and also, partly, in wall structure.

Critical remarks on the division of the family Miliolidae in Loeblich & Tappan's classification are given in Part I (1972).

BIOSTRATIGRAPHY

The Miocene sediments from which the Miliolidae under study come are referred to two stages: the Tortonian (Badenian [2]) and Sarmatian.

[2] The conception of replacement of the term "Tortonian" with "Badenian" in the Vienna Basin was put forward in the revision of the stratotypes and terms used so far in the geochronological and lithostratigraphical scale for the Central Paratethys region, initiated by the Congress of the Committee on Mediterranean Neogene Stratigraphy in Bologna in 1967 (Papp. *et al.*, 1968). This conception was upheld by the CMNS Congress in Lyon in 1971 (Carloni *et al.*, 1971) and the term was recommended for the Central Paratethys region.

In the present work the old term "Tortonian" is retained to simplify the references to the author's previous papers and thus to avoid obscurity. It seems expedient to explain that this term is here used as the Tortonian *sensu lato*, i.e. a geochronological unit based on the occurrence of planktonic and benthonic foraminifera, its lower boundary being marked out by the appearance of *Praeorbulina* in the Tortonian and the upper one by the appearance of *Anomalinoides dividens* in the Sarmatian. Compared with the situation in the Vienna Basin, this period corresponds to the geochronological unit "Badenian" proposed in 1968, the lower boundary of which is the bottom of the "Lagenidae Zone" and the upper one the top of the "Bulimina-Rotalia Zone".

The miliolid assemblages from the Miocene of Poland vary between particular stratigraphic zones. It may be stated in general that the groups of miliolid species living in the Tortonian differ in composition from those in the Sarmatian. Although in the Tortonian the assemblages vary from zone to zone, still they have some common features, e.g. the predominance of species belonging to the genera *Quinqueloculina*, *Cycloforina*, *Lachlanella*, *Sigmoilopsis*, *Siphonaperta*, *Miliolinella*, *Pyrgo*, *Sinuloculina*, *Triloculina* and other species having large-sized tests, sometimes reaching to 2—3 mm. The species living in the Sarmatian have small tests, the dimensions of which do not exceed 0.5—1 mm (except for the forms with the uniserial arrangement of chambers), and belong chiefly to the genera *Varidentella*, *Articulina*, *Articularia* and the species of *Cycloforina* other than those occurring in the Tortonian. Only a few Tortonian species persisted into the Sarmatian.

A list of the Miliolidae occuring in typical localities representing deposits varying in age is given by way of example in Table 1: for the Lower Tortonian — Karsy and Korytnica in the northern coastal region, Benczyn in the southern coastal region and Wieliczka in the region of the Foredeep; for the Upper Tortonian — Gliwice Stare in the north-western coastal region in Upper Silesia, Węglinek near Zaklików in the Roztocze Mts and Niskowa near Nowy Sącz in the southern coastal region. The Miliolidae from Dwikozy near Sandomierz are given for the Sarmatian, separately for the sandy deposits belonging to the lower microfaunal zone and for the argillaceous deposits of the upper one.

The stratigraphic distribution of the species under study given in Table 1 is based on the above-mentioned examples and on the species identified from a number of other outcrops and bore holes, the list of which is given in the section entitled Material. The localities at which individual species occur are mentioned in their descriptions in the palaeontological part.

The characteristic assemblages of the Miliolidae of the Tortonian and Sarmatian strata are discussed below.

Lower Tortonian

Zone with Orbulina suturalis. — The Lower Tortonian deposits abounding in the Miliolidae occur only in the northern and southern marginal zones, being rare in the central part of the Precarpathian Foredeep. The miliolids from the clayey-marly formations of Karsy and Korytnica near Jędrzejów make a typical example of the assemblages of the northern coastal facies. They are mainly numerous *Quinqueloculina* species, such as *Q. alexandri* QS and MS, *Q. anagallis*, mostly MS, *Q. buchiana*, mostly QS, *Q. dichotoma* QS and MS, *Q. lentica* QS and MS, *Q. parakneriana*, mostly QS, *Q. peregrina* MS, *Q. pseudobuchiana* QS and MS and abundant *Cycloforina badenensis*, *C. reticulata*, *C. vermicularis*, *Lachlanella incrassata*, *L. schroekingeri* and *Sigmoilopsis foeda*. A similar miliolid assemblage is met with in the bottom portion of the clayey deposits in the Miocene of the Holy-Cross Mts, between Tarnobrzeg and Chmielnik (bore holes: Młyny 1, Budy 1 and Grabki Duże N8). The miliolid fauna of the southern coastal region of the Lower Tortonian is exemplified by the assemblage from the clayey sediments of Benczyn near Wadowice, composed chiefly of the same species as the assemblages from Korytnica and Karsy area. Species known from Korytnica — *Quinqueloculina anagallis* QS, *Q. buchiana* QS and MS, *Q. haidingeri* MS, *Q. lentica* QS, *Q. parakneriana* QS, *Q. pseudobuchiana* QS, *Siphonaperta mediterranensis*, *Sigmoilopsis foeda*, *Sinuloculina consobrina* and *Sigmoilinita tenuis* — have also been found in the clay deposits of the bottom portion of the Lower Tortonian in bore-hole Łęki Dolne-1 near Tarnów.

Special attention should be given to the fact that the Miliolidae are very rare in the *Heterostegina* sands of the Cracow-Miechów region and in marly and sandy limestones or limestones of the Miechów region and the Holy-Cross Mts, although these also constitute coastal facies of the Lower Tortonian. The Miliolidae are lacking or represented by only few common species, like *Sigmoilinita tenuis* or *Sinuloculina consobrina*, in the microfaunal assemblages consisting chiefly of planktonic foraminifera in the central part of the Foredeep.

Zone with Uvigerina costai. — In the upper layers of the Lower Tortonian the assemblage of miliolids becomes impoverished all over the area of the occurrence of the Miocene deposits and it shows no differentiation into shallower and deeper facies. The microfauna of the salt clays of Wieliczka, where the Miliolidae are relatively more numerous than in other localities but all the same limited to a small number of species, is a typical exemplary assemblage of this zone. It contains, above all, numerous specimens of *Quinqueloculina akneriana* QS and very rare MS, *Q. triangularis* QS and rare MS, a small number of *Q. haidingeri* QS and MS, and typical species of these layers: *Q. pygmaea*, *Q. regularis*,

Sigmoilopsis foeda, *Pyrgo amphiconica* and *Pyrgoella ventruosa*. In other regions, e.g. in the Bochnia-Gdów area and in the Holy-Cross Mts, the Miliolidae of this zone are still poorer in species and represented only by small numbers of *Cycloforina suturalis* and *Sigmoilinita tenuis*.

Upper Tortonian

Zone with Neobulimina longa. — Between the Lower Tortonian zone with *Uvigerina costai* and Upper Tortonian zone with *Neobulimina longa* there was a period of formation of chemical deposits, in which no microfauna developed. Its slow development occurs after this period, but the Miliolidae do not play a major role yet. The microfaunal assemblages of this zone are composed partly of the species existing earlier in the zone with *Uvigerina costai* and partly of new species. This is not the case with the Miliolidae, among which the species known from the Lower Tortonian, like *Quinqueloculina regularis*, *Sigmoilinita tenuis*, *Pyrgo inornata* and *P. truncata*, are still observed.

Zone with Hanzawaia crassiseptata. — It come to a great development of the Upper Tortonian microfauna in this zone, at which there also appear a number of new miliolid species. In the coastal region the boundary between the two zones of the Upper Tortonian is not sharp, there being transitions between them or a direct succession of a great development of the benthonic microfauna, comprising new species, after the period of formation of chemical deposits. The Miliolidae develop more abundantly than previously and, although the species of the lower zone of the Upper Tortonian still persist among them, a few species not encountered before appear as well. The Miliolidae from Gliwice Stare in Upper Silesia make a typical example. The most characteristic species of this assemblage are: *Quinqueloculina buchiana* QS and MS, *Q. parakneriana* QS and MS, *Q. regularis*, *Q. pygmaea* and *Q. spondiungeriana* — as relicts of the Lower Tortonian forms; *Cycloforina contorta*, *C. gracilis*, *C. lachesis*, *C. lucida* (a group of related forms, characterized by a rough surface with short incised lines and a tendency to carinate peripheries of the chambers) and *C. suturata*; a group of several species of the genus *Hauerina*, i.e. *H. aspergilla*, *H. compressa*, *H. plana*, *H. podolica*, *H. tumida* and *Pseudohauerina ornatissima*, of which only *P. ornatissima* and *H. tumida* were recorded from lower layers; *Sigmoilopsis foeda*, *Siphonaperta granulata*, *S. mediterranensis*, *Miliolinella selene*, *M. valvularis*, *Affinetrina gualtieriana*, *A. planciana*, *Biloculinella labiata*, *Pyrgo clypeata*, *P. inornata*, *P. lunula*, *P. truncata*, *Pyrgoella controversa*, *P. globiformis*, *P. ventruosa*, *Sinuloculina consobrina*, *S. microdon*, *S. nitens*, *Triloculina angularis*, *T. eggeri*, *Sigmoilinita tenuis* and *Nummoloculina contraria*, out of which *Cycloforina suturata*, *Siphonaperta granulata*, *Affinetrina gualtierana*,

A. planciana, *Pyrgoella controversa*, *Sinuloculina microdon* and *Triloculina eggeri* are species, absent from the lower layer. In the deeper zone of the Foredeep, as in the Lower Tortonian, the Miliolidae are conspicuously poorer both in genera and in species.

Two miliolid assemblages from the coastal zone, referred to this zone, deserve special attention: the assemblage from the *Haliotis* limestones of Węglinek near Zaklików in the Roztocze Mts, which has hitherto been considered to be of Lower Tortonian age (Areń, 1962; Bielecka, 1959) and that from the clay and sand layers overlying the lignite formations at Niskowa near Nowy Sącz, formerly referred to the Upper Tortonian (Skoczylasówna, 1930) and recently to the Lower Tortonian (Bałuk, 1970). As regards the miliolid fauna of Węglinek, it has many species in common with the assemblage from Gliwice Stare (*Quinqueloculina spondiungeriana*, *Cycloforina lachesis*, *C. lucida*, *C. suturata*, *Hauerina aspergilla*, *H. compressa*, *H. podolica*, *H. tumida*, *Affinetrina planciana*, *Pyrgo inornata*). In addition, a few species unobserved below appear in it: *Pyrgo subsphaerica*, *Sinuloculina rixatoria*, *Affinetrina ucrainica*, *Flintina truncata* and *Miliolinella banatiana*. Other foraminifera, too, indicate the Upper Tortonian age of these strata e.g. *Praeorbulina indigena* (Łuczkowska, 1955, *vide* Łuczkowska, 1971) and therefore the determination of their Lower Tortonian age raises doubts. The age of the deposits from Niskowa is also controversial. To be sure, the numerous miliolids present in the lowest clay layer, capped by sands, are endemic in character and, as a whole, they can hardly be compared with the assemblages from other areas (e.g. it is only from here that *Miliola fabularoides*, *Siphonaperta ovalis*, *Podolia compacta* and *Crenatella mira* have been recorded), some elements, however, suggest the similarity of this microfauna to that of Węglinek or Gliwice Stare rather than to the Lower Tortonian fauna of Korytnica. The common elements are: *Quinqueloculina spondiungeriana*, in the older layers met with only in the highest portion of the sub-salt clays of Wieliczka (in the so-called "makowica"), *Cycloforina hauerina*, *C. lucida*, *Hauerina aspergilla*, *H. podolica*, *Sinuloculina inflata* and *S. cyclostoma*. For the above-mentioned reason the marine sediments at Niskowa have been referred provisionally to the Upper Tortonian, the closer determination of age being left as an open problem.

The rich Upper Tortonian miliolid assemblages, as well as the rest of the microfauna, suddenly vanish from the whole area of the occurrence of the Miocene deposits in Poland. New assemblages appear above them in the Sarmatian layers east of Cracow, whereas west of Cracow the Miocene sedimentation comes to an end and land deposits appear in the region of Gliwice Stare and further to the west, towards Kędzierzyn and Głogówek (Krach, 1954; Alexandrowicz, 1969).

Sarmatian

Tortonian-Sarmatian boundary and zone with Anomalinoides dividens. — A new miliolid species, *Cycloforina stomata*, appears directly after the numerous Tortonian species have vanished completely, which level may be recognized as the boundary between the Tortonian and Sarmatian. The period between the rapid extinction of the Upper Tortonian microfauna and the gradual development of the new Sarmatian one is characterized by this single species. The bottom layers of the Sarmatian are at first poor in fauna in general. The fauna consists chiefly of single specimens of redeposited Tortonian foraminifera, otoliths, fish remains, sometimes ostracods, numerous *Cycloforina stomata* and single specimens of *Anomalinoides dividens*. There is also a large amount of pyrite and many small, often pyritized, pelecypods and snails. These layers belong to the lower portion of the zone with *Anomalinoides dividens* and range in thickness from hardly several dozen centimetres to several metres in the coastal zone (Łuczkowska, 1964 and 1967), whereas in the foredeep zone they reach as many as several dozen or even several hundred metres. In this connection the mass occurrence of the species typical of this zone is observed either in the bottom layers of the Sarmatian, almost in contact with the Tortonian microfauna, or higher, above the bottom layer poor in fauna.

In the clay facies of the coastal zone there is a sharp boundary between the range of the Tortonian miliolids and that of the Sarmatian ones. For example, in bore-hole Wolica 107 near Szydłów there occurs a typical assemblage of the zone with *Hanzawaia crassiseptata* at a depth of 57—58 m, and directly above it, at depth of 56—57 m, *Cycloforina stomata* and single redeposited Tortonian forms. From a depth of 56 m upwards, *Anomalinoides dividens*, the typical species of this zone, occurs in very large numbers already. A similar situation is observed at other bore holes in the Szydłów region, e.g. Solec 105, where the bottom layers of the Sarmatian, bearing a poor assemblage with single specimens of *Anomalinoides dividens*, otoliths, fish remains, pyrite and *Cycloforina stomata* occur at a depth of 17.20—21.0 m and directly overlie lithologically identical strata with a rich Upper Tortonian microfauna. In bore-hole Wolica 101 near Szydłów an abundant assemblage with *Anomalinoides dividens*, *Varidentella rotunda* and *Articulina sarmatica* appears above the rich Upper Tortonian assemblage at a depth of 18.7 m, without any intermediate layers with a scanty microfauna.

An analogous situation is observed in the deeper zone of the Precarpatian Foredeep, e.g. in the central part. In bore-hole Niwka-1 the rich assemblages of the Upper Tortonian foraminifera including *Quinqueloculina regularis* and agglutinating species (constituting a facial equivalent of the assemblages with calcareous foraminifera from the zone

with *Hanzawaia crassiseptata* of the coastal zone) disappear abruptly at a depth of 494.90 m, being immediately replaced first by single specimens then by masses of *Cycloforina stomata*, *C. predcarpatica* and otoliths and a few redeposited Tortonian specimens, whereas *Anomalinoides dividens* does not appear in large numbers below 442 m. The bottom Sarmatian layers, underlying the layer in which this typical species is present, are about 57 m thick. In bore-hole Mielec-6 the rich Upper Tortonian assemblage with agglutinating foraminifers disappears suddenly at a depth of 829.2 m and barren layers with only few redeposited Tortonian specimens occur between 829.20 and 816.0 m, whereas *Cycloforina stomata* and otoliths appear in large numbers over 816 m and *Anomalinoides dividens*. *Cycloforina predcarpatica* and *Varidentella rosea*, typical of the Sarmatian, over 801 m.

As mentioned above, the bottom layers of the zone with *Anomalinoides dividens* are for the most part poor in microfauna and contain the new species *Cycloforina stomata*, which next persists into the higher layers of this zone, but no longer as abundant. The higher layers of the zone with *Anomalinoides dividens* are characterized by the appearance of further new miliolid species: *Articulina sarmatica*, *A. problema*, *A. multibullata*, *A. tamanica*, *Cycloforina cristata*, *C. fluviata*, *C. gracilissima*, *C. predcarpatica*, *C. toreuma*, *Varidentella latelacunata*, *V. pseudocostata*, *V. rosea* and *V. rotunda*. Except for *Cycloforina cristata*, *C. fluviata* and *C. gracilissima*, they occur mostly in large numbers. Only few Tortonian forms, like *Affinetrina cubanica*, *Sinuloculina consobrina*, *S. nitens* and *Sigmoilinita tenuis*, are observed, in addition to which there are sporadic, undoubtedly redeposited, single specimens of different Tortonian species (Łuczkowska, 1964 and 1967), which may form even a high percentage of the whole assemblage. The Sarmatian sands from Dwikozy near Sandomierz are a typical example of the occurrence of an assemblage of Sarmatian Miliolidae mixed with redeposited Tortonian species.

Zone with Cycloforina karreri ovata. — This zone contains a number of species from the lower layers, i.e., *Articulina problema*, *A. sarmatica*, *Cycloforina fluviata*, *C. gracilissima*, *C. predcarpatica*, *C. stomata*, *Affinetrina cubanica*, *Sinuloculina consobrina*, *S. nitens*, *Varidentella latelacunata*, *V. pseudocostata*, *V. rosea*, *V. rotunda* and *Sigmoilinita tenuis*. The new species that appear here in large numbers for the first time are *Cycloforina karreri ovata*, *Affinetrina voloshinovae timenda* and *Articularia karreriella*, occasional specimens of this last species being present as deep as the zone with *Anomalinoides dividens*. In general, this zone comprises a poor miliolid assemblage in so far as its specific differentiation is concerned. It often lacks any microfauna at all.

Zone with Varidentella sarmatica. — This is the highest Sarmatian zone with numerous miliolids in Poland. These are, above all, specimens of the typical species *Varidentella sarmatica*, occurring in masses beside

equally abundant *Varidentella reussi*, *Cycloforina predcarpatica*, *Articulina problema* and *Articularia articulinoides*. As can be seen, the species are few in number although the number of specimens is large.

The above-mentioned species abound in the northern coastal zone, e.g. in the region of Tarnobrzeg (Łuczkowska, 1964), whereas in the deeper zone of the Foredeep, where the Sarmatian deposits exceed 1000 m in thickness, they are met with more rarely. The microfauna found in the Sarmatian layers of the Foredeep is mostly a redeposited fauna washed out of the deposits of the Upper or Lower Tortonian and even those of the Cretaceous.

Zone with Elphidium hauerinum. — This zone, overlying the zone with *Varidentella sarmatica* has hardly any miliolids. From among the Sarmatian species, only dwarfish *Varidentella reussi* is encountered in it; however, it may well be that the rare specimens of this species come from the lower layers that have been washed away. The range of this zone is not known exactly, supposedly it occurs only locally in the region of Tarnobrzeg.

PALAEOECOLOGY

The Miliolidae are a foraminiferal group having small requirements in respect of water salinity, for they may be found in both salt and brackish waters, but their occurrence is frequently restricted to only certain depths and temperatures. In the contemporary seas they prevail over inner shelf and in open gulfs, in warm and shallow tropical and subtropical waters, at depths from zero to about 100 m (Norton, 1930; Lowman, 1949; Sigal, 1952; Matthes, 1956; Bandy & Arnal, 1960; Loeblich & Tappan, 1964; Bandy, 1964 *b*; Boltovskoy, 1965), where they may form 50 per cent or more of the whole population. They belong chiefly to different species of *Quinqueloculina* and *Triloculina* [3], which are good indicators of conditions in the vinicity of coasts. These genera are not dominant in the region of central and outer shelves, but here *Biloculinella* appears beside them. In the bathyal zone the miliolids are scarce except *Pyrgo* and *Pyrgoella*, which here develop various groups of species and grow to a large size (above 5 mm), whereas the shelf forms of *Pyrgo* do not usually exceed 1 mm.

Such a pattern of distribution of the Miliolidae is generally noted in tropical regions and those of warm water all over the world. In the Gulf of Mexico the Miliolidae are abundant at depths of 30 m (Shifflett, 1961), 70—100 m (the genus *Quinqueloculina* chiefly in the inner turbulent zone at 20—30 m; Phleger, 1960), or even down to 150 m (Parker, 1954), and do not descend below 180—220 m (Phleger & Parker, 1951). In Florida the

[3] The generic names are given after the authors cited.

Miliolidae abound from 0 to 120 m, forming up to 45 per cent of the population at 0—10 m (Norton, 1930) and in the Mississippi Sound they belong to the fauna of the coastal barrier and islets (together with *Elphidium* and "*Rotalia*") and that of the open gulf (Phleger, 1954). In Cuba they occur, also with *Elphidium* and *Ammonia*, in the inner shelf region (Bandy, 1964 *a*), while in the Bahama Is. live near the banks in the open ocean (Illing, 1952). In the region of the Atlantic shelf of the United States (Long Island) the Miliolidae are most numerous between 24 and 150 m (mostly *Quinqueloculina* and *Miliolinella*), their number decreasing with the distance from the shore (Murray, 1969); in North Carolina they occur in the central shelf zone at a depth of 0—45 m (Bandy & Arnal, 1957) and in the Gulf of California in the coastal zone of a normal 34 per thousand salinity (mainly *Quinqueloculina*; Bandy, 1961). In Santa Catalina the miliolids are numerous down to 18 m and lacking below 91 m (Mc Glasson, 1959). According to this author large numbers of miliolids are a reliable indication of very shallow regions.

Off the coast of North Asia the Miliolidae have been recorded from depths to 60 m, at which they live in small separate areas. They are chiefly *Quinqueloculina lamarckiana*, *Q. akneriana* and *Sigmoilina arenaria* (Polski, 1959). Along the coast of Southern China the Miliolidae inhabit the littoral region of quiet waters showing no influences of currents. Their diversity indicates shelf conditions (Waller, 1960). In the Persian Gulf miliolids are indicators of shallow (10—100 m) waters (Haake, 1970).

In the Mediterranean and Adriatic Seas the Miliolidae live under similar conditions. Blanc-Vernet (1969) writes that the Miliolidae, including agglutinating ones, form 20—40 per cent of the infralittoral environment in the Mediterranean Sea (down to 50—100 m). Schlumberger (1893) elaborated many species from the sands at a depth of 30—40 m in the Gulf of Marseilles. According to Le Calvez (1958) in the Gulf of Villefranche the agglutinating miliolids occur in shallow waters from 5 to 40 m and the calcareous ones somewhat deeper, down to 100 and 200 m, e.g. *Quinqueloculina contorta* — 10—70 m, *Q. undosa* and *Q. vermicularis* — 50—80 m, *Q. ungeriana* — 10—80 m, reticulate quinqueloculines — 5—20 m, *Pyrgo* — to 250 m, *Nummoloculina* — 150—300 m and *Sigmoilina tenuis* — to 700 m (generic names after Le Calvez). Kruit (1955) reports that in the Delta of the Rhone most of the population at 0—90 m consists of the Miliolidae, mostly *Quinqueloculina seminulum* and *Triloculina trigonula*, as well as *Elphidium crispum* and *Ammonia beccarii*. Glaçon (1963) studied the microfauna of the Tunisian coast, where she found abundant miliolids at depths to 26 m, in undersea meadows and beaches.

Investigations carried out in the Gulf of Naples showed that the Miliolidae occur there at various depths. At Ammontatura 20 species belonging to the genera *Quinqueloculina*, *Triloculina*, *Pyrgo*, *Spiroloculina*,

Sigmoilina and *Nummoloculina* were found at 200 m. They are for the most part small specimens (Moncharmont Zei, 1956). At depths from 180 to 315 m at Banco delle Vedove 32 species of miliolids were collected, including numerous *Quinqueloculina*, *Spiroloculina*, *Triloculina*, *Pyrgo* and *Biloculinella* (this last being considered to be characteristic of deep water), which form 4 per cent of the population there (Moncharmont Zei, 1962). In the Gulf of Pozzuoli numerous Miliolidae and Elphidiidae occur at 5 m and deeper to 110 m; there are large numbers of *Quinqueloculina* and *Pyrgo*. Forms of the genus *Quinqueloculina* are particularly typical of sandy and detritic deposits at 40 m (Moncharmont Zei, 1964). Off Capri 17 miliolid species were found at 85 m, mostly those of the genus *Quinqueloculina* (Cita, 1955).

In the Adriatic Sea the Miliolidae generally live in shallow off-shore regions, e.g. abundant *Quinqueloculina* at 37 m, *Quinqueloculina*, *Triloculina* and *Pyrgo* at 166 m (Cita & Chierici, 1962); numerous *Quinqueloculina dutemplei*, *Q. longirostra* and *Q. pulchella* live at depths ranging from 23 to 42 m (Chierici *et al.*, 1962) and 19 species, including only 2 species belonging to *Quinqueloculina*, i.e. *Q. padana* and *Q. seminulum*, several species of *Sigmoilina* and *Pyrgo*, and *Biloculinella labiata* were gathered at 218 m (d'Onofrio, 1959).

In the Ionian Sea *Triloculina* abounds at 15 m, *Quinqueloculina* between 12 and 30 m; the numbers of both genera decrease down to 100 m (Iaccarino, 1969). In the Ligurian Sea the Miliolidae occur in large numbers from 20 to 90 m, *Triloculina tricarinata* being particularly numerous down to 20 m (Giunta, 1955). In the Beirut region the percentage share of Miliolidae changes with depth. At 11 m they form 10 per cent of the whole population, at 27 m 45 per cent, at 54 m 19 per cent and at 246 m 8 per cent, *Sigmoilina*, *Miliolinella* and *Biloculinella* being dominant and *Quinqueloculina* showing a considerable fall in number. *Biloculinella labiata* and *Nummoloculina contraria* also occur at the greatest depth given above (Moncharmont Zei, 1968). In the Red Sea the Miliolidae and Textulariidae prevail at depths ranging from 21 to 73 m and both these families are represented from 70 to 300 m but the Textulariidae are dominant (Said, 1950).

The Miliolidae can also live in environments of reduced salinity. For example, Adams and Haynes (1965) list 14 species, mainly of the genera *Quinqueloculina*, *Triloculina* and *Miliolinella*, from the Holocene and contemporary marshes and estuaries in northern Wales (Great Britain). Lowman (1949) records their occurrence in strongly brackish and near-shore marine waters in the Gulf of Mexico (together with *Elphidium* and *Rotalia*). Some forms tolerate low temperatures, e.g. *Pyrgo*, which is also present in arctic waters and at great depths, down to 2000 m (Green, 1960) and as deep as 2500 m in the north-eastern part of the Pacific Ocean (Saidova, 1964).

In his study of the relation of the present Foraminifera to the deposit facies in the turbulent zone of Cardigan Bay (Wales), Atkinson (1971) gives interesting observations concerning the foraminiferal population as a whole, and so including the Miliolidae. He states that living foraminifera occur frequently in coarse grained deposits, whereas empty tests accumulate in large numbers in fine-grained deposits. The empty foraminiferal tests are washed away from the coarse-grained deposits to the fine-grained ones and only few large specimens remain in the former (e.g. *Massilina secans* is a good palaeoecological indicator of sublittoral conditions and coarse-grained substratum). Porcellaneous tests, as heavier and larger, are not generally so readily displaced by water movements. The same is true of the agglutinating foraminifers.

So far as the reconstruction of the palaeoecological conditions in the Miocene sea of southern Poland is concerned, a comparison with the occurrence of the Miliolidae in the present seas provides some information. Although most species of the Miocene miliolids differ from the contemporary ones (morphologically some of them come very near to the contemporary forms, e.g. *Quinqueloculina akneriana* to *Q. seminulum* (Linnaeus), *Q. buchiana* to *Q. lamarckiana* d'Orbigny, *Q. regularis* to *Q. pentagona* Giunta, *Triloculina neudorfensis* to *T. tricarinata* d'Orbigny and a number of other species), still they belong to the same genera and form similar groups. The analogies suggested are presented below by the example of the typical associations given in Table 1.

Karsy, Korytnica, Benczyn and Wieliczka have miliolid assemblages typical of the Lower Tortonian. The Lower Tortonian sea covered the area of the Precarpathian Foredeep (Text-fig. 1) and probably extended to the west as far as the eastern part of the Sudety Foreland, being connected with the Vienna Basin by a narrow strait of the Moravian Gate in the south. In the east the foreland of the East Carpathians in the USSR connects it with the Ukraine and Moldavia. In respect of area the sea was a third of the Adriatic Sea; it had its northern and southern coastlines irregular and indented and a well-developed shelf zone, in which lithothamnian reefs were formed in places. Virtually, it was not an open sea and it is risky to compare the conditions prevailing in it with those of open bays of the present oceans. Nevertheless, it is possible to draw parallels regarding the littoral zones.

Karsy and Korytnica are typical localities of the occurrence of the Lower Tortonian microfauna in the northern coastal zone. Their miliolid assemblages differ somewhat from each other, but they undoubtedly characterize similar environments, since they contain the same groups of genera and for the most part the same species. *Quinqueloculina* QS and MS and *Triloculina* predominate evidently, *Pyrgo*, *Pyrgoella* and *Miliolinella* occur in smaller numbers and even then are represented by small specimens. Among the quinqueloculines *Q. buchiana*, morphologically

resembling the contemporary species *Q. lamarckiana*, whose ancestral form it probably is, is the most numerous. The occurrence of abundant large and flat massiline forms of *Quinqueloculina* is also characteristic. Assemblages of this type indicate the conditions of an inner shelf zone, a depth not exceeding 50—80 m and warm water. The great variety of species (38) suggests normal salinity.

An assemblage of the same type is observed at Benczyn in the southern coastal zone and, consequently, the environment was probably similar. The miliolid assemblages of the same age found at Iwkowa, Żegocina, Przeciszów, Brzozowa and other localities are also a similar type.

The salt clays at Wieliczka are younger than those at Korytnica and the miliolids met with in them point to a somewhat different environment. The main feature of the Wieliczka assemblage is the occurrence of a large number of specimens against a reduced number of species (24) compared with the assemblages from Karsy and Korytnica. The abundance of specimens of *Quinqueloculina akneriana* QS and *Q. triangularis* QS comes to the fore; the massiline forms of these species are rare, instead the specimens of *Pyrgo* and *Pyrgoella* are considerably more numerous and larger. *Biloculinella* and *Nummoloculina* appear as well, and at the same time the number of quinqueloculine and triloculine species decreases. This suggests deeper water, below 100 m, and judging by the vertical distribution of *Biloculinella* and *Nummoloculina* in the Adriatic Sea the depths may have been about 200—250 m. A decrease in the number of species indicates a distance from the coast or a change in the chemical composition of water.

In the Upper Tortonian the connection with the Vienna Basin through the Moravian Gate was broken but that with the Ukraine and Moldavia persisted. The sea assumed characters of a bay, occupying approximately the same area as in the Lower Tortonian, but was shallower and with a belt of arenaceous and calcareo-detritic littoral deposits, especially in its north-eastern part. Its salinity, however, did not deviate much from the normal, which is evidenced by the richness of genera and species.

Gliwice Stare is a typical locality in the western part of this bay, with deposits containing the Upper Tortonian microfauna. Its miliolid assemblage is, as a rule, the same type as that at Wieliczka, i.e. it consists mainly of members of *Quinqueloculina*, big specimens of *Pyrgo*, *Nummoloculina* and *Biloculinella*, but also of a number of forms belonging to other species, e.g. *Cycloforina*, *Hauerina*, *Miliolinella*, *Pyrgoella*, *Affinetrina* (formerly *Triloculina*). Except for a few species that they have in common, e.g. *Cycloforina contorta*, *Quinqueloculina regularis* and *Q. pygmaea*, most of the species found at Gliwice Stare are absent from Wieliczka. Agglutinating species, like those of *Sigmoilopsis* and *Siphonaperta*, play an important part among them, and the whole assemblage shows a greater variety of species (39). All these observations suggest that the depth was smaller

than that at Wieliczka but larger than at Korytnica; presumably, it ranged from about 100 to 150 m.

Assemblages of a similar type occur also at Zgłobice, Chełm n/Rabą, Grabowiec, Brzeźnica, etc. in the southern coastal zone.

Sediments of probably the same age as those at Gliwice Stare occur at Węglinek and Niskowa (respectively, the northern and southern coastal zone). Their miliolid assemblages have the following characters in common: the almost complete lack of *Quinqueloculina* (except two species: *Q. bogdanowiczi* and *Q. spondiungeriana*), the presence of several species of *Cycloforina*, *Sinoloculina* and *Hauerina*, and the small number of specimens of *Pyrgo* (their complete lack at Niskowa) and *Triloculina*. It is striking that these assemblages lack elements which would indicate deeper water and that the number of miliolids is very large, at Węglinek more than 50 per cent of the assemblage (27 species) and at Niskowa nearly 100 per cent (16 species). At Niskowa there are also numerous agglutinating forms belonging to the genera *Miliola* and *Siphonaperta*. These assemblages point to shallow and warm waters of the infralittoral zone, normal salinity and a depth of 30—50 m.

Bogoria, Rybnica and Gieraszowice in the northern coastal zone have similar miliolid assemblages to that at Węglinek.

The sea of the Lower Sarmatian was still more limited in the west and its gulf reached supposedly to the region of Cracow. As early as its initial period the sea was very shallow, as can be judged from the mass occurrence of the specimens of *Anomalinoides dividens*, which probably lived in the environment of submarine meadows, attached to submerged plants, and from the Miliolidae, occurring abundantly in places, among which the specimens of *Articulina* indicate a depth of about 30 m. In the later period the miliolid assemblages become more and more uniform, some miliolid species occur in masses, together with those of *Elphidium*, which is typical of the faunae of coastal barriers and islets or the deltas of large rivers. The conditions became worse and worse, as the coastline moved to the east and the western areas of the bay emerged from water, which caused a reduction in the number of species, a decrease in the size of specimens and the appearance of degenerated forms.

A typical example of the development of Sarmatian assemblages in the coastal zone is provided by the detritic sediments at Dwikozy, which however at the lowest zone with *Anomalinoides dividens* contain a large number of redeposited specimens washed out of the Tortonian (at least 5 in 17 species). The higher Sarmatian zone with *Cycloforina karreri ovata* at Dwikozy contains considerably fewer miliolid species (5), its fauna is therefore more uniform and probably corresponds to the period of the progressive process of deterioration of the conditions, perhaps the desalting of sea-water.

Table 1

Stratigraphic range of the Miocene Miliolidae of Poland and their distribution in the main exposures

Species and Subspecies	Distribution in the main exposures: Localities									Stratigraphic range: Foraminiferal zones							
	Lower Tortonian				Upper Tortonian			Sarmatian		Lower Tortonian	Upper Tortonian		Sarmatian				
	Karsy	Korytnica	Benczyn	Wieliczka	Gliwice Stare	Węglinek	Niskowa	Dwikozy sands	Dwikozy clays	*Orbulina suturalis*	*Uvigerina costai*	*Neobulimina longa*	*Hanzawaia crassiseptata*	*Anomalinoides dividens*	*Cycloforina karreri ovata*	*Varidentella sarmatica*	*Elphidium hauerinum*
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Quinqueloculina																	
akneriana			×	×													
alexandri		×	×														
anagallis	×	×															
bogdanowiczi			×			×		×									
buchiana	×	×	×		×			×									
dichotoma	×	×						×									
haidingeri	×	×	×	×													
lentica	×	×		×		×											
parakneriana	×	×	×		×												
peregrina	×	×															
pseudobuchiana	×	×	×														
pygmaea			×	×	×												
regularis				×	×												
spondiungeriana				×	×	×	×	×									
triangularis			×	×				×									
Articularia																	
articulinoides									×								
karreriella									×								
Articulina																	
multibullata																	
nodosaroides	×	×															
problema								×									
sarmatica								×									
tamanica																	
tenella																	
Cycloforina																	
badenensis	×	×	×														
contorta		×	×	×	×			×									
cristata																	
fluviata								×									
gracilis	×	×			×												
gracilissima																	
hauerina						×	×	×									
karreri ovata									×								
lachesis		×			×	×											
lucida					×	×	×										
predcarpatica								×									
reticulata	×	×	×														
stomata																	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
suturalis				×													
suturata					×	×		×									
toreuma																	
vermicularis		×	×														
Hauerina																	
aspergilla					×	×	×										
compressa					×	×											
plana					×												
podolica					×	×	×										
tumida		×			×	×	×										
Lachlanella																	
incrassata	×		×														
schroekingeri		×						×									
undosa	×	×		×		×		×									
Miliola																	
fabularoides							×										
Podolia																	
compacta							×										
Pseudohauerina																	
ornatissima		×		×	×	×	×										
Sigmoilopsis																	
foeda	×	×		×	×												
Siphonaperta																	
granulata					×												
mediterranensis	×		×	×	×		×										
ovalis							×										
Miliolinella																	
banatiana						×											
enoplostoma grammostoma				×													
selene	×	×			×												
valvularis					×												
Affinetrina																	
cubanica					×			×									
gualtieriana					×												
planciana					×	×											
ucrainica						×											
voloshinovae timenda									×								
Biloculinella																	
labiata				×	×												
Crenatella																	
mira							×										
Flintina																	
truncata						×											
Pyrgo																	
amphiconica				×	×												
clypeata	×	×	×	×	×	×											
inornata	×			×	×	×											
lunula			×	×	×												
susphaerica						×											
truncata				×	×												
Pyrgoella																	
controversa					×												
globiformis	×	×			×	×											
ventruosa				×	×												
Sinuloculina																	
consobrina	×	×	×		×	×	×	×									
cyclostoma		×				×	×										
inflata						×	×	×									
mayeriana	×			×		×											
microdon					×												
nitens					×												
rixatoria						×		×									

cont.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Triloculina																	
angularis	×	×	×		×	×											
eggeri					×												
gibba	×	×	×			×		×									
gubkini								×									
intermedia	×	×					×										
neudorfensis	×			×	×												
Varidentella																	
georgiana																	
latelacunata																	
pseudocostata																	
reussi																	
rosea																	
rotunda																	
sarmatica																	
Sigmoilinita																	
tenuis	×	×	×	×	×												
tenuissima				×													
tschokrakensis		×		×													
sp.																	
Nummoloculina																	
contraria				×	×												
Spirosigmoilina																	
crenata		×			×												
speciosa	×	×															

DETAILED PART

MORPHOLOGY OF TESTS

Three factors contribute to the diversity of shapes in the Miliolidae: morphological variability, dimorphism and ontogeny. They do not act all at the same time in particular species, but are all related to each other to a certain degree. For example, various sizes of tests may point to the presence of specimens representing different ontogenetic stages, from the juvenile to the gerontic one (this is visible only in sections), but they may also reflect specific environmental conditions responsible now for a larger now for a smaller growth of tests in the same species (e.g. Sarmatian species *Varidentella reussi* or *V. rotunda*). Dimorphism also influences the diversity of shapes to some extent. Although the micro and mega I generations cannot be distinguished one from another on the basis of their size and shape (Part I, p. 348), the mega II generation may stand out as specimens which are small but higher than the other generations of this species (e.g. in *Quinqueloculina anagallis*, Text-fig. 7/5, or *Q. buchiana*, Pl. IV, Fig. 2).

As regards morphological variability, it is observed in most species, chiefly in the form of variation in the shape of tests, elongated, widened or rounded to a various degree, and that of ornamentation, e.g. the number

of ribs or striae, or their presence only in some specimens of a given species. There are only few species which have little varying morphological characters, e.g. *Quinqueloculina regularis* (Text-fig. 21/1, 2), *Q. pygmaea* (Text-fig. 21/3, 4) or *Siphonaperta ovalis* (Text-fig. 34/3). *Cycloforina contorta* is one of the most variable species as regards morphology. The periphery of its chambers has two longitudinal edges, which are sharp in typical forms but may be rounded to a various degree in other specimens (Text-fig. 26). Similarly, *Cycloforina vermicularis* may have an angular truncate periphery or a more rounded one without any signs of the angles (Text-fig. 32). The ribs on the chamber surfaces in *Lachlanella incrassata* may be either well or ill developed (Text-fig. 33/1, 2). *Sigmoilopsis foeda* may be regularly oval or S-shaped (Pl. XV, Figs 3, 4) and *Triloculina intermedia* has either keeled chambers or their edges are rounded (Pl. XXIII, Fig. 1), etc. Great variation in shape is especially frequent in Sarmatian species, like *Varidentella reussi* (Text-fig. 49), *Cycloforina karreri ovata* (Text-fig. 30) or some species of *Articulina* (e.g. *A. problema*, *A. multibullata* and *A. sarmatica*).

Some attention should also be given to the variation in the shape of the aperture and tooth, especially in such genera as *Cycloforina*, *Miliolinella*, *Pyrgo*, *Pyrgoella* and *Varidentella*. In *Cycloforina* the variable shape of the aperture occurs in the species that have the last chamber unextended and as a result the aperture may be round with a narrow tooth or slightly flattened at the base with a somewhat broader square tooth (e.g. in *Cycloforina suturalis*, *C. toreuma*, *C. predcarpatica* and *C. stomata*). In *Miliolinella* the shape of the tooth is differentiated and it assumes the form of a fairly broad or narrow apertural plate, e.g. in *M. valvularis* (Pl. XX, Figs 4, 5). This is also true of *Pyrgoella*, whose apertural plate may be narrowed so much as to become a tongue-shaped tooth, as in *P. controversa* (Pl. XXI, Figs 4—6). In *Pyrgo* the variation of the apertural shape can be seen particularly well in *P. amphiconica* (Pl. XX, Figs 6—8), in which the width of aperture may be nearly equal to the diameter of the test. The most variable shape of the aperture and tooth is observed in the genus *Varidentella*, whose aperture ranges from a transverse slit with a broad tape-shaped tooth to a large semicircular opening with a short square tooth (e.g. in *Varidentella sarmatica* or *V. latelacunata*).

ONTOGENY

The ontogenetic stages can be observed in transverse sections, which show the shape of the chambers from the juvenile stage to the adult one, whereas the structure of the aperture and tooth in an early stage is exposed by the removal of the external chambers.

Studying the sections of forms, from the juvenile to the adult or gerontic one, in different species, or observing the developmental stages of individual specimens, we can arrive at the following conclusions:

1) The size of test does not depend on the number of chambers but, above all, on the size of the proloculus. The larger the proloculus, the fewer are the chambers in specimens of the same size or, in other words, the juvenile stage of the mega I or mega II generation may be the same size as the adult stage of the micro generation. This is particularly well seen in the genera marked by the presence of three generation, i.e. in *Quinqueloculina*, *Triloculina* and *Pyrgo* (e.g. *Quinqueloculina anagallis*, Text-figs. 7, 8; *Q. buchiana*, Text-figs. 12, 13; *Q. lentica*, Text-fig. 18; *Q. parakneriana*, Text-fig. 19; *Q. pseudobuchiana*, Text-fig. 20; *Triloculina neudorfensis*, Text-fig. 46).

2) In the genus *Quinqueloculina*, producing the massiline adult (or gerontic?) stage (Part I, p. 346) such forms are met with that their membership in a given species is determined by the quinqueloculine i.e. juvenile stage only, since the massiline forms of various species closely resemble each other in shape. For example, *Quinqueloculina buchiana* MS, *Q. pseudobuchiana* MS and *Q. haidingeri* MS or *Q. akneriana* MS, *Q. triangularis* MS and *Q. parakneriana* MS are very much alike. At the same time the quinqueloculine stage is different in each of these species, in whose populations it besides prevails most frequently (except for *Q. haidingeri*, found mostly as MS), owing to which they can be distinguished without resorting to sections. This can be interpreted in two ways: either the genus *Massilina* actually exists and then the various shapes of the juvenile stage seen in the sections of similar forms indicate their polyphyletic origin or *Massilina* represents only an ontogenetic stage of *Quinqueloculina*, isomorphic in different species. The latter view has been assumed in the present work (see Part I).

3) As can be seen from sections, in a number of genera some species do not differ in their juvenile stage and their individual characters do not differentiate before several initial chambers have been developed. For example, in *Cycloforina contorta* and *C. lachesis* tubular chambers occur in the juvenile stage as in *C. gracilis* and *C. lucida* (Text-figs 26, 28) and only in a later stage angular edges appear in *C. contorta* and *C. lachesis*, but not in the other two species. Tubular chambers of the juvenile stage are also observed in other species which have edges or ribs in the adult stage: *Lachlanella schroekingeri* (Text-fig. 33/3, 4), *L. undosa* (Text-fig. 33/5, 6), *Cycloforina badenensis* (Text-fig. 25), *Triloculina intermedia* (Text-fig. 46/4), *T. neudorfensis* (Text-fig. 46/3), etc. In the genera *Miliolinella* and *Varidentella*, which are characterized by a turn of the coiling axis in the juvenile stage, this stage has a similar form in different species. It resembles *Miliolinella circularis* in appearance (e.g. in *Varidentella reussi*, Part I, Pl. XIII, Fig. 3) and is very often identified as that

(e.g. Serova, 1955, Pl. 9, Figs 13—15). It follows that, excepting the genus *Quinqueloculina*, the juvenile stage of other genera has no differentiated diagnostic characters.

4) Within the genus *Sinuloculina* there are species whose juvenile stage differs so much from the adult stage that these two stages are often identified as separate species (e.g. in *Sinuloculina microdon*, Part I, Text-fig. 10).

As regards the aperture and tooth, their shape in the juvenile stage may differ from that in the adult stage, which can be exemplified by the genus *Varidentella*. In *V. sarmatica* and *V. reussi* there occur adult specimens which have a toothless aperture, but removing their external chambers successively, one can find that in the juvenile stage the aperture is furnished with a well-developed broad tape-shaped tooth. *Hauerina* and *Miliola* have two types of the aperture and tooth; in the juvenile stage the aperture is round with a simple tooth, as in *Siphonaperta* or *Cycloforina*, whereas in the adult stage of both genera a cribrate plate develops and covers both the aperture and the tooth. (e.g. *Miliola fabularoides*, Pl. XIV, Figs 1—3). This fact has also been stated by Serova (1953 and 1960).

RELATED FORMS

It has been found that groups of such forms that their affinity is visible both in the similar structure of the juvenile stage and in some morphological characters in the adult stage and also in the similar nature of the walls can be distinguished in the Miliolidae from the Miocene of Poland. As early as 1912 Wiesner paid attention to the existence of different types of walls in the contemporary Miliolidae and tried to utilize this fact in classification (see the section "History of Studies on the Miliolidae").

The group mentioned in the preceding section and composed of *Cycloforina contorta*, *C. lachesis*, *C. lucida* and *C. gracilis*, which occur together in the deposits of the Upper Tortonian at Gliwice Stare, is conspicuous among the Miocene forms under study. As has been mentioned, this group is characterized by a similar juvenile stage, consisting of identical tubular chambers, whereas the adult stage shows a character developing from species to species, namely, the edges along the chambers. The initial form is completely void of edges and has tubular chambers in both juvenile and adult stages — *C. gracilis*. The next link, *Cycloforina lucida*, is less regular and more elongate, with signs of flattenings in the periphery of chambers. This feature develops further through the forms with two rounded edges belonging to *C. contorta* and typical forms of this species with sharp edges, to the last form of this row, *C. lachesis*, with a single keel, split only in the lower portion of the chambers.

The character that these species have in common is their rough surface with short incised lines, quite different from the smooth and shiny "porcellaneous" surface in other species. Except for pointing at the supposed relationship between these forms, however, the presence of rough walls does not seem to be of any major taxonomic importance.

A relationship can also be seen between different species of *Quinqueloculina* with shiny "porcellaneous" tests. It is manifested by the fact that, e.g. in some juvenile specimens of *Quinqueloculina anagallis*, whose tests are normally ornamented with ribs, an entirely smooth and shiny chamber appears as in *Q. buchiana* (Pl. I, Fig. 1). The relationship between *Q. peregrina* and *Q. dichotoma* is another example; they have quite a similar shape and internal structure and differ only in that *Q. dichotoma* has its surface ornamented with ribs. *Q. buchiana* also resembles *Q. pseudobuchiana* in shape and internal structure but differs from it in having slightly rounded edges of the chambers instead of keeled ones. *Q. akneriana* and *Q. triangularis* are also related forms and differ only in that *Q. triangularis* has a broader and higher test. There are presumably other related species as well: *Articulina sarmatica* and *A. multibullata*, *Pyrgoella ventruosa* and *P. controversa*, *Sinuloculina consobrina* and *S. nitens*, *Affinetrina gualtieriana* and *A. planciana* (both having a rough surface with short incised lines), *Varidentella reussi*, *V. sarmatica* and *V. latelacunata*, *V. pseudocostata* and *V. rotunda* and many other species.

INTERGENERIC TRANSITION FORMS

Difficulties encountered in determining some miliolid genera result chiefly from the fact that there are species having "mixed" diagnostic characters, which rose doubts if these species have been included in appropriate genera. Such characters are, above all, the shape of the aperture and tooth and the number of chambers seen from the outside. For example, Glaçon (1963) identifies a specimen as *Triloculina* aff. *Biloculina mutabilis* Martinotti, which indicates that she had difficulties in determining the genus. Colom (1942, p. 26), too, emphasizes these difficulties. Some authors even deny the value of the shape of aperture and tooth as a diagnostic character, because the aperture is often damaged or filled with deposit (Prell-Müssig, 1965; Le Calvez, 1970).

Species with "atypical" characters are not numerous in this group of Foraminifera, but not exceptions, since they also exist among other microorganisms; nevertheless, they bring about a confusion in classification. Different authors made different attempts to find a way out of this situation, in which they were dependent on characters taken into consideration in determining the genus. For example, defining the genus *Quinqueloculina*, Vella (1957) gives most attention to the shape of aperture

and tooth, not to the internal structure. To be sure, this leads to the separation of two subgenera of *Quinqueloculina* (see Part I, p. 351), but certain species remain in the nondescript group "*Quinqueloculina sensu lato*". Prell-Müssig (1965) gives more attention to the internal structure, but states that it is difficult to tell *Quinqueloculina* from *Triloculina*. Thus, she arrives at the conclusion that the triloculine forms that have a "quinqueradiate" internal structure (later termed "cryptoquinqueloculine" by Bogdanowich, 1969; see Part I, p. 353), should be included in the genus *Quinqueloculina*. Therefore, reverting partly to Williamson's conceptions from 1858, she pays no attention to the shape of aperture and the relations between this shape and the internal structure, and within one genus combines the forms which might be referred to at least three genera — *Quinqueloculina*, *Cycloforina* and *Sinuloculina* — and perhaps also to *Varidentella*.

The existence of intergeneric transition forms has also been demonstrated by Hofker (1971), who used the orthogeny of the species "*Miliolina antiqua*" Franke from the Albian of Holland and north-western Germany as an example. Although his studies concern the development of these forms with time in the layers about 200 m thick, an analogous phenomenon can be observed in layers of one and the same age or even in a single sample. Hofker shows that the species studied, numbered by him in the genus *Quinqueloculina*, traced from the lowest layer to the highest one, passes through the genus *Sigmoilina* into *Spirosigmoilina* without any distinct boundaries between them. In consequence, he disputes the value of these genera and proposes a unit superior to genus, i.e. the "gens", as a genuine biological unit. Exemplified by "*Miliolina antiqua*" the "gens" develops from a certain form and evolves in a definite direction to become another form different from the initial one. Hofker illustrates this evolutionary series with sections of the forms mentioned.

An analysis of Hofker's conception calls in question the genera determined by him, in which he includes the group of forms examined. In view of the round toothless aperture, the juvenile stage of quinqueloculine structure and the sigmoiline adult stage, at least two genera, i.e. *Quinqueloculina* and *Sigmoilina*, may be excluded. *Spirosigmoilina* has not an aperture at the end of a neck, either. A close analysis will supposedly show that they belong to still another genus. This, however, is not essential to our problem, but the fact that intermediate forms can analogously be observed in series representing the ontogenetic development in several species of *Quinqueloculina* derived from a single sample from the Miocene layers at Korytnica. They, too, comprise quinqueloculine forms together with massiline ones, the sections of which show intermediate stages between them (e.g. *Q. anagallis*, Text-figs 7, 8; *Q. buchiana*, Text-figs 12, 13; see section "Ontogeny"); nevertheless, they cannot be treated otherwise than as developmental stages of one species. We can hardly speak about

orthogenetic development here, for the direction of development of these forms with time has not been examined. In this case the intermediate forms between the genera *Quinqueloculina* and *Massilina*, visible in the sections, have contributed to the recognition of the genus *Massilina* as synonymous with *Quinqueloculina* and representing only its ontogenetic stage (MS).

There are also species with intermediate characters between the genera *Quinqueloculina* and *Varidentella*, *Varidentella* and *Cycloforina*, *Cycloforina* and *Sinuloculina*, and between *Miliolinella* and *Pyrgoella*. For instance, *Quinqueloculina regularis* and *Q. pygmaea*, with a typically quinqueloculine internal structure, have a lower aperture and a shorter tooth, just as in *Varidentella* (Text-fig. 21); *Varidentella rosea*, which has a subcircular aperture like that in *Cycloforina*, in its internal structure shows a turn of the coiling axis, as in *Varidentella* (Text-fig. 50); *Sinuloculina consobrina* and *S. nitens*, whose initial stage is a quinqueloculine one and the shape of aperture like that in *Cycloforina*, in the adult stage have only 3 chambers seen from the outside, as in *Sinuloculina* (Text-figs 40, 43); *Miliolinella valvularis*, in rare adult forms of which the last two chambers cover the preceding ones as in *Pyrgoella*, has a cryptoquinqueloculine internal structure like *Miliolinella* (Text-fig. 37).

The foregoing examples indicate that there are difficulties in the classification of the Miliolidae also within the taxonomic unit proposed. An investigation of the genetic relationships between the species belonging to particular genera would presumably diminish these difficulties, but such investigation is possible only when based on evolutionary series, as in Hofker's case. It, however, goes beyond the scope of the present work and makes the subject for a separate publication. The examples chosen do not exhaust the problem. Here the author wants only to signal the existence of problems connected with the presence of intermediate forms between genera and the necessity of further studies on the phylogenetic development of miliolid species.

SYSTEMATIC PART

DESCRIPTION OF SPECIES

Suborder **Miliolina** Delage & Hérouard, 1896
Superfamily **Miliolacea** Ehrenberg, 1839
Family **Miliolidae** Ehrenberg, 1839
Subfamily **Quinqueloculininae** Cushman, 1917, emend Łuczkowska, 1972
Genus *Quinqueloculina* d'Orbigny, 1826, emend Łuczkowska, 1972

Studies on the internal structure and ontogeny of various species of the Miocene Miliolidae have shown (Łuczkowska, 1972) that in the genus

Quinqueloculina we should include forms with the following morphological features: 5 or more chambers visible from outside; oval, elongated aperture with a long simple or bifid tooth; chambers with a floor in the adult; last chambers of the adults of most species added in a single plane. There are three exceptions among the Miocene species: *Quinqueloculina spondiungeriana*, *Q. pygmaea* and *Q. regularis*, the massiline stage of which has not been found. The first of them has a typical aperture with a simple tooth but the other two show a non-typical, semicircular or triangular opening and a broad tape-shaped tooth. It may well be that these two species belong to another genus or they are transitional forms between the genera *Quinqueloculina* and *Varidentella*, to which they approximate in having a short broad tooth. They cannot however be assigned to the genus *Varidentella*, because they have not a cryptoquinqueloculine internal structure nor does their coiling axis turn in the ontogeny.

× *Quinqueloculina akneriana* d'Orbigny, 1846

(Pl. VIII, Figs 1*a-c*, 2*a*, *b*, 3*a*, *b*; Text-figs 3—5)

1846. *Quinqueloculina akneriana* d'Orbigny; A. d'Orbigny, p. 290, Pl. 18, Figs. 16—21.
1846. *Quinqueloculina pauperata* d'Orbigny; *ibidem*, p. 286, Pl. 17, Figs 22—24.
1950*b*. *Miliolina akneriana* (d'Orbigny); A. K. Bogdanowich, p. 145, Pl. 1, Fig. 10.
1952. *Miliolina akneriana* (d'Orbigny); A. K. Bogdanowich, p. 111, Pl. 10, Fig. 5.
non 1955. *Miliolina akneriana* (d'Orbigny); M. J. Serova, p. 304, Pl. 2, Figs 1—3.
1956. *Quinqueloculina akneriana* d'Orbigny; A. Sulimski, p. 82, Pl. 4, Figs 4—8.
1961. *Quinqueloculina akneriana* d'Orbigny var. *akneriana* d'Orbigny; V. I. Didkovsky, p. 34, Pl. 5, Fig. 6.
1970. *Quinqueloculina akneriana* d'Orbigny; D. Verhoeve, p. 26, Pl. 1, Figs 4, 5.

Material. [1] — About 100 QS and 20 MS (Coll. No. F-101, Sec. No. 143—147, 254, 320, 321, 329—331).

Dimensions: [2] QS — L 0.8—1.1; B 0.55—0.75; T 0.4—0.6; MS — L 1.5—2.5; B 1.1—1.9; T 0.5—0.85.

Description. — QS oval, slender, tapering at both ends, high and triangular in transverse section, periphery subacute; chambers narrow, with flattened sides, middle chamber elongate, large, convex, fifth chamber clearly visible; MS flat, oval in outline, periphery broadly rounded; chambers broad, middle chamber small, oval, narrowing at both ends; sutures distinct, slightly depressed; wall in QS thin, in MS thickened; surface smooth, polished; aperture oval with a long simple or bifid tooth.

Variability. The test shape varies from oval to narrowly oval, the periphery may be more or less rounded (Text-fig. 3). A characteristic

[1], [2] The numbers indicate the amount of specimens; the abbreviations used are as follows: QS — quinqueloculine stage, MS — massiline stage, Coll. No. — collection number, Sec. No. — section number, L — length, B — breadth, T — thickness. Dimensions are given in mm.

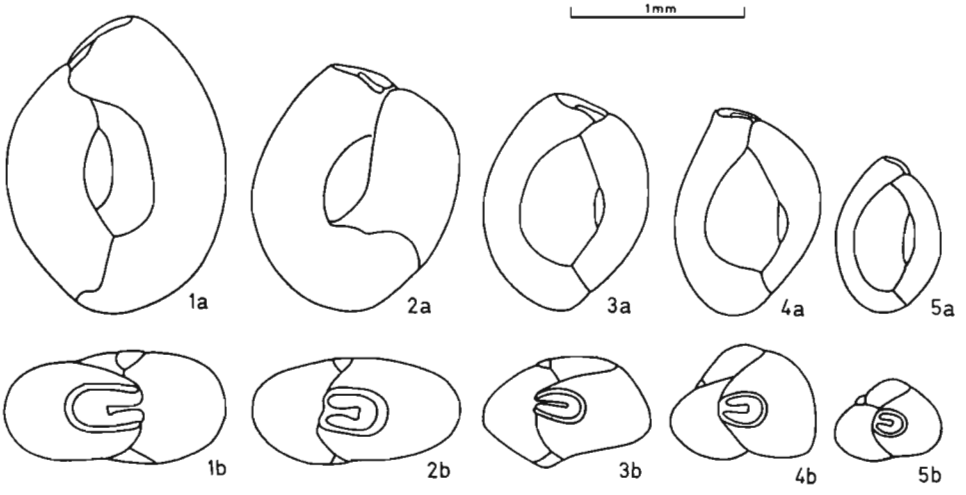


Fig. 3. Morphological variations and ontogeny of *Quinqueloculina akneriana* d'Orbigny, Lower Tortonian, Wieliczka; 1, 2 — MS; 3 — transitional form; 4, 5 — QS; *a* front view, *b* apertural view.

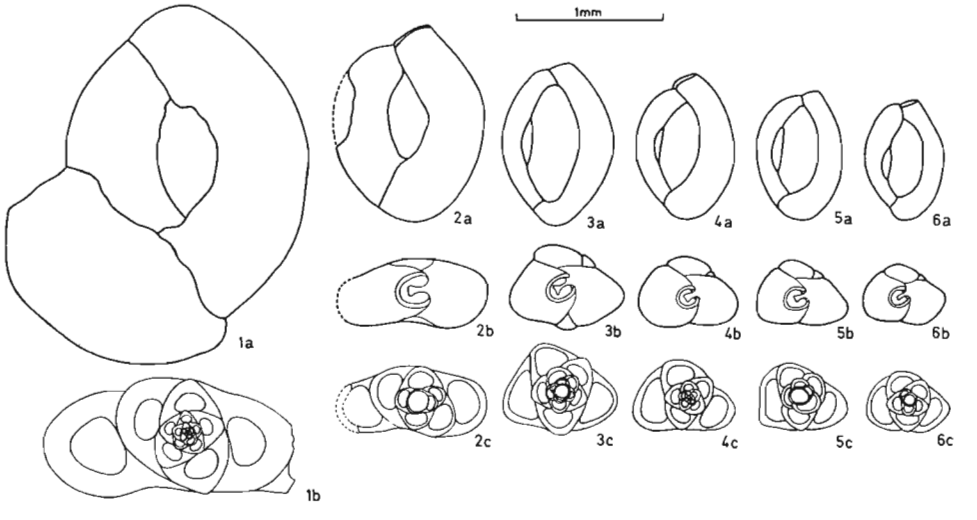


Fig. 4. Ontogeny and dimorphism of *Quinqueloculina akneriana* d'Orbigny, Lower Tortonian, Wieliczka; 1 — MS, micro generation, *a* front view, *b* cross-section; 2 — MS, mega I generation; 3, 5, 6 — QS, mega I generation; 4 *a* front view, *b* apertural view, *c* cross-section.

feature is the deformation of chambers in most of the quinqueloculine specimens, in which the frontal wall of each succeeding chamber is more convex than that of the back wall of the chamber.

Dimorphism. [3] Both QS and MS belong to the micro and mega I ge-

[3] The abbrevations: P — proloculus, PD — proloculus diameter.

nerations (Text-fig. 4). The mega II generation has not been found. PD: micro 20μ, mega I 70—160μ.

Ontogeny. — Only a few MS specimens have been found beside a large number of QS ones. The massiline stage was probably rarely attained in this species and mature individuals remained quinqueloculine. If we expose the juvenile stage by removing the external chambers of a specimen of "*Quinqueloculina pauperata* d'Orbigny" appearance, we receive a form of *Quinqueloculina akneriana* d'Orbigny appearance. (Text-fig. 5).

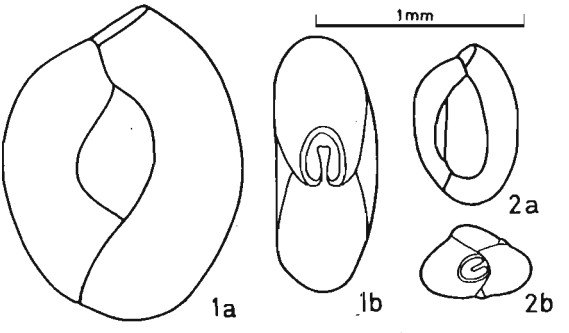


Fig. 5. *Quinqueloculina akneriana* d'Orbigny and its juvenile stage, Lower Tortonian, Wieliczka; 1 — MS; 2 — QS from inside MS; *a* front view, *b* apertural view.

The morphology of tests derived from the same sample indicates the presence of transitional forms between *Q. akneriana* and "*Q. pauperata*" (Text-fig. 3).

Remarks. — Our specimens are identical with the topotypes from Baden, but differ somewhat from d'Orbigny's illustration from 1846 in having a less rounded periphery. There is great morphological resemblance and probably also a relationship in internal structure between *Q. akneriana* and *Q. triangularis* d'Orbigny. *Q. akneriana* QS differs from *Q. triangularis* QS in its more slender shape and more distinct and depressed sutures. The aperture shape and the internal structure are identical in these species. The difference in the shape of tooth noted by d'Orbigny is insignificant as both species may have either a simple or a bifid tooth. The MS of both species is however indistinguishable, even in slightly damaged specimens. The QS of the mega II generation of both species is probably indistinguishable too, hence they are hard to identify. In spite of this conformity the quinqueloculine stage of these two species can be easily distinguished from each other on the basis of the test shape and therefore they are not regarded here as synonyms, as they are by some authors (e.g. Marks 1951, Verhoeve 1970). In the materials from Baden (Sooss) and Wieliczka both species are common and they differ evidently one from another. Both authors mentioned above synonymize a number of other species of d'Orbigny, Reuss, Bornemann and even *Q. seminulum*

(Linnaeus) with *Q. akneriana*. According to the author's observation none of these "synonymous" forms corresponds to *Q. akneriana*.

No such morphological variation as recorded by Gerke (1938) from the Spirialis Beds (Tchokrak horizon) in the East Forecaucasian area was observed in *Q. akneriana* from the Miocene material examined either from Baden or from Wieliczka. Gerke probably included a few different species, belonging even to different genera, in the range of variation of *Q. akneriana*.

The shape of test is similar to that of recent *Quinqueloculina neosigmoilinoides* Vella, 1957 (n.n. for *Q. sigmoilinoides* Vella, preoccupied, Kennet 1966), but differs from it in having a more slender shape of test, which taper at both ends.

Distribution. — Poland: Tortonian (Wieliczka). Austria: Tortonian, the vicinity of Baden, Vienna Basin. Czechoslovakia: Tortonian, Židlochovice and Devinska Nova Ves. Hungary: Sarmatian, the Mecsek Mts. Romania: Upper Tortonian and Sarmatian, Moldavia. USSR: Tchokrak (Middle Miocene), the Crimea-Caucasian region; Upper Tortonian, the south-western border of the Russian Platform, the Precarpathian Foredeep and Transcarpathians.

+ *Quinqueloculina alexandri* sp.n.

(Pl. IX, Figs 2*a-c*, 3*a*, *b*; Text-fig. 6)

1947. *Miliolina* aff. *boueana* (d'Orbigny); A. K. Bogdanowich, p. 22, Pl. 2, Fig. 1.
1952. *Miliolina* aff. *boueana* (d'Orbigny); A. K. Bogdanowich, p. 138, Pl. 18, Fig. 1.
1963. *Quinqueloculina* aff. *boueana* d'Orbigny; O. Djanelidze, p. 145, Pl. 1, Figs 1, 2; *cum syn.*

Holotypus: Pl. IX, Fig. 3*a*, *b*;
Paratypus: Pl. IX, Fig. 2*a-c*;
Locus typicus: Korytnica near Jędrzejów.
Stratum typicum: Lower Tortonian (Badenian), gray clay marls.
Derivatio nominis: after the forename of the famous author of the monograph on the Miliolidae of the USSR — Alexander Bogdanowich.

Diagnosis. — Test oval with broadly rouded periphery, flat; surface with numerous regular fine striae.

Material. — About 30 QS and about 50 MS, (Coll. No. F-102, Sec. No. 45, 46).

Dimensions: *Holotype* MS length 1.6 mm, breadth 1.25 mm, thickness 0.45 mm; *Paratypes* QS length 1.1—1.3 mm, breadth 0.75—1.0 mm, thickness 0.55 mm; MS length 1.35—2.5 mm, breadth 0.9—2.0 mm, thickness 0.5 mm.

Description. — Quinqueloculine stage regularly oval, periphery broadly rounded; chambers of uniform width, slightly inflated, midle chamber large, oval, inflated, fifth chamber poorly visible; massiline stage broadly

oval, flattened, periphery broadly rounded; middle chamber small, narrow and flat; sutures distinct, slightly depressed; wall thin; surface smooth, covered with numerous regular fine longitudinal striae; aperture large, oval, with flexuose margin, surrounded with a thickened rim.

Variability. No shape variation is observed. A distinctive feature of the species is the presence of characteristic fine striae, which are hardly visible in some specimens.

Dimorphism. Quinqueloculine forms belong mostly to the megalospheric I generation with a proloculus 70μ in diameter, massiline forms belong to the microspheric generation with a proloculus 20μ in diameter (Text-fig. 6). No differentiation of generations is observed in the test morphology.

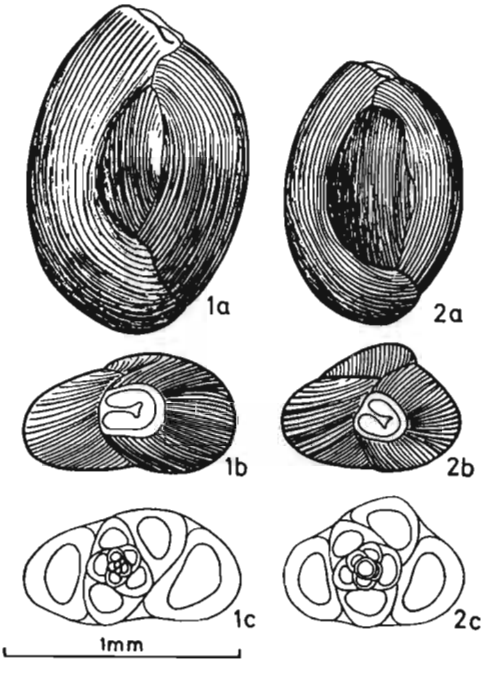


Fig. 6. Dimorphism of *Quinqueloculina alexandri* sp. n., Lower Tortonian, Korytnica; 1 — *MS*, micro generation, 2 — *QS* — mega I generation; *a* front view, *b* apertural view, *c* cross-section.

Remarks. — The quinqueloculine stage differs from *Quinqueloculina boueana* d'Orbigny from Nussdorf (Austria) in having a more oval shape and far more abundant fine striae. Specimens of *Q. boueana* from Vöslau (Austria) at the author's disposal have a slenderer shape and prominent longitudinal striae, about 12 on each chamber. According to A. K. Bogdanowich, who examined *Q. alexandri*, this species corresponds closely to the forms designated by him as *Quinqueloculina* aff. *boueana*. From

Q. schweyeri Bogdanowich from the Konka horizon (Middle Miocene) it differs in its broadly rouded periphery and more numerous striae.

Distribution. — Poland: Lower Tortonian (Korytnica, Karsy, Benczyn). USSR: Konka (Middle Miocene), the western Forecaucasian region and the West Ukraine.

Quinqueloculina anagallis sp.n.
(Pl. I, Figs. 1*a-c*, 2*a, b*, 3*a-c*; Text-figs 7—9, 11/1, 4)

Holotypus: Pl. I, Fig. 2*a, b*.
Paratypi: Pl. I, Figs 1*a-c*, 3*a-c*.
Locus typicus: Karsy near Jędrzejów.
Stratum typicum: Lower Tortonian (Badenian), gray clay marls.
Derivatio nominis: *anagallis* (Lat.) — ornamented.

Diagnosis. — Periphery sharply keeled, wall ornamented with numerous arcuate ribs, which form a rotatory pattern on the surface.

Material. — 20 QS and about 200 MS (Coll. No. F-103, Sec. No. 9, 12, 47—52, 54—58, 213, 216, 236—238, 240, 241).

Dimensions: *Holotype* MS length 1.7 mm, breadth 1.45 mm, thickness 0.5 mm; *Paratypes* QS length 0.5—1.25 mm, breadth 0.45—0.95 mm, thickness 0.25—0.75 mm; MS length 1.6—2.3 mm, breadth 1.3—2.1 mm, thickness 0.4—0.7 mm.

Description. — Quinqueloculine stage broadly oval, triangular or trapezoid in cross-section, periphery acute; chambers broad and flattened, middle chamber large, projecting and somewhat sloping, with distinct acute edge, fifth chamber visible as a narrow band; massiline stage large, flat, nearly circular, rhomboid in cross-section, periphery acute and keeled; last two chambers very broad with slightly inflated sides, very small middle chamber forms a small ridge in the central part of the test, surrouded with an annular depression, beside it there are sometimes traces of 1—2 flat chambers; sutures distinct, slightly depressed; surface smooth, polished, covered with numerous prominent arcuate ribs, which are often parallel to the periphery in quinqueloculine specimens, but usually slightly oblique to the periphery in massiline specimens; wall thin; aperture large, oval, surrouded with a thickened rim and with a long and bifid tooth; it is parallel to the acute periphery in massiline specimens, and oblique in quinqueloculine specimens.

Variability. A distinctive feature of the species is the wall ornamentation, in the richness of which some specimens differ somewhat from each other. The shape of test is invariable.

Dimorphism. Specimens of the microspheric, megalospheric I and megalospheric II generations have been observed. The massiline forms are mainly megalospheric II (Text-fig. 7), the megalospheric I generation is less numerous (Text-fig. 8) and the microspheric generation is quite

rare (Text-fig. 9). The quinqueloculine forms belong to the megalospheric I generation (Text-fig. 8). There is only slight variation in shape and ornamentation between the quinqueloculine and massiline groups, which are distinctly differentiated in respect of test size according to the proloculus diameter: the forms of the microspheric generation are the

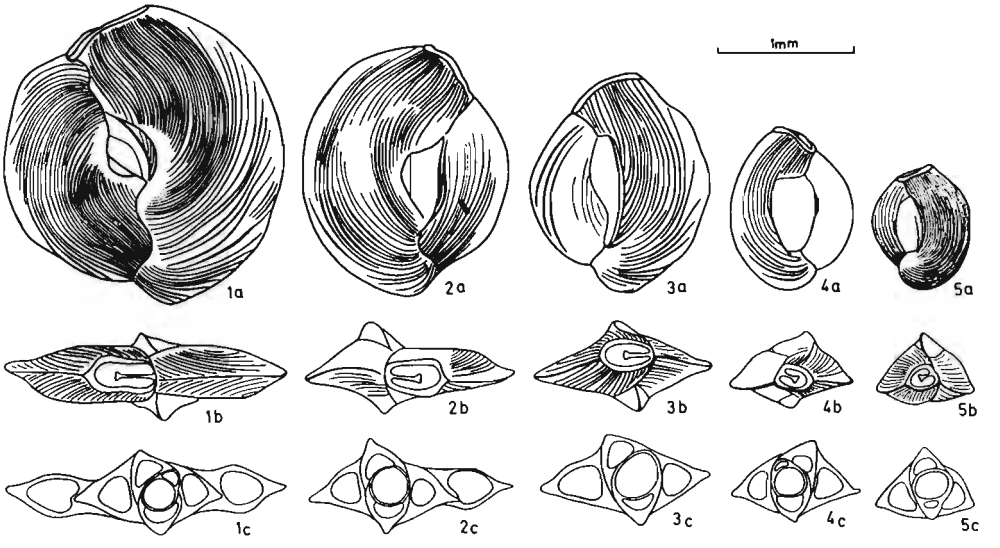


Fig. 7. Ontogeny of *Quinqueloculina anagallis* sp. n., Lower Tortonian, Karsy, mega II generation; 1-3 — *MS*; 4, 5 — *QS*; *a* front view, *b* apertural view, *c* cross-section.

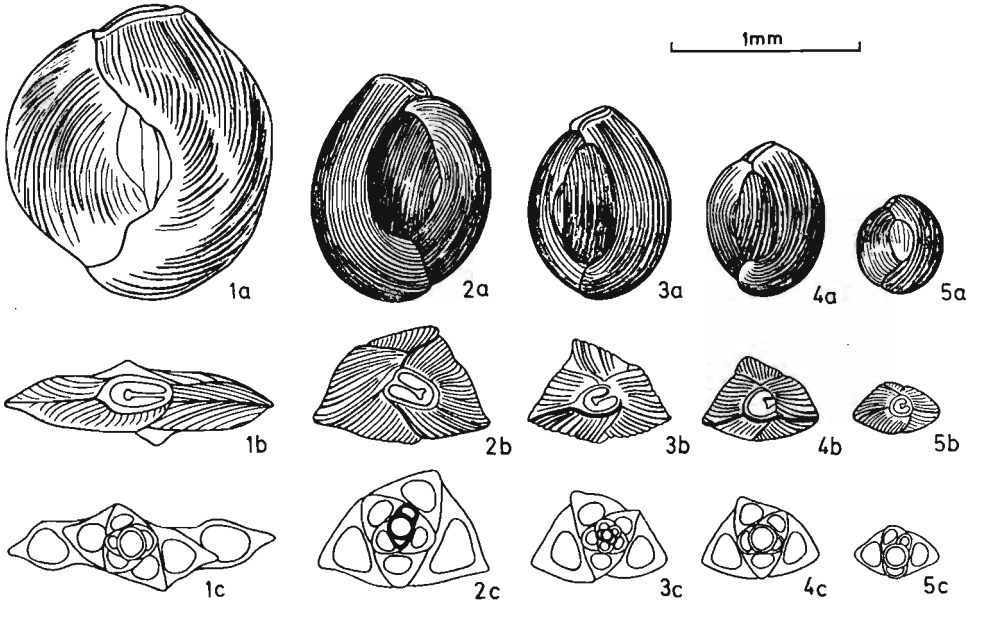


Fig. 8. Ontogeny of *Quinqueloculina anagallis* sp. n., Lower Tortonian, Karsy, mega I generation; 1 — *MS*; 2-5 — *QS*; *a* front view, *b* apertural view, *c* cross-section.

largest, those of megalospheric II generation are smaller and the forms of the megalospheric I generation are the smallest. The proloculus diameters are: microspheric — 20 μ, megalospheric I — 50—120 μ megalospheric II — 220—270 μ.

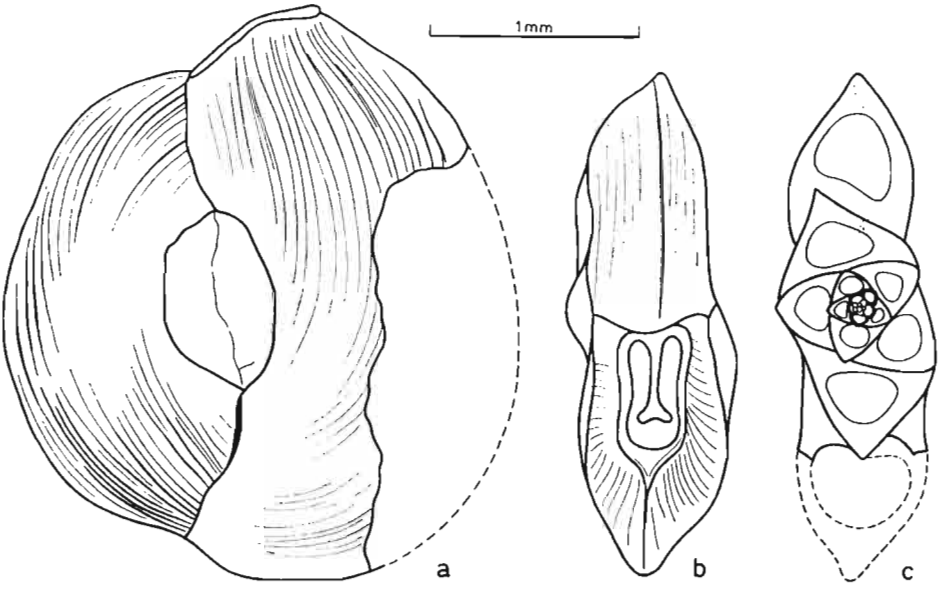


Fig. 9. *Quinqueloculina anagallis* sp. n., Lower Tortonian, Karsy; MS micro generation; *a* front view, *b* apertural view, *c* cross-section.

Ontogeny. — There are intermediate forms between the quinqueloculine and massiline stage. Particular stages of development observed in cross-sections show that the size of test is dependent on that of the proloculus rather than on the number of chambers. The specimens of the same size suggest that the larger the proloculus the fewer the chambers and vice versa, the smaller the proloculus the greater the number of chambers. The formation of the massiline stage in the megalospheric I generation begins after at least six chambers (besides the proloculus) of the quinqueloculine stage have been built. Next chambers are added in planes of coiling $\sim 180°$ apart, giving a slightly sigmoiline line in sections (Text-fig. 8/1). The formation of the massiline stage in the megalospheric II generation commences as early as 3—4 chambers of juvenile stage have been built and it proceeds in a slightly sigmoiline manner as well; the adult specimens possess about 4 chambers of massiline stage (Text-fig 7/1). Thus they are a good example of the partial reduction of the juvenile stage in connection with the reproductive cycle. The microspheric generation has about 20 chambers of quinqueloculine stage initially and only the last 3—4 chambers are massiline (Text-fig. 9). The juvenile specimens of massiline stage of the megalospheric I generation differ from those of

the megalospheric II generation only in their more slender shape and thicker test, which is triangular or trapezoid, not rhomboid, in cross-section. It may well be that the specimens of the megalospheric I generation remain quinqueloculine in the mature stage, without attaining the massiline arrangement of chambers.

Remarks. — Quinqueloculine forms resemble *Quinqueloculina dutemplei* d'Orbigny but differ from it in having more numerous and finer ribs. There is some similarity to *Q. buchiana* d'Orbigny in the shape of test and in that there are occasional specimens among the massiline forms with smooth early chambers, as in *Q. buchiana*, and ribbed later ones (Pl. I, Fig. 1). There are also forms with regular oblique wrinkles on the peripheral part of the smooth chamber walls of the juvenile stage, as in *Q. buchiana*, but in the later stage there appear ribs, as in *Q. anagallis* (Text-fig. 11/4). Such wrinkles are here regarded as disturbances in the normal continuous growth of chambers. Similar wrinkles, marked on the inner borders of chambers, occur in some massiline specimens, in which they resemble *Q. haidingeri* d'Orbigny (Text-fig. 11/1). Both species mentioned differ however from our specimens in having no chamber wall ornamentation at all.

Massiline forms are similar to *Massilina pulchra* Cushman & Gray from the Pliocene of California, but differ from it in their more acute periphery, the more inflated chambers and the different nature of the ribs, which make a rotatory pattern on the surface. They show great similarities in the test shape and chamber ornamentation to *Spiroloculina striatula* Ten Dam & Reinhold from the Middle Miocene of Holland, but differ from it in lacking an angular periphery and triple keel. Nevertheless, the two species are closely related, the more so as single specimens with only one keel have also been found in *S. striatula*. It seems that *Massilina* sp. *1*, described from the Lower Miocene of Westfalia (Indans 1962), corresponds morphologically to our specimens from the Tortonian.

Distribution. — Poland: Lower Tortonian (Karsy, Korytnica, Chomentów, Grabki Duże, Łęki Dolne). GFR: Lower Miocene, Westfalia. Romania: Lower Tortonian, Buitur.

Quinqueloculina bogdanowiczi (Serova, 1955)

(Pl. V, Figs 3 *a—c*, 4 *a—c*; Text-fig. 10)

1955. *Miliolina bogdanowiczi* Serova; M. J. Serova, p. 309, Pl. 4, Figs 1—3.
1961. *Quinqueloculina bogdanowiczi* (Serova); V. J. Didkovsky, p. 22, Pl. 1, Fig. 4.
1961. *Quinqueloculina brevia* Didkovsky; *ibidem*, p. 45, Pl. 9, Fig. 2.

Material. — About 200 QS and 20 MS (Coll. No. F-104, Sec. No. 126—130, 306).

Dimensions: QS — L 0.65-1.20; B 0.5-0.85; T 0.35-0.65; MS — L 1.2; B 1.1; T 0.5.

Description. — QS rhomboid with subacute periphery, subtriangular in cross-section; chambers slightly inflated, arcuate, central chamber small, convex, rhomboid in shape, with distinct roundish-angular edge, fifth chamber poorly visible or lacking; MS rhomboid-rounded, with subacute periphery, lenticular in cross-section; chambers broad, slightly inflated, two middle chambers small, flat; sutures flush and indistinct; surface smooth and dull; wall thick; aperture oval with simple tooth, slightly broadened at the end.

Variability. A remarkable and constant character of the species is the rhomboid shape of the test. The convexity of chambers is unstable and the outline of the periphery varies from subacute to acute.

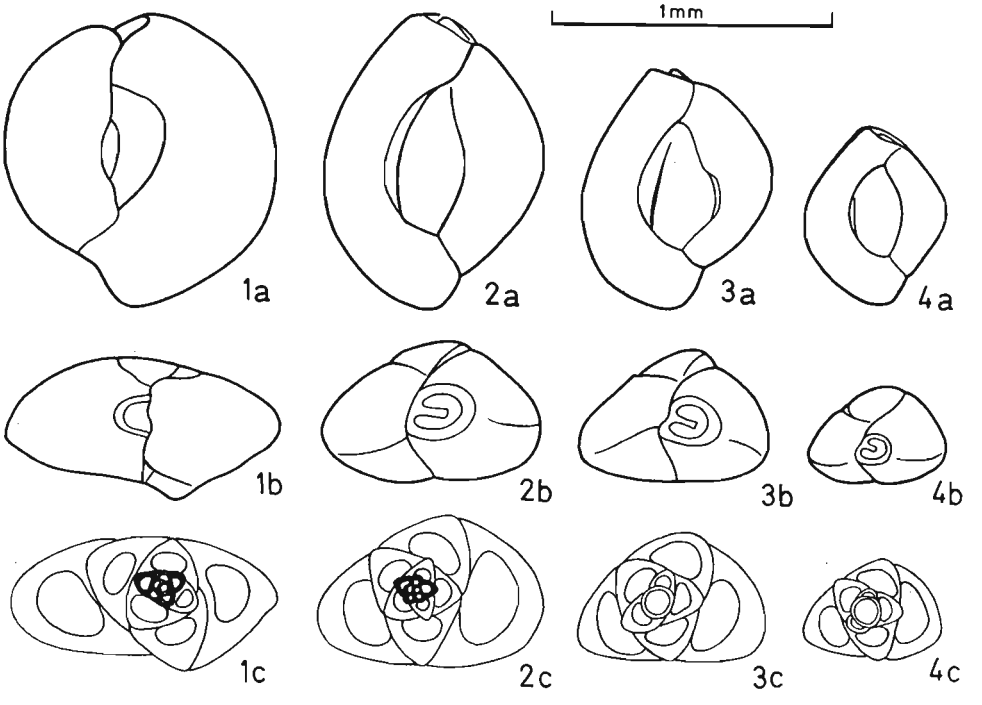


Fig. 10. Ontogeny and dimorphism of *Quinqueloculina bogdanowiczi* (Serova), Upper Tortonian, Węglinek; 1 — *MS*, micro generation; 2 — *QS*, micro generation; 3, 4 — *QS*, mega I generation; *a* front view, *b* apertural view, *c* cross-section.

Dimorphism. Micro and mega I generations are observed in cross-sections but are not conspicuous in the test morphology (Text-fig. 10). PD: micro 20—30 μ, mega I 100 μ.

Remarks. — From *Quinqueloculina triangularis* d'Orbigny it differs in the rhomboid shape and smaller thickness of the test and in its thicker wall.

Distribution. — Poland: Upper Tortonian (Benczyn, Bogoria, Bogucice, Brzeźnica, Gieraszowice, Rybnica, Węglinek, Zabawa). USSR: Lower and Upper Tortonian, the southwestern border of the Russian Platform; Lower Tortonian, the West Ukraine.

+ *Quinqueloculina buchiana* d'Orbigny, 1846

(Pl. IV, Figs 1 *a*—*c*, 2 *a*, *b*, 3 *a*, *b*, 4; Text-figs 11/2, 3; 12—14)

1846. *Quinqueloculina buchiana* d'Orbigny; A. d'Orbigny, p. 289, Pl. 18, Figs 10—12.
1846. *Quinqueloculina ungeriana* d'Orbigny; *ibidem*, p. 291, Pl. 18, Figs. 22—24.
1868. *Quinqueloculina ungeriana* d'Orbigny var. *stenostoma* Karrer; F. Karrer, p. 141, Pl. 2, Fig. 3.
1952. *Miliolina ungeriana* (d'Orbigny); A. K. Bogdanowich, p. 110, Pl. 10, Fig. 2.
1959. *Miliolina ungeriana* (d'Orbigny); M. Stancheva, p. 244, Pl. 4, Fig. 5.
1961. *Quinqueloculina ungeriana* d'Orbigny; V. J. Didkovsky, p. 38, Pl. 6, Fig. 3.

Material. — About 500 QS and about 100 MS (Coll. No. F-105, Sec. No. 79, 80, 82, 84, 94—96, 109, 210—212, 214, 215, 217—224).

Dimensions: QS — L 0.80-2.45; B 0.65-2.20; T 0.4-0.9; MS — L 1.95-3.50; B 1.70-3.20; T 0.5-0.8.

Description. — QS nearly circular, triangular or trapezoid in cross-section, periphery acute and keeled; chambers broad, flat, middle chamber

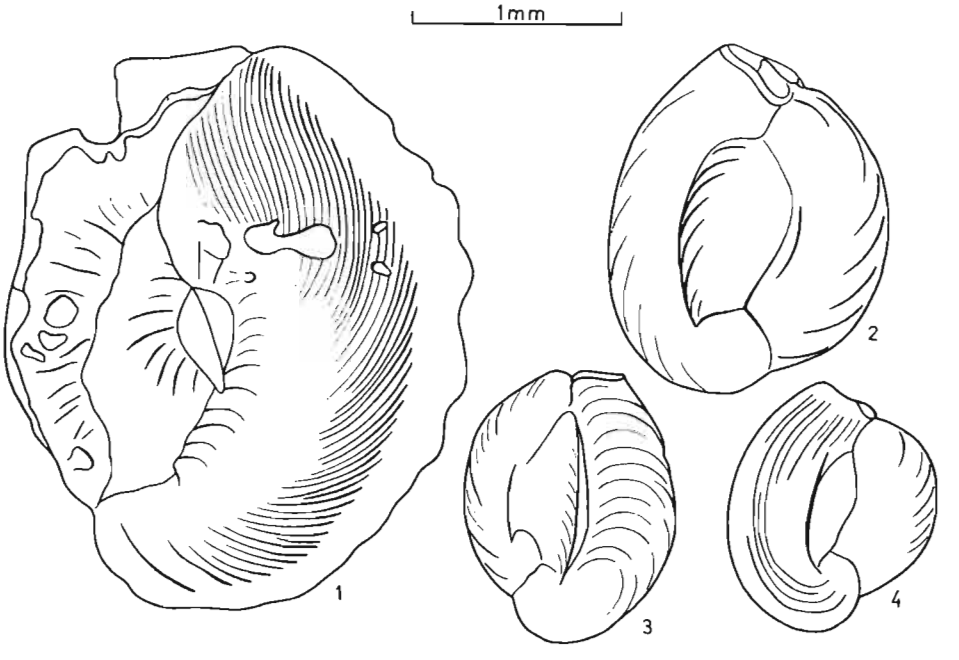


Fig. 11. Growth-lines on chamber edges of different species: 1 — *Quinqueloculina anagallis* MS sp. n. showing growth-lines as in *Q. haidingeri* MS d'Orbigny; 2 — *Quinqueloculina buchiana* QS d'Orbigny resembling "*Quinqueloculina ungeriana stenostoma*" Karrer; 3 — *Quinqueloculina buchiana* QS d'Orbigny resembling "*Quinqueloculina ungeriana*" d'Orbigny; 4 — *Quinqueloculina anagallis* QS sp. n. with growth-lines as in *Q. buchiana* and with striae as in *Q. anagallis*.

broad and sloping, with distinct acute edge, fifth chamber visible as a projecting band; MS rounded and flat, rhomboid in cross-section, periphery acute; chambers very broad, inflated, two small middle chambers form a small elevation; sutures distinct, flush; surface smooth, polished; aperture oval, with thickened rim in adult specimens, parallel to the periphery in massiline specimens and slightly oblique in quinqueloculine specimens.

Variability. The morphological features of this species are, as a rule, constant. There is only some variation in the sharpness of the edge and in the presence of oblique folds, connected with the growth of the test, on the sides or only edges of chambers in some specimens (Text-fig. 11/2, 3).

Dimorphism. Specimens of the micro, mega I and mega II generations are present. The micro generation is represented mainly by massiline

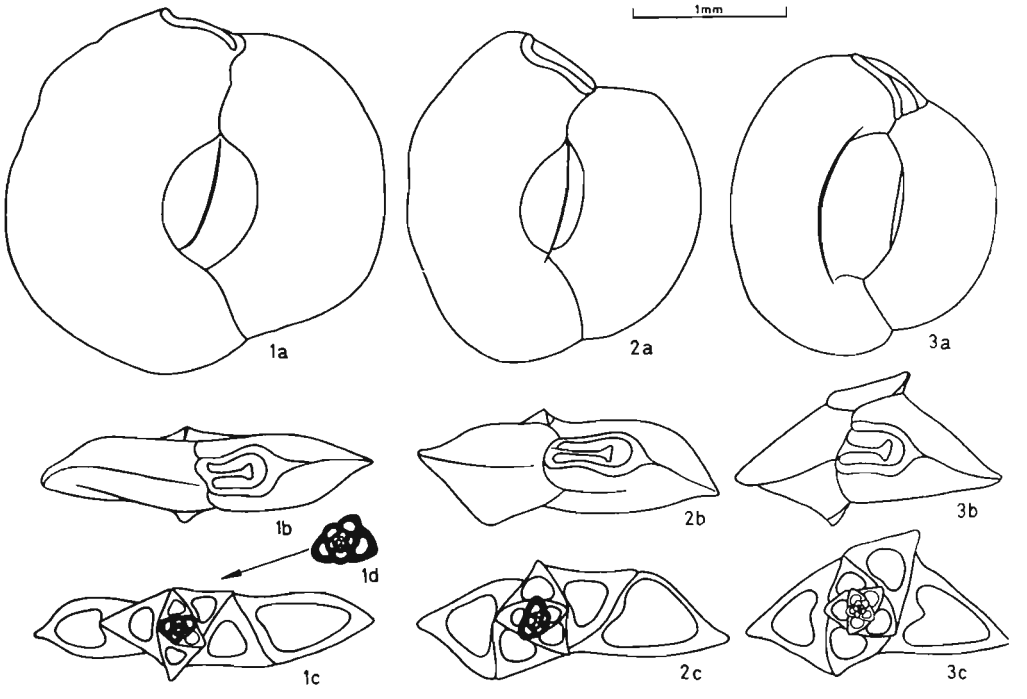


Fig. 12. Ontogeny of *Quinqueloculina buchiana* d'Orbigny, Lower Tortonian, Korytnica, micro generation; 1, 2 — *MS*, 3 — *QS*; *a* front view, *b* apertural view, *c* cross-section.

and large quinqueloculine forms (Text-fig. 12) the mega I generation has the shape of small quinqueloculine forms (Text-fig. 13/2—5). The mega II generation is rare, its size being usually greater than that of the mega I generation (Text-fig. 13/1). The massiline forms are also uncommon

and therefore a large amount of material must often be examined to find a single specimen. On the other hand, the quinqueloculine forms are abundant and include all the three generations, which can be distinguished however only in cross-sections. PD: micro — 20—25μ, mega I — 130—150μ, mega II — 250μ.

Ontogeny. — An examination of cross-sections shows that the quinqueloculine stage of massiline forms of micro generation is composed of about 16—18 chambers, which gradually but considerably increase in size

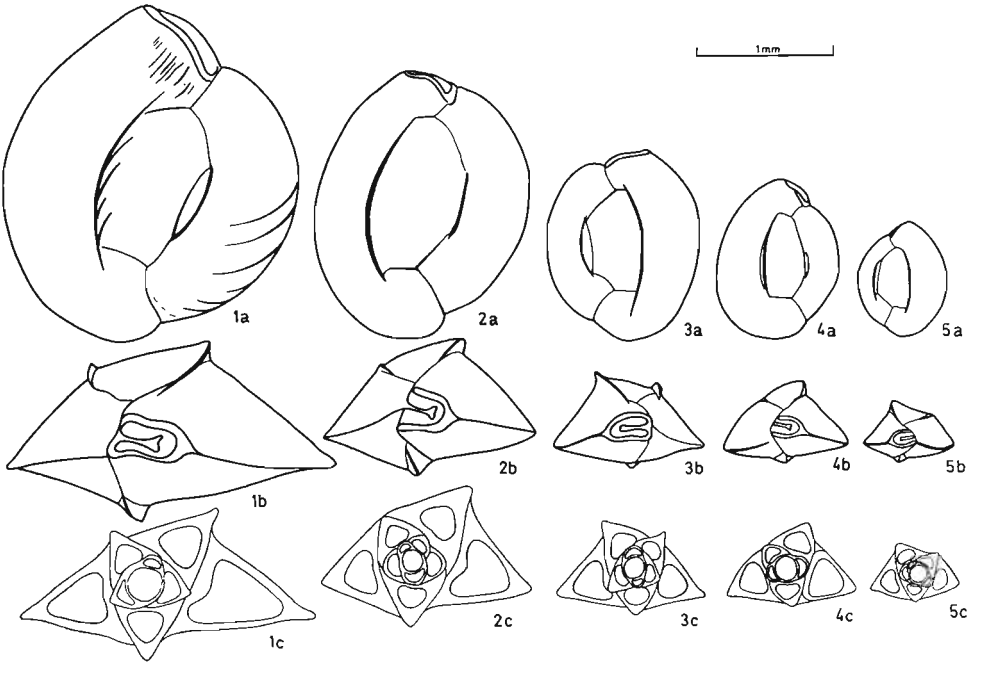


Fig. 13. Ontogeny of *Quinqueloculina buchiana* d'Orbigny, Lower Tortonian, Korytnica; 1 — QS, mega II generation; 2-5 — QS, mega I generation; *a* front view, *b* apertural view, *c* cross-section.

and are followed by 2—3 massiline chambers in planes about 180° apart (Text-fig. 12/1, 2), slightly sigmoiline in appearance. This is also seen in cross-sections of intermediate forms to the massiline stage (Text-fig. 12/3). The quinqueloculine forms of the mega II generation having a large proloculus (Text-fig. 13/1) and those of the mega I generation having a smaller proloculus (Text-fig. 13/2, 5) are composed of 7—10 chambers, gradually increasing in size. The size of tests is rather connected with the size of the proloculus than with the number of chambers, and the following interdependence may be stated: large proloculus — small number of chambers — large diameter of test; small proloculus — great number of chambers — small diameter of test; minute proloculus — very great number of chambers — large diameter of test.

Particular stages of the ontogenetic development of massiline forms may be observed on specimens the chambers of which are being removed successively (Text-fig. 14).

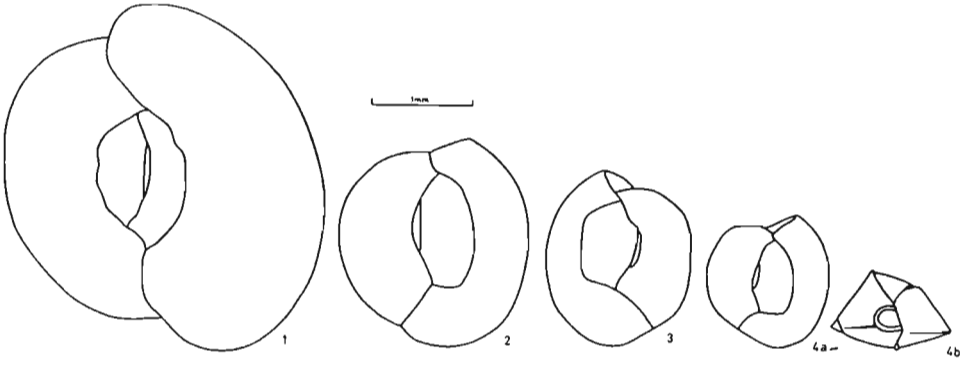


Fig. 14. *Quinqueloculina buchiana* d'Orbigny and its juvenile stage, Lower Tortonian, Benczyn; 1 — MS; 2-4 — QS from inside of the MS; *a* front view, *b* apertural view.

Remarks. — D'Orbigny (1846) described two species from the Miocene of the Vienna Basin, the morphology of which corresponds with that of our quinqueloculine forms: *Quinqueloculina buchiana*, having a smooth and polished test (d'Orbigny's illustration represents probably a damaged specimens with traces of regeneration) and *Q. ungeriana*, the surface of which is covered with oblique folds. Since such folds, regarded as signs of disturbances in the normal growth of tests may be observed in some specimens of both quinqueloculine and massiline forms not only in *Q. buchiana* but also in other species (e.g. *Q. haidingeri* d'Orbigny, *Q. anagallis* n.sp), *Q. ungeriana* has been recognized as a synonym of *Q. buchiana*. *Q. ungeriana stenostoma* Karrer is identical with the quinqueloculine forms of *Q. buchiana* and its corrugate border undoubtedly also represents marks of the abnormal growth of the test. Abundant specimens of *Q. buchiana* QS identical with ours were found in the materials from Baden, but none of them was massiline, probably owing to the small amount of the material examined. Surely, rare massiline forms were not observed by d'Orbigny either.

Q. buchiana MS is morphologically nearly identical with *Q. anagallis* sp.n. MS, from which it however differs in having a more solid test and no ornamentation, but it is indistinguishable from *Q. haidingeri* d'Orbigny MS, which is isomorphic but smaller. Differences between these two species are visible only in cross-sections which show high triangular quinqueloculine stage with flattened or slightly inflated sides and angular edges in *Q. haidingeri* MS (Text-fig. 16), whereas the quinqueloculine stage of *Q. buchiana* MS is lower, with flat or concave sides and acute, sharply keeled edges (Text-fig. 12).

Q. buchiana QS resembles three Recent species, described by d'Orbigny (1839) from Cuba: *Q. lamarckiana*, *Q. cuvieriana* and *Q. auberiana*. Since in the descriptions of *Q. buchiana* and *Q. ungeriana* from 1846 he did not mention the resemblance of these species to those described earlier from Cuba, he apparently considered them to be individual species. In the light of the descriptions of the species from Cuba, each of them is somewhat different from *Q. buchiana* in the shape of the aperture and test periphery.

Distribution. — Poland: Tortonian (Brzeźnica, Benczyn, Chomentów, Gliwice Stare, Grabki Duże, Iwkowa, Łęki Dolne, Karsy, Korytnica). Austria: Tortonian, the vicinity of Nussdorf and Baden, the Vienna Basin. Bulgaria: Tortonian, northwestern region of Bulgaria. Czechoslovakia: Tortonian, Židlochovice and Devinska Nova Ves. USSR: Tchokrak (Middle Miocene), North Caucasian and Crimea; Upper Tortonian, West Ukraine.

Quinqueloculina dichotoma (Reuss, 1850)

(Pl. II, Fig. 3*a-c*; Pl. III, Figs 1*a, b*, 2*a, b*; Text-fig. 15/4—7)

1850. *Triloculina dichotoma* Reuss; A. E. Reuss, p. 383, Pl. 49, Fig. 12*a-c*.

Material. — About 100 QS and about 80 MS (Coll. No. F-106, Sec. No. 111—115, 233—235).

Dimensions: QS — L 0.75—1.45; B 0.45—1.10; T 0.3—0.5; MS — L 1.6—1.8; B 1.25—1.45; T 0.5—0.7.

Description. — QS broadly oval, resembling *Quinqueloculina peregrina* d'Orbigny; surface smooth, polished, covered entirely or at least in the vicinity of edges and at the bottom of chambers with very tiny, longitudinal striae of various length, densely and irregularly distributed; the striae are well marked near the edges of chambers.

Variability. The number of striae and their distinctness are variable. There are intermediate forms between *Q. peregrina* and *Q. dichotoma*.

Dimorphism. Massiline forms, few in number, are the micro and mega I generations (Text-fig. 15/4, 5); much more frequent quinqueloculine forms belong only to the mega I generation (Text-fig. 15/6, 7). PD: micro — 20μ, mega I — 100—120μ. The differentiation of generations is not marked in morphology.

Remarks. — This species differs from *Quinqueloculina peregrina* in having a somewhat thicker test and in its striate surface, but the two species are undoubtedly related to each other. Similar finely striated forms occur in the Recent deposits of the Adriatic Sea, but they have a more elongated shape.

Distribution. — Poland: Lower Tortonian (Grabki Duże, Karsy, Korytnica). Austria: Tortonian, the vicinity of Baden, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice and Devinska Nova Ves.

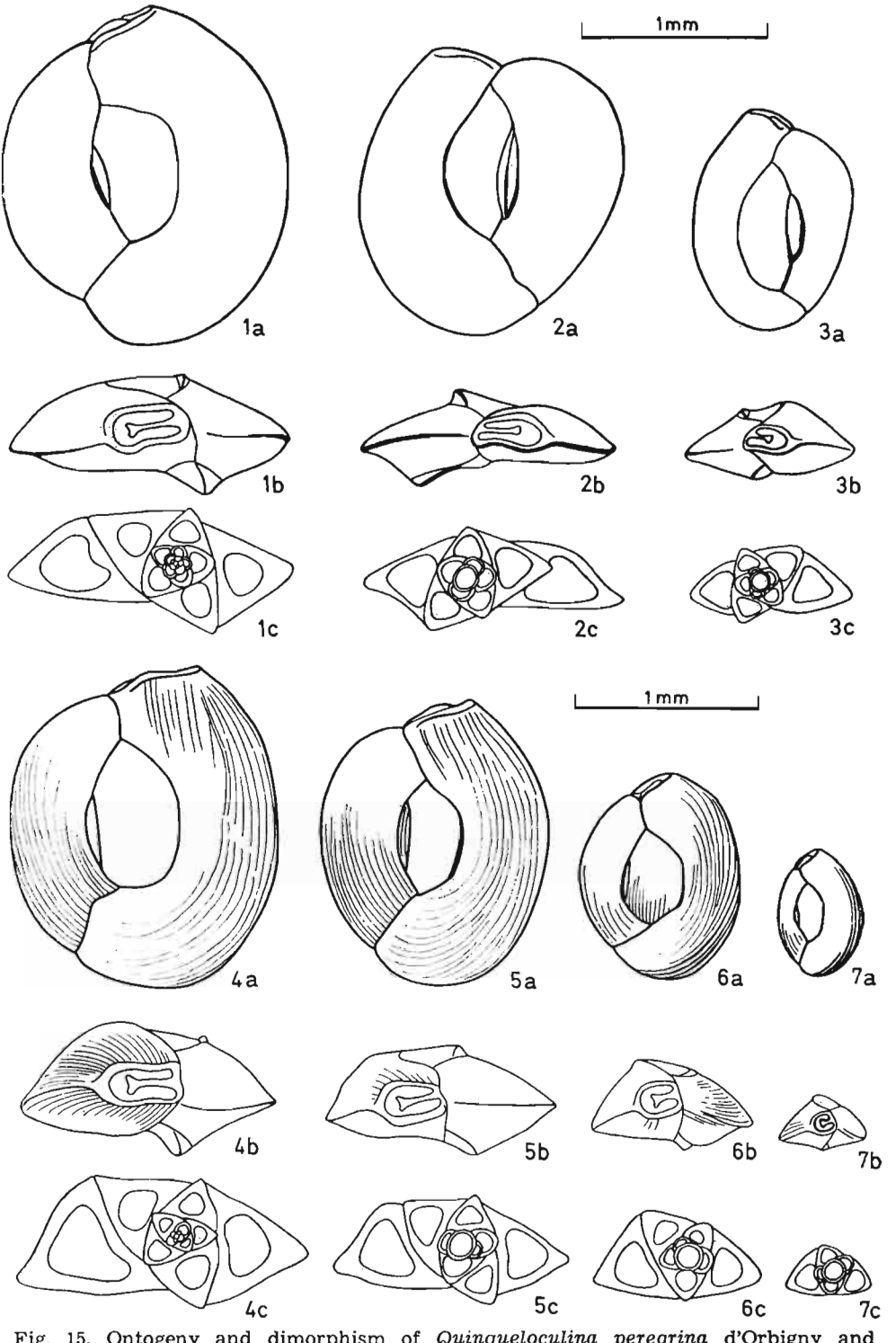


Fig. 15. Ontogeny and dimorphism of *Quinqueloculina peregrina* d'Orbigny and *Q. dichotoma* (Reuss); Lower Tortonian, Korytnica; 1-3 — *Q. peregrina*, 1 — MS, micro generation, 2 — MS, mega I generation, 3 — QS, mega I generation; 4-7 — *Q. dichotoma*, 4 — MS, micro generation, 5 — MS, mega I generation, 6, 7 — QS, mega I generation; *a* front view, *b* apertural view, *c* cross-section.

× *Quinqueloculina haidingeri* d'Orbigny, 1846

(Pl. III, Figs 3*a-c*, 4*a-c*; Text-figs 16, 17)

1846. *Quinqueloculina haidingeri* d'Orbigny; A. d'Orbigny, p. 289, Pl. 18, Figs 13—15.
1952. *Sigmoilina haidingeri* (d'Orbigny); A. K. Bogdanowich, p. 162, Pl. 24, Fig 1 (non Pl. 25, Fig. 1).
1962. *Massilina* sp. 2; J. Indans, p. 38, Pl. 2, Figs 4,5.
1968. *Massilina haidingeri* (d'Orbigny); I. Korecz-Laky, p. 151, Pl. 12, Figs 13, 14.
1968. *Quinqueloculina haidingeri* d'Orbigny; J. P. Margerel, p. 41, Pl. 4, Figs 9—11.
1971. *Sigmoilina haidingeri haidingeri* (d'Orbigny); B. Strashimirov, p. 133, Pl. 1, Fig. 21.

Material. — 5 QS and 15 MS (Coll. No. F-107, Sec. No. 124, 250—253, 255, 257—260, 312—314, 316, 322—326, 328, 342—345, 348).

Dimensions: QS — L 0.95—1.40; B 0.75—0.95; T 0.5—0.6; MS — L 2.0—2.8; B 2.2—2.8; T 0.6—0.7.

Description. — QS broadly oval, thick, subtriangular in cross-section, periphery acute; chambers broad, slightly inflated, middle chamber oval, tapering at both ends and with prominent edge, is nearly the same width as the last chambers, fifth chamber hardly visible or invisible; MS large, circular, flat, periphery acute; chambers broad, slightly inflated, smooth, with regular foldings on the inner edges of chambers in some specimens, 2—3 small and slightly inflated middle chambers are seen in the centre of the test; wall thick; surface smooth and polished; aperture large, oval, with sinuate edge and thickened rim.

Variability. Morphological features are constant. Some variation is seen in the convexity of chambers, which in the juvenile stage may be less inflated than in adult specimens.

Dimorphism. Massiline forms represent the micro and mega II generations, quinqueloculine forms are the mega I and mega II generations (Text-fig. 16). PD: micro — 20μ, mega I — 80μ, mega II — 200-220μ.

Remarks. — Massiline forms closely resemble *Quinqueloculina buchiana* d'Orbigny MS, the shape of which is identical, but the periphery more acute; the differences are visible only in sections, which show slightly inflated chamber walls in the juvenile stage of *Q. haidingeri*, whereas the walls of *Q. buchiana* are flat or concave and the edges are keeled (Text-fig. 12). Quinqueloculine forms are easy to distinguish thanks to the different convexity of chambers, as in the juvenile stage of massiline forms.

The species is rare in the materials from Wieliczka, and this is why a more detailed investigation of the internal structure has been carryied out on the topotypical material from Baden (Text-fig. 17). A large proloculus of mega II generation is visible in the cross-sections of massiline and quinqueloculine forms and only two specimens are microspheric. Juvenile forms of the mega II generation are 3 or 4-chambered when seen from outside (Text-fig. 17/6, 10).

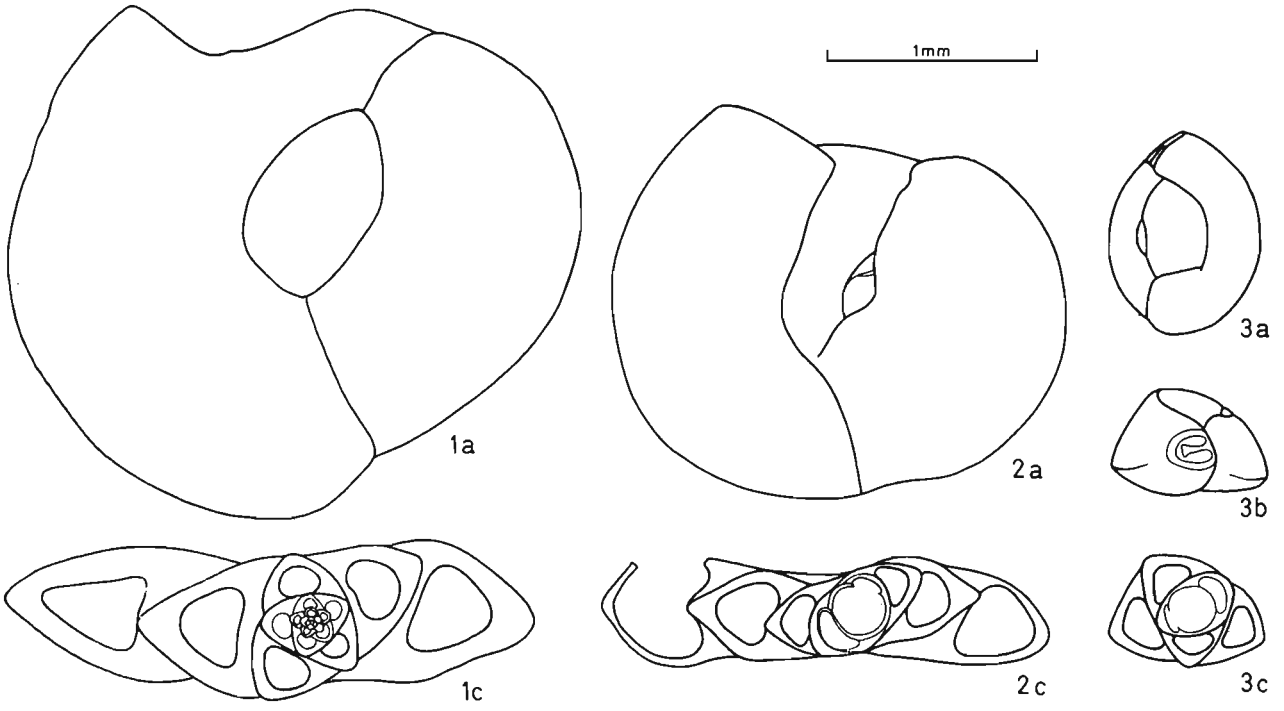


Fig. 16. Ontogeny and dimorphism of *Quinqueloculina haidingeri* d'Orbigny, Lower Tortonian, Wieliczka; 1 — MS, micro generation; 2 — MS, mega II generation; 3 — QS, mega II generation; *a* front view, *b* apertural view, *c* cross-section.

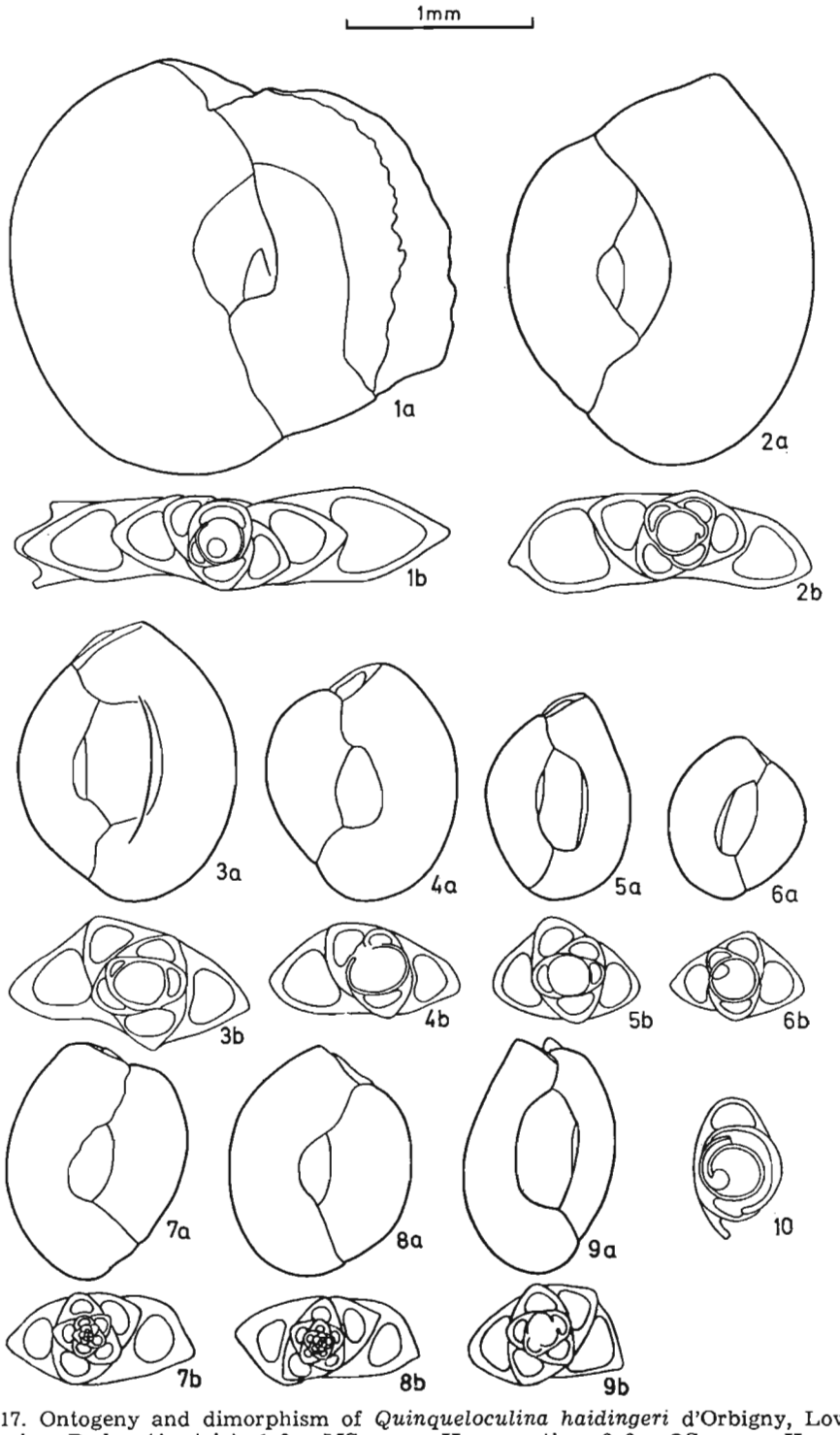


Fig. 17. Ontogeny and dimorphism of *Quinqueloculina haidingeri* d'Orbigny, Lower Tortonian, Baden (Austria); 1-2 — MS, mega II generation; 3-6 — QS, mega II generation; 7, 8 — MS, micro generation; 9 — QS, mega I generation; 10 — proloculus and two initial chambers of mega II generation; *a* front view, *b* cross-section.

Distribution. — Poland: Tortonian (Benczyn, Karsy, Łęki Dolne, Wieliczka). Austria: Tortonian, the vicinity of Baden, Vienna Basin. France: Redonien (Pliocene), the northwestern region of France. GFR: Lower Miocene, Westfalia. Hungary: Tortonian, Mecsek Mts. USSR: Tchokrak (Middle Miocene), Kuban, West Ukraine.

Quinqueloculina lentica sp.n.
(Pl. VI, Figs 1*a-c*, 2*a, b*, 3*a, b*; Text-fig. 18)

Holotypus: Pl. VI, Fig. 2*a, b*.
Paratypi: Pl. VI, Figs 1*a-c*, 3*a, b*.
Locus typicus: Korytnica near Jędrzejów.
Stratum typicum: Lower Tortonian (Badenian), gray clay marls.
Derivatio nominis: *lentica* — from lenticular shape of the test.

Diagnosis: Test circular, lenticular, with inflate chambers and acute periphery; most specimens are triloculine in appearance and have a small, oval middle chamber with a prominent edge.

Material. — About 150 QS and 20 MS, (Coll. No. F-108, Sec. No. 85—89, 102, 242—245, 247, 249).

Dimensions: Holotype MS length 1.8 mm, breadth 1.8 mm, thickness 0.8 mm; Paratypes QS length 0.6—2.0 mm, breadth 0.5—1.7 mm, thickness 0.35—0.9 mm; MS length 2.3—2.6 mm, breadth 1.8—2.3 mm, thickness 0.70—0.85 mm.

Description. — Quinqueloculine stage robust, compact, of nearly circular shape, lenticular in cross-section, periphery subacute; chambers broad, arcuate and inflated, middle chamber small, irregularly oval, tapering at both ends, slightly convex and with a distinct edge, fifth chamber narrow and small, often invisible so that some specimens have a triloculine appearance; massiline stage more flattened: sutures slightly depressed, distinct; wall thick; surface smooth, polished; aperture large, oval, surrounded with thickened rim, and oblique to the periphery.

Variability. A distinctive character of the species is its circular shape, lenticular outline in cross-section, and compact structure. The chamber edges may be more rounded in massiline forms.

Dimorphism. The massiline and large quinqueloculine forms are microspheric (Text-fig. 18/1, 2), the forms of triloculine appearance belong to the microspheric and megalospheric II generations (Text-fig. 18/3—7); no megalospheric I specimens have been found. Proloculus diameter: microspheric generation 10—20 μ, megalospheric II generation 150—270 μ. The massiline forms are rare.

Remarks. — This species is very close to *Quinqueloculina pseudobuchiana* n.sp, but differs in having a more circular shape of test, and more inflated chambers and in the triloculine appearance of most specimens. It differs from *Q. lenticularis* Reuss in its more inflated chambers and more acute periphery.

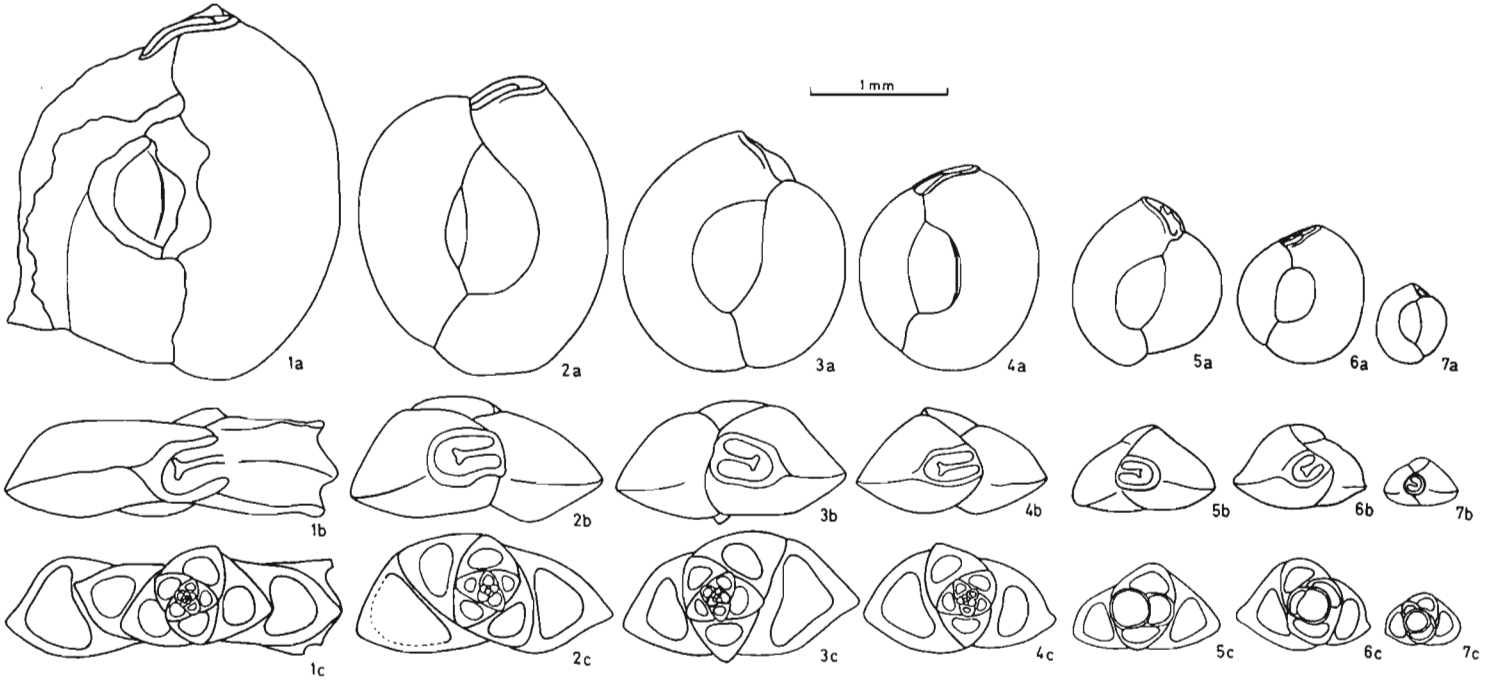


Fig. 18. Ontogeny and dimorphism of *Quinqueloculina lentica* n. sp., Lower Tortonian, Korytnica; 1 — MS, micro generation; 2 — QS, micro generation; 3, 4 — QS of triloculine appearance, micro generation; 5-7 — QS of triloculine appearance, mega II generation; *a* front view, *b* apertural view, *c* cross-section.

Distribution. — Poland: Lower Tortonian (Grabki Duże, Karsy, Korytnica, Łęki Dolne, Wieliczka).

Quinqueloculina parakneriana sp.n.
(Pl. VII, Figs 1*a*, *b*, 2*a*, *b*, 3*a*, *b*, 4*a*, *b*; Text-fig. 19)

Holotypus: Pl. VII, Fig. 4*a*, *b*.
Paratypi: Pl. VII, Figs 1*a*, *b*, 2*a*, *b*, 3*a*, *b*.
Locus typicus: Korytnica near Jędrzejów.
Stratum typicum: Lower Tortonian (Badenian), gray clay marls.
Derivatio nominis: *parakneriana* — close to *Q. akneriana*.

Diagnosis. — Test oval with broadly rounded periphery, thick and massive; walls inflated, tending to become flat.

Material. — 30 QS and 17 MS, (Coll. No. F-109, Sec. No. 232, 273, 352, 353, 356, 357).

Dimensions: Holotype MS length 2.2 mm, breadth 1.8 mm, thickness 0.75 mm; Paratypes QS length 1.1-1.7 mm, breadth 0.8-1.2 mm, thickness 0.6-0.75 mm; MS length 1.65-1.75 mm, breadth 1.25-1.45 mm, thickness 0.65-0.75 mm.

Description. — Quinqueloculine stage narrowly oval, tapering at both ends, periphery subrounded; chambers of uniform width, arcuate, sides nearly flat, middle chamber broad, much elongated, with prominent rounded edge, fifth chamber very small, occasionally invisible; massiline stage oval, large, robust, thick, slightly flattened, periphery nearly rounded with faintly marked edge; chambers broad, inflated, middle chamber elongate, narrowly oval, previous chambers slightly visible; sutures distinct, depressed; wall thick; surface smooth, polished; aperture large, elongate oval, with a flexuose margin surrounded with a thickened rim and furnished with a long bifid tooth.

Variability. Typical characters of the species are the oval shape of test, subrounded periphery and depressed sutures. The convexity of chambers is variable in massiline and large quinqueloculine forms, in which there is a tendency for the walls to become flattened and, as a result, a slightly pronounced keel is formed on one or two last chambers in some specimens.

Dimorphism. Only small quinqueloculine forms belong to the megalospheric II generation, having a proloculus 150 μ in diameter (Text-fig. 19/5). The other massiline and quinqueloculine forms studied are of the microspheric generation, the proloculus of which is 10—20 μ in diameter (Text-fig. 19/1—4).

Ontogeny. — As can be seen in sections, the roundeness of the periphery appears rather in adult specimens, being mostly subrounded in the juvenile stage. Most specimens of this species are quinqueloculine and they generally attain a large size. The massiline stage is rare.

Remarks. — Massiline forms differ from *Quinqueloculina akneriana* d'Orbigny MS in having a thicker and more massive test, a more slender

shape, more inflated walls, and a subrounded periphery with a slightly marked keel; quinqueloculine forms are more slender, having a low-triangular shape in cross-section and no tendency to the deformation of the chamber walls. The two species are otherwise undobtedly related. They

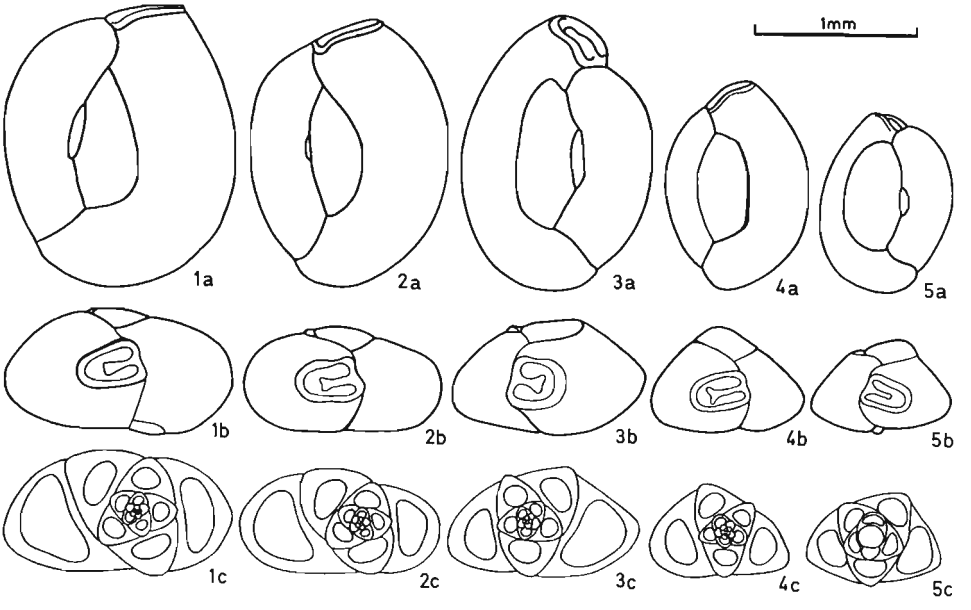


Fig. 19. Ontogeny and dimorphism of *Quinqueloculina parakneriana* n. sp., Lower Tortonian, Korytnica; 1, 2 — MS of quinqueloculine appearance, micro generation; 3, 4 — QS, micro generation; 5 — QS, mega I generation; *a* front view, *b* apertural view, *c* cross-section.

differ from *Q. pseudobuchiana* sp.n. in their more slender shape and rounded or subrounded, not acute or keeled, periphery. The massiline forms most resemble *Q. araucana* d'Orbigny from Recent seas, differ however in being twice as large and in having a more oval shape and a broader and bigger middle chamber. The quinqueloculine forms differ from *Q. laevigata* d'Orbigny in broader chambers and in more flattened walls.

Distribution. — Poland: Tortonian (Benczyn, Gliwice Stare, Grabki Duże, Iwkowa, Karsy, Korytnica, Łęki Dolne). Czechoslovakia: Lower Tortonian, Židlochovice.

Quinqueloculina peregrina d'Orbigny, 1846

(Pl. II, Figs 1*a-c*, 2*a*, *b*; Text-fig. 15/1—3)

1846. *Quinqueloculina peregrina* d'Orbigny; A. d'Orbigny, p. 292, Pl. 19, Figs 1—3.

Material. — 20 QS and 130 MS (Coll. No. F-110, Sec. No. 103—107).

Dimensions: QS — L 1.10-1.25; B 0.7-0.85; T 0.35-0.5; MS — L 1.40-1.85; B 1.05-1.55; T 0.4-0.5.

Description. — QS oval or narrowly oval, trapezoid in cross-section, periphery acute; chambers flat, narrow, arcuate, middle chamber oval, flat, tapering at both ends, fifth chamber appears as a narrow ridge; MS much flattened, broadly oval, periphery acute; chambers broad, flat, arcuate, two middle chambers are usually seen on both sides of the test; in adult specimens the narrow, prominent ridge of the third chamber is besides visible between them; sutures flat, distinct; surface smooth, polished; wall thin; aperture oval, with flexuose margins and thickened rim, and with a long bifid tooth.

Variability. The test shape and the degree of test flattening are variable. Quinqueloculine forms are narrowly oval and elongated, becoming more rounded and flattened as massiline chambers increase in number.

Dimorphism. Massiline forms are of the mega I and micro generations (Text-fig. 15/1, 2). Quinqueloculine forms represent only the mega I generation (Text-fig. 15/3). The differentiation of generations is not marked in morphology. PD: micro — 20 μ, mega I — 60—120 μ. Quinqueloculine forms are abundant and massiline forms rare.

Remarks. — This species differs from *Quinqueloculina haidingeri* d'Orbigny in having a more elongate shape, more flattened test, a more acute periphery and thinner walls. From *Q. dichotoma* (Reuss) it differs in its smooth, not striated surface. The shape of both these species is almost identical, being however more flattened in *Q. peregrina.*

Distribution. — Poland: Lower Tortonian (Grabki Duże, Karsy, Korytnica). Austria: Lower Tortonian, the vicinity of Baden, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice, Devinska Nova Ves. Italy: Miocene, Siena and Toscania region.

Quinqueloculina pseudobuchiana sp.n.

(Pl. IV, Fig. 5*a-c*, Pl. V, Figs 1*a, b*; 2*a, b*; Text-fig. 20)

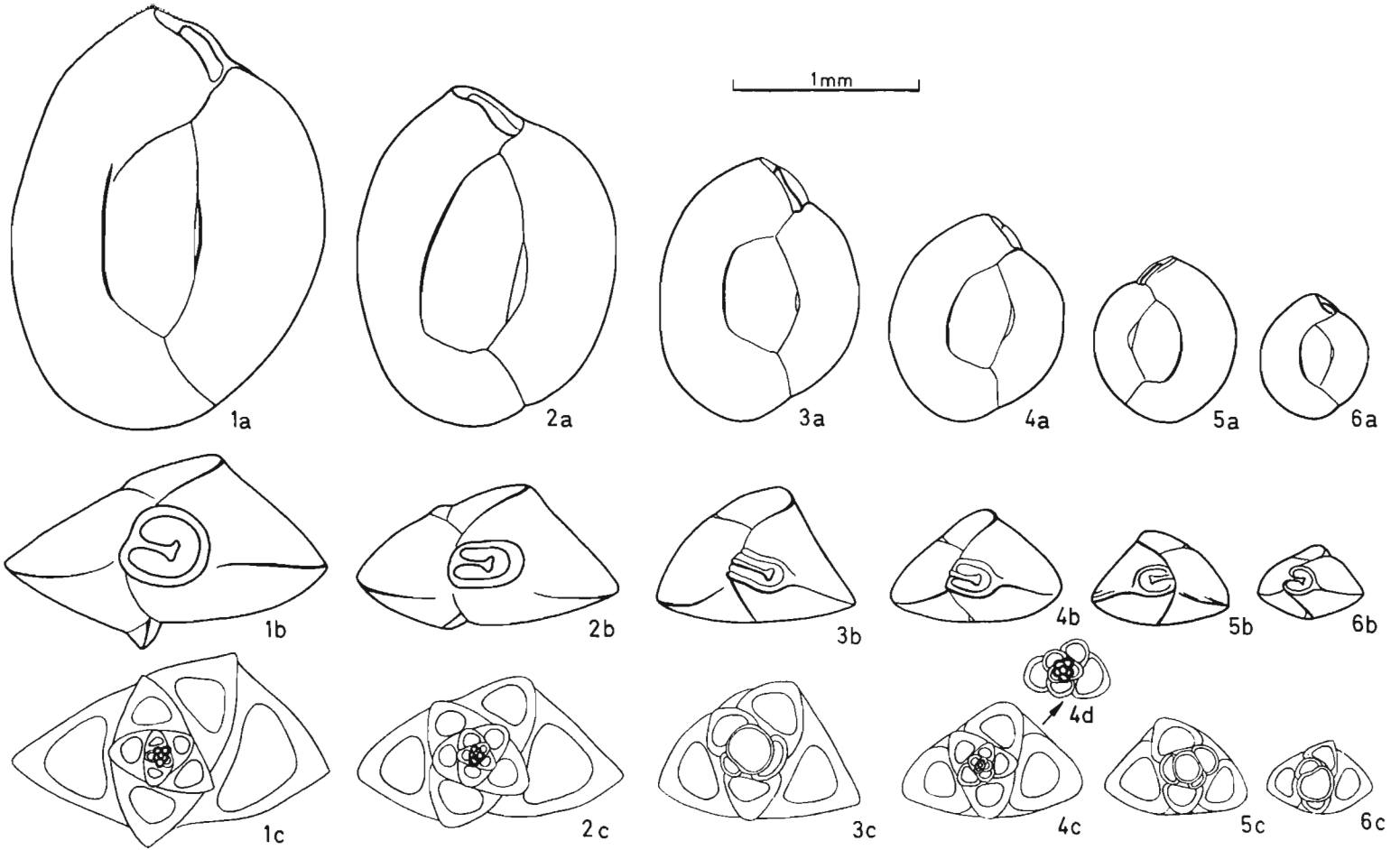
1952. *Miliolina ungeriana* (d'Orbigny); A. K. Bogdanowich, p. 110, Pl. 10, Fig. 3*a-c* (non 2*a, b*).

Holotypus: Pl. V, Fig. 2*a, b*.
Paratypi: Pl. IV, Fig. 5*a-c*, Pl. V, Fig. 1*a, b*.
Locus typicus: Korytnica near Jędrzejów.
Stratum typicum: Lower Tortonian (Badenian), gray clay marls.
Derivatio nominis: *pseudobuchiana* — false *Q. buchiana.*

Diagnosis. — Test broadly oval, chambers slightly inflated, periphery subacute, not keeled, middle chamber with slightly prominent edge, fifth chamber poorly visible.

Material. — About 120 QS and about 50 MS (Coll. No. F-111, Sec. No. 97—101, 227—231, 256, 269—272, 354, 355).

Dimensions: Holotype MS — length 2.0 mm, breadth 1.5 mm, thickness 0.75 mm; Paratypes QS — length 0.7-2.2 mm, breadth 0.6-1.6 mm,



[53]

Fig. 20. Ontogeny and dimorphism of *Quinqueloculina pseudobuchiana* sp. n., Lower Tortonian, Korytnica; 1 — MS of quinqueloculine appearance, micro generation; 2, 4 — QS, micro generation; 3, 5, 6 — QS, mega II generation; *a* front view, *b* apertural view, *c* cross-section.

thickness 0.4-0.9 mm; MS length 2.2-2.4 mm, breadth 1.6-1.9 mm, thickness 0.8-0.9 mm.

Description. — Quinqueloculine stage oval, triangular in cross-section, periphery subacute; chambers slightly inflated, middle chamber with slightly prominent edge, fifth chamber hardly visible as a narrow band; massiline stage broadly oval, somewhat depressed, lenticular in cross-section, periphery subacute; chambers broad, slightly inflated, middle chamber small, oval, tapering at both ends, a little convex, with somewhat prominent edge, fifth chamber narrow, distinct; sutures flat, hardly visible; wall thick, surface smooth, polished; aperture large, oval, surrounded with thickened rim, with long simple bifid tooth.

Variability. The periphery of quinqueloculine forms may be more or less acute and the walls may be quite flat.

Dimorphism. The large massiline forms and quinqueloculine forms belong to the microspheric generation and the small quinqueloculine forms to the microspheric and megalospheric II generations (Text-fig. 20). Proloculus diameters: microspheric — 10—20 μ, megalospheric II — 150—230 μ. The megalospheric I generation has not been found; the massiline forms are rare.

Remarks. — In general appearance this form resembles two species: *Quinqueloculina buchiana* d'Orbigny and *Q. lentica* sp.n.. From the first one it differs in having a more compact and thicker test and in lacking a sharp and keeled periphery. From the second one it differs in its elongated, not circular, shape and in more flattened walls. From *Q. parakneriana* sp.n. it is distinguished by the broader oval test and subacute, not rounded, periphery.

Distribution. — Poland: Lower Tortonian (Benczyn, Chomentów, Grabki Duże, Karsy, Korytnica, Łęki Dolne, Niechobrz). Czechoslovakia: Lower Tortonian, Židlochovice.

× *Quinqueloculina pygmaea* Reuss, 1850

(Pl. XXVII, Fig. 2*a-c*; Text-fig. 21/3, 4)

1850. *Quinqueloculina pygmaea* Reuss; A. E. Reuss, p. 384, Pl. 50, Fig. 3.
1970. *Quinqueloculina pygmaea* Reuss; D. Verhoeve, p. 28, Pl. 1, Fig. 10.

Material. — 30 QS (Coll. No. F-112, Sec. No. 379—381).

Dimensions: L 0.32-0.39; B 0.17-0.22; T 0.15-0.18.

Description. — Test narrowly oval, strongly elongated, regular, periphery narrowly rounded, somewhat truncate; chambers narrow and elongated, of uniform width, middle chambers narrow, slightly inflated; sutures poorly depressed, indistinct; wall thin; surface smooth and polished, with a light dull stripe along the edges of chambers; aperture very small, semicircular, with a broad and low tape-shaped tooth, which is occasionally lacking.

Variability and ontogeny. The remarkable feature of the species is the regular shape of the test. On the contrary, the tooth is variable in shape and may be partially or completely reduced. The sections show the micro generation. PD: 10—30 μ (Text-fig. 21/3, 4).

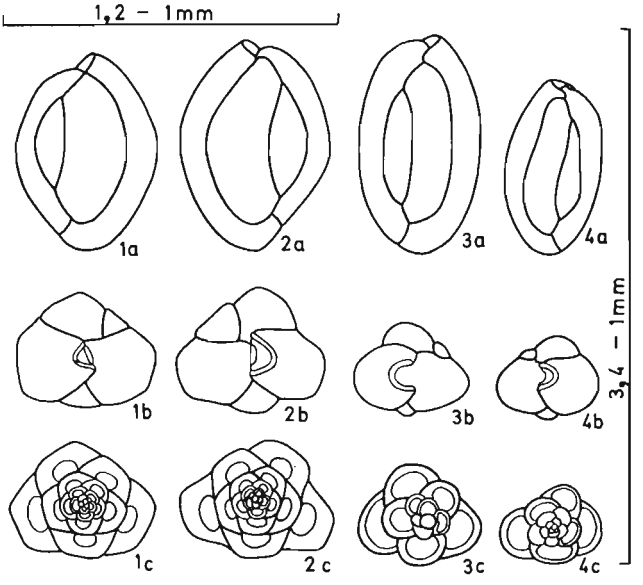


Fig. 21. Internal structure of *Quinqueloculina pygmaea* Reuss and *Quinqueloculina regularis* Reuss, Lower Tortonian, Wieliczka; 1, 2 — *Q. regularis*, micro generation; 3, 4 — *Q. pygmaea*, micro generation; *a* front view, *b* apertural view, *c* cross-section.

Remarks. — This species differs from *Quinqueloculina regularis* Reuss in the narrowly oval, strongly elongated shape of its test, narrower chambers and smaller dimensions, but it does not differ morphologically from *Quinquinella hornibrooki* Vella, 1957, which has even light stripes along the chamber edges. The only difference is its poorly developed tooth in the shape of a transverse tape, whereas the tooth of *Q. hornibrooki* has the shape of a semicircular plate. The aperture in *Q. pygmaea* corresponds rather to that in the genus *Varidentella* than in the genus *Quinqueloculina*, despite its typical quinqueloculine internal structure, and it is undoubtedly transitional between these two genera.

Distribution. — Poland: Tortonian (Benczyn, Budy, Gliwice Stare, Krywałd, Ligota Zabrska, Wieliczka, Zrecze). Austria: Tortonian, the vicinity of Baden, Vienna Basin.

× *Quinqueloculina regularis* Reuss, 1850
(Pl. XXVII, Fig. 1*a-c*; Text-fig. 21/1, 2)

1850. *Quinqueloculina regularis* Reuss; A. E. Reuss, p. 384, Pl. 50, Fig. 1*a-c*.
1960. *Quinqueloculina akneriana* d'Orbigny; N. N. Subbotina *et al.*, p. 28, Pl. 1, Fig. 1*a-c*.

1962. *Quinqueloculina badenensis planocarinata* Venglinsky; I. V. Venglinsky, p. 75, Pl. 5, Fig. 1*a-c*.

Material. — Over 150 QS (Coll. No. F-113, Sec. No. 307—311).

Dimensions: L 0.55-0.62; B 0.38-0.45; T 0.30-0.35.

Description. — Test rhomboidal, regular, periphery narrowly rounded and slightly truncate; chambers narrow, of uniform width, arcuate, trapezoid in cross-section, middle chambers large, strongly projecting, fifth chamber well marked, convex; sutures depressed, distinct; wall thick; surface smooth, polished; aperture small, triangular or semicircular in shape, with a short and broad, quadrangular, not bifid, tooth.

Variability. Distinctive features of the species are its slight morphological variability, very regular internal structure, truncate periphery and triangular or semicircular aperture. Only the shape of the tooth varies markedly from quadrangular to transversely rectangular or tape-shaped, being sometimes completely reduced. Such specimens with a reduced tooth were probably used by Reuss in describing the species.

Dimorphism and ontogeny. All specimens sectioned represent the micro generation; PD 20—30 μ. The sections show very thick walls and the unusually regular arrangement of low and wide, but constantly trapezoid chambers (Text-fig. 21/1, 2).

Remarks. — This species much resembles *Cycloforina suturalis* (Reuss), which however differs in its more oval, not rhomboidal, shape of the test, rounded, not truncate, periphery and circular, not triangular or semicircular, shape of the aperture. *Q. regularis* is probably related to *Q. padana* Perconig, from the Upper Pliocene of Italia and to *Q. pentagona* Giunta from Recent of the vicinity of Genoa, but these species have a much more truncate periphery in comparison with *Q. regularis*. This species corresponds rather to the genus *Varidentella* in its type of the aperture and tooth, although it has a typically quinqueloculine internal structure. It belongs, together with *Q. pygmaea*, to the supposed group of intermediate forms between the genera *Quinqueloculina* and *Varidentella*.

Distribution. — Poland: Tortonian (Brzeźnica, Budy, Chełm n/Rabą, Gliwice Stare, Grzybów, Ligota Zabrska, Krywałd, Wieliczka, Zrecze, Zgłobice). Austria: Tortonian, the vicinity of Baden, Vienna Basin. Czechoslovakia: Tortonian, Devinska Nova Ves. USSR: Upper Tortonian, the Precarpathian Foredeep and Transcarpathians.

Quinqueloculina spondiungeriana (Serova, 1955)
(Pl. X, Fig. 1*a-c*; Text-fig. 22)

1955. *Miliolina spondiungeriana* Serova; M. J. Serova, p. 307, Pl. 3, Figs. 1—3.
1961. *Quinqueloculina spondiungeriana* (Serova); V. J. Didkovsky, p. 49, Pl. 9, Fig. 1.

Material. — Over 100 QS (Coll. No. F-114, Sec. No. 131—132).

Dimensions: L 1.0-1.4; B 0.55-0.75; T 0.35-0.50.

Description. — Test much elongated, narrowly oval, tapering at both ends, triangular in cross-section, periphery acute; chambers narrow, flat, slightly arcuate, middle chamber narrow and elongated, with a prominent edge, fifth chamber hardly visible; sutures flat, distinct; wall thin; surface smooth, polished; aperture small, oval, with a simple narrow tooth.

Variability. The strongly elongated test and triangular cross-section are constant features of the species. The edge of the middle chamber is projecting to a various degree.

Dimorphism and ontogeny. The sections show the micro generation; PD 20 μ (Text-fig. 22). No massiline forms have been found. In the

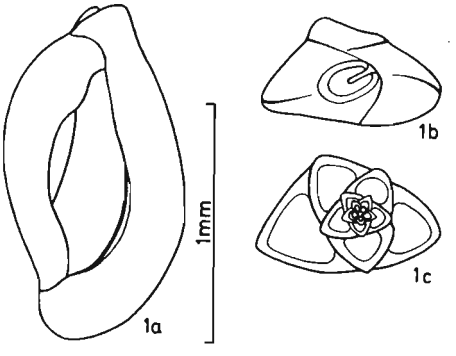


Fig. 22. Internal structure of *Quinqueloculina spondiungeriana* (Serova), Upper Tortonian, Węglinek, micro generation; *a* front view, *b* apertural view, *c* cross-section.

juvenile stage 2—3 tubular chambers are visible, whereas all the later chambers are uniform in shape, triangular in cross-section, with angular edges.

Remarks. — The specimens studied are identical with *Q. spondiungeriana* (Serova), the only difference being the less prominent edge of their middle chamber. They differ from *Q. venusta* Karrer in having an oval, not circular, aperture, a shorter tooth and less acute chamber edges. From *Q. stelligera* Schlumberger they differ in their oval aperture. and in the lack of truncate edges.

Distribution. — Poland: Tortonian (Bogoria, Brzeźnica, Grabki Duże. Grabowiec, Gliwice Stare, Dwikozy, Niskowa, Rybnica, Węglin, Wieliczka). Czechoslovakia: Lover Tortonian, Židlochovice. USSR: Lower Sarmatian. the southwestern border of the Russian Platform, West Ukraine.

× + *Quinqueloculina triangularis* d'Orbigny, 1846
(Pl. VIII, Figs 4*a-c*, 5*a-c*, Pl. IX, Fig. 1*a*, *b*; Text-figs 23, 24)

1846. *Quinqueloculina triangularis* d'Orbigny; A. d'Orbigny, p. 228, Pl. 18, Figs 7—9.
1959. *Miliolina podolica* Didkovsky; V. I. Didkovsky, p. 306, Text-figs 1—3.

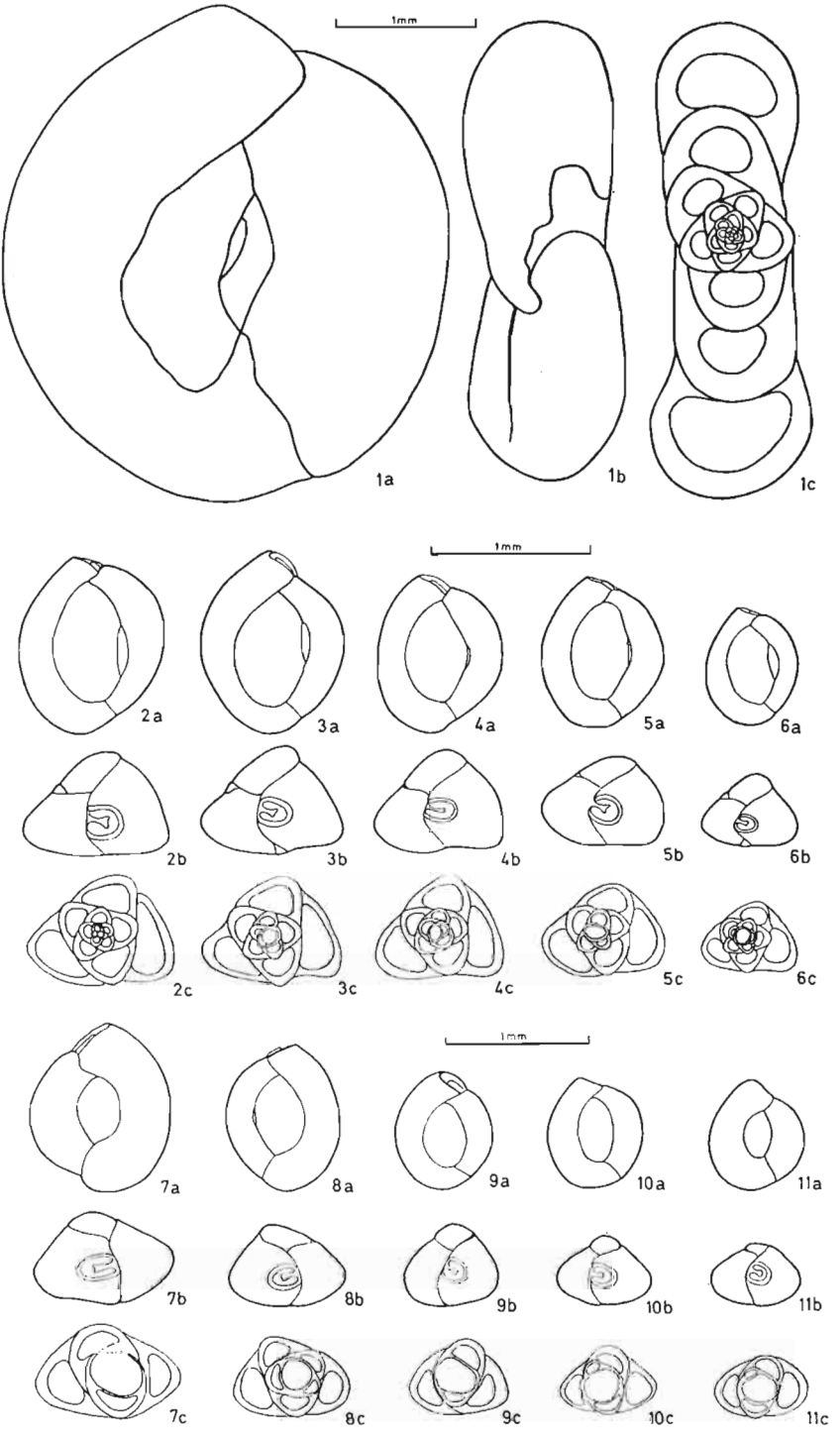


Fig. 23. Ontogeny and dimorphism of *Quinqueloculina triangularis* d'Orbigny, Lower Tortonian, Wieliczka; 1 — MS, micro generation; 2 — QS, micro generation, 3-6 — QS, mega I generation, 7-11 — QS, of triloculine appearance, mega II generation; *a* front view, *b* apertural view, *c* cross-section.

1968. *Quinqueloculina triangularis* d'Orbigny; J. P. Margerel, p. 16, Pl. 5, Figs 21—22 (non Pl. 6, Fig. 1).

1969*b*. *Quinqueloculina akneriana akneriana* d'Orbigny; A. K. Bogdanowich, p. 86, Pl. 2, Fig. 8*a*, *b*.

Material. — Over 1000 QS and 20 MS (Coll. No. F-115, Sec. No.139—142, 315, 317—319, 346, 347, 349—351).

Dimensions. QS — L 0.8-1.25; B 0.5-1.05; T 0.5-0.8; MS — L 1.65-3.5; B. 0.8-1.25; T 0.4-0.8.

Description. — QS broadly oval, thick, high-triangular in cross-section, periphery subacute; chambers broad, flat on one side and slightly inflated on the other; middle chamber large, broad, prominent; juvenile stage may be triloculine; MS large, flat, with broadly rounded periphery and indistinct middle chambers; sutures slightly depressed, indistinct; wall thin in QS, thick in MS; surface smooth, polished; aperture oval, not large, with a simple, bifid tooth.

Variability. The shape of massiline forms varies from circular to broadly oval, whereas the quinqueloculine and triloculine forms are always the same shape. A distinctive feature of the massiline forms is their rounded periphery, while the quinqueloculine forms show a particular deformation of chambers. which are increasingly more inflated on the front side than on the back side. This is well seen in cross-sections (Text-fig. 23).

Dimorphism. Massiline forms belong generally to the micro generation (Text-fig. 23/1), quinqueloculine forms to the micro and mega I generations (Text-fig. 23/2—6) and triloculine forms to the mega II generation (Text-fig. 23/7—11). The morphological differentiation of generations is not marked except for the size of the proloculus and the number of chambers. PD: micro — 20—30 μ, mega I — 100—110 μ, mega II — 200—300 μ.

Remarks. — Massiline forms show the same shape and internal structure as *Miliolina podolica* Didkovsky, 1959 does. It is clearly seen from the cross-section of this species given by its author (*op. cit.*, Text-fig. 2) and from those of our specimens, that the juvenile stage has its internal structure identical with that of *Quinqueloculina triangularis* d'Orbigny. The only difference betwen them is the thicker wall in the juvenile stage of the massiline forms of *Q. triangularis* which indicates that there is a possibility for calcium carbonate to accumulate on the chamber walls of the juvenile stage while successive massiline chambers are being built. The quinqueloculine stage removed from the inside of the massiline form corresponds morphologically to *Q. triangularis* (Text-fig. 24). It should be mentioned that both the species have been described from strata of the same age, namely *Q. triangularis* from the lithothamnian facies of the Upper Tortonian of Nussdorf in the Vienna Basin, and *M. podolica* from the clay facies of the Upper Tortonian in Podolia.

The species studied differs from *Quinqueloculina akneriana* d'Orbigny QS in its broadly oval test shape and indistinct, flat sutures, but at the same time it is similar in having the same deformation of chambers. The massiline forms differ in being more rounded then *Q. akneriana* MS, furthermore, they are similar to one another and undoubtedly represent closely related species.

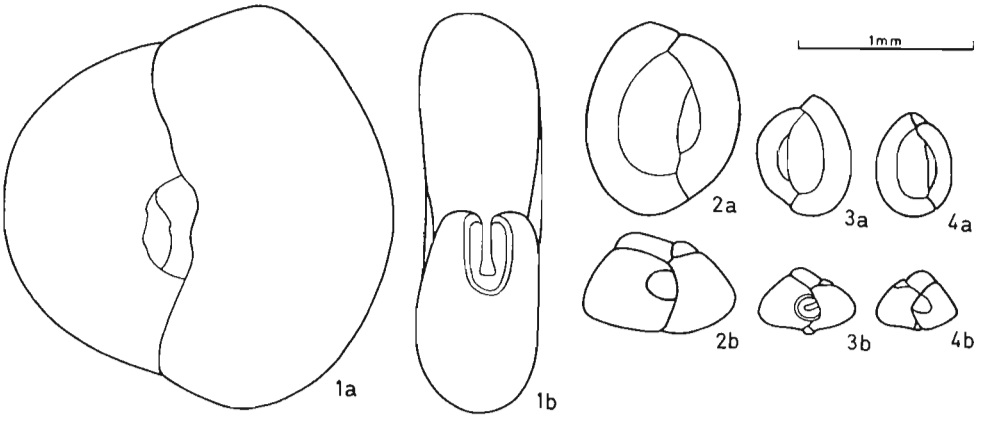


Fig. 24. *Quinqueloculina triangularis* d'Orbigny and its juvenile stage: 1 — MS, 2-4 — QS from inside MS; *a* front view, *b* apertural view.

Distribution. — Poland: Tortonian (Benczyn, Krywałd, Niechobrz, Wieliczka). Austria: Tortonian, the vicinity of Nussdorf, Vienna Basin. Czechoslovakia: Tortonian, Židlochovice, Devinska Nova Ves. France: Redonien (Pliocene), the nortwestern region of France. Italy: Miocene, the vicinity of Siena. USSR: Upper Tortonian, the Volhyn-Podolian Platform; Meotis (Pliocene), West Precaucasian Region. Recent: Adriatic, Rimini.

Genus *Articularia* n.gen.

Type species: *Articulina articulinoides* Gerke & Issaeva, 1952

Diagnosis: Initial part quinqueloculine or cryptoquinqueloculine, aperture circular or transversely oval, with a broad and low tooth; uniserial part composed of one or a few chambers which may be partially or totally evolute, arranged along the coiling axis, and terminating in a circular toothless aperture.

It differs from *Articulina* in its quinqueloculine, not planospiral or irregularly milioline, initial part.

Discussion. — Both Bogdanowich (1952) and Venglinsky (1959, 1961) state that in foraminiferal assemblages of the same Sarmatian age there are two different forms of articuline structure: the typical forms and the

"articulina-like" ones with a quinqueloculine or cryptoquinqueloculine initial part and a few chambers of the uniserial part. Bogdanowich supposed that the "articulina-like" forms do not belong to the genus *Articulina*; Venglinsky suggested, that they are "varieties" within the genus *Quinqueloculina* (e.g. *Quinqueloculina karreriella* var. *articulata* Venglinsky), as opposed to the typical *Articulina* with a well-developed uniserial part.

It is not clearly said in the definition of the genus *Articulina* what the initial part is like (d'Orbigny (1826) recorded a 3-chambered initial part, Cushman (1944) 3-chambered or quinqueloculine, Bogdanowich (1952) planispiral or streptospiral, probably quinqueloculine, and Loeblich & Tappan (1964) milioline with two chambers to a whorl, added in different planes of coiling), or how many chambers the uniserial part can attain. It may be supposed that even the presence of only one chamber of the uniserial part refers the specimen to the genus *Articulina*, and that therefore it is a distinctive character of this genus. On the other hand, the initial part may be various and the determination of the genus is not simple. The author's own observation and the works referred to above show that the group of "articulina-like" quinqueloculine forms differs from the typical articuline forms, in the presence of a well developed quinqueloculine initial part. This quinqueloculine initial part often occurs beside adult articuline forms with the uniserial part, e.g. in the Lower Sarmatian deposits of Poland. The difference between these "articulina-like" forms and the true *Articulina* consists in that *Articulina* passes in ontogeny through the *Cyclogyra*-stage (Bogdanowich, 1952, p. 190; Pl. 31, Figs 3, 4; Pl. 32, Fig. 3), or through the reduced milioline stage (or streptospiral stage according to Bogdanowich) and, in addition, as an adult, it has a well-developed many-chambered uniserial stage, whereas the "articulina-like" forms are clearly quinqueloculine in respect of the morphology of the initial part, followed by only a few chambers of the uniserial part. These features would refer them to separate families, i.e. forms with the quinqueloculine initial part to the family Miliolidae, subfamily Quinqueloculininae or Miliolinelinae, and forms with the cyclogyrine or reduced initial part — to the family Nubeculariidae, subfamily Nodobacullariinae. Unfortunately, the scarcity of material available did not allow the author to explicate this problem and for this reason the genus *Articulina* has been left in the family Miliolidae, subfamily Quinqueloculininae, the "articulina-like" forms being separated as a new genus *Articularia*, also placed provisionally in this subfamily.

In the materials studyied there are two forms which may be assigned to the genus *Articularia*: *A. articulinoides* (Gerke & Issaeva), usually accompanying *Varidentella reussi* (Bogdanowich) and probably related to this species, and *A. karreriella* (Venglinsky), designated previously by Venglinsky as *Articulina* aff. *kudakoensis* Voloshinova, whereas its

juvenile stage was identified as *Miliolina karreriella* Venglinsky. Later he joined these two species into one, *Quinqueloculina karreriella* var. *articulata*. *Articularia karreriella* occurs commonly in the company of *Cycloforina karreri ovata* (Serova), to which it may also be related.

In the materials investigated there also occur *Articulina* species with a cyclogyrine initial part, like *A. nodosaroides* (Karrer), *A. problema* Bogdanowich, *A. sarmatica* (Karrer). The other species need revision.

Articularia articulinoides (Gerke & Issaeva, 1952)
(Pl. XVII, Fig. 1*a*, *b*, 2*a-c*)

1952. *Articulina* (?) *articulinoides* Gerke & Issaeva; *in* A. K. Bogdanowich, p. 211, Pl. 23, Fig. 8.
1956. *Articulina* (?) *articulinoides* Gerke & Issaeva; A. G. Voroshilova *in* V. M. Pobiedina *et al.*, p. 118, Pl. 14, Fig. 3*a-c*.
1960. *Articulina* (?) *articulinoides* Gerke & Issaeva; M. Stancheva, p. 13, Pl. 2, Fig. 5.

Material. — Over 50 specimens (Coll. No. F-116).

Dimensions: Initial part: L 0.3-0.5; uniserial part L 0.3-0.4.

Description. — Initial part large, oval; chambers tubular in quinqueloculine or cryptoquinqueloculine arrangement; surface smooth, sutures double, flat; uniserial part composed of 1—2 elongated chambers, widened at the base and narrowing towards the end; aperture of the initial part semicircular with broad tape-shaped tooth; that of the uniserial part circular, surrounded with a thickened rim and without a tooth.

Variability and ontogeny. The initial part is morphologically uniform. The uniserial part has usually a slightly oblique position in relation to the coiling axis and there exists a series of intermediate forms between the quinqueloculine and uniserial stage.

Remarks. — The forms examined most resemble one of the forms illustrated by Bogdanowich, 1952, (Pl. 23, Fig. 8), while the other illustrations of this species (Fig. 6, 7) are somewhat different. They are also similar to *Articulina arcuata* Bogdanowich, 1967 from which they however differ in having a distinctly developed quinqueloculine stage and the chambers of uniserial stage basically inflated and more elongated. The initial stage of *A. articulinoides* is very close to *Varidentella reussi* (Bogdanowich), which was observed earlier by the authors of both species (Bogdanowich, 1952), who regarded them as related. The resemblance is particularly apparent in the semicircular shape of the aperture and in the broad, tape-shaped tooth. *A. articulinoides* may have arisen from *Varidentella reussi* and the initial stage of this process may have occurred in the Lower Sarmatian.

Distribution. — Poland: Lower Sarmatian (Grzybów, Miechocin, Mokrzyszów, Rytwiany). Bulgaria: Lower Sarmatian, the northwestern region of Bulgaria. USSR: Lower Sarmatian, North Caucasus, Azerbaijan, Ukraine, Moldavia.

Articularia karreriella (Venglinsky, 1958)
(Pl. XVII, Figs 3, 4*a*, *b*, 5, 6*a-c*)

1958. *Miliolina karreriella* Venglinsky; I. V. Venglinsky, p. 69, Pl. 9, Figs 1, 2.
1958. *Articulina* (?) aff. *kudakoensis* Voloshinova; *ibidem*, p. 97, Pl. 19, Figs 17, 18.
1961. *Quinqueloculina karreriella* Venglinsky var. *articulata* Venglinsky; I. V. Venglinsky, p. 101, *cum syn.*
1968. *Quinqueloculina karreriella* var. *articulata* Venglinsky; B. Ionesi, p. 262, Pl. 13, Figs 16—19.
1971. *Quinqueloculina electa* Maissuradze; L. S. Maissuradze, p. 56, Pl. 2, Fig. 2*a-c*.

Material. — Over 100 specimens (Coll. No. F-117).

Dimensions: Initial part: L 0.3-0.6; uniserial part L up to 1.

Description. — Initial part rhomboid-oval, chambers tubular in quinqueloculine or cryptoquinqueloculine arrangement, bent in the lower part at an angle of about 90° and covered with 6—7 irregular, longitudinal, sometimes bifurcate or slightly oblique, distinct ribs; middle chamber elongated, inflated, with 3—4 ribs; uniserial part composed of 2—3 chambers, which are strongly inflated in 1/3 of their height and narrowing toward the end, covered with about 8 ribs partly bifurcated on the inflated part of the chamber; sutures distinct, depressed; aperture of the initial part semicircular or circular, with low quadrate tooth; that of the uniserial part circular, small, without tooth.

Variability and ontogeny. The number and character of ribs are variable, they may be bifurcated on the uniserial part or not, whereas on the initial part they are often irregular and obliquely curved. The uniserial part often falls away leaving no traces on the initial part, owing to which this last part may be erroneously determined as *Quinqueloculina*. Sometimes the first chamber of the uniserial part grows obliquely to the coiling axis (Pl. XVII, Fig. 5) and may have various positions, as in *Articularia articulinoides* (Gerke & Issaeva).

Remarks. — Venglinsky (1958) noticed the resemblance of the initial part of *Articulina* (?) aff. *kudakoensis* Voloshinova to *Miliolina karreriella*, a quinqueloculine form determined by him from the same beds as *A.* aff. *kudakoensis* and suggested that they are "varieties" of the same "articulina-like" species of *Quinqueloculina*. Later (1961), basing himself on this observation, he described this "variety" as *Quinqueloculina karreriella* var. *articulata*, in its synonymy placing also the forms defined earlier as *Articulina* aff. *kudakoensis*. Hence it follows that he still acknowledged the two "varieties" of *Quinqueloculina karreriella*, one of which was quinqueloculine, the other articuline. As he did not make himself clear as to which of his "varieties" he considered to be a subspecies and the author's investigations show that both forms are only ontogenetical stages of the same species, the older specific name "karreriella" has been retained.

The quinqueloculine stage differs from *Cycloforina karreri ovata* (Serova) in lacking the short extension of the last chamber, in the less slender

shape of the test and less regular, bifurcate or sinuate ribs. Some specimens show a distinctive oblique position of ribs (Pl. XVII, Fig. 6), while in *C. karreri ovata* the ribs are regular and parallel to the coiling axis.

Distribution. — Poland: Lower Sarmatian (Dwikozy, Grzybów, Miechocin, Mokrzyszów, Rytwiany). Romania: Lower Sarmatian, Moldavia. USSR: Lower Sarmatian, West Georgia, Transcarpathians.

Genus *Articulina* d'Orbigny, 1826

Articulina multibullata n. sp.

(Pl. XVI, Figs 10*a*, *b*, 11—14)

Holotypus: Pl. XVI, Fig. 10.

Paratypi: Pl. XVI, Figs 11—14.

Locus typicus: Zrecze 3, bore-hole, depth 64.8-64.9 m.

Stratum typicum: Lower Sarmatian, Syndesmya clays.

Derivatio nominis: (Lat.) multum — many, bulla — bulb, from test composed of many bulbous chambers.

Diagnosis: The chambers of uniserial stage are strongly inflated, overhanging in the lower part and irregularly corrugated.

Material. — Over 100 specimes (Coll. No. F-118).

Dimensions: Holotype — L 0.85 mm; Paratypes — initial part length 0.20-0.25 mm; uniserial part length 1.0-1.5 mm.

Description. — Initial part coiled irregularly around proloculus in a planispiral, triloculine or quinqueloculine manner being sporadically somewhat evolute; uniserial part composed of about 6 chambers gradually increasing in size, bulbose in the lower part and ending in a tubular neck at the top; the inflated part of chambers is irregularly corrugated, showing overhanging protuberances which give the chambers an umbrella-like appearance; aperture circular, surrounded with thickened rim, without tooth.

Variability and ontogeny. The shape of the initial part is variable, from quinqueloculine to an irregular or confused arrangement of chambers; the first chamber of the uniserial part adheres to the initial part in a various way, embracing it partly (Pl. XVI, Figs 12—14). The uniserial part is sporadically arcuate (Pl. XVI, Fig. 10).

Remarks. — This species somewhat resembles *Articulina sarmatica* (Karrer), from which it however differs in the more inflated, crenulated and overhanging lower part of the chambers of the uniserial part.

Distribution. — Poland: Lower Sarmatian (Grzybów, Rytwiany, Zrecze).

+ *Articulina nodosaroides* (Karrer, 1867)

(Pl. XVI, Figs 15, 16*a*, *b*)

1867. ***Trilo**culina nodosaroides* Karrer; F. Karrer, p. 360, Pl. 2, Fig. 9*a-c*.

Material. — 15 incomplete specimens (Coll. No. F-119).

Dimensions: Initial part L 0.2; uniserial part L 1—3.

Description. — Initial part small, circular planispirally coiled as in *Adelosina*; uniserial part composed of 3—4 large, oval, elongated chambers much increasing in size and ornamented with 4—6 thick costae; aperture circular, without tooth, surrounded with a thickened rim.

Remarks. — The specimens of this conspicuous species are usually found as one-, rarely two- or three-chambered parts of the uniserial stage. No complete specimens occur in the materials investigated, thus the description is based on the well-preserved specimens from Vöslau in Vienna Basin. The initial part probably represents the mega II generation, like that in *Adelosina*. The micro generation has not been found in any of the materials examined, nor was it found by Karrer.

Distribution. — Poland: Lower Tortonian (Karsy, Korytnica). Austria: Lower Tortonian, vicinity of Baden and Vöslau, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice. Romania: Lower Tortonian, Lapugiu de Sus.

* + = *Articulina problema* Bogdanowich, 1952
(Pl. XVII, Figs 7—10)

1852. *Articulina problema* Bogdanowich; A. K. Bogdanowich, p. 205, Pl. 31, Figs 2, 3—6, 9.
1956. *Articulina problema* Bogdanowich; A. Sulimski, p. 86, Pl. 4, Fig. 1.
1958. *Articulina problema* Bogdanowich; I. V. Venglinsky, p. 93, Pl. 19, Figs 1—10.
1960. *Articulina problema* Bogdanowich; M. Stancheva, p. 13, Pl. 31, Fig. 6.
1968. *Articulina problema* Bogdanowich; B. Ionesi, p. 264, Pl. 14, Figs 13, 14.

Material. — Over 100 specimens (Coll. No. F-120)

Dimensions: Initial part L 0.1-0.3; uniserial part L up to a few mm.

Description. — Initial part small, composed of several chambers irregularly arranged around the proloculus, at first planispirally, then in a triloculine or quinqueloculine manner; uniserial part long, with many chambers slightly increasing in size, slender and somewhat inflated at the base like an amphora; surface smooth, in older specimens with irregular, longitudinal wrinkles; aperture circular, surrounded with a thickened rim, without tooth.

Variability and ontogeny. Variability is noted in the irregularly coiled initial part and in elongated chambers, which may be very slender but a little inflated at the base (Pl. XVII, Fig. 8) or they may be shorter and stouter (Pl. XVII, Fig. 7). Two generations, micro and mega, are present.

Remarks. — Forms with shorter and stout chambers resemble *Articulina sarmatica* (Karrer) from which they however differ in having more elongated chambers, which are never spherical.

Distribution. — Poland: Lower Sarmatian (Dwikozy, Grzybów, Miechocin, Mokrzyszów, Rytwiany, Zrecze). Bulgaria: Lower and Middle Sarmatian, North-West Bulgaria. Romania: Lower and Middle Sarmatian, Mol-

davian Platform. USSR: Lower and Middle Sarmatian, Precaucasian, Transcaucasian, Moldavia, Crimea, Georgia, Black sea Depression, Volhyn-Podolian Platform, Transcarpathians, Ukraine.

Articulina sarmatica (Karrer, 1877)
(Pl. XVII, Figs 11—13)

1877. *Vertebralina sarmatica* Karrer; F. Karrer, p. 376, Pl. 16, Fig. 12.
1952. *Articulina? sarmatica* (Karrer); A. K. Bogdanowich, p. 210, Pl. 23, Figs 1—5.
1968. *Articulina sarmatica* Karrer; B. Ionesi, p. 264, Pl. 14, Figs 8, 9.

Material. — Over 300 specimens (Coll. No. F-121)

Dimensions: Initial part L 0.1-0.2; uniserial part L up to a few millimetres.

Description. — Initial part irregular, composed of 2—5 chambers arranged planispirally initially, then in a triloculine or quinqueloculine way; uniserial part with numerous robust spherical chambers, closely adherent to each other, of which younger chambers often overlap (Pl. XVII, Fig. 11); sutures fairly broad, with irregular indentations (Pl. XVII, Fig. 12); surface rough, with irregular, transverse undulations and longitudinal wrinkles; aperture large, circular, surrounded with a thickened rim, without tooth.

Variability and ontogeny. The shape of chambers of the uniserial part is variable, initially spherical, then more inflated at the base. The surface ornamentation may be more or less distinct.

Remarks. — This species differs from *Articulina problema* Bogdanowich in its more compact, spherical chamber shape. From *A. multibullata* n. sp. it differs in lacking irregular protuberances on the inflated and overhanging part of chambers.

Distribution. — Poland: Lower Sarmatian (Budy, Dwikozy, Grzybów, Mokrzyszów, Zrecze). Austria: Sarmatian, vicinity of Vienna, Vienna Basin. Romania: Lower Sarmatian, Moldavian Platform. USSR: Lower Sarmatian, East- and West Precaucasian, Volhyn-Podolian Platform, Crimea and Black sea Depression, West Ukraine.

Articulina tamanica Bogdanowich, 1952
(Pl. XVI, Fig. 17)

1952. *Articulina tamanica* Bogdanowich; A. K. Bogdanowich, p. 204, Pl. 31, Fig. 1

Material. — 5 specimens (Coll. No. F-121)

Dimensions: Uniserial part — L over 1 mm.

Description. — The shape of the initial part unknown; uniserial part composed of elongated chambers like those in *Articulina problema* Bogdanowich, but covered with longitudinal, narrow furrows, cutting the surface into 15—20 fairly broad, flat bands.

Remarks. — This species differs from *Articulina problema* Bogdanowich and from *A. sarmatica* (Karrer) in having distinct, broad bands, not wrinkles, on the surface.

Distribution. — Poland: Lower Sarmatian (Grzybów). USSR: Lower Sarmatian, the western Kuban region and Taman peninsula.

Articulina tenella (Eichwald, 1853)
(Pl. XVII, Fig. 14)

1853. *Nodosaria tenella* Eichwald; E. Eichwald, Pl. 1, Fig. 5; *fide* Catalogue Ellis & Messina.
1952. *Articulina tenella* (Eichwald); A. K. Bogdanowich, p. 198, Pl. 29, Fig. 10.
1956. *Articulina tenella* (Eichwald); A. Sulimski, p. 88, Pl. 4, Fig. 3.

Material. — 3 specimens (Coll. No. F-123)

Dimensions: Initial part L 0.10-0.25; uniserial part L 0.35-0.65.

Descriptions. — Initial part slender, with tubular chambers in triloculine arrangement, ornamented with 2—3 longitudinal costae; uniserial part with tubular chambers, usually somewhat inflected, about 4—5 times as long as broad; surface ornamented with 5—6 longitudinal, low ribs; wall smooth; aperture circular, without tooth, surrounded with distinctive everted rim.

Distribution. — Poland: Upper Tortonian (Ligota Zabrska); Lower Sarmatian (Suchowola, Wielogóra). USSR: Miocene, Volhyn, West Ukraine.

Genus *Cycloforina* Łuczkowska, 1972
× *Cycloforina badenensis* (d'Orbigny, 1846)
(Pl. XI, Fig. 5; Text-fig. 25)

1846. *Quinqueloculina badenensis* d'Orbigny, p. 299, Pl. 20, Figs 10—12.
1881. *Quinqueloculina rakosiensis* Franzenau; J. Franzenau, p. 98, Pl. 3, Figs 7—9.
1952. *Miliolina badenensis* (d'Orbigny); A. K. Bogdanowich, p. 107, 108.
1955. *Miliolina badenensis* (d'Orbigny):, M. J. Serova, p. 303, Pl. 1, Figs 1—3.
1969. *Quinqueloculina badenensis* d'Orbigny; J. Korecz-Laky, p. 148, Pl. 12, Fig. 10.

Material. — 60 specimens (Coll. No. F-124, Sec. No. 173)

Dimensions: L 0.71-1.10, B 0.50-0.85, T 0.33-0.65.

Description. — Test large, robust, regular, broadly oval in shape and narrowing at both ends, periphery angular, in cross-section trapezoid; chambers of uniform width, with slightly inflated walls and two blunt carinae on the periphery placed not far apart, middle chamber large, projecting, with one edge along the chamber; sutures flat, distinct; surface matt; wall thick; aperture small, circular, flush with the periphery, with a short, bifid tooth.

Variability. A constant character of the species is the compact, robust test and small circular aperture. The shape of the test may sometimes be more elongated and the carinae more rounded. The specimens from

Vöslau, Vienna Basin, as well as our specimens show a bifid tooth not a simple one as recorded by d'Orbigny.

Dimorphism and ontogeny. The specimen sectioned belongs to the micro generation; PD 50μ. The cross-section shows tubular initial chambers, only from the 6th or 7th chamber onward the shape of chambers is trapezoid (Text-fig. 25.)

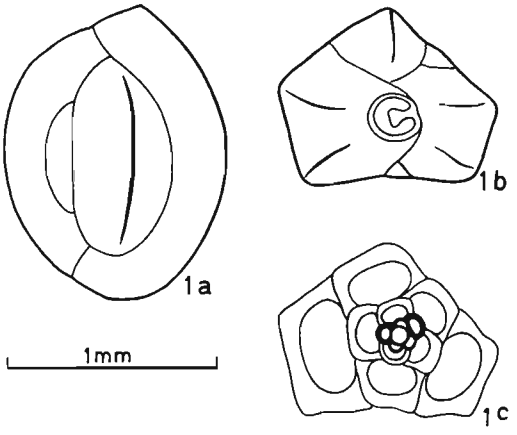


Fig. 25. Internal structure of *Cycloforina badenensis* (d'Orbigny), Lower Tortonian, Korytnica, micro generation; *a* front view, *b* apertural view, *c* cross-section.

Remarks. — In its angular periphery this species resembles *Cycloforina contorta* (d'Orbigny) which however differs in having an elongated and less regular test shape, carinate edges and rough surface covered with short fine longitudinal streaks. The specimens investigated are identical with *C. badenensis* from Vöslau (Vienna Basin).

Distribution. — Poland: Tortonian (Benczyn, Bogoria, Karsy, Korytnica). Austria: Tortonian, the vicinity of Baden, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice. Hungary: Tortonian, vicinity of Budapest. Tortonian and Sarmatian, Mecsek Mts. USSR: Middle Miocene, West Ukraine, southern border of the Russian Platform, North Caucasian.

+ *Cycloforina contorta* (d'Orbigny, 1846)

(Part I, Pl. XII, Fig. 3*a*-*c*; Part II, Pl. XI, Figs 2*a*, *b*, 3*a*, *b*; Text-Fig. 26)

1846. *Quinqueloculina contorta* d'Orbigny; A. d'Orbigny, p. 298, Pl. 20, Figs 4—6.
1952. *Miliolina contorta* (d'Orbigny); A. K. Bogdanowich, p. 109.

Material. — Over 100 specimens (Coll. No. F-150, Sec. No. 161, 162, 167—170).

Dimensions: L 0.8-1.4; B 0.45-0.8; T 0.3-0.5.

Description. — Test regular, narrowly oval, periphery angular and arcuate, of uniform width, and keeled; chambers narrow, with flattened

sides, which may be slightly depressed along the keels, ornamented with two sharp carinae placed wide apart on the periphery of the last chambers, the edge of the large middle chamber forms a prominent longitudinal keel coincident with the coiling axis; sutures distinct, depressed; surface rough, with fine irregular longitudinal grooves; aperture circular, often at the end of a short extension of the chamber, with a short bifid tooth.

Variability. The great morfological variability is expressed in a strong or weak development of two peripheral edges. Typical forms (Part I, Pl. XII, Fig. 3; Part II, Text-fig. 26/3, 4) are regular, having sharp keels

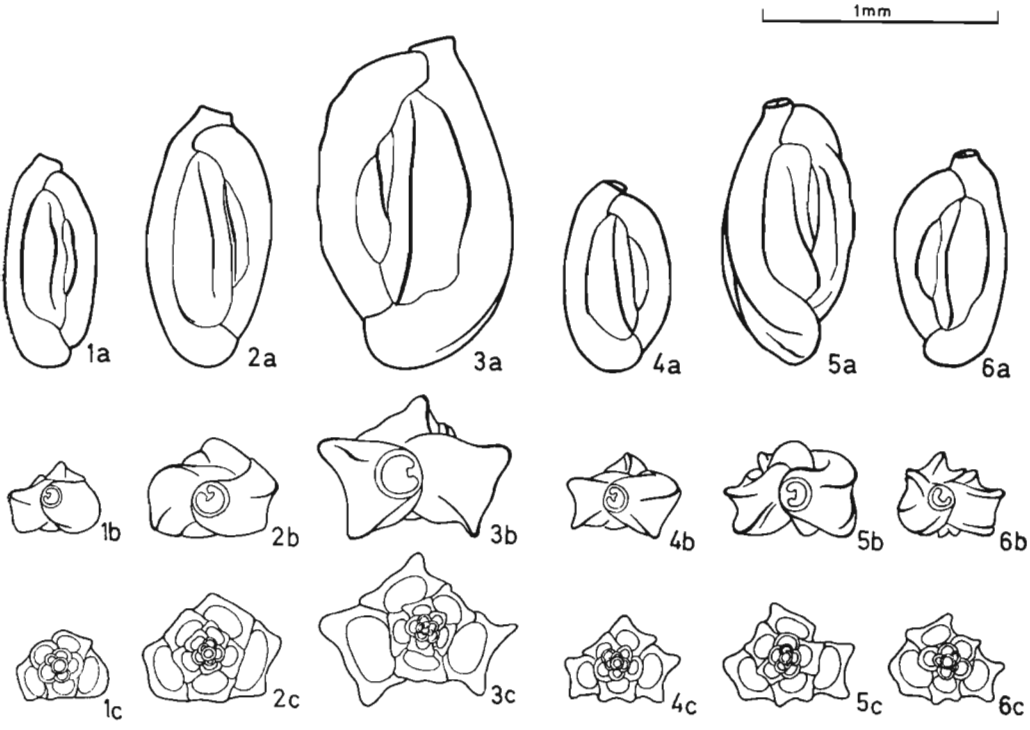


Fig. 26. Morphological variability and internal structure of *Cycloforina contorta* (d'Orbigny), Upper Tortonian, Gliwice Stare; 1, 2 — forms with bluntly keeled chamber edges; 3, 4 — typical forms; 5, 6 — forms with irregular carinate chamber edges; *a* front view, *b* apertural view, *c* cross-section.

and a characteristic axial position of the middle-chamber edge. The irregular forms may have blunt and sinuous chamber edges (Text-fig. 26/1, 2).

Dimorphism and ontogeny. There are such small differences in size between the proloculi of specimens investigated (20—50μ), that they may be regarded as belonging to the micro generation. The chambers of the juvenile stage are tubular, the next chambers, from the 6th or 7th onward, are angular in section and usually with two, exceptionally with one keel.

Remarks. — Forms with rounded edges are morphologically close to *Cycloforina gracilis* (Karrer), to which they are probably related, having

similar tubular chambers initially and angular in the mature stage only, while in *C. gracilis* they remain tubular throughout ontogeny. The rough streaky surface resembles that of *Cycloforina contorta striata* (Asano), but this species has a more oval and flattened test. The specimens of *C. contorta* from Steinabrunn in the Vienna Basin have also a rough streaky surface. Our specimens somewhat resemble *Cycloforina latidorsata* (Reuss), from which they however differ in having a more elongated, slender test.

Distribution. — Poland: Tortonian (Benczyn, Bogoria, Gliwice Stare, Korytnica, Niechobrz, Rybnica, Wieliczka). Austria: Tortonian, the vicinity of Nussdorf, Vienna Basin. Hungary: Tortonian and Sarmatian of the Mecsek Mts. USSR: Upper Eocene, South Ukraine; Middle Miocene, West Ukraine.

Cycloforina cristata (Millett, 1898)
(Pl. XIII, Fig. 7*a-c*)

1898. *Miliolina cristata* Millett; F. W. Millett, p. 506, Pl. 12, Fig. 3*a-c*.

Material. — 5 specimens (Coll. No. F-126)

Dimensions. L 0.28-0.32; B 0.20-0.24; T 0.13-0.14.

Descriptions. — Test small, broadly oval, periphery acute, serrated; chambers slightly inflated, broad, with serrated edges, the denticles are irregular in shape and number, from 7 to 10 on each chamber, middle chamber small, with a prominent edge, fifth chamber clearly visible; sutures depressed, distinct; wall thin; surface smooth, polished; aperture circular at the end of a short neck, with a simple tooth.

Variability. A distinctive feature of the species are sharp, serrated edges. The convexity of chambers and the number of denticles are variable.

Distribution. — Poland: Lower Sarmatian (Zrecze). Recent, Malay Archipelago.

* *Cycloforina fluviata* (Venglinsky, 1958.)
(Pl. XIII, Fig. 4*a-c*; Text-fig. 27/2).

1958. *Miliolina fluviata* Venglinsky; I. V. Venglinsky, p. 82, Pl. 15, Figs 4, 5.
1962. *Quinqueloculina fluviata* (Venglinsky). I. V. Venglinsky, p. 73, Pl. 4, Fig. 2*a-c*.

Material. — 20 specimens (Coll. No. F-127, Sec. No. 367).

Dimensions. L 0.40-0.46; B 0.25-0.27; T 0.18.

Description. — Test oval-quadrangular, periphery rounded; chambers broad and inflated at the bottom and narrowing towards the end, middle chamber elongated, slightly oblique, fifth chamber poorly visible; sutures slightly depressed, indistinct; wall thin; surface with longitudinal thick protuberances accumulated at the bottom of chambers and disappearing towards the end; aperture round or semicircular, flush with the periphery, with a short and quadrate tooth.

Variability. A characteristic feature of the species is its nearly quadrangular test shape and longitudinal protuberances on the periphery of the lower part of the chambers. The shape of chambers is variable, being straight or arcuate in the upper part.

Dimorphism and ontogeny. The specimen sectioned is microspheric; PD 20μ. The section shows a constant chamber shape during the ontogeny (Text-fig. 27/2).

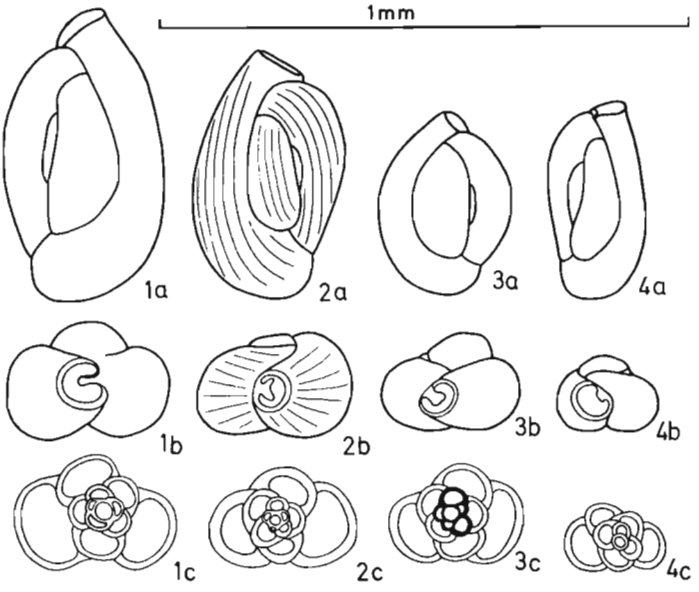


Fig. 27. Internal structure of *Cycloforina*: 1 — *C. stomata* sp. n., Lower Sarmatian, Budy-1 borehole, depth 212.7-212.8 m, micro generation; 2 — *C. fluviata* (Venglinsky), Lower Sarmatian, Zrecze-3 borehole, depth 11 m, micro generation; 3 — *C. suturalis* (Reuss), Lower Tortonian, Wieliczka, micro generation; 4 — *C. predcarpatica* (Serova), Lower Sarmatian, Zrecze-3 borehole, depth 11 m, micro generation; *a* front view, *b* apertural view, *c* cross-section.

Remarks. — This species differs from *Cycloforina predcarpatica* (Serova) in possessing longitudinal protuberances on the lower part of its much more inflated chambers.

Distribution. — Poland: Lower Sarmatian, southern border of the Holy-Cross Mts (Dwikozy, Rytwiany, Zrecze). Bulgaria: Lower Sarmatian, North-Western Bulgaria. Romania: Lower Sarmatian, Moldavia Platform. USSR: Lower and Middle Sarmatian, Precarpathians and Transcarpathians.

Cycloforina gracilis (Karrer, 1867)

(Pl. XII, Fig. 3*a-c*. Text-fig. 28/1)

1867. *Quinqueloculina gracilis* Karrer; F. Karrer, p. 361, Pl. 3, Fig. 2.
1952. *Miliolina gracilis* (Karrer); A. K. Bogdanowich, p. 130, Pl. 15, Fig. 4*a-c*.

1955. *Miliolina gracilis* (Karrer); M. I. Serova, p. 305, Pl. 2, Figs 4—6.
1959. *Quinqueloculina gracilis* Karrer; V. A. Krasheninnikov, p. 77, Pl. 11, Fig. 4.
1961. *Quinqueloculina gracilis* Karrer var. *gracilis* Karrer; V. I. Didkovsky, p. 17, Pl. 1, Fig. 1.
1968. *Quinqueloculina gracilis* Karrer; B. Ionesi, p. 261, Pl. 12, Figs 13, 14.
1969*b*. *Quinqueloculina gracilis* Karrer; A. K. Bogdanowich, p. 84, Pl. 2, Figs 1—3.

Material. — About 70 specimens (Coll. No. F-128, Sec. No. 171).

Dimensions: L 0.5-1.2; B 0.3-0.55; T 0.1-0.4.

Description. — Test oval, nearly quadrangular, periphery rounded; chambers tubular, regular, of uniform width, middle chamber convex, elongated, slightly curved, fifth chamber clearly visible; sutures depressed; surface rough, covered with longitudinal shallow grooves; aperture circular at the end of a short neck or lacking it, with a simple, bifid tooth.

Variability. The oval-quadrangular test shape and tubular chamber shape are constant. Variable features are the length of the extension of the last chamber, which occasionally disappears, and the periphery of the last chambers occasionally with traces of the edges, in which this species comes close to *Cycloforina contorta* (d'Orbigny).

Dimorphism and ontogeny. The specimens sectioned represent the micro generation; PD 40μ. All through the ontogeny tubular chambers of uniform shape are visible (Text-fig. 28/1).

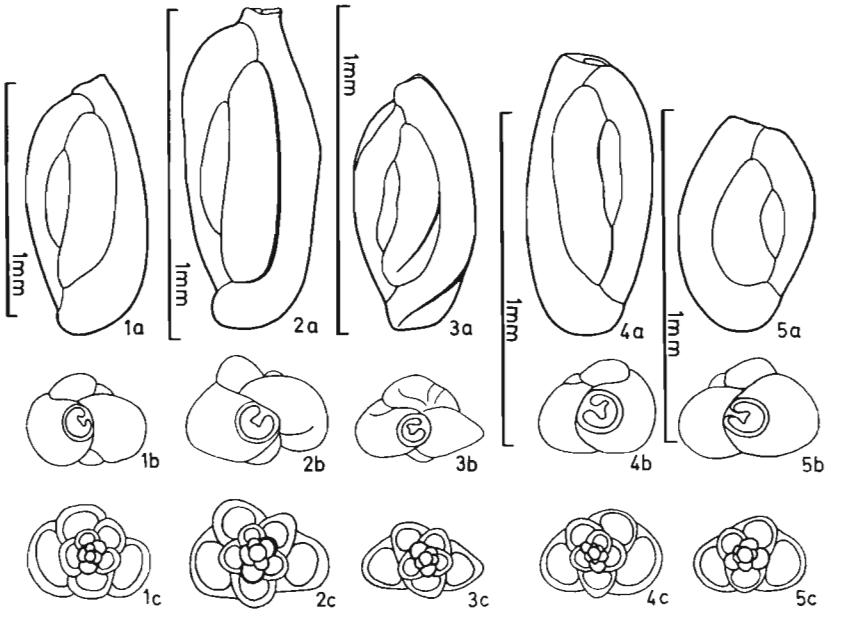


Fig. 28. Internal structure of *Cycloforina*: 1 — *C. gracilis* (Karrer), Upper Tortonian, Gliwice Stare, micro generation; 2 — *C. lucida* (Karrer), Upper Tortonian, Gliwice Stare, micro generation; 3 — *C. lachesis* (Karrer), Lower Tortonian, Korytnica, micro generation; 4 — *C. suturata* (Śmigielska), Upper Tortonian, Gliwice Stare, micro generation; 5 — *C. hauerina* d'Orbigny, Upper Tortonian, Niskowa, micro generation; *a* front view, *b* apertural view, *c* cross-section.

Remarks. — This species is closely related to *Cycloforina lucida* (Karrer) and *Cycloforina contorta* (d'Orbigny). It however differs from the former in the more solid compact structure of the test, its less elongated, oval-quadrangular shape and no tendency to the flattening of chambers and from the latter in lacking sharp carinae on the chamber edges; but there are transitional forms between these two species.

Distribution. — Poland: Tortonian (Brzeźnica, Chełm n/Rabą, Gliwice Stare, Karsy, Korytnica). Czechoslovakia: Lower Tortonian, Židlochovice. Romania: Lower Sarmatian, the Moldavia Platform. USSR: Neogen, Holubica near Pieniaky; Konka (Middle Miocene), North-Western Precaucasus, Crimea and West- and South- Ukraine; Meotis (Pliocene) Precaucasus.

* *Cycloforina gracilissima* (Bogdanowich, 1950)
(Pl. XIII, Fig. 6*a-c*)

1950*b*. *Miliolina lachesis* (Karrer) var. *gracilissima* Bogdanowich, p. 149, Pl. 2, Fig. 4*a-c*.
1952. *Miliolina gracilissima* Bogdanowich; A. K. Bogdanowich, p. 109, Pl. 10, Fig. 4*a-c*.

Material. — 20 specimens (Coll. No. F-129).

Dimensions: L 0.35-0.43; B 0.20-0.28; T 0.15-0.20.

Description. — Test very small, oval, narrowing at both ends, periphery angular with 2—3 sharp costae, which may be irregular, somewhat sinuate in outline or bifurcate at the bottom of chambers; chambers wide and inflated in the lower part and strongly narrowing toward the end, last chamber with a short neck, slightly expanded near the aperture, middle chamber inconspicuous, with 1—2 carinae; sutures distinct, depressed; wall thin, occasionally translucent; surface smooth, polished; aperture circular at the end of a short neck, with a small, quadrate tooth.

Variability. Typical features of the species are considerable chambers enlarged in the lower part and contracted in the upper part and the presence of irregular costae. The degree of expansion of the chambers and undulation of costae is variable.

Remarks. — Our forms have no such sharp carinae, as those in the species figured by Bogdanowich, but the other features of these two forms are coincident. No resemblance to *Cycloforina lachesis* (Karrer), suggested by Bogdanowich is observed.

Distribution. — Poland: Lower Sarmatian (Rytwiany, Zrecze). USSR: Tchokrak (Middle Miocene), West Precaucasus.

\+ *Cycloforina hauerina* (d'Orbigny, 1846)
(Pl. XII, Fig. 1*a-c*, Text-fig. 28/5)

1846. *Quinqueloculina hauerina* d'Orbigny; A. d'Orbigny, p. 286, Pl. 17, Figs 25—27.

Material. — 70 specimens (Coll. No. F-130, Sec. No. 369, 370).

Dimensions: L 0.5-0.65; B 0.3-0.4; T 0.2-0.3.

Description. — Test regular, oval, periphery rounded; chambers tubular, narrow, in the lower part strongly inflected, middle chamber large, distinct, convex, fifth chamber clearly visible; sutures depressed; surface smooth, dull; aperture circular, small with a simple or slightly bifid tooth, placed on a slight extension of the last chamber.

Variability. The characteristic features of the species are the regular oval test shape and tubular chambers. Morphological variability is inconsiderable.

Dimorphism and ontogeny. The cross-sections present semicircular chambers of uniform shape, slightly increasing in size; PD 40μ (Text-fig 28/5). The specimens sectioned represent the micro generation.

Remarks. — This species somewhat resembles the forms referred to as *Quinqueloculina seminulum* (Linné), but has its test much more approximating to oval and inflated, not flattened, sides of chambers. It has not been found in materials from Baden, from where the species was described, but numerous forms identical with ours occur at Vöslau. In comparison with the illustration of d'Orbigny from 1846, both the forms from Vöslau and ours are somewhat thicker, and more slender, and show a small extension of the last chamber in some specimens. From *Cycloforina gracilis* (Karrer) our forms differ in the more oval shape of the test and in the smooth and dull, not streaky, surface of chambers.

Distribution. — Poland: Tortonian (Bogoria, Bogucice, Brzeźnica, Chełm n/Rabą, Gieraszowice, Grabki Duże, Grabowiec, Iwkowa, Niskowa, Rybnica, Węglinek). Austria: Tortonian, vicinity of Baden, Vienna Basin.

* × *Cycloforina karreri ovata* (Serova, 1955)
(Pl. XIII, Figs 1*a-c*, 2*a-c*, Text-fig. 29/3, 30)

1955. *Miliolina costata* (Karrer) var. ovata Serova; M. J. Serova, p. 320, Pl. 9, Figs 10—12.

1958. *Miliolina karreri* (Reuss) var. *ovata* Serova; I. V. Venglinsky, p. 68, Pl. 9, Fig. 3*a-c*.

Material. — Over 100 specimens (Coll. No. F-131, Sec. No. 302, 303).

Dimensions: L 0.23-0.55; B 0.1-0.4; T 0.1-0.23.

Description. — Test oval or narrowly oval, periphery rounded; chambers tubular, of almost uniform width, middle chamber strongly elongated, slightly projecting above the surface, fifth chamber distinct; surface of all chambers covered with longitudinal, occasionally bifurcate, little ribs, the number of which oscillates between 10 on the last chambers and 4—6 on the middle one; sutures distinct, depressed; wall thin; aperture circular placed at the end of a short neck and with a low quadrate, slightly bifurcated tooth.

Variability. The test shape ranges from narrowly oval to broadly oval, the aperture may be flush with the surface or placed at the end of a short neck (Text-fig. 30). The ornamentation varies from simple longitudinal ribs running along the whole chamber to bifurcated, interrupted or undulate ones. The shape of the tooth is also variable and may be broad and quadrate in specimens without the neck, or short and narrow in those with it.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation, PD 30 μ. The chamber shape in cross-sections is constant (Text-fig. 29/3), and does not change during ontogeny.

Remarks. — The specimens of *Cycloforina karreri ovata* investigated

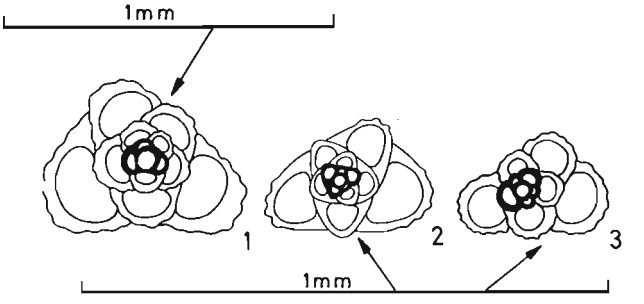


Fig. 29. Internal structure of *Cycloforina* indicated by cross-sections. 1 — *C. reticulata* (Karrer), Lower Tortonian, Korytnica, mega I generation; 2 — *C. toreuma* (Serova), Lower Sarmatian, Zrecze-3 borehole, depth 64.8-64.9 m, micro generation; 3 — *C. karreri ovata* (Serova), Lower Sarmatian, Machów 250 borehole, depth 84.3-85.3 m, micro generation.

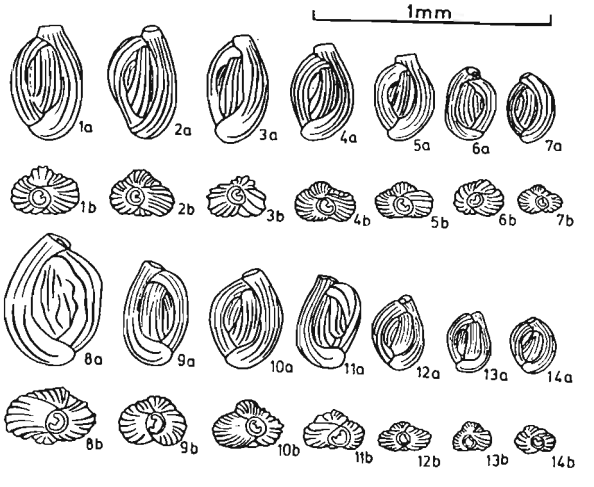


Fig. 30. Morphological variability of *Cycloforina karreri ovata*, Lower Sarmatian, Zrecze-3 borehole, depth 11 m; 1-7 — ovate specimens with typical ornamentation and with aperture on the prolongation of the chamber; 8-14 — broadly ovate specimens with irregular ornamentation and with the aperture without prolongation; *a* front view, *b* apertural view.

are less elongated and of smaller size than *Quinqueloculina karreri* (Reuss). They differ from *Cycloforina toreuma* (Serova) in having more regular ribs, occuring on the whole surface of the chambers, not on the periphery only.

Distribution. — Poland: Lower Sarmatian, (Budy, Dwikozy, Grzybów, Miechocin, Rytwiany, Zrecze). USSR: Lower Sarmatian, southwestern border of the Russian Platform, Precarpathian Foredeep, Transcarpathians.

Cycloforina lachesis (Karrer, 1868)
(Pl. XI, Fig. 1*a-c*; Text-fig. 28/3)

1868. *Quinqueloculina lachesis* Karrer; F. Karrer, p. 146, Pl. 2, Fig. 4.

Material. — 30 specimens (Coll. No. F-132, Sec. No. 366).

Dimensions: L 0.5-1.2; B 0.27-0.62; T 0.18-0.43.

Description. — Test irregularly quadrangular, elongate, periphery acute; chambers broad with single sinuous keel, which is divided into two blunt carinae at the base, middle chamber distinct, with single keel bent at the bottom; the whole test gives the impression of being irregularly twisted; sutures depressed; surface rough, marked by numerous irregular shallow longitudinal depressions; aperture small, circular, at the end of a narrow short neck, surrounded with a thickened rim.

Variability. A distinctive feature of the species is the distortion of the test and its rough surface. The width of the test is variable and the edges are more or less acute and sinuous.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation; PD 30 μ. The sections show a constant chamber shape during the ontogeny (Text-fig. 28/3).

Remarks. — The transverse marks which appear on the surface of the specimen figured by Karrer were not observed in specimens from Poland. As Karrer did not mention the presence of these marks in the description, they are regarded as a feature unimportant to the determination of the species.

Distribution. — Poland: Tortonian (Gliwice Stare, Korytnica, Węglinek). Czechoslovakia: Lower Tortonian, Židlochovice. Romania: Tortonian, Kostej in Banat.

Cycloforina lucida (Karrer, 1868)
(Pl. XII, Fig. 4*a-c*; Text-fig. 28/2)

1868. *Quinqueloculina lucida* Karrer; F. Karrer, p. 147, Pl. 2, Fig. 7.

Material. — 70 specimens (Coll. No. F-133, Sec. No. 174).

Dimensions: L 0.55-1.2; B 0.22-0.45; T 0.1-0.22.

Description. — Test strongly elongated, regular, protracted at both ends, periphery rounded; chambers tubular, narrow, of uniform width,

much elongated, at the basal end distinctly curved, middle chamber convex, elongated, fifth chamber clearly visible; sutures depressed; surface rough, covered with numerous, very small, longitudinal depressions; aperture at the end of a short narrowing neck and with a short bifid tooth.

Variability. Stable characteristics of the species are the strongly elongated test shape and tubular chambers, each of them being distinctively curved at the base. Variation occur as a small lateral flattening of the upper part of the chambers in some specimens, giving the test a slightly irregular appearance.

Dimorphism and ontogeny. The specimens sectioned represent the micro generation; PD 50 μ. The cross-sections show tubular chambers of uniform outline, the size of which increases gradually (Text-fig. 28/2).

Remarks. — The specimens investigated correspond to the description of Karrer, but they have a still more elongated shape than that presented in his illustration. They are closely related to *Cycloforina gracilis* (Karrer), differing only in their more elongated test shape and slightly irregular lateral flattening of the upper part of the chambers. Le Calvez (1958) considers *C. lucida* to be a form with arenaceous walls; in our specimens from the Miocene there are no agglutinated tests.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Ligota Zabrska, Niskowa, Węglinek). Romania: Tortonian, Kostej in Banat.

* *Cycloforina predcarpatica* (Serova, 1955)
(Pl. XIII, 8*a-c*, 9*a-c*; Text-fig. 27/4)

1955. *Miliolina predcarpatica* Serova; M. J. Serova, p. 322, Pl. 10, Figs 4—6.

Material. — Over 100 specimens (Coll. No. F-134, Sec. No. 364, 365).

Dimensions: L 0.35-0.40; B 0.17-0.20; T 0.13-0.15.

Description. — Test elongate, nearly quadrangular in outline, periphery rounded; chambers tubular, inflated at the base, last chamber strongly bent in the lower part and straightened at the end, middle chamber elongated, inflated; sutures depressed; wall thin; surface smooth, shiny, in some specimens delicately striated along the periphery; aperture small, semicircular, with a slightly sloping border and a low quadrate, somewhat bifid tooth.

Variability. The test shape varies somewhat, being elongate, oval or broadly oval. On the periphery of some specimens appear longitudinal, fairly regular striae, which makes them similar to *Cycloforina fluviata* (Venglinsky), from which they however differ in the less inflated basal part of their chambers and in lacking distinct ridges on the periphery.

Dimorphism and ontogeny. The sections show about 8 semicircular chambers of uniform shape and slightly increasing in size as added; PD 20 μ (Text-fig. 27/4).

Remarks. — This species differs from *Cycloforina stomata* n.sp. in having a small aperture without an everted border, narrower chambers and a more quadrangular test shape.

Distribution. — Poland: Lower Sarmatian, (Budy, Dwikozy, Grzybów, Miechocin, Mielec, Niwka, Rytwiany, Zrecze). USSR: Lower Sarmatian, Precarpathian Foredeep.

× + *Cycloforina reticulata* (Karrer, 1862)
(Pl. XI, Fig. 4*a*, *b*; Text-fig. 29/1)

1862. *Quinqueloculina reticulata* Karrer; F. Karrer, p. 449, Pl. 2, Fig. 5.

Material. — About 50 specimens (Coll. No. F-135, Sec. No. 297—301).

Dimensions: L 0.75-1.8; B 0.35-0.7; T 0.25-0.4.

Description. — Test large, narrowly oval, slender, periphery rounded; chambers tubular, of uniform width throughout, middle chamber projecting and large, fifth chamber usually visible; sutures distinct, depressed; surface rough, dull, covered with a regular reticulate ornamentation, composed of costae running obliquely in two directions and intersecting at an angle of about 60° to make a peculiar reticulate or bifurcate pattern along the chambers; wall thick; aperture large, circular, on a small extension of the last chamber, and with a short, bifid tooth.

Variability. The shape of chambers and the character of ornamentation are stable, only the manner in which the costae intersect is somewhat variable. Some specimens show reticulation on the lower part of the chambers only, whereas towards the end partly disappears and only the fork-like pattern remains.

Dimorphism and ontogeny. The specimens sectioned belong to the mega I generation, PD 60—90 μ. The sections show rounded chambers, regularly increasing in size (Text-fig. 29/1).

Remarks. — There are two species which are very close one to another: *Cycloforina reticulata* (Karrer) described from the Miocene of Forchtenau in the Vienna Basin and *Cycloforina zigzag* (d'Orbigny), described from the Miocene of Buitur in Romania. According to the descriptions and illustrations of both species, they differ only in that *C. reticulata* has reticulate ornamentation, while *C. zigzag* has a zigzag pattern. It might be thought that such closely related types of ornamentation represent one species, as the extensions of zigzag lines may develop into a reticulate ornament. A comparison of specimens investigated with the topotypes from Buitur revealed however that there exist also other features which support the separateness of these species, namely *C. zigzag* has a more oval, compact test shape, less depressed sutures, and more densely arranged costae (e.g. 10—15 on the middle chamber), which are strongly oblique and make a zigzag pattern on the chamber sides only sporadically slightly crossing each other on the periphery. On the other hand *C. re-*

ticulata has a more slender shape, more depressed sutures and fewer, less oblique and more prominent costae (7—10 on the middle chamber), which intersect on both the sides and the periphery, producing a reticulate ornament on them. The two species are closely related but they are easy to distinguish.

Distribution. — Poland: Lower Tortonian (Benczyn, Karsy, Korytnica). Austria: Tortonian, Forchtenau, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice. Romania: Tortonian, Buitur.

Cycloforina stomata n.sp.
(Pl. XIII, Fig. 5*a-c*; Text-fig. 27/1)

Holotypus: Pl. XIII, Fig. 5*a-c*.
Locus typicus: Bore-hole Budy-1 near Staszów, depth 212.7—212.8 m.
Stratum typicum: Lower Sarmatian, Syndesmya clays
Derivatio nominis: *stoma* — mouth, aperture: having a large distinctive aperture.
Diagnosis: Test oval, smooth with tubular chambers and broad sutures and with a characteristic large circular aperture with a short bifid tooth.

Material. — About 500 specimens, (Coll. No. F-136, Sec. No. 360, 361).

Dimensions: Holotype length 0.5 mm; breadth 0.34 mm; thickness 0.23 mm; Paratypes length 0.48-0.58 mm; breadth 0.24-0.35 mm; thickness 0.14-0.24 mm.

Description. — Test oval to narrowly oval, tapering at both ends, periphery rounded; chambers tubular, of uniform width throughout, middle chamber large and convex, fifth chamber narrow, occasionally visible; sutures broad and slightly depressed; surface smooth, polished; wall thin; aperture large, circular or semicircular, with a slightly sloping, everted border and a short narrow or quadrate, slightly bifid tooth.

Variability. The species is very variable in respect of test shape, which may be more or less elongated, the chambers being more or less inflated and the tooth shape varying from narrow and simple to broad and nearly quadrangular. The wall of some specimens that probably represent the gerontic stage may be covered with longitudinal, irregular wrinkles as in *Varidentella sarmatica* (Karrer). The aperture and tooth show distinct intermediate characters to the genus *Varidentella*, the tooth being shortened and enlarged and the aperture semicircular in some specimens. Most specimens have a circular aperture and a narrow bifid tooth.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation, the proloculus diameter is 30 μ. The regular quinqueloculine internal structure and the stable rounded shape of the chambers during the ontogeny are visible in cross-sections (Text-fig. 27/1).

Remarks. — This species much resembles *Varidentella sarmatica* (Karrer) but differs in having a large circular aperture with an everted border and a narrow or quadrate bifid tooth. It differs from *Varidentella latela-*

cunata (Venglinsky) in its oval test shape, tapering at both ends, in the rounded, not compressed periphery, the broad, not depressed sutures, and the circular aperture with a narrow and bifid tooth.

Distribution. — Poland: Lower Sarmatian, (Budy, Grzybów, Mielec, Niwka, Rytwiany).

× *Cycloforina suturalis* (Reuss, 1850)
(Pl. XII, Fig. 5*a-c*; Text-fig. 27/3)

1850. *Quinqueloculina suturalis* Reuss; A. E. Reuss, p. 385, Pl. 50, Fig. 9.
1867. *Quinqueloculina suturalis* Reuss; A. E. Reuss, p. 60, Pl. 3, Fig. 1.

Material. — About 150 specimens (Coll. No. F-137, Sec. No. 362, 363). Dimensions: L 0.23-0.65; B 0.20-0.45; T 0.15-0.35.

Description. — Test small, regularly oval, narrowing at both ends, periphery rounded; chambers tubular, arcuate, of uniform width, middle chamber large, very convex, fifth chamber small, clearly visible; sutures distinct, depressed; surface smooth, polished; aperture small, flush with the periphery, circular or semicircular, with a somewhat everted border and a short quadrate, slightly bifid tooth.

Variability. The characteristic features of the species are the regular, compact test shape and tubular chambers. The outline of the test varies from broadly oval to narrowly oval, its thickness being different in individual specimens. The aperture of young specimens is circular, in the mature specimens ranging from circular to semicircular or even extending transversely. The tooth shape is also variable, from short and bifid to quadrangular and tape-shaped, as in *Varidentella*. *C. suturalis* seems to belong to the group of forms, from which the species of *Varidentella* in the Lower Sarmatian originated.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation; PD 30 μ (Text-fig. 27/3). The sections show about 12 semicircular chambers, slightly compressed at the periphery and gradually increasing in size.

Remarks. — The specimens investigated were found in the topotype materials from Wieliczka and its vicinity. They are more regular than that figured by Reuss in 1850 and emended later in 1867, have a thicker test and a less rounded shape. Considering however the fact that the species has been described from the salt clays in Wieliczka and a thorough examination of these deposits did not result in the founding of specimens more resembling *Cycloforina suturalis* than those described above, they may most probably be assigned to this species. It is similar to *Quinqueloculina regularis* (Reuss), which however differs in the distinct rhomboid test shape, trapezoid outline of chambers in cross-section and triangular shape of the aperture. It somewhat resembles *Cycloforina hauerina* (d'Orbigny), in having tubular chambers, but this species differs

in much larger, more elongated and more flattened test shape and in the distinctly round aperture with a narrow bifid tooth.

Distribution. — Poland: Tortonian (Wieliczka).

* *Cycloforina suturata* (Śmigielska, 1957)
(Pl. XII, Fig. 2*a-c*; Text-fig. 28/4)

1957. *Quinqueloculina suturata* Śmigielska; T. Śmigielska, p. 259, Pl. 16, Fig. 7.

Material. — 20 specimens (Coll. No. F-193, Sec. No. 371, 372).

Dimensions: L 0.88-1.3; B 0.35-0.5; T 0.2-0.3.

Description. — Test strongly elongated, subquadrangular, tapering at both ends, periphery narrowly rounded; chambers narrow and elongate, with flattened sides, somewhat expanded at the base, and with faintly marked edge, middle chambers distinct, slightly convex; sutures distinct, depressed; surface smooth, polished; wall thin; aperture at the end of the somewhat protruding last chamber, round, and with a simple tooth bifid at the end.

Variability. Distinctive features of the species are the narrow and much elongated test shape, depressed sutures and flattened sides of the chambers. The variability of the test shape is of little importance.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation; PD 30—40 μ (Text-fig. 28/4). The sections show semicircular, regular chambers gradually increasing in size.

Remarks. — This species differs from *Cycloforina hauerina* (d'Orbigny) in having a much more elongated slender test shape. From *C. gracilis* (Karrer) it differs in the more slender shape and in the smooth and polished, not rough and streaky, surface.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Węglinek).

Cycloforina toreuma (Serova, 1955)
(Pl. XIII, Fig. 3*a-c*; Text-fig. 29/2, 31)

1955. *Miliolina toreuma* Serova; M. J. Serova, p. 317, Pl. 9, Figs 1—3.
1961. *Quinqueloculina toreuma* (Serova); V. J. Didkovsky, p. 23, Pl. 1, Fig. 9.

Material. — 40 specimens (Coll. No. F-139, Sec. No. 304, 305).

Dimensions: L 0.3-0.5; B 0.25-0.35; T 0.15-0.25.

Description. — Test broadly oval, periphery narrowly rounded; chambers broad, narrowing towards the end and with flattened sides, subtriangular in cross-section, middle chamber short and broad, slightly oblique, fifth chamber small but clearly visible; sutures distinct, depressed; surface smooth and polished, covered with 6—8 longitudinal ribs which are irregular, occasionally bifurcated or interrupted, placed mostly on the periphery and leaving the sides of chambers free; wall thin; aperture

circular, flush with the periphery and with a short quadrate, slightly bifid tooth.

Variability. The test shape is variable, being nearly circular or oval (Text-fig. 31). The ribs are more or less regular, beginning mostly at the

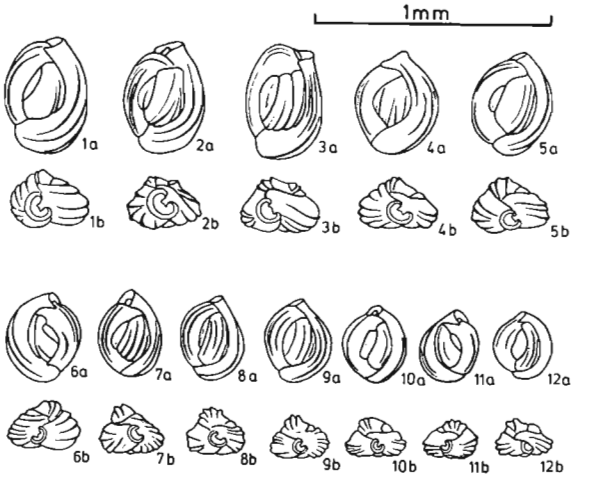


Fig. 31. Morphological variability of *Cycloforina toreuma* (Serova), Lower Sarmatian, Zrecze-3 borehole, depth 64.8-64.9 m; specimens arranged according to the size of the test; *a* front view, *b* apertural view.

base of chambers and disappearing towards the end. The tooth shape may be small and narrow to broad and bifid.

Dimorphism and ontogeny. The specimens sectioned are the micro generation; PD 30 μ. The sections show that all the chambers have a subtriangular outline and flattened sides throughout and increase gradually in size (Text-fig. 29/2).

Remarks. — This species differs from *Cycloforina karreri ovata* (Serova) in having irregular ribs placed on the periphery of chambers only and in the more flattened sides of chambers. From *Varidentella pseudocostata* (Venglinsky) it differs in the circular shape of the aperture, narrower tooth, smaller test dimensions, flattened sides of chambers, and more distinct ribs.

Distribution. — Poland: Lower Sarmatian, (Rytwiany, Zrecze). USSR: Upper Tortonian, Volhyn-Podolian Platform, West Ukraine.

+ *Cycloforina vermicularis* (Karrer, 1868)

(Pl. XIII, Fig. 10*a-c*; Text-fig. 32)

1868. *Quinqueloculina vermicularis* Karrer; F. Karrer, p. 150, Pl. 3, Fig. 1.

Material. — About 500 specimens (Coll. No. F-140, Sec. No. 35—44). Dimensions: L 0.65-1.5; B 0.47-1.0; T 0.3-0.7.

Description. — Test rhomboid-oval, subtriangular in cross-section, periphery subacute; chambers narrow with flattened sides, arcuate, of uniform width, middle chamber large and prominent, fifth chamber clearly visible; sutures distinct, slightly depressed; surface with thick longitudinal, sometimes slightly oblique or sinuous, interrupted grooves cutting the wall in such a fashion that the ridges arising between them make the impression of ribs; wall thick, dull; aperture circular, at the end of the poorly developed neck, and with a short tooth widening at the end.

Variability. Most of the specimens are triangular in cross-section, having the periphery subacute. There occur also specimens with the lower part of chambers dilated and truncate, and thus having the periphery angular in cross-section. The periphery only rarely remains angular throughout and in old specimens (Text-fig. 32/1); in other specimens it passes slowly into a normal, subangular periphery towards the end of the chambers, which gives the test the appearance of being irregularly bent as figured by Karrer.

Dimorphism and ontogeny. All specimens sectioned belong to the micro generation; PD 20—30 μ. The sections show that some specimens with the subacute periphery have it angular in the earlier chambers (Text-fig. 32/2, 4) and vice versa, those with the angular periphery may have it

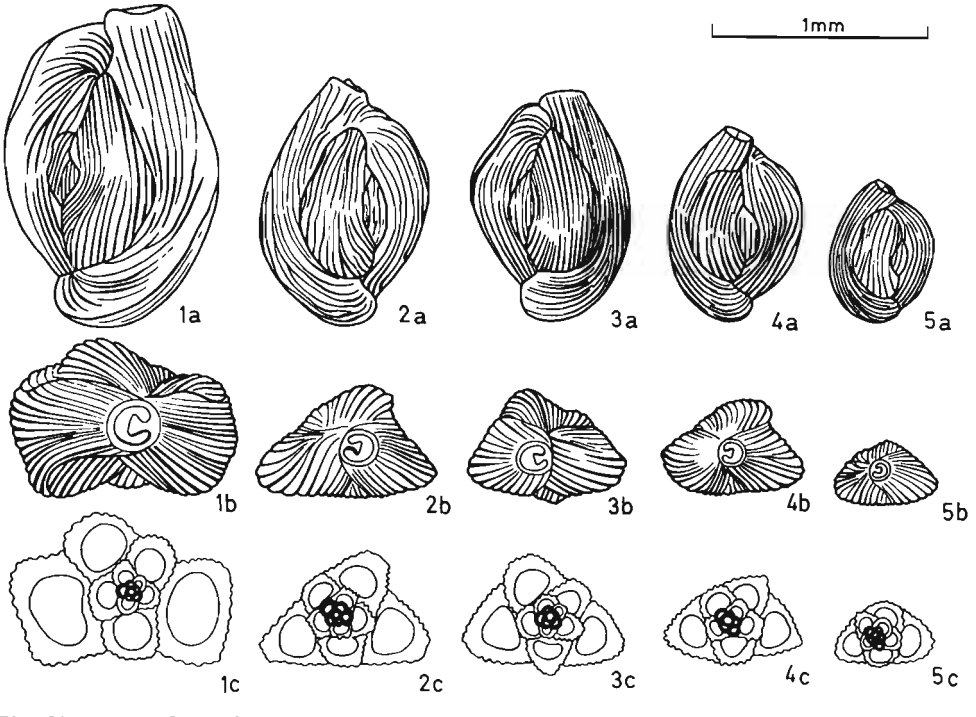


Fig. 32. Morphological variability and internal structure of *Cycloforina vermicularis* (Karrer); Lower Tortonian, Karsy; micro generation; 1 — form with angular chamber edges; 2 — form with truncate chamber edges; 3 — forms with subacute chamber edges; *a* front view, *b* apertural view, *c* cross-section.

subacute in the earlier stages (Text-fig. 32/1). Thus it might be assumed that variation in the outline of the periphery is connected with the ontogenetical variation of the species. The juvenile stage of all specimens has tubular chambers; the differentiation of the peripheral outline appears only in the penultimate or last whorl.

Remarks. — In comparison with the specimens from Lapugiu de Sus in Romania, which is locality of the same age as Kostej, the specimens investigated have a more regular test shape; the other features are identical.

Distribution. — Poland: Lower Tortonian (Benczyn, Korytnica). Czechoslovakia: Lower Tortonian, Židlochovice. Romania: Tortonian, Kostej in Banat and Lapugiu de Sus.

Genus *Hauerina* d'Orbigny, 1839

* *Hauerina aspergilla* (Karrer, 1868)

(Pl. XVIII, Fig. 5*a*, *b*)

1868. *Peneroplis aspergilla* Karrer; F. Karrer, p. 154, Pl. 3, Fig. 9.
1960. *Hauerina* sp. Bogdanowich; A. K. Bogdanowich, p. 249, Pl. 3, Fig. 6*a*, *b*.

Material. — 25 specimens (Coll. No. F-141).

Dimensions: L $\sim$ 0.60; B $\sim$ 0.52; T $\sim$ 0.22.

Description. — Test nearly circular, biconvex, depressed in the central part, periphery subacute; chambers irregularly inflated, 4—5 in the last whorl, overhanging at sutures and leaving only a small portion of the chambers of the previous whorl uncovered in the center of either side; sutures slightly depressed, occasionally sinuous and strongly bent backwards; surface smooth, polished; aperture large, irregularly triangular, with an inflated trematophore and numerous small pores.

Variability. — The test shape, the number and arrangement of chambers in the last whorl, and the flattening of the chambers are so variable that specimens uniform in shape are hardly ever met.

Remarks. — This species resembles *Hauerina tumida* Serova, 1955, from the Lower Sarmatian of the Forecarpathians in its shape variability but differs in having a larger, more flattened test and a nearly acute, not rounded, periphery. It differs from *H. irschavensis* Venglinsky & Burindina, 1965, from the middle Sarmatian of the Transcarpathians, in the less inflated chambers, subacute periphery and more elongated trematophore. The test shape is identical with that of *Hauerina* sp. Bogdanowich, 1960 from the Meotis of Kuban. The specimens from Lapugiu de Sus in Banat in Romania the locality of the same age as Kostej do not differ from ours.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Iwkowa, Niskowa, Węglinek). Romania: Tortonian, Kostej in Banat. USSR: Meotis (Pliocene), West Precaucasus.

+ *Hauerina compressa* d'Orbigny, 1846

(Pl. XVIII, Fig. 7*a*, *b*)

1846. *Hauerina compressa* d'Orbigny; A. d'Orbigny, p. 119, Pl. 5, Figs 25—27.
1955. *Hauerina compressa* d'Orbigny; M. J. Serova, p. 330, Pl. 14, Figs 1—3.

Material. — 20 specimens (Coll. No. F-142).

Dimensions: L ~ 0.68; B ~ 0.57; T ~ 0.15.

Description. — Test nearly circular, flat, in the central part concave; periphery subacute or acute; chambers slightly inflated, narrow and elongate, 3—4 in the last whorl, arranged planispirally around the previous chambers, two to a whorl, and covering the initial part which is indistinctly visible in the center of the test; sutures arcuate, bent backwards, depressed; surface smooth and polished, slightly transparent; aperture as a narrow, oval, inflated trematophore composed of about 12 fairly large irregular pores.

Variability and ontogeny. The juvenile specimens have two chambers to a whorl and their aperture is narrow with a long simple tooth, as in *Spirosigmoilina*. Later the chambers grow shorter and shorter, up to four to a whorl, as in typical specimens, and the aperture becomes trematophore.

Remarks. — In comparison with the typical forms of d'Orbigny, our specimens are more flattened, they have nearly foliaceous test shape and resemble *Hauerina fragilissima* (Brady), Recent. The specimens found in the material of the same age from Buitur in Romania are similarly flattened, but only occasional specimens show somewhat inflated walls, as figured by d'Orbigny. The species under study differs from *H. fragilissima* (Brady) in the more oval shape of the juvenile stage, in the presence of more then two chambers to a whorl in the mature stage, and in that its test is less flattened. From *H. bradyi* Cushman, Recent, it differs in its smooth, nor striated surface and in the less flattened test. From *H. atlantica* Cushman, Recent, it differs in the less inflated and more regular chambers.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Węglinek). Austria: the vicinity of Vienna. Romania: Tortonian, Buitur. USSR: Upper Tortonian, the Volhyn-Podolian Platform.

Hauerina plana Serova, 1955

(Pl. XVIII, Figs 1*a*, *b*, 2*a*, *b*)

1955. *Hauerina plana* Serova; M. J. Serova, p. 331, Pl. 14, Figs 4—6.

Material. — 30 specimens (Coll. No. F-144).

Dimensions: L ~ 0.35; B ~ 0.30; T ~ 0.12.

Description. — Test oval, much flattened, periphery subacute; outer

chambers semicircular, slightly inflated, narrowing somewhat near the aperture, two middle chambers small, flat, poorly visible in the center of the test; two or three chambers visible in the last whorl; sutures flat, indistinct, with light strips along the edges of the previous chambers; surface smooth, polished; aperture narrowly oval, trematophore, with about 10 fairly large pores.

Variability. The shape of the test is variable owing to the more or less involute placement of the last chamber.

Remarks. — This species differs from *Hauerina fragilissima* (Brady), Recent, in the smaller dimensions of the test, its more oval shape and the more inflated and broader chambers.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Ligota Zabrska). USSR: Upper Tortonian, the Volhyn-Podolian Platform.

Hauerina podolica Serova, 1955
(Pl. XVIII, Figs 3*a-c*, 4*a-c*)

1955. *Hauerina podolica* Serova; M. J. Serova, p. 327, Pl. 12, Figs 7—14.

Material. — 25 specimens (Coll. No. F-145).

Dimensions: L $\sim$ 0.50; B $\sim$ 0.40; T $\sim$ 0.25.

Description. — Test circular oval, lenticular in cross-section, periphery subacute; two outer chambers very broad, with nearly flat sides and somewhat enlarging near the aperture; 1—2 middle chambers very small, flat, poorly visible; sutures indistinct; surface smooth, dull; aperture triangular, large, trematophore, with 6—10 pores.

Variability. The test shape is variable as there is a tendency to the slightly evolute arrangement of the last chamber.

Remarks. — Morphologically this species stands close to *Podolia compacta* (Serova, 1953), but differs in having broader chambers, a lower test and a trematophore, not lyre-shaped, aperture. From *Hauerina subbotinae* Bogdanowich & Budanova, 1952, it differs in its more flattened sides, subacute periphery, and aperture with a small number of pores.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Ligota Zabrska, Niskowa, Węglinek). USSR: Upper Tortonian, the Volhyn-Podolian Platform.

Hauerina tumida Serova, 1952
(Pl. XVIII, Fig. 6*a*, *b*)

1952. *Hauerina tumida* Serova; in A. K. Bogdanowich, p. 178, Pl. 27, Fig. 7*a-c*.
1955. *Hauerina tumida* Serova; M. J. Serova, p. 331, Pl. 14, Figs 7, 8.

Material. — 15 specimens (Coll. No. F-146)

Dimensions. L $\sim$ 0.4; B $\sim$ 0.4; T $\sim$ 0.3.

Descriptions. — Test quadrangular-circular, thick, broadly oval in cross-section, periphery rounded; chambers broad, inflated, irregular, slightly overhanging, 3—4 in the last whorl; sutures depressed, slightly bent to the back; surface smooth, polished; aperture large, semicircular, with numerous small pores of different shape and dimensions.

Variability. The shape of the test is very variable as the structure of chambers is so irregular that practically each specimen is somewhat different.

Remarks. — This species differs from *Hauerina composita* Serova in its more inflated compact test, not flattened in the central part.

Distribution. — Poland: Tortonian (Gliwice Stare, Korytnica, Niskowa, Węglinek). USSR: Upper Tortonian, the Volhyn-Podolian Platform.

Genus *Lachlanella* Vella, 1957, emend. Łuczkowska, 1972

Lachlanella incrassata (Karrer, 1868)

(Pl. X, Figs 2*a-c*, 3*a-c*; Text-fig. 33/1, 2)

1868. *Quinqueloculina incrassata* Karrer; F. Karrer, p. 148, Pl. 2, Fig. 10.

Material. — About 200 specimens (Coll. No. F-147, Sec. No. 90—94).

Dimensions: L — 1.0-1.25; B — 0.6-0.85; T — 0.4-0.55.

Description. — Test oval, occasionally slightly tapering at both ends, periphery angular, trapezoid in cross-section; chambers flat, narrow, arcuate, last chamber somewhat enlarged near the aperture; middle chamber large prominent and broad, fifth chamber distinct; sutures flat, distinct; surface covered with fine striae, which are slightly oblique and bifurcated at the periphery, disappearing on chamber sides, where they leave irregular traces only; wall thin; aperture narrow, high, somewhat oblique to the periphery, surrounded with a slightly thickened edge and with a narrow long tooth a little bifurcated at the end.

Variability. The test shape is generally constant, except the periphery, which is occasionally rounded, and not angular (Text-fig. 33/1).

Dimorphism and ontogeny. The specimens sectioned represent the micro (?) generation; PD 50—60μ. The sections show the juvenile stage with 5—6 chambers, which are rounded in outline. It is only the succeding chambers that become trapezoid, the roundedness of the edges being variable in the course of ontogeny.

Remarks. — The specimens investigated differ somewhat from the specimen figured by Karrer in having a less angular periphery and somewhat oblique striae. The test ornamentation resembles that of *Quinqueloculina striolata* Reuss, which has similar bifurcated longitudinal striae, but its periphery is not angulate. *Lachlanella nussdorfensis* (d'Orbigny) differs in the more elongated slender test shape and in having fewer costae.

Distribution. — Poland: Lower Tortonian (Benczyn, Karsy, Korytnica). Czechoslovakia: Lower Tortonian, Židlochovice. Romania: Tortonian, Kostej in Banat.

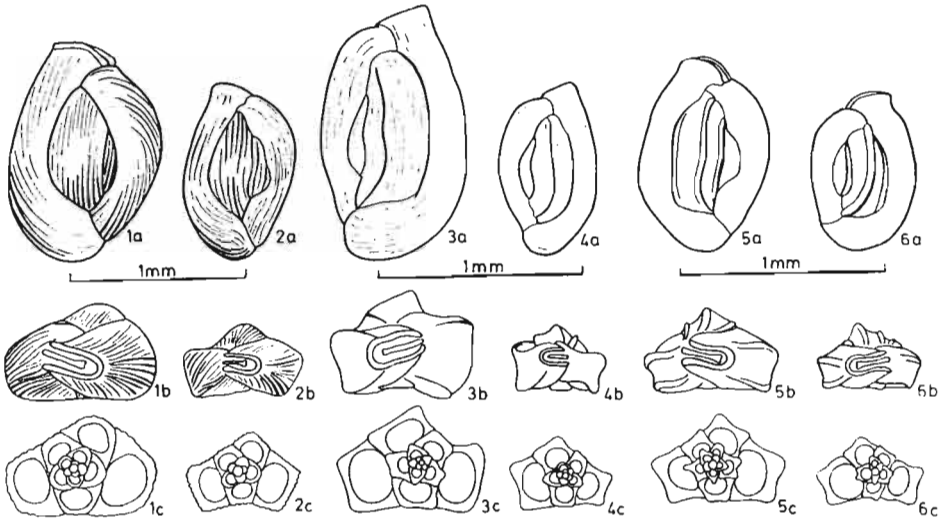


Fig. 33. Morphological variability, ontogeny and internal structure of *Lachlanella*: 1, 2 — *L. incrassata* (Karrer), Lower Tortonian, Korytnica, micro generation; 1 — form with subquadrate chambers; 2 — form with quadrate chambers; 3, 4 — *L. schroekingeri* (Karrer), Lower Tortonian, Korytnica, micro generation; 5, 6 — *L. undosa* (Karrer), Upper Tortonian, Węglinek, micro generation; *a* front view, *b* aperture view, *c* cross-section.

Lachlanella schroeckingeri (Karrer, 1868)
(Pl. X, Fig. 4*a-c*, Text-fig. 33/3, 4)

1868. *Quinqueloculina schroeckingeri* Karrer; F. Karrer, p. 149, Pl. 2, Fig. 12.

Material. — 15 specimens (Coll. No. F-148, Sec. No. 163, 164).

Dimensions: L — 0.85-1.25; B — 0.5-0.7; T — 0.35-0.50.

Description. — Test quadrangular-oval, tapering somewhat at the base, periphery angular, broad and somewhat keeled; chambers with concave sides, of uniform width, strongly bent basically, each of them provided with two edges somewhat sinuate in outline, middle chamber large, slightly convex, also with two sinuous edges specifically bent in the lower part; sutures flat, distinct; surface matt, covered thickly with irregular short longitudinal strips; wall thin; aperture narrow, high, with a long simple tooth.

Variability. Prominent features of the species are two sinous bent edges on the periphery and the matt surface with irregular strips. The test shape shows little variation.

Dimorphism and ontogeny. The specimens sectioned are microspheric; PD — 30μ. The sections show that the juvenile stage is composed of 2—3

tubular chambers, the next 3—4 chambers have one edge, and two edges occur only in the last whorl (Text-fig. 33/3, 4).

Remarks. — Morphologically, this species resembles *Cycloforina contorta* (d'Orbigny), but differs in its less acute and more sinuous edges, in the less elongated, more oval test shape and in the narrow and high, not circular aperture.

Distribution. — Poland: Lower Tortonian (Badenian), (Grabki Duże, Korytnica). Romania: Tortonian, Kostej in Banat.

Lachlanella undosa (Karrer, 1867)
(Pl. X, Fig. 5*a-c*; Text-fig. 33/5, 6)

1867. *Quinqueloculina undosa* Karrer; F. Karrer, p. 361, Pl. 3, Fig. 3.
1955. *Miliolina undosa* (Karrer); M. J. Serova, p. 315, Pl. 7, Figs 3—6.
1961. *Quinqueloculina undosa* Karrer; V. J. Didkovsky, p. 24, Pl. 1, Fig. 6*a-c*.

Material. — About 200 specimens (Coll. No. F-149, Sec. No. 165, 166). Dimensions: L — 0.80-1.0; B — 0.5-0.65; T — 0.3-0.4.

Description. — Test broadly oval, occasionally oval-quadrangular, periphery angular, bicarinate; chambers with concave sides, broad, with two thick carinae on the edges, wider apart at the base than at the top, the apertural end of the chambers being bent to the back and expanded, middle chamber prominent, with two thick carinae, specifically curved in the lower part, fifth chamber small, with one keel; sutures distinct, somewhat depressed; surface smooth, dull; wall thin; aperture narrow, high, with a long simple tooth.

Variability. Characteristic features of the species are thick distinct carinae specifically curved in the lower part, and the expansion of the apertural portions of the chambers. The test shape shows little variations.

Dimorphism and ontogeny. The specimens sectioned represent the micro generation; PD 30—40μ. The sections show the tubular initial chambers followed by those with one keel, and from the 4-th or 5-th chamber onward the edges are bicarinate (Text-fig. 33/5, 6).

Remarks. — This species is morphologically related to *Lachlanella schroeckingeri* (Karrer), to which also shows ontogenetical resemblance, but differs in having distinct thick carinae and not sinuous edges only, in its narrower aperture and smooth surface, not covered with irregular depressions. From *L. bicostoides* Vella it differs in its more slender test shape, expanded apertural portion and higher aperture. *L. collenae* Vella is very similar in test ornamentation and shape, which is however more elongated and the carinae are acute and not thickened. *L. subpolygona* (Parr) is somewhat more slender and flattened; it besides much resembles *L. undosa* and may be its junior synonym or at least may be regarded as its descendant.

Distribution. — Poland: Tortonian (Karsy, Korytnica, Wieliczka, Węglinek). Romania: Tortonian, Lapugiu de Sus. USSR: Upper Tortonian, the Volhyn-Podolian Platform.

Genus *Miliola* Lamarck, 1804

The genus *Miliola* differs from the genus *Dentostommina* Carman, 1933, in the type of the aperture, which is trematophore in *Miliola*, whereas in *Dentostommina* it is circular with crenulate border and bifid tooth. The type species *Miliola saxorum* Lamarck is of Eocene age, whereas the type species *Dentostommina bermudiana* (Carman) comes from the Recent of the Bermuda Is. It appears from an investigation of the Miocene forms that the aperture with a crenulate border and a short tooth occurs in the juvenile stage of *Miliola* specimens, or it may be seen in mature specimens, the trematophore of which is damaged. It would be advisable to revise the genus *Dentostommina*, which may be a junior synonym of *Miliola*. The author of this paper did not found the specimens corresponding to the genus *Dentostommina* in the Recent materials available.

× *Miliola fabularoides* (Karrer, 1865)

(Pl. XIV, Figs 1*a*, *b*; 2*a*, *b*; 3*a*, *b*; Text-fig. 34/1)

1865. *Quinqueloculina fabularoides* Karrer; F. Karrer, p. 704, Pl. 1, Fig. 3.
1865. *Quinqueloculina transilvaniae* Karrer; ibidem, p. 704, Pl. 1, Fig. 4.
1952. *Schlumbergerina bogdanovi* Serova; *in*: A. K. Bogdanowich, p. 171, Pl. 26, Fig. 3*a*-*c*.

Material. — 80 specimens (Coll. No. F-125, Sec. No. 418, 419).

Dimensions: L — 0.6-1.5; B — 0.4-0.85; T — 0.3-0.55.

Description. — Test irregularly oval, triangular with rounded edges in section, periphery rounded; chambers tubular, narrow, irregular, middle chambers large, slightly arcuate and strongly projecting above the surface; sutures depressed; wall agglutinated, with a small number of fine sand grains distributed irregularly in a surface layer of calcareous cement; surface rough, matt; aperture circular, trematophore, convex, with numerous small circular pores.

Variability and ontogeny. The shape and thickness of the test are very variable, there being irregular bends in the chambers. The amount of agglutinated material in the superficial layer of the test is also variable and so some specimens have a nearly smooth, matt surface. The trematophore if damaged leaves the aperture open, which is semicircular in shape, surrounded with a crenulate border and has a simple tooth like *Dentostommina* (Pl. XIV, Fig. 1). The sections show a regular quinqueloculine

chamber arrangement, the chambers increase gradually in size and have a transverse oval shape; PD 30μ (Text-fig. 34/1).

Remarks. — Karrer described two similar species from Lapugiu: *Quinqueloculina fabularoides* and *Q. transilvaniae*, making no mention of their agglutinated test. They differ in that *Q. fabularoides* has a trematophore

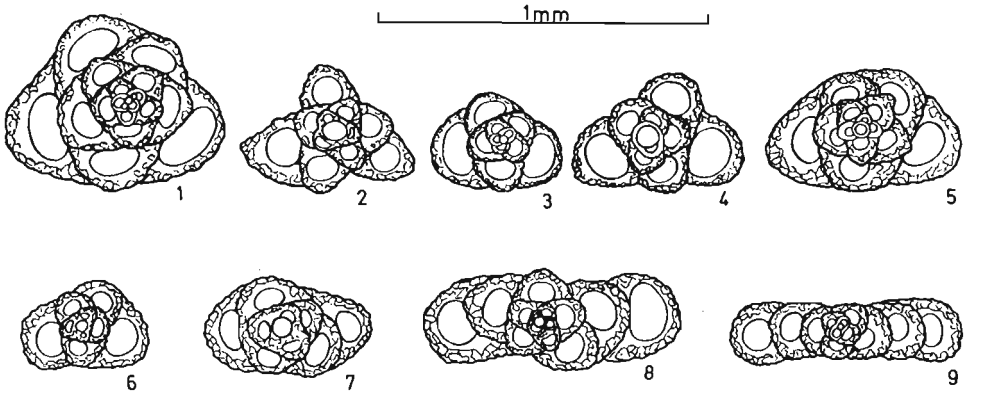


Fig. 34. Internal structure of *Miliola*, *Sigmoilopsis* and *Siphonaperta*: 1 — *Miliola fabularoides* (Karrer), Upper Tortonian, Niskowa, micro generation; 2 — *Siphonaperta granulata* (Śmigielska), Upper Tortonian, Gliwice Stare, mega I (?) generation; 3 — *Siphonaperta ovalis* sp. n., Upper Tortonian, Niskowa, mega I (?) generation; 4 — *Siphonaperta mediterranensis* (Bogdanowich); 5-9 — *Sigmoilopsis foeda* (Reuss), Lower Tortonian, Karsy, micro generation; 5, 6 — quinqueloculine stage, 7 — transitional stage, 8, 9 — sigmoiline stage.

aperture and *Q. transilvaniae* a circular one with a simple tooth. In the topotypic materials from Lapugiu de Sus numerous specimens corresponding to both species were found; it is however not possible to differentiate them into two distinct species on the basis of their morphology. It may well be that Karrer used the name *Q. transilvaniae* for specimens with the damaged trematophore, such specimens being frequent in the material from Lapugiu. Our specimens correspond to the topotypes from Lapugiu, there is however no reason to distinguish the specimens with the trematophore destroyed, or the juvenile specimens with the trematophore as yet undeveloped, as separate species.

Distribution. — Poland: Upper Tortonian (Niskowa). Romania: Tortonian, Lapugiu de Sus. USSR: Middle Miocene, the West Ukraine.

Genus *Podolia* Serova, 1961

Podolia compacta Serova, 1961

(Pl. XVIII, Fig. 10*a-c*)

1961. *Podolia compacta* Serova; M. J. Serova, p. 59, Pl. 4, Fig. 2.

Material. — 30 specimens (Coll. No. F-151)

Dimensions: L ~ 0.4; B ~ 0.32; T ~ 0.2.

Description. — Test oval, smal, triangular in cross-section, periphery subacute; chambers broad, with slightly inflated or flat sides, middle chamber small, faintly inflated, less than one-third the width of the test, fifth chamber poorly visible or invisible; sutures flat, indistinct; surface smooth, dull; aperture triangular, large, lyre-shaped, with a long simple tooth.

Variability. The walls are more or less inflated and, consequently, the periphery may be more or less rounded.

Remarks. — This species differs from *Podolia lyra* (Serova) in its more rounded test shape and subacute, not acute, periphery.

Distribution. — Poland: Upper Tortonian (Grabowiec, Niskowa). USSR: Upper Tortonian, Podolia.

Genus *Pseudohauerina* Ponder, 1972
+ *Pseudohauerina ornatissima* (Karrer, 1868)
(Pl. XVIII, Figs 8, 9*a-c*)

1868. *Quinqueloculina ornatissima* Karrer; F. Karrer, p. 151, Pl. 3, Fig. 2.
1917. *Hauerina ornatissima* (Karrer); J. A. Cushman, p. 63, Pl. 23, Fig. 5*a, b*.
1946. *Hauerina ornatissima* (Karrer); J. A. Cushman, p. 5, Pl. 1, Fig. 16*a-c*.
1955. *Hauerina ornatissima* (Karrer); M. J. Serova, p. 328, Pl. 13, Figs 1—4.

Material. — 40 specimens (Coll. No. F-143).

Dimensions: L 0.4-0.7; B 0.35-0.55; T 0.15.

Description. — Test irregularly rounded, flattened, periphery acute; outer chambers broad, with slightly inflated sides, 2—3 in the last whorl, middle chambers occupy a small area in the center of the test; surface covered with 6—8 transverse radiate plications, with concave intervening areas of the same breadth, filled with small transverse ridges and making the peculiar ornamentation of the test; sutures flat, indistinct; aperture triangular, trematophore, with about 10 circular, fairly large pores, placed at the end of the somewhat contracted last chamber.

Variability. The test shape is variable, as the last chamber of the 3-chambered planospiral stage may be more or less reduced in length.

Remarks. — As was stated by Cushman (1946), this species is often recognized in both Tertiary and Recent sediments. Observations of this author indicate however that it occurs only in the Miocene of Europe and that the Recent species are different. The Recent related species are: *Pseudohauerina occidentalis* (Cushman), differing in the rounded, not acute, periphery, in the more inflated central part of the test, and in the more numerous ridges on the chambers; *P. involuta* (Cushman), very close to *P. ornatissima*, from which it differs only in its broader chambers and more abundant plications; *P. orientalis* (Cushman), which differs in its more flattened test, gentler plications, and tinier pores in the aperture.

Distribution. — Poland: Tortonian (Gliwice Stare, Korytnica, Ligota Zabrska, Niskowa, Węglinek, Wieliczka). Romania: Tortonian, Kostej in Banat. USSR: Upper Tortonian, the Volhyn-Podolian Platform.

Genus *Sigmoilopsis* Finlay, 1947

The distinction between the quinqueloculine stage of *Sigmoilopsis* and that of *Siphonaperta* Vella, 1957, is difficult in some cases, the more so as within one species of *Sigmoilopsis* there occur specimens with broad flattened tests and those of juvenile stage with thicker tests, resembling *Siphonaperta* (e.g. in *Sigmoilopsis arenaria* (Brady) from the Indian Ocean, or in *S. foeda* (Reuss), from the Miocene of Wieliczka. The juvenile stage of *Sigmoilopsis* is generally characterized by its more compactly coiled test and inconspicuous middle chambers, which can hardly be distinguished while looked at from the outside.

× *Sigmoilopsis foeda* (Reuss, 1850)

(Pl. XV, Figs 1*a*, *b* — 4*a*, *b*; Text-fig. 34/5—9)

1850. *Quinqueloculina foeda* Reuss; A. E. Reuss, p. 384, Pl. 50, Figs 5, 6.
1957. *Sigmoilina plana* Śmigielska; T. Śmigielska, p. 260, Pl. 16, Fig. 5.

Material. — Over 500 specimens (Coll. No. F-152, Sec. No. 414, 420—423).

Dimensions: L 0.85-1.5; B 0.5-1.0; T 0.25-0.3.

Description. — Test massive, thick, flat, oval or rhomboid in shape, periphery broadly rounded; outer chambers tubular, arcuate, 2—3 middle chambers indistinct; sutures indistinct; wall rough, irregularly covered with sand grains of different size, protruding above the surface; aperture circular, at the end of a short narrow neck, with a thickened rim and a short tooth, widened at the end.

Variability and ontogeny. — The shape and thickness of the test are various, which is predominantly connected with ontogeny. The quinqueloculine stage is of relatively large size and this is why slender inflated specimens (Pl. XV, Fig. 3) occur beside the oval flattened specimens of the mature stage (Pl. XV, Figs 1, 2, 4). Sporadically the quinqueloculine stage is so large than it is poorly distinguishable from specimens belonging to *Siphonaperta*; it is usually marked by thicker walls, non-prominent middle chambers and indistinct flattened sutures (Text-fig. 34/4, 6). The sections show a distinct large quinqueloculine stage and 2—3 chambers of the planospiral stage (Text-fig. 34/7—9). The specimens sectioned belong to the micro generation; PD 20—60 μ.

Remarks. — This species differs from Recent *Sigmoilopsis arenaria* (Brady), in having a thicker wall and a shorter neck. Reuss claims that *S. foeda* is abundant in the Miocene of Wieliczka and this is also true of our materials from that locality. The illustration of Reuss is not clear enough and for this reason the topotype is figured in the present paper (Pl. XV, Fig. 5). *Sigmoilina plana* Śmigielska, 1957, from the Miocene of Gliwice Stare does not differ from the specimens of this species from Wieliczka. It differs from *Sigmoilina abbreviata* Venglinsky, 1967, from the Burdigalian of the Transcarpathians, in having a much broader test, more coarse-grained wall, and much shorter, poorly developed neck. From *Sigmoilopsis wanganuiensis* Vella, 1957, from the Holocene of New Zealand it hardly differs at all, but it is difficult to state if it is synonymous with *S. foeda* because of the lack comparative materials from New Zealand. *S. foeda* is often determined as *S. coelata* (Costa, 1855), from the Tertiary of Italia, which species however seems different.

Distribution. — Poland: Tortonian (Gliwice Stare, Grabki Duże, Karsy, Korytnica, Krywałd, Ligota Zabrska, Łęki Dolne, Wieliczka). Austria: Miocene, Möllersdorf, Vienna Basin. Czechoslovakia: Tortonian, Devinska Nova Ves, Židlochovice.

Genus *Siphonaperta* Vella, 1957

* *Siphonaperta granulata* (Śmigielska, 1957)

(Pl. XIV, Figs. 5*a*, *b*, 6*a*, *b*; Text-fig. 34/2)

1957. *Sigmoilina granulata* Śmigielska; T. Śmigielska, p. 260, Pl. 16, Fig. 14*a*, *b*.

Material. — 130 specimens (Coll. No. F-153, Sec. No. 417).

Dimensions: L 0.6-1.1; B 0.4-0.6; T 0.25-0.4.

Description. — Test oval, tapering at both ends, irregular, occasionally S-shaped, triangular in cross-section, periphery subrounded; chambers narrow, tubular, the basal end of the last chamber usually protruding and curved, the apertural end sometimes bent to the back and giving the chamber its S-shaped appearance, middle chambers large, tubular, elongated and strongly projecting beyond the surface of the test; sutures strongly depressed; wall with a number of coarse sand grains in the surface layer of calcareous cement; surface very rough, studded with sand particles of different size and shape in a disorderly manner; aperture circular, at the end of a very short neck, extending beyond the outline of the test, with an exserted lip and a short narrow or quadrate tooth.

Variability and ontogeny. The test shape varies from oval to S-shaped. The extension of the chamber is also variable, being very short or lacking at all. The characteristic features of the species are very prominent chambers, with deep grooves between them. The internal structure is irregularly quinqueloculine, the chambers increase considerably in size

and are almost round in cross-section. The specimens sectioned belong to the mega I (?) generation; PD 70 μ (Text-fig. 34/2).

Remarks. — This species differs from *Sigmoilina rustica* Bermudez from the Middle Miocene of the Dominican Republic in more elongated and lower test.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Ligota Zabrska).

* *Siphonaperta mediterranensis* (Bogdanowich, 1950)

(Pl. XIV, Figs. 7*a*, *b*, 8*a*, *b*; Text-fig. 34/4)

1950*b*. *Sigmoilina mediterranensis* Bogdanowich; A. K. Bogdanowich, p. 160, Pl. 6, Fig. 2*a-c*.
1952. *Sigmoilina mediterranensis* Bogdanowich; A. K. Bogdanowich, p. 165, Pl. 24, Fig. 3.
1958. *Sigmoilina mediterranensis* Bogdanowich; I. V. Venglinsky, p. 87, Pl. 17, Fig 1*a-c*.
1959. *Sigmoilina mediterranensis* Bogdanowich; V. A. Krasheninnikov, p. 86, Pl. 2, Fig. 3.

Material. — 50 specimens (Coll. No. F-154, Sec. No. 415).

Dimensions: L 0.7-1.2; B 0.35-0.55; T 0.25-0.4.

Description. — Test narrowly oval or quadrangularly oval, periphery broadly rounded; outer chambers thick, tubular, basically curved and usually straight at the top, middle chamber large, tubular, convex, fifth chamber poorly visible or invisible; sutures depressed, indistinct; wall calcareous, roughened by a thin coating of fine sand grains; aperture round, at the end of an only slightly developed neck, with a definite lip and a short simple tooth.

Variability and ontogeny. The test shape is variable, as the last chamber may be arcuate or straight at the apertural end. The thickness of the test and the length of the extension of the last chamber are also variable, being more or less well-developed. The section shows the irregular quinqueloculine internal structure. The specimen sectioned represents the mega I (?) generation; PD 70 μ (Text-fig. 34/4).

Remarks. — The autor of the species figured a specimen, the test morphology of which resembles our specimens; it has a prominent middle chamber and a narrowly oval test. However, he mentioned in the description that the species includes also flat forms, broadly oval in shape and with the spiroloculine arrangement of chambers in the mature stage. In our materials from coeval beds both forms described by Bogdanowich occur together. As Bogdanowich does not illustrate the flattened forms, and our analogical flat forms from the Miocene of Wieliczka have been identified as *Sigmoilopsis foeda* (Reuss), it is supposed that Bogdanowich's flat forms also belong to this last species. The slender quinqueloculine

forms, with a projecting middle chamber and depressed sutures are regarded as belonging to *S. mediterranensis* (Bogdanowich). Nevertheless, slender and convex forms without depressed sutures and distinct convex middle chambers should be cosidered to be juvenile stages of *Sigmoilopsis foeda* (Reuss).

Distribution. — Poland: Tortonian (Benczyn, Brzeźnica, Gliwice Stare, Grabki Duże, Karsy, Krywałd, Ligota Zabrska, Łęki Dolne, Niskowa, Wieliczka). Czechoslovakia: Tortonian, Devinska Nova Ves, Židlochovice. USSR: Miocene, Tarkhan and Tchokrak of Crimea and Caucasus; Konka of West- and East Precaucasian region; Lower Sarmatian of Transcarpathians.

Siphonaperta ovalis n.sp.
(Pl. XIV, Fig. 4*a-c*; Text-fig. 34/3)

Holotypus: Pl. XIV, Fig. 4.
Locus typicus: Niskowa near Nowy Sącz.
Stratum typicum: Upper Tortonian (Badenian) clays underlaying sands.
Derivatio nominis: ovalis (Lat.) — from the oval shape of the test.

Diagnosis. — Test regularly oval; surface evenly covered with fine sand grains of nearly the same size.

Material. — 40 specimens (Coll. No. F-155, Sec. No. 416).

Dimensions: Holotype length 0.6 mm; breadth 0.35 mm; thickness 0.2 mm; Paratypes length 0.45-1.0 mm; breadth 0.3-0.55 mm; thickness 0.1-04 mm.

Description. — Test regularly oval, triangular with rounded edges in cross-section, periphery broadly rounded; outer chambers arcuate, of uniform width, with flattened sides, last chamber slightly extended downwards, middle chamber convex, distinct, occupying about one-third of test breadth, fifth chamber small but clearly visible; sutures distinct, slightly depressed; wall calcareous, regularly covered with fine sand grains, which are even with the surface; aperture circular, flush with the periphery or at the end of the slightly extended last chamber, with a distinct lip and a simple tooth slightly widened at the end.

Variability and ontogeny. The distinctive features of the species are the constant regular shape of the test and the uniform type of wall agglutination. The sections show a regular quinqueloculine arrangement of chambers which gradually increase in size and are square-oval in cross-section. The specimens sectioned belong to the micro generation, proloculus diameter is 20 μ (Text-fig. 34/3).

Remarks. — This species does not resemble any form known to the author from literature and materials available.

Distribution. — Poland: Upper Tortonian (Niskowa).

Subfamily **Miliolinellinae** Vella, 1957, emend. Łuczkowska, 1972
Genus *Miliolinella* Wiesner, 1931, emend. Łuczkowska, 1972
+ *Miliolinella banatiana* nom.n.
(Pl. XIX, Figs 1—5, Text-fig. 35)

1868. *Triloculina dilatata* Karrer; F. Karrer, p. 139, Pl. 2, Fig. 1: non *Quinqueloculina dilatata* d'Orbigny, 1839, preoccupied.

Material. — 60 specimens (Coll. No. F-156, Sec. No. 339, 393—401).
Dimensions: L 0.4-0.6; B 0.35-0.6; T 0.20-0.40.

Description. — Test circular, usually broader than longer, centrally depressed, periphery broadly rounded; chambers broad, inflated, semicircular in outline, middle chamber small, two last chambers of adult specimens tending to become planispiral, occasionally slightly evolute; sutures depressed, distinct, with narrow strip along the sutures; surface smooth, glossy, in large specimens covered with irregular transverse wrinkles; wall thin; aperture large, broad and low, semicircular, with an everted border and a broad and low, sickle-shaped tooth.

Variability. The last chamber may be more or less inflated, having flattened sides and a rounded periphery in some specimens (Pl. XIX, Figs 1, 2), while in others the periphery is so much enlarged and swollen, that the test becomes triangular in cross-section (Pl. XIX, Fig. 5).

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation; PD 30—50 μ. The internal structure is initially cryptoquinqueloculine, then irregularly triloculine to become planispiral in the adult stage, as in *Sinuloculina* (Text-fig. 35). A turn of the coiling axis appears after a few juvenile chambers (Text-fig. 35/1, 2). The coiling axis may undergo another change, which is indicated by the tendency for the last chamber to uncoil in some specimens (Pl. XIX, Figs 2, 4a, b).

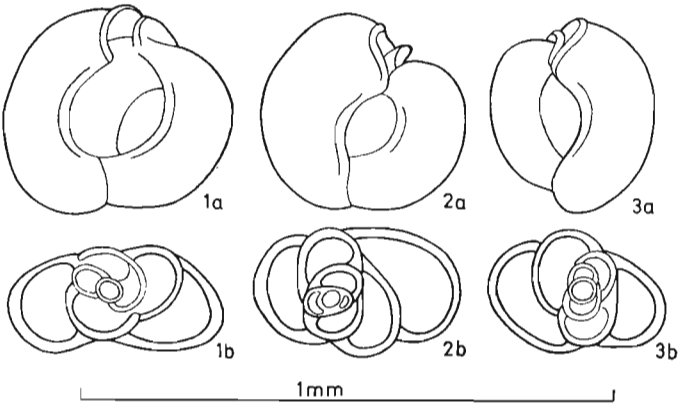


Fig. 35. Morphological variability and internal structure of *Miliolinella banatiana* nom. n., Upper Tortonian, Węglinek, micro generation; 1, 2 — evident turn of coiling axis; 3 — typical form; *a* side view, *b* cross-section.

Remarks. — This species approach morphologically to *Miliolinella circularis* (Bornemann), but differs in having a quadrangular-oval test shape, not tapering at the end, in its rough surface, covered with transverse wrinkles, and in the broader aperture with a sickle-shaped tooth. It resembles also *M. subrotunda* (Montagu), but differs in the quadrangular-oval test shape and in the tendency for its several last chambers to be arranged in a single plane. From *M. dilatata* (d'Orbigny) it differs in its more compact and higher test and more inflated chambers.

Distribution. — Poland: Upper Tortonian (Ligota Zabrska, Węglinek, Wierzchowiska). Romania: Tortonian, Kostej in Banat.

× *Miliolinella enoplostoma grammostoma* (Reuss, 1867)
(Pl. XX, Fig. 3a-c)

1867. *Triloculina enoplostoma grammostoma* Reuss; A. E. Reuss, p. 71, Pl. 2, Fig. 5.

Material. — 6 specimens (Coll. No. F-157).

Dimensions: L 0.7-0.8; B 0.55-0.7; T 0.4-0.7.

Description. — Test compact, nearly circular, triangular in cross-section, periphery broadly rounded; chambers inflated, with flattened sides, broad at the base and considerably narrowing towards the end, last chamber large, inflated, somewhat contracted at the periphery, middle chamber oval, distinct, occupying one-third of the breadth of the front side; sutures distinct, with slightly marked groove along the inner chamber edge; surface smooth, polished; aperture small, semicircular with a small semicircular flap, which is depressed in the middle.

Variability. The flattening of the last chamber periphery is variable, which gives it its irregular, more or less triangular appearance in cross-section. Some specimens lack the flap in the aperture.

Remarks. — The specimen figured originates from Wieliczka and coincides with the description of Reuss, the other specimens of this species found in Wieliczka are less regular in shape. It resembles *Triloculina austriaca* d'Orbigny in morphology, but differs in the aperture with a flap. It differs from *Miliolinella valvularis* (Reuss) in the marked flattening of the last chamber periphery, as in *Triloculina*, and in its much smaller aperture. The author expressed the opinion earlier (Łuczkowska, 1967) that *M. enoplostoma grammostoma* corresponds rather to *M. valvularis* (Reuss). In fact, these two forms are very close to each other. Considering however that in Wieliczka only a few morphologically differentiable specimens of either species have been found, and none of the abundant specimens of *M. valvularis* from other localities of the Upper Tortonian has a flattened periphery of the last chamber, as in *M. enoplostoma grammostoma*, the subspecies from Wieliczka has been retained as valid.

Distribution. — Poland: Tortonian (Wieliczka).

Miliolinella selene (Karrer, 1868)

(Pl. XX, Figs 1, 2; Text-fig. 36)

1868. *Triloculina selene* Karrer; F. Karrer, p. 138, Pl. 1, Fig. 12.
1950*b*. *Miliolina selene* (Karrer); A. K. Bogdanowich, p. 155, Pl. 5, Fig. 3.
1952. *Miliolina selene* (Karrer); A. K. Bogdanowich, p. 119, Pl. 12, Fig. 1.
1959. *Miliolina selene* (Karrer); M. Stancheva, p. 243, Pl. 3, Fig. 3.
1970. *Quinqueloculina selene* (Karrer); V. J. Didkovsky & Z. N. Satanovskaja, p. 32, Pl. 18, Fig. 9 *cum syn.*
1971. *Quinqueloculina selene* (Karrer); B. Strashimirov, p. 131, Pl. 1, Figs. 13, 14.

Material. — Over 500 specimens (Coll. No. F-158, Sec. No. 289—293).

Dimensions: L 0.45-0.8; B 0.35-0.6; T 0.25-0.4.

Description. — Test elongate, oval, rounded-triangular in cross-section, periphery rounded; chambers broad, somewhat broader at the base and narrowing towards the aperture, semicircular in cross-section, with flattened sides, middle chamber oval, tapering at both ends, placed slightly obliquely; sutures flat, occasionally with a shallow groove along the chamber edges; wall thin; surface smooth, polished; aperture of variable shape, semicircular or transverse-slitlike, filled with a flap or with a tape-shaped arcuate tooth.

Variability. — The thickness of the test and the rounded periphery are variable and, as a result, the test has a rounded-triangular or broadly oval shape in cross-section. The last chamber varies from broad to narrow.

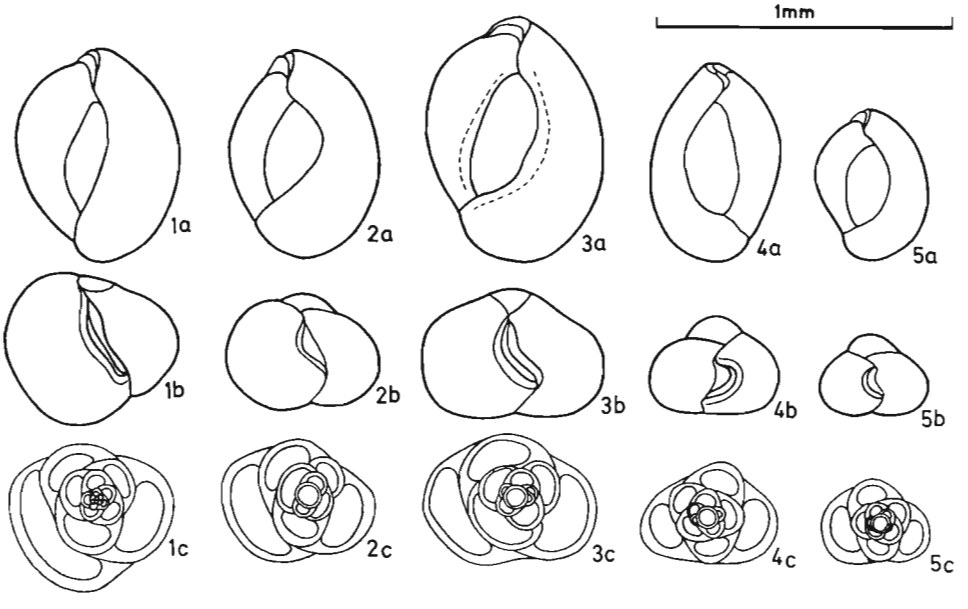


Fig. 36. Morphological variability, internal structure and dimorphism of *Miliolinella selene* (Karrer), Upper Tortonian, Gliwice Stare; 1 — form with pseudotriloculine chamber arrangement, micro generation; 2, 3 — forms with pseudotriloculine chamber arrangement, mega I generation; 4, 5 — forms with cryptoquinqueloculine chamber arrangement, mega I generation; *a* front view, *b* apertural view, *c* cross-section.

Dimorphism and ontogeny. The sections show forms of the micro generation, PD 10 μ (Text-fig. 36/1) and mega I generation, PD 50—70 μ (Text-fig 36/2—5). The internal structure of the micro generation is cryptoquinqueloculine initially, then pseudotriloculine, e.g. with one acute and two obtuse (over 130°) angles, measured between the three last chambers (Text-fig. 36/1). The mega I generation is cryptoquinqueloculine throughout. There also exist specimens with four (Pl. XX, Fig. 1) or even five chambers visible from outside (Pl. XX, Fig. 2).

Remarks. — This species differs from *Miliolinella valvularis* (Reuss) in its more elongated test shape, thinner wall, and broader, transversely contracted aperture.

Distribution. — Poland: Tortonian (Gliwice Stare, Grabki Duże, Karsy, Korytnica, Krywałd, Ligota Zabrska, Zrecze). Bulgaria: Tortonian, the north-western and north-eastern regions of Bulgaria. Czechoslovakia: Lower Tortonian, Židlochowice. Romania: Tortonian, Kostej in Banat. USSR: Lower Oligocene, West Siberia and Middle Asia; Middle Miocene, West-Precaucasian region, Dagestan, Georgia, Abkhasia, Crimea; Lower Tortonian, Volhyn-Podolia Platform.

× *Miliolinella valvularis* (Reuss, 1851)
(Pl. XX, Figs 4, 5; Text-fig. 37)

1851. *Triloculina valvularis* Reuss; A. E. Reuss, p. 85, Pl. 7, Fig. 56.

Material. — About 100 specimens (Coll. No. F-159, Sec. No. 285, 288, 294—296).

Dimensions: L 0.35-1.0; B 0.32-0.85; T 0.25-07.

Description. — Test regularly oval, periphery broadly rounded, cross-section broadly oval or triangular-oval in outline; chambers broad, inflated, slightly narrowing at both ends, middle chamber convex, oval or narrowly oval with tapering ends, occupying one-third of the breadth of the front side; sutures somewhat depressed, with longitudinal groove along the chamber edges; surface smooth; wall thick; aperture semicircular or slightly triangular, with sinuous border and tongue-shaped flap, the central portion of which is slightly depressed.

Variability. The number of chambers visible from outside is variable, three in typical specimens or two in non-typical ones in which the last chambers embrace those of the previous whorls so that only a narrow trace of the third chamber remains between them (Pl. XX, Fig. 5a-c). The aperture flap of such "pseudobiloculine" specimens is thickened and convex, without a depression in the central part. The "pseudobiloculine" specimens resemble *Pyrgoella*, but they never have chambers arranged in a single plane.

Dimorphism and ontogeny. The specimens sectioned represent the micro generation, PD 10 μ, and the mega I generation, PD 70—100 μ. The

internal structure of both generations is initially triloculine, then irregularly triloculine, one of the angles measured between the three last chambers being less than 90° and two exceeding 120° (Text-fig. 37/2, 3). Large two-chambered forms have always an irregular triloculine (pseudo

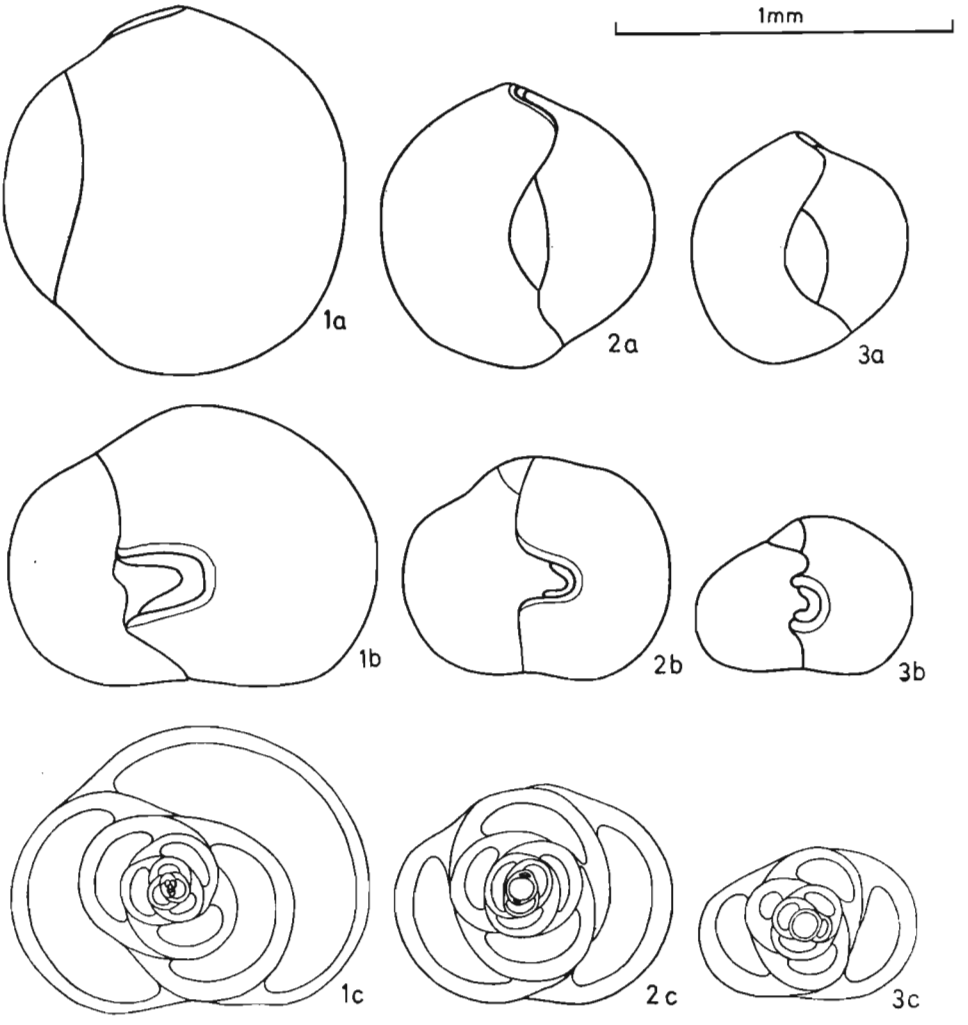


Fig. 37. Ontogeny and dimorphism of *Miliolinella valvularis* (Reuss), Upper Tortonian, Krywałd borehole, depth 72-74 m; 1 — pseudobiloculine form, micro generation; 2 — pseudotriloculine form, mega I generation; 3 — cryptoquinqueloculine form, mega I generation; *a* front view, *b* apertural view, *c* cross-section.

triloculine) chamber arrangement despite their "pseudobiloculine" appearance (Text-fig. 37/1).

Remarks. — Pseudobiloculine forms differ from *Pyrgoella ventruosa* (Reuss) and *P. controversa* (Bogdanowich) in having larger tests, thicker walls, a more oval shape and pseudotriloculine internal structure. They

differ from *Miliolinella enoplostoma grammostoma* (Reuss) in lacking a distinctive flattening of the last chamber periphery. Compared with the topotypes from Hermsdorf, the specimens studied do not show any essential differences.

Distribution. — Poland: Upper Tortonian (Brzeźnica, Budy, Gliwice Stare, Grzybów, Krywałd, Ligota Zabrska, Zgłobice, Zrecze). GDR: Oligocene, Hermsdorf near Berlin.

Genus *Affinetrina* Łuczkowska, 1972

× *Affinetrina cubanica* (Bogdanowich, 1947)

(Pl. XXVI, Fig. 4*a-c*, Text-fig. 38/5)

1947. *Miliolina cubanica* Bogdanowich; A. K. Bogdanowich, p. 20, Pl. 1, Fig. 6.
1952. *Miliolina cubanica* Bogdanowich; A. K. Bogdanowich, p. 129, Pl. 15, Fig. 2, 3.

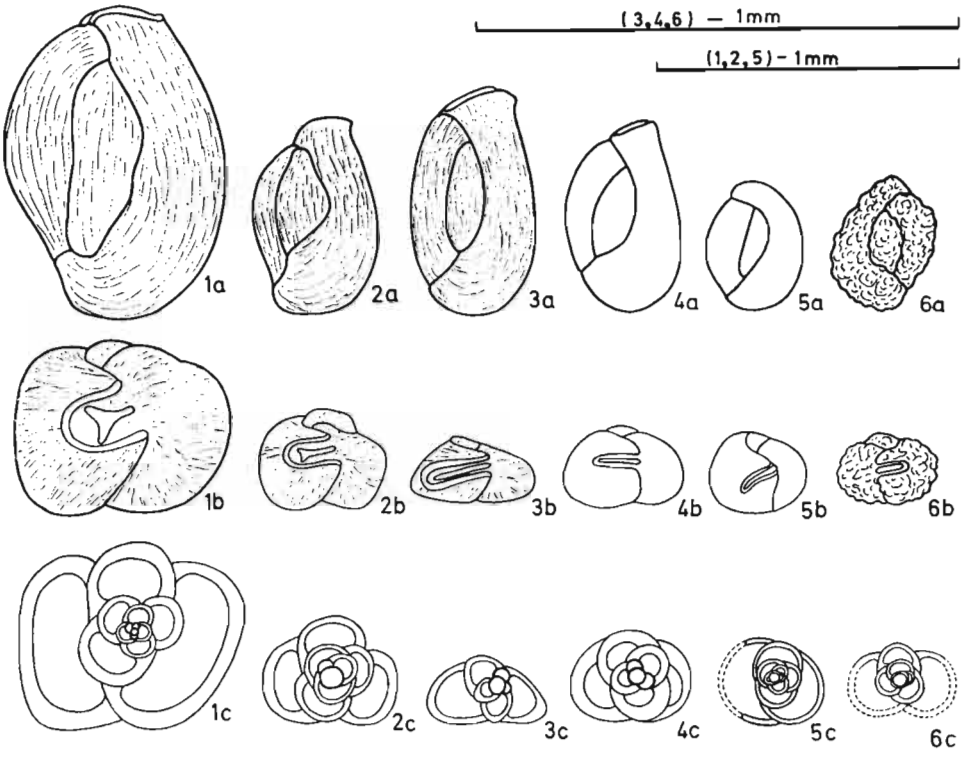


Fig. 38. Morphology and internal structure of *Affinetrina*: 1,2 — *A. planciana* (d'Orbigny), Upper Tortonian, Gliwice Stare; 1 — micro generation, triloculine chamber arrangement, periphery broadly rounded and truncate, 2 — mega I generation, pseudotriloculine chamber arrangement, periphery rounded; 3 — *A. gualtieriana* (d'Orbigny), Upper Tortonian, Gliwice Stare, micro generation, cryptoquinqueloculine chamber arrangement, subacute periphery; 4 — *A. ucrainica* (Serova), Upper Tortonian, Węglinek, micro generation, cryptoquinqueloculine chamber arrangement; 5 — *A. cubanica* (Bogdanowich), Lower Sarmatian, Zrecze-3 borehole, depth 11 m, micro generation, triloculine chamber arrangement; 6 — *A. voloshinovae timenda* (Chutzieva), Lower Sarmatian, Zrecze-3 borehole, depth 11 m, micro generation, pseudotriloculine chamber arrangement; a front view, b apertural view, c cross-section.

1961. *Triloculina cubanica* (Bogdanowich) var. *cubanica* (Bogdanowich); V. J. Didkovsky, p. 109, Pl. 18, Fig. 4*a-c*.

Material. — 15 specimens (Coll. No. F-160, Sec. No. 340, 403).

Dimensions: L — 0.2-0.4; B — 0.15-0.35; T — 0.1-0.2.

Description. — Test very small, nearly circular, tapering towards the aperture, periphery broadly rounded; chambers inflated, slightly narrowing towards the aperture, middle chamber narrow and oblique; sutures somewhat depressed; wall thin; surface smooth, polished; aperture in the form of a high narrow slit, slightly widened at the top, placed somewhat oblique to the penultimate chamber, sloping, and filled with a simple longitudinal tooth.

Variability. Some specimens of this species are more regularly oval in shape. Its prominent feature is the arcuate border of the aperture, which is always in an oblique position.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation; PD 30 μ. The internal structure initially cryptoquinqueloculine, then triloculine (Text-fig. 38/5).

Remarks. — This species differs from *Affinetrina ucrainica* (Serova, 1952) in its more rounded test shape, considerably thinner wall, and the oblique position of the aperture.

Distribution. — Poland: Upper Tortonian, Gliwice Stare, Grabowiec, Grzybów, Węglinek, Zrecze). USSR: Lower and Middle Sarmatian, Black sea Depression, North and West Caucasus and Ukraine.

Affinetrina gualtieriana (d'Orbigny, 1839)

(Pl. XXVI, Figs 1, 2; Text-fig. 38/3)

1839. *Triloculina gualtieriana* d'Orbigny; A. d'Orbigny, *in*: Ramon de la Sagra, p. 170, Pl. 9, Figs 5—7; *fide* Catalogue Ellis & Messina.

Material. — 60 specimens (Coll. No. F-161, Sec. No. 390—392).

Dimensions: L — 0.3-0.6; B — 0.18-0.35; T — 0.1-0.2.

Description. — Test quadrangular-oval, elongated, regular, subtriangular in cross-section, periphery narrowly rounded; chambers flat, of nearly uniform width, strongly expanded at the aperture, middle chamber narrow and elongated; sutures flat, distinct; wall thin; surface covered with irregular thick short striations, giving the test its rough appearance; aperture high, narrow, with arcuate border, which is bent to the back and parallel to the flattening of the test, with long simple tooth, sometimes projecting beyond the aperture edge.

Variability. The test shape is stable, the flattening of chambers variable, its degree being occasionally slightly differentiated. The number of chambers visible from outside varies from 3 to 5.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation; PD 30 μ. The internal structure is cryptoquinqueloculine

throughout, only the juvenile stage being sometimes quinqueloculine (Text-fig. 38/8). The chambers of juvenile stage show a broadly rounded periphery, which becomes narrowly rounded as they grow.

Remarks. — This species differs from *Affinetrina planciana* (d'Orbigny) in having distinctly flattened sides also in adult specimens, whereas in *A. planciana* the periphery becomes enlarged and inflated in the course of growth. It differs also in its much more flattened sutures, thinner walls, and higher and narrower aperture. From *A. deplanata* Rhumbler it differs in the distinctive distension of chambers near the aperture, where they are also bent to the back.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Ligota Zabrska). Cuba: Recent.

+ *Affinetrina planciana* (d'Orbigny, 1839)
(Part. I, Pl. XIII, Figs 4*a-c*, 5*a-c*; Part. II, Text-fig. 38/1, 2)

1839. *Triloculina planciana* d'Orbigny; A. d'Orbigny, *in*: Ramon de la Sagra, p. 173, Pl. 8, Figs 17—19; *fide* Catalogue Ellis & Messina.

Material. — 80 specimens (Coll. No. F-179, Sec. No. 206, 209).

Dimensions: L — 0.6-1.2; B — 0.4-0.95; T — 0.3-0.5.

Description. — Test rhomboid-oval, irregular, tapering at both ends, strongly inflated, periphery broadly rounded and somewhat truncate; chambers broad at the base, narrowing upwards and broadened again at the aperture, middle chamber irregularly oval tapering at both ends, slightly convex; sutures distinct, depressed; wall thick; surface covered all over with irregular short longitudinal striations giving the test its rough appearance; aperture surrounded with a thickened rim, high and narrow, bent distinctly to the back and filled with a long tooth slightly bifurcated at the end.

Variability. The thickness of the test is variable, the test being nearly square in cross-section in large specimens; then the chambers become more inflated, the periphery truncate and the aperture widened, with a Y-shaped tooth. The aperture of typical specimens is high and narrow.

Dimorphism and ontogeny. The specimens sectioned represent the micro generation, PD 20 μ, and the mega I generation, PD 80 μ. The internal structure of the micro generation is initially cryptoquinqueloculine, then triloculine (Text-fig. 38/1), that of the mega I generation is irregularly triloculine throughout (Text-fig. 38/2). The broadly rounded periphery of chambers is kept throughout the ontogeny.

Remarks. — This species differs from *Affinetrina gualtieriana* (d'Orbigny) in the higher and irregular test, more inflated chambers, depressed sutures and broader aperture. The similarity of these species is visible in the rough, irregularly striated surface. The recent specimens of this species found in the materials from the Mediterranean Sea do not differ from

ours. Morphologically our species much resembles *Triloculina ukrainica* (Serova) var. *satanovi* Didkovsky from the Upper Tortonian (Badenian) of Ukrainian SSR, but differs distinctly in the rough, longitudinally irregularly striated surface.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Węglinek). Cuba and Jamaica: Recent.

Affinetrina ucrainica (Serova, 1952)
(Pl. XXVI, Fig. 3*a-c*; Text-fig. 38/4)

1952. *Miliolina ucrainica* Serova; *in*: A. K. Bogdanowich, p. 104, Pl. 8, Fig. 2.
1955. *Miliolina cuneata* (Karrer) var. *ucrainica* Serova; M. J. Serova, p. 308, Pl. 3, Figs 7—9.
1959. *Triloculina confirmata* Krasheninnikov; V. A. Krasheninnikov, p. 83, Pl. 7, Fig. 3*a-c*.
1961. *Triloculina ukrainica* (Serova) var. *ukrainica* (Serova); V. J. Didkovsky, p. 94, Pl. 19, Fig. 1*a-c*.
1968. *Triloculina ukrainica* (Serova); B. Ionesi, p. 263, Pl. 11, Figs 18—20.
1970. *Quinqueloculina guriana* Djanelidze; O. Djanelidze, p. 101, Pl. 19, Fig. 4*a-c*, *cum syn.*

Material. — 20 specimens (Coll. No. F-163, Sec. No. 402).

Dimensions: L 0.3-0.65; B 0.2-0.45; T 0.15-0.35.

Description. — Test oval-quadrangular, periphery rounded; chambers broad and curved at the base, become straight and narrow towards the end, middle chamber oval and small; sutures slightly depressed; wall thick; surface smooth, polished; the aperture occurs as a high narrow slit, parallel to the flattening of the test, filled with a thin longitudinal tooth.

Dimorphism and ontogeny. The micro generation with the P diameter 30 μ has been found; its internal structure is cryptoquinqueloculine. The shape of chambers is invariably semicircular in cross-section (Text-fig. 38/4).

Remarks. — This species differs from *Affinetrina cubanica* (Bogdanowich) in the larger and more elongated test shape, thiner walls, and aperture parallel and not oblique, to the flattening of the test. It has also a cryptoquinqueloculine, not triloculine internal structure in the adult stage, and semicircular, not sickle-shaped, chamber cross-sections. It is very similar to *Quinqueloculina seminulum meotica* (Gerke) and to *Q. pseudocuneata* Gerke (in Bogdanowich, 1969), but differs from the first form in its more rounded periphery and higher test, and from the other form in the higher and narrower aperture. Both forms are compared by Gerke with *Q. seminulum* or were described before as "varieties" of *Q. seminulum*. However, judging from the description and illustrations both these forms have a little in common with *Q. seminulum*, because the type of aperture refers them to the genus *Affinetrina*, and their internal structure, according to Gerke, is cryptoquinqueloculine. On the basis of these characters, they should be included in the genus *Affinetrina*.

Quinqueloculina guriana Djanelidze has also been synonymized with *A. ucrainica* although this author reports that the difference between these two forms consists in the presence of a keel on the last chamber of *A. ucrainica*. Since in the description of this species the author did not mention the presence of the keel, and neither it is figured in the illustrations of *A. ucrainica*, this feature has been omitted in the present description.

Distribution. — Poland: Upper Tortonian (Bogucice, Ligota Zabrska, Rytwiany, Węglin). Romania: Lower Sarmatian, the Moldavian Platform. USSR: Upper Tortonian, Volhyn-Podolian Platform, West Ukraine, Georgia.

Affinetrina voloshinovae timenda (Chutzieva, 1960)
(Pl. XXVI, Fig. 5*a-c*; Text-fig. 38/6)

1960. *Quinqueloculina voloshinovae* (Bogdanowich) var. *timenda* Chutzieva; *in* A. K. Bogdanowich, p. 245, Pl. 1, Figs 5, 6.

Material. — 40 specimens (Coll. No. F-164, Sec. No. 404, 405).

Dimensions: L 0.25-0.35; B 0.15-0.25; T 0.12-0.2.

Description. — Test very small, oval in shape, periphery rounded; chambers somewhat inflated, broad at the base and narrowing towards the aperture, middle chamber small and narrow; sutures depressed, indistinct, masked with ornamentation; wall thin; surface ornamented with short irregular ridges, running in different directions; aperture very narrow, high, parallel to the flattening of the test and filled with a long narrow tooth.

Variability. This species is characterized by its ornamentation which is irregular and variable. There exist spinose or nodulose protuberances in some specimens and they are prominent in the lower part of the chambers and disappear near the aperture.

Dimorphism and ontogeny. The specimens sectioned represent the micro generation; PD 30 μ. The internal structure is triloculine, the chambers of the last whorl are irregularly triloculine (Text-fig. 38/6).

Remarks. — This species morphologically resembles *Affinetrina cubanica* (Bogdanowich, 1947), but differs in the ornamentation of the test. It is very close to *Varidentella nanae* (Maissuradze) in its shape and ornamentation, but differs in the distinct high and narrow aperture with a long tooth, and not broad and low with a quadrate tooth. It is quite like *Triloculina taiwanica* Ishizaki, 1943, from the Pliocene of Formosa, differs however in having a higher test, tapering at the top, a narrower aperture and the ornamentation composed of irregular ridges, not of irregular costae.

Distribution. — Poland: Lower Sarmatian, (Dwikozy, Grzybów, Zrecze). USSR: Middle Sarmatian, West Precaucasian region.

Genus *Biloculinella* Wiesner, 1931
+ *Biloculinella labiata* (Schlumberger, 1891)
(Pl. XXI, Figs 8, 9)

1891. *Biloculina labiata* Schlumberger; C. Schlumberger, p. 556, Pl. 9, Figs 60—62, Text-figs 13, 14.

1911. *Biloculina haddoniana* Wright; J. Wright, p. 14, Pl. 2, Fig. 22*a*, *b*; *fide* Catalogue Ellis & Messina.

1957. *Pyrgo haddoniana* (Wright); T. Śmigielska, p. 263, Pl. 16, Fig. 12.

Material. — About 100 specimens (Coll. No. F-165).
Dimensions: L 0.45-1.1; B 0.35-0.9; T 0.25-0.75.

Description. — Test oval, slightly tapering at both ends; chambers somewhat inflated, penultimate chamber narrowing and truncate at the base, rounded at the top; chamber sides slightly sloping, narrow, of uniform width, with narrowly rounded periphery; surface smooth, polished; aperture broad, semicircular, nearly filled up with a semicircular flat flape, which is somewhat inclined towards the last chamber.

Variability. The test shape is variable, being circular (Pl. XXI, Fig. 8) or oval (Pl. XXI, Fig. 9).

Dimorphism and ontogeny. From Schlumberger's illustration it follows that in this species there exist micro (p. 170, Fig. 14) and mega II? (p. 169, Fig. 13) generations, which do not differ in morphology. The internal structure of the micro generation is initially quinqueloculine, then cryptoquinqueloculine and finally biloculine.

Remarks. — Schlumberger's illustrations (Pl. 9, Figs. 60—62) and text-figures of this species show a sharp and keeled periphery of chambers. Such a keeled periphery has not been met by the author with any of the Recent specimens, from the Adriatic and the Mediterranean Sea or in the Miocene specimens, the shape of which is identical with that of specimens from Recent seas. The illustration of a paratype of *B. labiata* given by Loeblich & Tappan (1964, p. C 467, Fig. 355, 3—5) shows an acute periphery, like that in Schlumberger's specimens, distinguishing this species from the Recent and fossil specimens mentioned above. However, on the basis of the identical shape of chambers and aperture, the Miocene specimens have been recognized as belonging to *B. labiata*.

Distribution. — Poland: Tortonian (Badenian), (Gliwice Stare, Grzybów, Ligota Zabrska, Wieliczka). Recent: Mediterranean Sea.

Genus *Crenatella* Łuczkowska, 1972
Crenatella mira Łuczkowska, 1972

The description and illustrations are given in Part I.

Genus *Flintina* Cushman, 1921
Flintina truncata (Karrer, 1865)
(Pl. XXIV, Figs 3, 4)

1865. *Triloculina truncata* Karrer; F. Karrer, p. 704, Pl. 1, Fig. 2*a-c*.
1904. *Miliolina subrotunda* Montagu, sp.; H. Sidebottom, p. 8, Pl. 3, Figs 1—7.

Material. — 20 specimens (Coll. No. F-167).

Dimensions: L 0.65-0.8; B 0.75-0.8; T 0.5.

Description. — Test subrounded, broader at the top, periphery broadly rounded; 2—3 chambers of the last whorl much inflated, very broad, middle chamber partly visible in the upper part of one side only; sutures distinct, flat, with a marked rim along the inner edges of chambers; surface smooth, polished, with faint transverse wrinkles; wall thin; aperture very large, circular or oval, surrounded with a thickened rim and with a massive, short Y-shaped tooth, projecting somewhat above the aperture border.

Variability. The test shape is very variable, as the evolving chambers of the last whorl are irregular. There exist specimens, the last chamber of which deviates slightly from the coiling axis (Pl. XXIV, Fig. 3), and others with the last chamber shorter and more inflated (Pl. XXIV, Fig. 4).

Remarks. — This species described from the Leitha-limestones at Steinabrunn (Austria), has not been found by the author in materials available from Austria. It is morphologically similar to *Sinuloculina cyclostoma* (Reuss), but differs in being more expanded at the top and in having more than two chambers in the last whorl. From *Flintina tutkowskii* Bogdanowich from the Middle Sarmatian of the West Ukraine it differs in its broadly rounded, not narrowly rounded or acute, periphery. From *F. corporata* Bogdanowich from the Konka beds of the West Caucasian Foreland it differs in the more inflated chambers and the broader apertural end of chambers; otherwise, the two species are very similar.

Distribution. — Poland: Upper Tortonian (Bogoria, Węglinek). Austria: Tortonian, Steinabrunn, Vienna Basin.

Genus *Pyrgo* Defrance, 1824
× *Pyrgo amphiconica* (Reuss, 1850)
(Pl. XXII, Figs 6*a*, *b*, 7, 8; Text-fig. 39/2)

1850. *Biloculina amphiconica* Reuss; A. E. Reuss, p. 382, Pl. 49, Fig. 5.
1867. *Biloculina amphiconica* Reuss var. *plastystoma* Reuss; A. E. Reuss, p. 53, Pl. 1, Fig. 8.
1867. *Biloculina larvata* Reuss; *ibidem*, p. 70, Pl. 2, Fig. 3.

Material. — Over 500 specimens (Coll. No. F-168, Sec. No. 406, 407).

Dimensions: L 0.4-1.5; B 0.4-1.5; T 0.25-1.0.

Description. — Test nearly circular, truncate at both ends; chambers strongly inflated, with acute edges, periphery narrow, undulate, that of

penultimate chamber projecting above the surface; sutures distinct; surface smooth, polished; aperture very broad, occasionally occupying the whole breadth of the test, with a low and wide, tape-shaped tooth which has lateral extensions at both sides.

Variability and ontogeny. The topotypes from Wieliczka show a very variable aperture which may be small (Pl. XXII, Figs 7, 8) or wide and low (Pl. XII, Fig. 6.). The convexity of chambers is also variable, for they are sometimes more inflated basically, and then the lateral outline of the test is S-shaped, as in *Pyrgo inornata* d'Orbigny. The specimens sectioned belong to the micro generation; PD 10 μ. The internal structure is initially irregularly triloculine, then biloculine. The juvenile triloculine stage is very small in comparison with the biloculine stage (Text-fig. 39/2).

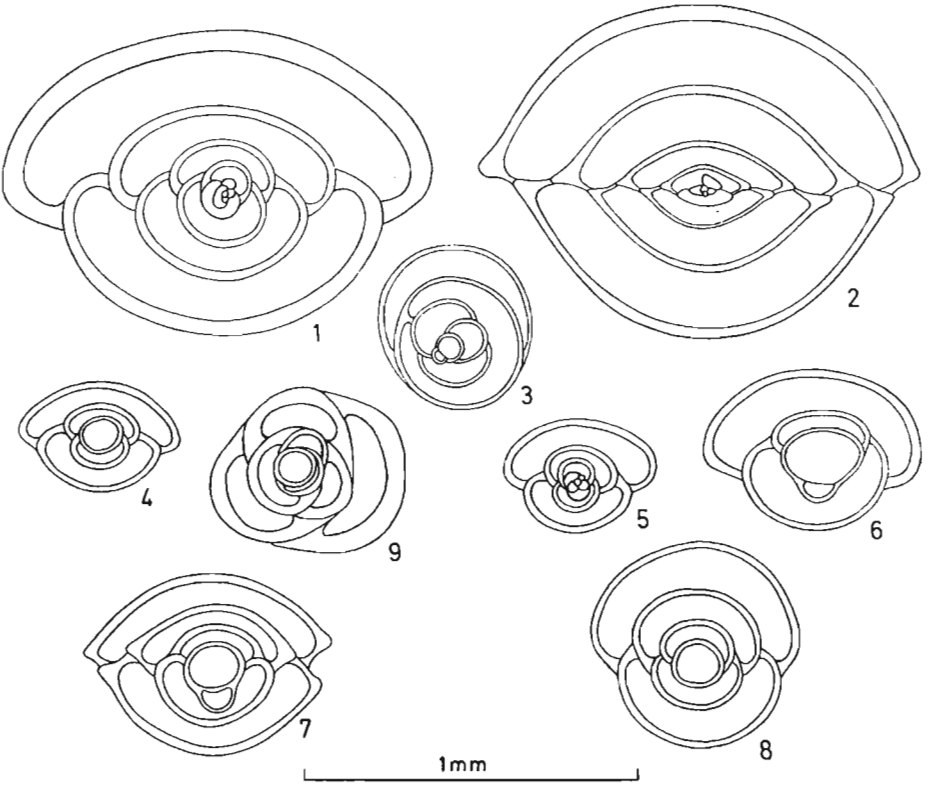


Fig. 39. Internal structure of *Pyrgo* and *Pyrgoella*: 1 — *Pyrgo truncata* (Reuss), Lower Tortonian, Wieliczka, micro generation; 2 — *Pyrgo amphiconica* (Reuss), Lower Tortonian, Wieliczka, micro generation; 3 — *Pyrgoella ventruosa* (Reuss), Lower Tortonian, Wieliczka, mega I generation; 4 — *Pyrgo clypeata* (d'Orbigny), Lower Tortonian, Karsy, mega I generation; 5, 6 — *Pyrgo inornata* (d'Orbigny), Upper Tortonian, Gliwice Stare; 5 — micro generation, 6 — mega II generation; 7 — *Pyrgo lunula* (d'Orbigny), Upper Tortonian, Gliwice Stare, mega I (?) generation; 8 — *Pyrgo subsphaerica* (d'Orbigny), Upper Tortonian, Gliwice Stare, mega I (?) generation; 9 — *Pyrgoella controversa* (Bogdanowich), Upper Tortonian, Gliwice Stare, mega I generation.

Remarks. — The topotypes from Wieliczka have not an acute process at the base, like that figured by Reuss (*op. cit.*, Pl. 49. Fig. 5). On the contrary, the lower edge of the test is truncate and parallel to the aperture edge. The form illustrated by Reuss was probably an atypical one, or the spine at the base was a part of the apertural tooth left after the removal of the last chamber. The variety "platystoma" distinguished by Reuss (1867, Pl. 1. Fig. 8.) and *Pyrgo larvata* (Reuss) which was found in materials from Wieliczka only in the form figured in Pl. XXII, Fig. 8 of this paper, lie within the variation range of *P. amphiconica*. This species differs from *P. lunula* (d'Orbigny) in the more inflated test, much narrower chamber sides, narrower slitlike aperture, and low and broad tooth. The topotypes of *P. lunula* from Baden (Austria) are actually more flattened and have broader chamber sides and a considerably smaller aperture. It is not clear, however, if these characters are not ones of juvenile *P. amphiconica*, because such juvenile specimens of *P. amphiconica* may be found in materials from Wieliczka (Pl. XXII, Fig. 7.). Owing to the scarcity of the material from Baden available it is not possible to decide the problem.

Distribution. — Poland: Tortonian (Gliwice Stare, Wieliczka).

+ *Pyrgo clypeata* (d'Orbigny, 1846)

(Pl. XXII, Fig. 2*a*, *b*; Text-fig. 39/4)

1846. *Biloculina clypeata* d'Orbigny; A. d'Orbigny, p. 263, Pl. 15, Figs 19—21.

Material. — About 100 specimens (Coll. No. F-169, Sec. No. 435).

Dimensions: L 0.55-1.3; B 0.4-1.1; T 0.3-0.9.

Description. — Test broadly oval, slightly tapering towards the aperture, narrowly oval in cross-section; chambers moderately inflated, arcuate in cross-section, lower part of penultimate chamber extended downwards and truncate, chamber edges, rounded, chamber periphery fairly broad, widened at the base, and nearly flat; sutures distinct, not depressed; surface smooth, polished; aperture semicircular, small, slightly prominent, with a transverse quadrangular tooth and small lateral processes.

Variability and ontogeny. Only the shape of the test, oval or more rounded, is variable. The characteristic feature of the species are nearly flat chamber sides, which are expanded at the bottom. The specimen sectioned belongs to the mega I generation; PD 110μ. The internal structure is biloculine throughout (Text-fig. 39/4).

Remarks. — From *Pyrgo* (*Biloculinella?*) *affinis* (d'Orbigny, 1846) this species differs in its quadrangular, not arcuate, tooth and more flattened test.

Distribution. — Poland: Tortonian (Benczyn, Gliwice Stare, Grzybów, Karsy, Korytnica, Krywałd, Ligota Zabrska, Węglinek, Wieliczka). Austria:

Tortonian, Baden, Nussdorf, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice.

× *Pyrgo inornata* (d'Orbigny, 1846)

(Pl. XXII, Fig. 3*a*, *b*; Text-fig. 39/5, 6)

1846. *Biloculina inornata* d'Orbigny; A. d'Orbigny, p. 266,, Pl. 16, Figs 7—9.
1867. *Biloculina bulloides* d'Orbigny var. *truncata gracilis* Reuss; A. E. Reuss, Pl. 2, Fig. 2.
1868. *Biloculina tenuis* Karrer; F. Karrer, p. 133, Pl. 1, Fig. 5.
1952. *Pyrgo inornata* (d'Orbigny); A. K. Bogdanowich, p. 168, Pl. 25, Figs 3, 4.
1956. *Pyrgo inornata* (d'Orbigny); A. Sulimski, p. 74, Pl. 2, Fig. 2*a*-*c*.

Material. — About 200 specimens (Coll. No. F-170, Sec. No. 436*a*, *b*). Dimensions: L 0.4-1.3; B 0.2-0.95; T 0.25-0.9.

Description. — Test oval, tapering towards the aperture and expanded at the base; chambers inflated, usually semicircular in cross-section, lower part of penultimate chamber narrowing downwards and truncate; periphery broadly rounded; chamber sides narrow at the top, broader at the base and somewhat sloping; sutures distinct; surface smooth, polished; aperture small, semicircular, with a low transverse-quadrangular tooth of variable width and with small lateral processes.

Variability and ontogeny. The test shape is variable and oscillates between regularly oval and narrowly oval. The convexity of the penultimate chamber is also variable; it usually occurs in the central portion, but is occasionally displaced upwards, with the lower portion of the chamber flat. Such specimens morphologically resemble *Pyrgo oblonga* (d'Orbigny). The specimens sectioned represent the micro generation, with the proculus diameter 10 μ, and the mega II generation, the proculus of which is very large, its diameter being 320 μ (Text-fig. 39/5, 6). The internal structure of the micro generation is initially irregularly triloculine, later biloculine, that of the mega II generation is biloculine throughout.

Remarks. — This species differs from *Pyrgo oblonga* (d'Orbigny, 1839) in the more regular shape of the test, which does not taper so much at the top and expand at the base. *P. tenuis* (Karrer, 1868) from the Miocene of Kostej probably represents the juvenile stage of *P. elongata*, the test of which may have a similarly elongated and flattened shape. *P. bulloides truncata gracilis*, figured by Reuss (1867) from the Miocene of Wieliczka, does not differ from *P. inornata* from Baden. The topotypes of *P. inornata* from Baden are identical with those from the Miocene of Poland, but they are more flattened than the specimen in d'Orbigny's illustration. As both more or less inflated forms occur in our material, the convexity of the test has been assumed to be exponent of intraspecific variability. From *P. clypeata* (d'Orbigny, 1846) *P. inornata* differs distinctly in its more

elongated, narrowing upwards test shape and in the more rounded periphery.

Distribution. — Poland: Tortonian (Bogucice, Brzeźnica, Gieraszowice, Gliwice Stare, Grzybów, Karsy, Krywałd, Ligota Zabrska, Wieliczka). Austria: Tortonian, Baden, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice. Romania: Tortonian, Kostej in Banat. USSR: Middle Miocene, West Ukraine.

× *Pyrgo lunula* (d'Orbigny, 1846)
(Pl. XXII, Fig. 5*a*, *b*; Text-fig. 39/7)

1846. *Biloculina lunula* d'Orbigny; A. d'Orbigny, p. 264, Pl. 15, Figs 22—24.
1868. *Biloculina scutella* Karrer; F. Karrer, p. 134, Pl. 1, Fig. 7.
1952. *Pyrgo lunula* (d'Orbigny); A. K. Bogdanowich, p. 169, Pl. 25, Fig. 6, 7.
1956. *Pyrgo lunula* (d'Orbigny); A. Sulimski, p. 76, Pl. 2, Fig. 1*a*-*c*.

Material. — About 150 specimens (Coll. No. F-171, Sec. No. 433).
Dimensions: L 0.55-1.4; B 0.5-1.5; T 0.35-1.0.

Description. — Test circular, regular, lenticular in cross-section; chambers slightly inflated, circular, arcuate in cross-section; periphery acute; chamber sides fairly broad, undulating, flat or slightly sloping; sutures distinct; surface smooth, polished; aperture semicircular, somewhat flattened at the top, with a transverse quadrangular low tooth and lateral processes.

Variability and ontogeny. The convexity of the chambers and the width of the aperture and tooth are variable. The specimen sectioned belongs to the mega I generation; PD 130 μ. The internal structure is biloculine throughout (Text-fig. 39/7).

Remarks. — This species is very close to *Pyrgo amphiconica* (Reuss), but differs in having broader chamber sides, a more flattened test and an aperture which is less extended laterally. The topotypes from Baden correspond to d'Orbigny's illustration and to our specimens from the Upper Tortonian.

Distribution. — Poland: Tortonian (Benczyn, Bogucice, Brzeźnica, Gliwice Stare, Grzybów, Krywałd, Ligota Zabrska, Suchowola, Wieliczka). Austria: Tortonian, Baden, Vienna Basin. Romania: Tortonian, Kostej in Banat. USSR: Upper Tortonian, Volhyn-Podolian Platform.

Pyrgo subsphaerica (d'Orbigny, 1839)
(Pl. XXII, Fig. 4*a*, *b*; Text-fig. 39/8)

1839. *Biloculina subsphaerica* d'Orbigny; A. d'Orbigny, *in*: Ramon de la Sagra, p. 162, Pl. 8, Figs 25—27; *fide* Catalogue Ellis & Messina.

Material. — About 50 specimens (Coll. No. F-172, Sec. No. 434).
Dimensions: L 0.35-0.75; B 0.25-0.65; T 0.28-0.7.

Description. — Test nearly spherical, tapering at the top and truncate at the base; chambers strongly inflated with the periphery rounded in the upper part and becoming gradually acute towards the base; chamber sides narrow at the top and broad at the base, having a peculiar sinuous three-lobed form; sutures indistinct; surface smooth, polished; aperture large, circular, in nearly horizontal position, surrounded with a thickened rim, and with a short bifid tooth.

Variability and ontogeny. The chamber periphery may be more or less rounded, sometimes remaining rounded also at the base. The aperture border is variable as well; it is usually in the shape of a thickened rim protruding to the outside or a collar inclined to the inside. The specimen sectioned belongs to the mega I ? generation; PD 120 μ. The internal structure is biloculine throughout (Text-fig. 39/8). The juvenile specimens are more elongated than the adult ones.

Remarks. — Our specimens have more acute periphery and the three-lobed form of the lower part, in comparison with d'Orbigny's illustration. However, as among the members of this species there are also some specimens with the poorly developed acuteness of the periphery, it may be assumed that the rounded periphery lies within the limits of intraspecific variability.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Węglinek). Recent: Cuba and Jamaica.

+ × *Pyrgo truncata* (Reuss, 1867)

(Pl. XXII, Fig. 1*a*, *b*; Text-fig. 39/1)

1867. *Biloculina bulloides* d'Orbigny var. *truncata* Reuss; A. E. Reuss, p. 53, Pl. 2, Fig. 1.
1868. *Biloculina anodonta* Karrer; F. Karrer, p. 133, Pl. 1, Fig. 6.
1868. *Biloculina bulloides* d'Orbigny var. *calostoma* Karrer; *ibidem*, p. 132, Pl. 1, Fig. 4.

Material. — About 300 specimens (Coll. No. F-173, Sec. No. 408, 409). Dimensions: L 0.45-1.8; B 0.4-1.8; T 0.4-1.7.

Description. — Test circular, sometimes somewhat tapering at the top, broadly oval in cross-section; chambers strongly inflated, the penultimate chamber of nearly the same size as the last one, being narrower and truncate at the base; periphery rounded, chamber sides sloping and forming a narrow border around the penultimate chamber; sutures depressed; surface smooth, polished; aperture semicircular, sometimes slightly protruded and truncate, with a low and broad tooth and lateral processes.

Variability and ontogeny. — The test shape varies from slightly elongated, with the penultimate chamber extended downwards and truncate, to circular, nearly spherical, with the penultimate chamber circular too. Large, circular forms may lack the tooth, as in *Pyrgo anodonta* (Kar-

rer). The specimens sectioned belong to the micro generation; PD 10 μ, (Text-fig 39/1). The juvenile stage is irregularly triloculine, then biloculine chambers are added. The size of the juvenile stage is very small in comparison with the biloculine stage.

Remarks. — Our specimens correspond to the topotypes from Wieliczka and to Reuss's illustration. Large forms identical with *Pyrgo anodonta* (Karrer) and *P. bulloides calostoma* (Karrer) from Kostej are also found among them. In the comparative materials from Lapugiu there are also forms with the apertural tooth resembling that of *P. anodonta* and others with the protruded and truncate penultimate chamber, as in *P. truncata*. As the nearly spherical shape is characteristic of both forms, and the chamber extension may be regarded as intraspecific variation, they have been recognized as synonyms. It seems that *P. truncata* (Reuss) may be considered an individual species, and not a subspecies of *P. bulloides* (d'Orbigny), as its circular shape and broad apertural tooth distinguish it from this species. *P. truncata* differs from *P. simplex* (d'Orbigny) in its distinctly narrower and more oblique chamber sides and in the protruded penultimate chamber.

Distribution. — Poland: Tortonian (Brzeźnica, Chełm n/Rabą, Gliwice Stare, Karsy, Krywałd, Ligota Zabrska, Rybnica, Wieliczka, Zrecze). Czechoslovakia: Tortonian, Židlochovice. Romania: Tortonian, Kostej in Banat, Lapugiu de Sus.

Genus *Pyrgoella* Cushman & E. M. White, 1936

This genus contains forms with a spherical test and the last chamber covering all but the penultimate chamber, like *Pyrgoella globiformis* (Karrer) and *P. ventruosa* (Reuss), and forms with a more regularly oval shape of the test, oval or triangular in cross-section. The last chamber of the latter does not cover the penultimate one, but, what is more, leaves also the third chamber visible between them, as in *P. controversa* (Bogdanowich). Such forms with the third chamber exposed and with a tongue-like flap in the aperture are usually recognized as belonging to the genus *Miliolinella*, which is not correct in the light of the materials studied. The test of these forms shows a tendency to become spherical or egg-shaped, and the last chamber in adult specimens embraces nearly all the chambers of the preceding whorls, whereas in the genus *Miliolinella* the test rather shows a tendency to become flattened, and there are three, four or five chambers visible from outside. The internal structure of *Miliolinella* is initially cryptoquinqueloculine, then pseudotriloculine, having one acute angle, and two angles, between the last three chambers, exceeding 120°, and in the genus *Pyrgoella* the initial part is pseudotriloculine, then biloculine.

Pyrgoella controversa (Bogdanowich, 1965)
(Pl. XXI, Figs 4*a-c*, 5*a*, *b*, 6*a*, *b*; Text-fig. 39/9)

1965. *Pyrgo ? controversa* Bogdanowich; A. K. Bogdanowich, p. 42, Pl. 3, Fig. 3.

Material. — 50 specimens (Coll. No. F-174, Sec. No. 437).

Dimensions: L 0.4-0.95; B 0.35-0.85; T 0.3-0.65.

Description. — Test circular-oval, slightly tapering at the top, oval in cross-section; periphery broadly rounded, chambers broad, embracing those of the previous whorls entirely and leaving only two last chambers visible, occasionally also a narrow trace of the third chamber; sutures flat, poorly visible, with a wide border along the chamber edge; wall thick; surface smoth, polished; aperture high, somewhat contracted at the top, filled with a narrow tongue-shaped flap.

Variability. The test shape is variable in cross-section, being irregularly circular in three-chambered forms (Pl. XXI, Fig. 4), irregularly oval in forms whose third chamber appears only in a narrow slit between the last two chambers (Pl. XXI, Fig. 6), and narrowly oval in forms with the last chamber embracing not only the third chamber, but also the most part of the second chamber (Pl. XXI, Fig. 5). The shape of the aperture and tooth is also variable, from semicircular with a flap of the same shape to high and narrow, filled with a narrow, tongue-like or even simple tooth (Pl. XXI, Figs 4, 5). Variation in test shape is very likely connected with dimorphism.

Dimorphism and ontogeny. The sections show a pseudotriloculine internal structure initially, then biloculine. The specimen sectioned represent the mega I generation, the P diameter of which is 70 μ (Text-fig. 39/9). In cross-section the chamber shape is semicircular initially, then sickle-shaped.

Remarks. — This species differs from *Pyrgoella ventruosa* (Reuss) from the Miocene of Wieliczka in its less spherical test shape, slight flattening of the chamber sides, transverse wrinkles present in some specimens, considerably thicker wall, and oblong tongue-like tooth. The two forms however seem to be related. Forms whose third chamber is distinctly visible are very similar to *Miliolinella valvularis* (Reuss) from the Septarien clays of Hermsdorf near Berlin, but differ in the more oval test, tapering at the top, the narrower and higher aperture, and the tongue-like tooth. It is conceivable that all the three forms represent an evolutionary series, from *Miliolinella valvularis* in the Oligocene through *Pyrgoella ventruosa* in the Lower Tortonian to *Pyrgoella controversa* in the Upper Tortonian.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Ligota Zabrska, Krywałd, Zrecze). USSR: Konka (Upper Tortonian) West Precaucasian region.

Pyrgoella globiformis (Karrer, 1867)
(Pl. XXI, Fig. 7*a*, *b*)

1867. *Biloculina globiformis* Karrer; F. Karrer, p. 357, Pl. 2, Fig. 1*a-c*.

Material. — About 50 specimens (Coll. No. F-175).

Dimensions: L 0.55-0.9; B 0.55-0.8; T 0.55-0.8.

Description. — Test nearly spherical; last chamber large and inflated, embracing those of preceding whorls, so that the penultimate chamber is visible beneath the aperture only as an oval trace tapering at the base; sutures indistinct; aperture large, semicircular, at the top of a small extension of the last chamber, with a small semicircular, arcuately bent tooth or without tooth.

Variability. The spherical test shape may be sometimes irregular, i.e. the last chamber may be more or less inflated laterally. The tooth may be semicircular or triangular in shape, or it may be partly or entirely reduced. A peculiar feature of the species is the weak junction of chambers, which, as a result, disintegrate readily.

Remarks. — This species differs from Recent *Pyrgoella sphaera* (d'Orbigny) in having a semicircular aperture and tooth, not modified by supplementary opening. From *P. globulus* (Bornemann) from the Oligocene it differs in the semicircular aperture, somewhat projecting above the surface and in the elliptical not circular, penultimate chamber.

Distribution. — Poland: Tortonian (Gliwice Stare, Karsy, Korytnica, Węglinek). USSR: Neogene, West Ukraine, Holubica near Pieniaky.

× *Pyrgoella ventruosa* (Reuss, 1867)
(Pl. XXI, Figs 1*a*, *b*, 2*a*, *b*, 3; Text-fig. 39/3)

1867. *Biloculina ventruosa* Reuss; A. E. Reuss, p. 69, Pl. 1, Fig. 9.
1877. *Biloculina grinzingensis* Karrer; F. Karrer, p. 375, Pl. 16*a*, Fig. 8.
1898. *Biloculina dokići* Pavlović; P. S. Pavlović, p. 122, Figs 1—3 (*in* Catalogue Ellis & Messina).

Material. — 30 specimens (Coll. No. F-178, Sec. No. 410, 411).

Dimensions: L 0.7-1.3; B 0.55-1.1; T 0.6-1.3.

Description. — Test egg-shaped, circular-oval in cross-section, periphery broadly rounded; chambers very broad, inflated, last chamber embraces those of preceding whorls except the penultimate one, also sometimes a very small trace of the third chamber is visible; sutures indistinct, flat, with a wide border along the chamber edge; surface smooth, polished; aperture semicircular or oval, high, open, with a semicircular flap, which is depressed at the centre.

Dimorphism and ontogeny. The specimen sectioned belongs to the mega I generation; PD 70 μ. The internal structure is pseudotriloculine initially, then biloculine (Text-fig. 39/3). The chamber shape in cross-section semicircular in the early stage, becomes sickle-like later.

Remarks. — This species occurs rarely at Wieliczka and corresponds to Reuss's illustration and description. It differs from *Pyrgoella controversa* (Bogdanowich) in its more spherical test, broader aperture with a semicircular flap-like, not oblong and tongue-like, tooth and in the considerably thinner wall.

Distribution — Poland: Tortonian (Brzeźnica, Gliwice Stare, Rybnica, Wieliczka). Austria: Tortonian, vicinity of Vienna (Grinzing). Yugoslavia: Tertiary, Serbia.

Genus *Sinuloculina* Łuczkowska, 1972

+ × *Sinuloculina consobrina* (d'Orbigny, 1846)

(Pl. XXV, Figs 5*a-c*, 6, 7*a-c*; Text-fig. 40)

1846. *Triloculina consobrina* d'Orbigny; A. d'Orbigny, p. 277, Pl. 17, Figs 10—12.
1952. *Miliolina consobrina* (d'Orbigny) var. *nitens* (Reuss); A. K. Bogdanowich, p. 125, Pl. 14, Figs. 2, 3.
1952. *Miliolina consobrina* (d'Orbigny) var. *sarmatica* Gerke; *ibidem*, p. 126, Pl. 14, Fig. 6*a-c*.
1955. *Miliolina nitens* (Reuss); M. J. Serova, p. 31, Pl. 5, Figs 1—6.
1955. *Triloculina consobrina* d'Orbigny; E. Łuczkowska, p. 104, Pl. 6, Fig. 10*a-c*.
1956. *Triloculina consobrina* d'Orbigny; A. Sulimski, p. 78, Pl. 3, Fig. 1*a-c*; *cum syn.*

Material. — 100 specimens (Coll. No. F-177, Sec. No. 175—177).

Dimensions: L 0.7-1.2; B 0.32-0.5; T 0.2-0.3.

Description. — Test narrowly oval, flattened, tapering at the top and rounded at the base, periphery rounded; chambers narrow, broader at the base and near the aperture, last chamber usually slightly protruded and oblique at the top or extended to form a short narrow neck, middle chamber large, narrow and long, slightly oblique, fifth chamber usually invisible or marked as a poorly visible tape; 3—5 chambers visible from outside; sutures flat, indistinct; wall thin; surface smooth, polished; aperture small, circular, sometimes on a small extension of the last chamber, and with a short and bifid tooth.

Variability. The test shape is distinctive and stable. The apertural end is variable with a short neck or without it. The number of the chambers visible from outside is also variable, usually three, but occasionally four or five chambers being seen, as in *Quinqueloculina*.

Dimorphism and ontogeny. The sections show a variable internal structure, quinqueloculine or cryptoquinqueloculine, like that in *Sinuloculina nitens* (Reuss). The PD is 30 μ, typical of the micro generation. The shape of the chambers in cross-section does not change during the ontogeny (Text-fig. 40) and is usually semicircular or triangular-semicircular.

Remarks. — This well-known species occurs commonly and fairly abundantly. It was assigned to the genus *Quinqueloculina* or *Triloculina*, according to the number of visible chambers; it was divided into a

number of "varieties" (e.g. by Gerke & Bogdanowich, 1952) or on the contrary, different species were placed under this name. Our form from Węglinek is identical with the topotypes from Nussdorf and with the members of this species from Baden, Vöslau, Buitur and Lapugiu. It

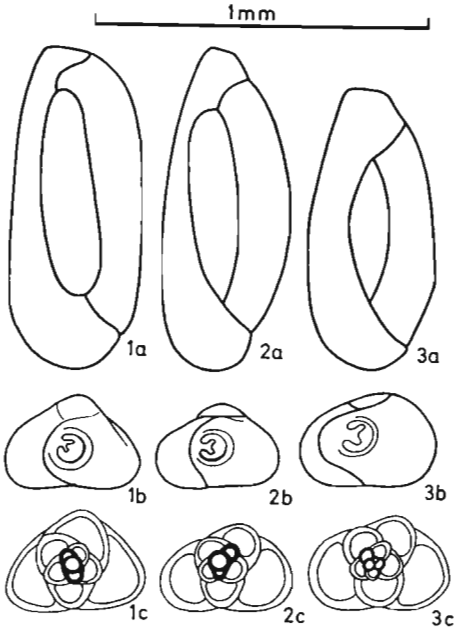


Fig. 40. Morphological variability and internal structure of *Sinuloculina consobrina* (d'Orbigny), Upper Tortonian, Węglinek, micro generation; 1 — form without chamber extension and with subacute periphery; 2, 3 — forms with chamber extension and with rounded periphery; *a* front view, *b* apertural view, *c* cross-section.

differs from *Sinuloculina nitens* (Reuss) in having a less slender and more oval test, which is characteristically rounded and broadened at the base, and in the oblique position of the middle chamber.

Distribution. — Poland: Tortonian (Benczyn, Bogoria, Bogucice, Chełm n/Rabą, Gieraszowice, Gliwice Stare, Grabki Duże, Grabowiec, Karsy, Korytnica, Ligota Zabrska, Łęki Dolne, Niechobrz, Niskowa, Pobitno, Rybnica, Węglinek, Zgłobice, Zrecze). Austria: Tortonian, Nussdorf, Baden, Vöslau, Vienna Basin. Romania: Tortonian, Buitur, Lapugiu.

+ × *Sinuloculina cyclostoma* (Reuss, 1850)

(Part. I, Pl. XII, Figs 4*a-c*, 5*a-c*; Text-fig. 41)

1850. *Biloculina cyclostoma* Reuss; A. E. Reuss, p. 382, Pl. 49, Fig. 6.
1952. *Miliolina pyrula* (Karrer); A. K. Bogdanowich, p. 102, Pl. 7, Fig. 3.
1962. *Triloculina pyrula* Karrer; I. V. Venglinsky, p. 83, Pl. 9, Fig. 1*a-c*.
1963. *Triloculina* aff. *Biloculina mutabilis* Martinotti; G. Glaçon, p. 136, Pl. 14, Fig. 1*a-c*.

Material. — About 100 specimens (Coll. No. F-176, Sec. No. 199, 200, 202—204).

Dimensions: L 0.75-0.9; B 0.55-0.85; T 0.48-0.5.

Description. — Test thick, broadly oval, oval in cross-section, periphery broadly rounded; chambers broad, inflated, semicircular, middle chambers very small, often invisible, two or three chambers visible from outside; sutures flat, indistinct, with a narrow border along the chamber edges; wall thin; surface smooth, polished; aperture large, circular, strongly oblique, surrounded with a thickened rim, and with large tooth bifid at the end and projecting above the aperture edge.

Variability. The test may be more or less inflated, being often triloculine and nearly circular in cross-section in small specimens, whereas large biloculine forms are laterally compressed and with sligthly depressed sutures. The length of the apertural tooth is variable as well, being sometimes short, and spine-shaped, or usually long and solid, projecting above the aperture border, and with a specifically perforate septum.

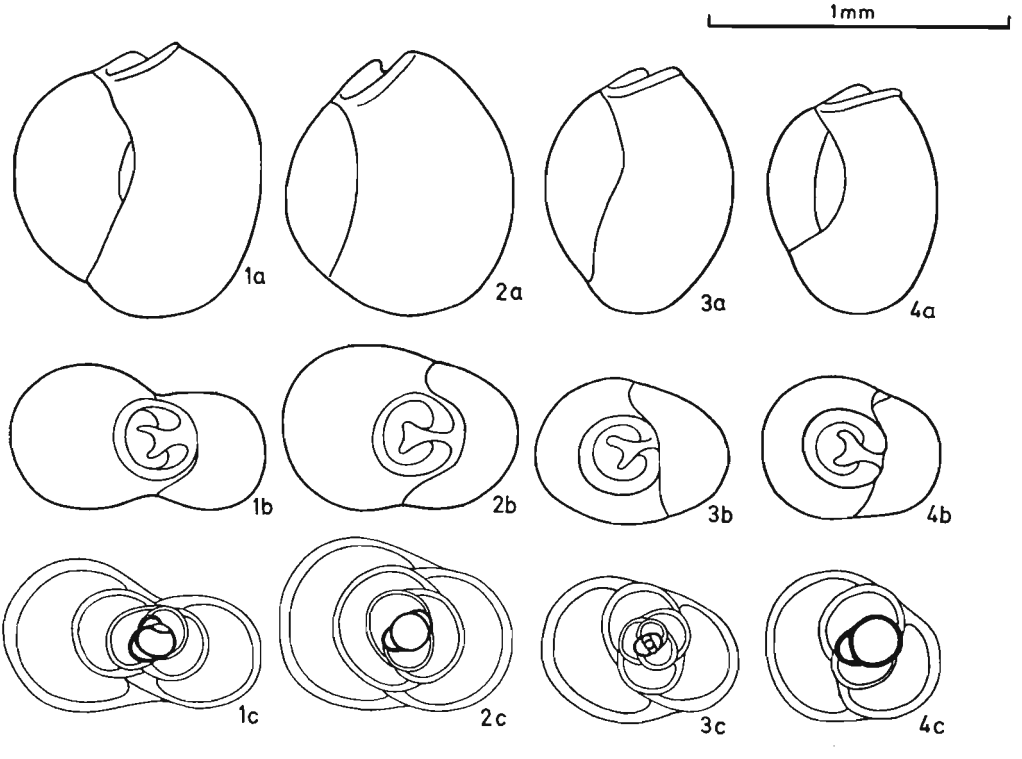


Fig. 41. Morphological variability, internal structure and dimorphism of *Sinuloculina cyclostoma* (Reuss), Upper Tortonian, Węglinek; 1, 2 — biloculine forms, mega I (?) generations, initial part irregularly triloculine, then planospiral; 3 — biloculine form, micro generation, initial part cryptoquinqueloculine, then pseudotriloculine; 4 — triloculine form, mega I (?) generation, internal structure pseudotriloculine; *a* front view, *b* apertural view, *c* cross-section.

Dimorphism and ontogeny. The sections show the micro generation with the proculus 30 μ in diameter and the mega I ? generation with the proculus 120—150 μ in diameter. The internal structure, initially cryptoquinqueloculine, then triloculine, becomes finally irregular biloculine, with chambers situated opposite each other and embracing the preceding ones in such a way that they form a sinusoid line in cross-section (Text-fig. 41). All chambers have a similar semicircular cross-section in the course of ontogeny.

Remarks. — This species differs from *Sinuloculina inflata* (d'Orbigny) in its nearly circular test shape, more inflated broad chambers and characteristic large aperture with a thickened rim. It is very similar to *S. pyrula* (Karrer) from Lapugiu and *S. decipiens* (Reuss) from Grinzing, which are probably synonyms. A comparison of our specimens with the topotypes of *S. pyrula* from Lapugiu and Buitur and with *S. decipiens* from Vöslau shows that they differ in their more elongated test, more inflated chambers, flat and broad sutures, and large aperture with a thickened rim. The juvenile specimens are somewhat similar to *S. pyrula*, but adults differ conspicuously in their tendency to the biloculine chamber arrangement and the lateral compression of the test. In comparison with the description of *S. cyclostoma* (Reuss) our forms have a thicker tooth, but a short and thin tooth, like that figured by Reuss, occurs both in single specimens of our forms and in some comparative specimens of *S. cyclostoma* from Buitur.

Distribution. — Poland: Upper Tortonian (Gieraszowice, Grabowiec, Korytnica, Ligota Zabrska, Niskowa, Węglinek). Austria: Tortonian, vicinity of Vienna (Grinzing). Romania: Tortonian, Buitur. USSR: Middle Miocene, West Ukraine, Transcarpathians. Recent: Mediterranean Sea.

+ × *Sinuloculina inflata* (d'Orbigny, 1826)
(Pl. XXIV, Fig. 6*a-c*)

1826. *Triloculina inflata* d'Orbigny; A. d'Orbigny, p. 300, *in* Catalogue Ellis & Messina.
1846. *Triloculina inflata* d'Orbigny; A. d'Orbigny, p. 278, Pl. 17, Figs 13—15.
1970. *Triloculina inflata inflata* d'Orbigny; V. J. Didkovsky & Z. N. Satanovskaja, p. 57, Pl. 34, Fig. 4, *cum syn.*

Material. — 12 specimens (Coll. No. F-162).

Dimensions: L 0.7-1.3; B 0.4-0.7; T 0.3-0.5.

Description. — Test elongate, quadrangular-oval, cross-section circular-oval, periphery broadly rounded; chambers broad, tubular, more inflated and curved at the base and straightened at the end; two or three chambers visible from outside; surface smooth, polished; aperture circular, large with a robust tooth bifid at the end.

Variability. The lower part of chambers may be more or less inflated.

The juvenile stage obtained from the inside of an adult specimen does not differ morphologically from it, being only of much smaller proportions.

Remarks. — Our specimens correspond to the comparative specimens from Vöslau and Buitur, only that they are slenderer in shape. From *Triloculina gubkini* (Bogdanowich) they differ in the broadly rounded, not flattened periphery and in the oval, not triangular outline in cross-section: they are however very close to each other. Morphologically they resemble *Sinuloculina mayeriana* (d'Orbigny), but differ in having a considerably thicker massive test and specifically inflated and expanded lower parts of chambers.

Distribution. — Poland: Tortonian (Bogoria, Grabowiec, Niskowa, Rybnica, Węglinek, Wieliczka). Austria: Tortonian, Nussdorf, Vöslau, Vienna Basin. Italia: Pliocene, Castell' Arquato. Romania: Tortonian, Buitur, USSR: Upper Tortonian, the Volhyn-Podolian Platform, the Precarpathian Foredeep, Blak Sea Depression; Meotian (Pliocene) the South Ukraine. Recent: Mediterranean Sea.

+ *Sinuloculina mayeriana* (d'Orbigny, 1846)

(Pl. XXV, Fig. 8*a*-*c*; Text-fig. 42)

1846. *Quinqueloculina mayeriana* d'Orbigny; A. d'Orbigny, p. 287, Pl. 18, Figs 1—3.

Material. — About 100 specimens (Coll. No. F-180, Sec. No. 116—120). Dimensions: L 1.0-1.45; B 0.5-0.9; T. 0.3-0.5.

Description. — Test quadrangular-oval or elongate, flattened; periphery rounded; chambers flat, broad, somewhat broader at the base, last chamber straighened or bent towards the aperture, third chamber slightly convex or flat, narrow and elongated; usually three or rarely two chambers visible from outside; sutures flat, distinct, with a fairly broad, faintly marked border along the chamber edges; wall thin; surface smooth, usually matt; aperture circular, rimless, with a sinuous border and a large tooth bifid at the end, and often protruding above the aperture edge.

Variability. The test shape is variable, being sometimes more flattened, with a tendency to the S-shaped bending of the last chamber.

Dimorphism and ontogeny. All specimens sectioned belong to the micro ? generation, having a PD 50—70 μ. The internal structure is cryptoquinqueloculine initially, then biloculine, the opposite chambers being arranged in a sinusoid line (Text-fig. 42). The chamber outline is unchangeably semicircular in cross-section. The juvenile specimens removed from the inside of adults do not differ from them in shape.

Remarks. — This species differs from *Sinuloculina microdon* (Reuss) in the more oval and less elongate test shape, more flattened sides, and less depressed sutures. From *S. rixatoria* (Franzenau) it differs in the less inflated quadrangular-oval test shape, the lack of the thickened rim round

the aperture, the thicker tooth, and in having usually three chambers visible from outside.

Distribution. — Poland: Tortonian (Karsy, Korytnica, Rybnica, Węglinek, Wieliczka, Zrecze). Austria: Tortonian, Nussdorf, Vienna Basin.

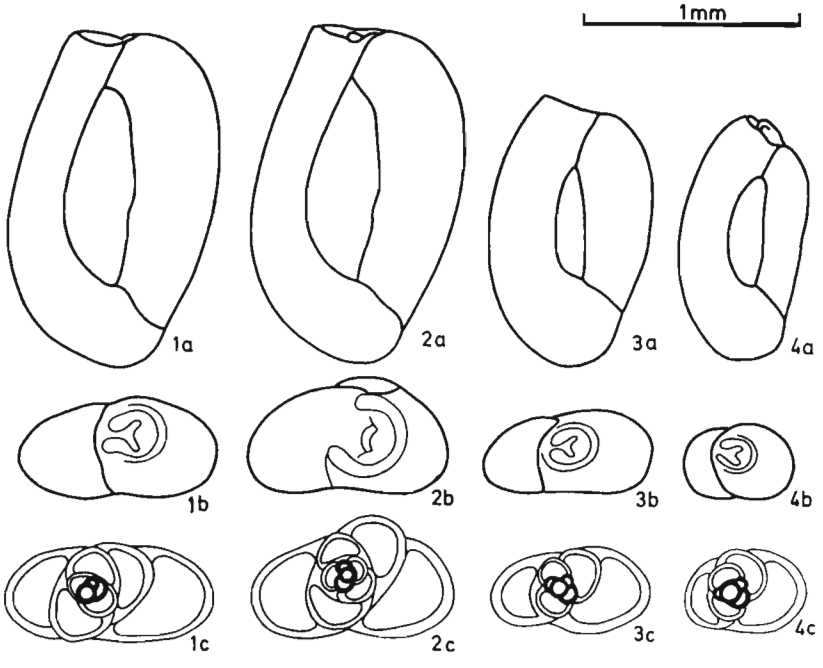


Fig. 42. Morphological variability and internal structure of *Sinuloculina mayeriana* (d'Orbigny), Upper Tortonian, Węglinek, micro (?) generation; 1, 3 — flattened forms, initial part cryptoquinqueloculine, then in a single plane; 2, 4 — inflate forms, cryptoquinqueloculine throughout; *a* front side, *b* apertural view, *c* cross-section.

+ *Sinuloculina microdon* (Reuss, 1850)

(Pl.XXV, Figs 3*a-c*, 4; Text-fig. 43/1)

1850. *Triloculina microdon* Reuss; A. E. Reuss, p. 382, Pl. 49, Fig. 9.

Material. — About 100 specimens (Coll. No. F-181, Sec. No. 178).

Dimensions: L 0.6-1.1; B 0.25-0.47; T 0.2-0.3.

Description. — Test slender, nearly quadrangular, flattened, periphery rounded; chambers tubular, expanding and bending at the base, straightened towards the aperture, middle chamber narrow, elongate, slightly convex, in somewhat oblique position; three chambers visible from outside; sutures distinct, undulating, with a small border along the chamber edge; wall thin; surface smooth, polished; aperture circular, large, even with the periphery, and with a short, tooth, bifid at the end.

Variability. The test shape varies from nearly quadrangular to more oval, narrowing at both ends. Some specimens are with longitudinal

wrinkles (Pl. XXV, Fig. 4). The juvenile specimens are narrowly oval in shape, the last chamber being somewhat protruded upwards.

Dimorphism and ontogeny. The section show the micro generation; PD 40 μ. The internal structure is cryptoquinqueloculine, the juvenile stage being sometimes irregularly quinqueloculine (Text-fig. 43/1). The

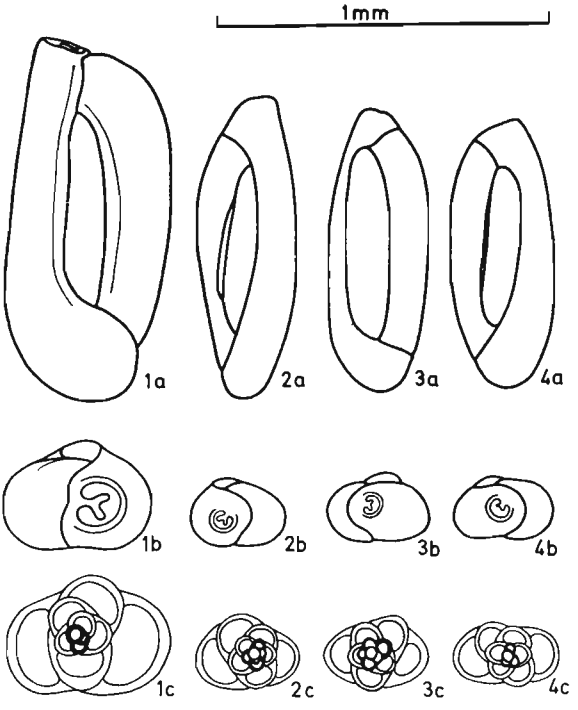


Fig. 43. Ontogeny and internal structure of *Sinuloculina*: 1 *S. microdon* (Reuss), Upper Tortonian, Gliwice Stare, micro generation; 2-4 — *S. nitens* (Reuss), Upper Tortonian, Gliwice Stare, micro generation; 2 — form with extension of last chamber, 3 — typical form, 4 — form without extension of last chamber; *a* front view, *b* apertural view, *c* cross-section.

juvenile stage, obtained from the inside of an adult by the removal of the last chambers, is a very narrow and slender specimen, resembling *Sinuloculina consobrina* (d'Orbigny) (Part I, Text-fig. 10).

Remarks. — The juvenile stage obtained from the inside of the test differs from *Sinuloculina consobrina* (d'Orbigny) in having a characteristic slender shape. It differs from *S. nitens* (Reuss) in the less slender test shape and the chambers bent distinctly at the base. Adult specimens resemble *Sinuloculina laevigata* (d'Orbigny) in their quadrangular test shape, differ however in distinctly elongated and more flattened test and in the less inflated lower part of chambers. The single specimen of *S. microdon*, found in the comparative materials from Vöslau, is similar to our form; compared with our forms, both this specimen and that

figured by Reuss from Baden, are however rather oval, not quadrangular in shape. This being the only difference and at that probably representing geographical variation, the specimen was identified as *S. microdon*. Our adult specimens are somewhat similar to *Miliolina collaris* Gerke & Issaeva, differ however in their broader and more massive chambers, in the lack of a narrow extension of the last chamber, and in the tendency to have a wrinkled periphery.

Distribution. — Poland: Tortonian (Bogoria, Bogucice, Gliwice Stare, Karsy). Austria: Tortonian, Baden, Vöslau, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice.

Sinuloculina nitens (Reuss, 1850)
(Pl. XXV, Figs 1*a-c*, 2; Text-fig. 43/2—4)

1850. *Triloculina nitens* Reuss; A. E. Reuss, p. 383, Pl. 49, Fig. 10*a-d*.
1970. *Triloculina nitens* Reuss; V. J. Didkovsky & Z. N. Satanovskaja, p. 59, Pl. 36, Fig. 4.

Material. — About 100 specimens (Coll. No. F-182, Sec. No. 179—181). Dimensions: L 0.8-0.9; B 0.3; T about 0.2.

Description. — Test very narrow and elongate, nearly quadrangular in shape, sometimes with a slight extension of the last chamber, depressed, periphery rounded; chambers narrow, somewhat expanded at the base and near the aperture, middle chamber narrow and long, a little convex, fifth chamber often occurs as a narrow tape; 3—5 chambers visible from outside; sutures sligthly depressed, distinct; wall thin; surface smooth, polished; aperture circular, small, even with the periphery or at the end of a slight extension of the chamber, and with a short bifid tooth.

Variability. The length/width ratio of the test is variable, and so are the degree of the roundedness of chambers at the base and the apertural extension of the last chamber. There occur specimens whose apertural end is nearly horizontally truncate, the last chamber being even with the periphery, and others with the last chamber extended to form a small constricted neck. The test of forms with the projecting apertural end narrows at both ends (Text-fig. 43/2), whereas forms which lack a neck are rounded at the base and truncate at the end and resemble *Sinuloculina consobrina* (d'Orbigny) (Text-fig. 43/4). The number of chambers visible from outside oscillates between three and five.

Dimorphism and ontogeny. The internal structure of juvenile stage is quinqueloculine, becoming irregularly quinqueloculine or cryptoquinqueloculine in the adult stage. The specimens sectioned belong to the micro generation with the proloculus 30—40 μ in diameter. The chambers are semicircular in cross-section throughout the ontogeny.

Remarks. — This species, described from Grinzing in Austria, morphologically resembles *Sinuloculina consobrina* (d'Orbigny) from Nussdorf in

Austria. According to Reuss, it however differs in the bifid, not simple, tooth in the aperture and in the more flattened sutures. The present investigation shows that the difference between these two species given by Reuss is not important, as both the characteristics of the aperture and tooth and those of the sutures oscillate within the same limits in both species. On the other hand, a true difference between them is the much greater elongation of the test of *S. nitens*. The lengh/breadth ratio of the specimen from Grinzing figured by Reuss is 2.7, that of our specimens from Gliwice Stare 2.5-3.0, and these values calculated for *S. consobrina* from Nussdorf and our specimens from Węglinek are, respectively, 2.4 and about 2.2. In materials from Nussdorf, Vöslau, Buitur and Lapugiu only *S. consobrina* has been found, and therefore there is no certainty as to what *S. nitens* is like. As the lengh/breadth ratio and morphology of *S. nitens* correspond to those in our specimens, it has been decided to place them in this species tentatively.

Distribution. — Poland: Upper Tortonian (Gieraszowice, Gliwice Stare, Ligota Zabrska, Węglinek). Austria: Tortonian, vicinity of Vienna (Grinzing). Czechoslovakia: Lower Tortonian, Židlochovice. USSR: Upper Tortonian, Volhyn-Podolian Platform and Black Sea Depression; Middle Miocene, Caucasus; Meotian (Pliocene), Black Sea Depression.

× *Sinuloculina rixatoria* (Franzenau, 1890)
(Pl. XXIV, Fig. 5*a-c*; Text-fig. 44)

1890. *Biloculina rixatoria* Franzenau; A. Franzenau, p. 165, Pl. 2, Fig. 1*a-c*.

Material. — About 100 specimens (Coll. No. F-183, Sec. No. 121—125). Dimensions: L 1.15-1.4; B 0.55-0.95; T 0.4-0.5.

Description. — Test narrowly oval, slender, tapering at both ends, flattened, obliquely truncated at the top; periphery rounded; chambers flat, broad, elongated, with a sinuous inner edge and the apertural end occasionally slightly protruded; two chambers visible from outside; sutures distinct, broad, with a narrow border marked along the chamber edges; wall thin; surface smooth, dull; aperture circular, even with the periphery or on a small extension of the chamber, surrounded with a thickened rim, and with a large thick bifid tooth, which often projects above the aperture border.

Variability. The test shape is variable, being more cylindrical in small specimens and flattened and oval in section in large specimens. In rare forms there is also a small narrow trace of the third chamber.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation, PD 50 μ, and the mega I generation, PD about 130 μ. The internal structure of juvenile stage is irregularly triloculine, then irregularly biloculine; opposite chambers embrace the preceding ones and

are arranged in a sinuous line (Text-fig. 44). The juvenile stage removed from the inside of an adult specimen does not differ morphologically from it.

Remarks. — This species differs from *Sinuloculina mayeriana* (d'Orbigny) in its more slender test shape, the thickened rim round the

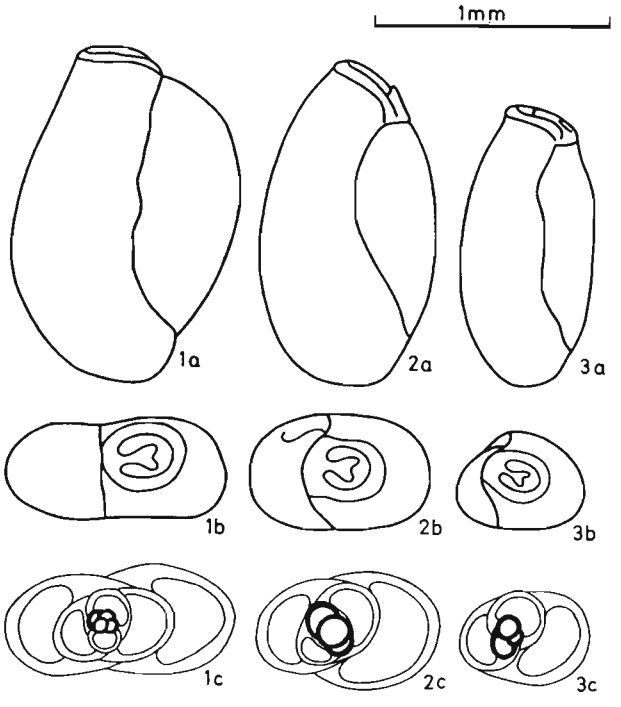


Fig. 44. Ontogeny and dimorphism of *Sinuloculina rixatoria* (Franzenau), Upper Tortonian, Węglinek; 1 — micro generation, biloculine form with irregularly triloculine initial part, next chambers arranged in a single plane; 2, 3 — biloculine forms, mega I generations, pseudotriloculine throughout; *a* front view, *b* aperture view, *c* cross-section.

aperture and the biloculine arrangement of last chambers. It differs from *S. cyclostoma* (Reuss) in the more slender elongated test and in its flattening. It is similar to *S. bacillum* (Martinotti) from which it however differs in the more flattened test, its more expanded middle part, and the large and circular, not slitlike, aperture.

Distribution. — Poland: Upper Tortonian (Węglinek). Romania: Tortonian, Buitur.

Genus *Triloculina* d'Orbigny, 1826, emend. Łuczkowska, 1972

Triloculina angularis d'Orbigny, 1850

(Pl. XXIII, Fig. 3*a*, *b*)

1850. *Triloculina angularis* d'Orbigny; A. d'Orbigny, p. 409, *in* Catalogue Ellis & Messina.

Material. — About 70 specimens (Coll. No. F-184, Sec. No. 190).

Dimensions: L 0.45-0.85; B 0.27-0.5; T 0.22-0.45.

Description. — Test narrowly oval, slender, tapering at both ends, triangular in cross-section; chambers broad, with flattened periphery and slightly rounded edges, middle chamber slightly prominent, flat; sutures a little depressed; surface smooth, polished; wall thin; aperture circular with a long tooth bifid at the end.

Variability and ontogeny. The chamber periphery is flattened to a various degree, but never quite flat. The internal structure is regularly triloculine throughout. The specimen sectioned belong to the mega II generation, the proloculus being 200 μ in diameter.

Remarks. — This species is very close to *Triloculina neudorfensis* Toula, but differs in its smaller dimensions, slenderer shape, flattened, and not concave, periphery and rounded edges. It is similar to *Triloculina tricarinata* d'Orbigny, differs however in its rounded, not acute, edges and in the non-concave periphery. It corresponds most to *T. angularis* d'Orbigny, but its edges are more rounded.

Distribution. — Poland: Tortonian (Benczyn, Bogucice, Gliwice Stare, Karsy, Korytnica, Krywałd, Ligota Zabrska, Niechobrz, Węglinek). France: Tertiary.

Triloculina eggeri (Bogdanowich, 1952)
(Pl. XXIV, Figs 1*a-c*, 2*a*, *b*; Text-fig. 45)

1952. *Miliolina austriaca* (d'Orbigny) var. *eggeri* Bogdanowich; A. K. Bogdanowich, p. 98, Pl. 5, Fig. 8*a-c*, *cum syn.*

Material. — About 300 specimens (Coll. No. F-185, Sec. No. 182—187).

Dimensions: L 0.48-0.95; B 0.3-0.65; T 0.25-0.5.

Description. — Test broadly oval, narrowing at the top, rounded-triangular in cross-section; chambers narrow with broad and slightly flattened periphery, tapering at the end and twisted, middle chamber convex, elongate-oval, sligthly oblique; sutures depressed, distinct, with a narrow border along the chamber edges; wall thick; surface smooth, polished; aperture circular, with a slightly everted border and a short bifid tooth.

Variability and ontogeny. The breadth of chambers and their number in the outer whorl are variable. There exist specimens with strongly expanded chambers and a nearly triangular outline in cross-section (Pl. XXIV, Fig. 1*a-c*) and others resembling *Quinqueloculina*, with less inflated chambers, of which 4—5 are visible from outside. Such 4—5-chambered specimens represent the juvenile stage of *T. eggeri* (Pl. XXIV, Fig. 2*a-b*). In adult specimens longitudinal striae appear occasionally. The internal structure is cryptoquinqueloculine or even quinqueloculine initially, then irregularly triloculine. The specimens sectioned belong to

the mega I generation, the proloculus being 70—80 μ in diameter (Text-fig. 45). The shape of chambers in cross-section is semicircular initially, then expanded to the sides and flattened.

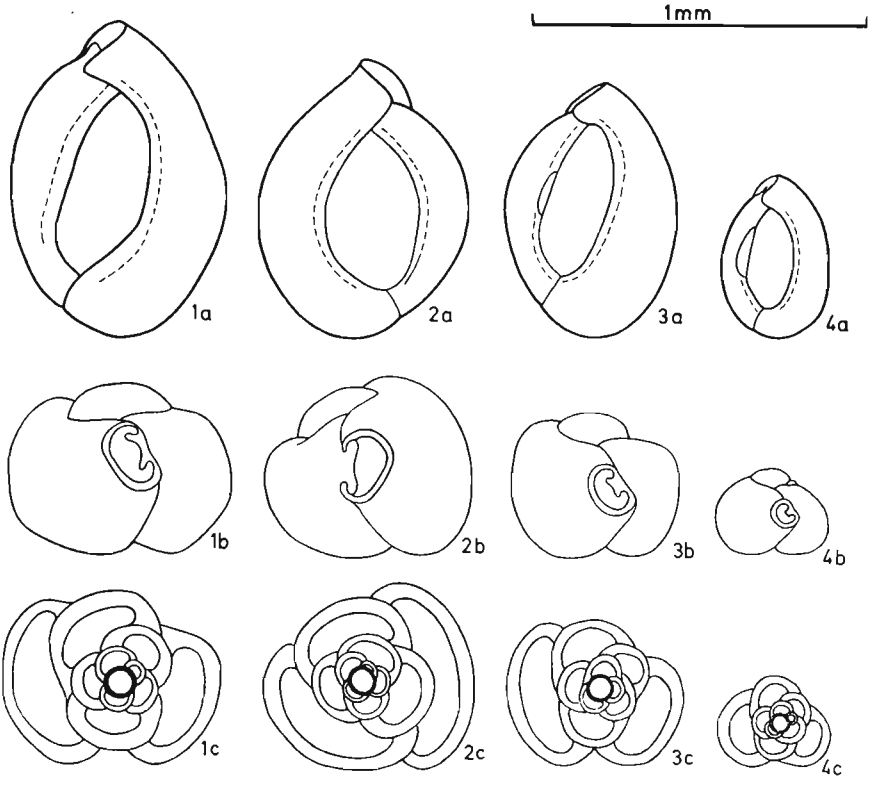


Fig. 45. Morphological variability and internal structure of *Triloculina eggeri* (Bogdanowich), Upper Tortonian, Gliwice Stare, mega I generation; 1, 3 — cryptoquinqueloculine forms; 2 — typical form with initial quinqueloculine part; 4 — juvenile quinqueloculine stage; *a* front view, *b* apertural view, *c* cross-section.

Remarks. — This species differs from *Triloculina austriaca* d'Orbigny in its more inflated chambers slightly twisted near the top.

Distribution. — Poland: Upper Tortonian (Gliwice Stare, Krywałd, Ligota Zabrska). USSR: Tchokrak (Middle Miocene), Crimea-Caucasian region and Ukraine.

+ *Triloculina gibba* d'Orbigny, 1826

(Pl. XXIII, Fig. 2*a-c*; Text-fig. 46/2)

1826. *Triloculina gibba* d'Orbigny; A. d'Orbigny, p. 299, *in* Catalogue Ellis & Messina.
1846. *Triloculina gibba* d'Orbigny; A. d'Orbigny, p. 274, Pl. 16, Figs 22—24.
1970. *Triloculina gibba gibba*; V. J. Didkovsky & Z. N. Satanovskaja, p. 56, Pl. 33, Fig. 3; *cum. syn.*

Material. — About 100 specimens (Coll. No. F-186, Sec. No. 191—196). Dimensions: L 0.71-0.91; B 0.54-0.72; T 0.55-0.70.

Description. — Test broadly oval, tapering at both ends, rounded-triangular in cross-section; chambers broad, with slightly inflated periphery and rounded erges, extending not far from the sutures, middle chamber inflated; sutures strongly depressed, distinct; wall thick; surface smooth, polished; aperture circular, with a long tooth, bifid at the end.

Variability and ontogeny. The chambers may be more or less inflated, and the edges more or less rounded, thus the cross-section may be triangular or rounded-triangular in outline. The specimens sectioned belong to the mega I generation, the PD is about 120 μ. The internal structure is regularly triloculine (Text-fig. 46/2).

Remarks. — Compared with the specimens of *Triloculina gibba* from Nussdorf and Vöslau and with Recent specimens from the Adriatic Sea

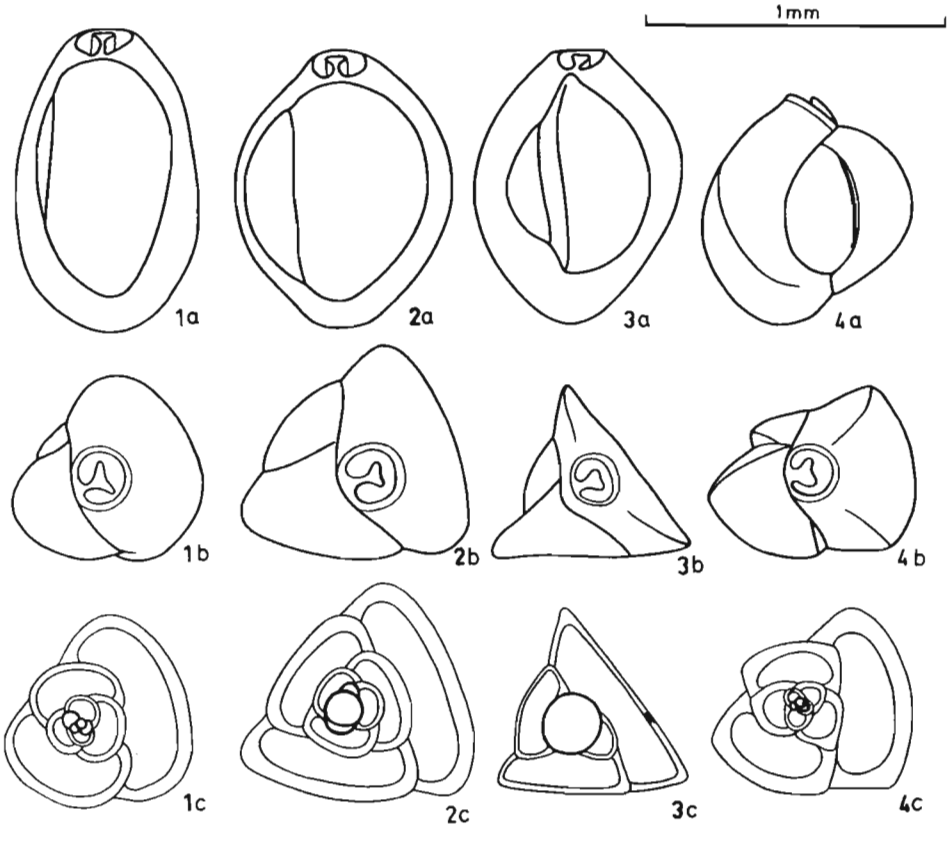


Fig. 46. Internal structure and morphology of *Triloculina*: 1 — *T. gubkini* (Bogdanowich), Upper Tortonian, Węglinek; initial part cryptoquinqueloculine, later pseudotriloculine, micro (?) generation; 2 — *T. gibba* d'Orbigny, Lower Tortonian, Korytnica; typical triloculine internal structure, mega I generation; 3 — *T. neudorfensis* Toula, Lower Tortonian, Wieliczka; typical triloculine internal structure, mega II generation; 4 — *T. intermedia* Karrer, Lower Tortonian, Karsy; irregularly triloculine internal structure, micro generation; *a* side view, *b* apertural view, *c* cross-section.

(Punta Grossa near Triest), our forms have more inflated chambers. They however differ from *Triloculina austriaca* d'Orbigny in their more elongated shape, less inflated periphery, triangular outline in cross-section, and less depressed sutures. From *T. angularis* they differ in the more rounded edges and more inflated periphery.

Distribution. — Poland: Tortonian (Benczyn, Bogoria, Bogucice, Gieraszowice, Grabowiec, Karsy, Korytnica, Krywałd, Rybnica, Węglinek). Austria: Tortonian, Nussdorf, Vöslau, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice. Italia: Pliocene, Castell'Arquato. USSR: Lower and Upper Tortonian, the Volhyn-Podolian Platform, the Precarpathian Foredeep; Konka (Upper Tortonian), Black Sea Depression, Transcaucasus and Caucasus. Recent: Adriatic Sea.

Triloculina gubkini (Bogdanowich, 1952)

(Pl. XXIII, Fig. 5*a-c*; Text-fig. 46/1)

1952. *Miliolina gubkini* Bogdanowich; A. K. Bogdanowich, p. 101, Pl. 7, Fig. 4.

Material. — 9 specimens (Coll. No. F-187, Sec. No. 205).

Dimensions: L 0.8-1.4; B 0.5-0.9; T 0.4-0.7.

Description. — Test elongate, oval-quadrangular, periphery broadly rounded and slightly compressed, triangular with rounded apices in cross-section; chambers broad, with flattened periphery, somewhat broader at the base and narrowing towards the aperture, third chamber elongated, slightly convex, narrow; sutures depressed; surface smooth, polished; wall thin; aperture circular, somewhat narrower at the base and with a short and bifid tooth.

Variability and ontogeny. The test shape is stable. The chambers of juvenile stage have a more rounded periphery, which becomes flattened as they grow. The internal structure initially cryptoquinqueloculine, then pseudotriloculine (Text-fig. 46/1): PD about 60 μ.

Remarks. — This species differs from *Sinuloculina inflata* (d'Orbigny) in the more inflated chambers, depressed at the periphery, and the triangular-circular, not oval, outline in cross-section.

Distribution. — Poland: Upper Tortonian (Bogoria, Gieraszowice, Góry Wysokie, Miechocin, Węglinek). USSR: Tarkhan (Middle Miocene), North Caucasus.

+ *Triloculina intermedia* Karrer, 1868

(Pl. XXIII, Fig. 1*a-c*; Text-fig. 46/4)

1868. *Triloculina intermedia* Karrer; F. Karrer, p. 138, Pl. 1, Fig. 11.

1878. *Triloculina plicata* Terquem; O. Terquem, p. 61, Pl. 6, Fig. 2.

1893*a*. *Triloculina marioni* Schlumberger; C. Schlumberger, p. 62, Pl. 1, Figs 38—41, p. 63, Figs 7, 8.

1970. *Triloculina intermedia* Karrer; V. J. Didkovsky & Z. N. Satanovskaja, p. 58, Pl. 35, Fig. 3.

Material. — About 300 specimens (Coll. No. F-188, Sec. No. 188—197). Dimensions: L 0.4-1.0; B 0.34-1.0; T 0.24-0.9.

Description. — Test irregularly circular, oval-triangular in cross-section; two last chambers broad, inflated, tapering at both ends, with two prominent edges on the periphery; these edges are wide apart, more or less acute and sometimes sinuous; third chamber small, slightly convex, oval, with one edge on the periphery; sutures depressed; wall thick; surface smooth, polished; aperture circular-triangular, with a short and bifid tooth.

Variability and ontogeny. This characteristic species is variable in the form of chamber edges, which range from slightly marked edge to prominent flexuose keel. The internal structure is irregularly triloculine. The initial part consist of about 5 tubular chambers, the succeding 2—3 chambers are with one edge on the periphery and only in the adult stage two edges occur on the chambers. The specimens sectioned belong to the micro generation; PD 30 μ (Text-fig. 46/4).

Remarks. — Compared with Karrer's illustration of the species, our form is somewhat larger and with less prominent edges. The specimens from Buitur and Vöslau show as variable chamber edges as those in our specimens from Karsy. The same variability is observed in *Triloculina marioni* Schlumberger, found by the author in comparative materials from the Adriatic Sea, from Punta Grossa near Triest, and regarded as a synonym of *T. intermedia.* It differs from *T. affinis* d'Orbigny in its much shorter, laterally expanded test.

Distribution. — Poland: Lower Tortonian (Karsy, Korytnica, Niskowa). Austria: Tortonian, Vöslau. Greece: Upper Pliocene, Rhode Island. Romania: Tortonian, Kostej in Banat, Buitur. USSR: Middle Miocene, Volhyn-Podolian Platform, Precarpathian Foredeep, Transcarpathians. Recent: Mediterranean Sea.

× *Triloculina neudorfensis* Toula, 1900

(Pl. XXIII, Fig. 4*a*, *b*; Text-fig. 46/3)

1900. *Triloculina neudorfensis* Toula; F. Toula, p. 11, Pl. 12, Fig. 2*a-c*.
1867. *Triloculina tricarinata* d'Orbigny; A. E. Reuss, p. 55, Pl. 2, Fig. 4*a-c*.

Material. — 40 specimens (Coll. No. F-189, Sec. No. 189).

Dimensions: L 0.6-2.5; B 0.35-2.1; T 0.35-1.8.

Description. — Test oval or broadly oval, tapering at both ends, triangular with concave sides in cross-section; chambers very broad, with concave periphery and acute edges, with a broad border along the sutures, middle chamber small, nearly flat; sutures slightly depressed; wall thin; surface smooth, polished; aperture triangular-rounded, with a long and bifid tooth.

Variability and ontogeny. The large and broad specimens agree in general with the illustration given by Toula. The juvenile stage taken out of the inside of such large specimens is more elongated in shape. The specimen sectioned represents the mega II generation, its proloculus being 180 μ in diameter. The internal structure is regularly triloculine (Text-fig. 46/3).

Remarks. — The single specimen figured by the author of the species, found in Neudorf on March (Devinska Nova Ves) in Czechoslovakia, West Slovakia, and *Triloculina tricarinata* d'Orbigny, described by Reuss from the Miocene of Wieliczka, correspond closely to our specimens. The Recent specimen of *T. tricarinata*, which was described from the Black Sea, is however different from *T. neudorfensis*. As regards the Recent specimens of *T. tricarinata* found in the comparative materials from the Gulf of Aden, they are much smaller in size and have more acute edges and a narrower chamber border than *T. neudorfensis*.

Distribution. — Poland: Tortonian (Karsy, Krywałd, Wieliczka). Czechoslovakia: Miocene, Theben-Neudorf on the March (Devinska Nova Ves) in Western Slovakia.

Genus *Varidentella* Łuczkowska, 1972

Varidentella georgiana n.sp.

(Pl. XXVII, Figs 3*a-c*, 4*a-c*; Text-fig. 47)

1971. *Quinqueloculina sp.*; L. S. Maissuradze, p. 53, Pl. 4, Figs 3, 4.

Holotypus: Pl. XXVII, Fig. 3*a-c*.

Paratypus: Pl. XXVII, Fig. 4*a-c*.

Locus typicus: Machów 255 bore-hole, depth 73 m.

Stratum typicum: Lower Sarmatian, Syndesmya clays.

Derivatio nominis: *georgiana* — from Georgia (Caucasus) from which L. S. Maissuradze distinguished *Quinqueloculina* sp.

Diagnosis: Test nearly circular, covered densely with longitudinal striae, aperture transverse-slitlike with a low tape-shaped tooth.

Material. — Over 100 specimens (Coll. No. F-190, Sec. No. 148—151).

Dimensions: Holotype length 0.4 mm; breadth 0.28 mm; thickness 0.2 mm. Paratypes length 0.28-0.35 mm; breadth 0.22-0.26 mm; thickness 0.15-0.20 mm.

Description. — Test circular-oval, periphery rounded; chambers broad at the base and narrowing towards the aperture, last chamber extended and inclined towards the penultimate chamber, middle chamber large, convex, oval; sutures distinct, depressed; wall thin; surface covered densely with fine longitudinal striae, running sligthly obliquely on the last chamber; aperture low and broad, sometimes transversely slitlike, with a low tapeshaped tooth or surrounded with everted border only and without tooth; the aperture edge strongly sloping, occasionally perpendicular to the penultimate chamber and somewhat deflected.

Variability. The shape of test is variable from oval to circular. The terminal portion of the last chamber may be sometimes more or less inclined towards the penultimate one, the test being then circular in shape and the middle chambers having an oblique position. The terminal portion of the last chamber does not adhere closely to the test wall in some specimens, being somewhat deflected from the surface terminally; thus the aperture has the shape of a transverse slit at the end of the last chamber which is surrounded with a thickened border and lacks the tooth.

Dimorphism and ontogeny. The specimens sectioned represent the microspheric generation, with a proloculus 20—40 μ in diameter and a megalospheric I generation, with a proloculus 80 μ in diameter. A turn

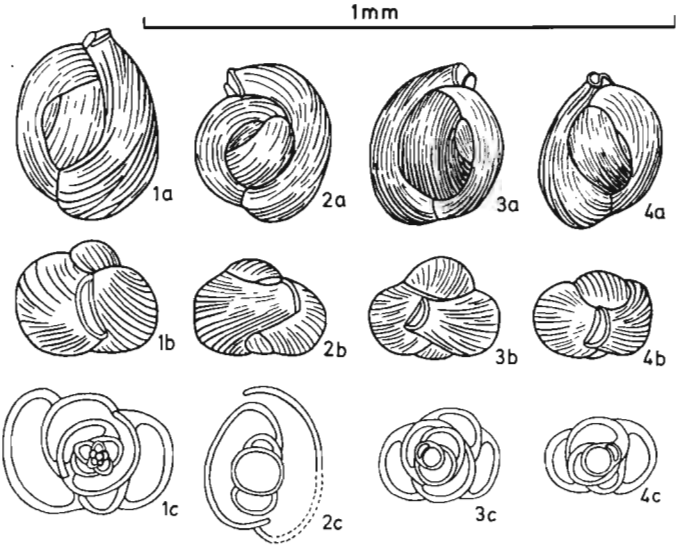


Fig. 47. Morphological variability and internal structure of *Varidentella georgiana* sp. n., Lower Sarmatian, Machów 290 borehole, depth 26-27 m: 1 — micro generation, typical form, turn of coiling axis visible in the ontogeny; 2 — mega I generation, rounded form showing oblique position of central chambers, turn of coiling axis visible in the ontogeny; 3 — micro generation, juvenile stage irregular triloculine, then quinqueloculine; 4 — micro generation, juvenile form with irregular chamber arrangement; *a* front view, *b* apertural view, *c* (except no. 2) — cross-section, no. 2 — longitudinal section.

of the coiling axis appears distinctly after a few juvenile chambers (Text-fig. 47).

Remarks. — This species approaches morphologically to *Varidentella reussi* (Bogdanowich), but differs in having a characteristic aperture and definite regular striae which are not wrinkles like those in gerontic specimens of *V. reussi*. It differs from Recent *Triloculina fichteliana* d'Orbigny from Cuba and from Recent *T. webbiana* d'Orbigny from the Canary Is. in more elongated shape and in having a low tape-shaped tooth in the aperture. From Recent *T. suborbicularis* d'Orbigny (not

Quinqueloculina suborbicularis d'Orbigny) from the Antilles it differs in a thicker test and a slitlike, not circular aperture.

Distribution. — Poland: Lower Sarmatian, (Miechocin, Mokrzyszów, Machów). USSR: Middle Sarmatian, West Georgia.

Varidentella latelacunata (Venglinsky, 1953)
(Pl. XXVII, Figs 7*a-c*, 8*a*, *b*)

1953. *Miliolina latelacunata* Venglinsky; I. V. Venglinsky, p. 131, Pl. 2, Figs 7—9.
1958. *Miliolina latelacunata* Venglinsky; I V. Venglinsky, p. 79, Pl. 14, Fig. 3*a-c*.

Material. — 20 specimens (Coll. No. F-191).

Dimensions: L 0.4-0.5; B 0.22-0.32; T 0.15-0.20.

Description. — Test narrowly oval, strongly elongated, periphery broadly rounded or somewhat contracted; chambers tubular, inflated, last chamber bent at the base and nearly straight or S-shaped near the aperture, middle chamber convex and projecting above the surface, fifth chamber often invisible; sutures strongly depressed, narrow; surface smooth; aperture circular or transversely oval, surrounded with everted border and with a low and broad, slightly bifid tooth.

Variability. This species has typically depressed sutures and a very variable shape of the aperture, circular to transversely oval. Consequently, the shape of tooth is also variable, quadrate (Pl. XXVII, Fig. 8) to low and broad, with lateral processes (Pl. XXVII, Fig. 7). The shape of the test varies from oval to narrowly-oval. There are 3—5 chambers visible from outside.

Remarks. — Compared with the description and illustration of Venglinsky this form has a more variable shape of the aperture, which is rarely circular, and a broader tooth. It is very similar to *Cycloforina stomata* n.sp., but differs in a more elongated shape of the test, more depressed sutures, contracted periphery and smaller aperture. It is also similar to *Varidentella sulacensis* (Gerke), differs however in its more inflated chambers and everted border of the aperture.

Distribution. — Poland: Lower Sarmatian, (Budy, Grzybów, Mielec, Rytwiany, Zrecze). USSR: Lower Sarmatian, Transcarpathians.

Varidentella pseudocostata (Venglinsky, 1958)
(Pl. XXVI, Fig. 7*a-c*)

1958. *Miliolina pseudocostata* Venglinsky; I. V. Venglinsky, p. 70, Pl. 10, Figs 1—3; Pl. 11, Figs 1—3.
1962. *Quinqueloculina pseudocostata* (Venglinsky); I. V. Venglinsky, p. 74, Pl. 4, Figs 3, 4.

Material. — 42 specimens (Coll. No. F-192).

Dimensions: L 0.42-0.75; B 0.3-0.57; T 0.23-0.4

Description. — Test nearly circular, robust, periphery broadly rounded; chambers broad, semicircular in shape, narrowing towards the aperture, middle chamber large, slightly convex, oval, tapering at both ends, fifth chamber poorly visible; sutures distinct, depressed; wall thin; surface covered with faint longitudinal bifurcated striae, placed mostly on the periphery of chambers, wide apart at the base and more and more tightly arranged towards the aperture, where they dissapear; aperture large, semicircular, with low, quadrate, bifurcated tooth.

Variability. The intensity of ornamentation is variable from faint, poorly visible striae on the lower part of the chamber to distinct ones running along the whole chamber.

Remarks. — This species differs from *Varidentella rotunda* (Gerke) in having a broadly rounded periphery, covered with thick striae. From *Cycloforina toreuma* (Serova) it differs in its larger and more robust test, semicircular aperture, quadrate tooth, finer striae and inflated sides of chambers.

Distribution. — Poland: Lower Sarmatian, (Budy, Grzybów, Rytwiany, Zrecze). USSR: Lower Sarmatian, Transcarpathians.

+ *Varidentella reussi* (Bogdanowich, 1947)

(Part I, Pl. XIII, Figs 1*a-c*, 2*a*, *b*, 3; Part II, Text-figs 48, 49)

1947. *Miliolina reussi* Bogdanowich; A. K. Bogdanowich, p. 21, Pl. 1, Fig. 4*a*, *b*.
1952. *Miliolina reussi* Bogdanowich; A. K. Bogdanowich, p. 119, Pl. 13, Fig. 1*a-c*.
1956. *Miliolina reussi* Bogdanowich; V. M. Pobedina *et al.*, p. 109, Pl. 11, Figs 1—3.
1958. *Miliolina reussi* Bogdanowich; I. V. Venglinsky, p. 83, Pl. 16, Fig. 2*a-c*.
1961. *Quinqueloculina reussi* (Bogdanowich); V. J. Didkovsky, p. 50, Pl. 10, Fig. 5.
1962. *Quinqueloculina reussi* (Bogdanowich); I. V. Venglinsky, p. 74, Pl. 4, Fig. 1*a-c*.
1971. *Quinqueloculina reussi* (Bogdanowich); L. S. Maissuradze, p. 48, Pl. 4, Figs 1, 2.

Material. — Over 1000 specimens (Coll. No. F-193, Sec. No. 152—154, 274—284).

Dimensions: L 0.3-0.4; B 0.25-0.35; T 0.2-0.25.

Description. — Test broadly oval, tapering at both ends, periphery broadly rounded; chambers broad, narrowing towards the aperture, last chamber often extended and inclined towards the penultimate one, middle chamber broad, inflated and slightly oblique, fifth chamber poorly visible or invisible; sutures flat and broad; wall thin; surface smooth, dull, wrinkled in gerontic specimens; aperture narrow, semicircular or transversely slitlike, with everted border, oblique to the periphery and with transverse quadrangular, tape-shaped tooth, sometimes with two fine angular corners.

Variability. The test shape ranges from nearly circular (Text-fig. 48) to broadly oval (Text-fig. 49). The shape of the aperture varies from semicircular to slitlike in specimens, the apertural end of which is strongly inclined towards the penultimate chamber. The shape of the

tooth varies from slight ridge-like swelling at the base of the aperture to low transverse tape. There occur longitudinal irregular wrinkles, like in *Cycloforina predcarpatica* (Serova), in some specimens (Part I, Pl. XIII, Fig. 2) probably representing gerontic stage of the species.

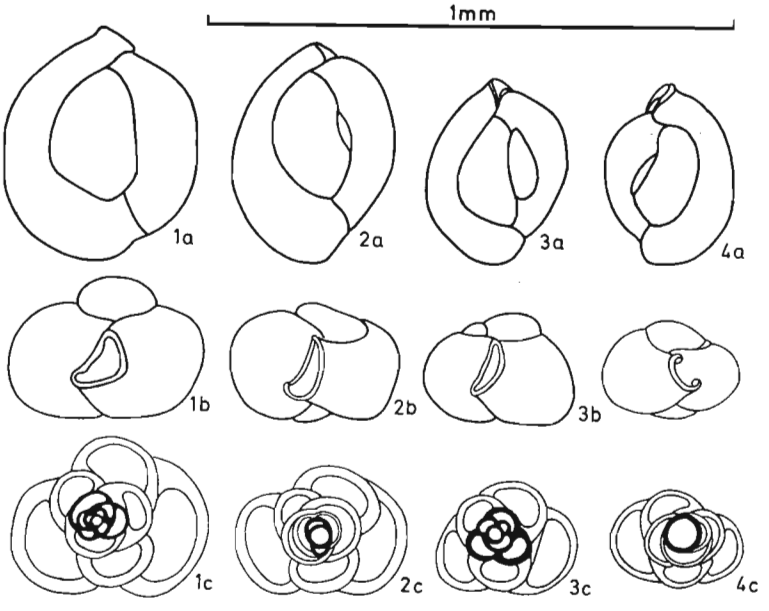


Fig. 48. Morphological variability and internal structure of *Varidentella reussi* (Bogdanowich), Lower Sarmatian, Miechocin 0-3 borehole, depth 54.6-55.7 m, rounded forms: 1 — micro generation with initial part irregular, then quinqueloculine; 2 — micro generation, initial part with turn of coiling axis, later quinqueloculine; 3 — micro generation, initial part cryptoquinqueloculine, then quinqueloculine; 4 — mega I generation with irregularly quinqueloculine internal structure; *a* front view, *b* apertural view, *c* cross-section.

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation, PD 20—40 μ (Text-figs 48/1—3, 49/1—4) and to the mega I generation, PD 70 μ (Text-fig. 48/4). The internal structure is quinqueloculine or cryptoquinqueloculine. The juvenile stage of the micro generation is composed of about 7 chambers in a quinqueloculine arrangement, then the coiling axis turns by about 90° and the subsequent 2—3 chambers grow nearly perpendicularly to the main axis; finally the coiling axis may return to the previous direction and the mature specimens may have a quinqueloculine appearance. The juvenile specimens with transparent walls show a distinct oblique position of the middle chambers after the coiling axis has been changed (Part I, Pl. XIII, Fig. 3).

Remarks. — This species differs from *Varidentella sarmatica* (Reuss) in its more compact, broadly oval or nearly circular shape of the test, low and broad aperture with tape-like tooth and dull, often wrinkled surface. From *Cycloforina stomata* sp. n. it differs in slitlike, not circular aperture

and in tape-shaped, not narrow and bifid tooth. From *Varidentella latelacunata* (Venglinsky) it differs in more circular test shape, lower aperture and tooth and flattened sutures.

Our form corresponds to the comparative specimens of *Varidentella reussi* (Bogdanowich), kindly given the author by A. K. Bogdanowich,

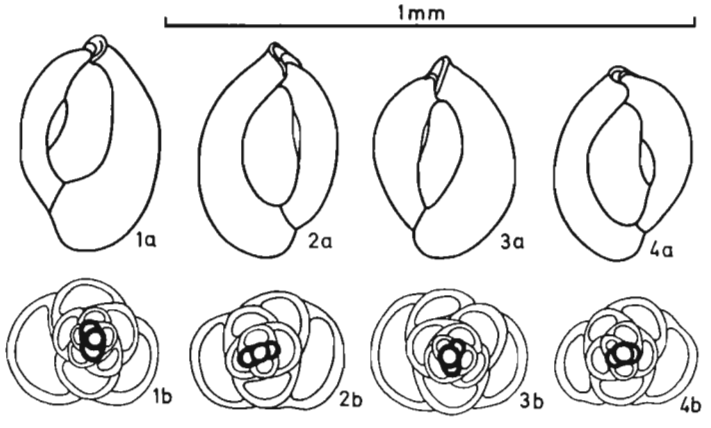


Fig. 49. Morphological variability and internal structure of *Varidentella reussi* (Bogdanowich), Lower Sarmatian, Miechocin 0-3 borehole 54.6-55.7 m, elongate forms: 1-4 — micro generation, irregularly quinqueloculine chamber arrangement; *a* front view, *b* cross-section.

they however differ from the comparative specimens of *Varidentella sarmatica* (Karrer) from Nexing in the Vienna Basin.

Distribution. — Poland: Lower Sarmatian, (Machów, Miechocin, Mokrzyszów, Piaseczno, Rytwiany). Austria: Lower Sarmatian, Nexing. USSR: Lower Sarmatian, Precaucasian and Ukraine.

Varidentella rosea (d'Orbigny, 1839)

(Pl. XXVII, Figs 9*a-c*, 10*a*, *b*; Text-fig. 50)

1839. *Triloculina rosea* d'Orbigny; A. d'Orbigny, p. 69, Pl. 3, Figs 18—20; *fide* Catalogue Ellis & Messina.

Material. — 60 specimens (Coll. No. F-194, Sec. No. 135—138).

Dimensions: L 0.3-0.65; B 0.27-0.54; T 0.2-0.35

Description. — Test nearly circular, periphery broadly rounded; chambers broad, inflated, middle chamber large, irregularly oval, strongly convex, fifth chamber poorly visible or invisible; sutures broad, depressed; wall thin; surface smooth, polished, covered with irregular transverse wrinkles in larger specimens; aperture large, semicircular, with small, ridge-like tooth, occasionally partly reduced or lacking; aperture border strongly sloping, sometimes nearly perpendicular to the periphery and everted in some specimens.

Variability. The border of the aperture may be more or less everted, the shape of tooth varies from broad tape to narrow ridge or may be reduced, leaving only small traces (Text-fig. 50).

Dimorphism and ontogeny. The sections show the mega I (?) generation; PD 60—80 μ. The internal structure is cryptoquinqueloculine (Text-fig. 50); there is a turn in the coiling axis by about 90° after the juvenile stage.

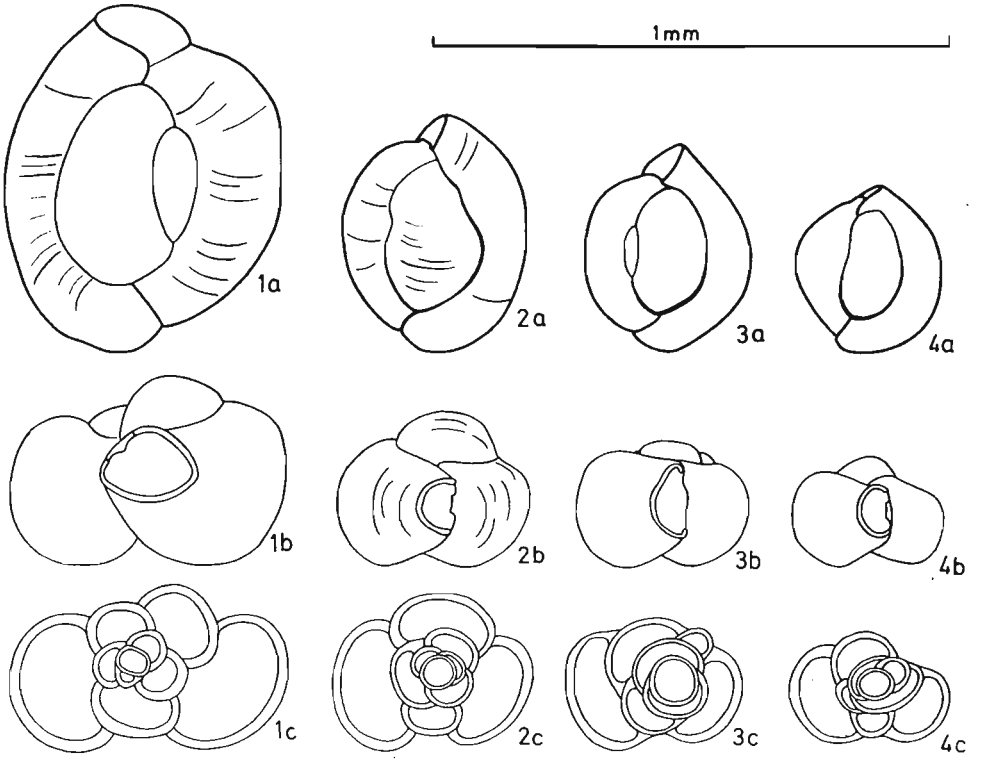


Fig. 50. Morphology and internal structure of *Varidentella rosea* (d'Orbigny), Lower Sarmatian, Budy-1 borehole, depth 190.8-190.9 m, mega I generation; 1 — large specimen with quinqueloculine chamber arrangement; 2 — irregularly cryptoquinqueloculine chamber arrangement; 3, 4 — small specimens with turn of coiling axis visible in juvenile stage; *a* front view, *b* apertural view, *c* cross-section.

Remarks. — This species differs from *Cycloforina stomata* sp. n. in its more circular shape, more inflated chambers, depressed sutures, semicircular, large aperture and small, tape-like tooth, from *Varidentella rotunda* (Gerke) in much more inflated chambers and depressed sutures and from *Sinuloculina rotunda* (d'Orbigny) in having a more circular test, more inflated chambers and broad semicircular aperture with a tape-like tooth.

Distribution. — Poland: Lower Sarmatian, (Budy, Dwikozy, Grzybów, Mielec, Rytwiany, Wierzchowiska, Zrecze). Cuba: Recent.

Varidentella rotunda (Gerke, 1938)

(Pl. XXVII, Figs 5*a-c*, 6; Text-fig. 51)

1938. *Miliolina akneriana* (d'Orbigny) var. *rotunda* Gerke; A. A. Gerke, p. 296, Pl. 1, Fig. 1.

1950*b*. *Miliolina akneriana* (d'Orbigny) var. *rotunda* Gerke; A. K. Bogdanowich, p. 145, Pl. 1, Fig. 10.

1952. *Miliolina akneriana* (d'Orbigny) var. *rotunda* Gerke; A. K. Bogdanowich, p. 113, Pl. 11, Fig. 2.

1955. *Miliolina akneriana* (d'Orbigny) var. *rotunda* Gerke; M. J. Serova, p. 323, Pl. 10, Figs 7—9.

Material. — Over 100 specimens (Coll. No. F-195, Sec. No. 358, 359, 368, 373—378).

Dimensions: L 0.45-0.8; B 0.37-0.65; T 0.27-0.45

Description. — Test circular-oval, subtriangular in cross-section, periphery rounded; chambers broad, arcuate, slightly narrowing towards the aperture, with flattened sides, middle chamber oval, convex, fifth chamber poorly visible or invisible; last chamber often extended and inclined towards penultimate one, and thus the middle chambers have an oblique position; sutures indistinct; surface smooth, polished; wall thin, occasionally

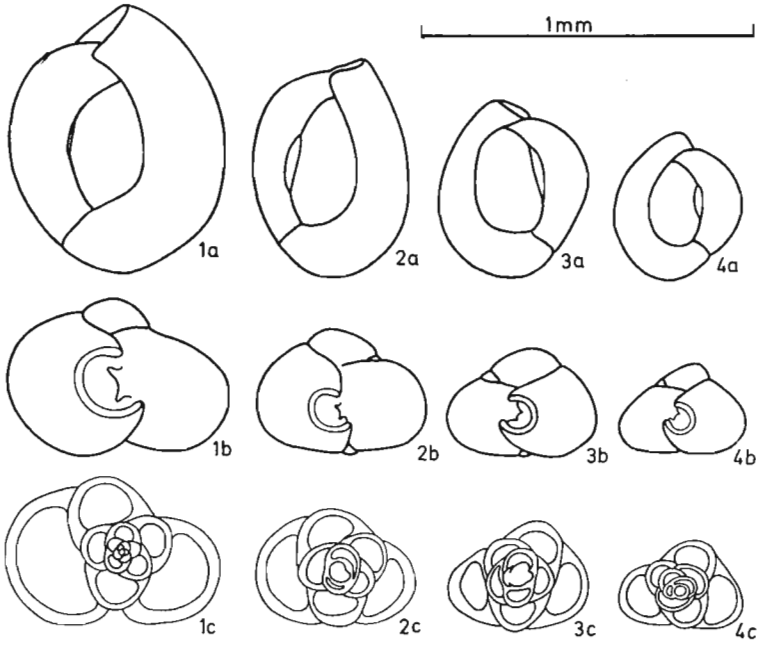


Fig. 51. Ontogeny and dimorphism of *Varidentella rotunda* (Gerke), Lower Sarmatian, Grzybów 28 borehole, depth 159.8-160.0 m: 1 — micro generation with cryptoquinqueloculine internal structure; 2, 3 — mega I (?) generation with irregularly quinqueloculine internal structure; 4 — juvenile specimen of micro generation with turn of coiling axis visible in juvenile stage; *a* front view, *b* apertural view, *c* cross-section.

transparent; aperture large, semicircular, oblique and with a short, quadrate, bifid tooth.

Variability. A characteristic feature of this species is its stable subcircular shape, subtriangular in cross-section and a short, quadrangular tooth. The convexity of the middle chamber is variable, as well as the apertural extension which may be inclined towards the penultimate chamber in some specimens (Pl. XXVII, Fig. 6).

Dimorphism and ontogeny. The specimens sectioned belong to the micro generation, PD 20 μ and mega I (?) generation, PD 50—60 μ (Text-fig. 51). The internal structure is quinqueloculine or cryptoquinqueloculine and there are 3, 4 or 5 chambers visible from outside. In the juvenile stage of the mega I (?) generation there is a tendency for the coiling axis to turn (Text-fig. 51/4).

Remarks. — This species closely resembles *Varidentella pseudocostata* (Venglinsky), but differs in its smaller dimensions, more flattened sides of chambers, narrowly rounded periphery and lack of ornamentation. There is however no resemblance to *Quinqueloculina akneriana* d'Orbigny either in the shape of the test and its internal structure or in the character of the aperture and tooth; thus the form is regarded as a separate species, not a subspecies of *Q. akneriana.*

Distribution. — Poland: Upper Tortonian and Lower Sarmatian, (Budy, Dwikozy, Grzybów, Ligota Zabrska, Miechocin, Mielec, Mokrzyszów, Rytwiany, Wierzchowiska, Zrecze). USSR: Tortonian (Tchokrak), the Crimea-Caucasian region and West Precaucasus; Lower Sarmatian, Russian Platform.

+ *Varidentella sarmatica* (Karrer, 1877)

(Pl. XXVI, Fig. 6*a-c*; Text-fig. 52)

1877. *Quinqueloculina sarmatica* Karrer var. *typica* Karrer; F. Karrer, p. 375, Pl. 16, Fig. 11*a*.

1877. *Quinqueloculina sarmatica* Karrer var. *elongata* Karrer; *ibidem*, p. 375, Pl. 16, Fig. 11*b*.

1877. *Quinqueloculina sarmatica* Karrer var. *virgata* Karrer; *ibidem*, p. 375, Pl. 16, Fig. 11*c*.

1971. *Quinqueloculina* aff. *sartaganica* (Krasheninnikov); L. S. Maissuradze, p. 50, Pl. 3, Fig. 5.

Material. — Over 100 specimens (Coll. No. F-196, Sec. No. 157—159).

Dimensions: L 0.3-0.35; B 0.2-0.22; T 0.15.

Description. — Test elongate oval, slender, periphery rounded; chambers of uniform width, arcuate, last chamber slightly extended and inclined towards the back side of the test, middle chamber large and convex, elongate oval in shape, fifth chamber occasionally visible or invisible; sutures slightly depressed, broad; surface smooth, polished, with

longitudinal wrinkles in gerontic specimens; wall thin; aperture large, semicircular, oblique, with an everted border and a low, tape-shaped tooth, sometimes with two angular corners.

Variability. The aperture may be semicircular and oblique or high and nearly perpendicular to the periphery. The tooth may be partly or entirely reduced, leaving the opening of the aperture empty (Text-fig. 52).

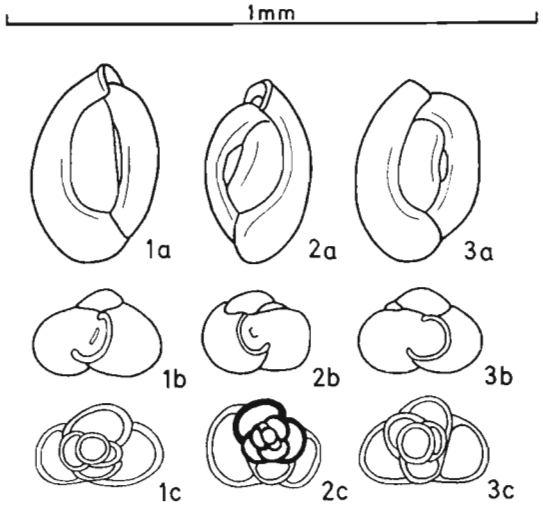


Fig. 52. Morphological variability and internal structure of *Varidentella sarmatica* (Karrer), Lower Sarmatian, Zrecze-3 borehole, depth 101.9-102.0 m, micro (?) generation: 1 — irregularly triloculine chamber arrangement; 2 — irregularly quinqueloculine chamber arrangement; 3 — quinqueloculine chamber arrangement; *a* front view, *b* apertural view, *c* cross-section.

Dimorphism and ontogeny. The sections show the micro (?) generation, PD 30—60 μ. The internal structure is quinqueloculine or cryptoquinqueloculine. The juvenile stage removed from the inside of the mature specimens without a tooth in the aperture, show a broad tooth with two corners, like that in *Varidentella reussi* (Bogdanowich).

Remarks. — This species differs from *Varidentella reussi* in the slenderer test, semicircular, higher aperture and smooth, polished surface. From *V. latelacunata* (Venglinsky) it differs in its narrower, less inflated chambers and more flattened, not depressed sutures. The thorough examination of the material from Nexing in the Vienna Basin I succeeded in finding hardly 5 specimens of *V. sarmatica*, which correspond morphologically to our specimens and have a transverse tape-shaped tooth in the aperture. They differ however from *V. reussi*, which is easy to distinguish in materials from Lower Sarmatian of Poland.

Distribution. — Poland: Lower Sarmatian, (Machów, Piaseczno, Rytwiany, Zrecze). Austria: Lower Sarmatian, Nexing, Vienna.

Subfamily **Sigmoilinitinae** subfam. n.

Diagnosis: Two chambers to whorl, initial stage sigmoiline, i.g. with chambers alternating in planes of coiling at angles increasing gradually to 180°, later chambers usually in a single plane. Eocene to Recent. Genera included: *Sigmoilinita* Seiglie, 1965; *Nummoloculina* Steinmann, 1881; *Schlumbergerina* Munier-Chalmas, 1882; *Spirosigmoilina* Parr, 1942.

Genus *Sigmoilinita* Seiglie, 1965
× + *Sigmoilinita tenuis* (Czjzek, 1848)
(Pl. XVI, Figs 1—3; Text-fig. 53/3)

1848. *Quinqueloculina tenuis* Czjzek; J. Czjzek, p. 149, Pl. 13, Figs. 31—34.
1877. *Spiroloculina berchtoldsdorfensis* Karrer, p. 375, Pl. 16*a*, Fig. 10.
1951. *Sigmoilina tenuis* (Czjzek); P. Marks, p. 39, Pl. 5, Fig. 7.
1952. *Sigmoilina tenuis* (Czjzek); A. K. Bogdanowich, p. 159, Pl. 23, Figs 1—4.
1956. *Sigmoilina tenuis* (Czjzek); A. Sulimski, p. 83, Pl. 1, Fig. 1a-e.
1960. *"Sigmoilina" tenuis* (Czjzek); R. W. Barker, Pl. 10, Figs 7, 8, 11.
1965. *Sigmoilinita tenuis* (Czjzek); G. A. Seiglie, p. 72.
1968. *Spiroloculina tenuis* (Czjzek); I. Korecz-Laky, p. 63, Pl. 4, Fig. 11.
1970. *Sigmoilina tenuis* (Czjzek); D. Verhoeve, p. 28, Pl. 1, Fig. 11.

Material. — About 100 specimens (Coll. No. F-197, Sec. No. 426, 427). Dimensions: L 0.4-0.6; B 0.18-0.3; T 0.04-0.05

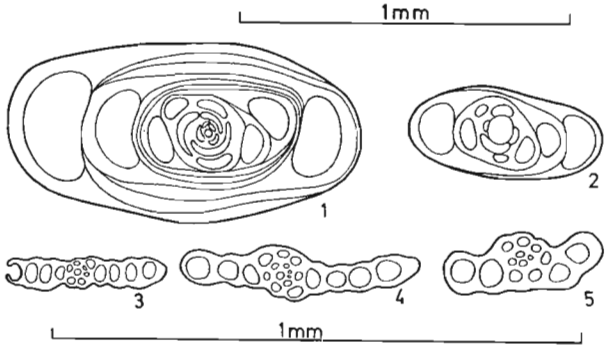


Fig. 53. Internal structure of *Nummoloculina*, *Sigmoilinita* and *Spirosigmoilina*: 1, 2 — *Nummoloculina contraria* (d'Orbigny), Lower Tortonian, Wieliczka; 1 — micro generation, 2 — mega I generation; 3 — *Sigmoilinita tenuis* (Czjzek), Upper Tortonian, Krywałd borehole, depth 72-74 m, micro generation; 4 — *Spirosigmoilina speciosa* (Karrer), Lower Tortonian, Korytnica, micro generation; 5 — *Spirosigmoilina crenata* (Karrer), Lower Tortonian, Korytnica, micro generation.

Description. — Test rhomboid-oval, tapering at both ends, flat, periphery rounded; chambers tubular, narrow, arranged stepwise in a single plane, 3—5 on each side of the slightly oblique juvenile stage, two outer chambers broad with flattened sides and slightly marked longitudinal grooves along the sutures; sutures somewhat depressed; surface smooth,

polished; wall thin; aperture small, circular, placed at the end of a short neck and with a short and simple tooth.

Variability and ontogeny. The characteristic features of this species are stable. The shape of juvenile specimens is narrow and slender (Pl. XVI, Fig. 3), while the mature specimens are broader and slightly rhomboid (Pl. XVI, Fig. 1). The sections show a sigmoiline chamber arrangement in the juvenile stage, then the chambers are added in a single plane (Text-fig. 53/3).

Remarks. — This species differs from *Sigmoilinita tenuissima* (Reuss) from the Miocene of Wieliczka in having broader chambers with flattened sides and a more rhomboid test. From *S. tschokrakensis* (Gerke) it differs in a more numerous chambers with more flattened sides, and in rhomboid-oval shape. The forms investigated correspond morphologically to the topotypes from Baden, Vienna Basin.

Distribution. — Poland: Tortonian (Benczyn, Brzozowa, Budy, Grabki Duże, Grzybów, Gliwice Stare, Karsy, Korytnica, Łęki Dolne, Krywałd, Miechocin, Rytwiany, Wieliczka, Zrecze). Austria: Lower Tortonian, Baden, Vienna Basin. Czechoslovakia: Lower Tortonian, Židlochovice. USSR: Miocene, Precaucasian region and Ukraine.

× + *Sigmoilinita tenuissima* (Reuss, 1867)
(Pl. XVI, Figs 4—6)

1867. *Spiroloculina tenuissima* Reuss; A. E. Reuss, p. 71, Pl. 1, Fig. 11.
1955. *Sigmoilina tenuissima* Reuss; M. J. Serova, p. 326, Pl. 12, Figs 5, 6.

Material. — 70 specimens (Coll. No. F-198).
Dimensions: L 0.4-0.45; B 0.2-0.25; T 0.04

Description. — Test oval, rounded at the base and tapering towards the aperture, flattened, periphery rounded; chambers tubular, narrow, arranged in a single plane, 2—3 on each side of slightly oblique juvenile stage; sutures slightly depressed, indistinct; wall thin, transparent; surface smooth, polished; aperture small, circular, at the end of a short neck and with a short, simple tooth.

Variability. The shape of the test is stable. The number of chambers of the planispiral stage depends on the ontogeny.

Remarks. — This species, described from the Miocene in Wieliczka, differs from *Sigmoilinita tenuis* (Czjzek) from Baden in having narrower, tubular chambers, a more regular shape and fine, transparent wall. The topotypes from Wieliczka are figured in Plate XVI, Figs. 4—6.

Distribution. — Poland: Tortonian, (Wieliczka, Zgłobice). Czechoslovakia: Tortonian, Devinska Nova Ves. USSR: Tortonian, the Precarpathian Foredeep.

Sigmoilinita tschokrakensis (Gerke, 1938)
(Pl. XVI, Figs 8*a*, *b*, 9*a*, *b*)

1938. *Sigmoilina tschokrakensis* Gerke; A. A. Gerke, p. 308, Pl. 3, Figs 1—18.
1952. *Sigmoilina tschokrakensis* Gerke; A. K. Bogdanowich, p. 161, Pl. 23, Figs 6, 7; *cum syn.*
1970. *Sigmoilina tschokrakensis* Gerke; O. Djanelidze, p. 107, Pl. 16, Fig. 1*a*, *c*.

Material. — 30 specimens (Coll. No. F-199)

Dimensions: L 0.5-0.6; B 0.25-0.3; T 0.15-0.17

Description. — Test oval, tapering at both ends, flattened, in the central part slightly convex, periphery rounded; chambers tubular with flattened sides, 2—3 chambers of planispiral stage somewhat broader than those of sigmoiline stage in the centre of the test; sutures depressed; surface smooth, dull; aperture small, circular, at the end of a short neck and with a short, simple tooth.

Variability and ontogeny. The shape of the test is very variable, according to the description of Gerke. Juvenile specimens are slenderer, the mature ones are broader and flat.

Remarks. — This species differs from *Sigmoilinita tenuis* (Czjzek) and *S. tenuissima* (Reuss) in its broader, tubular chambers, more compact test, convex in the central part and dull wall. It is similar to *Sigmoilina elliptica* Galloway & Wissler, Pleistocene, but differs in the more elongate test and in the presence of a tooth in the aperture.

Distribution. — Poland: Tortonian (Grabki Duże, Korytnica, Wieliczka). USSR: Tortonian, the Crimea-Caucasian region.

Sigmoilinita sp.
(Pl. XVI, Fig. 7*a-c*)

Material. — 1 specimen (Coll. No. F-200).

Dimensions: L 0.72; B 0.4; T 0.15

Description. — Test quadrangular-oval, flat, periphery rounded; chambers tubular, thick, somewhat bent at the base and straight near the aperture, two last chambers arranged in a single plane, three middle chambers of sigmoiline stage in test centre; sutures depressed, distinct; wall matt; aperture circular, at the end of a short neck, surrounded with a thickened rim and having a short and simple tooth.

Remarks. — No mention of this form has been found in the literature available to the author; it is however so distinct and well preserved, that it has been decided to state its presence only.

Distribution. — Poland: Upper Tortonian (Krywałd).

Genus *Nummoloculina* Steinmann, 1881

× + *Nummoloculina contraria* (d'Orbigny, 1846)

(Pl. XV, Figs 5*a-c*, 6*a*, *b*; Text-fig. 53/1, 2)

1846. *Biloculina contraria* d'Orbigny; A. d'Orbigny, p. 266, Pl. 16, Figs 4—6.
1881. *Nummoloculina contraria* (d'Orbigny); G. Steinmann, p. 31, Pl. 2, Figs 1—8.
1951. *Nummoloculina contraria* (d'Orbigny); P. Marks, p. 40.
1958. *Nummoloculina contraria* (d'Orbigny); I. V. Venglinsky, p. 65, Pl. 7, Figs 4, 5.

Material. — Over 50 specimens (Coll. No. F-201, Sec. No. 424, 425, 432). Dimensions: L 0.5-1.65; B 0.45-1.55; T 0.3-0.7

Description. — Test large, robust, circular, flat, periphery rounded; chambers broad, flat, 2—5 in the last whorl, covering those of the preceding whorls entirely; sutures very lightly depressed, arcuate, sometimes S-shaped, irregular; wall thick; surface smooth, polished; aperture large, semicircular or triangular, filled with semicircular or triangular flap.

Variability. The characteristic features of this species are stable, only the number of chambers in the last whorl is variable.

Dimorphism and ontogeny. The sections show chambers strongly increasing in size, the sides of which entirely cover all the preceding chambers except the periphery of the penultimate one (Text-fig. 53/1, 2). In the juvenile stage of the micro generation a turn of the coiling axis occurs after 2—3 chambers have been built; another turn, back to the previous position, follows the creation of the next 6 chambers. The turn of coiling axis in the ontogeny of the mega I generation is less distinct; PD: micro — 20 μ, mega I — 70 μ. The large specimens belong probably to the micro generation, the small ones — to the mega I generation.

Remarks. — Wiesner, 1923 (*fide* Barker, 1960) considered *Planispirina sigmoidea* Brady, 1884, the type species of the genus *Sigmoilina*, to be a synonym of *Nummoloculina contraria* (d'Orbigny). Thus the genus *Sigmoilina* became a synonym of the genus *Nummoloculina*. It seems however, that *Planispirina sigmoidea* does not belong to the species *Nummoloculina contraria*, though it is a juvenile stage of *Nummoloculina*. It is very similar to *Nummoloculina circumcostata* Margerel, from the Pliocene of France but differs in the lack of a distinct border near the periphery and in a flat, not convex central part of the test.

Distribution. — Poland: Tortonian (Brzeźnica, Gliwice Stare, Grzybów, Krywałd, Ligota Zabrska, Rybnica, Wieliczka). Austria: Tortonian, Baden, Vienna Basin. Czechoslovakia: Tortonian, Devinska Nova Ves, Židlochovice.

Genus *Spirosigmoilina* Parr, 1942

+ *Spirosigmoilina crenata* (Karrer, 1868)

(Pl. XVII, Figs 15*a*, *b*, 16*a*, *b*; Text-fig. 53/5)

1868. *Spiroloculina crenata* Karrer; F. Karrer, p. 135, Pl. 1, Fig. 9.
1917. *Massilina crenata* (Karrer); J. A. Cushmann, p. 57, Pl. 20, Fig. 2*a*, *b*.

1946. *Hauerina speciosa* (Karrer); J. A. Cushman, p. 5, Pl. 1, Fig. 14*a*, *b*.
1952. *Spiroloculina (?) crenata* Karrer; A. K. Bogdanowich, p. 154, Pl. 22, Fig. 4*a-c*.
1955. *Spiroloculina crenata* Karrer; M. J. Serova, p. 326, Pl. 12, Figs 1—4.

Material. — 10 specimens (Coll. No. F-202, Sec. No. 413, 430, 431).

Dimensions: L 0.35-0.45; B 0.25-0.37; T 0.1-0.15

Description. — Test broadly oval, flat, periphery truncate; two outer chambers narrow, arcuate, of uniform width, arranged in a single plane, middle chambers in sigmoiline arrangement, 1—3 on each side of juvenile stage; sutures depressed; surface covered with 5—8 large, prominent protuberances on each chamber, separated by broad furrows and making a regular corrugate pattern on the periphery; wall smooth, polished; aperture elongate, narrow somewhat broader at the base and at the top, with lateral edges enlarged and somewhat bent inwards, and filled with a long, simple tooth.

Variability and ontogeny. The shape of the aperture is variable. It is usually as an elongated slit, filled entirely with a simple tooth, but in some specimens the lateral extensions are somewhat sinuous and inclined inside the aperture. The number of protuberances on each chamber is also variable but not greater than 8 on each chamber. The internal structure is sigmoiline. The sections show chambers gradually increasing in size, arranged in two spiral lines then in a sinusoid line to attain a planispiral arrangement finally (Text-fig. 53/5).

Remarks. — Our specimens are identical with those from Lapugiu and Buitur in Romania, having the same elongated narrow aperture. Only two specimens from Buitur have sinuous and inclined lateral edges of the aperture. This character of the aperture is connected with the ornamentation of the test, but probably caused Cushman (1946) to include this species in the genus *Hauerina*. However, none of the specimens investigated, either from Korytnica or from Buitur in Romania, has a cribrate aperture; besides, they both have a sigmoiline, not quinqueloculine, internal structure, as in *Hauerina*.

Collins (1958) is of the opinion that the Recent species named *Spiroloculina crenata* Karrer by Brady (1884) is similar to but not identical with this species; nevertheless, neither does it belong to the genus *Hauerina*, having a sigmoiline initial stage. Collins considers it to be a new species belonging to the genus *Spirosigmoilina* and gives it the name of *Spirosigmoilina bradyi*.

This species is very similar to the related species *Spirosigmoilina speciosa* (Karrer), but differs in having fewer and larger protuberances in the chambers, a thicker test and truncate periphery.

Distribution. — Poland: Tortonian (Gliwice Stare, Karsy, Korytnica). Romania: Tortonian, Kostej in Banat, Lapugiu, Buitur. USSR: Miocene, West Ukraine.

+ *Spirosigmoilina speciosa* (Karrer, 1868)
(Pl. XVII, Figs 17*a*, *b*, 18*a*, *b*; Text-fig. 53/4)

1868. *Spiroloculina speciosa* Karrer; F. Karrer, p. 135, Pl. 1, Fig. 8.
1946. *Hauerina speciosa* (Karrer); J. A. Cushman, p. 5, Pl. 1, Fig. 13*a*, *b*.
1960. *Hauerina speciosa* (Karrer); R. W. Barker, Pl. 11, Figs 10, 11.

Material. — 30 specimens (Coll. No. F-203, Sec. No. 412, 428, 429).
Dimensions: L 0.55; B 0.4-0.52; T 0.08-0.12.

Description. — Test broadly oval, very thin and flat, periphery rounded; chambers of planispiral stage narrow, arcuate, 3—4 on each side of the sigmoiline stage, which is seen in the central part of the test as small proturberances; sutures depressed; surface covered with 10—14 regular transverse bumps on each chamber, making a corrugate pattern on the periphery; wall smooth, polished; aperture elongate, narrow, slitlike, with edges inclined to the inside and filled with a long, simple tooth.

Remarks. — Cushman regarded this species as belonging to the genus *Hauerina*, as he did *Spirosigmoilina crenata* (Karrer), despite its sigmoiline internal structure (Text-fig. 53/4). It differs from *S. crenata* in the greater number of bumps on the chambers, more flattened test and rounded, not truncate periphery.

Distribution. — Poland: Tortonian (Karsy, Korytnica). Czechoslovakia: Tortonian, Židlochovice. Romania: Tortonian, Kostej in Banat.

Institute of Regional Geology and Coal Deposits
Department of Palaeontology and Stratigraphy
Academy of Mining and Metallurgy
Kraków, Al. Mickiewicza 30
February, 1973

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INDEX OF DESCRIBED GENERA AND SPECIES

EWA ŁUCZKOWSKA

MILIOLIDAE (FORAMINIFERIDA) Z MIOCENU POLSKI CZĘŚĆ II. STRATYGRAFIA, PALEOEKOLOGIA I OPISY GATUNKÓW

Streszczenie

Badane materiały pochodzą z odsłonięć i z wierceń, rozmieszczonych głównie w brzeżnych facjach Zapadliska Przedkarpackiego (Text-fig. 1). Wykaz miejscowości, z których zostały pobrane na obszarze Polski oraz pochodzenie materiałów porównawczych z miocenu innych krajów i z mórz współczesnych podano w rozdziale pt. „Materiał".

Przy określaniu rodzajów wzięto pod uwagę dwie cechy, jako główne kryteria taksonomiczne: budowę wewnętrzną i charakter ujścia. Ilość komór widocznych na zewnątrz okazała się cechą drugorzędną, często jednakową u przedstawicieli różnych rodzajów. Przy opisach gatunków ograniczono się do omówienia strony przedniej, posiadającej większą ilość widocznych komór oraz profilu, tj. zarysu od strony ujścia, mającego duże znaczenie dla odróżniania gatunków. Strona tylna, posiadająca mniejszą ilość widocznych komór, nie wnosi do opisu nic nowego w porównaniu z poprzednimi cechami. Terminologia użyta w opisach jest objaśniona na Text-fig. 2.

Identyfikację gatunków starano się oprzeć na materiałach z miejscowości typowych lub z utworów równowiekowych sąsiednich obszarów. W związku z tym przy nazwach gatunków zastosowano następującą symbolikę:

* — gatunek zidentyfikowany na podstawie porównania z holotypem.
× — gatunek zidentyfikowany na podstawie porównania z okazami z tej samej miejscowości i poziomu co holotyp.
\+ — gatunek zidentyfikowany na podstawie materiałów z innej miejscowości, z tego samego regionu i poziomu co holotyp.
= — gatunek zidentyfikowany po konsultacji z autorem gatunku.

Badania zmienności morfologicznej niektórych gatunków, ich ontogenezy, zróżnicowania generacji itp. były przeprowadzane na przekrojach poprzecznych, ukazujących komorę embrionalną i kolejne stadia rozwojowe (patrz część I). Przekroje (naszlify) sporządzano w zasadzie sposobem opisywanym przez Bogdanowicza (1952, str. 49), jednak z zastosowaniem pewnych usprawnień, umożliwiających obserwowanie przebiegu czynności pod binokularem. Wszystkie szlifowane okazy były rysowane w schematycznym zarysie przed rozpoczęciem szlifowania i następnie rysowano ich przekrój.

STRATYGRAFIA

Badane miliolidy pochodzą z utworów miocenu, należących do dwóch pięter: tortonu (badenianu) i sarmatu. Nazwa „badenian" została zaproponowana przez Pappa *et al.* (1968) dla utworów należących do tortonu w Basenie Wiedeńskim, lecz nie odpowiadających ściśle stratotypowi tortonu we Włoszech. W niniejszej pracy stosowana jest dawna nazwa „torton" dla ławiejszego nawiązania do poprzednich prac autorki i uniknięcia niejasności, z tym jednak zastrzeżeniem, że odnosi się ona do tortonu. s. l.

Zespoły miliolidów z miocenu Polski różnią się w poszczególnych poziomach stratygraficznych. Ogólnie można stwierdzić, że w tortonie żyły zupełnie inne gatunki miliolidów aniżeli w sarmacie. Ich występowanie w typowych miejscowościach, reprezentujących różne wiekowo utwory, oraz zasięg stratygraficzny podano na Tabeli 1.

Granica między tortonem i sarmatem zaznacza się w miejscu prawie całkowitego zaniku licznych gatunków tortońskich miliolidów i pojawienia się nowego, sarmackiego gatunku *Cycloforina stomata*. Liczne występowanie tego gatunku w spągowych utworach sarmatu charakteryzuje okres pomiędzy nagłym wyginięciem mikrofauny górnotortońskiej a stopniowym rozwojem mikrofauny sarmackiej.

PALEOEKOLOGIA

Odtworzenie przypuszczalnych warunków paleoekologicznych w morzu mioceńskim jest możliwe na podstawie porównania z występowaniem miliolidów w morzach współczesnych. Typowymi przykładami dolnotortońskich zespołów miliolidów północnej strefy przybrzeżnej są zespoły z Kars i Korytnicy, a w południowej strefie — z Benczyna, Iwkowej, Żegociny, Przeciszowa, Brzozowej. Można przyjąć, że wskazują one na warunki wewnętrznego szelfu, na głębokość nie większą od 50—80 m oraz na ciepłe wody. Duża rozmaitość gatunków (38) mówi o normalnym zasoleniu.

W Wieliczce występują utwory młodsze w porównaniu z Korytnicą. Spotykane w nich miliolidy wskazują na nieco odmienne środowisko, na wody głębsze, sięgające poniżej 100 m, być może do 200-250 m. Zmniejszenie ilości gatunków wskazuje na oddalenie od brzegów, albo na zmiany w składzie chemicznym wód.

W górnym tortonie zasolenie morza nie odbiegało od normalnego, na co wskazuje duże bogactwo rodzajów i gatunków. W Gliwicach Starych, typowej miejscowości dla strefy przybrzeżnej w zachodniej części morza, występują zespoły mówiące o głębokości mniejszej aniżeli w Wieliczce, ale większej niż w Korytnicy. Przypuszczalnie można je określić w granicach około 100-150 m. Podobne warunki panowały również w południowej strefie przybrzeżnej, np. w Zgłobicach, Chełmie n/Rabą, Grabowcu, Brzeźnicy itd. W północno-wschodniej części pasa przybrzeżnego (np. w Węglinku, Bogorii, Gieraszowicach, Rybnicy) i w silnie na południe wysuniętej zatoce (w Niskowej) występują utwory przypuszczalnie tego samego wieku co w Gliwicach Starych, jednak wskazujące na inne warunki: na płytkie, ciepłe wody strefy infralitoralnej, posiadające normalne zasolenie i głębokość około 30-50 m.

W dolnym sarmacie od początku występowały zespoły miliolidów wskazujące na niewielkie głębokości, przypuszczalnie około 30 m. W późniejszym okresie zespoły stawały się bardziej jednostajne, widoczne jest masowe występowanie pewnych gatunków, typowe dla faun przybrzeżnych barier i wysepek lub delt większych rzek. Warunki coraz bardziej się pogarszały, co widoczne jest w redukcji ilości gatunków, zmniejszeniu wielkości okazów i powstawaniu form zdegenerowanych. Zjawiska te być może oznaczały wysładzanie się wód pod koniec dolnego sarmatu na wschodnim obszarze morza sarmackiego w Polsce.

MORFOLOGIA SKORUPEK

Na różnorodność kształtów u miliolidów składają się trzy czynniki: zmienność morfologiczna, dimorfizm i ontogeneza. Nie wszystkie wchodzą w rachubę równocześnie u poszczególnych gatunków, jednak wszystkie są z sobą w pewnym stopniu powiązane. Np. różne wielkości skorupek mogą świadczyć o obecności osobników reprezentujących różne stadia ontogenetyczne, od młodocianych do starczych, lecz także mogą być wyrazem specyficznych warunków środowiska, powodujących mniejszy lub większy wzrost skorupek u tych samych gatunków. Również dimorfizm w pewnym stopniu wpływa na różnorodność kształtów. Mimo iż generacje mikro i mega I są nie do odróżnienia na podstawie wielkości i kształtu skorupek (część I, str. 348 oraz przekroje *Quinqueloculina*), jednak generacja mega II może się uwydatnić w postaci osobników małych pod względem wielkości, ale o wyższych skorupkach w porównaniu z innymi generacjami danego gatunku (np. u *Quinqueloculina anagallis*, Text-fig. 7/5 lub *Q. buchiana*, Pl. IV, Fig. 2).

Zmienność morfologiczna jest wyrażona głównie jako zmienność kształtu skorupek, w różnym stopniu wydłużonego, rozszerzonego lub zaokrąglonego i jako zmienność ornamentacji, np. w ilości żeberek lub prążków, albo ich pojawieniu się tylko na pewnej ilości okazów danego gatunku. Na uwagę zasługuje również zmienność kształtu ujścia i zęba, szczególnie u takich rodzajów jak *Cycloforina*, *Miliolinella*,

Pyrgo, *Pyrgoella*, *Varidentella*. Istnieją tylko nieliczne gatunki o mało zmiennych cechach morfologicznych.

ONTOGENEZA

Śledząc u różnych gatunków przekroje szeregów form od młodocianych do dorosłych lub starczych, względnie obserwując stadia rozwoju poszczególnych okazów można dojść do następujących wniosków: 1) Wielkość skorupki nie jest zależna od ilości komór lecz przede wszystkim od wielkości proloculus. Im większy proloculus tym mniej komór u osobników tej samej wielkości, czyli stadium juwenilne generacji mega I lub mega II może mieć tę samą wielkość co stadium dorosłe generacji mikro. 2) U rodzaju *Quinqueloculina*, wytwarzającego dorosłe (lub starcze?) stadium massilinowe, obserwuje się takie gatunki, u których jedynie stadium kwinkwelokulinowe decyduje o przynależności do danego gatunku, gdyż kształty tych massilinowych form mogą być bardzo podobne u różnych gatunków. Można to interpretować dwojako. Albo istnieje rodzaj Massilina, a różne kształty stadium juwenilnego widoczne na przekrojach podobnych form świadczą o ich polifiletycznym pochodzeniu albo rodzaj *Massilina* reprezentuje tylko stadium ontogenetyczne rodzaju *Quinqueloculina*, izomorficzne u różnych gatunków. W pracy przyjęto to drugie stanowisko (patrz część I). 3) U szeregu rodzajów można zaobserwować na przekrojach, że młodociane stadium niektórych gatunków może mieć podobną postać, a cechy indywidualne różnicują się dopiero po utworzeniu kilku początkowych komór (np. u rodzajów *Cycloforina*, *Lachlanella*, *Triloculina*). Wynika stąd, że poza rodzajem *Quinqueloculina*, stadium młodociane u innych rodzajów nie ma zróżnicowanych cech diagnostycznych. 4) W obrębie rodzaju *Sinuloculina* istnieją gatunki, których stadium juwenilne różni się tak od stadium dorosłego, że oba stadia bywają oznaczane jako odrębne gatunki.

Jeżeli chodzi o rozwój kształtu ujścia i zęba, to u niektórych rodzajów, np. u *Varidentella*, *Hauerina*, *Miliola*, są one inne w stadium młodocianym aniżeli w dorosłym.

FORMY POKREWNE

Zaobserwowano, że wśród miliolidów z miocenu Polski można wyróżnić grupy form w obrębie jednego rodzaju, których pokrewieństwo zaznacza się zarówno w podobnej budowie stadium juwenilnego, jak i w pewnych cechach morfologicznych w stadium dorosłym oraz w podobnym charakterze ścianki.

FORMY PRZEJŚCIOWE MIĘDZY RODZAJAMI

Trudności w określeniu niektórych rodzajów miliolidów wynikają głównie z tego powodu, że istnieją gatunki posiadające cechy diagnostyczne „mieszane", nastręczające wątpliwości co do zaliczenia ich do określonych rodzajów. Do takich cech należą głównie kształt ujścia i zęba oraz ilość komór widocznych na zewnątrz. Takie gatunki można traktować jako formy przejściowe między rodzajami, przy czym o przynależności do określonego rodzaju może zadecydować budowa wewnętrzna. Wśród

mioceńskich miliolidów spotyka się formy o cechach przejściowych pomiędzy rodzajami *Quinqueloculina* i *Varidentella*, *Varidentella* i *Cycloforina*, *Cycloforina* i *Sinuloculina*, *Miliolinella* i *Pyrgoella*. Ich obecność świadczy o trudnościach w klasyfikacji i o konieczności dalszych badań nad rozwojem filogenetycznym wielu gatunków.

CZĘŚĆ SYSTEMATYCZNA

Część systematyczna zawiera opisy 103 gatunków i podgatunków, w tym 9 sp. n. i 1 n. nom. Został również wydzielony jeszcze jeden nowy rodzaj *Articularia*, w obrębie rodziny Quinqueloculininae, który różni się od *Articulina* tym, że posiada kwinkwelokulinową, nie płasko spiralną lub nieregularnie miliolinową budowę stadium juwenilnego. Wydzielono także nową podrodzinę Sigmoilinitinae, obejmującą gatunki z sigmoilinowym stadium początkowym, nie kwinkwelokulinowym jak u Quinqueloculininae ani kryptokwinkwelokulinowym jak u Miliolinellinae. Do nowych gatunków należą: *Quinqueloculina alexandri*, *Q. anagallis*, *Q. lentica*, *Q. parakneriana*, *Q. pseudobuchiana*, *Articulina multibullata*, *Cycloforina stomata*, *Siphonaperta ovalis*, *Varidentella georgiana*. Nową nazwę *Miliolinella banatiana* nadano gatunkowi *Miliolinella dilatata* (Karrer), który jest homonimem *M. dilatata* (d'Orbigny).

ЭВА ЛУЧКОВСКА

MILIOLIDAE (FORAMINIFERIDA) ИЗ МИОЦЕНА ПОЛЬШИ ЧАСТЬ II. СТРАТИГРАФИЯ, ПАЛЕОЭКОЛОГИЯ И ОПИСАНИЯ ВИДОВ

Резюме

ВСТУПЛЕНИЕ

Материалы для исследований были добыты в обнажениях и буровых скважинах, расположенных, в основном, в периферической части Предкарпатского прогиба (фиг. 1). Перечень местностей, в которых были взяты образцы на территории Польши, а также местонахождения использованного для сравнения материала из миоцена других стран и из современных морей, указаны в главе п.з. „Материал".

В определении родов в качестве основных таксономических критериев использовались два признака — внутреннее строение и характер устья. Количество наблюдаемых снаружи камер оказалось второстепенным признаком, часто одинаковым у представителей разных родов. Описания видов ограничиваются характеристикой передней стороны, отличающейся большим количеством заметных камер, и профиля, т.е. очертания со стороны устья, играющего роль важного признака в определении видов. Задняя сторона, характеризующаяся меньшим количеством заметных камер, не вносит ничего нового в описания, по сравнению с предыдущими признаками. Объяснение терминологии, применявшейся в описаниях, дано на фигуре. 2. Определения видов автор стремился основывать на материалах из характерных местонахождений или на одновозрастных образованиях смежных районов. В связи с этим названия видов снабжены следующими индексами:

* — вид, определенный на основании сопоставления с голотипом.
× — вид, определенный на основании сопоставления с экземплярами из того же местонахождения и того же горизонта, в которых был найден голотип.
\+ — вид, определенный на основании материалов из другого местонахождения, но из того же региона и того же горизонта, в которых был найден голотип.
= — вид, определенный на основании консультации с автором голотипа.

Изучение морфологических особенностей некоторых видов, их онтогенеза, генерационных признаков и пр. проводилось на поперечных сечениях, вскрывающих эмбриональную камеру и последовательные стадии развития (см. часть I). Сечеиня (аншлифы) изготовлялись в принципе методом, описанным Богдановичем (1952, стр. 49), с некоторым усовершенствованием, позволяющим вести наблюдения по ходу действия под бинокуляром. Производилась схематическая зарисовка всех экземпляров до шлифовки и зарисовка сечений после шлифовки.

СТРАТИГРАФИЯ

Изученные милиолиды были добыты из двух ярусов миоцена — тортонского (баденского) и сарматского. Название „баденский ярус" было предложено Паппом и др. (1968) в отношении пород, относящихся к тортону Венского бассейна, но полностью не эквивалентных тортонскому стратотипу в Италии. В настоящей работе употребляется прежнее название „тортон" для большей четкости и прямой увязки с предыдущими работами автора, однако с оговоркой, что это название относится к тортону *s. l.*

Сообщества милиолид, представленные в разных стратиграфических горизонтах миоцена Польши, отличаются друг от друга. В общем можно отметить, что милиолиды тортонского века коренным образом отличаются от видов, существовавших в сармате. Их распространение в типовых местонахождениях, представляющих разновозрастные образования, и стратиграфические интервалы приведены в таблице I.

Граница между тортоном и сарматом намечается в месте почти полного исчезновения многочисленных тортонских милиолид и появления нового, сарматского вида *Cycloforina stomata*. Богатое распространение этого вида в подошвенных слоях сармата знаменует период между резким исчезновением верхнетортонской микрофауны и постепенным развитием сарматской микрофауны.

ПАЛЕОЭКОЛОГИЯ

Восстановление предполагаемых палеоэкологических условий миоценового моря возможно на основании сопоставления с условиями обитания милиолид в современных морях. Типичными примерами нижнетортонских сообществ милиолид северной прибрежной зоны являются сообщества из местонахождений Карсы и Корытница, для южной зоны — Бенчин, Ивкова, Жегоцина, Пшецишув и Бжозова. Можно предполагать, что они характеризуют условия внутреннего шельфа с теплыми водами и глубиной не более 50—80 м. Значительное разнообразие видов (38) является показателем нормальной солености.

В Величке распространены более молодые отложения, по сравнению с Корытницей. Встречающиеся в этих отложениях милиолиды характеризуют немного

иную, более глубоководную среду, с глубинами порядка 100 и, возможно, даже 200—250 м. Сокращение количества видов свидетельствует об отдалении береговой линии или изменениях химизма морской воды.

В верхнем тортоне соленость моря не отклонялась от нормальной солености, что доказывается обилием родов и видов. В Гливицах Старых — типичном местонахождении прибрежной зоны в западной части водоема представлены сообщества, характеризующие более мелководные условия по сравнению с Величкой, но более глубоководные, чем в Корытницы. По всей вероятности, глубины составляли 100—150 м. Сходные условия господствовали также в южной прибрежной зоне, например в местонахождениях Зглобице, Хелм-на-Рабе, Грабовец, Бжезница и др. В северо-восточной части прибрежной полосы (Венглинек, Богория, Герашовице, Рыбница) и в выступающем далеко на юг заливе (Нискова) залегают отложения одновозрастные, очевидно, с осадками местонахождения Гливице Старе, но определяющие другие условия — теплое, мелководное море инфралиторальной зоны, глубиной порядка 30—50 м, характеризующееся нормальной соленостью.

В низах нижнего сармата распространены сообщества милиолид, характеризующие небольшие глубины, вероятно порядка 30 м. Выше появляются более однообразные сообщества, отмечается массовое распространение некоторых видов, которые характеризуют условия прибрежных барьеров, островов или дельт крупных рек. Условия все больше ухудшались, что выражено сокращением количества видов, уменьшением размеров особей и появлением дегенерированных форм. Эти явления знаменуют, возможно, опреснение моря в конце раннего сармата в восточной части сарматского водоема Польши.

МОРФОЛОГИЯ РАКОВИН

Разнообразие форм раковин милиолид обусловлено тремя факторами: морфологической изменчивостью, диморфизмом и онтогенезом. Эти факторы проявляются неодновременно у отдельных видов, однако все они до некоторой степени взаимосвязаны. Итак, разная величина раковин может отражать наличие особей, представляющих разные онтогенетические стадии, от младенческих до старческих, но также может быть следствием специфических условий среды обитания, обусловивших большее или меньшее развитие раковин у одних и тех же видов. Диморфизм тоже в определенной степени влияет на разнообразие форм. Несмотря на то, что генерации микро и мега I неразличимы на основании величины и формы раковин (часть I, стр. 348 и сечения *Quinqueloculina*), то, однако, генерация мега II может проявляться в виде особей небольшой величины, но обладающих более высокой раковинкой по сравнению с другими генерациями данного вида (например у *Quinqueloculina anagallis*, фиг. 7/5 или *Q. buchiana*, табл. IV, фиг. 2).

Морфологические особенности выражены, главным образом, разными формами раковин (разным удлинением, шириной и округленностью) и скульптурными особенностями (разным количеством ребришек или рубцов или их нали-

чием лишь у некоторых экземпляров данного вида). Важным признаком является также разная форма устья и зуба, особенно у таких родов как *Cycloforina*, *Miliolinella*, *Pyrgo*, *Pyrgoella*, *Varidentella*. Очень редко встречаются виды, у которых морфологические признаки изменяются в незначительной степени.

ОНТОГЕНЕЗ

Наблюдения сечений ряда форм разных видов в порядке от младенческих стадий по взрослые или старческие, или же изучение стадий развития отдельных экземпляров позволяет сделать следующие заключения:

1) Величина раковины не зависит от количества камер и обусловлена, прежде всего, величиной начальной камеры. Чем больше начальная камера, тем меньше камер у особей одинаковой величины. Следовательно, младенческая стадия генерации мега I или мега II может иметь такую же величину, как и взрослая стадия генерации микро. 2) В составе рода *Quinqueloculina*, образующего взрослую (или старческую?) массилиновую стадию, наблюдаются такие виды, у которых единственно квинквелокулиновая стадия является решающим признаком принадлежности к данному виду, так как формы массилиновых стадий могут быть весьма сходны у разных видов. Это можно рассматривать двояко: либо существует род *Massilina*, а разные формы младенческой стадии, наблюдающиеся на сечениях сходных форм, свидетельствуют о их полифилетическом происхождении, либо же род *Massilina* представляет лишь онтогенетическую стадию рода *Quinqueloculina*, изоморфную у разных видов. В работе принята вторая точка зрения (см. часть I). 3) На сечениях экземпляров ряда родов можно наблюдать, что младенческая стадия некоторых видов имеет сходный облик, а индивидуальные признаки проявляются только лишь после сформирования нескольких начальных камер (например, роды *Cycloforina*, *Lachlanella*, *Triloculina*). Отсюда следует, что за исключением рода *Quinqueloculina* младенческая стадия других родов лишена индивидуальных диагностических признаков. 4) Внутри рода *Sinuloculina* присутствуют виды, младенческая стадия которых настолько отличается от взрослой стадии, что их принимают в качестве разных видов.

Что касается формы устья и зуба, то у некоторых родов, например у *Varidentella*, *Hauerina*, *Miliola* они имеют разный вид в младенческой и взрослой стадиях.

РОДСТВЕННЫЕ ФОРМЫ

Наблюдения показали, что среди милиолид миоцена Польши можно заметить такие группы форм внутри одного рода, родственная связь которых выражена так сходным строением младенческой стадии, как и некоторыми морфологическими признаками взрослой стадии, а также сходным типом стенки.

ПРОМЕЖУТОЧНЫЕ ФОРМЫ МЕЖДУ РОДАМИ

Трудность определения некоторых родов милиолид обусловлена, в основном, тем, что существуют виды со „смешанными" диагностическими признаками, вызывающими неуверенность в отнесении их к определенному роду. К таким при-

знакам относятся, прежде всего, форма устья и зуба и количество камер, наблюдающихся снаружи. Такие виды можно рассматривать в качестве промежуточных форм между отдельными родами, а решающее значение в определении принадлежности к определенному роду имеет внутреннее строение. Среди миоценовых милиолид встречаются промежуточные формы между родами *Quinqueloculina* и *Varidentella*, *Varidentella* и *Cycloforina*, *Cycloforina* и *Sinuloculina*, *Miliolinella* и *Pyrgoella*. Присутствие таких форм значительно затрудняет классификацию и требует дальнейшего изучения филогенетической эволюции многих видов.

СИСТЕМАТИЧЕСКАЯ ЧАСТЬ

В систематической части представлены описания 103 видов и их подвидов, в том числе 9 sp. n. и 1 n. nom. Определен также новый род *Articularia* внутри семейства Quinqueloculininae, отличающийся от *Articulina* тем, что имеет квинквелокулиновое, не плоскоспиральное или нерегулярно милиолиновое строение младенческой стадии. Определено также новое подсемейство Sigmoilinitinae, охватывающее виды с сигмоилиновой начальной стадией, не квинквелокулиновой, как у Quinqueloculininae и не криптоквинквелокулиновой, как у Miliolinellinae. К новым видам относятся: *Quinqueloculina alexandri*, *Q. anagallis*, *Q. lentica*, *Q. parakneriana*, *Q. pseudobuchiana*, *Articulina multibullata*, *Cycloforina stomata*, *Siphonaperta ovalis*, *Varidentella georgiana*. Новое название — *Miliolinella banatiana* присвоено виду *Miliolinella dilatata* (Karrer), который является гомонином *M. dilatata* (d'Orbigny).

EXPLANATION OF PLATES

Plate I

Figs 1-3. *Quinqueloculina anagallis* sp. n. Lower Tortonian, Karsy near Jędrzejów; *1* — MS, with smooth penultimate chamber (F-103/3) paratype; *2* — MS, holotype (F-103/2); *3* — QS, paratype (F-103/1); × 36. Page 40
a, *c* — opposite sides, *b* — apertural view.

Plate II

Figs 1, 2. *Quinqueloculina peregrina* d'Orbigny. Lower Tortonian, Korytnica near Jędrzejów; *1* — MS, 5-chambered form (F-110/2); *2* — QS, (F-110/1); × 36. Page 57

Fig. 3. *Quinqueloculina dichotoma* Reuss. Lower Tortonian, Korytnica near Jędrzejów; MS (F-106/3); × 36. Page 49
a, *c* — opposite sides, *b* — apertural view.

Plate III

Figs 1, 2. *Quinqueloculina dichotoma* Reuss. Lower Tortonian, Karsy near Jędrzejów; *1* — QS (F-106/1); *2* — MS, 5-chambered form (F-106/2); × 36. Page 49

Figs 3, 4. *Quinqueloculina haidingeri* d'Orbigny. Lower Tortonian, Wieliczka; *3* — QS (F-107/1); *4* — MS (F-107/2); × 36. Page 51
a, *c* — opposite sides, *b* — apertural view.

Plate IV

Figs 1-3. *Quinqueloculina buchiana* d'Orbigny. Lower Tortonian, Korytnica near Jędrzejów; *1* — QS, mega I generation (F-105/1); × 36; *2* — QS, mega II geneneration (F-105/2), × 60; *3* — MS (F-105/3), × 36. Page 45
Fig. 4. *Quinqueloculina buchiana* d'Orbigny. Lower Tortonian, Grabki Duże N-8 borehole, depth 198.8-199.8 m; QS (F-105/4); × 42. Page 45
Fig. 5. *Quinqueloculina pseudobuchiana* sp. n. Lower Tortonian, Korytnica near Jędrzejów; QS, paratype (F-111/1); × 36. Page 58
a, *c* — opposite sides, *b* — apertural view.

Plate V

Figs 1, 2. *Quinqueloculina pseudobuchiana* sp. n. Lower Tortonian, Korytnica near Jędrzejów; *1* — QS, paratype (F-111/2); *2* — MS, holotype (F-111/3); × 36. Page 58
Figs 3, 4. *Quinqueloculina bogdanowiczi* (Serova). Upper Tortonian, Węglinek; *3* — QS (F-104/1); *4* — MS (F-104/2); × 42. Page 43
a, *c* — opposite sides, *b* — apertural view.

Plate VI

Figs 1-3. *Quinqueloculina lentica* sp. n. Lower Tortonian, Korytnica near Jędrzejów; *1* — QS, paratype (F-108/1); *2* — MS, 5-chambered form, holotype (F-108/2); *3* — MS, 3-chambered form, paratype (F-108/3); × 36. Page 54
a, *c* — opposite sides, *b* — apertural view.

Plate VII

Figs 1-4. *Quinqueloculina parakneriana* sp. n. Lower Tortonian, Korytnica near Jędrzejów; *1* — QS, juvenile specimen, paratype (F-109/1); *2* — QS, paratype (F-109/2); *3* — MS, 5-chambered form paratype (F-109/3); *4* — MS, holotype (F-109/4); × 36. Page 56
a, *c* — opposite sides, *b* — apertural view.

Plate VIII

Figs 1-3. *Quinqueloculina akneriana* d'Orbigny. Lower Tortonian, Wieliczka; *1* — QS („*Quinqueloculina akneriana* d'Orbigny"), (F-101/1), × 42; *2* — QS, transitional form (F-101/2), × 36; *3* — MS („*Quinqueloculina pauperata* d'Orbigny"), (F-101/3), × 36. Page 35
Figs 4, 5. *Quinqueloculina triangularis* d'Orbigny. Lower Tortonian, Wieliczka; *4* — QS („*Quinqueloculina triangularis* d'Orbigny"), (F-115/1), × 42; *5* — QS, mega II generation (F-115/2), × 36. Page 63
a, *c* — opposite sides, *b* — apertural view.

Plate IX

Fig. 1. *Quinqueloculina triangularis* d'Orbigny. Lower Tortonian, Wieliczka; MS („*Massilina podolica* Didkovsky"), (F-115/3); × 36. Page 63

Figs 2, 3. *Quinqueloculina alexandri* sp. n. Lower Tortonian, Korytnica near Jędrzejów; *2* — QS, paratype (F-102/1); *3* — MS, holotype (F-102/2); × 42. Page 38
a, *c* — opposite sides, *b* — apertural view.

Plate X

Fig. 1. *Quinqueloculina spondiungeriana* (Serova). Upper Tortonian, Węglinek; QS (F-114/1); × 42. Page 62

Figs 2, 3. *Lachlanella incrassata* (Karrer). Lower Tortonian, Korytnica near Jędrzejów; *2* — form with angular periphery, distinctly striated (F-147/1); *3* — form with sligthly rounded periphery, weakly striated (F-147/2); × 36. Page 93

Fig. 4. *Lachlanella schroekingeri* (Karrer). Lower Tortonian, Grabki Duże N-8 borehole, depth 198.8-199.8 m; (F-148/1); × 42. Page 94

Fig. 5. *Lachlanella undosa* (Karrer). Upper Tortonian, Węglinek; (F-149/1); × 60. Page 95
a, *c* — opposite sides, *b* — apertural view.

Plate XI

Fig. 1. *Cycloforina lachesis* (Karrer). Lower Tortonian, Korytnica near Jędrzejów (F-132/1). Page 82

Figs 2, 3. *Cycloforina contorta* (d'Orbigny). Upper Tortonian, Gliwice Stare; *2* — specimen with S-shaped edges (F-150/2); *3* — specimen with rounded edges (F-150/3). Page 74

Fig. 4. *Cycloforina reticulata* (Karrer). Lower Tortonian, Karsy near Jędrzejów; (F-135/1). Page 84

Fig. 5. *Cycloforina badenensis* (d'Orbigny). Lower Tortonian, Korytnica near Jędrzejów; (F-124/1). Page 73
a, *c* — opposite sides, *b* — apertural view.
all figures × 60.

Plate XII

Fig. 1 *Cycloforina hauerina* (d'Orbigny). Upper Tortonian, Węglinek; (F-130/1). Page 79

Fig. 2. *Cycloforina suturata* (Śmigielska). Upper Tortonian, Gliwice Stare; (F-193/1) Page 87

Fig. 3. *Cycloforina gracilis* (Karrer), Upper Tortonian, Gliwice Stare; (F-128/1) Page 77

Fig. 4. *Cycloforina lucida* (Karrer). Upper Tortonian, Gliwice Stare; (F-133/1) Page 82

Fig. 5. *Cycloforina suturalis* (Reuss). Lower Tortonian, Wieliczka; (F-137/1); × 98. Page 86
a, *c* — opposite sides, *b* — apertural view,
all figures × 60, except Fig. 5.

Plate XIII

Figs 1, 2. *Cycloforina karreri ovata* (Serova). Lower Sarmatian, Zrecze-3 borehole, depth 11 m; *1* — specimens with shorter neck (F-131/1); *2* — specimen with extended neck (F-131/2). Page 80

Fig. 3. *Cycloforina toreuma* (Serova). Lower Sarmatian, Zrecze-3 borehole, depth 64.0-64.9 m; (F-139/1). Page 87

Fig. 4. *Cycloforina fluviata* (Venglinsky). Lower Sarmatian, Zrecze-3 borehole, depth 11 m; (F-136/1). Page 76

Fig. 5. *Cycloforina stomata* sp. n. Lower Sarmatian, Budy-1 borehole, depth 212.7-212.8 m; holotype (F-136/1). Page 85

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a, *c* — opposite sides, *b* — apertural view,
all figures × 68, except Fig. 10.

Plate XIV

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a — front view, *b* — apertural view,
all figures × 60.

Plate XV

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Fig. 4. *Sigmoilopsis foeda* (Reuss). Lower Tortonian, Wieliczka; topotype (F-152/4); × 60. Page 99

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a, *c* — opposite sides, *b* — apertural view.

Plate XVI

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Fig. 16. *Articulina nodosaroides* (Karrer). Lower Tortonian, Karsy near Jędrzejów; specimen with initial part broken (F-119/2). Page 70

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a, c — opposite sides, *b* — apertural view,
all figures × 68.

Plate XVII

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a, c — opposite sides, *b* — apertural view.

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Plate XVIII

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Fig. 4. *Hauerina podolica* Serova. Upper Tortonian, Węglinek; (F-145/2). Page 92

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a, *c* — opposite sides, *b* — apertural view, all figures × 98.

Plate XX

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a, *c* — opposite sides, *b* — apertural view, all figures × 60.

Plate XXI

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a, *c* — opposite sides, *b* — apertural view,
all figures × 60.

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all figures × 60.

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a, *c* — opposite sides, *b* — apertural view,
all figures except Fig 2 × 60.

Plate XXIV

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a, *c* — opposite sides, *b* — apertural view,
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Plate XXV

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a, *c* — opposite sides, *b* — apertural view,
all figures except Fig. 8 × 60.

Plate XXVI

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a, *c* — opposite sides, *b* — apertural view.

Plate XXVII

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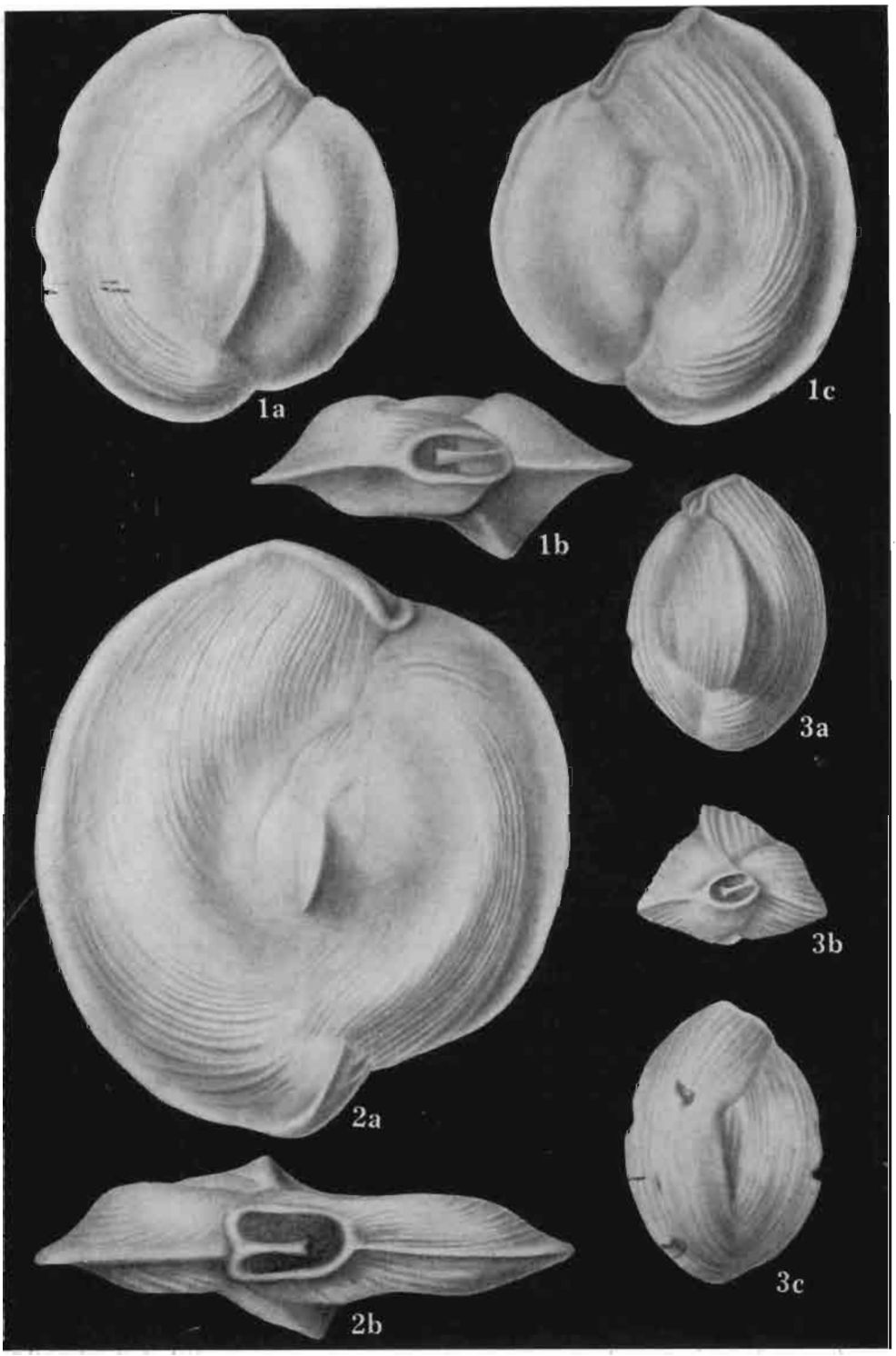
a, *c* — opposite sides, *b* — apertural view.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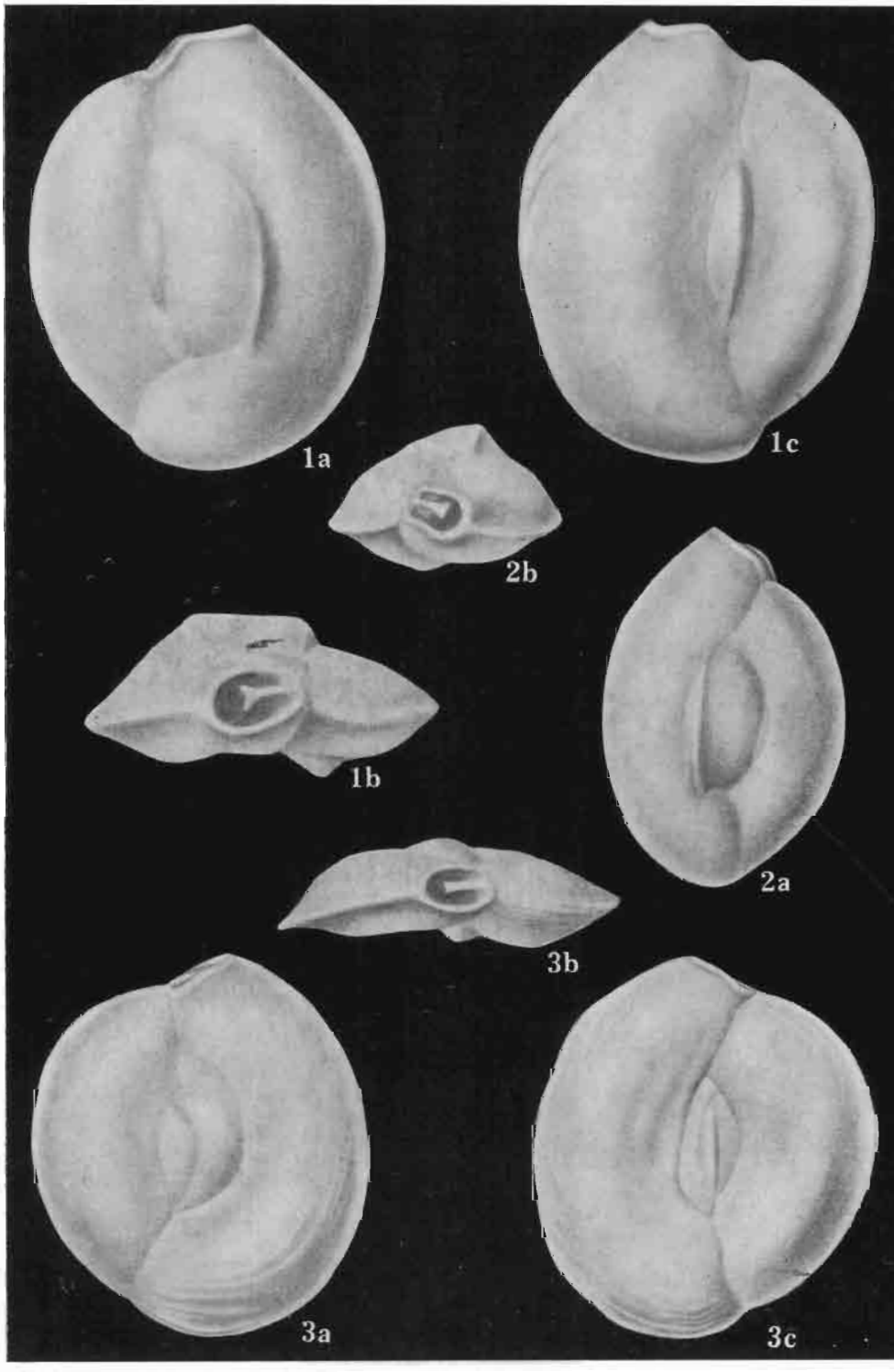
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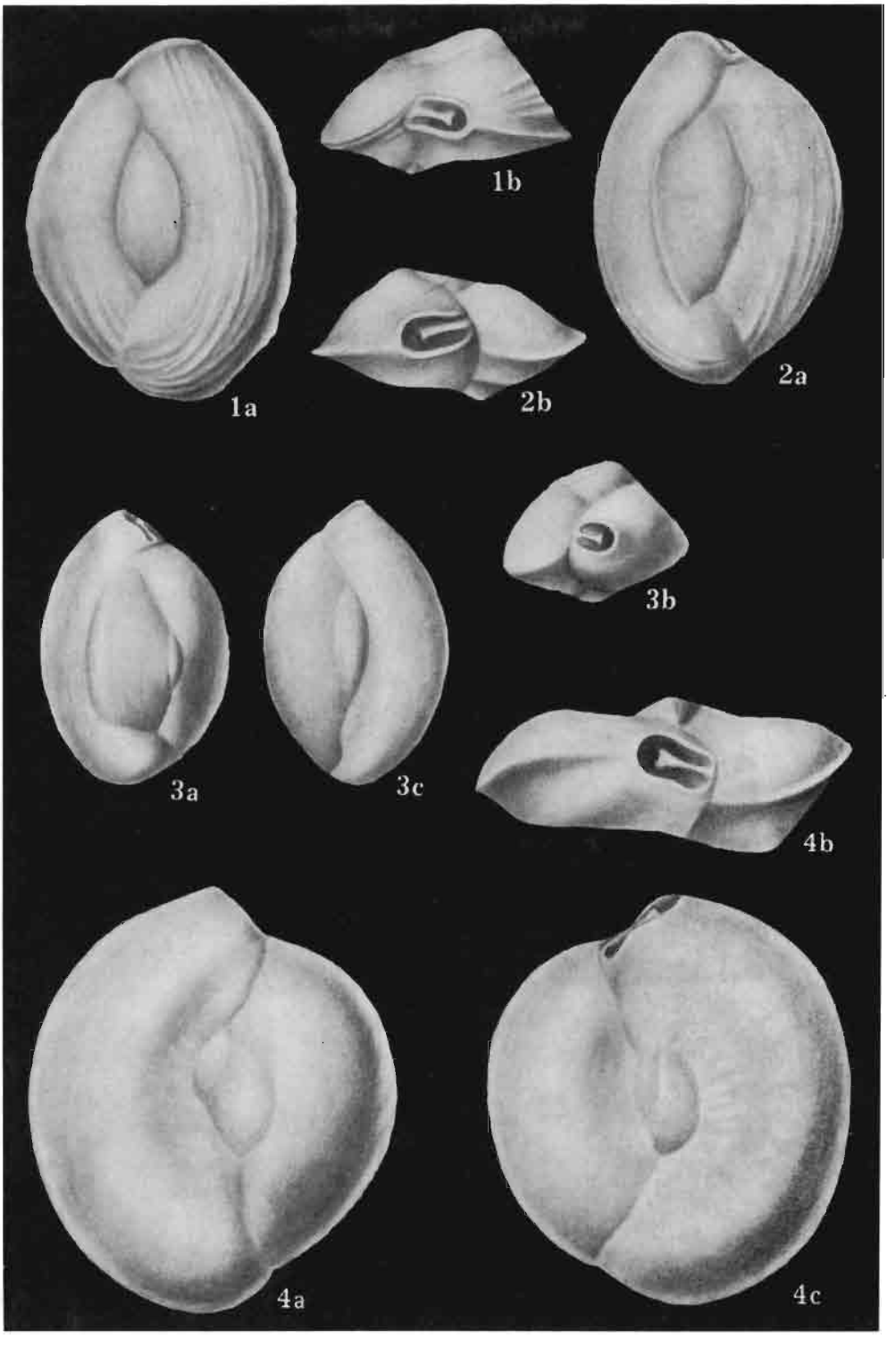
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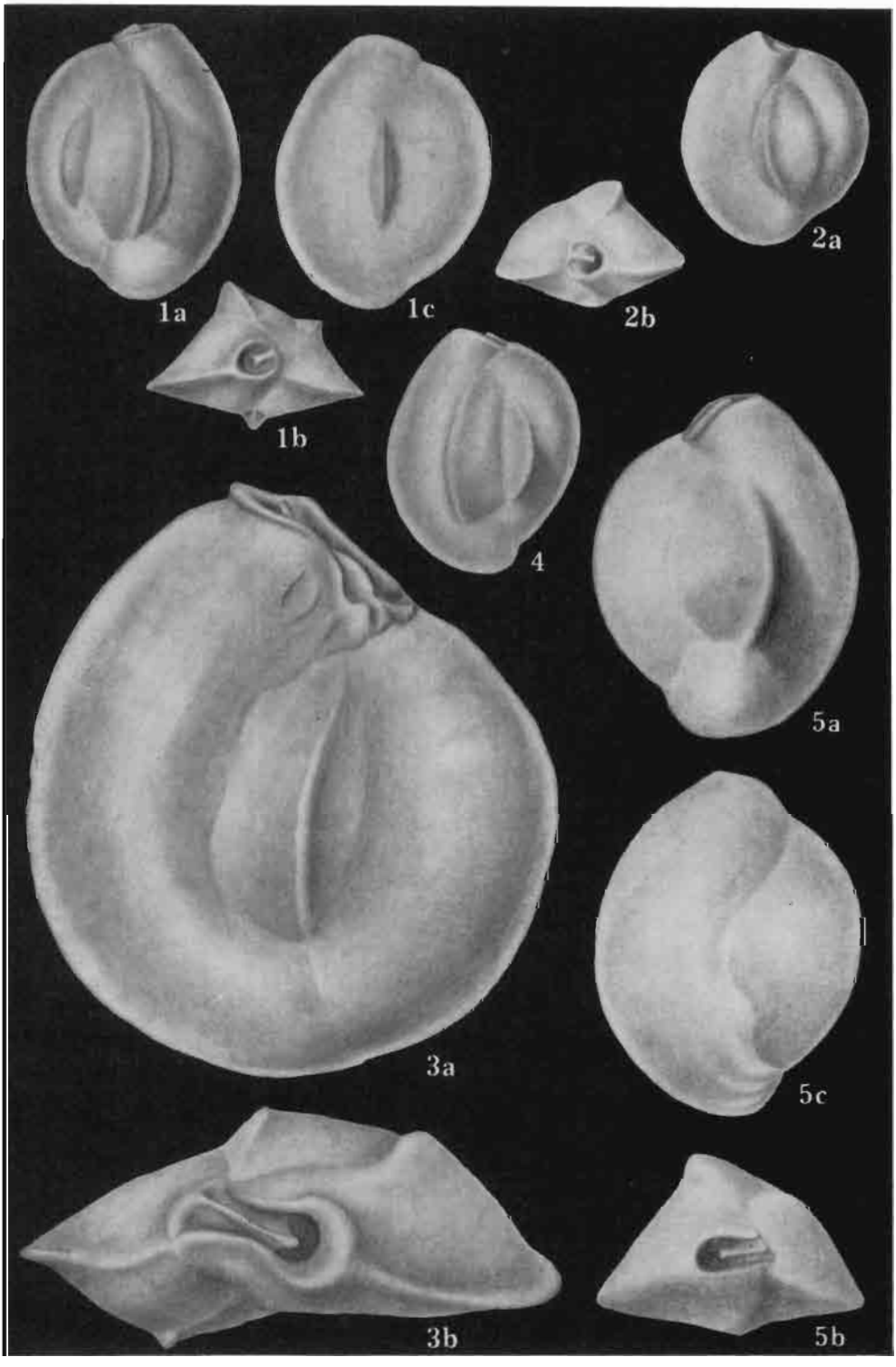
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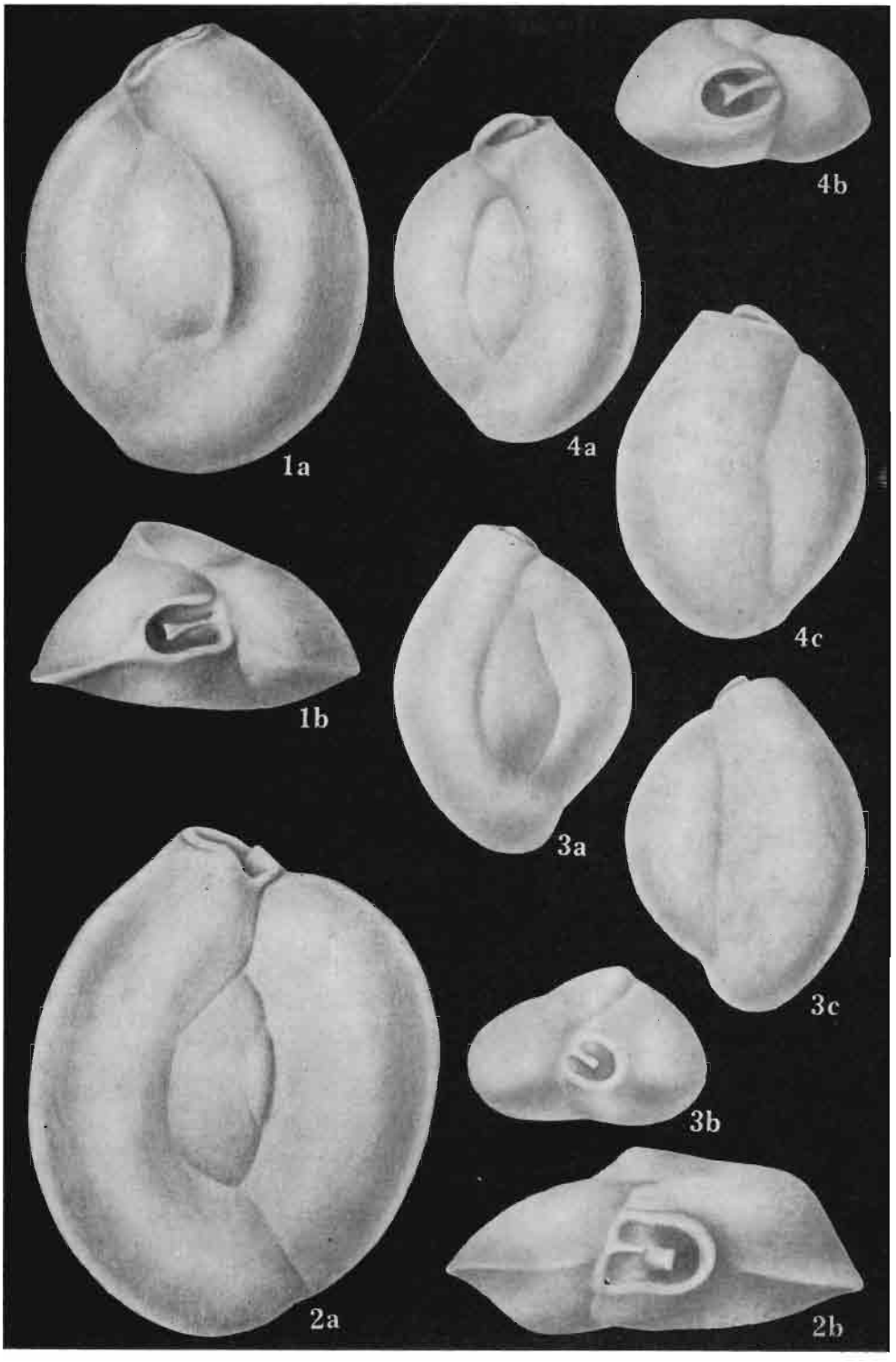
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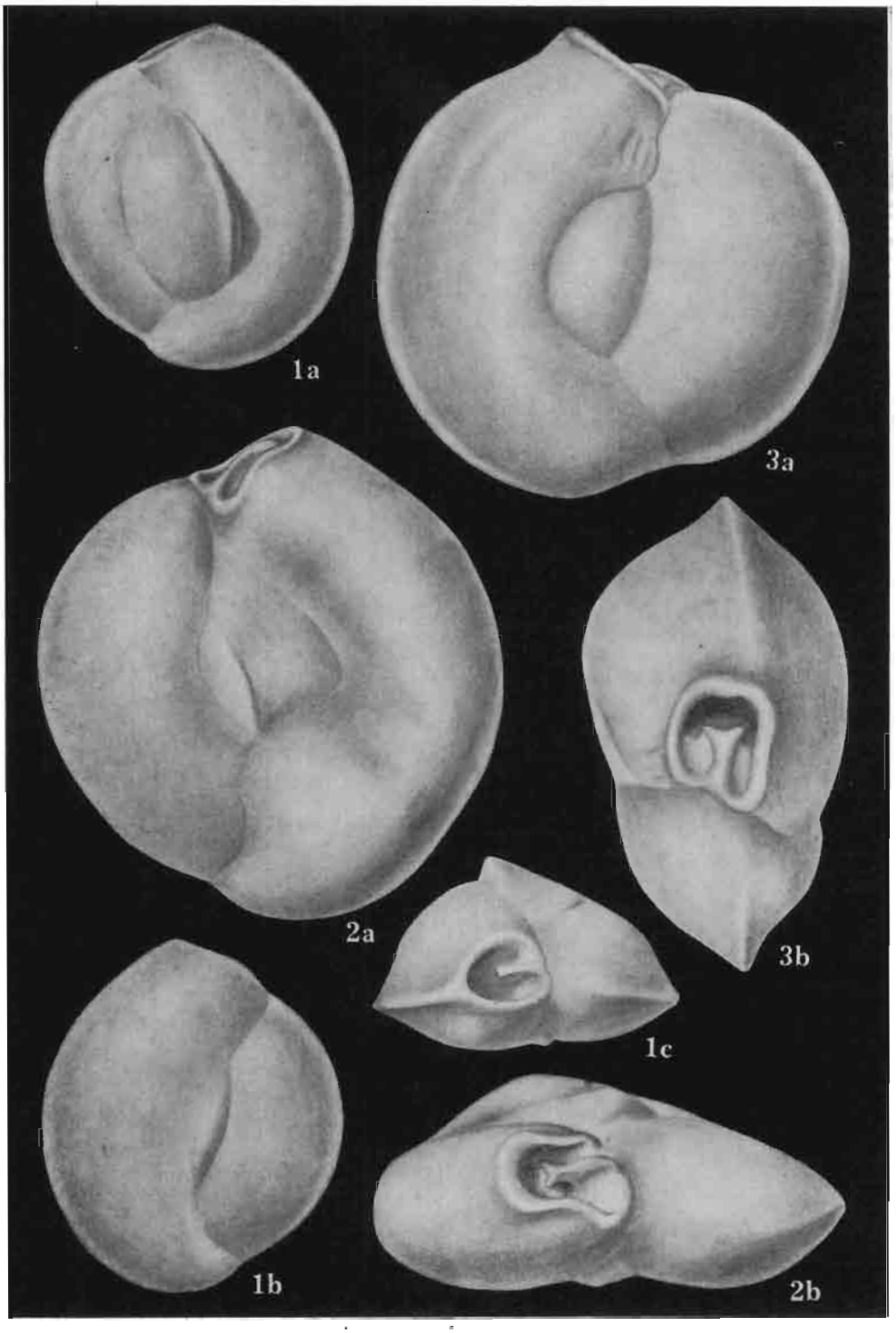
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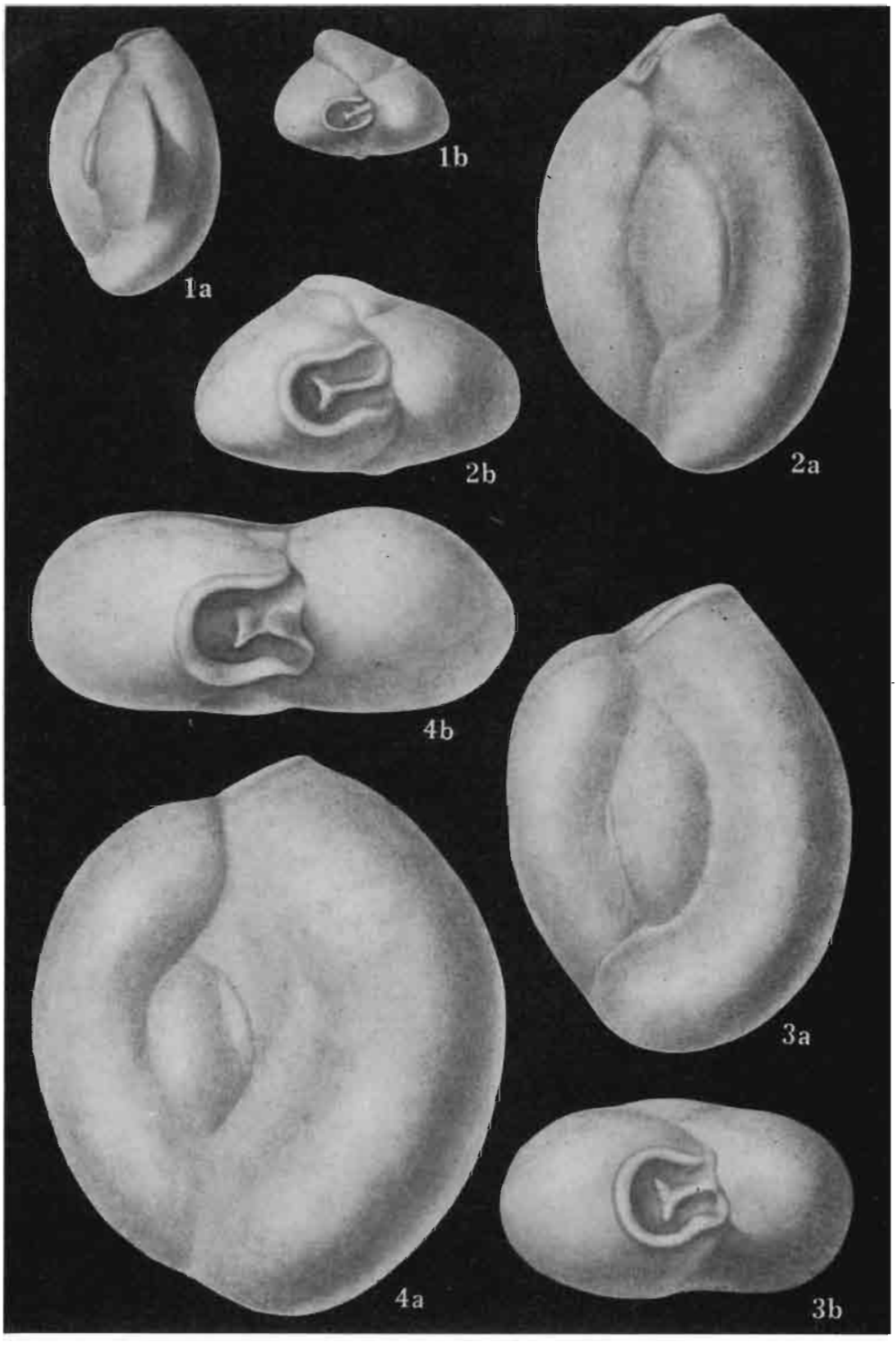
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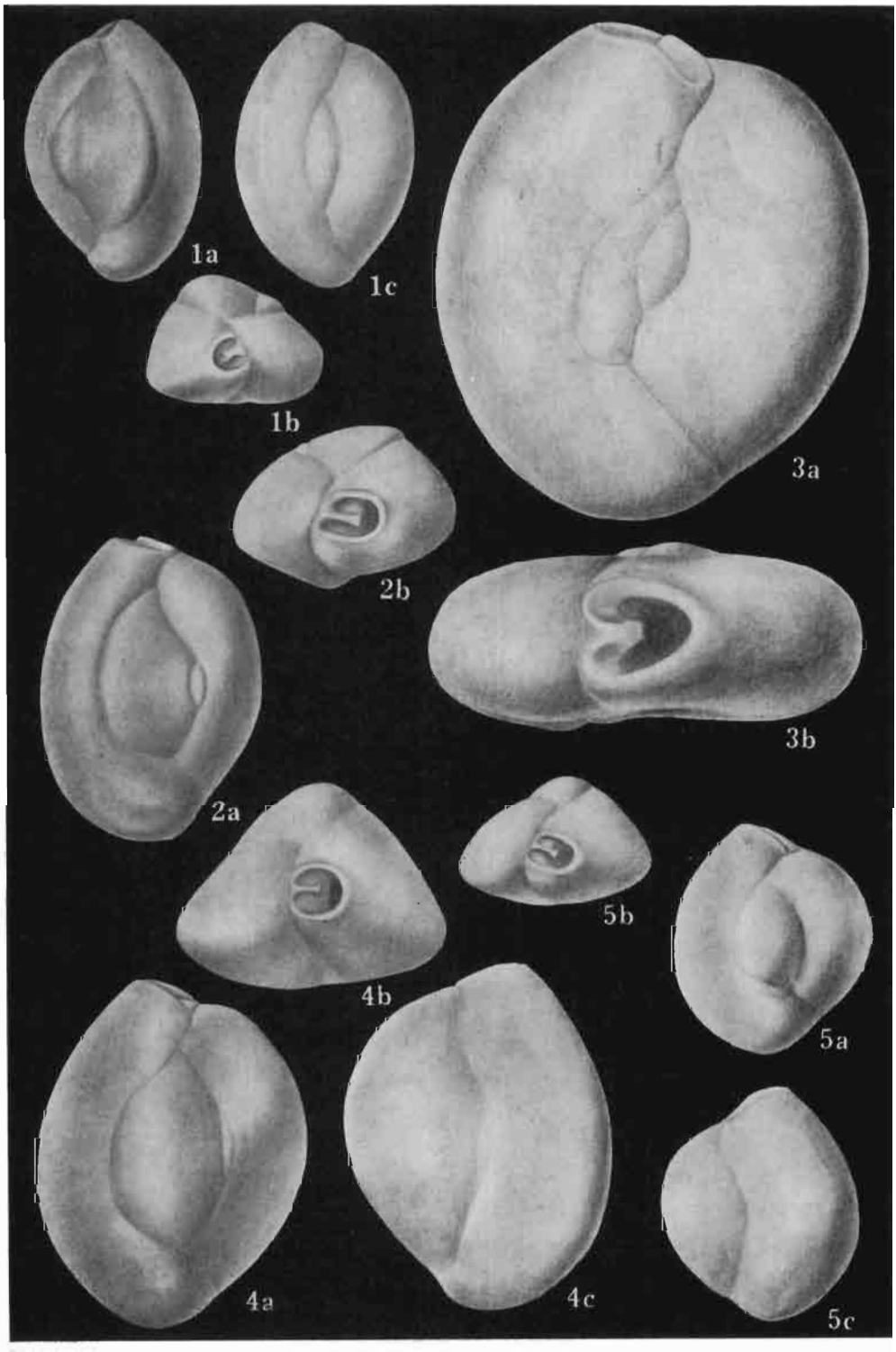
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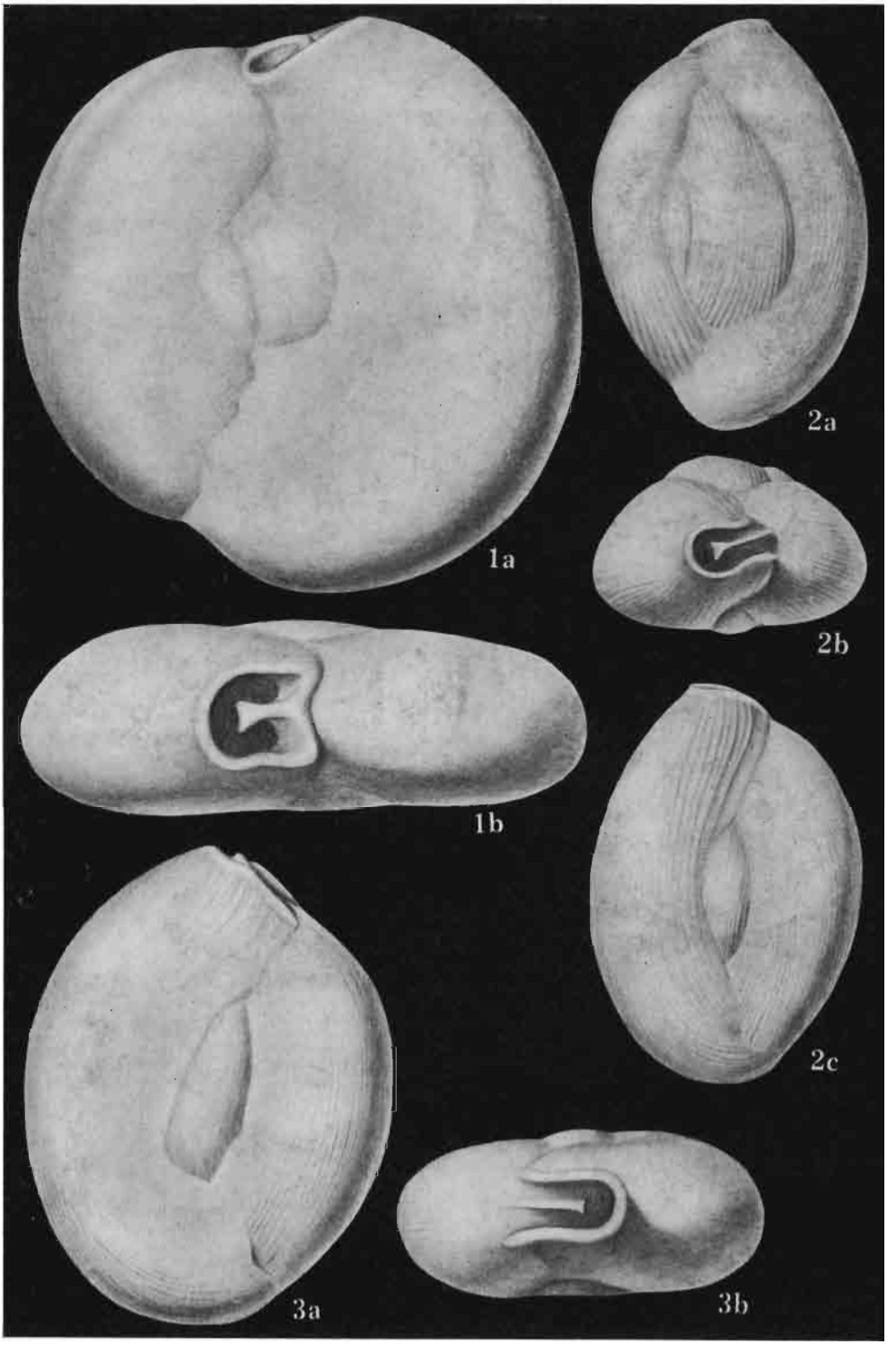
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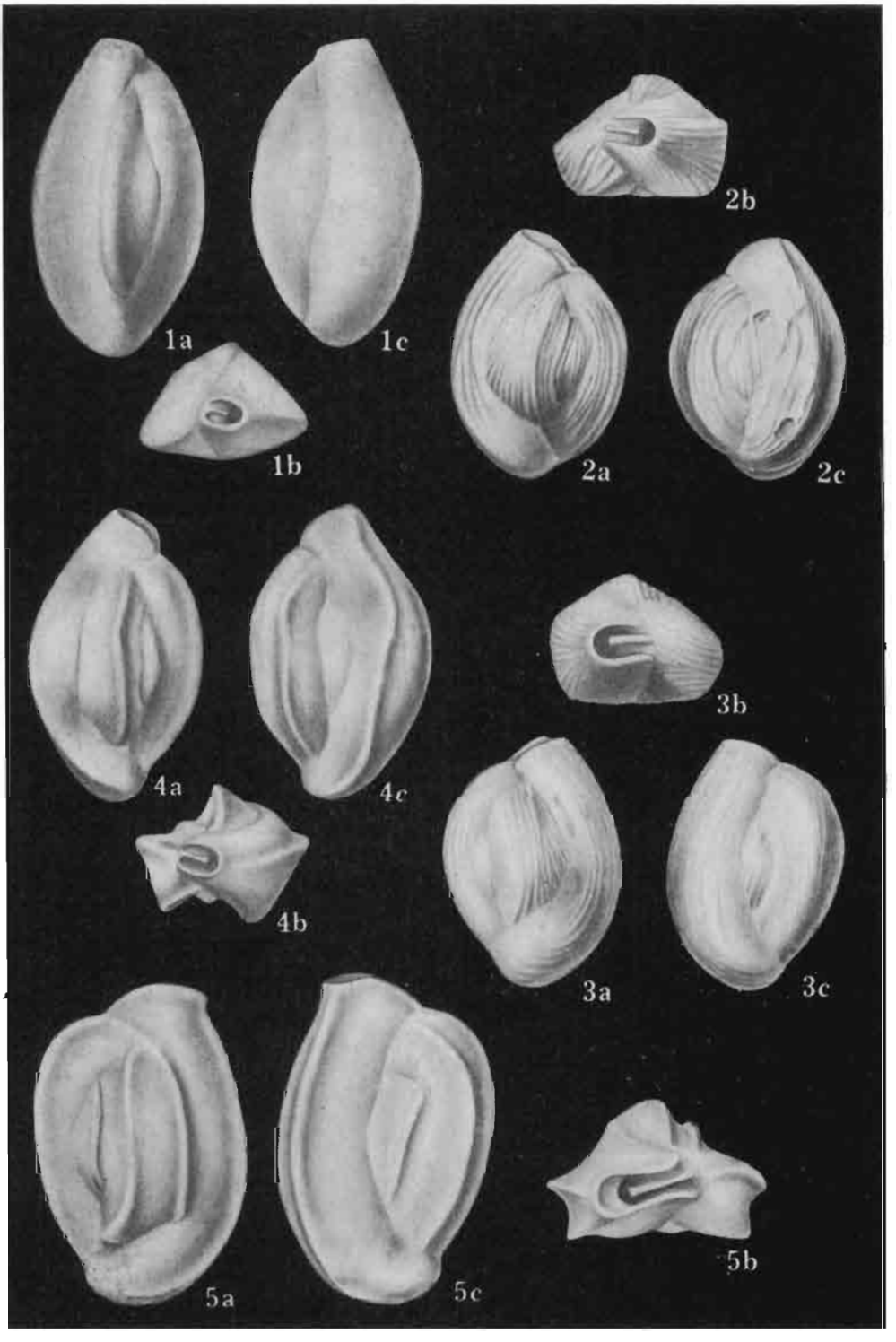
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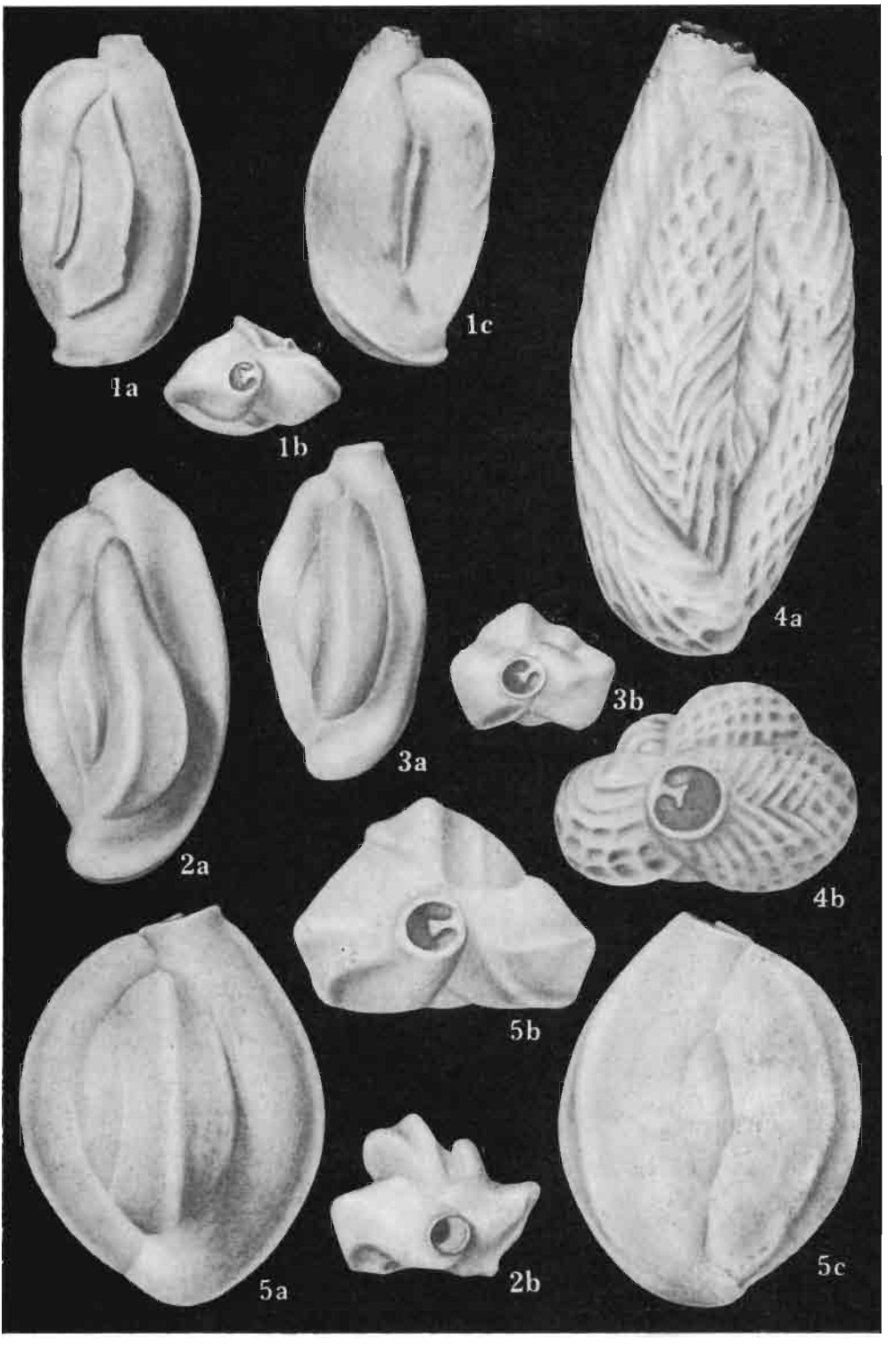
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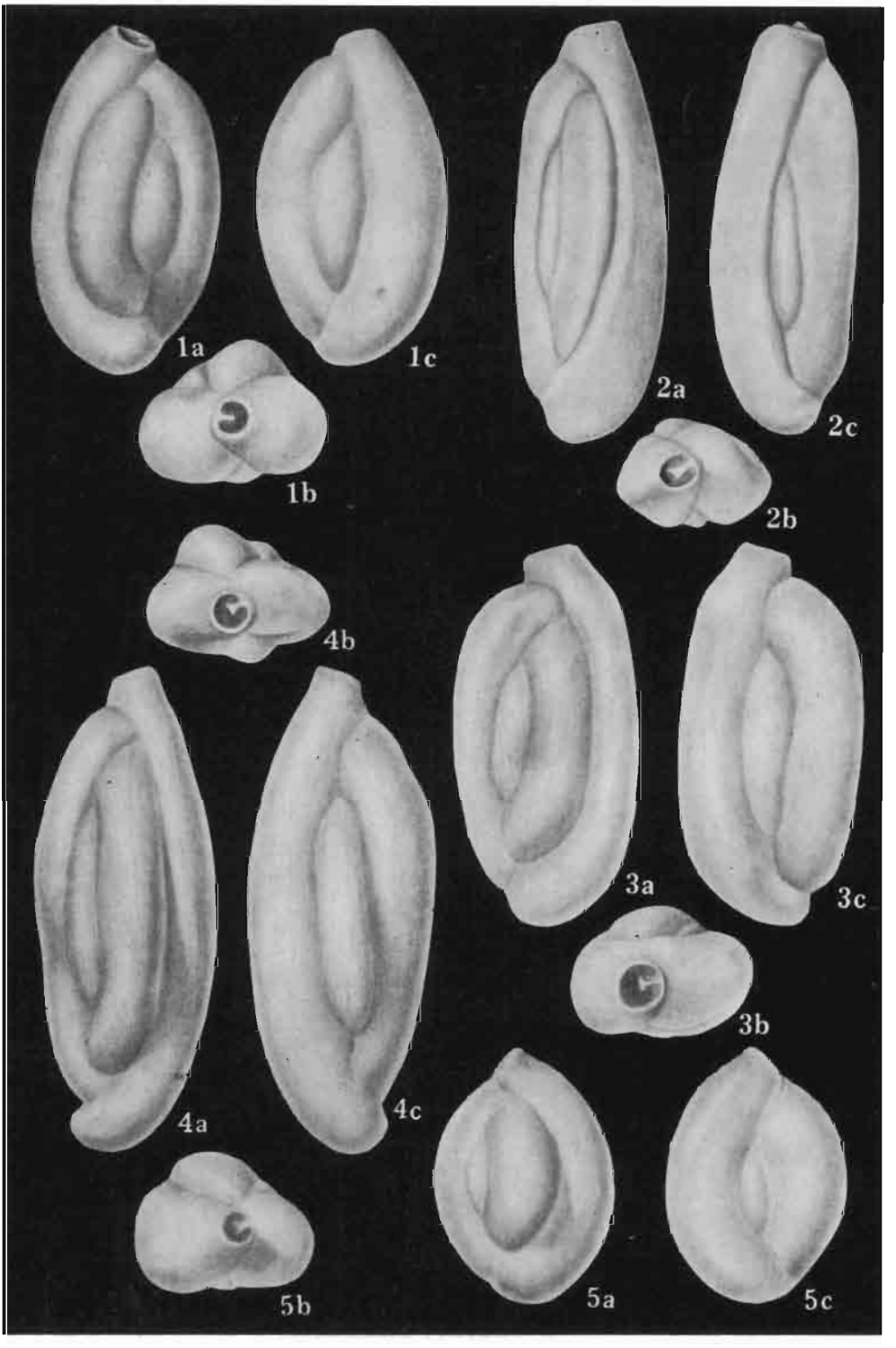
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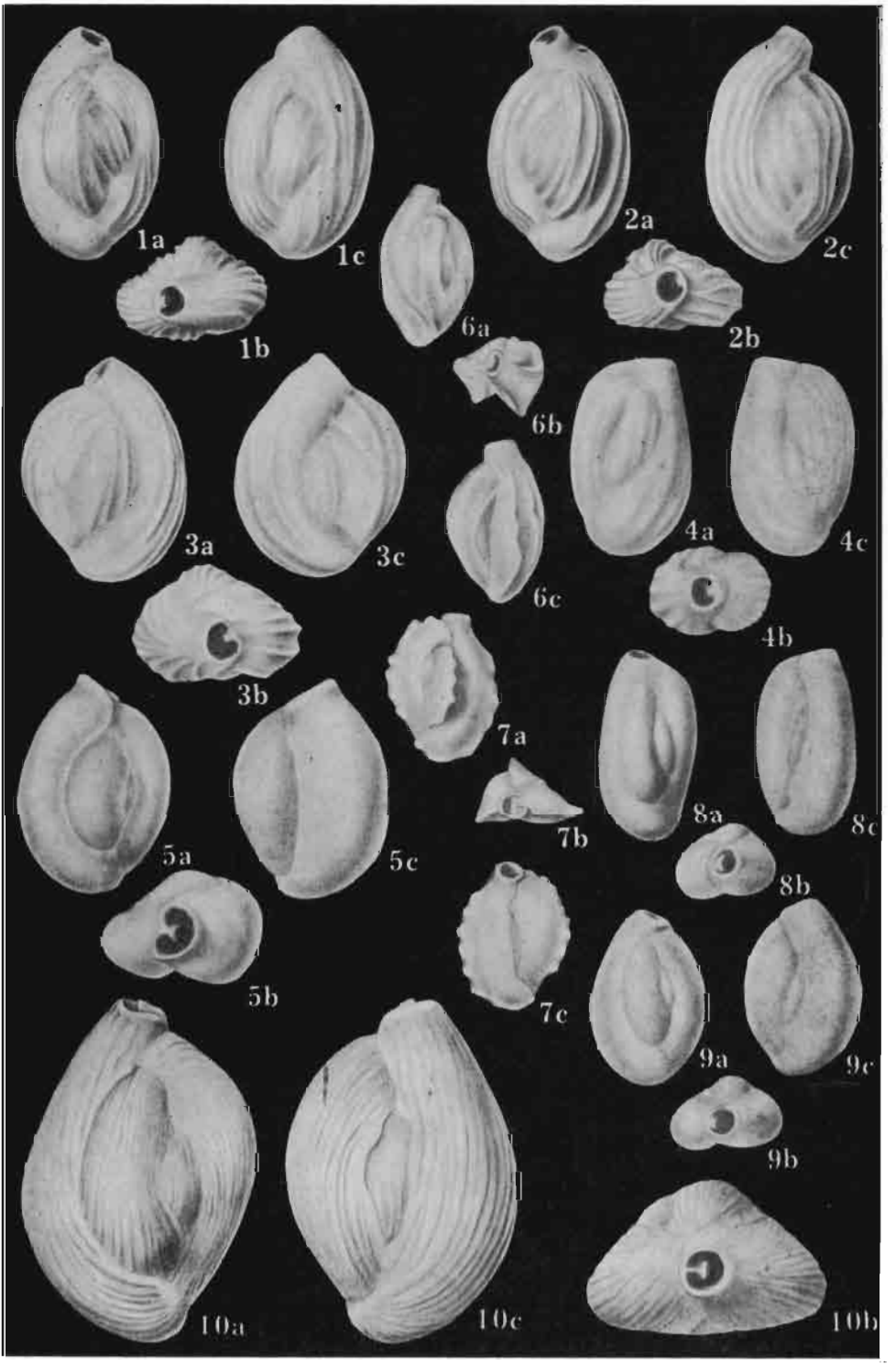
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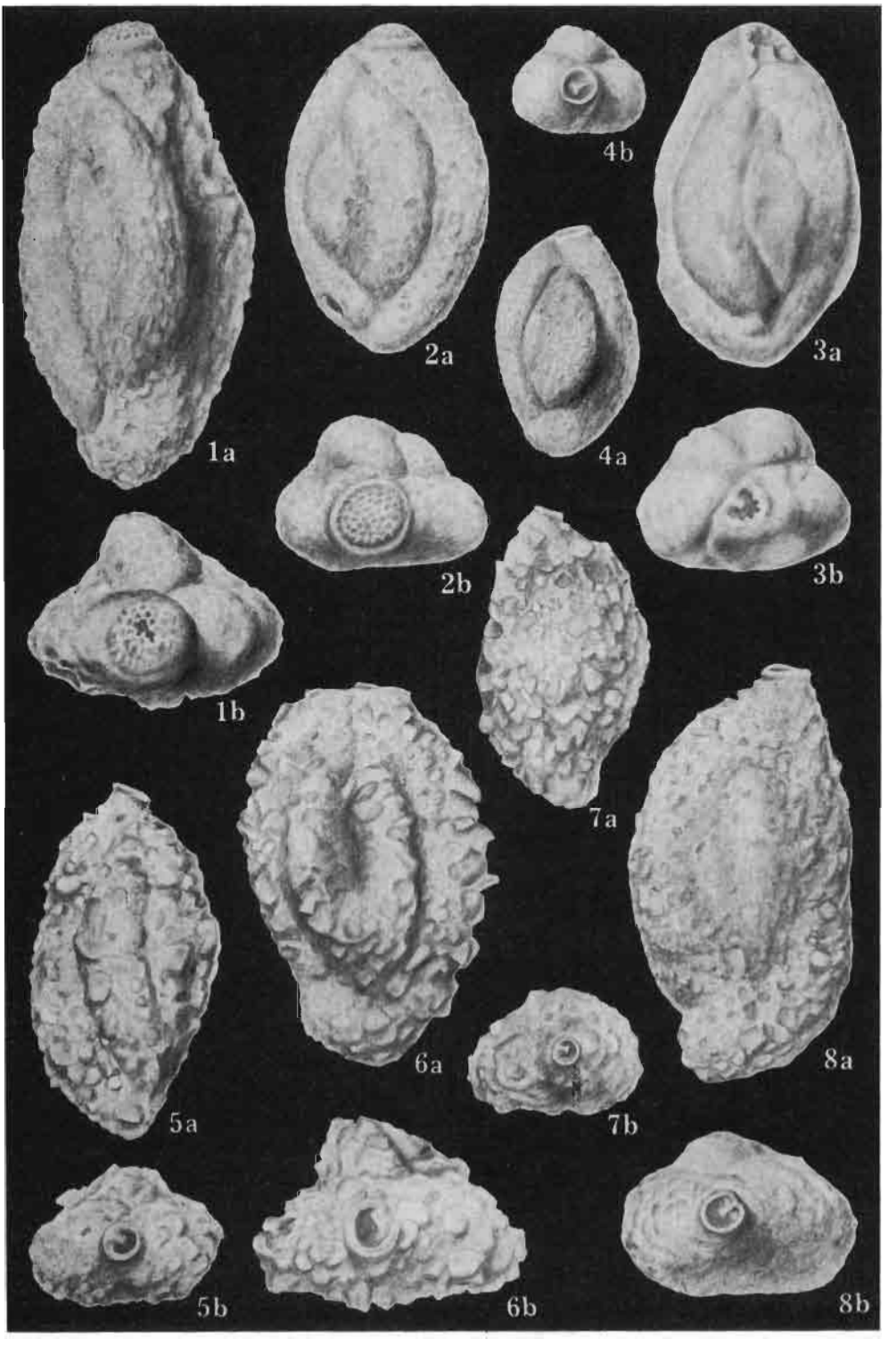
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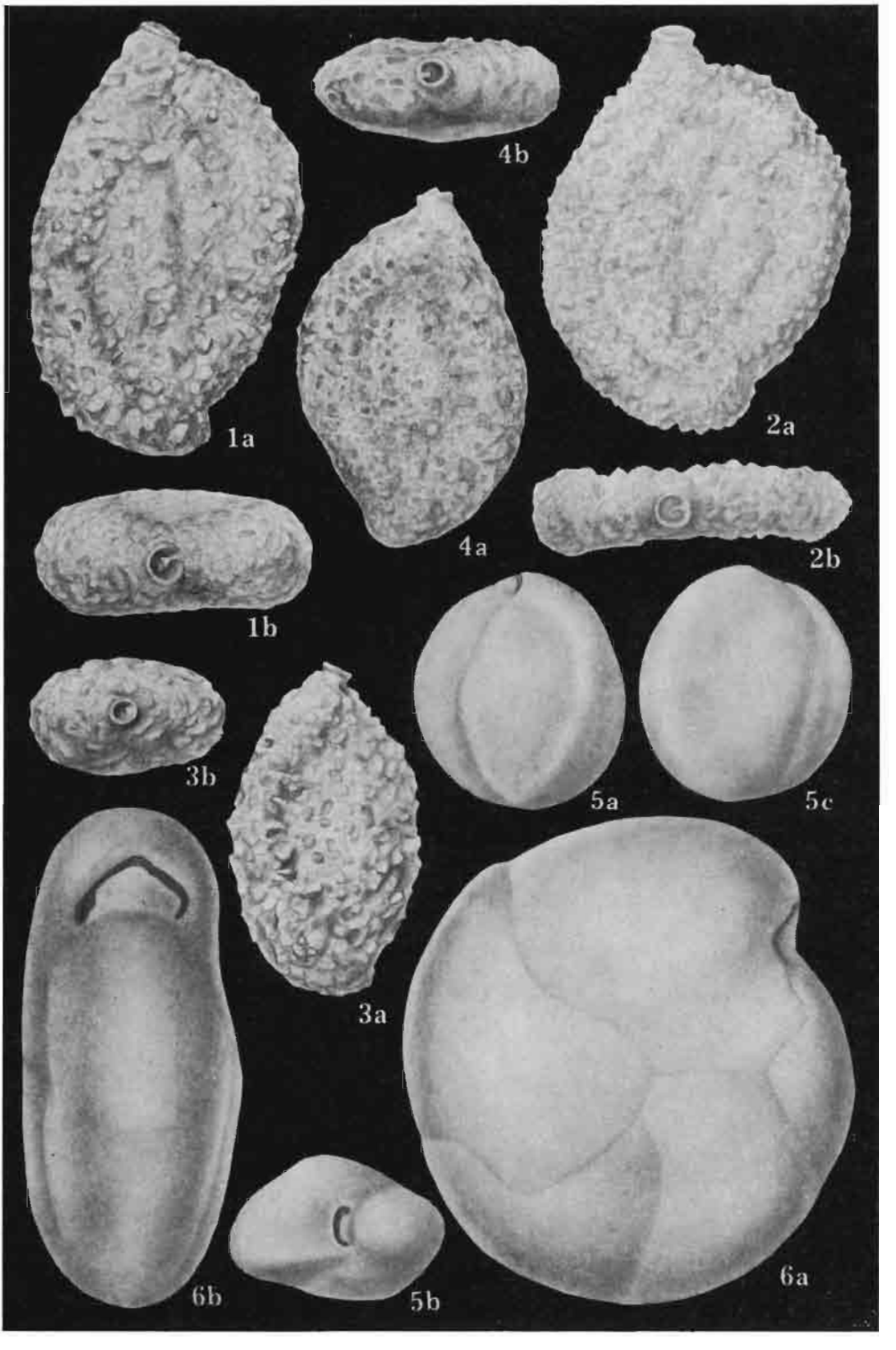
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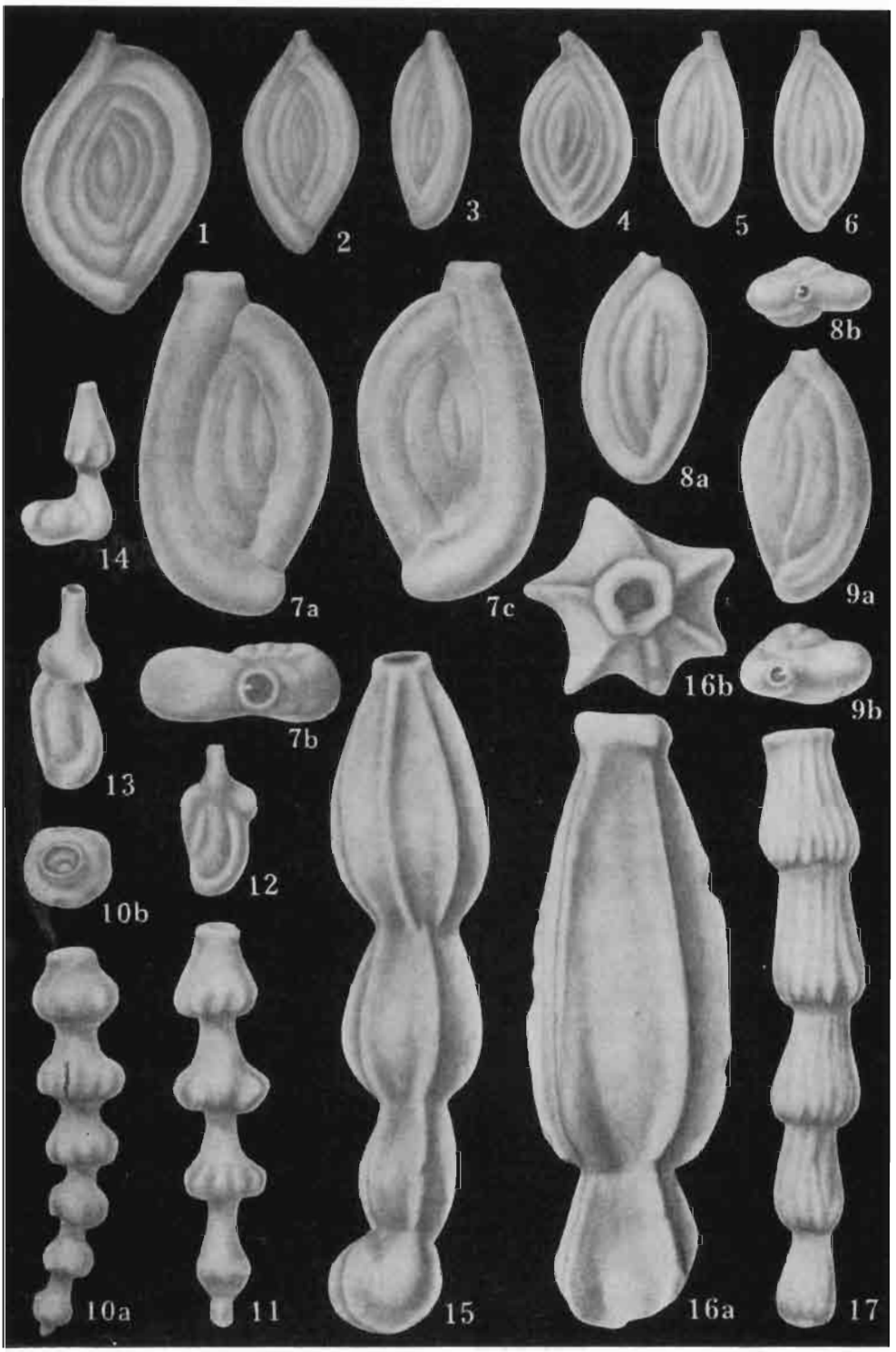
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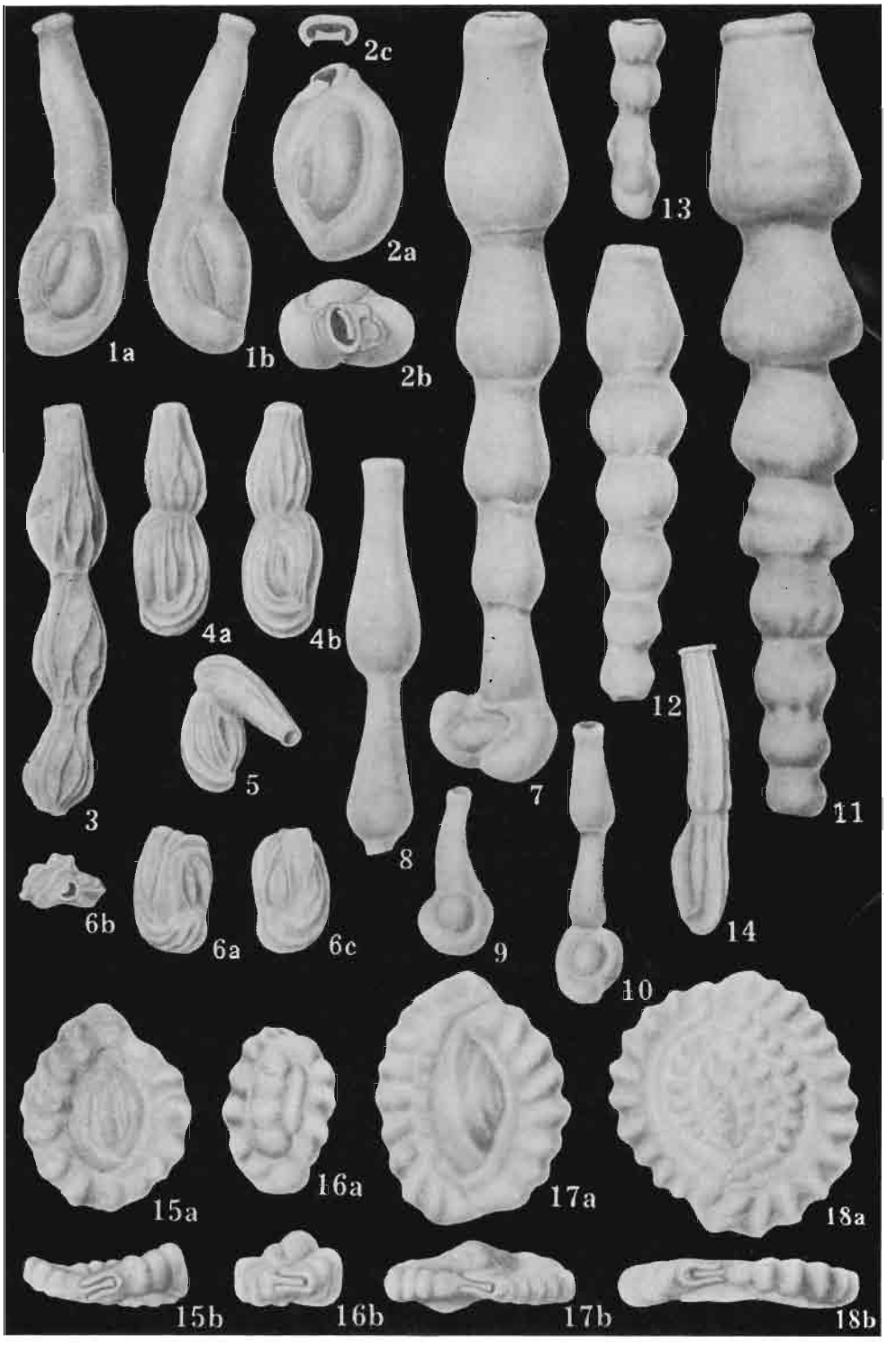
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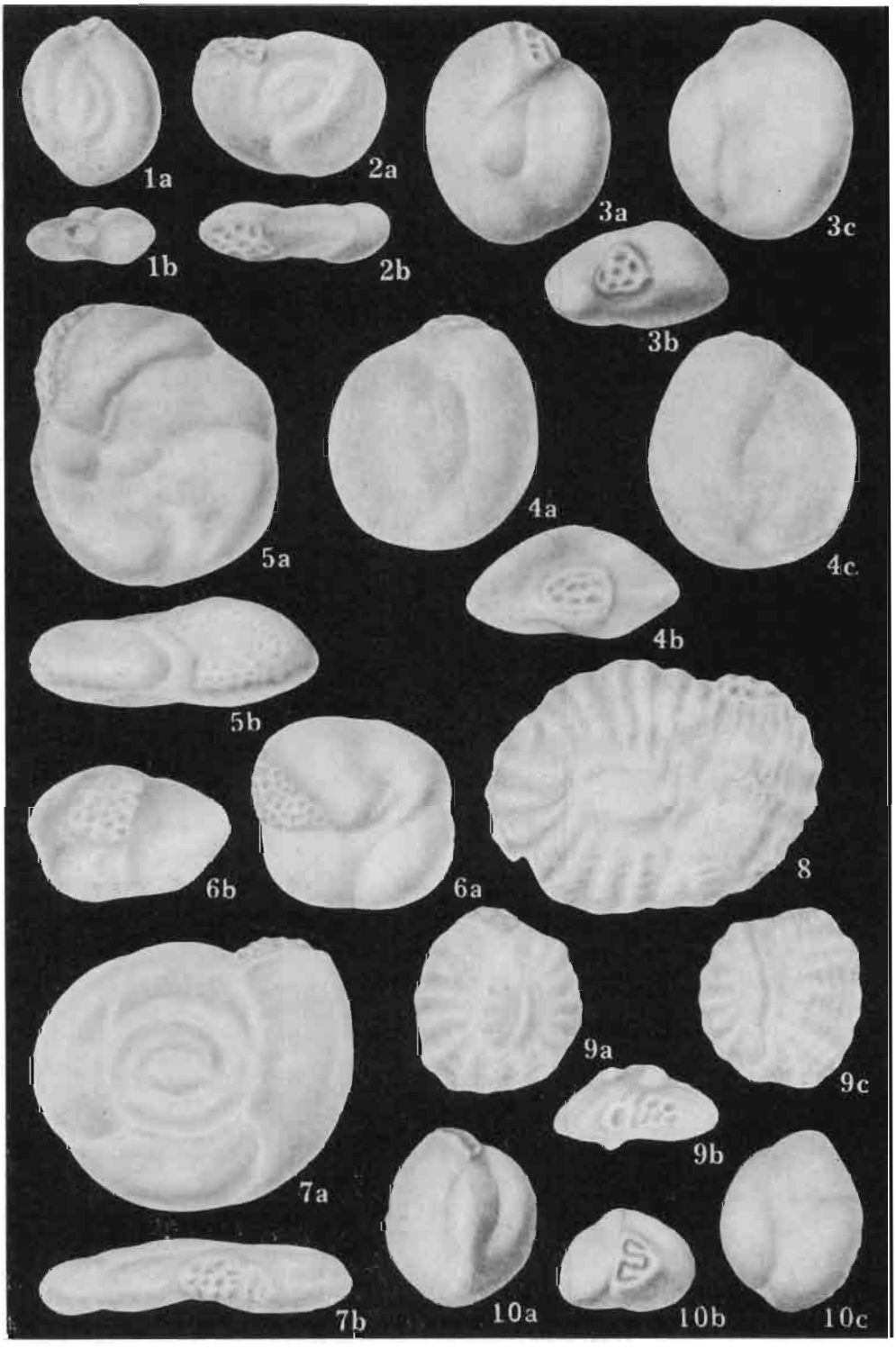
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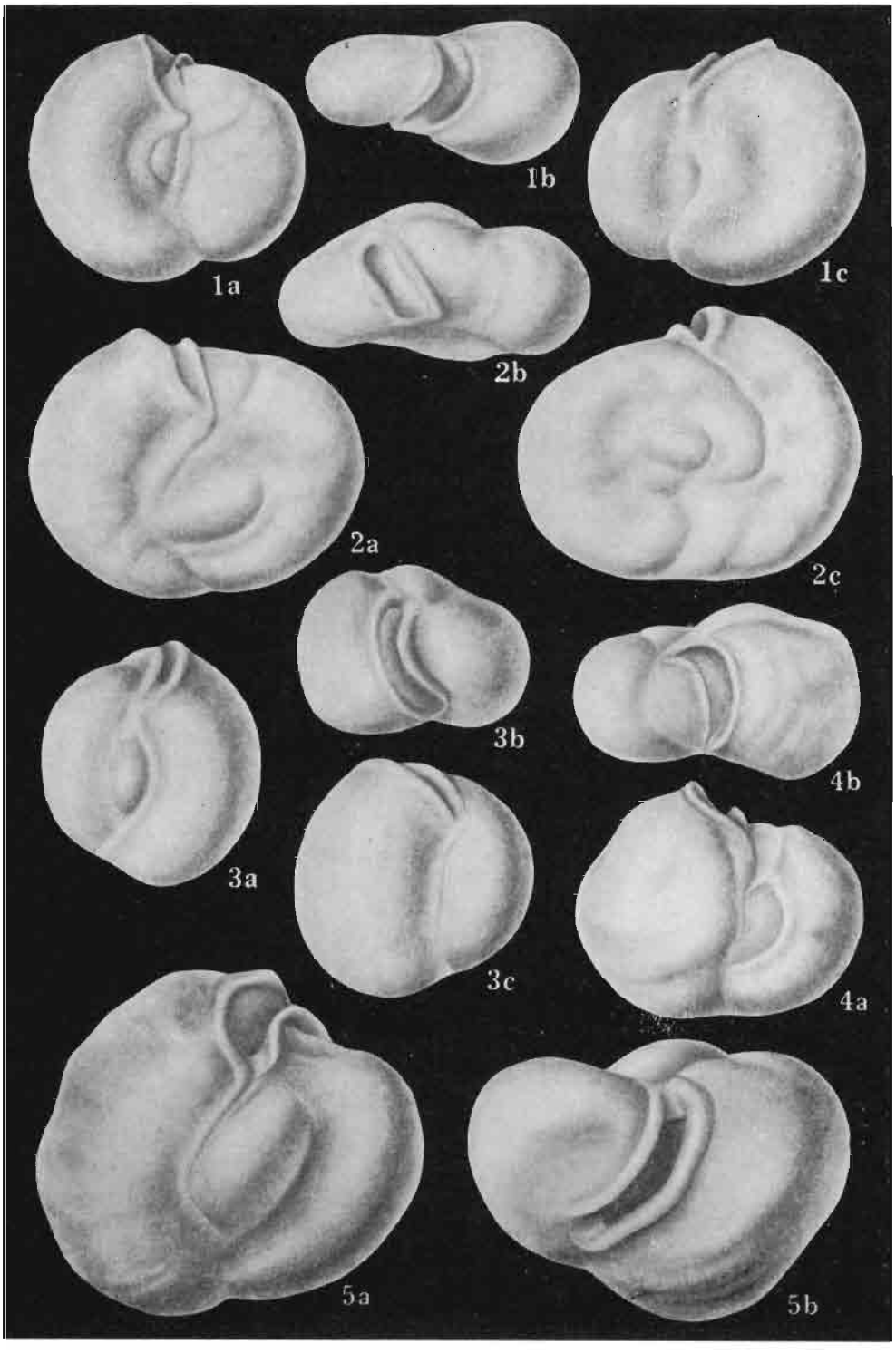
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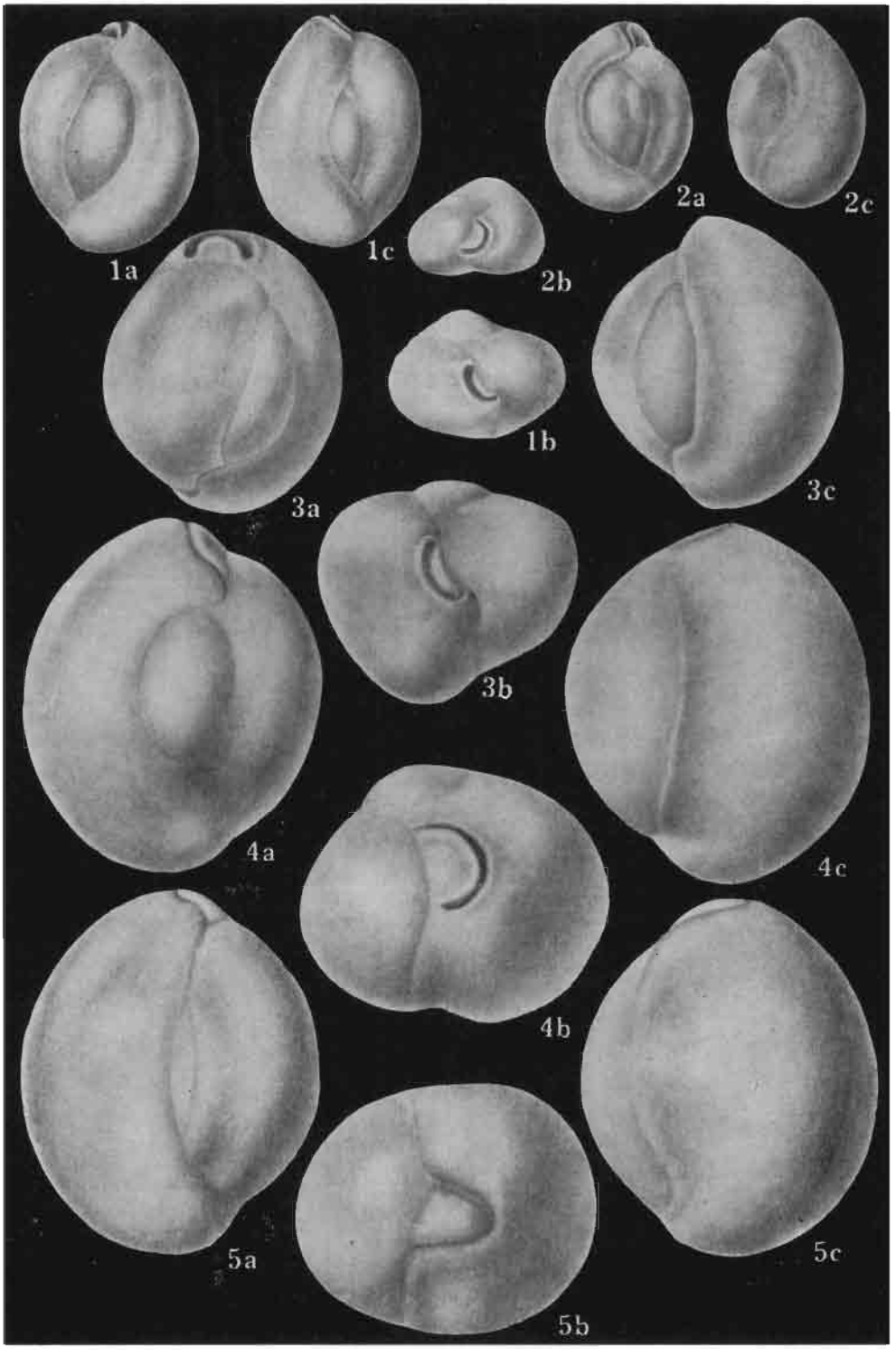
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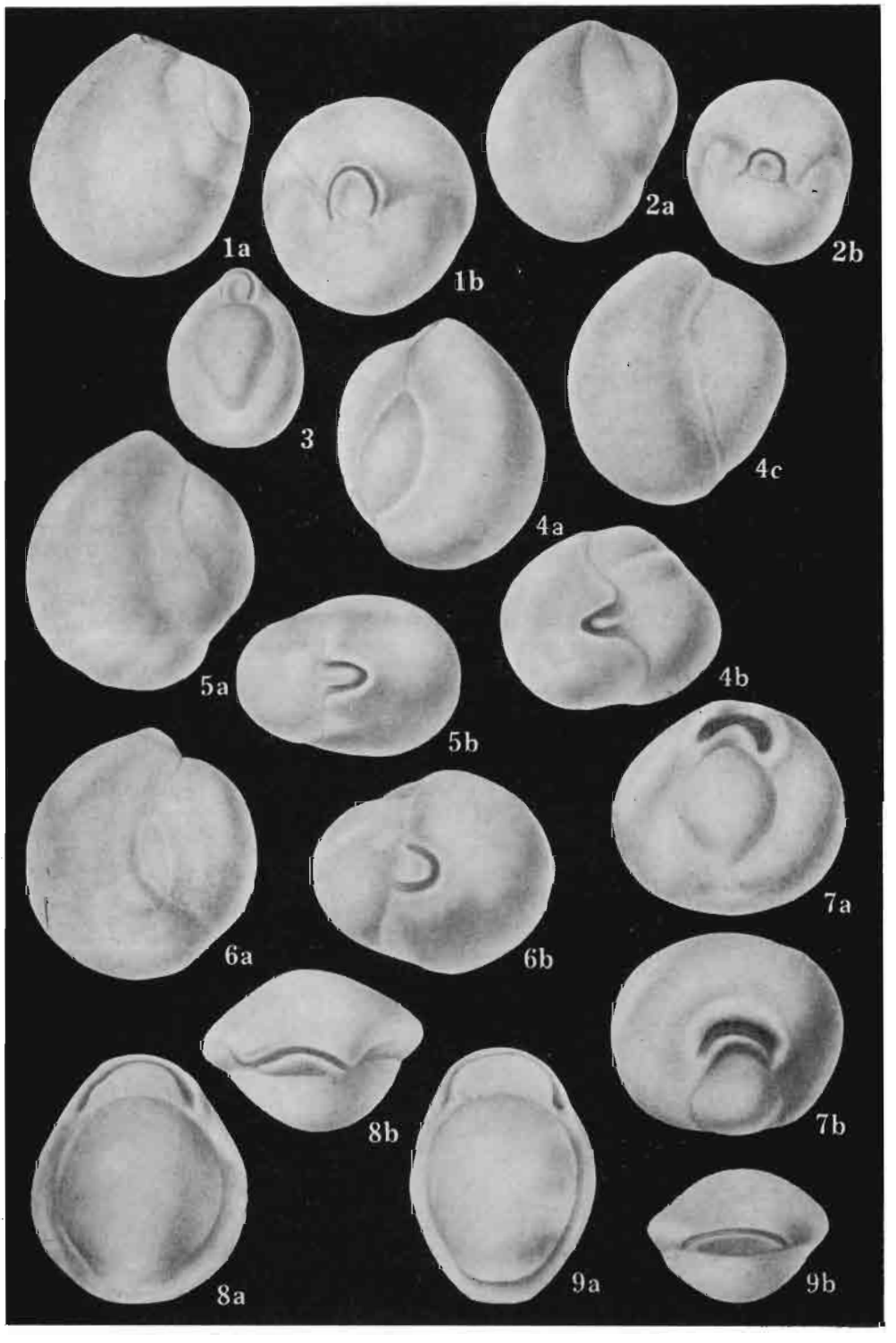
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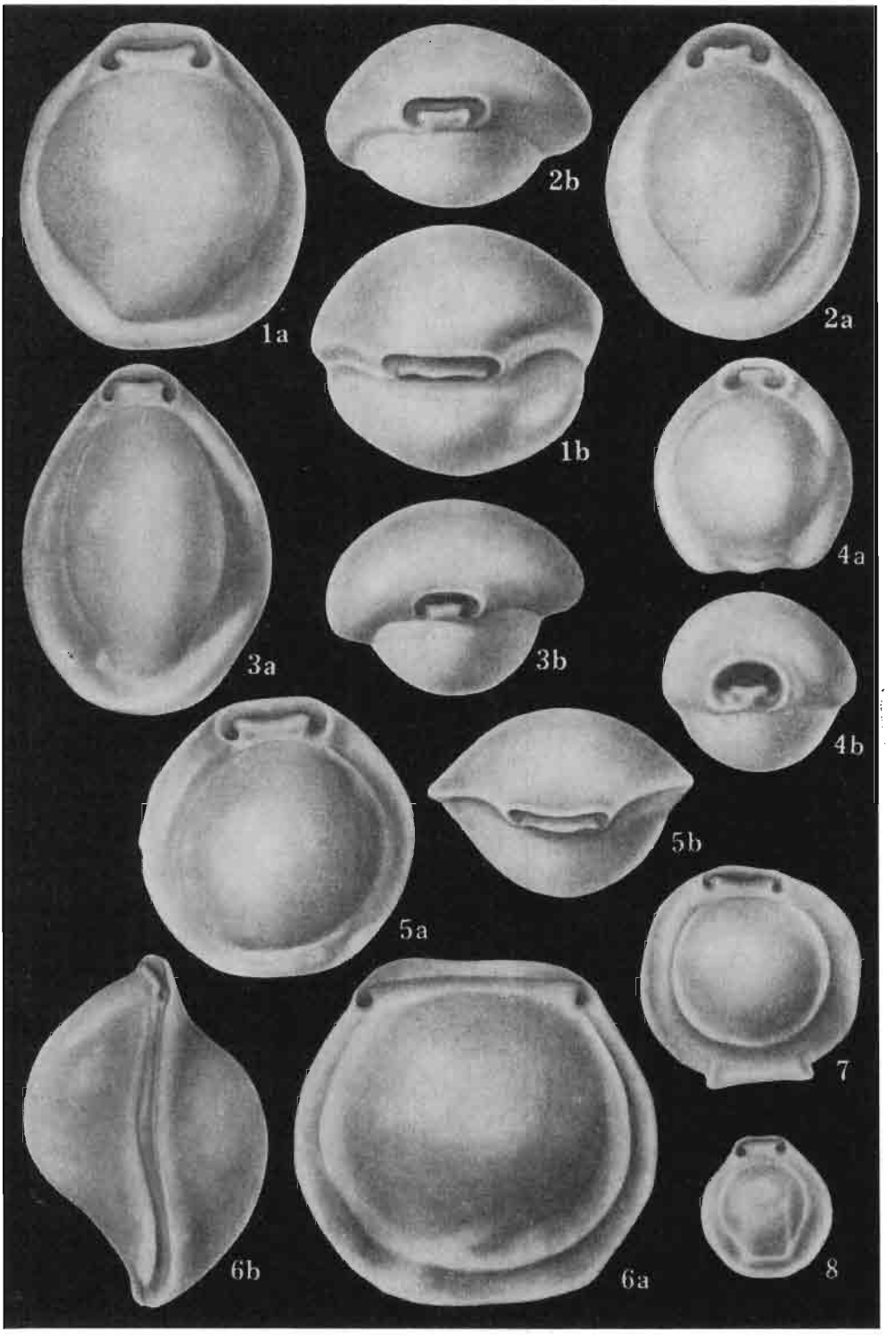
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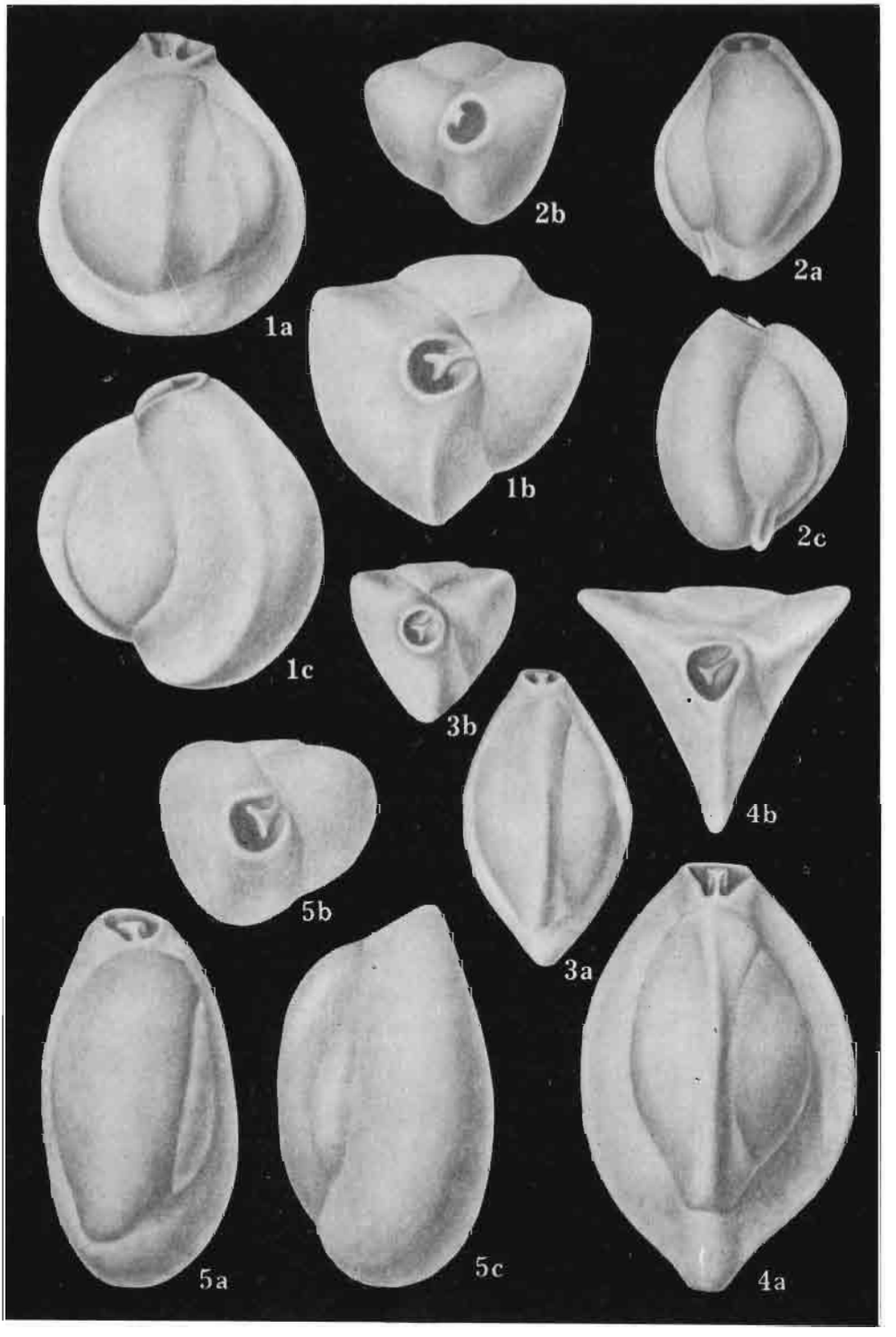
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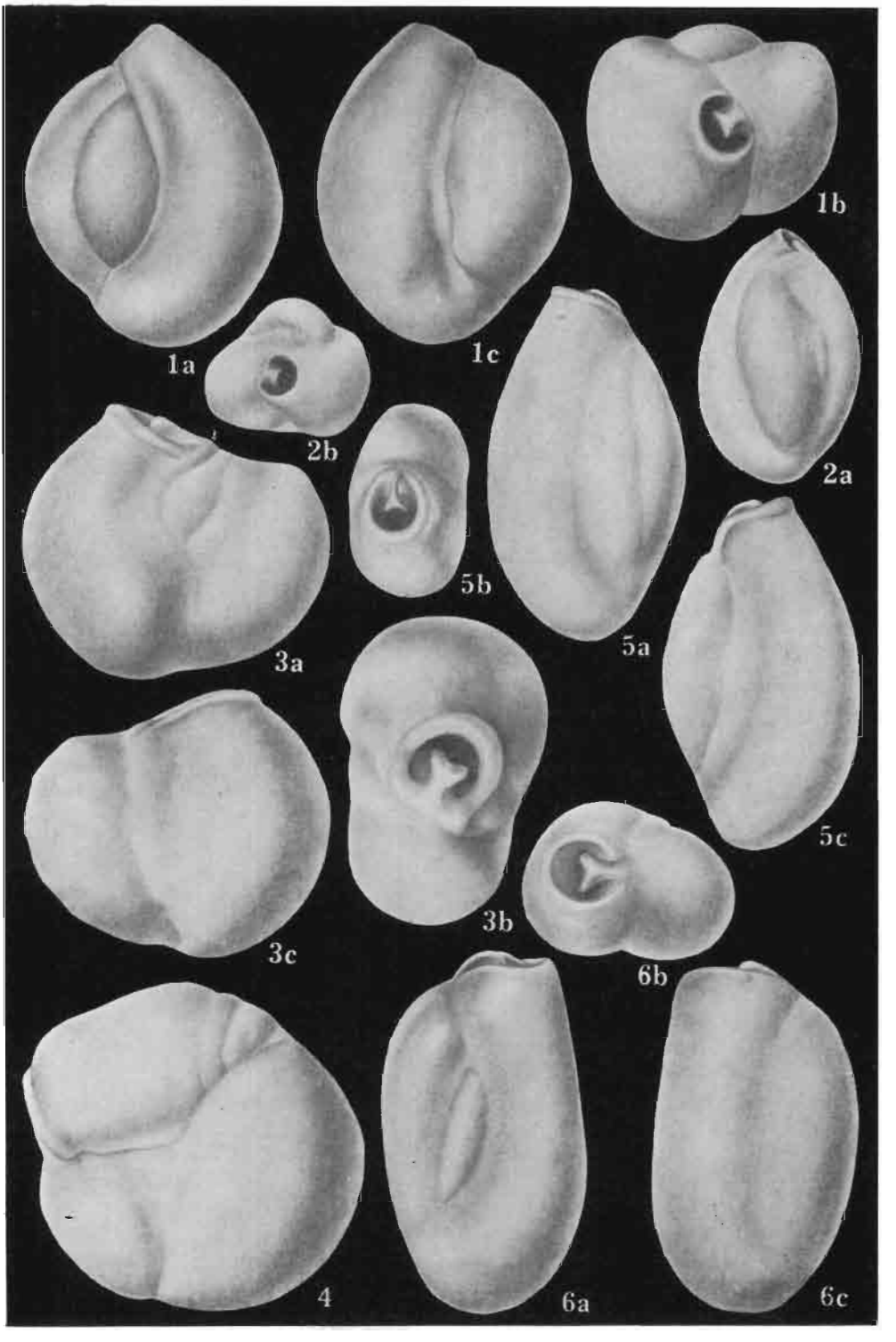
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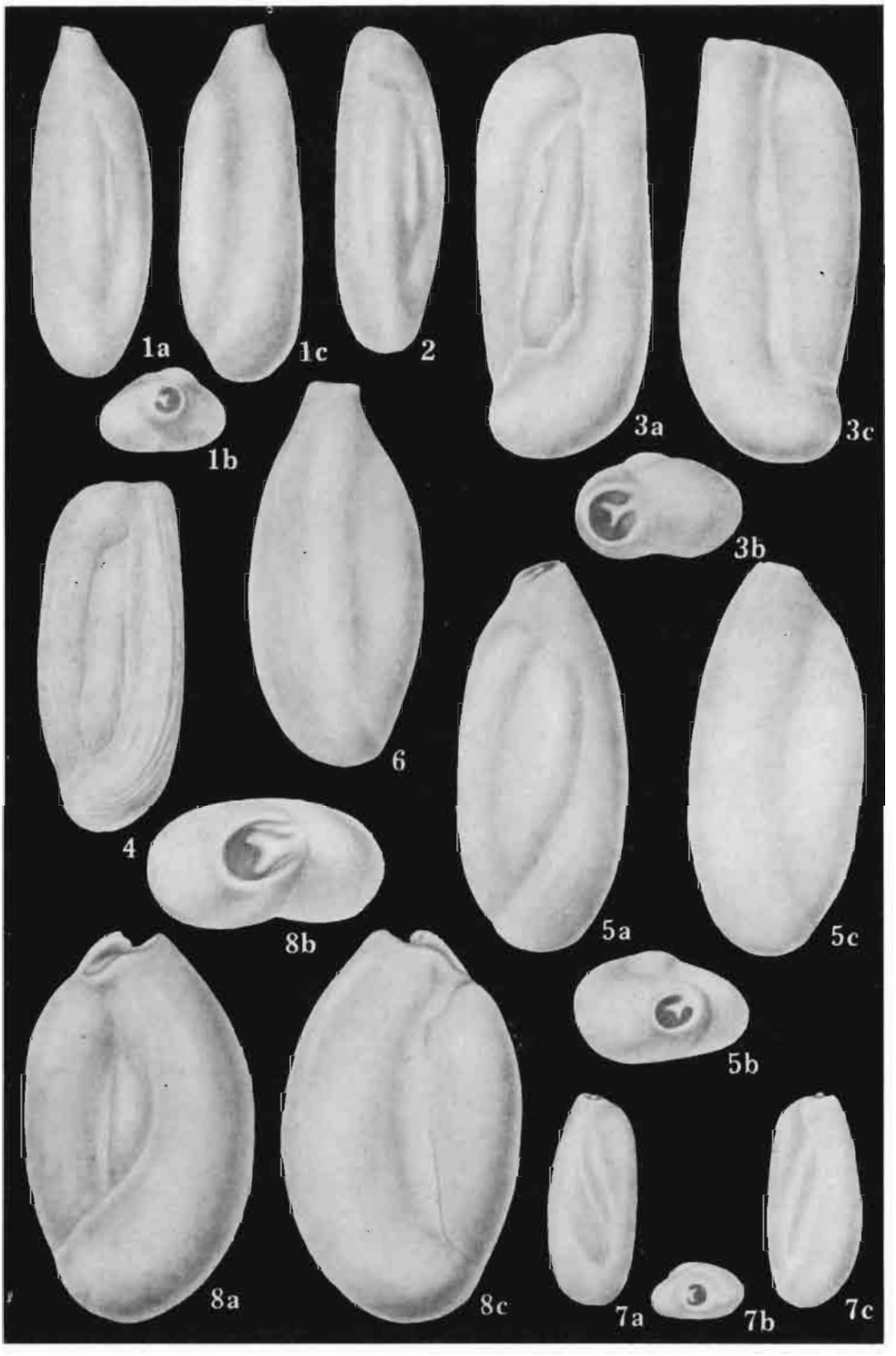
6c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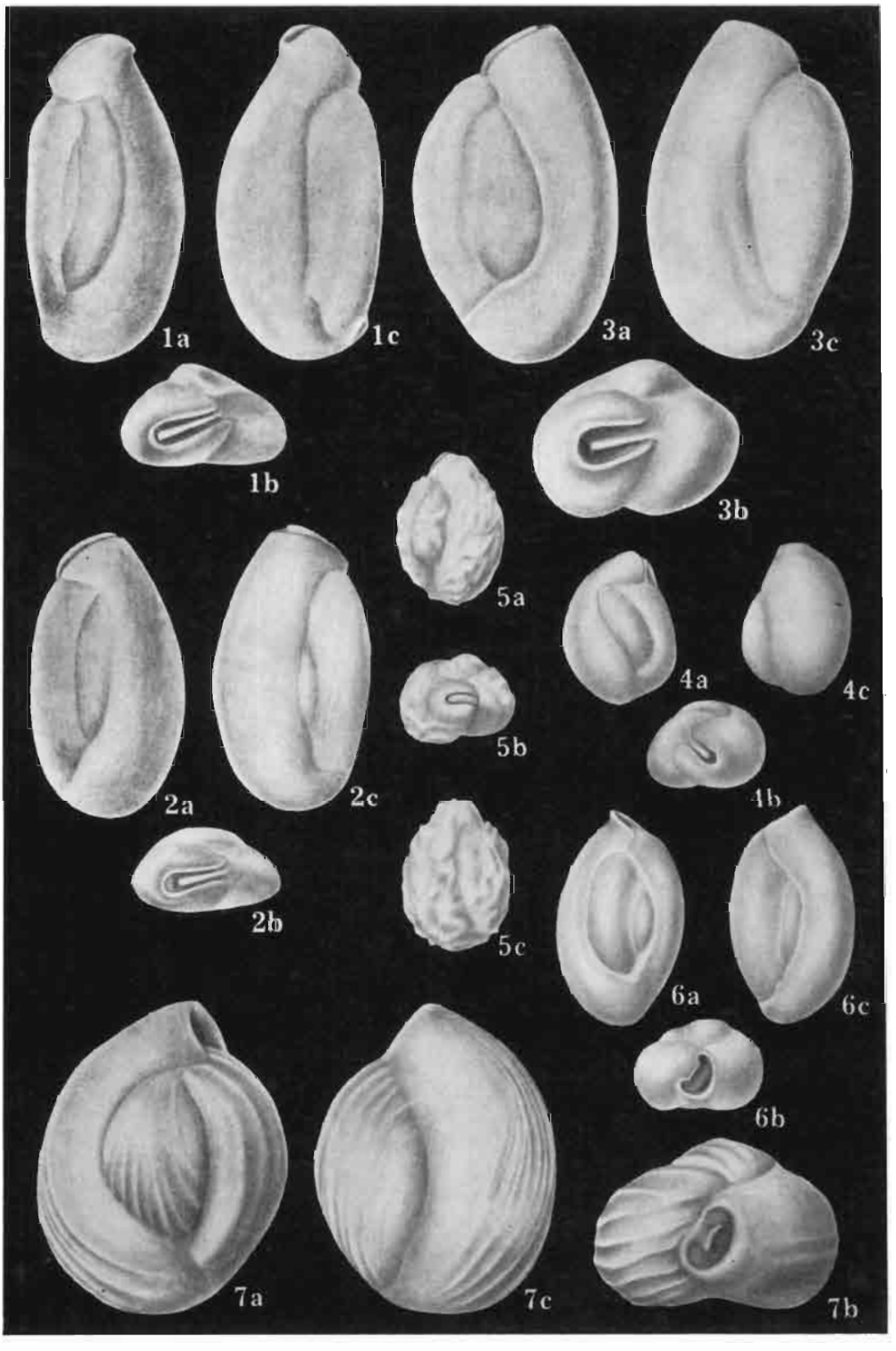
7c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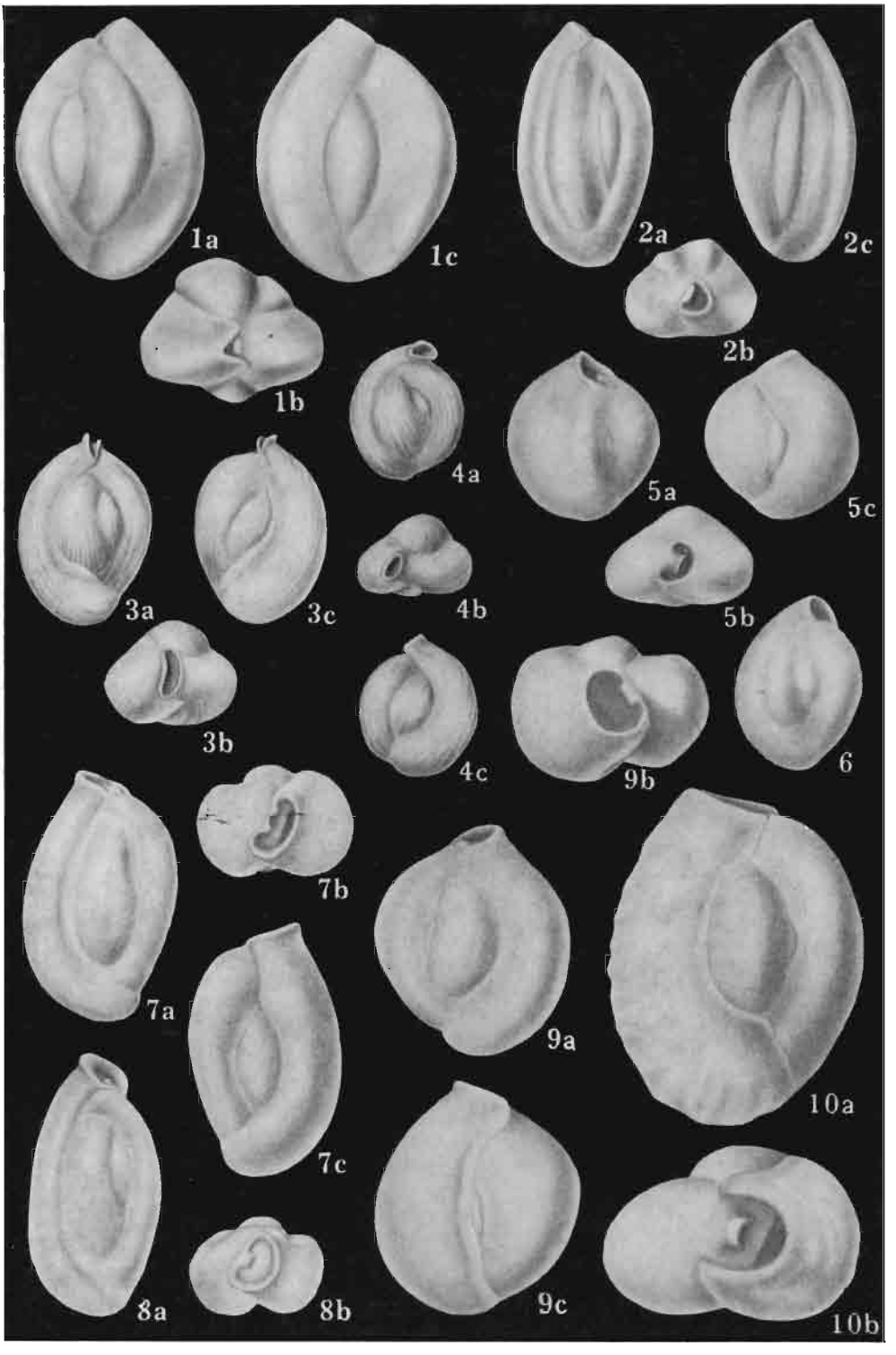
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8b
9c
10b