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EVOLUTION OF THE JURASSIC AND CRETACEOUS SMOOTH-WALLED *LENTICULINA* (FORAMINIFERIDA) OF POLAND

Contents

Abstract. — Three developmental phases of the *Lenticulina* have been distinguished, including (1) Lias, (2) Dogger — Lower Cretaceous and (3) Upper Cretaceous. The phylogenetic changes in the *Lenticulina* led to a decrease in the number of chambers in the out ~~inn~~er whorl with a simultaneous increase in test size, in the degree of involution, and in the diameter of umbilical areas, as well as with a progressive development of the *Robulus* slit in aperture. The decrease in the number of chambers in out ~~inn~~er whorl occurs in independent ways, by: 1 — a decrease, in the geological time, of the number of chambers forming the test and 2 — a decrease in the number of chambers in outer whorl, with a simultaneous increase in the total number of chambers, in the length of spiral and number of whorls.

Thirty-one species have been studied and morphotypes distinguished in polymorphic species. Simple statistical methods and microstructural studies were applied.

The stratigraphic range of the following, so far confused, species: *Lenticulina gottingensis* (Bornemann), *L. muensteri* (Roemer) and *L. rotulata* Lamarck was established.

INTRODUCTION

The aim of the present paper was to study the foraminifers of the genus *Lenticulina* Lamarck, very common and widely distributed in the Jurassic and Cretaceous deposits, in particular their non-ornamented forms most difficult to identify taxonomically. It may be easily found on the basis of a review of the *Lenticulina*, described so far, that in addition to forms whose occurrence is confined to particular stages or epochs, there also exist species with a vast time range stretching from the Mesozoic up to the Recent. *Lenticulina muensteri* (Roemer), *L. varians* (Bornemann) or *L. subalata* (Reuss) are among the species which are considered as conservative and long-lived. As shown by recent studies, tracing a given species in the geological time sometimes allows one to reveal certain permanent differences between older and younger forms. Precisely for this purpose studies were conducted on the material from Polish territory to enable conclusions on the stratigraphic usefulness of the *Lenticulina* and on its evolution.

The present writer's studies were mostly based on the materials from borings and on the samples from outcrops. A total of more than 700 samples were examined, 56 of them from the Upper Cretaceous section of the area on the Vistula River, the rest making up fragmentary cores of

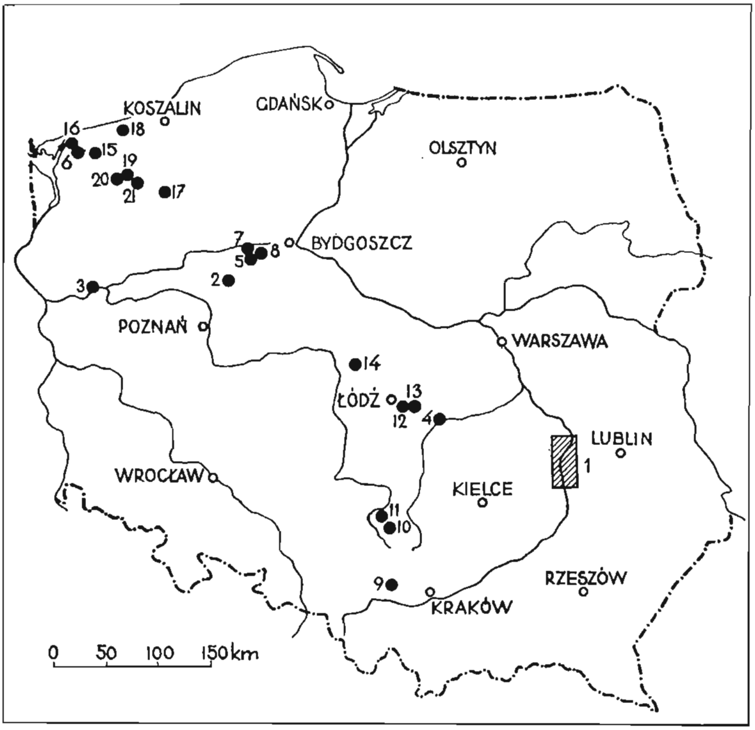


Fig. 1. Map of the localization of geological borings and outcrops: (*1*) Upper Cretaceous outcrops in the gorge of the Vistula River; (*2*) Murczyn boring, Wągrowiec sheet of map; (*3*) Gorzów Wielkopolski boring; Gorzów sheet; (*4*) Łazisko boring, environs of Tomaszów Mazowiecki; (*5*) Kcynia II boring, Kcynia sheet; (*6*) Kłodzino boring, environs of Kamień Pomorski; (*7—8*) Kcynia I and IV borings, Kcynia sheet; (*9*) Trzebionka boring, environs of Trzebinia; (*10—11*) Jaworznik and Turów borings, environs of Żarki; (*12—13*) Gałkówek III and H_2 borings, environs of Gałkówek; (*14*) Borucice boring, environs of Łęczyca; (*15*) Mechowo boring, environs of Kamień Pomorski; (*16*) Kamień Pomorski boring, Kamień Pomorski sheet; (*17*) Przytoń boring, Czaplinek sheet; (*18*) Gołańcz boring, environs of Kołobrzeg; (*19—21*) Radowo Małe II and III and Strzmiele V borings, environs of Łobez.

boreholes from the Polish Lowland. The Upper Cretaceous materials, collected by Professor K. Pożaryska and Professor W. Pożaryski, were kindly made available by them to the writer.

The localities of borings and outcrops are presented in Figs 1 and 2. The boreholes, selected for studies, met the following requirements: they had an accurate, sometimes already published stratigraphic record and a rich microfauna preserved as best as possible. In addition, the writer made use of comparative materials from other countries, mostly coming from the collections of the Micropaleontological Laboratory, Polish Academy of Sciences, where they had been accumulated by Professor W. Pożaryski and from the Institute of Geological Sciences, Polish Academy of Sciences, collected by Professor O. Pazdro.

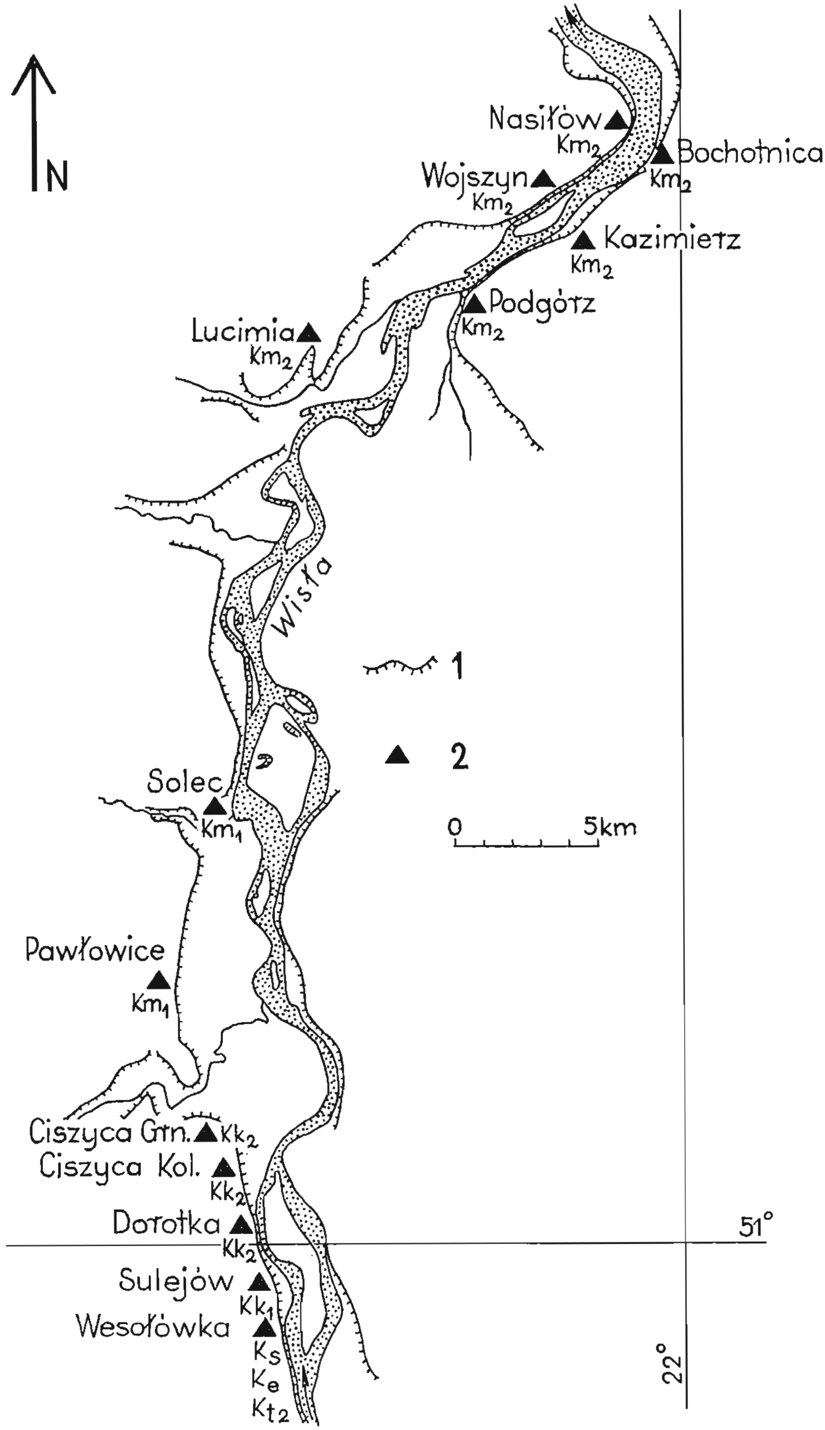


Fig. 2. The place of sampling from the Upper Cretaceous in the gorge of the Vistula River (after Pożaryski, 1938; simplified). (1) alluvial bank of the Vistula valley; (2) sampling place.

The stratigraphic list of the materials described (Tab. 1) has been prepared on the basis of the Lithological-Stratigraphic Table of Poland (Cieśliński S. *et al.,* 1969), whose stratigraphic division tallies with that accepted for the Polish Lowland at the Tenth European Micropaleontological Conference held in 1967.

A considerable number of borings representing the Liassic may attract the attention in the stratigraphic list. These borings were selected on purpose to enrich the collection of the Liassic foraminifers. A gap in the list occurring in the Barremian-Aptian sector results from the paleographical situation of Poland during that period.

Acknowledgements

The present paper has been prepared under the guidance of Professor Krystyna Pożaryska, to whom the writer expresses her heartful gratitude. She also feels indebted to Professor Olga Pazdro for frequent discussions and advice in the course of elaborating the subject. Thanks are extended to the management of the Geological Institute in Warsaw for making the material from borings available to the writer, in particular to the Institute's micropaleontologists: Dr. W. Bielecka, Dr. J. Sztejn, Dr. E. Gawor-Biedowa and J. Kopik M.Sc., for their aid in selecting materials, making appropriate literature available and their advice and remarks. The photographs of foraminifers have been taken by Miss M. Wąsak and figures drawn by Mrs. K. Budzyńska, both from the Palaeozoological Institute, Polish Academy of Sciences, Warsaw.

The collection of specimens described in the present paper is housed in the Palaeozoological Institute Polish Academy of Sciences, (abbr. Z.PAL.).

WORKING METHODS

Separating all lenticulinoid foraminifers from macerated rock samples, the writer collected a material of some thousand specimens, of which, on the basis of a similarity to the holotypes, she sorted out the tests, which could be included in broadly understood populations of non-ornamented species of the *Lenticulina*. Each test was studied from the viewpoint of external morphology and many of them also in regard to their internal structure. Non-transparent and poorly preserved tests were observed in oil immersion and in the form of thin sections.

A strikingly large degree of the morphological variability in the *Lenticulina* was observed even after a perfunctory review of the material, which induced the writer to apply statistical methods. A numerical description makes a morphological observation precise by supplementing it by numerical data, which unequivocally determine the variability range

Table 1

A stratigraphic list of the materials described from borings and outcrops. All names, beginning with that provided with an asterisk, designate geological borings

BORINGS and OUTCROPS	LIAS				DOGGER					MALM			LOWER CRETACEOUS						UPPER CRETACEOUS					
	Hett.	Sin.	Pliens.	Toarc.	Aal.	Bajoc.	Kuiav.	Bath.	Callov.	Oxf.	Kim.	Volg.	Infra-val.	Val.	Hot.	Bar.	Apt.	Alb.	Cenom.	Tur.	Coniac.	Sant.	Camp.	Maestr.
Vistula valley outcrops																no foraminifers			■	■	■	■	■	■
Mutczyn *																			■	■				
Gorzów Wlp.																		■						
Łazisko													■	■	■									
Kcynia II												■	■	■										
Kłodzino												■												
Kcynia I											■	■												
Kcynia IV									■	■	■													
Trzebionka									■															
Jaworznik							■	■																
Turów							■	■																
Gałkówek III							■																	
Gałkówek H1					■	■	■																	
Borucice					■	■																		
Mechowo	■	■	■	■																				
Kamień Pomorski	■	■	■																					
Przytoń			■																					
Gołańcz			■																					
Radowo Małe II			■																					
Radowo Małe III			■																					
Strzmiele V			■																					

Table 2

The occurrence of smoth-walled *Lenticulina*-species in the Jurassic and Cretaceous of Poland

Species	JURASSIC			CRETACEOUS	
	LIAS	DOGGER	MALM	LOWER	UPPER
L. gottingensis (Bornemann)	+				
L. acutiangulata (Terquem)	+				
L. polygonata (Franke)	+				
L. varians (Bornemann)	+				
L. constricta (Kaptarenko)		+			
L. oolithica (Terquem)		+			
L. involvens (Wiśniowski)		+			
L. primarea (Blank)		+			
L. sp. 1		+			
L. biexcavata (Mjatliuk)		+	+		
L. hebetata (Schwager)		+	+		
L. ruesti (Wiśniowski)		+	+		
L. inflata (Wiśniowski)		+	+		
L. uhligi (Wiśniowski)					
morphotype *jurensis*		+	+		
morphotype *uhligi*		+	+		
L. muensteri (Roemer)					
morphotype *gibba*		+			
morphotype *wisniowskii*		+	+		
morphotype *integra*		+	+		
morphotype *russiensis*		+	+	?	
morphotype *tumida*		+	+	+	
morphotype *muensteri*		+	+	+	
morphotype *crassa*				+	
morphotype *H*				+	
L. nodosa (Reuss)					
morphotype *nodosa*				+	
morphotype *gibber*				+	
L. angulosa (Chapman)				+	
L. gaultina (Berthelin)				+	
L. circumcidanea (Berthelin)				+	
L. pulchella (Reuss)				+	
L. vonderschmitti (Gandolfi)				+	
L. subangulata (Reuss)				+	
L. rotulata Lamarck				+*	+
L. acuta (Reuss)				+*	+
L. sp. 2					+
L. neoorbicula Hofker					+
L. marcki (Reuss)					+
L. pondi (Cushman)					+
L. semilovortex Hanzlíková					+
L. cf. adelinensis (Keijzer)					+
L. umbonata (Reuss)					+

* species appear in the Albian

of the characters under study and facilitate comparisons between populations coming from various geological horizons. To characterize the *Lenticulina* simple statistical methods were applied, viz. the analysis of a single parameter making up a definite feature of the individual — and the analysis of two and three parameters simultaneously. For this purpose, measurements were taken of assemblages mostly consisting of 100 specimens each, coming from the Liassic, Dogger, Malm and Lower Cretaceous. The assemblages of the Upper Cretaceous *Lenticulina* was so pronouncedly different morphologically that proving this fact statistically was superfluous. The writer sought to decide whether the assemblages of the *Lenticulina* variable in age, broadly understood as one and the same species *L. muensteri* (Roemer), actually represent one strongly variable species, or more species and, in addition, what are the differences occurring between them in the geological time.

Taking tests for measurements, the writer did her best to avoid selectivity. For this purpose, the material was spread on the tray by means of a ruler (since a fractional division was caused by pouring directly from a bag) and only damaged specimens were discarded. Measurements were taken of a larger diameter of the test (L), smaller diameter (B), thickness (T), number of chambers in the outer whorl (Nch) and, sometimes, diameters of umbonal disc and proloculus and number of inner chambers. In addition, values were calculated of $\frac{L}{B}$ and $\frac{B}{T}$, which determine the degrees of the involution and convexity of test. The various arrangements of these data on the diagram of coordinates yielded results in the form of spreads and graphs. The curves of variability were smoothed by the method of least squares (Guter & Owczyński, 1967, Chapter 3).

However, the statistical analysis only partly met expectations. It enabled a numerical expression of the range of variability of the characters analyzed and allowed the writer to indicate the most typical specimens by determining the intervals to which fell the largest number of individuals, but it did not decide the taxonomic assignment of specimens. The results obtained emphasized the fluctuation of characters and the occurrence of chains of variability. Such assemblages, marked by a many-trend variability, were characterized from the practical viewpoint by means of a morphotype analysis, that is, the composition of population was presented as a sum of the morphotypes, described morphologically and numerically and illustrated by histograms.

Studies on the microstructure of test walls were conducted on the basis of thin sections observed in the transmitted light. Sections were prepared according to generally accepted principles, embedding the tests in laxide and grinding them with a frosted-glass plate. Grinding powders were used for large specimens.

REMARKS ON CLASSIFICATION OF THE *LENTICULINA*

In 1804, studying the Upper Cretaceous fauna of Meudon in the Paris Basin, Lamarck was the first to use the generic name *Lenticulites*, calling the Recent *Lenticulina* "les lenticulines". Despite his opinion that in both cases we have to do with one and the same genus, he used the ending "-ites" for fossil forms to emphasize difference in time. According to Loeblich & Tappan (1964), the name *Lenticulina* is objective.

Lamarck mentioned three species of the genus *Lenticulites*: *L. planulata*, *L. variolaria* and *L. rotulatus*, but only the last-named, later considered as a genotype, was presented by him in a figure published in Annales du Muséum (1806, Pl. 62 (14), Fig. 11). The schematic form of this drawing and the scanty description caused that later authors gave up the name *Lenticulites* (*recte Lenticulina*), replacing it with the better characterized genus *Cristellaria*, erected by Lamarck in 1816 for tests marked by similar type of structure, although somewhat different in details. This name was convenient from the practical viewpoint as it was applied to the group of widely variable but related foraminifers.

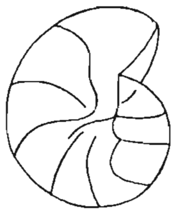
Several later names used for these foraminifers did not take on, except for the name *Robulina* introduced by d'Orbigny (1826), which has been widely applied for nearly 100 years.

A new light on the problem of adequate calling of the foraminifers of the group "*Cristellaria*" was thrown by Cushman (1927). He had the opportunity of studying original materials of Lamarck, preserved at the Museum of the University of Caen, France. The model (Lamarck's "type slide") included three tests, the central one of which, best preserved was drawn and described by Cushman as a "genotype" of the genus *Lenticulina*. As a result of his studies, Cushman arrived at the conclusion that the species *Lenticulina rotulata* Lamarck is undoubtedly identical with a well-known form called *Cristellaria rotulata* Lamarck and that the name *Lenticulina* should be used as having priority (Cushman, 1927*b*, p. 142; 1927*c*, p. 169) [1].

Comparing Lamarck's original drawing (Text-fig. 3) with Cushman's illustration of a specimen from Lamarck's model (Text-fig. 4), one can hardly agree that we have to do with one and the same form. Since Lamarck's original materials got mislaid during the last war, it is now impossible to repeat the observations. In 1968, the present writer visited Muséum National d'Histoire Naturelle in Paris, where by courtesy of Dr Y. le Calvez she was able to study d'Orbigny's and Terquem's collections, as well as holotypes of some of the *Lenticulina* housed there. For the sake of comparison, the present paper contains the writer's draw-

[1] In this connection, interesting seems to be Thalmann's (1949) assertion that *Lenticulina rotulata* Lamarck cannot be assigned to the foraminifers since Lamarck's original drawing does not absolutely concern a foraminifer.

ing of specimens of *Cristellaria rotulata* from d'Orbigny's collection, which, the same as Lamarck's original materials come from the Upper Cretaceous of Meudon, France (Text-fig. 5). Due to the specimens being fixed for good in the position in which she shows them, the writer could not draw



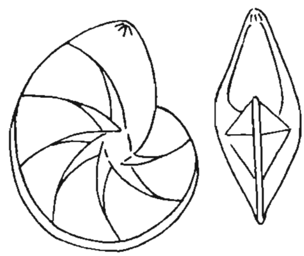


Fig. 3. *Lenticulina rotulata* Lamarck, 1804; according to Lamarck (*fide* Cat. of Foram., Ellis & Messina), Upper Cretaceous of France.
Fig. 4. *Lenticulina rotulata* Lamarck, 1804. Type species of the genus *Lenticulina*; according to Cushman (1927); on the basis of Lamarck's original collection.

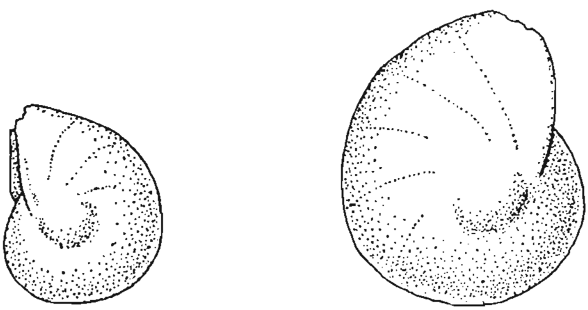


Fig. 5. *Lenticulina rotulata* Lamarck, 1804. A drawing of specimens from d'Orbigny's collection from the Upper Cretaceous of France; drawn by the present writer.

them viewed from the apertural face. D'Orbigny's specimens are more similar to Lamarck's than to Cushman's drawings and are in conformity with the tests of *Lenticulina rotulata* from the Upper Cretaceous of Poland.

The difficulties which arise in identifying the non-ornamented *Lenticulina* are connected with the lack of distinct and sufficiently permanent characters which might serve as a basis for division. In analyzing large assemblages it is possible sometimes to form series of specimens, which represent the transition from involutely coiled forms, through semi-involute, up to the developing ones, from flat to rotund and from small to large tests, a fact to which attention has already been called by Uhlig (1883), Lutze (1960) and Cifelli (1960). This hinders the determination of the range of intraspecific variability and working out generic diagnoses as, for example, in a single sample abounding in the *Lenticulina,* in which the writer found tests transitional between the genera *Lenticulina* and *Planularia* or *Lenticulina* and *Astacolus,* although, according to Loeblich &

Tappan (1964) these genera make up independent taxons in the foraminiferal taxonomy. For these reasons, some authors describing these tests even now use the categories of subgenera within the earliest erected genus *Lenticulina*.

The smooth-walled *Lenticulina* are devoid of the single character which might serve as a basis for a taxonomic separation. It is only the sum of features which makes up taxonomic characteristics. The greatest taxonomic importance is ascribed by the writer to the development of sutures and arrangement of chambers in the spiral. These characters are most fundamentally decisive concerning the nature of test and they are usually best preserved and relatively permanent. Of smaller importance are the number of chambers and size of tests, which may be subject to considerable fluctuations. The convexity of tests is of minor importance and using it as a basis for dividing populations is, therefore, unjustified. Such characters as the presence or absence of the keel and the development of aperture are of accessory importance only and they cannot play an independent role in taxonomic distinction.

VARIABILITY IN THE *LENTICULINA* POPULATIONS

The *Lenticulina* are benthic foraminifers which settle the bottom zones of basins with a normal salinity and live at various depths. Their considerable vertical range is accompanied by an extensive geographical distribution. This is a geologically old genus, in which a complete cycle of alternating sexual and asexual generations occurs. These phenomena result in a considerable degree of variability in the *Lenticulina* populations.

In the material under study, the greatest variability of the *Lenticulina* occurs in the Dogger, in particular in the Bajoccian, Kuiavian (Vesulian) and Bathonian. In the studies on these tests conducted so far, stress was more frequently laid on finding differences, while a smaller importance was ascribed to common characters of entire assemblages. This resulted in erecting a large number of *Lenticulina* species, many of which are actually no more than transitional forms or express ontogenetic variability and gerontic deviations. Undoubtedly, it is difficult to decide in particular cases whether variable characters should be treated as an intraspecific or interspecific variability. In studies on the non-ornamented *Lenticulina*, it is important to use as a basis a large collection of tests in order to obtain a possibly complete range of variability.

The assemblages of the *Lenticulina* under study in particular samples have been divided into groups of specimens making up indubitable species and those including specimens whose taxonomic rank could not be unequivocally determined. In the former case we have to do with pronouncedly heterogenic groups, while in the latter the forms in particular assemblages, although fundamentally similar to each other morphologically, are not uniform in character due to their wide range of variability. This phenomenon may be a result of either convergence or polymorphism, which are considered below in succession.

Convergence. As a taxon, each species differs from other ones in its morphological and physiological characters, particularly in the domain of reproduction, and ecological requirements. However, there is also a phenomenon of the coexistence of populations of different species which are very similar morphologically. In this case, all differences are preserved, except for the morphological ones. For such species the name "sibling species" was suggested by Mayr (Mayr, Linsley & Usinger, 1953).

If one assumes that the *Lenticulina* group under the present study represents sibling species, thus, analyzing the nature of variability we should consider these species as related to each other in a continuous manner (a wide overlap) both in space and time. This is shown by the gradation of characters which makes arranging of the variability series possible. There is no simple method of dividing such an assemblage, for practical purposes, into separate species. A division based on some characters is, due to the diversity of combinations, inadequate in relation to the remaining ones. Adequate seems to be in this case a term, used by Barnard (1950) to determine the Liassic *Lenticulina* from Dorset Coast, England, namely "the *Lenticulina plexus*". The abundance of the species of the *Lenticulina* erected gives ample evidence of an extensive option in dividing such populations. Such a procedure may, however, supply us only with ever new "species" which in ultimate cases may even be represented by a single specimen-species and this does not, of course, meet the requirements of a modern presentation of a species understood as a population.

Polymorphism. Analyzing a heterogeneous assemblage of the *Lenticulina* from the viewpoint of polymorphism, the writer assumed that in the case in which the populations were fundamentally similar morphologically we might believe that they were not completely separated as is in the case of different species. As shown by studies on foraminifers conducted under controlled conditions some species are strongly polymorphic (see Loeblich & Tappan, 1964).

With a considerable susceptibility of the *Lenticulina* to ecological stimuli and a rapid rate of their reproduction, these organisms widely distributed (horizontally and vertically) might develop a considerable morphological variability. The accumulation of differences was bound to evoke a genetic diversity in population, expressed in consolidating certain morphological variants. The more specimens of the *Lenticulina* in a sample, the more distinct was the intergradation of characters, but also the larger number of individuals represented a definite type of variability. A curve, drawn for such a population, displays an undulating line, whose valleys are not sufficiently deep to be treated as zones of division and peaks not so high to make up a basis for interpreting them as separate species.

A conspicuous interdependence between the polymorphic variability and geographical distribution of the Eocene *Lenticulina* was emphasized by Thalman (1934), who distinguished three geographical races corresponding to three geographical areas: European, Central American and New Zealandian. The local ecotypes may deviate distinctly from parental forms.

The possibility of hybridization and the probability of mutations in the *Lenticulina* are not unlikely, although most differences thus developed are inconstant. Factors, affecting the variability of a population, cause that we have to do with an extensive range of a species, with its many interrelated strains.

In the case under study, variability groups are not treated as separate subspecies, since it would cause the necessity to separate many subspecies within a single assemblage (see Mayr, Linsley & Usinger, 1953). A morphotype analysis *sensu* Sylvester-Bradley (1958) has been applied by the present writer as a practical solution.

A population makes up a sum of morhotypes, which are most strongly expressed by individuals in which definite variability characters are most strongly developed. Known in paleontology (applied to corals, graptolites, oysters, echinoids), the morphotype analysis allows one to avoid descriptions of many species similar to each other.

A sexual dimorphism represents a peculiar case of polymorphism. In the *Lenticulina*, microspheric (B, according to Hofker) and megaspheric (A_1 and A_2, according to Hofker) individuals occur irregularly and not in each species. No microspheric specimens are recorded in *L. gottingensis* (Bornemann), while in *L. ruesti* (Wiśniewski) both small and large individuals have a microspheric proloculus, though varying in the number of chambers and whorls. Trimorphism occurs in the *Lenticulina* more frequently than assumed on the whole. Most A_2 specimens represents only the youngest growth stages. Relatively few specimens are in more advanced stages of the ontogenetic development, so that there is a possibility to arrange a developmental series of generation A_2. Forms A_2 are usually called by different specific names, for example, *L. rotulata* Lamarck and *L. ovalis* (Reuss) or *L. inflata* (Wiśniowski) and *L. hoplites* (Wiśniowski), which are different generations of one and the same species.

Most frequently, proloculi strongly differ in size within a species, for example, in *L. muensteri* (Roemer), *L. uhligi* (Wiśniowski), *L. nodosa* (Reuss), etc. The phenomenon of plastogamy causes the formation of sexual individuals with proloculi much larger than in usual forms of sexual generation. Some megalospheric specimens may have proloculi identical in size with those of microspheric ones. These facts give ample evidence that the division of a population into individuals formed sexually and asexually, based on the size of proloculus, is impossible. The boundaries between these groups are obliterated by the occurrence of intermediary values.

Some aspects of the individual variability in the *Lenticulina* are explained by ontogeny.

The size of tests is a strongly variable character. In some species, very large differences in size are connected neither with ontogeny, nor sexual dimorphism. Giant individuals are sometimes accompanied by many defective, abnormal tests. We have here to do, may be, with a polyploidy. The individual variability also concerns the number and shape of chambers in a whorl and the degree of the involution of test, which in turn affects the outline of tests. The inconstant characters also include the shape of periphery (with or without a keel), of the umbonal disc (with or without an umbonal boss) and of aperture. In the *Lenticulina*, a radiate terminal aperture is a constant generic character, which may be, however, variously modified within a species. In *L. muensteri* (Roemer), the most common is a radiate aperture, with an additional shallow notch which can be wedgelike or having parallel margins. It may also form an additional small opening in the apertural chamberlet, shaped like a slender triangle. Other tests are devoid of these elements. Radiate, round or triangular apertures or triangular with a narrow, long "*Robulus*" slit were found

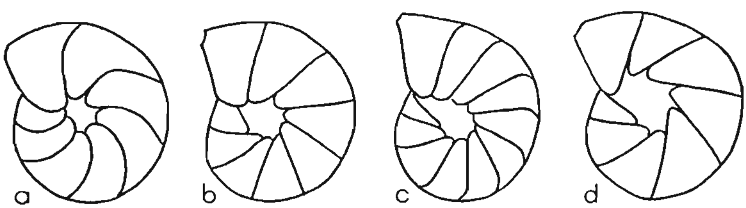


Fig. 6. The main types of the arrangement and shape of sutures in the *Lenticulina* species under study: (*a*) arcuate, (*b*) rectilinear, radiate, (*c*) oblique, (*d*) tangential.

in *L. uhligi* (Wiśniowski), *L. gaultina* (Berthelin) and *L. subangulata* (Reuss). More constant in character are the sutures, whose arrangement may be, depending on the species, tangential, radiate or arcuate. The species of the *Lenticulina* here described are marked by sutures running flush with the surface of test, or, less frequently, slightly depressed or slightly elevated. Specimens, in which earlier sutures are raised above the surface of test, the latest ones depressed and the remaining flat, may be found in species having flat sutures. In large, fully grown *Lenticulina*, the loss of the planispiral type of structure resulting from the lateral displacement of last chambers, is a fairly frequent phenomenon. Trochospiral, lenticulinoid tests were separated by Howe & Wallace (1932) to form the genus *Darbyella*. In later studies, many authors considered the darbyelloid tests as representing a gerontic stage of the *Lenticulina*, since

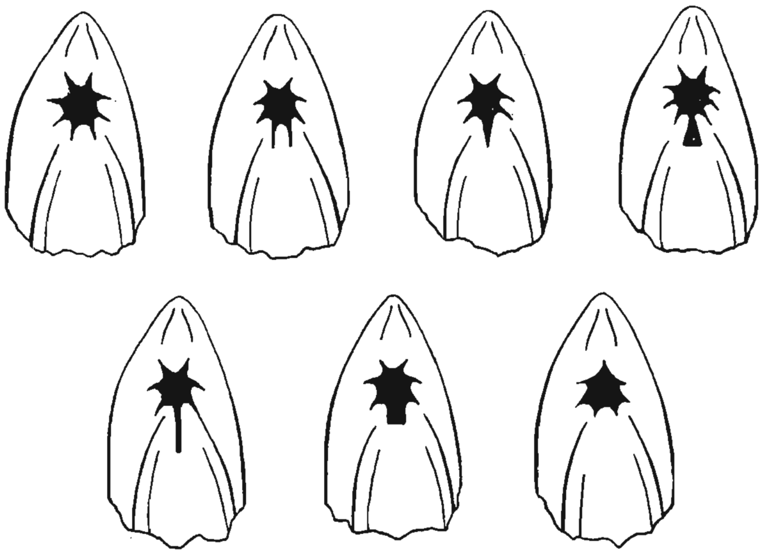


Fig. 7. The development of apertures in the *Lenticulina* species under study. The structure of aperture is variable also in one and the same species.

species of the genus *Darbyella* have their symmetric equivalents. Other anomalies, fairly common in the *Lenticulina,* are the occurrence of additional chambers and apertures fused with tests in various places, the occurrence of double proloculi and the regenerative phenomena resulting from traumatic changes (Pożaryska, 1957; Kuznetzova, 1960b).

The morphology and size of tests of the *Lenticulina* are closely correlated with facies. Comparative studies have been conducted on assemblages of the Callovian *Lenticulina* from the clayey facies of Łuków and from the marly-calcareous facies of Kcynia and Trzebionka. In other cases, the *Lenticulina* has also been studied from the Lower Oxfordian of Kcynia (calcareous samples) and from the Lower Oxfordian of Warboys Brick Pit in England (clayey samples). It was found that the tests from the clayey facies were very well developed, reached large dimensions with a smaller number of chambers in outer whorl and occurred in abundance. The *Lenticulina* from the calcareous facies displayed a constant tendency to build a larger number of chambers in outer whorl, sometimes with a decrease in the size of tests and with an impoverishment of the entire assemblage. These specimens had narrower chambers and better developed umbonal bosses. In the calcareous facies, the non-ornamented *Lenticulina* become sometimes completely displaced from their environment, in which ornamented species continue to develop. Thus, the conditions of the clayey facies were the most favourable to the life requirements of the smooth-walled *Lenticulina,* while those of the calcareous facies were unfavorable. The results obtained by the writer supplement to a certain extent the former data obtained by, among other authors, Seibold & Seibold (1960), Bielecka (1960), Gawor-Biedowa (1960) and Garbowska (1970).

OBSERVATIONS OF THIN SECTIONS

The list of authors, who over many years have studied the microstructure of the foraminifers, is fairly long. A brief review of earlier papers is contained in Wood's (1949) work, while more contemporary authors are cited by Norling (1968).

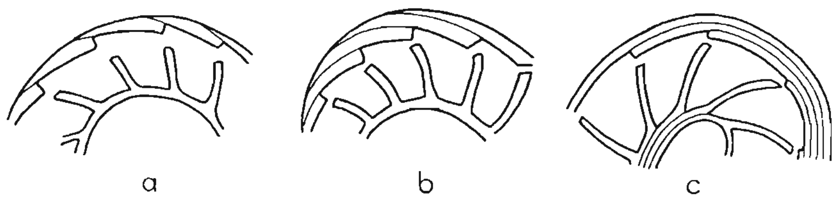


Fig. 8. Types of the microstructure of wall in the genus *Lenticulina* Lamarck. (*a*) nonlamellar type, (*b*) imbricate type, (*c*) multilamellar type (according to Kuznetzova, 1961, but slightly modified).

In 1957, studying the lamination of wall in the Lagenidae, Gerke introduced a division into what is known as primary and secondary lamination. The studies on the primary lamination led to the separation of several various types of microstructure, which was later used for the classification of foraminifers (Reiss, 1958). The secondary lamination is formed together with the growth of an individual as a result of covering a former part of test with the wall of newly secreted chambers. The microstructure of the genus *Lenticulina* studied by Johannsen (1952), Kuznetzova (1961), Norling (1968) and other authors, reveal that it is radiate, with a monolaminar, calcareous, finely perforate primary wall. Calcite crystals are thin, with a fibrous texture, arranged perpendicularly to test surface and running usually over the entire thickness of wall. Studying the microstructure of the Jurassic *Lenticulina* and comparing them with those of the Cretaceous and Tertiary, Kuznetzova (1961) suggests the following three types of structures (Text-fig. 8):

a) *Lenticulina* having a monolamellar wall, developing their tests by a simple addition of new chambers, without covering the older ones; test wall is monolaminar from the proloculus up to the last chamber;
b) *Lenticulina* with an imbricate structure, in which the wall of a new chamber always overlaps posteriorly some part of preceding chambers; this makes them secondarily multilaminar depending on how far posteriorly reaches the overlapping lamina;
c) *Lenticulina* with a multilamellar wall, in which the wall of each newly

formed chamber overlaps simultaneously the entire formerly developed part of test; a maximum number of lamellae in a wall is equal to that of chambers in the whorl.

Identical results were obtained by Norling (1968) as he studied the Liassic *Lenticulina*. The types of microstructure, mentioned above, were called by him respectively nonlamellar, mesolamellar and lamellar. In the Polish material, the occurrence of all the three types of the microstructure of wall was found by the present writer.

In the studies on the Liassic *Lenticulina*, most space was devoted to the species *L. gottingensis* (Bornemann) (Pl. XVII, Figs 1—4). A differentiated thickness of the wall of proloculus may be observed in all thin sections, which results from the manner of adding the first chamber, whose wall prolongs posteriorly, stratifying onto the wall of proloculus. When the next chamber is added in turn, its wall also prolongs posteriorly, overlapping in an imbricate manner the preceding chamber. Such a manner of adding new chambers persists only in the juvenile stage (Pl. XVII, Figs 3b, 4); later, there occurs a transition to the nonlamellar type with slight posterior overlapping of a preceding chamber. Norling (1968) expressed the opinion that the tests of *L. gottingensis* have a nonlamellar wall, with a rather high overlapping of the primary lamella. Since neither photographs nor figures of the microstructure of this species were given by Norling, it is difficult to say how great are the differences in results.

L. acutiangulata (Terquem) develops a mesolamellar type of the microstructure of wall, but it seems that the posterior overlapping of the primary lamella is in this species more extensive. Due to the scarcity of material, the writer limited her studies to the observation of polished surfaces (Pl. II, Figs 4c, 5, 6). As a result of the nonlamellar adding of chambers, according Norling's (1968) earlier observations, no lamination occurs in the wall of *L. polygonata* (Franke) (Pl. II, Fig. 8c). No test with multilamellar microstructure and with the complete overlapping of the test was found among the Liassic *Lenticulina*. One such case was only cited by Norling (1968) for *L. turbiniformis* (Terquem).

Compared with the Liassic species, the Doggerian ones display much more microstructural combinations. *L. uhligi* (Wiśniowski) (Pl. XVIII, Figs 2—4) and *L. muensteri* (Roemer) (Pl. XIX; Pl. XX, Figs 1, 2), the most common of the Doggerian species are marked by an imbricate type of microstructure with two to three laminae in a wall. They are distinguishable in thin sections, since adding new chambers in these species takes place according to a somewhat different pattern of spiral. Likewise, the arrangement of sutures and shape of chambers, in particular the youngest, are also different. A certain relationship is here outlined between the convexity of tests and the thickness of their wall. Externally delicate and flat specimens of *L. uhligi*, in equatorial section represented microspheric individuals with a thinner wall. Biconvex, more robust specimens in the same section revealed a thicker spiral suture and a megalospheric proloculus.

L. biexcavata (Mjatliuk) keeps a very uniform character of microstructure, with two thin laminae in a wall (Pl. XVII, Fig. 5).

Several species of the *Lenticulina* display, during their ontogenetic development, a combined type of microstructure resulting from a change in the pattern of adding chambers. In *L. inflata* (Wiśniowski) (Pl. XVIII, Fig. 5), the chambers of the first whorl are marked by the mesolamellar microstructure, in which lamellae more strongly overlap posteriorly, that is, the outer wall is markedly thicker than the septum and considerable disproportions are noted in the thickness of the prolocular wall. The wall of chambers of the next whorl grows thinner and displays, over the entire sector except for the final chamber, a uniform thickness, which results from turning into a type of microstructure with covering posteriorly only one chamber. A decrease in the degree of stratification in the course of the growth of tests is also observed in *L. involvens* (Wiśniowski) (Pl. XVIII, Fig. 1). In the juvenile stage, the wall consists of two laminae; later, there occurs a transition to the nonlamellar type, first with a larger and then slight posterior overlapping of the primary lamella.

In the large-test, Doggerian species *L. ruesti* (Wiśniowski) (Pl. IV, Fig. 5), the mesolamellar microstructure occurs in the first whorl, multilamellar in the next whorl and the recurrence of imbricate lamination is observed in the outer whorl.

Another large-test Jurassic species, *L. oolithica* (Terquem) (Pl. XVIII, Fig. 6) displays such a high degree of the posterior overlapping of the primary lamella that we may in fact assume the occurrence of multilamellar microstructure, in particular in the younger part of test. The primary lamella covers preceding chambers, depositing itself on them from the spiral side. Ventrally, the anterior wall is built directly on the wall of a preceding whorl. In *L. oolithica*, the type of microstructure constitutes a very important taxonomic character, since it distinguishes this species from sometime nearly identical tests from the range of the Lower Cretaceous *L. muensteri*.

In the Lower Cretaceous, the writer have not found tests with thick, multilamellar walls such as in the Jurassic *L. oolitica* and *L. ruesti* (if we disregard specimens of *L. rotulata*, which appear in the lowermost Albian). In this stage, predominant species, *L. muensteri* of the *muensteri* and *crassa* morphotypes, *L. gaultina* and *L. nodosa*, have the mesolamellar type of microstructure. In thin sections, they are easily distinguishable on the basis of different characters, such as the shape of chambers and spiral and outline of test in equatorial section.

A true multilamellar microstructure have been found within the range of Upper Cretaceous species. In *L. rotulata* Lamarck (Pl. XX, Figs 3—6) and *L. neoorbicula* Hofker, the primary lamella covers the test on the spiral and ventral side, since the anterior wall also covers the preceding whorl. Up to eight laminae are visible in transverse section. In forms with a well developed umbo, the thickness of laminae considerably increases in the equatorial part and decreases towards poles (Pl. XX, Fig. 6). Species with the multilamellar microstructure concur in the Upper Cretaceous with still abundant mesolamellar ones.

In the genus *Lenticulina* the mesolamellar manner of adding chambers with a varying degree of the primary lamella's posterior overlapping is a decidedly predominant type of microstructure during the entire period under study. Species with the nonlamellar and lamellar microstructure, in which the entire test is covered are considerably less frequent. In a marked majority of species, the type of microstructure is, except for minor fluctuations, constant within one species. A dependence of microstructure on the manner of reproduction seems to occur in some species.

The multilamellar microstructure is most frequently observed in assemblages of the Upper Cretaceous *Lenticulina,* whereas such a manner of adding chambers has never been met with in the Liassic *Lenticulina.* A slightly mesolamellar type of microstructure with transition to the nonlamellar type occurs in a common Liassic species, *L. gottingensis.* In the Dogger, species with a large number of laminae forming a wall appear besides weakly mesolamellar and nonlamellar forms. Three laminae in a wall may be observed in the long-lived species *L. muensteri* which occurs from the Dogger through the Lower Cretaceous. The Upper Cretaceous *L. rotulata* and *L. neoorbicula* have a lamellar microstructure. This is indicative of an evolutionary trend to reinforce the test by the multilamellar manner of adding new chambers. Since the species of the *Lenticulina,* which first appear in the Upper Cretaceous, also include forms with a slightly imbricate manner of depositing the wall, this trend is not, however, general in character. The wall is thin and the durability of the test results from a larger number of closely coiled whorls as, for example, in *L. umbonata* (Reuss).

The microstructure of test wall in the *Lenticulina* constitutes a character of a various taxonomic importance in different species. In few species, it is an important character, but usually it plays an accessory role. The microstructure, in combination with other characters of internal structure observed in thin sections (the shape and arrangement of chambers, shape of spiral and transverse outline of test), allows one to identify some species of the *Lenticulina* on the basis of thin sections alone.

The thickness of primary lamella and, respectively, of septa is not uniform in various species of the *Lenticulina.* Septal walls thicker than these in the Cretaceous species are more frequent in the Jurassic ones. Septa are uniform in structure and are straight or slightly deflected posteriorly. In the upper part, their width is larger at the aperture than in the remaining sector. Septa are usually connected with the wall of the preceding whorl by a simple fusion. Another type of connection, that is, the growth of septum by overlapping the wall of a preceding whorl, was found in assemblages of the Upper Cretaceous *Lenticulina*.

In all the *Lenticulina* examined in thin sections apertures are similar to each other. The apertural hole is seen in equatorial section as a gap in the septal wall in the place of its contact with the outer wall of test. Sometimes, an apertural chamberlet is observed, which is connected with the proper chamber by a fine suture. The apertural chamberlet has not so far been described in the Liassic *Lenticulina*. Its sporadic occurrence was observed in the Polish Liassic material. Its more frequent occurrence in species younger geologically does not mean that this is a progressive evolutionary character. This fine element has a slender chance of preservation in older species. Wick (1937), who was first to study apertures in thin sections, considered the shape of aperture as a character suitable for separating Jurassic, Cretaceous and Tertiary species. The results obtained by the present writer, confirming Johannsen's (1952) studies, do not support Wick's opinion. The radial type of aperture is a constant character of all the *Lenticulina* studied.

The writer's observations of the porosity are in conformity with previous opinions that there is a relationship between a degree of lamination and the presence, dimensions and number of pores, which seems to show that pores perform certain functions in the process of forming lamellae (Krasheninnikov, 1956; Norling, 1968). In our material, the most porous are tests with multilamellar walls, regardless of their geological age (*L. oolithica, L. rotulata*). In slightly mesolamellar and nonlamellar species, it is more difficult to observe pores in thin sections.

CHARACTERISTICS OF THE JURASSIC AND CRETACEOUS *LENTICULINA* ASSEMBLAGES

The oldest lenticulinoid tests, determined inequivocally, come from the Permian. Bartenstein (1948) mentions the *Lenticulina* beginning with the Devonian. According to Brotzen (1963), the Paleozoic forms perhaps should not yet be considered as the *Lenticulina sensu stricto*. Other Paleozoic "*Cristellaria*", described by Chapman (1900) as allegedly coming from the Cambrian of England, later turned out to be Lower Liassic forms.

The occurrence of the *Lenticulina* in the Lias of Poland is considerably less numerous in regard to species and specimens than in Western Europe, which results from the paleogeographical situation and character of sedimentation. Three Polish regions, in which the foraminifers have ever been found in the Liassic marine intercalations are mentioned by Kopik (1960, 1964). These are: the Pomeranian-Kuiavian anticlinorium, the Szczecin synclinorium and the northern margin of the Holy Cross Mountains. The most abundant development of the Liassic microfauna in Poland occurred in the Pliensbachian. The richest and best preserved assemblage of the *Lenticulina* was found in the Uptonia jamesoni beds in the north-western part of the Pomeranian-Kuiavian swell (Gołańcz, Radowo Małe III, Mechowo and Kamień Pomorski borings), from which the following species of the *Lenticulina* were described: *L. gottingensis* (Bornemann), *L. acutiangulata* (Terquem), *L. polygonata* (Franke) and *L. varians* (Bornemann). The populations of these species are fairly uniform. Analyzed statistically, *L. gottingensis,* the most frequent of the Liassic non ornamented species of the *Lenticulina,* was not difficult for interpreting the results obtained. *L. muensteri* (Roemer), a species appearing in the Dogger, derives from *L. gottingensis,* but, as shown by the writer's studies (p. 165), these forms cannot be identified with each other, as it may be frequently found in literature.

A close relationship of *L. gottingensis, L. acutiangulata* and *L. polygonata* has been emphasized in descriptions of the Liassic *Lenticulina.* Some authors (e.g., Hoffmann & Martin, 1960) suggest to consider the latter two species as subspecies of *L. gottingensis.* The present writer's material of *L. acutiangulata* and *L. polygonata* was scant, but it revealed, in the course of studies on the microstructures and internal structure, the presence of constant distinguishing characters, which, in connection with the deviations in external morphology, gave evidence of their being separate species. On the basis of the material studied, the range of the occurrence of *L. acutiangulata* and *L. polygonata* has been limited in the present paper to the Lias. In Lias delta (Domerian), they are considered as convenient stratigraphic indexes (Franke, 1936). The problem of the species *L. varians* (Bornemann) has been left by the writer as open to discussion, as it requires a separate study, which should be started with establishing a lectotype.

The Aalenian transgression brings a microfauna which is scarce in the number of species and their tests are poorly preserved. A better situation is observed in the Bajocian, but the optimum conditions for the development of the *Lenticulina* occur in the Kuiavian and Bathonian. A clayey-muddy sedimentation type is represented by the material sampled from borings at Turów and Jaworznik, which abounds in very well-preserved *Lenticulina.* The nucleus of the assemblages of non-ornamented *Lenticulina* is formed mostly by three species, which occur repeatedly and more or less abundantly in each sample. Quantitatively, the first place is occupied by *L. uhligi* (Wiśniowski), followed by *L. muensteri* (Roemer) and *L. inflata* (Wiśniowski). The populations of the *Lenticulina* display an extensive variability. Earlier attempts at separating these forms (Uhlig, 1883; Bartenstein, 1956, 1962; Lutze, 1960; Cifelli, 1960) usually led to the conclusion that it was highly improbable to separate them identically by two different investigators. The heterogeneity of the species *L. muensteri*, studied statistically, is expressed by an undulating variability curve.

Conscpicuous trends in the extensive variability range of species may be considered as preponderant morphological variants. The present writer has concluded that if varying morphological types are related with each other to form one set, there is only one species present. The Doggerian tests of the group of *L. muensteri* have been described as six morphotypic groups (see Systematic Part). Two morphotypic groups have been distinguished in *L. uhligi* (Wiśniowski). In addition to the species mentioned above, nine smooth-walled species of the *Lenticulina* have been described from the Dogger and Malm. *L. constricta* (Kaptarenko), *L. oolithica* (Terquem), *L. involvens* (Wiśniowski), *L. primarea* Blank, *L.* sp. 1 and *L. muensteri* morphotype *gibba* are limited to the Dogger, while the remaining species and morphotypes pass to the Malm (Tabl. 2).

A change in facies from clayey-marly to more calcareous, which takes place at the end of the Dogger, distinctly reflects in the character of the *Lenticulina*. In clayey samples from the Callovian of Łuków, microfauna is richer, better developed and displaying similarity to older Doggerian assemblages (Bathonian, Kuiavian), while that from calcareous samples (Kcynia IV and Trzebionka borings) more accurately corresponds to the picture obtained for the Lower Oxfordian.

In the Oxfordian, calcareous-marly and marly-muddy types of sedimentation are established in Poland. The samples from Kcynia contain relatively numerous *Lenticulina* only in the lowest part of the profile. The scarcity of the *Lenticulina*, started as early as the Middle Oxfordian, is also observed in the Upper Oxfordian. Since it also concerns other genera (Bielecka & Styk, 1964), it indicates the existence, during that period, of unfavorable living conditions for the foraminifers. A partial recurrence of the clayey facies in the Kimmeridgian forms better conditions and is marked by the appearance of new species, which are, however, agglutinated forms and ornamented *Lenticulina*. The smooth-walled *Lenticulina* are few, on the whole dwarfed and their tests are poorly preserved, recrystallized. In the Volgian (Portlandian), these species disappear, probably as the result of an increasing regression of the Jurassic sea. Only the ornamented *Lenticulina* continue to live here and well develop, which gives evidence of variable environmental requirements of the *Lenticulina*. From other European areas (Franconia, Southern Germany), *L. muensteri* is mentioned in the Middle and Upper Tithonian (Groiss, 1963).

The Lower Cretaceous transgression brought once again an abundant fauna. The richest assemblage of the *Lenticulina* is contained in the Infra-Valanginian marine sediments developed in the clayey-marly facies. Much the same as in the Dogger, three smooth-walled species of the *Lenticulina* predominate in the Lower Cretaceous, i.e., *L. muensteri* (Roemer), already known from the Jurassic and continuing its occurrence, *L. gaultina* (Berthelin) and *L. nodosa* (Reuss). As shown by an analysis of the Lower Cretaceous assemblages of *L. muensteri,* despite its long-lasting occurrence, this species is not conservative. Only two of its Jurassic morphotypes, *muensteri* and *tumida,* occur in the Lower Cretaceous samples. The third, *russiensis,* has been related tentatively by the writer to the Lower Cretaceous, since only a few such specimens occur in her material. Only one of the Jurassic morphotypes, viz. *muensteri,* develops progressively in the geological time, while the other two are clearly becoming extinct. None other Jurassic morphotypes pass to the Lower Cretaceous. Instead two new, previously unknown morphotypes of *L. muensteri* appear. They are morphotype *crassa* and morphotype *H.* In the Lower Cretaceous material under study, the position of morphotype *crassa* is predominant. It persists for the longest time, occurring even in the Albian in which its occurrence terminates. In addition to *L. muensteri,* two morphotypes of the *L. nodosa* (Reuss) have been described. A total of eight species have been distinguished in the Lower Cretaceous, that is, besides those mentioned above, also *L. angulosa* (Chapman), *L. circumcidanea* (Berthelin), *L. pulchella* (Reuss), *L. vonderschmitti* (Gandolfi) and *L. subangulata* (Reuss).

As a result of epeirogenic movements, at the end of the Hauterivian the sea receded from the area of Poland, to which, in the profile under study, corresponds the Barremian-Aptian gap (Table 1). The period of the great Upper Cretaceous transgression was initiated in the Albian. The Upper Cretaceous beds outcropped in the Vistula river gorge, from which comes the samples for the studies on the *Lenticulina,* were described stratigraphically by Pożaryski (1936) and microfaunally by Pożaryska (1957). In the Albian, populations of the *Lenticulina* display a mixed character. Some species, typical of the Lower Cretaceous, occur here for the last time, together with few species in principle characteristic of the Upper Cretaceous, which appear for the first time (the first *L. rotulata* and the first *L. acuta*). In regard to dimensions, the Albian tests are on the average larger than in the Lower Cretaceous.

The assemblages of the Upper Cretaceous *Lenticulina* are marked by a considerable increase in the dimensions of tests. Even a perfunctory review allows one to distinguish the Upper from Lower Cretaceous assemblages. Certain morphological types of test structure, which occur in the Lower Cretaceous are also observed here, for example, *L. nodosa* (Reuss) becomes replaced by *L. pondi* Cushman, *L. subangulata* (Reuss) has its polygonal equivalent in the form of a species, provisionally determined as *L.* sp. 2 and a general outline of structure type characteristic of *L. muensteri* is repeated by *L. rotulata* Lamarck. In addition to these species, there occur other ones, representing new morphological types, which first appear in the Upper Cretaceous. These are species with many narrow chambers, strongly deflected posteriorly such as *L. semilovortex* Hanzliková or with very low whorls and frequently with a giant umbonal disc such as *L. umbonata* (Reuss) or *L. neoorbicula* Hofker. Altogether, nine smooth-walled species have been described from the Upper Cretaceous. In many cases, these are cosmopolitan forms (for example, *L. rotulata, L. pondi, L. marcki, L.* cf. *adelinensis*). The characters of the *Lenticulina* assemblages (the numbers of specimens and species, development of their tests) confirms a general view that living conditions favorable to the benthic foraminifers existed in the Cretaceous from the Emscherian to the Maastrichtian (Pożaryski & Witwicka, 1956; Witwicka, 1958; Gawor-Biedowa, 1960; Gawor-Biedowa & Witwicka, 1960; Huss, 1962). Three of the species described, that is, *L. umbonata* (Reuss), *L.* cf. *adelinensis* (Keijzer) and a species, for which the symbol *L.* sp. 2 has been adopted, are mentioned from the Tertiary. The present writer's studies have extended the range of their occurrence. The presence of the Tertiary forms as early as in the Upper Cretaceous and the continuous tendency to reach large dimensions, frequently with a small number of chambers in the outer whorl, cause that the Upper Cretaceous assemblages display a closer relationship to the Tertiary than Lower Cretaceous ones. Beginning with the Upper Cretaceous the percentage of the *Lenticulina* in the foraminiferal assemblage steadily drops. They become displaced by more and more abundantly developing trochospirally coiled species. In Recent deposits, the *Lenticulina* make up an insignificant percentage of the foraminiferal assemblages.

CHARACTERISTICS OF PARTICULAR FEATURES IN THE EVOLUTIONARY ASPECT

The identical pattern of structure and the lack of ornamentative elements make the identification of the smooth-walled *Lenticulina* difficult. In studies on these species, considerable importance is attributed to the number of chambers in the final whorl in relation to the dimensions of test. These are easily observable characters which may be expressed numerically.

Species of the *Lenticulina*, described from the Liassic samples, are marked by seven to nine chambers in the outer whorl, with an average size of test of 0.4 to 0.6 mm. *L. gottingensis* sporadically reaches even eleven chambers per whorl and a diameter of 0.92 mm, which is among the largest dimensions recorded in the Lias. A relatively small total number of chambers, (on the average 11—12), so that the spiral only rarely reaches 1.5 coils, is observed in equatorial sections of tests. Only microspherical individuals of *L. acutiangulata* exceed 1.5 coils, having to 16 chambers.

Many new species, including those marked by a many-sided variability, appear in the Dogger. On the whole, they are marked by a larger number of chambers in the outer whorl, mostly ten. Of the twelve forms described only three, that is, *L. biexcavata* (Mjatliuk), *L. inflata* (Wiśniowski) and *L. hebetata* (Schwager) had less than ten chambers. The occurrence of large tests of the order of 1.5 mm, representing the species *L. oolithica* (Terquem), *L. ruesti* (Wiśniowski) and *Lenticulina* sp., having fifteen and more chambers in the outer whorl, has for the first time been observed in this material. *L. uhligi* (Wiśniowski), predominant in the Dogger, reaches twelve chambers per whorl, with mean dimensions of 0.45 mm. The size of the Doggerian *Lenticulina* is mostly contained within limits of 0.35 and 0.70 mm, while their value "L" widely exceeds these limits.

In the sections of tests of various Doggerian species we have most frequently to do with specimens consisting of 1.5 coils formed, on the average, by twelve to sixteen chambers. Next, a more or less the same percentage is represented by forms which display a bit more or a bit less coiled spiral (1.25 and 1.75 coils). The largest number of coils, nearly three, was recorded in *L. ruesti* with a total of 33 chambers. Large-size tests occur more numerously in the Bathonian than Kuiavian (Vesulian).

In the Callovian, a larger number of chambers per whorl corresponds to average-sized tests. This tendency persists in the Lower Malm, manifested more strongly in the case of assemblages from the calcareous rather than clayey facies. This phenomenon is not accompanied by a progressive increase in the size of tests, which sometimes even become smaller. Chambers are arranged close to each other and relatively large, thick umbilical areas give the tests a robust look. Conspicuous is the tendency of chambers to grow upwards (the final chambers are high).

In the Upper Kimmeridgian, an increase in the number of chambers per whorl is observed no more. The assemblages of the smooth-walled *Lenticulina* are strongly impoverished. In the Volgian (Portlandian), there are in fact only ornamented *Lenticulina*, having well developed tests and mostly nine chambers in the outer whorl. A poor state of preservation of the material makes studies on the internal structure of the smooth-walled Malmian species difficult. Their tests are frequently recrystallized.

In the Lower Cretaceous, contrary to the Dogger, predominant are species with a small number of chambers per whorl. Of the nine species described six have eight or less chambers in the outer whorl, one, *L. nodosa* (Reuss), on the average nine chambers, with some specimens even reaching eleven, and only two have on the average ten and maximum thirteen chambers, continuing, a gradual increase with time in the number of chambers and length of spiral. The last-named two are *L. muensteri* (Roemer) morphotype *crassa* and *L. gaultina* (Berthelin). In these forms, the large number of chambers corresponds to large general dimensions of the test, exceeding 1 mm. The remaining species may be closed within an interval of 0.4—0.6 mm. In sections, they reveal somewhat more than one whorl, but only rarely as much as 1.5 whorls. The largest number of chambers and whorls has been recorded in the Lower Cretaceous *Lenticulina* populations within the range of microspheric specimens of *L. muensteri* morphotype *crassa*, which reach up to 2.5 coils and to 25 chambers.

In the Upper Cretaceous, a conspicuous predominance is observed of species with a small number of chambers in the outer whorl over forms having many chambers. Of the nine species described only two, that is, *L. rotulata* Lamarck and *L. neoorbicula* Hofker, have on the average ten and twelve chambers in the outer whorl. The remaining species develop an outer whorl containing seven to nine chambers. A total number of chambers, reached in the Upper Cretaceous, is very large, almost never less than twenty and, in the case of *L. neoorbicula* and *L. rotulata*, even close to 30. This large total number of chambers is accompanied by large dimensions of tests, averaging 0.8 to 1.6 mm. The largest specimens, up to 2.7 mm in diameter, represent the species *L. marcki* (Reuss) and *L. neoorbicula* Hofker. A small number of chambers in the outer whorl, with a large total number of chambers, is possible due to the occurrence of a longer spiral in the Upper Cretaceous species. It usually consists of more than two coils, such as in *L. umbonata* (Reuss) having even more than three coils. It is only in one species, *L. pondi* Cushman, that incomplete two coils have been found.

In the assemblage under study, *L. muensteri* (Roemer) was an object of particular attention. Due to is longevity, this species is particularly suitable for observing evolutionary changes in its various characters. Attention was called by hitherto conducted studies to the fact that in *L. muensteri* changed the number of chambers in its outer whorl over its history. Lutze (1960) was the first to analyze this phenonemon. On the basis of a comparison of the results obtained for the Callovian and Oxfordian populations with those concerning the Cretaceous forms, this author developed the hypothesis that the large number of chambers per whorl in the Jurassic forms (eleven) and smaller in the Cretaceous specimens (eight — nine) perhaps gives evidence of the phylogenetic development or may indicate a change in the ratio of micro-to megalospheric individuals. Lutze's observations were later confirmed by Groiss's (1963) and Winter's (1970) studies, who also analyzed Kimmeridgian and Tithonian populations. Winter (1970) observes that while in the Lower Kimmeridgian the apexes of curves unequivocally indicate eleven and more chambers, in the Middle Tithonian they fall to nine chambers per whorl. This is in conformity with the results the present writer obtained even prior to the publication of Winter (Text-fig. 36). The studies also included Bajocian and Kuiavian populations. An analysis of *L. muensteri* she conducted for these two stages produced unequivocal curves indicating nine chambers in the outer whorl, with a considerable part of ten-chamber tests. In equatorial sections of tests, a total number of chambers usually amounts from twelve to seventeen and they mostly form 1.5 to 1.75 coils. Specimens displaying two full coils are rare and reach a maximum of 21 chambers.

In the Callovian, similar studies were conducted on specimens from the clayey (Łuków) and calcareous-marly (Trzebionka, Kcynia IV) facies. In the former case, the apex of curve indicated nine chambers, with a larger number of specimens with ten chambers per whorl than in the lower stages of the Dogger. In the case of Trzebionka, the curve reached its apex with ten chambers with a considerable percentage of eleven-chamber tests and in the Kcynia IV with eleven chambers. A tendency to a larger number of chambers per outer whorl is observed continuously in the Lower Oxfordian. Most tests examined, which were connected with the calcareous facies, displayed ten and eleven chambers in the outer whorl. The shifting of curve apex towards a large number of chambers is not in the Polish material as conspicuous as that obtained by Winter (1970).

A curve with its peak once again falling to nine chambers per whorl was obtained for the Upper Kimmeridgian (Kcynia I). Taking into account Winter's (1970) curves, drawn for the Lower Kimmeridgian and Middle Tithonian, the moment of decrease in the number of chambers should be placed on the boundary between the Lower and Upper Kimmeridgian.

Due to a poor state of preservation, studies on the Malmian tests from Poland could not be enriched by observations of thin sections. Seibold & Seibold (1955) give numerical data for twelve specimens of *L. muensteri* from the Lower Malm, obtained from thin sections. Their spirals mostly consist of 1.5 to 2 coils and of seventeen to nineteen chambers. The largest specimen, 1 mm in diameter and with a small initial chamber, reaches 2.75 coils with a total number of 23 chambers. Making perfunctory use of the data cited above, it should be emphasized that the tests studied by the Seibolds were selected mostly of large specimens and, therefore, they represent somewhat higher than average values.

In the Lower Cretaceous *L. muensteri*, the number of chambers in the outer whorl is smaller than that recorded in the Jurassic. An analysis of Infravalanginian samples (Kcynia II) produced curves, whose peaks unequivocally indicated eight chambers. The next place was taken by nine-chamber tests. A total number of chambers in the Lower Cretaceous is, on the other hand, larger than in the Dogger and mostly amounts to fifteen — eighteen. In the Lower Cretaceous, much the same as in the Jurassic, the most common are *L. muensteri* tests consisting of 1.5 to 1.75 coils of spiral, but the percentage of specimens reaching 1.75 coils is considerably larger. Individuals reaching two to two and a half coils, with a maximum number of 25 chambers, are fairly frequent.

When we compare other characters of *L. muensteri* in the evolutionary aspect, attention is attracted by the fact that an increase in the size of tests — insignificant on the average, is accompanied by a conspicuous increase in the index of convexity. This tendency is expresed in the Lower Cretaceous in the appearance of the morphotype *crassa* and in a somewhat higher degree of convexity observed within the range of the remaining long-lived morphotypes. At the same time, tests become more circular. Although statistically obtained dependences $N\left(\frac{L}{B}\right)$ for the Dogger and Lower Cretaceous do not display major differences, the present writer believes that such differences would be more distinct in an increased statistical set, since, as a result of morphological observations, a more frequent occurrence was observed of individuals displaying the tendency to a semi-involute uncoiling of tests within the range of the Jurassic than Cretaceous populations. In the Lower Cretaceous, the uncoiling tests of *L. muensteri* occur sporadically, while almost completely circular are fairly frequent. In addition, many Lower Cretaceous tests display the tendency to a slightly polygonal outline and to a certain convexity of older sutures. At the same time, there is also a larger part of individuals having a distinctly marked umbonal disc.

Changes occurring with the lapse of time in some of the morphological characters analyzed concern not only the species mentioned above, but also the *Lenticulina* assemblages at all. On the whole, species with an elongate test are more numerous in the Jurassic and those with a circular test, reaching a larger number of whorls, in the Upper Cretaceous. In the Malm, very conspicuous is the compactness of the structure of tests, which consist of closely arranged, narrow chambers, the final ones of them tending to become pointedly elevated. The occurrence of certain characters during a definite geological period has also been observed. Thus, for example, species displaying such characters as nodes on the periphery (*L. nodosa*, *L. pondi*), enormous umbonal discs and low whorls (*L. neoorbicula*, *L. umbonata*) and a considerable posterior deflection of suture lines (*L. semilovortex*) occur only in younger, Cretaceous assemblages.

The changes of apertures in geological time have already been analyzed many times. Very exhaustive is in this respect Kuznetzova's (1960a) work. The "*Robulus*" slit (the genus *Robulus* Montfort, 1808), described in the

Pliocene lenticuliniform specimens, begins to form considerably earlier, as it is observed in the Cretaceous and Jurassic *Lenticulina,* usually within the range of high-aperture species.

CONCLUSIONS

During the period between the Lower Jurassic and the Upper Cretaceous the following three distinct phases are distinguishable in the development of the smooth-walled *Lenticulina:* (1) Liassic, (2) Dogger through Lower Cretaceous and (3) Upper Cretaceous.

In the Liassic of Poland, the composition of *Lenticulina* assemblages is only slightly differentiated specifically. Species occur not very abundantly and are fairly uniform in character, that is, their tests are relatively large and reach on the average a small number of chambers in the outer whorl. A total number of chambers and length of spiral are on the whole small likewise. A weakly mesolamellar and nonlamellar type of microstructure is as a rule observed in thin sections.

The Dogger-through-Lower Cretaceous phase makes up a period of an abundant blossoming of the *Lenticulina* microfauna. Deposits abound in species, some of them many-sidedly variable, and in specimens. As compared with the Liassic assemblages, the Late Jurassic tests have on the average more chambers and a longer spiral. The mesolamellar type of the microstructure of wall pronouncedly predominates in thin sections. The comparison with the Lower Cretaceous *Lenticulina* reveals the tendency to decrease the number of chambers per whorl. This tendency continues in the Upper Cretaceous.

The Upper Cretaceous is a period during which characteristic large-test *Lenticulina* species occur. They reach a large total number of chambers and whorls. The multilamellar type of the microstructure of wall is relatively most frequent within the range of these species.

The species of the *Lenticulina* developed in the Jurassic and Cretaceous in more than one way and there is no uniform pattern of evolution, which might include the whole of the *Lenticulina* assemblages. A decrease in the number of chambers in the outer whorl, observed in geological time, reflects trends independent of each other. One of the trends is manifested by a decrease in the number of chambers in the outer whorl, with a simultaneous increase in a total number of chambers resulting in an increase in the length of spiral and number of whorls. This trend is not displayed by fairly numerous, newly appearing Lower Cretaceous species, which have a short spiral and in which a small number of chambers in the outer whorl also corresponds with a small total number of chambers forming the test.

Taking into account the above, along with the fact that tests with strongly bent chambers which considerably overlap each other posteriorly first appear in the Upper Cretaceous, the writer declares herself in favour of the hypothesis that the spiral forms derive from the uncoiled ones and not vice-versa.

The importance of the smooth-walled *Lenticulina* for the stratigraphic purposes is rather limited. These assemblages distinctly differ from each other only in the intervals of geological epochs (Table 2).

A stratigraphical range of species much more extensive than hitherto accepted has been found in many cases. Despite an extensive time range of occurrence, a shortened period of their optimum development is observed, which may be of a certain importance to stratigraphy. The long-lived species may also be useful, since over a long stretch of time they are not completely conservative and are subject to microevolutionary changes. Conducting such observations requires, however, a considerable experience. As follows from comparing histograms of *L. muensteri*, during the life-span of this species some morphotypes were eliminated, while some others survived undergoing microevolutionary changes and yet others appeared as new ones. Such a development of this species may, despite its longevity, be very well made use of for stratigraphic purposes, since particular evolutionary forms may serve as stratigraphic indicators. This is the more important as many species of the *Lenticulina* constitute cosmopolitan forms.

DESCRIPTIONS

Suborder **Rotaliina** Delage & Hérouard, 1896
Family **Nodosariidae** Ehrenberg, 1838
Genus *Lenticulina* Lamarck, 1804

Type species: Lenticulina rotulata Lamarck, 1804

Tests, which, according to Loeblich & Tappan (1964), are marked by the following characters: multilocular, hyaline, calcareous, having perforate walls, coiled planispirally, involute or tending to uncoil, round or oval, pointed upwards, biconvex have been assigned to the genus *Lenticulina*. Furthermore, their characteristics include: periphery smooth or with a keel. Chambers subtriangular, wider than higher, gradually increasing. Sutures arcuate or straight, tangential or radial, flush, depressed or elevated in relation to the surface of test. Aperture radiate, situated on the apex of chamber near the outer margin, sometimes with an additional „*Robulus*" slit.

Depending on the manner of adding new chambers, the structure of test wall is nonlamellar, mesolamellar (tegular) or multilamellar. Microstructure of primary wall homogeneous, radial.

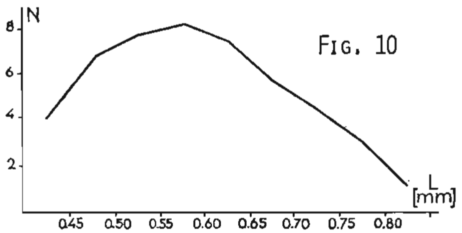
Lenticulina gottingensis (Bornemann, 1854)
(Pl. I; Pl. II, Fig. 3; Pl. XVII, Figs 1—4)

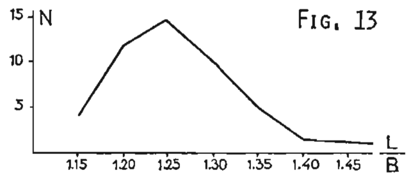
1854. *Robulina gottingensis* Bornemann; Bornemann, p. 43, Pl. 4, Figs 40, 41.
1860. *Cristellaria rotulata* Lamarck; Jones & Parker, p. 453, Pl. 20, Fig. 43.
1908. *Cristellaria rotulata* Lamarck; Issler, p. 87, Pl. 7, Figs 311—315.
1936. *Cristellaria (Lenticulina) gottingensis* (Bornemann); Franke, p. 116, Pl. 11, Fig. 22.
1937. *Cristellaria (Lenticulina) münsteri* (Roemer); Bartenstein & Brand, p. 174, Pl. 3, Fig. 30; Pl. 4, Fig. 69.
1938. *Cristellaria (Lenticulina)* (247); Wicher, Pl. 20, Fig. 6.
1941. *Cristellaria münsteri* (Roemer); Macfadyen, p. 31, Pl. 2, Fig. 23.
1951. *Lenticulina münsteri* (Roemer); Barnard, p. 7, Pl. 2, Fig. 1.
1957. *Lenticulina gottingensis* (Bornemann); Nørvang, p. 382, Figs 153—162, 166, 167.
1960. *Lenticulina "muensteri"* Roemer; Hoffmann & Martin, p. 124, Pl. 11, Fig. 14.
1961. *Lenticulina (Lenticulina) münsteri* (Roemer); Pietrzeniuk, p. 67, Pl. 5, Fig. 3.
1961. *Lenticulina münsteri* (Roem.); Trifonova, p. 275, Pl. 1, Fig. 6.
1963. *Lenticulina (Lenticulina) gottingensis gottingensis* (Bornemann); Rabitz, p. 202, Pl. 16, Fig. 4.
1966. *Lenticulina münsteri* (Roemer); Del Sere, p. 166, Pl. 14, Figs 7, 9, 10.
1968. *Lenticulina muensteri muensteri* (Roemer); Welzel, p. 41, Pl. 2, Fig. 30.
non 1969. *Lenticulina gottingensis* (Bornemann); Brouwer, p. 37, Pl. 7, Figs 7, 8.

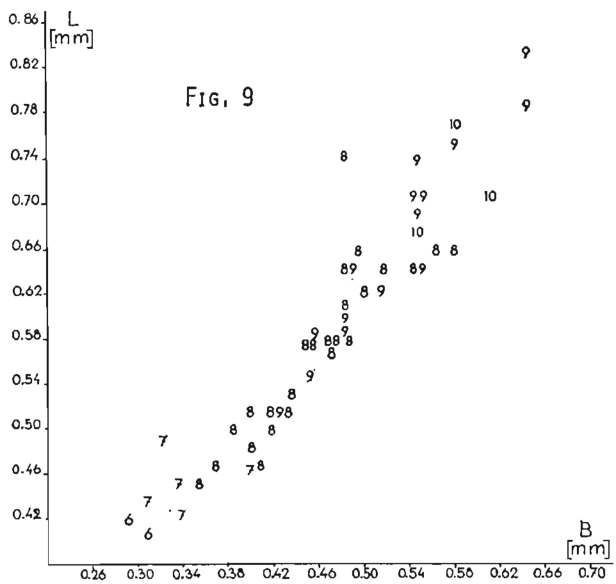
Material. — A hundred, variously preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)	$\frac{L}{B}$	$\frac{B}{T}$
Specimens:						
— minimum	7	0.32	0.27	0.16	1.18	1.69
— common	8	0.58	0.46	0.27	1.26	1.70
— maximum	9	0.92	0.65	0.36	1.41	1.80

Description. — Tests involute, gently biconvex, mostly 0.58 mm in size (Text-fig. 10), 0.28—0.30 mm thick, subcircular in outer outline. The ratio of the longer L to shorter B diameter mostly fluctuating within limits of 1.20 and 1.30 (Text-fig. 13). Periphery rounded or acute, keel-less. Six to eleven, mostly eight, chambers occur in final whorl (Text-fig. 11). Chambers flat, triangular, the final one slightly elongated. Sutures distinct, fairly wide, gently deflected posteriorly, flush with test surface. Umbo small, flat. Apertural face triangular, gently deflected, laterally limited by slightly developed margins. Apertural radii short, shallow, more or less distinct. Apertural chamberlet rarely preserved. An additional, small notch or a distinct, fairly long slit is frequently observed in the plane of apertural face.







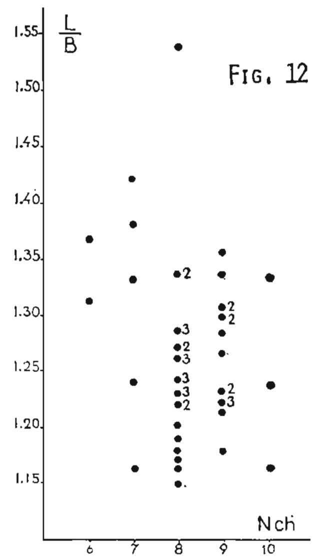
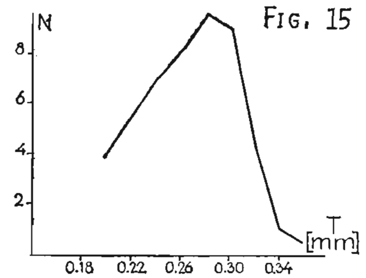


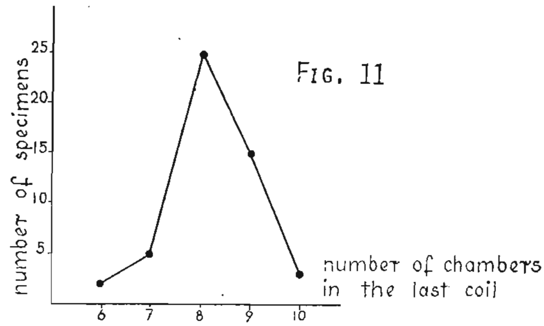
Fig. 9. A scatter diagram of the tests of *Lenticulina gottingensis* (Bornemann), depending on the longer diameter of test L and shorter diameter of test B. The figures 6 to 10 denote the number of chambers in the final whorl. Pliensbachian, Gołańcz boring, depth 274 m.

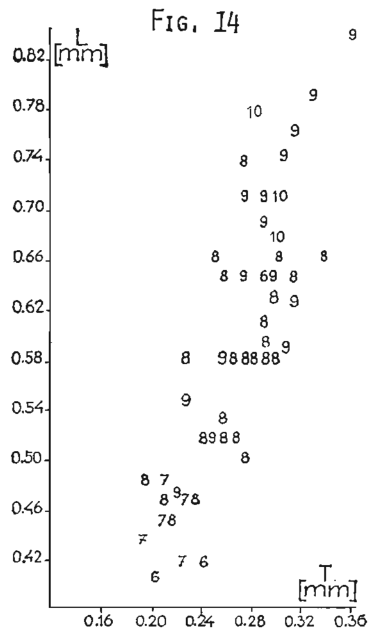
Fig. 10. The curve of variability in the size of tests for fifty specimens of *L. gottingensis* (Bornemann). L — longer diameter of test, N — number of individuals. Pliensbachian, Gołańcz boring, depth 274 m.

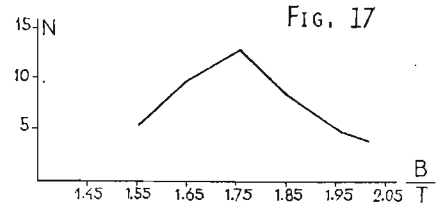
Fig. 12. A scatter diagram of the tests of *L. gottingensis* (Bornemann) depending on value $\frac{L}{B}$ for specimens with a definite number of chambers in the final whorl. L — longer diameter, B — shorter diameter. The figures near dots denote the number of specimens with the same values. Pliensbachian, Gołańcz boring, depth 274 m.

Fig. 13. The curve of variability in value $\frac{L}{B}$ for fifty specimens of *L. gottingensis* (Bornemann). L — longer diameter, B — shorter diameter, N — number of individuals. Pliensbachian, Gołańcz boring, 274 m.









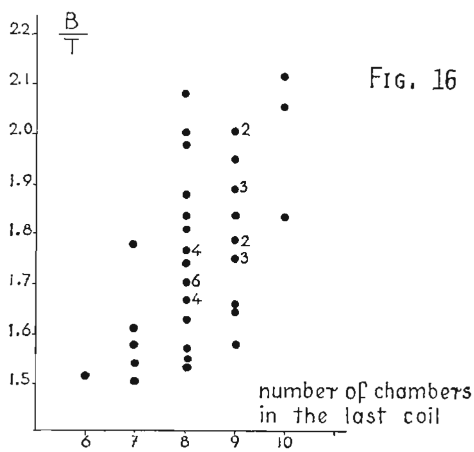


Fig. 11. The curve of the frequency of occurrence of individuals with an identical number of chambers in the final whorl for fifty tests of *L. gottingensis* (Bornemann). Pliensbachian, Gołańcz boring, depth 274 m

Fig. 14. A scatter diagram of the tests of *L. gottingensis* (Borneman), depending on the longer diameter of test L and convexity T. The figures 6 to 10 denote the number of chambers in the final whorl. For 50 specimens. Pliensbachian, Gołańcz boring, 274 m.

Fig. 15. The curve of variability in the convexity of tests of *L. gottingensis* (Bornemann). T — convexity, N — number of individuals. For 50 specimens. Pliensbachian, Gołańcz, 274 m.

Fig. 16. A scatter diagram of the tests of *L. gottingensis* (Bornemann) depending on $\frac{B}{T}$ for those with a definite number of chambers in the final whorl. B — shorter diameter, T — thickness. The figures near dots denote the number of specimens with the same values. Pliensbachian, Gołańcz, 274 m.

Fig. 17. The curve of variability in $\frac{B}{T}$ for 50 specimens of *L. gottingensis* (Bornemann). B — shorter diameter, T — thickness, N — number of specimens. Pliensbachian, Gołańcz, 274 m.

Equatorial section. The whole spiral consists of about 1.3, sometimes 1.5, whorls. Proloculus megalospheric, 0.06 to 0.09 mm in diameter. The next chamber smaller than proloculus, triangular. Further chambers of the young stage rapidly increase their dimensions. Specimens with eight chambers in the final whorl have one to three chambers (plus proloculus) in the inner part and those with nine chambers — two to five. Microstructure of wall slightly mesolamellar to nonlamellar (p. 115).

Variability. — The variability in some characters of the species under study has been elaborated quantitatively. The dependence of the dimensions of tests on the number of chambers, which is on the whole proportional, is shown in Text-fig. 9. The scatter diagram is presented in a linear arrangement, from which, however, certain deviations may be observed. The range of variability in the longer diameter L in eight-chamber tests fluctuates within limits of 0.45 and 0.75 mm and has a large area common with nine-chamber tests, in which the range of variability in the longer diameter amounts to 0.52—0.84 mm. Few ten-chamber tests, occurring in our material, are smaller than strongly developed nine-chamber individuals. An identical number of chambers corresponds, therefore, to a considerable differentiation in the size of tests, or, in other words, a variable number of chambers may be observed with an identical size. In the Liassic of Poland, the most common are tests with eight chambers in the final whorl (Text-fig. 11). The second place is taken by those with nine chambers and the third — with seven chambers. Other tests are very few and represent an insignificant percentage of the entire assemblage. The most frequent sizes of tests of *L. gottingensis* are contained within limits of 0.48 and 0.63 mm, the peak frequency falling to a value of 0.58 mm (Text-fig. 10).

The variability in the shape of tests has been examined from the viewpoint of a ratio of the longer to shorter diameter $\frac{L}{B}$ and of that of the shorter diameter to the thickness of test $\frac{B}{T}$ in particular stages of ontogenetic development. A fairly extensive differentiation is depicted by the pattern of dots as shown in Text-fig. 12. For specimens closely coiled $\frac{L}{B}$ amounts to about 1.15 and for those tending to uncoil — about 1.4. Since the uncoiled part is in all cases damaged, the few strongly uncoiling specimens have not been taken into account in the diagram. A peak value of $\frac{L}{B}$ variability curve is 1.25 (Text-fig. 13). These are specimens strongly resembling Bornemann's holotype.

The range of variability in the dumpiness of tests has been studied from the viewpoint of a dependence of thickness on the size of test (Text-fig. 14) and of changes in $\frac{B}{T}$ ratio with a definite number of chambers in outer whorl (Text-fig. 16). An increase in the thickness of test is proportional to an increase in the size of the specimen (Text-figs. 17 and 18). The largest variability of T occurs in tests with eight and nine chambers in outer whorl, which are most common. The variability of T in tests with six, seven and ten chambers in outer whorl is contained within the range of values T for eight- and nine-chamber tests. The most frequent value of $\frac{B}{T}$ amounts to about 1.75; in few most convex forms this index amounts to about 1.5 and in flat forms to about 2.0 (Text-fig. 17). Considerable fluctuations in values of $\frac{L}{B}$ and $\frac{B}{T}$ are also displayed by specimens with an identical number of chambers in outer whorl. Regardless of the degree of convexity of tests, the umbonal disc is always flat.

Remarks. — In reviewing the synonymy of *L. gottingensis* Bornemann), striking is the fact that this species has frequently been described under the name *Cristellaria* (*recte Lenticulina*) *rotulata* Lamarck or *L. muensteri* (Roemer). The former, found in the Senonian of the Paris Basin, is characteristic of the Upper Cretaceous, while the latter was described from the Lower Cretaceous deposits of Northern Germany. Calling the Liassic form by these two names was a misunderstanding caused by the similarity of descriptions, not based on a direct comparison of these tests and, in the case of the Cretaceous species, much too sketchy.

The diagnosis of the species *L. gottingensis* presented by Bornemann is as follows: "Test lenticular, convex. Periphery angular, smooth. Seven

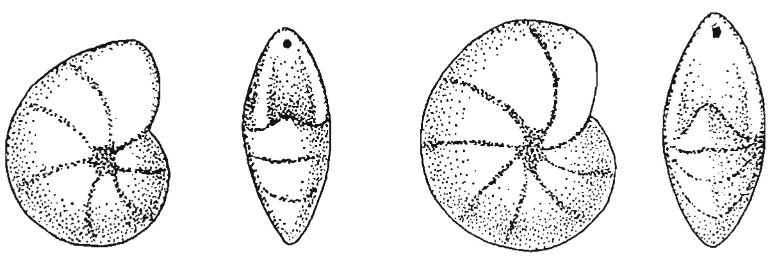


Fig. 18. *Lenticulina gottingensis* (Bornemann, 1854). A copy of Bornemann's original drawings (*fide* Cat. of Foram., Ellis & Messina).

to nine slightly deflected chambers in the final whorl. One or two completely involute whorls. Apertural face of the final chamber reversed heartlike in shape, convex. Aperture narrow. Diameter 0.6 to 0.8 mm (Bornemann, 1854, p. 43) Copies of Bornemann's original drawings are shown in Text-fig. 18. The Liassic specimens from Poland are in conformity with Bornemann's description and do not display any fundamental deviations from other authors' works, although the dimensions of tests are on the average somewhat smaller than those cited from the territory of Western Europe.

As a result of studies on tests conducted in the continuous Liassic-Upper Cretaceous section, the present writer believes that the species *L. gottingensis* (Bornemann), *L. muensteri* (Roemer) and *L. rotulata* Lamarck represent separate taxons. Differences between them are expressed in outer characters, in their internal structure, as well as in the microstructure of walls. The results of comparative analysis are presented in the remarks on the species *L. muensteri* and in the chapter on the evolution of the *Lenticulina*. *L. gottingensis* is closely related to *L. acutiangulata* (Terquem) and *L. polygonata* (Franke). (see also p. 119).

The specimen presented by Brouwer (1969) as *L. gottingensis* (Bornemann) does not resemble in appearance the test ilustrated by Bornemann. It seems to have a well-developed keel, an umbilical button and wide, conspicuous sutures, which project over the surface of test.

In Welzel's (1968) opinion, *L. rustica* (d'Orbigny) is a subspecies of *L. muensteri* (*recte L. gottingensis*), but the specimen illustrated by Welzel differs from typical specimens of *L. gottingensis* only in a small degree of departing the final chambers from umbo (1968, p. 42, Pl. 2, Fig. 31).

Some specimens of *L. gottingensis* in the final stage of development display the tendency to uncoil their tests and to adopt a serial arrangement. As emphasized by Barnard (1950), this leads sometimes to the situation in which younger specimens are identified correctly, while adult individuals corresponding to them, with uncoiled final chambers are assigned to *L. matutina* (d'Orbigny). Differences between the species mentioned above are expressed in the proportions of the spiral to the straight part of test and in a varying degree of its convexity.

Forms which, maintaining the same pattern of structure, develop such elements of ornamentation as sutural ribs, keel and umbilical button, are derived from smooth tests of *L. gottingensis*. In literature on the Liassic they are described as *L. subalata* (Reuss), *L. toarcense* Payard and *L. faveolata* (Franke).

The discussion of *L. gottingensis* should also include Kübler's & Zwingli's (1868) forms from the Toarcian of Switzerland, described as *Cristellaria communis*, *C. rotalina* and also the uncoiling species *C. rotunda* and *C. turbinoides*. However, it is difficult to assume any definite attitude towards them since their very perfunctory descriptions and illustrations of specimens plunged in immersion substances, do not give in fact any notion on the appearance of these tests.

Occurrence. — This is a Liassic species of a European range (Poland, Germany, Denmark, Sweden, England, Italy, Bulgaria). In the Polish material it occurs in the Pliensbachian of the Gołańcz, Radowo Małe III, Przytoń and Machowo borings. The holotype comes from the Liassic of the environs of Göttingen, Germany.

Lenticulina acutiangulata (Terquem, 1864)
(Pl. II, Figs 4—6)

1864. *Robulina acutiangulata* Terquem; Terquem, p. 430, Pl. 10, Fig. 20 (*fide* Cat. of Foram. Ellis & Messina).
1961. *Lenticulina (Lenticulina) acutiangulata* (Terq).; Pietrzeniuk, p. 67, Pl. 5, Fig. 1 (here older synonymy).
1968. *Lenticulina muensteri acutiangulata* (Terq.); Welzel, p. 43, Pl. 2, Fig. 29.

Material. — Seven fairly well preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
smaller specimen	7	0.48	0.40	0.20
larger specimen	9	0.63	0.53	0.27

Description. — Polish specimens of *L. acutiangulata* are in the greatest conformity with Nørvang's (1957) description of this species.

Equatorial section. Internal part of spiral consisting of one to six chambers and a proloculus varying in size. The smallest proloculus, 0.038 mm, is observed in a specimen consisting of fifteen chambers; the largest, 0.065 mm, occurs in an eight-chamber specimen. Microstructure of wall mesolamellar.

Remarks. — As compared with the holotype, the tests of Polish specimens are devoid of elevated umbilical button and their keel does not include the final chamber. Specimens from the comparative material from Germany have usually a better developed, wider keel. In Polish samples, specimens representing a transition from the keel-less *L. gottingensis* to *L. acutiangulata* having a distinct, transparent keel, are more abundant than typical forms (Pl. II Fig. 3).

In contrast to Nørvang's (1957) description, the sutures of Polish specimens are usually flat, distinct and gently deflected posteriorly. Specimens with sutures slightly raised above the surface of test are similar to the Liassic ornamented species, described as *L. subalata* (Reuss), *L. toarcense* Payard and *L. faveolata* (Franke). Interesting remarks on comparisons of *L. acutiangulata* with *L. cultrata* (Montfort) are presented by Welzel (1968).

As compared with *L. gottingensis*, *L. acutiangulata* has a longer spiral (1.5 coils) and a larger number of chambers. The sections of its tests reveal the presence of micro- and megalospheric forms, while only megalospheric ones occur in *L. gottingensis*. Likewise, an overlap of laminae reaching far more posteriorly in this species than in *L. gottingensis* is observed in the microstructure of its wall.

Occurrence. — This is a Liassic species known from Denmark, France, Germany and Poland. It passes for a good stratigraphic index of the Domerian. In Poland it occurs rarely in the Pliensbachian (Radowo Małe III, Mechowo and Kamień Pomorski borings). The holotype comes from the Pliensbachian of France, A. capricornu beds.

Lenticulina polygonata (Franke, 1936)
(Pl. II, Figs 7, 8)

1936. *Cristellaria (Lenticulina) polygonata* Franke; Franke, p. 118, Pl. 12, Figs. 1, 2.
1960. *Lenticulina "polygonata"* Franke; Hoffmann & Martin, p. 124, Pl. 11, Fig. 17.
1968. *Lenticulina muensteri polygonata* (Franke); Welzel, p. 42, Pl. 2, Fig. 38 (here older synonymy).
non 1969. *Lenticulina polygonata* Franke; Brouwer, p. 37, Pl. 7, Fig. 9.

Material. — Five tests, including four very well-preserved.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
smaller specimen	7	0.44	0.31	0.19
larger specimen	9	0.84	0.65	0.36

Description. — Tests from the Polish material correspond to Franke's (1936) description.

Equatorial section. Megalospheric forms with few inner chambers. Proloculus 0.1 mm in maximum dimension. Microstructure of wall non-lamellar.

Remarks. — Specimens, in which the polygonal outline and the elevation of sutures above the surface of test are indistinct, are similar to *L. gottingensis* (Bornemann). The polygonal shape of tests is most distinctly marked in later ontogenetic stages.

In contrast to the holotype, the tests examined display a radiate aperture with poorly developed radii.

Forms with identical characters were first presented by Jones & Parker from Chellaston near Derby, England (1860, Pl. 20, Fig. 42), and included by these authors in *Cristellaria rotulata* (Lam.).

In 1936, Franke found these tests in the Liassic of Germany and considered them as a separate species.

Brouwer's (1969, Pl. 7, Fig. 9) specimen, differ from Franke's specimens in a strong upward extension and non-polygonal outline.

Occurrence. — This is a rare Liassic species, known from Denmark, Germany and Poland, usually cited from the Domerian. In the material under study single specimens occur in the Pliensbachian samples (Mechowo, Gołańcz and Przytoń borings).

Lenticulina varians (Bornemann, 1854)
(Pl. II, Figs 1, 2)

pars 1854. *Cristellaria varians* Bornemann: Bornemann, p. 41, Pl. 4, Fig. 33 (non Figs 32 and 34).
1854. *Cristellaria granulata* Bornemann; Bornemann, p. 41, Pl. 4, Fig. 36.
1854. *Cristellaria minuta* Bornemann; Bornemann, p. 42, Pl. 4, Fig. 37.
1854. *Cristellaria convoluta* Bornemann; Bornemann, p. 42, Pl. 4, Fig. 38.
1908. *Cristellaria varians* Bornemann; Issler, p. 86, Pl. 6, Figs 306, 307; Pl. 7, Figs 308, 310.
1936. *Cristellaria (Lenticulina) varians* Born.; Franke, p. 112, Pl. 11, Figs. 9—12.
1936. *Cristellaria (Lenticulina) minuta* Born.; Franke, p. 112, Pl. 11, Fig. 8.
1936. *Cristellaria (Lenticulina) convoluta* Born.; Franke, p. 113, Pl. 11, Fig. 14.
1937. *Cristellaria (Lenticulina) varians* Bornemann; Bartenstein & Brand, p. 176, Pl. 1A, Fig. 18; Pl. 2A, Figs 16, 20; Pl. 3, Fig. 31; Pl. 5, Fig. 60.
1938. *Cristellaria (Lenticulina) varians* Born.; Wicher, Pl. 20, Figs 2, 5.
1941. *Cristellaria varians* Bornemann; Macfadyen, p. 35, Pl. 2, Fig. 28.
pars 1947. *Lenticulina varians* (Bornemann) *f. recta* (Franke); Payard, p. 86, Pl. 7. Fig. 3 (non Figs 4, 5).
1957. *Astacolus varians* (Bornemann); Nørvang, p. 377, Figs 124, 125.
1961. *Lenticulina (Lenticulina) varians* (Bornemann); Pietrzeniuk, p. 66, Pl. 5, Figs 2, 8.
pars 1963. *Lenticulina (Astacolus) varians* (Bornemann); Rabitz, p. 203, Pl. 16, Figs 2, 3, 6 (non Fig. 1).
1968. *Lenticulina varians varians* (Bornemann); Welzel, p. 43, Pl. 2, Figs. 32, 33.

Material. — Twenty-seven well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
smaller specimen	8	0.35	0.22	0.11
larger specimen	9	0.67	0.43	0.21

Description. — Test smooth, oval, slightly biconvex, in the lower part spiral, elongated and tapering upwards, tending to uncoil final chambers. No complete detachment of chambers from spiral observed. Periphery sharp, rarely with a keel running only over the spiral part of test. Seven to nine chambers, distinctly separated by sutures, occur in the final whorl. Sutures flat, in the spiral part arcuate, further nearly straight. Apertural face oval, elongate, gently curved in outline. Aperture radiate, terminal, situated on the apex of a strongly elongated final chamber.

Variability. — Variable are the proportions of the spiral part in relation to the developed part of test, which results from a variable tendency to elongate and straighten the final chambers. A strong upward elongation is mostly observed in two to three final chambers, which are at the same time flatter. Sutures are usually flush with the surface of test and only rarely somewhat thickened. The final suture may be slightly depressed.

Remarks. — The original description of the species *L. varians* (Bornemann) is accompanied by illustrations of three specimens varying in the development of test. This differentiation, as well as the fact that Bornemann did not indicate a holotype cause that this species is very broadly understood. In the presentation of various authors, the synonymy of *L. varians* includes sometimes up to a dozen or so names of other species marked by characters of the genera *Lenticulina, Astacolus, Planularia* and *Palmula* (*Flabellina*). No satisfactory explanation of the problem of *L. varians* was offered by an analysis of Bornemann's original collection conducted by Rabitz (1963), who selected from his tests a lectotype of *L. varians*, but its illustration was fairly unclear and did not present the apertural face (Rabitz, 1963, Pl. 16, Fig. 1). No explanation has also been given why this and not other specimen was chosen and to which of Bornemann's original illustrations it is the most similar. Analyzing her own material, the present writer considers the tests, corresponding in development to that on Bornemann's Fig. 33, as being the most typical *L. varians*. In Rabitz's (1963) paper, they are most similar to the specimen presented in Pl. 2, Fig. 2. These are tests commonly considered to be the most "true" *L. varians*. For this reason, no forms departing from the above presentation have been included in the synonymy. There is a necessity of a thorough revision of this species and of comparative studies of the forms which are identified as *L. varians* from the Late Jurassic and Cretaceous deposits.

In addition to *L. varians* having sutures flush with the surface of test, varieties with costate sutures (the form *suturatis-costata* Franke, 1936) and accessory longitudinal grooves running over the surface of test (*L. varians rhumbleri* Franke in Welzel, 1968) are cited in literature. No such forms have been found in the material under study.

Occurrence. — This is a Liassic species of a European range (Poland, Germany, Denmark, England, France, Italy). In Poland most frequent in the Pliensbachian (Kamień Pomorski and Mechowo borings). The holotype comes from the Liassic of the environs of Göttingen, Northern Germany.

Lenticulina constricta (Kaptarenko, 1961)
(Pl. VII, Fig. 8)

1961. *Planularia constricta* Kaptarenko; Kaptarenko-Chernousova, p. 75, Pl. 11, Figs 6*a*, *b*, *v*; 7*b*.

Material. — Four specimens, three of them very well preserved.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
smaller specimen	10	0.65	0.47	0.23
larger specimen	10	0.74	0.55	0.27

Description. — Test fairly large, planispiral, semi-involute, circular in outline in the ventral part and tapering and pointed upwards. Periphery rounded or acute. Test composed of 1.5 whorls. Five to seven chambers of the inner whorl and a round proloculus 0.04 to 0.06 mm in diameter are exposed in the middle part. Outer whorl consisting of ten triangular chambers. Final chambers become gradually narrower and higher. Sutures flat, almost quite straight, near periphery deflected posteriorly. Final sutures may be slightly depressed. Apertural face elongate, narrow, with poorly developed, thin lateral margins or without margins at all. In the lower part, it rests on the preceding whorl, narrowing upwards in a neck-like manner. Aperture radiate, terminal, with a small, pointed apertural chamberlet. Apertural opening close.

Remarks. — The tests with the above characters may constitute one of the many morphological variants of *Lenticulina varians* (Bornemann), which might be proven, however, only on the basis of a revision of *L. varians*. Specimens from the Kuiavian (Vesulian) of Poland accurately correspond to the holotype, although they are somewhat smaller. They correspond more accurately to the characters of the genus *Lenticulina* rather than *Planularia*, as only the final part of whorl is flat.

Occurrence. — This species is rare. In Poland found in the Kuiavian (Vesulian) of the Turów boring. The holotype comes from the Aalenian of the Dneper-Donets Depression.

Lenticulina oolithica (Terquem, 1877)
(Pl. III, Figs 11, 12; Pl. XVIII, Fig. 6)

1877. *Robulina oolithica* Terquem; Terquem, p. 496, Pl. 17, Figs 10a, b (non *Cristellaria oolithica* Terquem, p. 493, Pl. 16, Figs 27a, b; 28a, b) (fide Cat. of Foram. Ellis & Messina).
pars. 1886. *Cristellaria mamillaris* Terquem; Terquem, p. 37, Pl. 4, Figs 1a, b; 3a, b
1961. *Lenticulina (Lenticulina) umbonata* Kaptarenko; Kaptarenko-Chernousova, p. 19, Pl. 2, Figs 5a, b.
1961. *Lenticulina confragosa* Blank; Blank, p. 213, Pl. 1, Figs 7a, b.
?1961. *Lenticulina sowerbyi* (Schwager) subsp. *donbassica* Blank; Blank, p. 209, Pl. 1, Figs 3a, b; 6a, b.

Material. — Twenty-two variously preserved specimens.

	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	11	0.55	0.47	0.29
common	11	0.90	0.77	0.48
maximum	15	1.55	1.25	0.58

Description. — Tests large, discoidal, involute. Periphery obtuse. Outer whorl consisting of 10 to 15 narrow, triangular chambers. Last formed chambers slightly detached from umbo. Umbonal disc relatively large, semi-transparent, slightly convex, sometimes nodose. Sutures flat, arcuate, in the final part of whorl slightly depressed, while older sutures may slightly project. Apertural chamberlet not very distint. Apertural opening fairly large, round or subtriangular, indistinctly radiate, with a larger notch in the plane of apertural face.

Equatorial section. The whole spiral mostly consists of about twenty chambers forming a bit more than 1.5 whorls. The largest specimen, of which a thin section has been made, consists of twenty-five chambers, forming more than two whorls. Proloculi 0.054 to 0.073 mm in diameter. Spiral suture thick. Microstructure of the wall multilamellar.

Remarks. — The tests of *L. oolithica* (Terquem) from the Vesulian of Central Poland very accurately correspond to Terquem's specimen (housed at Museum d'Histoire Naturelle in Paris). In addition to typical forms, the writer's collection contains specimens pronouncedly tending to uncoil the test and which are very similar to *L. sowerby donbassica* Blank (Blank, 1961, p. 209, Pl. 1, Figs 3a, b). Single, strongly biconvex specimens, with a low final part of whorl, have also been observed. These differences may be explained by an intraspecific variability.

The multilamellar microstructure of the wall is an important feature of this species. It strongly differs these tests from some externally similar specimens from the group of *L. muensteri* (Roemer) morphotype *muensteri*, having considerably thinner walls imbricate in microstructure.

The species included in the synonymy are marked by identical characters of the morphology of test (large dimensions, large number of narrow chambers, arcuate sutures, large, distinct umbonal disc, obtuse periphery) and all of them come from the Bajocian.

Occurrence. — This species is known from France, Poland and the USSR (the region of Dnepropetrovsk and Kharkov). In the material under study, it occurs in the Kuiavian (Vesulian) and Lower Bathonian of the Turów and Jaworznik borings. The holotype comes from the Lower Bajocian of the environs of Metz, France.

Lenticulina involvens (Wiśniowski, 1890)

(Pl. III, Figs 1—4; Pl. XVIII, Fig. 1)

1890. *Cristellaria involvens* Wiśniowski; Wiśniowski, p. 44, Pl. 2, Figs 32a, b.

Material. — Sixty-five well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	8	0.25	0.20	0.10
common	8	0.39	0.31	0.16
maximum	10	0.48	0.37	0.18

Description. — Tests small, circular in outline, involute, slightly biconvex, consisting of more than one whorl. Keel not very prominent, transparent, not reaching one or two last chambers. Chambers flat, triangular, seven to ten of them (mostly eight) in outer whorl. Sutures distinct, slightly raised above the surface of test, somewhat deflected posteriorly. Umbonal area small, flat, transparent, in the form of a small circle corresponding to the proloculus. Apertural face bordered by distinctly outlined lateral margins. Apertural chamberlet frequently preserved, pointed, with a small apertural opening.

Equatorial section. Mostly two to three inner chambers and a proloculus 0.04 to 0.06 mm in diameter are visible. The wall of test, slightly mesolamellar in microstructure in the early ontogenetic stage, passes to the nonlamellar type in the younger part of test.

Variability. — Variability is mostly manifested in the development of sutures. The tests quite smooth, with flat sutures, are present as well as the specimens having costate sutures. The final suture may be depressed and the final chamber somewhat swollen. Some tests are devoid of keel and have an acute periphery. The tendency to uncoil is also observed in this species.

Remarks. — As compared with the holotype, the tests described differ in the development of sutures, which are slightly elevated, while Wiśniowski describes a smooth test.

Occurrence. — This relatively frequent species has not so far been cited from other areas besides Poland, where it is known from the Kuiavian (Vesulian) to the Bathonian in the Turów and Jaworznik borings, as well as from the Callovian of Łuków and of the environs of Cracow (holotype).

Lenticulina primarea Blank
(Pl. III, Figs. 9, 10)

1961. *Lenticulina primarea* Blank; Blank, p. 217, Pl. 1, Figs 8a, b.

Material. — Twenty-eight well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	0.40	0.34	0.20
common	8	0.67	0.58	0.32
maximum	9	0.90	0.71	0.32

Description. — A detailed description of the species is given in Blank's (1961) work.

Remarks. — Usually only large and quite grown up individuals display an outline of the axial section of test identical with that of the holotype. In most other species, the swelling of the final chambers and the tendency to uncoil are not so intensive. In apertural face view tests are gently lenticulate in outline, with a depressed spiral suture between final chambers and umbonal disc. Some specimens display an only incipient umbonal disc, while in some others it has a definite form. Two to three inner chambers and a megalospheric proloculus occur in the inner part of test when observed in the equatorial section.

Occurrence. — In the Polish material, in the Kuiavian (Vesulian) and Bathonian of the Turów boring. In the USSR, in the Upper Bajocian of the Dnepropetrovsk (the holotype) and Kharkov, in the Garantiana garantiana Zone.

Lenticulina species 1

(Pl. VII, Figs 9, 10)

Material. — Five specimens, four of them very well preserved.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
small specimen	10	0.53	0.41	0.27
large specimen	17	1.00	0.81	0.48

Description. — Tests robust, oval in outline, strongly biconvex. The profile of the apertural face passes gently into the spiral part of test, as the angle between the final chamber and a whorl is close to 180°. Periphery obtuse. Outer whorl consisting of ten to seventeen narrow chambers, separated by straight, flat, obliquely running sutures. Near periphery, the sutures fan out. Umbonal disc big, flat, shifted towards the ventral margin of test. In larger specimens it is opaque, in smaller ones semi-transparent, with a translucent inner part of whorl. It consists of few chambers and is situated near the ventral margin of test. A very thick spiral suture may be observed in oil immersion. Apertural face only slightly separated from the lateral surfaces of test, at the bottom barely divided by a preceding whorl. Apertural opening large, slightly serrate, with additional small notch on the side of the apertural face.

Remarks. — The tests described have many characters in common with the species *L. uhligi* (Wiśniowski), but they cannot be unequivocally assigned to it, since they differ from this species in larger dimensions, big umbonal disc, considerably larger number of chambers and fan-like terminations of sutures. They may be mutants of *L. uhligi,* which occur in this material as single tests.

Occurrence. — In Kuiavian (Vesulian) from the Turów boring.

Lenticulina biexcavata (Mjatliuk)
(Pl. III, Figs 5—8)

1900. *Cristellaria lageniformis* Deprat; Deprat, p. 38, Pl. 5, Fig. 9 (fide Cat of. Foram.).
1939. *Cristellaria biexcavata* Mjatliuk; Mjatliuk, p. 56, Pl. 4, Figs 41, 42.
1961. *Lenticulina (Lenticulina) biexcavata* (Mjatliuk); Kaptarenko-Chernousova, p. 17, Pl. 2, Figs 1a, b.

Material. — Forty-two variously preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	0.32	0.24	0.13
common	7	0.52	0.39	0.19
maximum [2)]	9	0.84	0.50	0.23

Description. — The following details supplement the descriptions given so far: sutures distinct, arcuate, in the oldest part of the specimen flat, further gradually more and more depressed. Chambers flat to swollen and convex, respectively. Final chambers extended upwards, frequently detached from umbo and then four chambers of inner whorl are partially exposed in addition to proloculus. In a common specimen, proloculus 0.042 mm in equatorial diameter. In apertural view, the test displays a considerable increase in width, as a result of which the thickness of specimens in the final part of whorl is considerably larger than in the initial part, so that the umbilical area becomes depressed.

Remarks. — This species differs from others in such characteristic, permanent features as convex chambers and depressed sutures and lateral sides. The tests described by Deprat (1900) represent one of the morphological variants of our species. In the Polish material, only three out of 42 tests correspond to Deprat's illustration (see Cat. of Foram.), while the remaining ones are developed in conformity with the description and illustration of the species *L. biexcavata* (Mjatliuk). For this reason, it seems advisable to maintain the specific name *biexcavata,* which includes typical forms and not a rare instance of variability.

As compared with the holotype, Polish specimens have fewer chambers, mostly seven of them occurring in outer whorl.

L. mironovi (Dajn), which does not display the tendency to elongate tests and differs in appearance in the equatorial face view, is closely related to *L. biexcavata.*

Occurrence. — In Polish material in the Kuiavian (Vesulian) and Callovian in the Turów and Jaworznik borings and in the comparative material from Łuków. In the USSR: Upper Bajocian of the environs of Kharkov and Lower Volgian of the area on the Volga River (holotype). In France: Lower Kimmeridgian.

2) The largest specimen has an uncoiling test with uniserial arrangement of the final part.

Lenticulina hebetata (Schwager, 1865)
Pl. IV, Fig. 6; Pl. V, Figs 1,2)

1865. *Cristellaria hebetata* Schwager; Schwager, p. 134, Pl. 7, Fig. 2.
1890. *Cristellaria hebetata* Schwager; Wiśniowski, P. 46, Pl. 2, Fig. 22.
1956. *Lenticulina (Lenticulina) münsteri hebetata* (Schwager); Seibold & Seibold, p. 111, Figs 4k, 1 (on p. 122).

Material. — Twenty well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	6	0.48	0.38	0.23
common	8	0.58	0.48	0.26
maximum	8	1.00	0.84	0.46

Description. — Polish tests correspond in development to the holotype.

Remarks. — The tests available are identical with Wiśniowski's (1890) specimens of this species and differ from the holotype only in reaching larger dimensions and being slightly polygonal in outline. These characters are, however, mentioned by the Seibolds (1956) in their revision of Schwager's (1865) work. They also find in this species a variable development of periphery, with or without a keel, which is also observed in the Polish material. One can, however, hardly agree with considering this form as one of the subspecies of *L. muensteri* (Roemer). Despite its considerable variability, *L. muensteri* has never displayed a conspicuously tangential arrangement of chambers and a periphery having a transparent keel.

The tests of *L. hebetata* have sometimes been assigned to *L. cultrata* (Montfort). The latter have the *L. muensteri* type of structure, with a wide, transparent keel and many chambers in outer whorl (up to twelve). However, referring these Jurassic tests to the Tertiary species *L. cultrata* seems uncorrect.

Occurrence. — Poland: not very numerous in the Kuiavian (Vesulian) and Callovian in the Turów boring and in *C. ornatum* clays of the environs of Cracow (Wiśniowski, 1890). Germany: Lower Malmian (the holotype comes from the Lower Oxfordian, Terebratula impressa Zone).

Lenticulina ruesti (Wiśniowski, 1890)
Pl. IV, Figs 1—5)

1890. *Cristellaria Rüsti* Wiśniowski; Wiśniowski, p. 41, Pl. 2, Fig. 17c.
1960. *Lenticulina rüsti* (Wiśniowski); Bielecka, p. 53, Pl. 3, Fig. 22.
1965. *Lenticulina (Lenticulina) omphalovorticosa* Farinacci; Farinacci, p. 240, Fig. 22.

Material. — Thirty, mostly well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	10	0.74	0.61	0.37
common I	11	0.92	0.78	0.44
common II	11	0.84	0.71	0.42
maximum	15	1.53	1.31	0.71

Description. — The tests under study are in full conformity with than on Wiśniowski's Fig. 17c (1890) and correspond to the greatest extent to Bielecka's (1960) description and remarks.

In equatorial section, both thin sections and natural fractures, reveal a thick spiral suture and many trapezoidal chambers. A grown-up individual may reach to 33 chambers, forming nearly three complete whorls. Proloculus small, circular, 0.02 to 0.03 mm in diameter. A gradual increase in the thickness of spiral suture, which is multilamellar in microstructure, is clearly visible.

Remarks. — The tests, described by Farinacci (1965) from the Malmian of Umbria as a new species, *L. omphalovorticosa* Farinacci, are in complete conformity with the specimens characterized above.

Occurrence. — In Polish literature this species is known from the Callovian (holotype) and Lower Malm. In the material under study, it occurs from the Bathonian to the Oxfordian of the Turów, Trzebionka and Kcynia IV borings. In addition, in the Malm of Italy.

Lenticulina inflata (Wiśniowski, 1890)

Pl. V, Figs 3—10; Pl. XVIII, Fig. 5)

1890. *Cristellaria inflata* Wiśniowski; Wiśniowski, p. 47, Pl. 3, Fig. 13.
1890. *Cristellaria hoplites* Wiśniowski; Wiśniowski, p. 48, Pl. 3, Fig. 16.
1959. *Lenticulina (Lenticulina) blanckenhorni* (Sellheim); Ziegler, p. 102, Pl. 5, Fig. 8.
1961. *Lenticulina (Lenticulina)* aff. *inflata* (Wiśniowski); Kaptarenko-Chernousova, p. 12, Pl. 1, Fig. 3.

Material. — More than 100 well preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	5	0.29	0.21	0.17
common	7	0.61	0.48	0.29
maximum	7	0.87	0.71	0.42

Description. — Tests robust, thick-walled, involute, circular or oval and even or slighty undulate in outline, convex. Periphery thick, roller-like, sometimes acute or with an incipient keel. Chambers form slightly more than one whorl, but there are also numerous specimens, which do not reach a complete whorl. Chambers irregularly swollen, less frequently flat, wide, triangular, usually seven of them in outer whorl. Sutures distinct, depressed or flat, gently arcuate or straight, all types frequently present on one and the same test. In completely grown-up individuals, depressed sutures are sometimes accompanied by rounded ridges, which fade out towards the periphery of test. Usually, umbilical pit in young individuals present and in older one umbilical area flat. Umbonal disc lacking. Apertural face heart-shaped and bordered by thick, swollen lateral margins. A squat, low apertural chamberlet occurs in the extension of the sloping outline of the final chamber.

Equatorial section. Megalospheric individuals are composed of five chambers, while microspherical ones reach up to twelve chambers, of which no more than three are inner chambers, along with a proloculus variable in size from 0.032 to 0.057 mm.

Variability. — This species is marked by a considerable degree of variability, which concerns the outline of tests, shape and convexity of chambers and development of sutures and periphery. In addition, tests display a considerable variability in size, not always justified by sexual dimorphism.

Remarks. — A considerable individual variability and the presence of micro-and megalospheric forms were probably the reason why Wiśniowski (1890) described these tests as two separate species, *L. inflata* (Wiśniowski) nad *L. hoplites* (Wiśniowski).

A species cited by Ziegler (1959) from the Vesulian and Callovian of Bavaria, that is, *L. blanckenhorni* (Sellheim) has here been included in the synonymy of *L. inflata* (Wiśniowski). Although no description of this species was given by Ziegler, but its illustration is in a complete conformity with Polish tests of *L. inflata* (Wiśniowski). By the right of priority, Wiśniowski's name should be used, the more so as Sellheim's (1893) original description is unavailable on the whole.

L. krymholtsi Kuznetzova, described from the Volgian of the region on the Volga River (Dajn & Kuznetzova, 1971), is closely related with *L. inflata* (Wiśniowski). Together with a considerable similarity of the two species, there are also the following differences: in *L. krymholtsi* tests are flat, smaller and more elongate in outline as a result of a stronger uncoiling.

Occurrence. — This species is known from the Lowermost Vesulian up to Kimmeridgian in Germany, Poland and the USSR. (Dneper-Donets Depression and the Middle Volga Region). In the material under study, it occurs fairly numerously in the Kuiavian (Vesulian) and Bathonian of the Turów and Jaworznik borings, less frequently in the Callovian of the

Trzebionka boring and rarely in the Oxfordian of the Kcynia IV boring. The holotype comes from the Upper Callovian of the region of Cracow, *C. ornatum* clays.

Lenticulina uhligi (Wiśniowski, 1890)
(Pl. VI; Pl. VII, Figs 1—7; Pl. XVIII, Figs 2—4)

1890. *Cristellaria Uhligi* Wiśniowski; Wiśniowski, p. 43, Pl. 3, Fig. 12.
1890. *Cristellaria ovato-acuminata* Wiśniowski; Wiśniowski, p. 41, Pl. 2, Fig. 28.
1890. *Cristellaria lepida Reuss* var. *jurensis* Wiśniowski; Wiśniowski, p. 45, Pl. 2, Fig. 30.
1890. *Cristellaria Oppeli* Schwager; Wiśniowski, p. 46, Pl. 2, Fig. 34.
1960. *Lenticulina ovato-acuminata* (Wiśniowski); Bielecka, p. 50, Pl. 2, Fig. 18.
1961. *Planularia lepida* (Reuss) var. *jurensis* (Wiśniowski); Kaptarenko-Chernousova, p. 65, Pl. 12, Fig. 6.
?1971. *Lenticulina sokolovi* Kuznetzova; Dajn & Kuznetzova, p. 117, Pl. 1, (20), Fig. 7.

Material. — More than 2000 well preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	6	0.26	0.19	0.11
common	9	0.42	0.35	0.19
maximum	12	0.87	0.67	0.35

Description. — Tests planispiral, involute to semi-evolute, oval in outline, pointed upwards. The line of the profile of apertural face extends onto the spiral part of test, so that the angle between the final chamber and whorl approaches 180°. Sides variably convex. Periphery obtuse, less frequently acute. Tests reach 1.5 and sometimes 1.7 whorls. The inner whorl is situated near the ventral margin of test. Outer whorl consist usually of 9 to 10 narrow, slowly increasing chambers. Sutures flat, oblique, near periphery bent posteriorly. Umbonal disc thickened, semitransparent, relatively large; in slightly convex specimens small, transparent. Apertural face high triangular, not separated distinctly from the lateral walls of test, at the bottom divided by a preceding whorl. Aperture terminal, slightly radiate, with an accessory, small slit or a subtriangular opening on the side of apertural face. A small, pointed apertural chamberlet is observed sometimes.

Variability. — As already emphasized by Wiśniowski (1890), this species is marked by a considerable degree of variability. In analyzing the variability in characters, the present writer noticed that, despite polymorphism, some combinations of characters repeated more frequently than some others.

Two main morphological variants have been separated for *L. uhligi*:

(1) *Lenticulina uhligi* morphotype *jurensis* (Pl. VI, Figs 1—10; Pl. XVIII, Fig. 2):

Dimensions:	Nch	L (mm)	B (mm)	T (mm)	$\frac{L}{B}$	$\frac{B}{T}$
Specimens:						
minimum	6	0.26	0.19	0.11	1.37	1.73
common	9	0.44	0.33	0.19	1.33	1.74
maximum	12	0.78	0.36	0.29	1.39	1.93

The tests assigned to this morphotype correspond to Wiśniowski's (1890) specimens identified as *Cristellaria lepida* (Reuss) var. *jurensis* Wiśniowski. They are marked by a relatively delicate, thin-walled, slightly convex test. They reach the largest number of chambers recorded in this species (to 20) and have the longest spiral (to 1.7 whorls). Sutures distinct. Umbonal disc flat, transparent, with a well visible inner whorl. In young stages, most numerous in the material under study, umbo corresponds in outline to proloculus. In equatorial sections of tests, the thickness of spiral suture is on the average smaller than in the morphotype *uhligi*.

(2) *Lenticulina uhligi* morphotype *uhligi* (Pl. VII, Figs 1—7; Pl. XVIII, Figs 3, 4)

Dimensions:	Nch	L (mm)	B (mm)	T (mm)	$\frac{L}{B}$	$\frac{B}{T}$
Specimens:						
minimum	8	0.35	0.31	0.19	1.13	1.63
common	10	0.45	0.37	0.23	1.22	1.61
maximum	12	0.87	0.67	0.35	1.30	1.91

The tests assigned to this morphotype correspond to the species *L. uhligi* (Wiśniowski) *sensu* Wiśniowski (1890) and *L. ovato-acuminata* (Wiśniowski) *sensu* Wiśniowski (1890) and Bielecka (1960). They are marked by thick walls, relatively very convex tests and a fairly large, thickened umbonal disc. In the older part of the test, sutures indistinct. In equatorial sections, spiral suture is mostly thicker than in the morphotype *jurensis*.

Remarks. — The quantitative ratio of the tests of morphotype *jurensis* and *uhligi* in a population displays a certain dependence on the facies and the manner of reproduction. More delicate tests of the morphotype *jurensis* predominate in the Vesulian clayey deposits and in the Callovian of Łuków, while more calcareous samples from the Upper Bathonian and Malmian display a predominance of the robust tests of the morphotype *uhligi*. In equatorial sections of tests, specimens with a thinner spiral suture more frequently represented microspheric individuals.

As follows from a specification of the ontogenetic series of tests of the morphotype *jurensis* and a comparison of adult forms with the Upper

Cretaceous *L. lepida* (Reuss), Wiśniowski's hypothesis on a close relationship of these forms has not been corroborated. A considerable similarity to *L. sokolovi* Kuznetzova shows that this is probably a variety of *L. uhligi*. In relation to *L. abscisa* (Grzybowski), *L. uhligi* differs in small dimensions and a well developed spiral part of the test. A general pattern of the structure of *L. uhligi* is continued in the Lower Cretaceous by *L. gaultina* (Berthelin).

Interesting enough, this species, most common in the Doggerian and Malmian samples under study, has very rarely been cited in literature outside of Poland. Maybe, it is not separated from *L. muensteri* (Roemer), which is fairly variously understood. The differences between these species concern the outline of test, shape of sutures and manner of arranging the inner whorl.

Occurrence. — In the material under study, from the Bajocian to Kimmeridgian in the Gałkówek, Turów, Jaworznik, Trzebionka, Kcynia I, II and IV borings. In addition, in the USSR (the Callovian and Oxfordian of the Dneper-Donets Depression and Donbas, the Oxfordian of the region of Poltava and the Volgian of the Middle Volga Region). The holotype comes from the Callovian of the environs of Cracow.

Lenticulina muensteri (Roemer, 1839)

(Pl. VIII; IX; X; XI, Figs 1—6; Pl. XIX; Pl. XX, Figs 1,2)

1839. *Robulina Münsteri* Roemer; Roemer, p. 48, Pl. 20, Fig. 29 (*fide* Cat. of Foram. Ellis & Messina).
?1839. *Robulina gibba* Roemer; Roemer, p. 47, Pl. 20, Fig. 30 (*fide* Cat. of Foram. Ellis & Messina).
1841. *Robulina Münsteri* Roemer; Roemer, p. 98, Pl. 15, Fig. 30.
1841. *Robulina crassa* (Roemer); Roemer, p. 98, Pl. 15, Fig. 32.
1862. *Cristellaria Münsteri* Röm.; Reuss, p. 77, Pl. 9, Figs 3, 4.
1867. *Cristellaria vulgaris* Schwager; Schwager, p. 661, Pl. 34, Fig. 19.
1867. *Cristellaria Sowerbyi* Schwager; Schwager, p. 660, Pl. 34, Fig. 18.
1880. *Cristellaria macrodisca* Reuss; Berthelin, p. 48, Pl. 3, Figs 11, 14.
1890. *Cristellaria rotulata* Lam. var. aff. *C. gaultina* Berthelin; Wiśniowski, p. 40, Pl. 2, Figs 21a, 21b.
1890. *Cristellaria göttingensis* Bornemann; Wiśniowski, p. 44, Pl. 2, Fig. 33.
1896. *Cristellaria rotulata* (Lamarck) var. *macrodiscus* Reuss; Chapman, p. 6, Pl. 1, Fig. 9.
1922. *Cristellaria münsteri* Römer; Paalzow, p. 29, Pl. 3, Fig. 16.
1932. *Lenticulina münsteri* Römer; Paalzow, p. 101, Pl. 5, Figs 23, 24; Pl. 6, Figs 1, 2.
1935. *Lenticulina rotulata* Lamarck; Eichenberg, p. 8, Pl. 4, Figs 2a, b, c.
1939. *Cristellaria wiśniowski* Mjatliuk; Mjatliuk, p. 97, Pl. 4, Fig. 43a, b.
1950. *Cristellaria münsteri* (Roemer); Fursenko & Polenova, p. 22, Pl. 1, Fig. 10.
1951. *Lenticulina* (*Lenticulina*) *crassa* (Roemer); Bartenstein & Brand, p. 283, Pl. 5, Fig. 110.
1952. *Lenticulina münsteri* (Roemer); Barnard, p. 339, Fig. B5.
1953. *Lenticulina münsteri* (Roemer); Barnard, p. 185, Fig. A10.

1954. *Lenticulina münsteri* (Roemer); Bielecka & Pożaryski, p. 33, Pl. 4, Fig. 12a, b.
1955. *Lenticulina (Lenticulina) münsteri* (Roemer); Seibold & Seibold, p. 104, Fig. 4a—c.
1955. *Cristellaria tumida* Mjatliuk *in* litt. Mitjanina; *in* Mitjanina, p. 139, Pl. 3, Fig. 10.
1957. *Lenticulina münsteri* (Roemer); Sztejn, p. 37, Pl. 4, Fig. 23.
1957. *Lenticulina münsteri* (Roemer); Said & Barrakat, p. 42, Pl. 1, Fig. 29.
1958. *Lenticulina muensteri* (Roemer); Said & Barrakat, p. 248, Pl. 1, Fig. 10; Pl. 3, Fig. 25; Pl. 4, Fig. 35.
1959. *Lenticulina münsteri* (Roemer); Stančeva, p. 134, Pl. 3, Figs 5, 5a.
1960. *Lenticulina rotulata* (Lamarck); Bielecka, p. 52, Pl. 3, Fig. 23.
1960. *Lenticulina (Lenticulina) münsteri* (Roemer); Lutze, p. 448, Fig. 10a—e.
1961. *Lenticulina (Lenticulina) münsteri* (Roemer); Kaptarenko-Chernousova, p. 10, Pl. 1, Fig. 2.
1961. *Lenticulina (Lenticulina) integra* Kaptarenko; Kaptarenko-Chernousova, p. 11, Pl. 1, Fig. 7a, b.
1961. *Lenticulina (Lenticulina) wiśniowskii* (Mjatliuk); Kaptarenko-Chernousova, p. 10, Pl. 1, Fig. 1.
1961. *Lenticulina tumida* Mjatliuk; Mjatliuk, p. 147, Pl. 1, Fig. 5.
1963. *Lenticulina muensteri* (Roemer); Groiss, p. 41, Pl. 1, Fig. 8.
1963. *Lenticulina* ex gr. *tumida* Mjatliuk; Mitjanina, p. 138, Pl. 3, Figs 1—3.
1964. *Lenticulina muensteri* (Roemer); Barbieri, p. 757, Pl. 58, Fig. 4.
1965. *Lenticulina (Lenticulina) münsteri* (Roemer); Farinacci, p. 240, Fig. 21.
1965. *Lenticulina (Lenticulina)* ex gr. *muensteri* (Roemer); Hanzliková, p. 69, Pl. 5, Fig. 1a, b.
pars 1965. *Lenticulina muensteri* (Roemer); Gordon, p. 840, text-figs 5a, b, c; 6 (here synonymy).
pars 1966. *Lenticulina muensteri* (Roemer); Gordon, p. 326, Pl. 1, Figs 11—13.
1967. *Lenticulina muensteri* (Roemer); Gordon, p. 840, Pl. 4, Figs 12—14.
1967. *Lenticulina (Lenticulina) münsteri* (Roemer); Michael, p. 34, Pl. 3, Fig. 5 (here synonymy).
1968. *Lenticulina münsteri* (Roemer); Guyader, p. 134, Pl. 19, Figs 20—23.
1970. *Lenticulina muensteri* (Roemer); Garbowska, p. 59, Fig. 26.
1970. *Lenticulina rotulata* (Lamarck); Garbowska, p. 60, Fig. 27.
1971. *Lenticulina (Lenticulina) muensteri* (Roemer); Bartenstein, Bettenstaedt & Kovatcheva, p. 133, Pl. 1, Figs 13, 14.
1973. *Lenticulina muensteri* (Roemer); Dailey, p. 51, Pl. 5, Fig. 5a, b.

Material. — About 2000 tests, mostly very well preserved.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	0.29	0.23	0.12
common	9	0.61	0.52	0.29
maximum	11	1.23	1.07	0.70

Variability. — *L. muensteri* (Roemer) is a long-lived species, the largest variability of which is recorded in the Kuiavian (Vesulian) and Bathonian. The analysis of abundant populations revealed extensively variable characters of this species, which results in an application of many specific names to a plexus of the *L. muensteri*. At first, the writer sought to divide these tests into species described so far. In recording the variability in characters of many populations, she found it to be a vain effort, leading only to the erection of further new species. Forms described as separate species from the Malm of the European part of the USSR occur abundantly in the writer's material as early as the Vesulian, in which all of them concur in these same samples. These distinctly marked groups of variability should not be examined in the category of separate taxons, since they are connected with each other by transitional forms, so that a wide overlap occurs between them. In addition, a segregation conducted in grown-up inidividuals is not possible in the case of specimens in younger development stages.

For the assemblage displaying such characteristic properties the writer has assumed the conception of polymorphism. More strongly fixed combinations of characters, displayed by a larger number of individuals, have been described as definite morphotypes. The following six morphotypes of *L. muensteri,* for which the names were maintained under which the tests were once described as separate species, have been distinguished in the Dogger: *wiśniowskii, muensteri, gibba, integra, tumida* and *russiensis* (see a histogram in Text-fig. 19). Only two morphotypes known from the Dogger, *muensteri* and *tumida,* have been found unquestionably in the Lower Cretaceous, which the holotype of *L. muensteri* comes from. Due to having at her disposal only a few tests from the Lower Cretaceous, one more Jurassic morphotype, that is, *russiensis* is only tentatively reported by the writer to the Lower Cretaceous. It is only the morphotype *muensteri* which develops progressively in geological time, while the remaining two Jurassic morphotypes represent in the Lower Cretaceous lines which are clearly disappearing. Other Jurassic morphotypes do not occur in the Lower Cretaceous, while two new ones appear, morphotype *crassa* and morphotype *H* (a histogram in Text-fig. 27). In the material under study, morphotype *crassa* occurs for the longest time, reaching the Albian, in which the species *L. muensteri* becomes extinct.

Statistical analysis of L. muensteri

The results presented below concern two samples, one of which comes from a depth of 417.4 m in Parkinsonia parkinsoni Zone of the Kuiavian (Vesulian) of the Turów boring and the other from a depth of 262.7 m in the Infravalanginian of the Kcynia II boring. Statistical assemblages included 100 specimens each.

a. Jurassic assemblage

Depending on the values L and B, the scatter diagram shown in Text-fig. 20 is arranged linearly and limited by border values of 0.29 and 1.06 mm. Despite the fact that the lowermost part of the area is occupied by individuals marked by a small number of chambers (Nch) per whorl (on the average 7 to 8 chamber in outer whorl) and the upper part by those with a large Nch (10, 11 and 12 chambers), over an extensive middle sector, due to varying size of specimens with identical Nch, specimens with, e.g., eight chambers and eleven chambers in outer whorl occur at one and the same point. This is clearly visible in Text-fig. 21, where curves N(L) for tests with a definite Nch have an extensive common area of values.

Curve N(L) for the entire population have its branches inclined towards each other, but instead of a uniform apex, there appear undulations. Curves drawn separately for tests, having 8, 9 and 10 chambers in outer whorl, display similar properties, the most distinct undulations being observed in a curve for nine chambers which are most numerous in the population. The heterogeneity observed in the population is not expressed unequivocally, since succeeding crests in undulation are not separated from each other by distinct depressions, which is a result of the abundance of tests of average size. The highest, extreme undulation, with its peak expressed by value L = 0.40 mm corresponds to the tests of morphotypes *wiśniowskii* and *gibba*. Single individuals of morphotypes *integra* and *russiensis* also occur in this area. A small undulation, following that mentioned above, with its peak value of L = 0.46 mm continues to include mostly the tests of morphotypes *wiśniowskii* and *gibba*, with a marked influence of morphotypes *tumida* and *muensteri*. The middle undulation, with its peak value of 0.54 mm is most mixed in character and represents the area of range of all morphotypic groups. In this interval, most numerous are the tests of morphotypes *integra* and *tumida*. The last, large undulation with its peak value of L = 0.66 mm, mostly includes the tests of morphotype *muensteri*, with considerable influence of morphotypic groups *integra* and *tumida* still observed there. A far-reaching extension of the curve towards high values of L concerns the tests of morphotype *muensteri*.

Altogether, more than 80 per cent of all individuals are contained within an interval of L = 0.40 to 0.66 mm. A mean value of L for tests with eight chambers in outer whorl amounts to about 0.40 mm, for those with nine chambers to about 0.46 mm and for those with ten chambers to about 0.66 mm.

The scatter diagram in the interval of L and T coordinates displays a considerable variability in the thickness of tests (Text-fig. 22). Extreme values of the scatter diagram obtained amount to 0.13 mm and 0.51 mm, but a vast quantity of individuals is contained in an interval of 0.16 to 0.36 mm. On the whole, there occurs a proportional correlation between the convexity and size of test on the one hand and the number of chambers in outer whorl on the other. Curve N(T) represents a uniform picture of a population, for which a mean value of T amounts to 0.20 to 0.24 mm (Text-fig. 23). The curve for individuals with eight chambers in outer whorl is only slightly undulate: small tests of morphotypes *wiśniowskii*

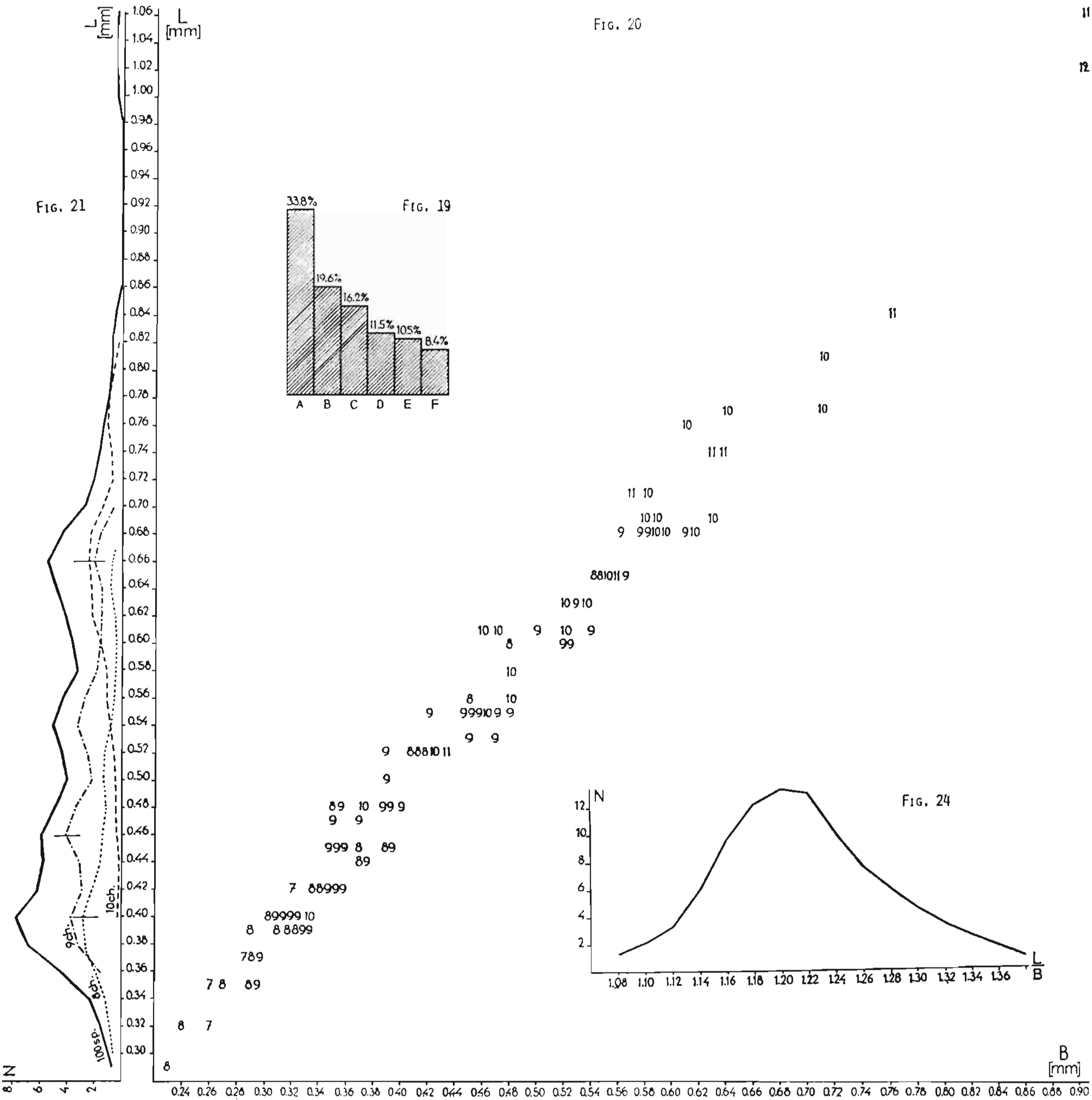


Fig. 19. A histogram showing a Doggerian population of *L. muensteri* (Roemer). A — morphotype *wiśniowskii*, *B* — morphotype *muensteri*, *C* — morphotype *gibba*, *D* — morphotype *integra*, *E* — morphotype *tumida*, *F* — morphotype *russiensis*. A sample from the Parkinsonia parkinsoni Zone, Turów, 417.40 m. For 408 tests.

Fig. 20. A scatter diagram of *L. muensteri* (Roemer) depending on the longer diameter of test L and shorter diameter of tests B. The figures 7 to 12 denote the number of chambers in outer whorl. For 100 specimens. Kuiavian (Vesulian), Turów, 417.40 m.

Fig. 21. The curve of variability in the size of tests for 100 specimens of *L. muensteri* (Roemer). L — longer diameter, N — number of specimens. Kuiavian (Vesulian), Turów, 417.40 m.

Fig. 24. The curve of variability in value $\frac{L}{B}$, determining the degree of tests coiling in *L. muensteri* (Roemer). L — longer diameter, B — shorter diameter, N — number of specimens. For 100 tests. Kuiavian, Turów, 417.40 m.

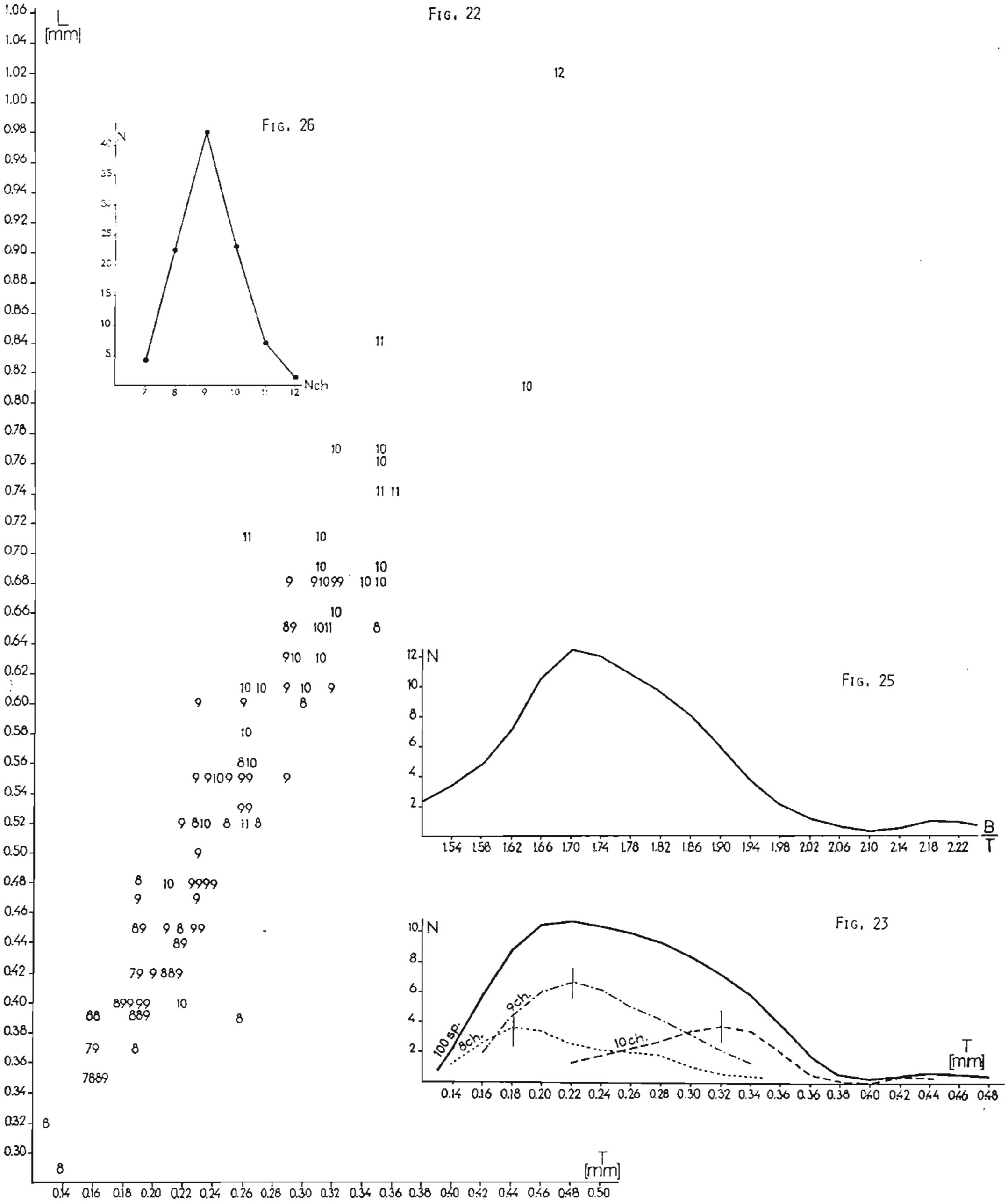


Fig. 22. A scatter diagram of *L. muensteri* (Roemer) depending on the longer diameter of test L and convexity T. The figures 7 to 12 denote the number of chambers in outer whorl. For 100 specimens. Kuiavian (Vesulian), Turów, 417.40 m.

Fig. 23. The curve of the frequency of occurrence of individuals with a definite convexity for 100 tests of *L. muensteri* (Roemer). T — convexity, N — number of individuals. Kuiavian (Vesulian), Turów, 417.40 m.

Fig. 25. The curve of variability in value $\frac{B}{T}$ determining the degree of convexity of *L. muensteri* tests. B — shorter diameter, T — convexity, N — number of specimens. For 100 tests. Kuiavian (Vesulian), Turów, 417.40 m.

Fig. 26. The curve of the frequency of occurrence of *L. muensteri* individuals with a definite number of chambers in outer whorl. N — number of individuals, Nch — number of chambers in the final whorl. For 100 specimens. Kuiavian (Vesulian), Turów, 417.40 m.

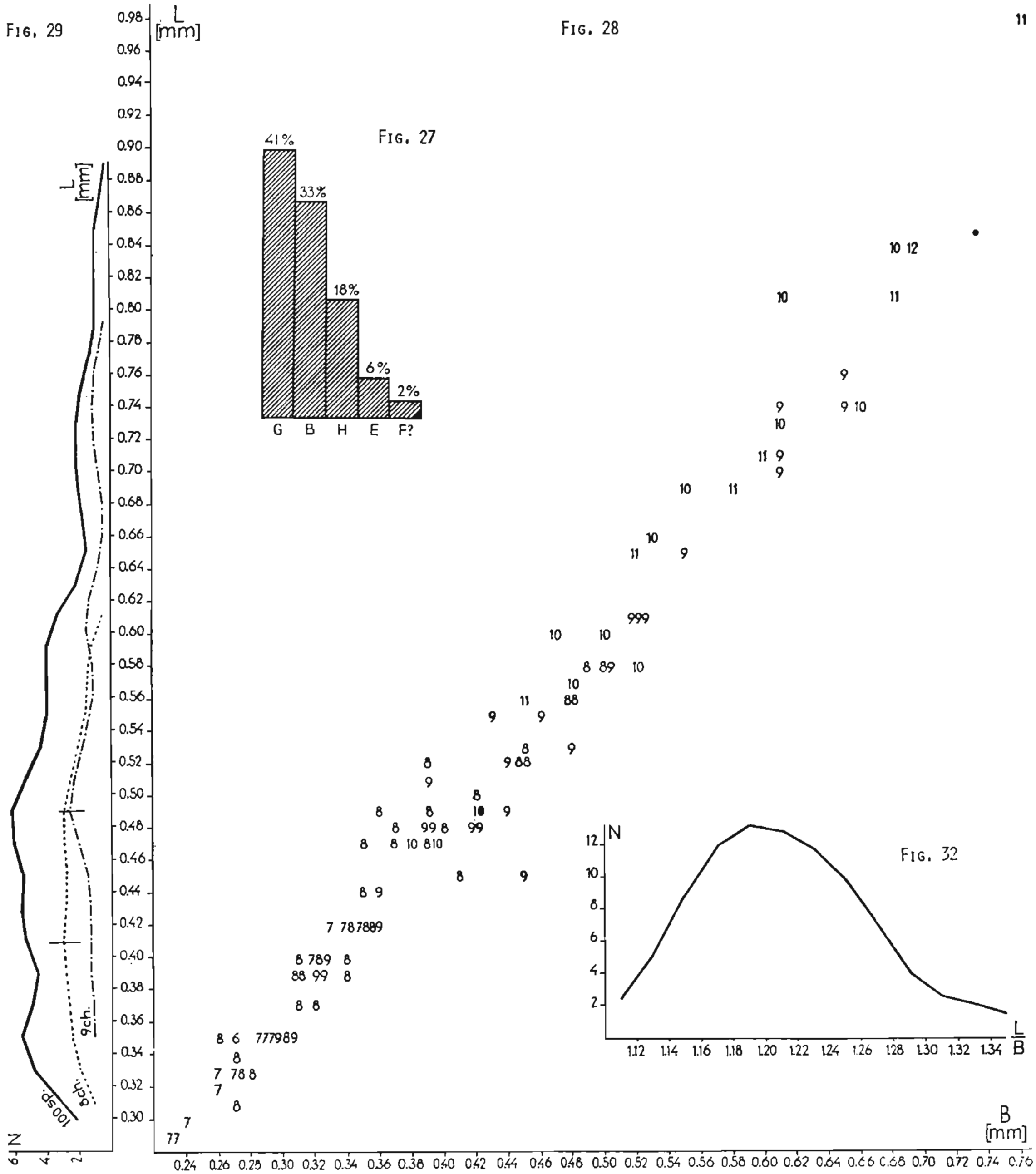


Fig. 27. A histogram showing the composition of a Lower Cretaceous population of *L. muensteri* (Roemer). B — morphotype *muensteri*, E — morphotype *tumida*, F — morphotype *russiensis*, G — morphotype *crassa*, H — morphotype *H*. A sample from the Infravalanginian, Kcynia II boring, depth 262.70 m. For 484 specimens.

Fig. 28. A scatter diagram of *L. muensteri* (Roemer) depending on the longer diameter of tests L and shorter diameter of tests B. The figures 6 to 12 denote the number of chambers in outer whorl. For 100 specimens. Infravalanginian, Kcynia II, 262.70 m.

Fig. 29. The curve of variability in size of tests for 100 individuals of *L. muensteri* (Roemer). L — longer diameter, N — number of individuals. Infravalanginian, Kcynia II, 262.70 m.

Fig. 32. The curve of variability in value $\frac{L}{B}$ for 100 specimens of *L. muensteri* (Roemer). L — longer diameter, B — shorter diameter, N — number of individuals. Infravalanginian, Kcynia II, 262.70 m.

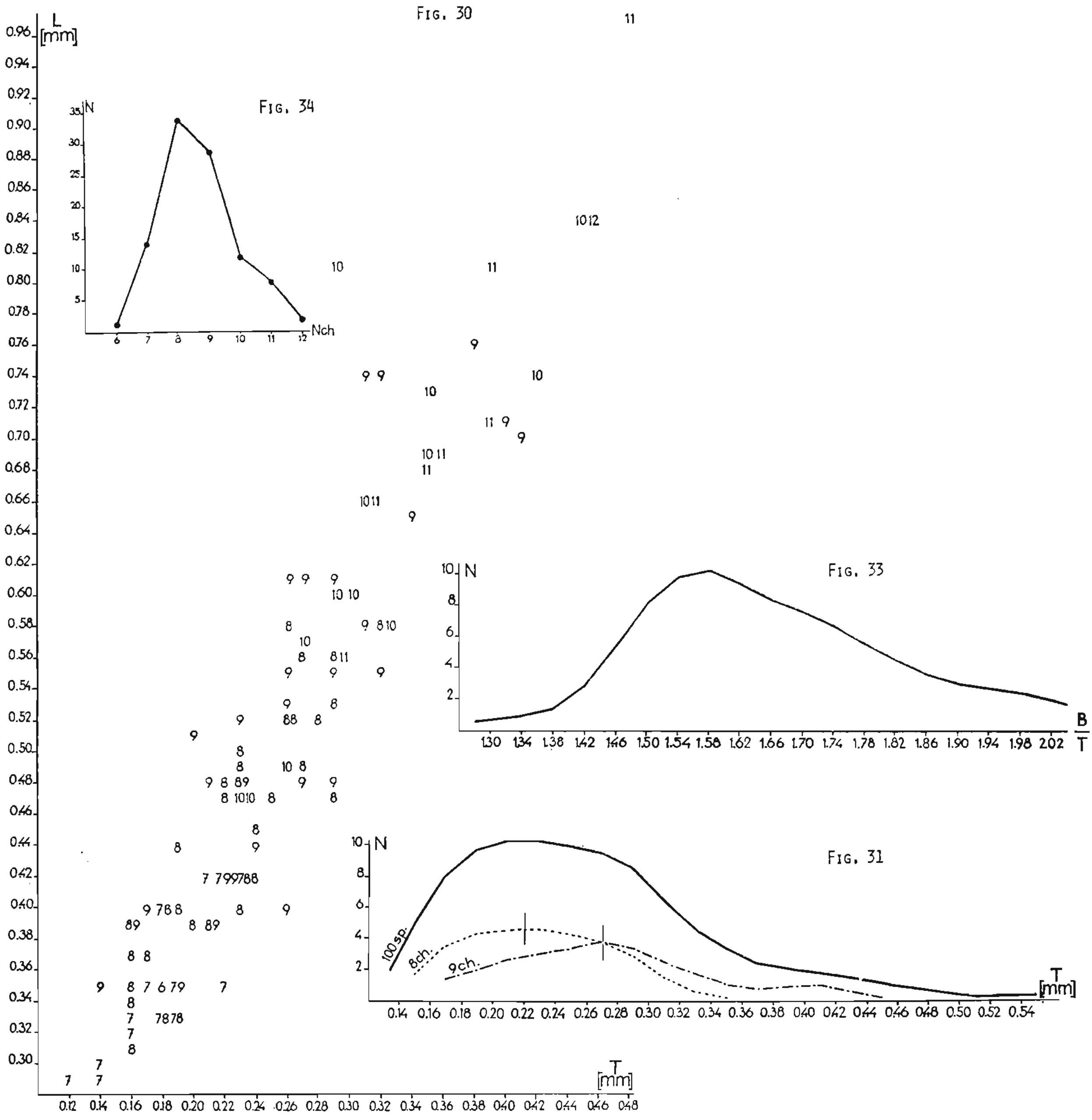


Fig. 30. A scatter diagram of *L. muensteri* (Roemer) depending on the longer diameter of tests L and convexity T. The figures 6 to 12 denote the number of chambers in outer whorl. For 100 specimens. Infravalanginian, Kcynia II, 262.70 m.

Fig. 31. The curve of variability in the convexity of tests for 100 individuals of *L. muensteri* (Roemer). T — convexity, N — number of individuals. Infravalanginian, Kcynia II, 262.70 m.

Fig. 33. The curve of variability in value $\frac{B}{T}$ for 100 specimens of *L. muensteri* (Roemer). B — shorter diameter, T — convexity, N — number of specimens. Infravalanginian, Kcynia II, 262.70 m.

Fig. 34. The curve of the frequency of occurrence of *L. muensteri* individuals with a definite number of chambers in outer whorl. N — number of individuals, Nch — number of chambers in the final whorl. For 100 tests. Infravalanginian, Kcynia II, 262.70 m.

and *gibba* are assembled around a value of T amounting to 0.18 to 0.20 mm and the tests of the remaining morphotypes around a value of T amounting to 0.26 to 0.28 mm.

A mean value of T on a curve for tests with nine chambers in outer whorl amounts to 0.22 mm and is represented by tests of various morphotypic groups, mostly *wiśniowskii* and *gibba*. A mean value of T on a curve for tests with ten chambers in outer whorl amounts to 0.32 mm and concerns the tests of morphotypes *integra, tumida* and *muensteri*. A far-reaching extension of the curve towards high values of T concerns the tests of morphotype *muensteri*.

The dependence $N\left(\frac{L}{B}\right)$, determining the degree of involution of the Doggerian *L. muensteri* is shown in Text-fig. 24. A maximum number of tests are accumulated within an interval of 1.20 to 1.22. The curve of dependence $N\left(\frac{B}{T}\right)$, determining the degree of convexity of the tests under study, ascends abruptly up to its peak at a value of 1.70 and then gradually drops (Text-fig. 25).

An analysis of the population in respect to the frequency of occurrence of individuals with a definite number of chambers in outer whorl yielded a curve with an unequivocal apex, falling at nine chambers per whorl (Text-fig. 26). Then, there occur a more or less equal number of individuals with ten and eight chambers in outer whorl. This result has repeatedly been obtained in many samples from the Parkinsonia parkinsoni and Perisphinctes tenuiplicatus Zones.

b. *Lower Cretaceous assemblage*

The scatter diagram of tests within an interval of L and B coordinates is similar to that obtained for the Dogger (Text-fig. 28). Curve N(L) for the entire population is also undulating in character (Text-fig. 29). A pronounced majority of undulations is contained within an interval of L of 0.35 to 0.59 mm, with its peak value at 0.49 mm. Curves N(L) for tests with a definite Nch have a large common area, despite their being shifted in relation to each other. Curve N(L) for eight chambers in outer whorl runs monotonous over a long stretch, while that for specimens with nine chambers have distinct undulations. An extreme undulation, with its apex at a value of $L = 0.35$ mm corresponds to the tests of morphotype *H*. Single tests of morphotypes *muensteri* and *crassa* also occur in this area. The next, small oscillation near $L = 0.43$ mm, records a more numerous appearance of the tests of morphotypes *muensteri and crassa*. The highest oscillation, with its apex at value $L = 0.49$ mm makes up an area of the range of all morphotypic groups. A curve for individuals with nine chambers in outer whorl, also reaching its peak in this place, concerns, in the pronounced majority of tests, morphotype *H*. The next undulation, with its peak at value L = 0.59 mm, consists of the individuals of morphotype *muensteri*, with considerable part of morphotype *crassa* and the terminating range of the tests of morphotype *H*. The second undulation, falling here in a curve for nine chambers, mostly concerns the tests of morphotype *muensteri*. The last oscillation of the curve, contained within limits of values L = 0.70 to 0.74 mm, includes the tests of morphotype *crassa*, with cosiderable part of those of morphotype *muensteri*. The writer believes that an analysis of a larger statistical assemblage might yield a more coherent picture.

The arrangement of dots within an interval of L and T coordinates (Text-fig. 30) presents on the whole a proportional interdependence of those parameters. Much the same as in Dogger, a pronounced majority of individuals are contained between T = 0.16 and 0.36 mm. Curve N(T) renders its peak within an interval of T = 0.21 to 0.23 mm and does not display oscillation (Text-fig. 31). It is only the curve for individuals with nine chambers in outer whorl that displays a slight undulation: the tests of morphotypes *muensteri* and *tumida* are mostly accumulated at T = = 0,27 mm, while a value of T = 0.41 mm mostly corresponds to the tests of morphotype *crassa*.

Dependence $N\left(\frac{L}{B}\right)$ is shown in Text-fig. 32. The curve reaches its peak within an interval of 1.18 to 1.20 and indicates a somewhat larger degree of involution of the Lower Cretaceous tests. Curve $N\left(\frac{B}{T}\right)$ is asymmetric, ascends abruptly up to a value of 1.58 and then drops gradually (Text--fig. 33).

A curve with its peak falling to eight chambers has been yielded by an analysis of the population in regard to the frequency of occurrence of individuals with a definite number of chambers in outer whorl. The next in succession are the tests having nine chambers (Text-fig. 34).

1) *Lenticulina muensteri* morphotype *wiśniowskii* (Pl. VIII, Figs. 1—4; Pl. XIX, Fig. 1):

Dimensions:	Nch (mm)	L (mm)	B (mm)	T	$\frac{L}{B}$	$\frac{B}{T}$
Specimens:						
minimum	7	0.32	0.26	0.15	1.23	1.60
common	9	0.40	0.31	0.19	1.29	1.63
maximum	10	0.52	0.42	0.23	1.24	1.83

Tests assigned to this morphotype correspond to the species *L. wiśniowskii* (Mjatliuk) *sensu* Mjatliuk (1939) and Kaptarenko-Chernousova (1961). Similar specimens from the Oxfordian and Kimmeridgian of France are illustrated by Guyader (1968, Pl. 19, Fig. 2) as forms within the range of variability of *L. muensteri.*

These tests are marked by small dimensions, slight convexity and a small, circular umbo corresponding in outline to proloculus which is about 0.05 mm in diameter. Test forming somewhat more than one whorl. Number of chambers in outer whorl seven to eleven, on the average nine. Final chamber upturned, slightly swollen and terminating in an apertural chamberlet.

Together with morphotype *muensteri* and young individuals of morphotype *russiensis,* the tests of morphotype *wiśniowskii* form an overlap. In the shape of test and development of umbo they are closely related with morphotype *gibba.*

2) *Lenticulina muensteri morphotype muensteri* (Pl. X; XIX, Figs. 4—6)
Dimensions of tests from the Kuiavian (Vesulian):

	Nch	L (mm)	B (mm)	T (mm)	$\frac{L}{B}$	$\frac{B}{T}$
Specimens:						
minimum	8	0.60	0.48	0.30	1.25	1.60
common	10	0.68	0.58	0.34	1,17	1.71
maximum	12	1.02	0.90	0.47	1.13	1.91

Dimensions of tests from the Infravalanginian:

	Nch	L (mm)	B (mm)	T (mm)	$\frac{L}{B}$	$\frac{B}{T}$
Specimens:						
minimum	7	0.42	0.33	0.18	1.22	1.50
common	9	0.73	0.63	0.40	1.16	1.57
maximum	12	1.13	0.94	0.55	1.20	1.71

The tests of morphotype *muensteri* correspond to those of the species *L. muensteri sensu stricto.* They usually consist of 1.5 whorls; at most to 2.5 whorls in the Infravalanginian and to incomplete 2 whorls in the Dogger. Seven to twelve chambers occur in outer whorl, in the Dogger on the average ten, in the Infravalanginian nine.

In contrast to other Jurassic morphotypes, morphotypes *muensteri* was favoured by the environment as it not only fixed with time, but also displayed a progressive development. In the Infravalanginian it increases the size of tests, length of spiral and number of chambers.

In the Doggerian population, morphotype *muensteri* forms an overlap with morphotypes *wiśniowskii* and *integra* and in the Lower Cretaceous with morphotype *crassa* and morphotype H.

3) *Lenticulina muensteri morphotype gibba* (Pl. VIII, Figs 5—8; Pl. XIX, Fig. 2)

Dimensions:	Nch	L	B	T	$\frac{L}{B}$	$\frac{B}{T}$
Specimens:		(mm)	(mm)	(mm)		
minimum	8	0.29	0.23	0.14	1.26	1.64
common	9	0.39	0.32	0.19	1.22	1.68
maximum	10	0.56	0.48	0.26	1.17	1.85

The tests assigned to this morphotype correspond to those of the species *L. gibba* (Roemer). They are similar to morphotype *wiśniowskii,* from which they differ, however, in the development of sutures and a somewhat closer coiling of the test. Sutures fairly wide, nearly straight, nearly radiate, at the peripheral margin fan-like.

The writer is in doubt how to examine those tests, since the character of their sutures deviates from a description of the holotype of *L. muensteri*. However, a close similarity to morphotype *wiśniowskii* and the fact that, as far as the writer knows, this species of Roemer has not generally been accepted in literature, seem to allow one to consider these tests within the range of morphological variability of *L. muensteri*. These tests have been found in the Doggerian assemblages only.

4) *Lenticulina muensteri morphotype integra* (Pl. VIII, Figs 9—11):

Dimensions:	Nch	L	B	T	$\frac{L}{B}$	$\frac{B}{T}$
		(mm)	(mm)	(mm)		
Specimens:						
minimum	7	0.42	0.32	0.19	1.31	1.68
common	10	0.65	0.55	0.31	1.18	1.77
maximum	11	0.74	0.63	0.35	1.17	1.80

The tests of this morphotype correspond to the species *L. integra* (Kaptarenko-Chernousova, 1961), described from the Lower Oxfordian of the Poltava Region. These are specimens, closely coiled involutely, with a rounded periphery and a relatively large, flat, transparent umbonal disc, through which inner chambers may easily be counted. There are four to eight of them, forming up to 0.75 inner whorl. Proloculus variable in diameter within limits of 0.04 and 0.07 mm, frequently 0.05 mm.

The tests of morphotype *integra* form a large overlap with morphotype *tumida*. It is particularly difficult to separate younger individuals, since distinct differences in arrangement of sutures and outline of test, occur in the adult ontogenetic stage. There are also transitional forms to morphotype *muensteri*.

5) *Lenticulina muensteri morphotype tumida* (Pl. VIII, Figs 12—15; Pl. XIX, Fig. 3):

Dimensions of tests from the Kuiavian (Vesulian):

Specimens:	Nch	L (mm)	B (mm)	T (mm)	$\frac{L}{B}$	$\frac{B}{T}$
minimum	8	0.45	0.37	0.22	1.21	1.68
common	9	0.68	0.61	0.32	1.11	1.91
maximum	11	0.84	0.76	0.35	1.10	2.17

Dimensions of tests from the Infravalanginian:

Specimens:	Nch	L (mm)	B (mm)	T (mm)	$\frac{L}{B}$	$\frac{B}{T}$
minimum	8	0.31	0.27	0.16	1.15	1.69
common	8	0.56	0.48	0.27	1.17	1.77
maximum	11	0.84	0.76	0.39	1.10	1.95

The tests assigned to this morphotype correspond to those of the species *L. tumida* [3] (Mjatliuk) *sensu* Mjatliuk (1955, 1961) and Mitjanina (1963). These are large tests, sometimes polygonal in the outline of their youngest part. In the Dogger, final chambers of some specimens are extended in a hornlike manner at the contact of sutures and periphery. Sutures distinct, slightly bent. Umbonal disc identical with that in morphotype *integra*, with inner whorl and proloculus visible through the transparent wall. Proloculus in sectioned individuals, 0.032 to 0.081 mm in size.

The variability in the morphotype *tumida*, occurring with the lapse of time, is expressed in a decrease in the number of individuals, in the size of test, number of chambers and length of spiral. The largest specimens, consisting of two complete whorls occurred in the Callovian. They frequently had eleven chambers in outer whorl, while in the Lower Cretaceous such specimens were rare.

In the Doggerian population, the morphotype *tumida* forms an overlap with the morphotype *integra*; specimens with more straightened sutures form transition to the morphotype *gibba*.

In the Polish material from the Lower Cretaceous, the tests of the morphotype *tumida* are few. They were more numerous in comparative samples from the Berriasian of Speeton Clay, England.

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[3] The name *tumida* is a homonym, since it has proviously been used by Karrer (1870) to designate *Lenticulina* from the Upper Cretaceous of Germany.

6) *Lenticulina muensteri morphotype russiensis* (Pl. IX, Figs 3—10):
Dimensions of the Kuiavian (Vesulian) tests:

Specimens:		Nch	L (mm)	B (mm)	T (mm)	L/B	B/T
minimum		10	0.40	0.33	0.22	1.19	1.53
common	I	10	0.61	0.46	0.27	0.31	1.73
	II	10	0.58	0.48	0.31	1.20	1.58
maximum		12	1.07	0.82	0.45	1.30	1.81

Dimensions of the Infravalanginian tests:

Specimens:	Nch	L (mm)	B (mm)	T (mm)	L/B	B/T
minimum	9	0.52	0.40	0.23	1.30	1.74
common	10	0.74	0.55	0.32	1.34	1.71
maximum	11	0.97	0.68	0.35	1.43	1.94

The tests assigned to this morphotype correspond to the species *L. russiensis* (Mjatliuk) *sensu* Mjatliuk (1939) and Kaptarenko-Chernousova (1961). Similar specimens are illustrated by Guyader (1968, Pl. 19, Figs 20—23) as forms within the range of variability of *L. muensteri* as they are similar to *L. russiensis* (Mjatliuk).

Tests oval in outline, semi-evolutely coiled, tending to uncoil. Rarer, specimens are circular, involute with a larger convexity and umbonal disc. Chambers narrow, bent, closely arranged in whorl. In the terminal part of test, sutures may be slightly depressed and, in the outer whorl, somewhat raised.

Due to a small number of specimens from the Lower Cretaceous, which the writer had at her disposal, it is difficult to state if this is the morphotype *russiensis* passing to the Lower Cretaceous or only detached, single forms of variability in the Lower Cretaceous morphotype *muensteri*. The Lower Cretaceous tests are larger, more elongate, and having wider chambers.

In the Doggerian populations, the morphotype *russiensis* forms an overlap with the morphotypes *wiśniowskii* and *muensteri*.

7) *Lenticulina muensteri morphotype crassa* (Pl. XI, Figs 3—6; Pl. XX, Figs 1, 2):

Dimensions:	Nch	L (mm)	B (mm)	T (mm)	L/B	B/T
Specimens:						
minimum	7	0.35	0.29	0.19	1.21	1.53
common	10	0.70	0.61	0.41	1.15	1.49
maximum	12	1.23	1.07	0.70	1.15	1.53

The tests of this morphotype correspond to *L. crassa* (Roemer) and are marked by a large convexity, well developed umbonal button and not very distinct, arcuate or straight sutures. They reach up to 2.5 whorls and 23 chambers. Proloculus widely varying in diameter from 0.03 to 0.08 mm. The tests of the morphotype *crassa* form an extensive overlap with the morphotype *muensteri*.

8) *Lenticulina muensteri morphotype H* (Pl. XI, Figs 1, 2):

Dimensions:	Nch	L (mm)	B (mm)	T (mm)	$\frac{B}{L}$	$\frac{B}{T}$
Specimens:						
minimum	7	0.29	0.23	0.12	1.26	1.92
common	8	0.42	0.33	0.17	1.27	1.94
maximum	9	0.64	0.52	0.25	1.23	2.08

These are small, slightly convex tests, frequently somewhat polygonal in outline, consisting of slightly more than one whorl. Final sutures slightly depressed and, correspondingly, final chambers slightly swollen. Umbo small, circular, corresponding in outline to proloculus. The tests of this morphotype are similar to some forms of the range of variability of *L. nodosa* (Reuss).

Remarks. — All tests assigned to *L. muensteri*, regardless of their variability, correspond to a fundamental presentation of the holotype, except for the morphotype *gibba*, in which, however, the differences concern one character only. Text-fig. 35 contains Roemer's original illustra-

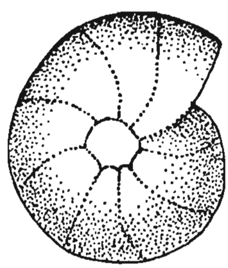

Fig. 35. *Lenticulina muensteri* (Roemer), 1839). A copy of Roemer's original drawing (*fide* Cat. of Foram., Ellis & Messina).

tion of *L. muensteri*, whose original description is as follows: "Tests slightly smaller (than in *Robulina gibba*), convex, with a somewhat projecting, dark-colored umbonal disc, from which run about eight uncolored and not projecting, strongly curved lines (inter-chamber septa)." In his next work, Roemer (1841) gave another description of *L. muensteri*, extended by new details: "Text subround, flatly vaulted, with a fairly large, flat, darker umbonal area and about nine chambers, which are bent posteriorly, have gently arcuate inter-chamber septa and fairly sharp margin."

On the basis of these descriptions, later authors started to cite *L. muensteri* first from the Lower Cretaceous and then extended its occurrence over the entire Jurassic and Cretaceous. The present writer basing on her

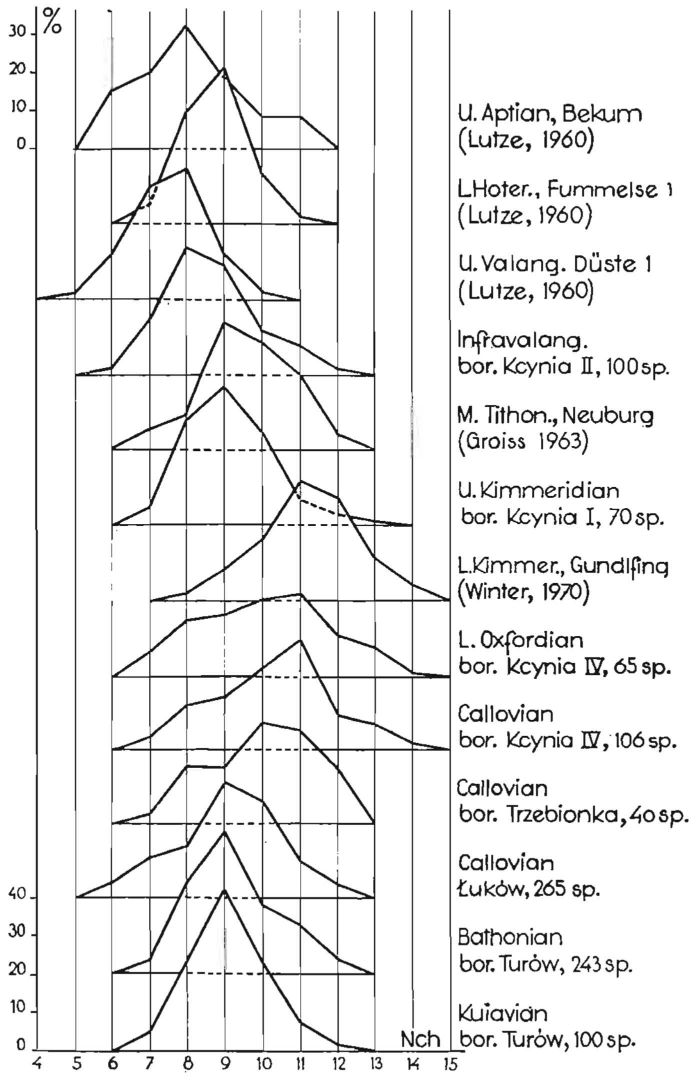

Fig. 36. Collected curves of the frequency of occurrence of the individuals with a definite number of chambers in outer whorl for a population of *L. muensteri* (Roemer) within the Dogger — Lower Cretaceous interval.

material stated that this species occurs only from the Dogger to Lower Cretaceous. A related species, *L. gottingensis* (Bornemann), probably an ancestor of *L. muensteri*, frequently considered to be its synonym, occurs in the Lower Jurassic.

The statistical and microstructural studies have enabled the determination of certain characters, separating these two smooth-walled species. In *L. gottingensis* the curve of the frequency of occurrence of individuals with a definite number of chambers in outer whorl, has its peak at eight chambers. There are less nine-chamber and yet less ten-chamber tests. Such a population corresponds to an average size of specimen of 0.58 mm. The same curve for the Doggerian *L. muensteri* have its peak at nine chambers, with a considerable share of ten-chamber tests. Curve N(L) for the Doggerian *L. muensteri* with eight chambers in outer whorl reaches its peak at a value of L = 0.38 to 0.40 mm and with nine chambers at L = 0.49 mm. Tests in *L. göttingensis* are larger and flatter than in *L. muensteri*. In addition, all Liassic forms have a flat, poorly marked umbonal disc and a rarely occurring apertural chamberlet. The range of variability in *L. gottingensis* is pronouncedly smaller and statistical curves, obtained for this species, are easily interpretable. The variability in *L. muensteri* is very large and it has been worked up by separating the six morphotypes.

In the sections of tests, the number of all chambers in the Liassic species is much smaller, not exceeding 14, while in the Doggerian *L. muensteri* it is 20. They rarely form in the Liassic forms more than 1.5 whorls, while in the Dogger they form two whorls. Concerning the microstructure of wall in the Liassic species, we note in it a thicker primary lamella and correspondingly thicker inter-chamber septa. The microstructure is of the slightly mesolamellar type, passing to the nonlamellar while in *L. muensteri* laminae overlap posteriorly to a considerably larger extent.

In the Dogger, a considerable similarity to *L. muensteri* is displayed by *L. oolithica* (Terquem), which, however, differ from it in a robust test, large dimensions (up to 1.55 mm), large number of chambers in outer whorl (up to 15) and a multilamellar microstructure of the wall.

In the Lower Cretaceous, most similar to *L. muensteri* is *L. gaultina* (Berthelin), which differs from it in the outline of test, straight sutures tangentially arranged to umbo and a large number of chambers. The Lower Cretaceous *muensteri*-shaped tests, provided with sutural ribs, are assigned to *L. roemeri* (Reuss), those with a keel to *L. cultrata* (Montfort) and those with a keel and ribs to *L. subalata* (Reuss).

In the Upper Cretaceous, *L. muensteri* is replaced by *L. rotulata* Lamarck, which has frequently been confused with *L. muensteri*. Observing the smooth-walled *Lenticulina* in profile, we may easily notice an increase in the size of tests in the Upper Cretaceous, which gives the Upper Cretaceous *Lenticulina* assemblages, with *L. rotulata* as a predominant species, a very different character. For morphological and microstructural differences between these two species — see Remarks on the species *L. rotulata*.

Occurrence. — A common species with a world-wide distribution, occurring from the Dogger (Aalenian) through the Lower Cretaceous (Albian). In the material under study it occurs in the Dogger, Lower and Middle Malm and Lower Cretaceous of many borings. The holotype comes from the Lower Cretaceous of the environs of Schöppenstadt, North Germany.

Lenticulina nodosa (Reuss)
(Pl. XII, Figs 4—12)

1862. *Robulina nodosa* Reuss; Reuss, p. 78, Pl. 9, Fig. 8.
1963. *Astacolus gibber* Espitalié & Sigal; Espitalié & Sigal, p. 36, Pl. 13, Figs 8—11.
1966. *Lenticulina (Lenticulina) nodosa* (Reuss); Dieni & Massari, p. 118, Pl. 3, Figs 14, 15. (here older synonymy).
1966. *Lenticulina nodosa* (Reuss); Moullade, p. 51, Pl. 4, Figs 9—12.
1967. *Lenticulina (Lenticulina) nodosa* (Reuss); Michael, p. 34, Pl. 3, Figs 8, 11.
1967. *Lenticulina (Astacolus) barremiana* Michael; Michael, p. 41, Pl. 3, Fig. 9; Pl. 20, Figs 85, 86, 91, 108.
1971. *Lenticulina (Lenticulina) nodosa* (Reuss); Bartenstein, Bettenstaedt, Kovatcheva, p. 141, Pl. 2, Fig. 33.
1972. *Lenticulina nodosa* (Reuss); Neagu, p. 204, Pl. 5, Figs 1—6.
1973. *Lenticulina (Lenticulina) nodosa* (Reuss); Bartenstein & Kaever, p. 234.
1973. *Lenticulina (Astacolus) barremiana* Michael; Bartenstein & Kaever, p. 230, Pl. 4, Figs 67, 68.

Material. — More than 300 mostly well-preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	0.31	0.25	0.14
common	9	0.56	0.45	0.22
maximum	11	1.37	0.74	0.42

Description. — The Polish tests are most similar to those described by Bartenstein & Brand (1951).

Variability. — In the material under study, *L. nodosa* (Reuss) displays considerable differences in the size of test and number of chambers forming them, which not always explains trimorphism occurring in this species. Sometimes microspheric individuals are smaller than the megalospheric ones. In addition to tests corresponding to the holotype there also occur specimens, in which peripheral nodes are indistinct. Such tests are polygonal in outline and flatter. Specimens displaying a considerable degree of uncoiling, sometimes almost quite straightened, have been found by the writer in some samples abounding in *L. nodosa.*

The following two morphotypes have been distinguished for *L. nodosa.*

1) *Lenticulina nodosa morphotype nodosa* (Pl. XII, Figs 4—8, 12):

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	0.32	0.26	0.15
common	9	0.56	0.45	0.22
maximum	11	1.35	1.15	0.35

The test of this morphotype represent *L. nodosa* (Reuss) *sensu stricto*. These are undoubtedly the same forms which were described by Liszka (1950) as *L. pilicensis* (Liszka). This morphotype predominates in the population.

2) *Lenticulina nodosa morphotype gibber* (Pl. XII, Figs 9—11):

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	9	0.89	0.55	0.32
common	9	1.06	0.71	0.40
maximum	11	1.37	0.74	0.42

The morphotype *gibber* includes the specimens of *L. nodosa* with an uncoiled test. The extreme link in the series of variability, arranged according to an increasing degree of the uncoiling of test, is represented by specimens corresponding to *Astacolus gibber* Espitalié & Sigal (1963) as well as to *Lenticulina* (*Astacolus*) *barremiana* Michael (1967). They are relatively few and in the material under study occur from the Upper Infravalanginian to the Hauterivian, always accompanied by the tests of the morphotype *nodosa*. These facts testify against treating these tests as a separate species [4]. Michael's forms from the Barremian of Germany reach larger dimensions than the Polish specimens.

Remarks. — Specimens of *L. nodosa* with indistinct peripheral nodes approach to forms of *L. muensteri* morphotype *H*. The Upper Cretaceous *L. pondi* Cushman, which differs in larger and more uniform dimensions, more closely coiled spiral having lower whorls, and in larger convexity and larger umbonal disc, is derived from *L. nodosa*.

Occurrence. — This is a Lower Cretaceous, cosmopolitan species (Europe, Africa, Arabia, Central America). In the material under study fairly frequent from the Infravalanginian through the Hauterivian of the Kcynia II boring and in the comparative material of the same age from Wąwał. The holotype comes from the Lower Cretaceous of Germany (Hils).

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[4] While this paper was in print, Bartenstein's work (1974) appeared in which Michael's species is considered as a subspecies within *C. nodosa*.

Lenticulina angulosa (Chapman, 1896)
(Pl. XIII, Figs 12—14)

1896. *Cristellaria secans* Reuss var. *angulosa* Chapman; Chapman, p. 3, Pl. 1, Fig. 4.
1933. *Lenticulina secans* Reuss var. *angulosa* Chapman; Eichenberg, p. 172, Pl. 20, Fig. 4.
1935. *Lenticulina secans* Reuss var. *angulosa* Chapman; Eichenberg, p. 9, Pl. 4, Fig. 8.
1974. *Lenticulina (Lenticulina) angulosa* (Chapman); Bartenstein, p. 539, Pl. 2, Figs 3, 4.

Material. — Thirty tests, on the whole well-preserved.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	8	0.47	0.38	0.29
common	8	0.66	0.55	0.37
maximum	9	0.80	0.66	0.47

Description. — Tests robust, planispiral, strongly biconvex, slightly polygonal in outline. A narrow, opaque rim runs on the margin of the test. Outer whorl consisting of eight to nine chambers. Sutures distinct, rectilinear, tangentially arranged, the youngest flat, older ones thick, provided with ribs which are more strongly developed near umbonal disc and fading out towards the periphery of the test. Umbonal disc large, thickened, not projecting over the surface of test. Apertural face triangular, bordered by rounded lateral margins. Aperture with an apertural chamberlet and a distinct apertural slit on the side of the apertural face.

Remarks. — The tests discussed are marked by distinct and permanent characters, which, in the writer's opinion should not be examined within the range of variability of *L. secans* (Reuss), which is round in outline, with a keel on the periphery, composed of a larger number of narrower chambers and nearly twise as large.

Occurrence. — Fairly rare in the Upper Infravalanginian and Valanginian of the Kcynia II boring. The holotype comes from the Albian of Folkstone, England; Eichenberg's specimens come from the Barremian and Aptian of the Netherlands.

Lenticulina gaultina (Berthelin, 1880)
(Pl. XI, Figs 7—9; Pl. XII, Figs 1—3)

1880. *Cristellaria gaultina* Berthelin; Berthelin, p. 49, Pl. 3, Figs 15—19.
1896. *Cristellaria gaultina* Berthelin; Chapman, p. 7, Pl. 1, Fig. 10.
1935. *Robulus gaultinus* Berthelin; Eichenberg, p. 156, Pl. 16, Fig. 6.
1957. *Lenticulina gaultina* (Berthelin); Sztejn, p. 34, Pl. 3, Fig. 19.
1959. *Robulus gaultinus* (Berthelin); Stančeva, p. 143, Pl. 4, Figs 5, 7.
1962. *Lenticulina (Lenticulina) subgaultina* Bartenstein; Bartenstein, p. 136, Pl. 13, Figs 1, 2.

1965. *Lenticulina (Lenticulina) gaultina* (Berthelin); Neagu, p. 10, Pl. 3, Figs 1, 2.
1970. *Lenticulina gaultina* (Berthelin); Neagu, p. 51, Pl. 30, Figs 27, 28.
1973. *Lenticulina gaultina* (Berthelin); Dailey, p. 50, Pl. 5, Fig. 1a, b.

Material. — Several hundred variously preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	9	0.40	0.29	0.18
common	10	0.61	0.48	0.30
maximum	13	1.60	1.35	0.65

Description. — Corresponding to that of the holotype.

Remarks. — The tests of *L. gaultina* (Berthelin) are variable in size and degree of their upward tapering. The largest specimens come from the Albian. The more circular specimens are similar to *L. muensteri* (Roemer). Those having strongly elongated latest chambers were separated by Bartenstein (1962) into a new species, *L. (L.) subgaultina* Bartenstein. *L. gaultina* is sometimes described in literature as a form with a wide keel (Tappan, 1940; Kaptarenko-Chernousova, 1967). The present writer had an opportunity to see Berthelin's original collection. The tests of *L. gaultina* had an obtuse or acute periphery, devoid of keel (cf. paratype, Pl. XI, Fig. 9).

Occurrence. — A Lower Cretaceous species, known from many localities in Europe and from America (Dailey, 1973), cited most frequently from the Hauterivian through the Albian. In the material under study: the Infravalanginian through the Albian of the Kcynia II and Łazisko borings. The holotype comes from the Albian of the Paris Basin.

Lenticulina circumcidanea (Berthelin, 1880)
(Pl. XIII, Figs 1—4)

1880. *Cristellaria circumcidanea* Berthelin; Berthelin, p. 52, Pl. 3, Fig. 1.
1896. *Cristellaria circumcidanea* Berthelin; Chapman, p. 2, Pl. 1, Fig. 2.
1960. *Lenticulina circumcidanea* Berthelin; Gorbatszik, p. 90, Pl. 6, Fig. 1.

Material. — Thirty-five mostly well-preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	6	0.25	0.21	0.12
common	7	0.44	0.37	0.19
maximum	8	0.61	0.50	0.26

Description. — Tests involute, circular or slightly polygonal in outline, slightly convex. An opaque peripheral rim, indistinct in young individuals, runs on the margin of test. Chambers gently deflected posteriorly, younger ones markedly swollen. Sutures arcuate, gradually more and more depressed. Umbonal area small, flat or slightly depressed as a result of the swelling of chambers. In young individuals, umbo corresponds in outline to proloculus. Apertural face slightly convex, heart-shaped. A triangular opening occurs in the apertural chamberlet on the side of the apertural face.

Remarks. — The specimens described display a considerable similarity to *L. turgidula* (Reuss) subspecies *involuta* Dieni & Massari (1966) from the Upper Valanginian of Sardinia, from which they differ in fact only in the development of keel. There is also a similarity to *L. lituola* (Reuss) from Michael's (1967) work.

Occurrence. — A species known from the Albian of France, England and the USSR. In the material under study it occurs in the Upper Infravalanginian Valanginian and Hauterivian of the Kcynia II and Łazisko borings. The holotype comes from the Albian of the Paris Basin.

Lenticulina pulchella (Reuss, 1862)
(Pl. XIII, Figs 5—7)

1862. *Cristellaria pulchella* Reuss; Reuss, p. 71, Pl. 8, Fig. 1.
1965. *Lenticulina (Robulus) pulchella* (Reuss); Neagu, p. 12, Pl. 4, Figs 3—6.

Material. — Seventeen mostly well-preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	6	0.32	0.20	0.13
common	8	0.72	0.52	0.25
maximum	8	1.07	0.84	0.39

Description. — Tests planispiral, tending to uncoil, oval, slightly convex, upwards pointed. Periphery acute. Seven to eight, rapidly increasing chambers, in outer whorl. Final chambers slightly swollen on the proximal side. Sutures slightly arcuate, older ones flat, indistinct, final ones slightly depressed. Umbonal disc lacking. Apertural face longitudinally heart-shaped, swollen.

Remarks. — The tests described, similarly as Neagu's (1965) specimens, differ from the holotype in a smaller number of chambers. They display a considerable similarity to *L. discrepans* (Reuss), in which the tendency to uncoiling the test is less marked and which is widely oval in outline.

Occurrence. — According to Reuss (1862), it occurs in the Lower Cretaceous of Germany (Upper Hils and Lower Albian). In the material under study, in the Upper Infravalanginian, Valanginian and Hauterivian of the Łazisko boring and in the comparative material of the same age from Wąwał. In addition, the Albian of Rumania.

Lenticulina vonderschmitti (Gandolfi, 1942)
(Pl. XIII, Figs 10, 11)

1942. *Cristellaria (Lenticulina) vonderschmitti* Gandolfi; Gandolfi, p. 55, Fig. 12 (*fide* Cat. of Foram. Ellis & Messina).

Material. — Nine, not very well-preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	6	0.35	0.22	0.13
common	7	0.55	0.42	0.22
maximum	8	0.80	0.57	0.31

Description. — Test elongate, in the lower part spirally coiled, upwards erect, slightly convex, polygonal in outline. Periphery obtuse. Outer whorl consisting of six to eight flat, triangular, rapidly increasing chambers. Final chamber pointed upwards and slightly swollen. Sutures straight, flat, the final one slightly depressed. Umbonal disc lacking. Apertural face longitudinally heart-shaped, slightly swollen, ventrally resting on the preceding whorl.

Remarks. — The test of *L. vonderschmitti* are similar to uncoiled specimens of *L. nodosa* (Reuss), but devoid of any ornamentation. As compared with *L. pulchella*, they have more elongate tests, polygonal outline and no depresion between the older and younger part of the outer whorl.

Occurrence. — Infrequent in the Upper Infravalanginian, Valanginian and Hauterivian of the Łazisko boring and in the comparative material of the same age from Wąwał (in samples containing gypsum inclusions). The holotype comes from the Lower Cretaceous of Switzerland.

Lenticulina subangulata (Reuss, 1862)
(Pl. XIII, Figs 8, 9)

1862. *Cristellaria subangulata* Reuss; Reuss, p. 74, Pl. 8, Fig. 7.
1934. *Robulus subangulatus* Reuss; Eichenberg, p. 157, Pl. 16, Fig. 4.
1951. *Lenticulina (Lenticulina) subangulata* (Reuss); Bartenstein & Brand, p. 283, Pl. 5, Fig. 111.
1965. *Lenticulina (Lenticulina) subangulata* (Reuss); Neagu, p. 10, Pl. 3, Figs 21, 22.

Material. — Sixty, on the whole well-preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	0.40	0.33	0.20
common	8	0.60	0.48	0.31
maximum	10	0.78	0.62	0.36

Description. — The tests under study are in conformity with the original description of holotype and with Bartenstein & Brand's (1951) extended description.

Remarks. — Two forms under the name "*subangulata*", one, *Cristellaria* (*Cristellaria*) *subangulata* Reuss from the Lower Cretaceous (Reuss, 1862) and the other, *Cristellaria* (*Robulina*) *subangulata* Reuss from the Oligocene (Reuss, 1863), are described by Reuss. This species is also cited from the Upper Cretacecous (Franke, 1925, 1928; Marie, 1947; Pożaryska, 1957). The writer's comparison of the Lower and Upper Cretaceous forms precludes their assignment to one and the same species, since the latter are more similar to a Tertiary rather and not Upper Cretaceous species. The Lower Cretaceous tests are smaller, less convex, with more, frequently radially arranged chambers and with a small, poorly developed umbo.

Occurrence. — Lower Cretaceous of Europe. In the material investigated, the Infravalanginian and Valanginian of the Kcynia II boring. The holotype was described from the Lower Cretaceous of Northern Germany (Hils).

Lenticulina species 2
(Pl. XIV, Figs 4, 5)

1863. *Cristellaria* (*Robulina*) *subangulata* Reuss; Reuss, p. 53, Pl. 6, Fig. 64. (*fide* Cat. of Foram., Ellis & Messina).
1925. *Cristellaria subangulata* Reuss; Franke, p. 74, Pl. 6, Fig. 1.
1928. *Cristellaria* (*Robulina*) *subangulata* Reuss: Franke, p. 112, Pl. 10, Fig. 13.
1941. *Lenticulina subangulata* (Reuss); Marie, p. 101, Pl. 9, Fig. 106.
1957. *Lenticulina subangulata* (Reuss); Pożaryska, p. 128, Pl. 18, Fig. 2.

Material. — Twenty-five well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	6	0.55	0.45	0.25
common	7	0.87	0.72	0.43
maximum	8	1.13	0.97	0.51

Remarks. — The tests are in conformity with Reuss's description of *Cristellaria* (*Robulina*) *subangulata* Reuss, 1863. For differences in relation to *L. subangulata* — see Remarks on that species. Since no studies have been conducted by the writer on the Tertiary material, the problem of the name of this species remains for the time being open.

Occurrence. — A species known from the Upper Cretaceous of Europe (France, Germany, Poland) and passing to the Tertiary (Reuss, 1863). In the material under study, it occurs not very abundantly from the Emscherian to the Maastrichtian in the section on the Vistula River.

Lenticulina rotulata Lamarck, 1804
(Pl. XV; XX, Figs 3—6)

1804. *Lenticulina rotulata* Lamarck; Lamarck, p. 188 (*fide* Cat. of Foram. Ellis & Messina).
1806. *Lenticulites rotulata* Lamarck; Lamarck, Pl. 62, Fig. 11 (*fide* Cat. of Foram. Ellis & Messina).
1818. *Nautilus comptoni* Sowerby; Sowerby, p. 45, Pl. 121 (*fide* Cat of Foram. Ellis & Messina).
1840. *Cristellaria rotulata* d'Orbigny; d'Orbigny, p. 26, Pl. 2, Figs 15—18.
1845. *Cristellaria rotulata* d'Orbigny; Reuss, p. 34, Pl. 8, Figs 50, 70; Pl. 12, Fig. 25.
1845. *Cristellaria ovalis* Reuss; Reuss, p. 34, Pl. 8, Fig. 49; Pl. 12, Fig. 19; Pl. 13, Figs 60—63.
1851. *Cristellaria Spachholtzi* Reuss; Reuss, p. 33, Pl. 3, Fig. 10.
1891. *Cristellaria rotulata* Lamarck; Beissel, p. 55, Pl. 10, Figs 20—25, 28—33.
1892. *Cristellaria rotulata* Lamarck; Perner, p. 38, Pl. 4, Figs 1—10.
1899. *Cristellaria rotulata* Lamarck; Egger, p. 122, Pl. 11, Figs 3, 4.
1899. *Cristellaria Spachholtzi* Reuss; Egger, p. 115, Pl. 24, Figs 10, 11.
1925. *Cristellaria rotulata* Lamarck; Franke, p. 72, Pl. 6, Fig. 4.
1925. *Cristellaria rotulata* Lamarck f. *Spachholtzi* Reuss; Franke, p. 73, Pl. 6, Fig. 5.
1925. *Cristellaria ovalis* Reuss; Franke, p. 72, Pl. 6, Fig. 3.
1932. *Lenticulina rotulata* Lamarck; Cushman, p. 334, Pl. 50, Fig. 3.
1934. *Cristellaria rotulata* Lamarck; Dajn, p. 21, Pl. 2, Fig. 12.
1936. *Lenticulina comptoni* Sowerby; Brotzen, p. 48, Pl. 2, Fig. 5; Pl. 3, Fig. 8; Text-figs 11—15.
1950. *Lenticulina rotulata* Lamarck; Visser, p. 223, Pl. 2, Fig. 6.
1954. *Lenticulina rotulata* Lamarck; Hagn, p. 33, Pl. 3, Fig. 12.
1954. *Lenticulina comptoni* (Sowerby); Hagn, p. 34, Pl. 3, Fig. 9.
1957. *Lenticulina comptoni* (Sowerby); Pożaryska, p. 121, Pl. 12, Fig. 5; text-fig. 27.
1957. *Lenticulina* (*Lenticulina*) *comptoni* (Sowerby); Hofker, p. 114, text-figs 117, 118.
1959. *Lenticulina rotulata* Lamarck; Stančeva, p. 135, Pl. 3, Fig. 4.
1972. *Lenticulina comptoni* (Sowerby); Hanzliková, p. 67, Pl. 15, Fig. 2.

Material. — Several hundred variously preserved tests.

Dimensions [5]:	Nch	L (mm)	B (mm)	T (mm)	$\frac{L}{B}$	$\frac{B}{T}$
Specimens:						
minimum	9	0.85	0.74	0.45	1.15	1.89
common	10	1.60	1.38	0.77	1.16	1.79
maximum	12	2.50	2.10	1.20	1.19	1.75

Description. — Polish tests are in conformity with d'Orbigny's (1840) description, as well as with Beissel's (1891) and Brotzen's (1936) more detailed elaborations.

Equatorial section. Microspheric specimens B have up to thirty narrow, high chambers and a very small proloculus merely about 0.032 mm in diameter. In specimens of generation A_1, prolocular diameter fluctuates between 0.13 and 0.23 mm. Proloculus, situated centrally, accompanied

[5] Concerning the tests of generations B and A_1.

by mostly about seventeen lower and less closely arranged chambers, up to eleven of them in outer whorl. The forms of generation A_2 are smaller, slightly different in shape, mostly semicircular as the test does not grow to reach a full spiral. They have a large, oviform proloculus situated near the ventral margin of test, up to 0.32 mm in diameter and having up to nine chambers.

Microstructure of wall in *L. rotulata* is multilamellar.

Remarks. — Similarly as d'Orbigny (1840), the writer has referred *L. comptoni* (Sowerby) to the synonymy of *L. rotulata*. *L. comptoni* (Sowerby) has frequently been considered as a separate taxon due to its umbonal boss, lacking in typical *L. rotulata*. Having at her disposal an abundant material, the writer was able to study accurately the intra specific variability in *L. rotulata*. As shown by an analysis of many assemblages conducted from the viewpoint of the development of umbonal disc, a marked majority, that is, about 85 per cent of the entire population have a distinctly developed and moderately convex umbonal disc; about 10 per cent have an umbonal disc developed very strongly in the form of a projecting node with other morphological characters unchanged; the remaining few tests have a flat umbonal disc, which is indistinct in outline. Sometimes, they have an identical arrangement of chambers with that in *L. spachholtzi* (Reuss), that is, with a slight detachment of final chambers from the whorl. In their general character, these tests also do not differ from the most common group. Such a distribution of variability is indicative of the homogeneity of population and, therefore, the division of tests into those having (*L. comptoni*) and not having (*L. rotulata*, *L. spachholtzi*) an umbonal boss, should be considered as artificial. *L. ovalis* (Reuss) mostly represents immature megalospheric individuals A_2 of *L. rotulata*, while the specimens representing more advanced stages of ontogenetic development are relatively rare. They allow one to construct a developmental series of generation A_2. The conclusion may thus be drawn that only some species of generation A_2 reach a complete development.

Similar tests have also been found within the range of Lower Cretaceous and Jurassic assemblages also including trimorphic species. These tests have separate specific names.

Although *L. rotulata* is a species well-known and frequently described for a long time, its name was more than once applied erroneously, to the Recent, Tertiary and Jurassic *Lenticulina*. Sometimes, *L. rotulata* was identified with *L. muensteri* (Roemer). The differences between them concern the dimensions of tests, vaulting of lateral walls and umbonal disc and the microstructure of wall.

Occurrence. — A common cosmopolitan Upper Cretaceous species (Europe, North America, Australia). In the material under study it occurs from the Albian to Maastrichtian in the section on the Vistula River. The holotype comes from the Upper Cretaceous of the Paris Basin.

Lenticulina acuta (Reuss, 1860)
(Pl. XIV, Figs 10)

1860. *Cristellaria acuta* Reuss; Reuss, p. 69, Pl. 10, Fig. 3a, b.
1928. *Cristellaria gibba* d'Orb. f. *acuta* Reuss; Franke, p. 106, Pl. 10, Fig. 12.
1954. *Lenticulina acuta* (Reuss); Hagn, p. 34, Pl. 3, Fig. 3.
?1957. *Lenticulina acuta* (Reuss); Pożaryska, p. 120, Pl. 15, Fig. 5.

Material. — Fourteen well-preserved specimens.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	1.00	0.77	0.55
common	9	1.10	0.80	0.52
maximum	9	1.29	0.96	0.54

Remarks. — The Polish specimens are in conformity with Hagn's (1954) illustration of this species and, as compared with the holotype, they have one to two chambers less in their outer whorl.

Occurrence. — A rare Upper Cretaceous species known from Germany and Poland. In the material under study, single specimens from the Albian to Maastrichtian in the section on the Vistula River. The holotype comes from the Upper Cretaceous of Westphalia.

Lenticulina neoorbicula Hofker, 1957
(Pl. XVI, Figs 3—5)

1957. *Lenticulina (Robulus) neoorbicula* Hofker; Hofker, p. 127, text-fig. 143.
?1957. *Lenticulina (Lenticulina) orbicula* (Reuss); Hofker, p. 112, text-figs 113, 114.

Material. — Twenty-five variously preserved tests.

Dimensions [6]:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	10	0.87	0.74	0.45
common	12	1.30	1.07	0.74
maximum	14	2.23	1.92	1.23

Description. — Tests large, circular, slightly pointed upwards, planispiral, involute, strongly biconvex. Periphery acute. Outer whorl low, composed of ten to fifteen chambers. Sutures flat, older ones indistinct, tangential to radiate in arrangement. Umbonal area occupied by a huge

[6] The above measurements concern the tests of generations B and A_1.

umbonal disc, which is on the whole flat, sometimes slightly convex. Apertural face small, with slightly developed lateral margins. Aperture radiate with a "*Robulus*" slit.

A trimorphic species, with a multilamellar type of the microstructure of wall visible in thin sections.

Remarks. — The Polish specimens differ from the holotype in a lack of keel. It seems that *L. neoorbicula* should also include forms described by Hofker (1957) as *Lenticulina* (*L.*) *orbicula* (Reuss).

As compared with *L. rotulata* Lamarck, *L. neoorbicula* differs in robust tests, larger convexity, development of umbonal disc and a low outer whorl.

Occurrence. — In the section of the Cretaceous on the Vistula River, Cenomanian to Maastrichtian, fairly rare. The holotype comes from the Upper Cretaceous of Northern Germany.

Lenticulina marcki (Reuss, 1860)
(Pl. XIV, Fig. 11)

1860. *Cristellaria Marcki* Reuss; Reuss, p. 212, Pl. 9, Fig. 4.
1891. *Cristellaria umbilicata* Beissel; Beissel, p. 56, Pl. 10, Figs 44—47.
1928. *Cristellaria marcki* Reuss; Franke, p. 103, Pl. 9, Fig. 20.
1946. *Margulina pseudomarcki* Cushman; Cushman, p. 60, Pl. 20, Figs 27, 28.
1954. *Margulina pseudomarcki* Cushman; Frizzell, p. 85, Pl. 9, Fig. 20.
1957. *Lenticulina marcki* (Reuss); Pożaryska, p. 125, Pl. 16, Fig. 5.

Material. — Twenty well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	8	0.74	0.53	0.32
common	9	1.52	1.17	0.58
maximum	12	2.70	1.74	0.84

Description. — The Polish specimens do not differ from the holotype.

Equatorial section. Inner sector of the spiral usually consisting of ten chambers, arranged to form somewhat more than one whorl plus a round proloculus about 0.07 mm in diameter. The youngest chambers are smaller than the proloculus and falciform. Further chambers are triangular and overlapping each other. In the outer sector of the spiral, the chambers are at first subquadrangular and then, in the uncoiled part, they form elongate, low triangles, slightly deflected posteriorly.

Remarks. — The writer does not see any distinct differences between Reuss's species and *Margulina pseudomarcki* Cushman, except for larger dimensions of the tests described by Cushman, but this can be ascribed to ecological conditions. In the comparative material from the Upper Cretaceous of the State of Texas, other cosmopolitan species of the *Lenticulina* are also larger.

Occurrence. — This is an Upper Cretaceous species, known from the territories of Europe (Germany, Poland) and America. In the material under study, it occurs fairly rarely in the Upper Vistula Region from the Turonian to the Maastrichtian. The holotype comes from the Senonian of Westphalia.

Lenticulina pondi (Cushman, 1931)
(Pl. XIV, Figs 8, 9)

1931. *Robulus pondi* Cushman; Cushman, p. 25, Pl. 2, Fig. 9.
1946. *Robulus pondi* Cushman; Cushman, p. 52, Pl. 16, Figs 1—5.
1946. *Lenticulina multinodosa* Schijfsma; Schijfsma, p. 57, Pl. 3, Fig. 10.
1946. *Lenticulina mariae* Schijfsma; Schijfsma, p. 56, Pl. 3, Fig. 9.
1954. *Lenticulina mariae* Schijfsma; Hagn, p. 35, Pl. 3, Fig. 4.
?1959. *Lenticulina mariae* (Schijfsma); Stančeva, p. 139, Pl. 2, Fig. 6; Pl. 3, Fig. 3.
1972. *Lenticulina mariae* Schijfsma; Hanzliková, p. 68, Pl. 15, Fig. 5.

Material. — Fifteen variously preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	8	0.42	0.35	0.23
common	9	0.65	0.57	0.38
maximum	11	1.23	1.10	0.65

Remarks. — The Polish specimens are most similar to those of Schijfsma (1946). The present writer considers *L. mariae* Schijfsma and *L. multinodosa* Schijfsma to represent particular forms of the variability of one species. The variant *mariae* is considerably more frequent than *multinodosa*, which is represented by specimens with most completely developed specific characters. Transitional forms are present between both types. A similar fact was noticed by the present author in *L. nodosa* (p. 166).

The American specimens, described by Cushman (1937), are very similar to those from Europe. The differences between them concern only a larger number of chambers per whorl and a lower degree of convexity in the American specimens, which may be connected with ecological differences.

The species *L. pilicensis* Liszka, which is a synonym of *L. nodosa* (Reuss), is erroneously included by Stančeva (1959) to the synonymy of *L. mariae* Schijfsma (*recte L. pondi* (Cushman)). *L. pondi* derives from *L. nodosa*, from which it differs in larger, more robust, more closely coiled and more convex tests. Its whorls are lower, sutures more rectilinear, apertural face small and umbonal area larger.

Specimens of *L. pondi*, corresponding to the form *multinodosa*, are similar to those of Chapman (1896), described from the Albian of Folkstone, England as *Cristellaria secans* Reuss var. *angulosa* Chapman.

Occurrence. — This, fairly rare Upper Cretaceous species, is known from Europe, (the Netherlands, Germany, Poland, Czechoslovakia) and America. According to Stančeva (1959), it also occurs in the Barremian and Aptian of Bulgaria. In the material under study, it occurs in the Cretaceous section on the Vistula River from the Turonian to the Maastrichtian. The holotype comes from the Upper Cretaceous of America (the State of Tennessee).

Lenticulina semilovortex Hanzliková, 1969
(Pl. XIV, Figs 6, 7)

1941. *Lenticulina pseudovortex* Marie; Marie, p. 103, Pl. 10, Fig. 109.
1972. *Lenticulina semilovortex* Hanzliková; Hanzliková, p. 68, Pl. 16, Fig. 11 (here older synonymy).

Material. — Ninety mostly well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	0.32	0.27	0.16
common	9	0.81	0.73	0.40
maximum [7]	11	1.60	1.45	0.78

Remarks. — In addition to forms, corresponding to the holotype, the Polish material contains tests having a narrow, transparent keel.

A Tertiary species, called *L. vortex* (Fichtel & Moll), which differs in deflected sutures, strongly extended posteriorly and in narrower chambers, is most closely related to *L. semilovortex*.

Occurrence. — This is an Upper Cretaceous species with a European range, including Belgium, the Netherlands, Germany, Poland and Czechoslovakia. In the material under study, fairly frequent in the profile of the Cretaceous of the Vistula Region from the Emscherian to Maastrichtian. The holotype comes from the Upper Cretaceous of France.

Lenticulina cf. *adelinensis* (Keijzer, 1945)
(Pl. XVI, Figs 1, 2)

?1945. *Robulus adelinensis* Keijzer; Keijzer, p. 252, Pl. 16, Fig. 9 (*fide* Cat. of Foram. Ellis & Messina).
?1945. *Robulus adelinensis* Keijzer var. *nipeensis* Keijzer; Keijzer, p. 194, Pl. 2, Figs 23, 24 (*fide* Cat. of Foram. Ellis & Messina).

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[7] Tests of *L. semilovortex* very rarely exceed 1.20 mm in diameter.

Material. — Thirty variously preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	6	0.87	0.71	0.49
common	7	1.45	1.32	0.77
maximum	7	2.10	1.80	1.00

Description. — Tests planispiral, involute, fairly strongly biconvex, with a slightly undulate outline, the valleys occur at contacts of sutures and periphery and crests — in intersutural spaces. Periphery provided with a keel, which is either sharp and thin, or heavy and rounded. Six to eight or, rarely, nine large chambers occur in outer whorl. Sutures arcuate, wound up on umbonal disc, flat of slightly depressed, extended fanwise at the ends. Older sutures slightly raised near umbonal disc. Umbonal disc slightly marked, or with a distinct, flat umbilical button. Apertural face limited laterally by well developed margins. A pointed apertural chamberlet or a large, radiate apertural opening with a distinct "*Robulus*" slit occur at the end of the final chamber in the extension of the descending outline of the test. The slit is sometimes bordered by a lip.

Equatorial section. The grown-up individuals have about twelve inner chambers, which form more than 1.5 inner whorls. Proloculus large, round, about 0.19 mm in diameter.

Remarks. — The tests under study do not correspond to any of the European species. They have many characters in common with *L. adelinensis* from the Tertiary of Cuba, from which they differ in a larger number of chambers in outer whorl and a smaller degree of the vaulting of lateral walls. A similar specimen is also illustrated, but, unfortunately, not described, by Hanzliková (1972) from the Upper Cretaceous of Czechoslovakia as *L. inhabilis* (Israelsky).

On the territory of Europe, Stančeva (1959) cites *L. adelinensis* (Keijzer) var. *nipeensis* (Keijzer) from the Eocene of Bulgaria. *L. melvilli* (Cushman & Renz) and *L. americana* (Cushman), described from the Tertiary of North America, are closely related to *L. adelinensis*.

Occurrence. — A rather infrequent species. Maastrichtian of the Vistula Region.

Lenticulina umbonata (Reuss, 1851)
(Pl. XIV, Figs 1—3)

1851. *Robulina umbonata* Reuss; Reuss, p. 68, Pl. 4, Fig. 24 (*fide* Cat. of Foram. Ellis & Messina).

?1865. *Cristellaria (Cristellaria) duracina* Stache; Stache, p. 237, Pl. 23, Fig. 16 (*fide* Cat. of Foram. Ellis & Messina).

Material. — Thirty on the whole well preserved tests.

Dimensions:	Nch	L (mm)	B (mm)	T (mm)
Specimens:				
minimum	7	0.32	0.29	0.19
common	7	0.44	0.40	0.24
maximum	8	0.58	0.52	0.27

Description. — *Equatorial section.* Grown-up individuals reaching up to three whorls and twenty chambers. Due to low whorls and fairly widely spaced, oblique inter-chamber septa, chambers are low and wide. Proloculus small, circular, about 0.04 mm in diameter.

Remarks. — Among the Upper Cretaceous *Lenticulina* species, which are on the whole large, these small tests with a large umbonal disc and low whorls are easily distinguishable. Compared with the holotype, they have one to two chambers more in outer whorl. Older sutures are sometimes slightly elevated above the surface of test. More strongly convex specimens are usually devoid of keel.

L. umbonata displays a considerable similarity to *L. duracina* (Stache). Maybe, they are conspecific and the differences in the convexity and diameter of test express individual variability.

Occurrence. — In the Cretaceous section on the Vistula River, beginning with the Emscherian, first as single specimens and more frequent in the Maastrichtian. The holotype comes from the Eocene of the environs of Berlin.

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BRONISŁAWA JENDRYKA-FUGLEWICZ

EWOLUCJA GŁADKOŚCIENNYCH LENTIKULIN (FORAMINIFERIDA) W JURZE I KREDZIE POLSKI

Streszczenie

Przeprowadzono szczegółową analizę zespołów gładkościennych lentikulin jurajskich i kredowych w oparciu o materiały z 20 wierceń na Niżu Polskim i z odsłonięć górnej kredy nadwiślańskiej (Tekst-fig. 1). Opisano 31 gatunków stosując dla gatunków polimorficznych analizę morfotypową (cf. Sylvester-Bradley, 1958). Dla długowiecznego gatunku *L. muensteri* (Roemer) wyróżniono 8 morfotypów, dla *L. uhligi* (Wiśniowski) dwa morfotypy i dwa morfotypy dla *L. nodosa* (Reuss). Dzięki zastosowaniu prostych metod statystycznych i badaniom mikrostrukturalnym wyodrębniono od siebie i ustalono zasięg stratygraficzny następujących, do tej pory mieszanych ze sobą gatunków: *L. gottingensis* (Bornemann), *L. muensteri* (Roemer) i *L. rotulata* Lamarck.

Zestawienie opracowanych gatunków w profilu pokazuje wyraźnie zmiany składu zespołów w zależności od epok geologicznych. Dzięki procesom mikroewolucji gładkościenne lentikuliny mogą być wykorzystane również dla stratygrafii.

Badania szlifów cienkich potwierdziły występowanie u lentikulin trzech głównych typów mikrostruktury ścianki: niewarstwowego, dachówkowego i wielowarstwowego. Zdecydowanie dominującym jest typ dachówkowy. Częstsze występowanie typu niewarstwowanego w zespołach geologicznie starszych, a typu wielowarstwowego w zespołach młodszych przemawia za występowaniem tendencji do wzmocnienia skorupki przez powlekanie warstewką kalcytową całej starszej części skorupki podczas narastania kolejnych komór. Zjawisko to nie ma ogólniejszego charakteru, gdyż u gatunków *Lenticulina*, pojawiających się po raz pierwszy w kredzie górnej liczne odznaczają się niewielkim stopniem dachówkowego nawarstwiania. Ścianka tych lentikulin jest cienka, a odporność na zniszczenie zapewnia skorupce większa ilość niskich, ciasno skręconych zwojów. Mikrostruktura ścianki wespół z elementami budowy wewnętrznej danego gatunku, obserwowanymi w szlifie, stanowi użyteczną cechę dla identyfikacji gatunków.

W oparciu o wyniki badań morfologicznych, mikrostrukturalnych i statystycznych wykonano charakterystykę różnowiekowych populacji lentikulin, w powiązaniu z charakterem facjalnych osadów, oraz analizę zachowania się w czasie geologicznym poszczególnych cech. Stwierdzono, że rozwój filogenetyczny tych otwornic nie przebiega wg jednego schematu. Ogólnie biorąc, ewolucja lentikulin szła w kierunku zmniejszania się liczby komór w zwoju zewnętrznym przy zwiększaniu rozmiarów ogólnych. Zakres zmienności populacji zawężał się. W młodszych geologicznie zespołach pojawiają się formy o wielkich dyskach pępkowych, o silnym wygięciu szwów do tyłu, o bardzo niskich zwojach i z intensywnie wykształconą szczeliną „robulusową". Zmniejszanie się liczby komór w zwoju zewnętrznym postępowało

niezależnymi drogami: 1. przez zmniejszanie się w czasie geologicznym liczby komór w skorupce; 2. przez zmniejszanie się liczby komór w zwoju zewnętrznym przy zwiększaniu się sumarycznej liczby komór, zwiększaniu się długości spirali i ilości skrętów.

Wyróżniono 3 fazy rozwojowe lentikulin, które obejmują następujące odcinki czasu: lias, dogger-kredę dolną i kredę górną. W liasie polskim lentikuliny są mało urozmaicone gatunkowo i nieliczne. Gatunkiem dominującym jest *L. gottingensis* (Bornemann). Okres dogger-kreda dolna charakteryzuje się wielkim rozkwitem lentikulin. Zespoły składają się z dużej liczby gatunków i osobników, z dużym udziałem długowiecznego gatunku *L. muensteri* (Roemer). Powyżej w profilu silnie zaznacza się tendencja do zwiększania skorupek, co nadaje zespołom górnokredowych lentikulin odrębność. Gatunkiem dominującym jest *L. rotulata* Lamarck. Liczne gatunki górnokredowe mają rozprzestrzenienie kosmopolityczne. Powiązanie mikrofauny górnokredowej z trzeciorzędową jest wyraźniejsze aniżeli górnokredowej z dolnokredową. Od kredy górnej maleje udział lentikulin, gdyż są one permanentnie wypierane przez coraz bujniej rozwijające się gatunki trochospiralne.

БРОНИСЛАВА ЕНДРЫКА-ФУГЛЕВИЧ

ЭВОЛЮЦИЯ ГЛАДКОСТЕННЫХ ЛЕНТИКУЛИН (FORAMINIFERIDA) ИЗ ЮРЫ И МЕЛА ПОЛЬШИ

Резюме

Проведено детальное изучение гладкостенных юрских и меловых лентикулин по материалам из 20 буровых скважин, пройденных на площади Польской низменности, и обнажений верхнего мела вдоль р. Вислы. Описание охватывает 31 видов. К полиморфным видам применялся морфотипный анализ (cf Sylvester-Bradley, 1958). Определено восемь морфотипов долгоживущего вида *L. muensteri* (Roemer) и по два морфотипа видов *L. uhligi* (Wiśniowski) и *L. nodosa* (Reuss). Благодаря применению простых статистических методов и микроструктурных анализов удалось разделить смешиваемые до сих пор виды *L. gottingensis* (Bornemann), *L. muensteri* (Roemer) и *L. rotulata* Lamarck, а также определить интервалы их стратиграфического распространения.

Распределение изученных видов в разрезе показывает изменение состава сообществ по геологическим эпохам. Благодаря признакам микроэволюции гладкостенные лентикулины могут использоваться и в стратиграфии.

Наблюдения шлифов подтвердили наличие у лентикулин трех основных типов микроструктуры стенок: неслоистого, черепитчатого и многослойного. Решительно преобладает черепитчатый тип стенки. Неслоистый тип чаще наблюдается в геологически более древних сообществах, а многослойный — в младших, что является признаком укрепления раковины, совершающегося путем покрытия кальцитовой оболочкой старшей части раковины при наращивании последовательных камер. Это явление не имеет общего характера, так как многие виды *Lenticulina*, появляющиеся впервые в верхнемеловых отложениях, лишь в небольшой степени проявляют черепитчатое наслоение. Эти лентикулины обладают тонкой стенкой, а их прочность достигается благодаря наличию большого числа низких, туго свернутых оборотов. Микроструктура стенки и элементы внутреннего строения данного вида, которые можно наблюдать в шлифе, составляют надежные признаки определения видов.

На основании морфологических, микроструктурных и статистических анализов составлена характеристика разновозрастных совокупностей лентикулин в увязке с фациальным составом осадков, а также изучена эволюция отдельных признаков во времени. Констатировано, что филогенетическое развитие этих фораминифер не подчинялось единой схеме. В общих чертах, эволюция лентикулин шла в направлении сокращения количества камер внешнего оборота с одновременным увеличением общих размеров. Интервал варьирования совокупностей сокращался. В геологически младших сообществах представлены формы с крупными пупочными дисками, со швами, сильно вытянутыми назад, с очень низкими оборотами и сильно развитой „робулюсовой" щелью. Сокращение количества камер происходило по-разному: 1) путем уменьшения количества камер в раковине в течение определенного геологического времени, 2) путем уменьшения количества камер во внешнем обороте при увеличении общего количества камер, увеличении длины спирали и количества оборотов.

Выявлены три фазы развития лентикулин, соответствующие следующим интервалам времени: лейас, доггер — нижний мел, верхний мел. В лейасе Польши лентикулины немногочисленны и мало дифференцированы в видовом отношении. Преобладает вид *L. gottingensis* (Bornemann). Интервал доггер — нижний мел характеризуется обильным расцветом лентикулин. Сообщества включают большое число видов и особей, в большом количестве представлен долгоживущий вид *L. muensteri* (Roemer). Выше по разрезу постепенно появляются сообщества лентикулин с крупными раковинами, что составляет отличительный признак верхнемеловых сообществ. Здесь преобладает вид *L. rotulata* Lamarck. Многие верхнемеловые виды характеризуются космополитическим распространением. Верхнемеловая микрофауна проявляет большее сходство с третичной микрофауной чем с нижнемеловой. С верхнего мела отмечается сокращение количества лентикулин, так как они последовательно замещаются все более обильно появляющимися трохоспиральными видами.

EXPLANATION OF PLATES

Plate I

Individual variability in *Lenticulina gottingensis* (Bornemann).
All specimens from one and the same sample.
Pliensbachian, Gołańcz boring, 274.0 m. x 40.(F. XVII/1—7).
a — side view, *b* — apertural face view, *c* — equatorial section view.

Fig. 1. A specimen with six chambers in outher whorl.
Figs. 2, 4. Specimens with eigth chambers in outer whorl.
Figs. 3, 5, 6. Specimens with nine chambers in outer whorl.
Fig. 7. Specimen with ten chambers in outer whorl.

Plate II

a — side view, *b* — apertural face view, *c* — equatorial section view. All Figs. ×40.

Fig. 1. *Lenticulina varians* (Bornemann). Pliensbachian, Mechowo boring 650.0 m. (F. XVII/14).
Fig. 2. *Lenticulina varians* (Bornemann). A specimen from the comparative material. Upper Pliensbachian, *Amaltheus margaritatus* Zone. Sample no. 14, England. (F. XVII/15).
Fig. 3. *Lenticulina gottingensis* (Bornemann). A specimen with characters transitional to *L. acutiangulata* (Terquem). Pliensbachian, Gołańcz boring, 274.0 m. (F. XVII/8).
Fig. 4. *Lenticulina acutiangulata* (Terquem). A specimen from the comparative material. Lower Pliensbachian, Lauereiche, South Germany. (F. XVII/11).
Figs. 5, 6. *Lenticulina acutiangulata* (Terquem). Equatorial sections of megalo- and microspheric specimens. Pliensbachian, Radowo Małe III boring, 172.7 m. (F. XVII/9, 10).
Fig. 7. *Lenticulina polygonata* (Franke). Pliensbachian, Przytoń boring 254.0 m. (F. XVII/12).
Fig. 8. *Lenticulina polygonata* (Franke). Pliensbachian, Mechowo boring 650.0 m. (F. XVII/13).

Plate III

Except for Figs 3 and 4 all specimens in the Plate from the Middle Kuiavian (Middle Vesulian) of the Turów boring, 417,4 m. Those in Figs 3 and 4 from the Callovian of Łuków. a — side view, b — apertural face view. ×60.

Figs. 1—4. *Lenticulina involvens* (Wiśniowski). (F. XVII/16—19).
Figs 5—8. *Lenticulina biexcavata* (Mjatliuk). (F. XVII/20—23).
Figs 9, 10 *Lenticulina primarea* Blank. (F. XVII/24, 25).
Figs 11, 12. *Lenticulina oolithica* (Terquem). (F. XVII/26, 27).

Plate IV

a — side view, *b* — apertural face view.
All figures ×50 except for Fig. 6, ×60.

Figs 1—5. *Lenticulina ruesti* (Wiśniowski). Fig. 5 — natural fracture. A multillamellar spiral suture is visible. Bathonian, Turów boring, 352,7 m. (F. XVII/28—32).

Fig. 6. *Lenticulina hebetata* (Schwager). Middle Kuiavian (Middle Vesulian), Turów boring, 417,4 m.

Plate V

All specimens in the Plate from the Middle Kuiavian (Middle Vesulian) of the Turów boring, 418,6 m. *a* — side view, *b* — apertural face view. ×60.

Figs 1, 2. *Lenticulina hebetata* (Schwager). Fig. 1 — specimen without keel; Fig. 2. — specimen with keel. (F. XVII/33, 34).

Figs 3—10. Individual variability in *Lenticulina inflata* (Wiśniowski). (F. XVII/35—42).

Plate VI

All specimens from the Middle Kuiavian (Middle Vesulian) of the Turów boring, 417,4 m. *a* — side view, *b* — apertural face view. ×60.

Figs 1—10. *Lenticulina uhligi* (Wiśniowski) morphotype *jurensis*. Specimens in various development stages and with a varying number of chambers in outer whorl. (F. XVII/43—52).

Figs 11, 12. *L. uhligi* (Wiśniowski). Specimens with characters transitional to *Lenticulina uhligi* (Wiśniowski) morphotype *uhligi*. (F. XVII/53, 54).

Plate VII

All specimens from the Middle Kuiavian (Middle Vesulian) of the Turów boring, 417,4 m. *a* — side view, *b* — apertural face view. ×60.

Figs 1—7. *Lenticulina uhligi* (Wiśniowski) morphotype *uhligi*. Specimens in various development stages and with a varying number of chambers in outer whorl. Move robust character of the tests is visible than in *Lenticulina uhligi* morphotype *jurensis*. Fig. 5. — natural fracture. (F. XVII/55—61).

Fig. 8. *Lenticulina constricta* (Kaptarenko). (F. XVII/62).

Figs 9, 10. *Lenticulina* sp. 1. (F. XVII/63, 64).

Plate VIII

Except for Fig. 12 all specimens in the Plate from the Middle Kuiavian (Middle Vesulian) of the Turów boring, 417.4 m. Those in Fig. 12 from the Infravalanginian of the Kcynia II boring, 262.7 m. *a* — side view, *b* — apertural face view. ×60.

Figs 1—4. *Lenticulina muensteri* morphotype *wiśniowskii*. (F. XVII/65—68).

Figs 5—8. *Lenticulina muensteri* morphotype *gibba*. (F. XVII/69—72).

Figs 9—11. *Lenticulina muensteri* morphotype *integra*. (F. XVII/73—75).

Figs 12—15. *Lenticulina muensteri* morphotype *tumida*. (F. XVII/76—79).

Plate IX

a — side view, *b* — apertural face view. All Figs ×60.

Figs 1, 2. *Lenticulina muensteri* morphotype *tumida*. Callovian of Łuków. (F. XVII/80, 81).
Figs 3—8. *Lenticulina muensteri* morphotype *russiensis*. Middle Kuiavian (Middle Vesulian) of the Turów boring, 417,4 m. (F. XVII/82—87).
Figs 9, 10. *Lenticulina muensteri* morphotype? *russiensis*. Infravalanginian of the Kcynia II boring, 262,7 m. (F. XVII/88, 89).

Plate X

Lenticulina muensteri (Roemer) morphotype *muensteri*. Specimens with a varying number of chambers in outer whorl. a — side view, b — apertural view. All Figs ×60.

Figs 1—5. Middle Kuiavian (Middle Vesulian) of the Turów boring, 417,4 m. (F. XVII/100—104).
Figs 6—10. Infravalanginian of the Kcynia II boring, 262,7 m. (F. XVII/105—109).

Plate XI

Except for Fig. 9 all specimens in the Plate from the Infravalanginian of the Kcynia II boring, 262,7 m. Those in Fig. 9 from the Albian of France. *a* — side view, *b* — apertural face view.

Figs 1, 2. *Lenticulina muensteri* (Roemer) morphotype H. ×60 (F. XVII/110, 111).
Figs 3—6. *Lenticulina muensteri* (Roemer) morphotype *crassa*. ×60 (F. XVII/112—115).
Figs 7, 8. *Lenticulina gaultina* (Berthelin). ×50. (F. XVII/116, 117).
Fig. 9. *Lenticulina gaultina* (Berthelin). Paratype, Berthelin's collection. ×30.

Plate XII

All specimens are from the Infravalanginian, ×50. Fig. 11 ×40. *a* — side view, *b* — apertural face view.

Figs 1—3. *Lenticulina gaultina* (Berthelin). Kcynia II boring, 262,7 m. (F. XVII/118—120).
Figs 4—8, 12. *Lenticulina nodosa* (Reuss) morphotype *nodosa*. Figs 4—6 depict trimorphism. Wąwał. Figs 7, 8. Kcynia II boring, 262,7 m. F. XVII/119—124).
Figs 9—11. *Lenticulina nodosa* (Reuss) morphotype *gibber*. Various stages of uncoiling of the tests are observed. Wąwał. (F. XVII/125—127).

Plate XIII

All specimens are from the Infravalanginian, ×50. *a* — side view, *b* — apertural face view.

Figs 1—4. *Lenticulina circumcidanea* (Berthelin). Figs 1, 4 Kcynia II boring, 262,7 m. Figs 2, 3. Wąwał. (F. XVII/128—131).

Figs 5—7. *Lenticulina pulchella* (Reuss). Specimens in various development stages. Wąwał (F. XVII/132—134).

Figs 8, 9. *Lenticulina subangulata* (Reuss). Kcynia II boring, 262.7 m. (F. XVII/135, 136).

Figs 10, 11. *Lenticulina vonderschmitti* (Gandolfi). Wąwał (F. XVII/137/138). 137/138).

Figs 12—14. *Lenticulina angulosa* (Chapman). Specimens in various development stages. Kcynia boring, 262,7. (F. XVII/139—141).

Plate XIV

a — side view, *b* — peripheral face view. All Figs ×30 except for Figs 1—3 and 8, ×40.

Figs 1—3. *Lenticulina umbonata* (Reuss). Specimens in various development stages and with variably developed periphery. Maastrichtian, Kazimierz. (F. XVII/142—144).

Figs 4, 5. *Lenticulina* sp. 2. Emscherian, Wesołówka. (F. XVII/145, 146).

Figs 6, 7. *Lenticulina semilovortex* Hanzliková. Specimens with a variably developed periphery, without keel and with transparent keel. Emscherian, Wesołówka. (F. XVII/147, 148).

Figs 8, 9. *Lenticulina pondi* Cushman. Fig. 8 — specimen closely coiled involutely, Fig. 9 — uncoiling specimen. Emscherian, Wesołówka. (F. XVII/149, 150).

Fig. 10. *Lenticulina acuta* (Reuss). Santonian, Wesołówka. (F. XVII/151).

Fig. 11. *Lenticulina marcki* (Reuss). Emscherian, Wesołówka. (F. XVII/152).

Plate XV

Trimorphism in *Lenticulina rotulata Lamarck*. All specimens from Emscherian, Wesołówka, ×30; Fig. 10 ×40. *a* — side view, *b* — apertural face view; Figs 8—10 — natural fractures. (F. XVII/153—162).

Figs 1-3. Various ontogenetic stages of megalospheric specimens A_2 corresponding to *L. ovalis* (Reuss).

Figs 4-6. Specimens corresponding to *L. comptoni* (Sowerby).

Fig. 7. Specimen without umbilical button.

Fig. 8. microspheric specimen B.

Fig. 9. megalospheric specimen A_1.

Fig. 10. megalospheric specimen A_2.

Plate XVI

a — side view, *b* — apertural face view. All Figs ×30.

Figs 1, 2. *Lenticulina* cf. *adelinensis* (Keijzer). Specimens with a variable development of periphery.
Fig. 1 — periphery thinning and turning into a transparent keel.
Fig. 2 — periphery with a roller-like peripheral sheath. Maastrichtian, Kazimierz. (F. XVII/163, 164).

Figs 3—5. *Lenticulina neoorbicula* Hofker. Fig. 3 — megalospheric specimen A_2. Fig. 5 — microspheric specimen B. Emscherian, Wesołówka. (F. XVII/ 165—167).

Plate XVII

Figs 1—4. Microstructure of test wall in *Lenticulina gottingensis* (Bornemann). Figs 1, 2 — Pliensbachian, Gołańcz boring, 274 m, ×100. Fig. *3a* — specimen from the comparative material. Domerian, Dobertin, the German Democratic Republic, ×100. Fig. *3b* — part of Fig. *3a* showing an imbricate stratification of laminae. Variable thickness of the wall of proloculus visible, ×200. Fig. 4 — two laminae in the wall visible, ×175.

Fig. 5. Microstructure of test wall in *Lenticulina biexcavata* (Mjatliuk). Middle Kuiavian (Middle Vesulian), Turów boring, 417.4 m, ×120.

Plate XVIII

All specimens from Middle Kuiavian (Middle Vesulian), Turów boring, 417,0 m.

Fig. 1. *Lenticulina involvens* (Wiśniowski), ×140.

Fig. 2. *Lenticulina uhligi* (Wiśniowski) morphotype *jurensis*. Microspheric adult specimen, ×60.

Fig. 3, 4. *Lenticulina uhligi* (Wiśniowski) morphotype *uhligi*. Megalospheric specimens, ×110.

Fig. 5. *Lenticulina inflata* (Wiśniowski), ×70.

Fig. 6. *Lenticulina* oolithica (Terquem). A multilamellar wall is pierced by bundles of pores, ×120.

Plate XIX

Microstructure of test wall in *Lenticulina muensteri* (Roemer). All specimens, except those from Figs 5, 6 come from the Middle Kuiavian, Turów boring, 417.6 m. Figs 5 and 6 from the Infravalanginian, Kcynia II boring, 262.7 m.

Fig. 1. Morphotype *wiśniowskii*, ×130.

Fig. 2. Morphotype *gibba*, ×130.

Fig. 3. Morphotype *tumida*, 125.

Fig. 4. Morphotype *muensteri*, ×100.

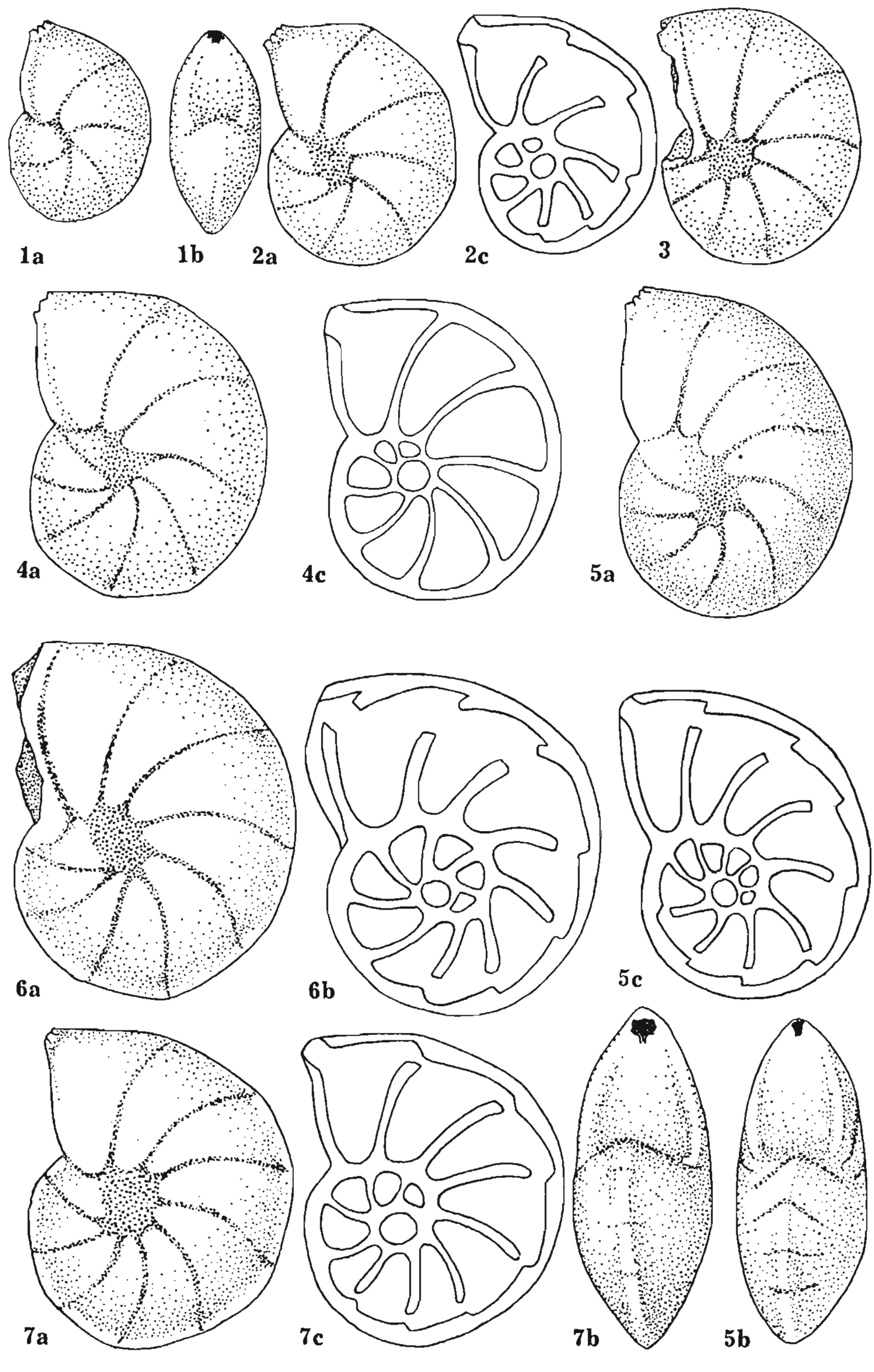
Fig. 5. Morphotype *muensteri*. Microspheric specimen, ×50.

Fig. 6. Morphotype *muensteri*. Megalospheric specimen, ×95.

Plate XX

Figs 1, 2. *Lenticulina muensteri* morphotype *crassa*. Microspheric and megalospheric specimens. Infravalanginian, Kcynia II boring, 262,7 m, ×70.

Figs 3—6. *Lenticulina rotulata* Lamarck. Santonian, Wesołówka, ×40. Fig. 3 — a specimen of megalospheric generation A_1. Fig. 4 — a specimen of megalospheric generation A_2. Fig. 5 — a specimen of microspheric generation B. Fig. 6 — longitudinal section showing a multilamellar microstructure and a system of pores.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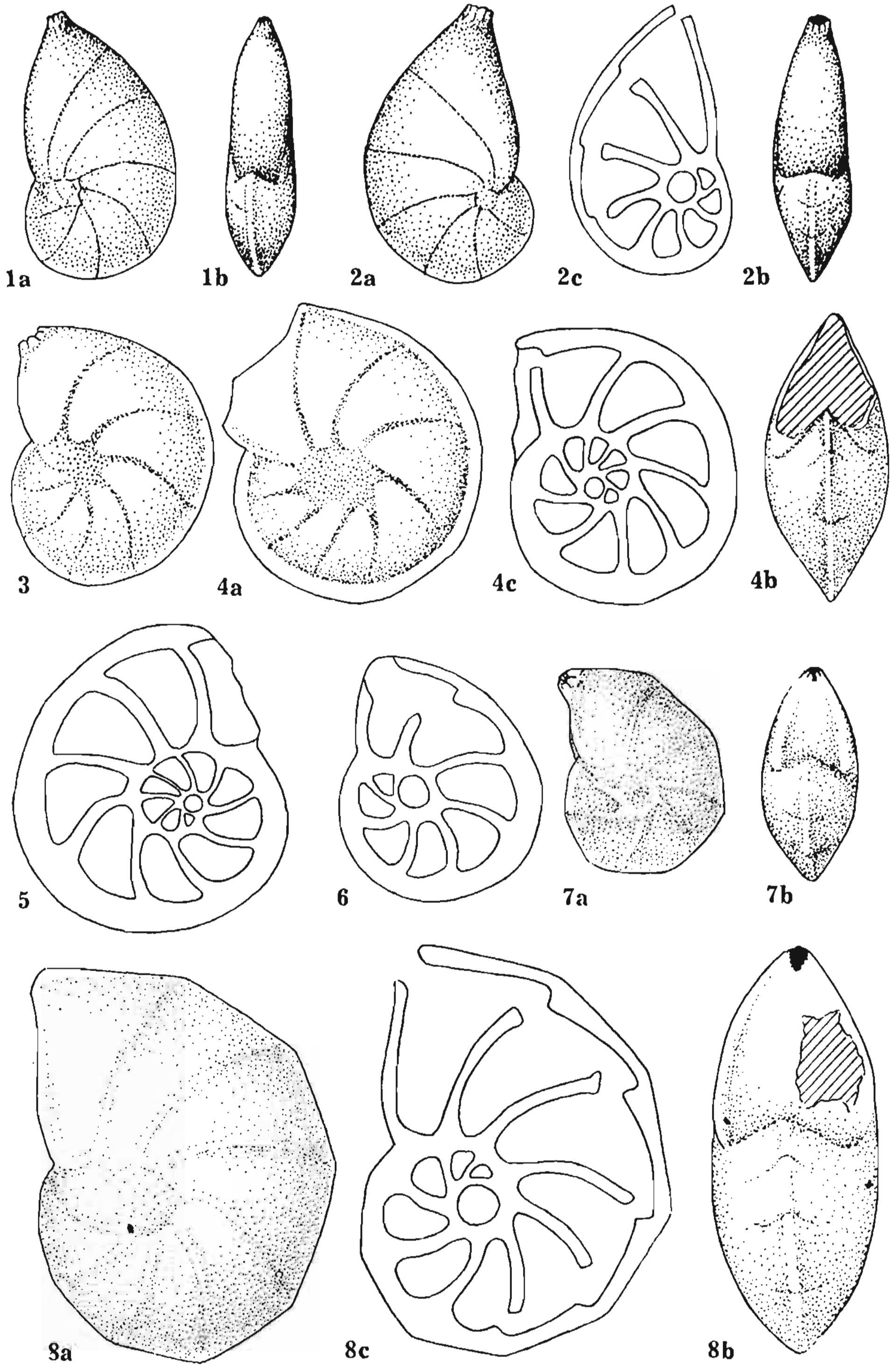
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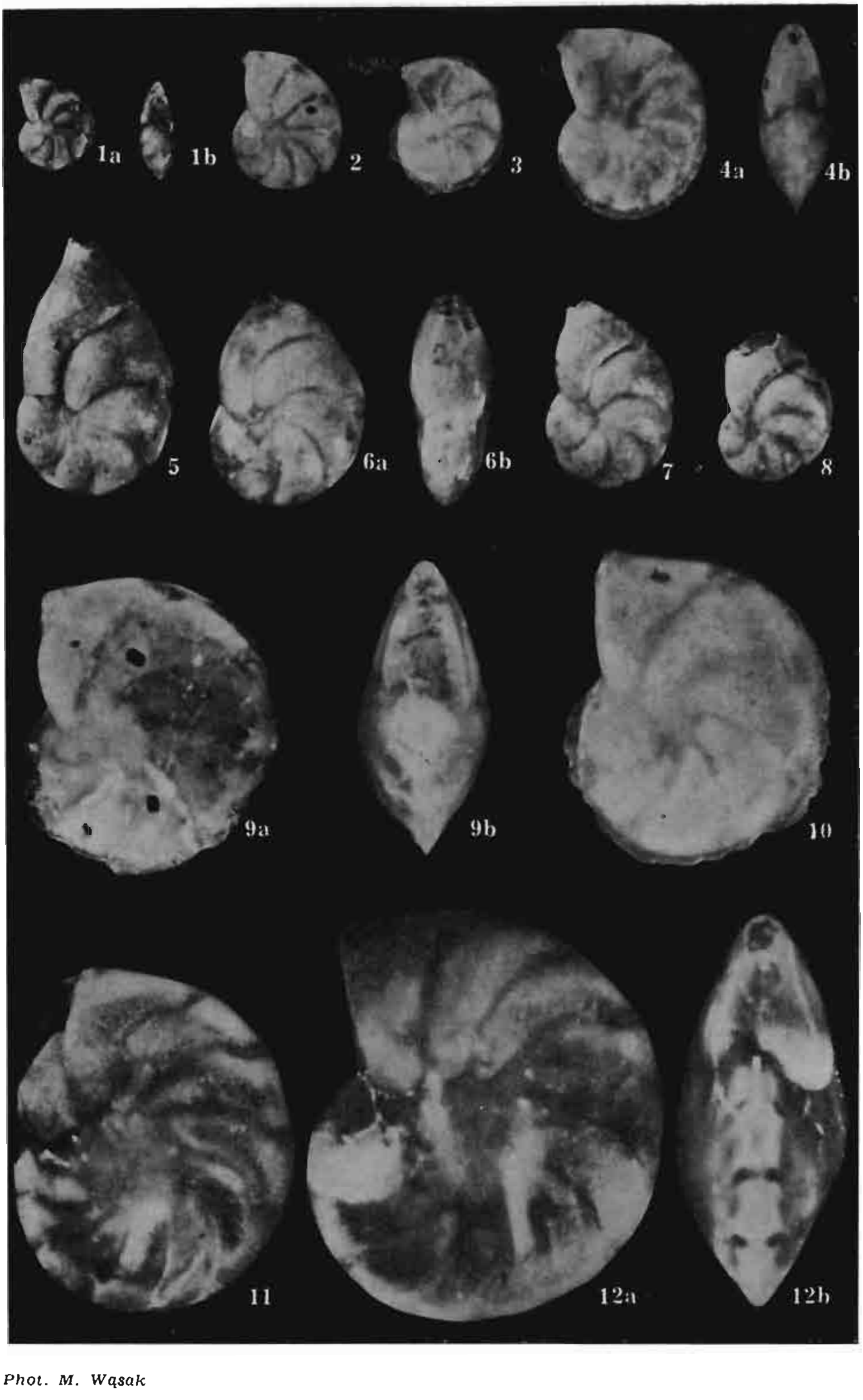
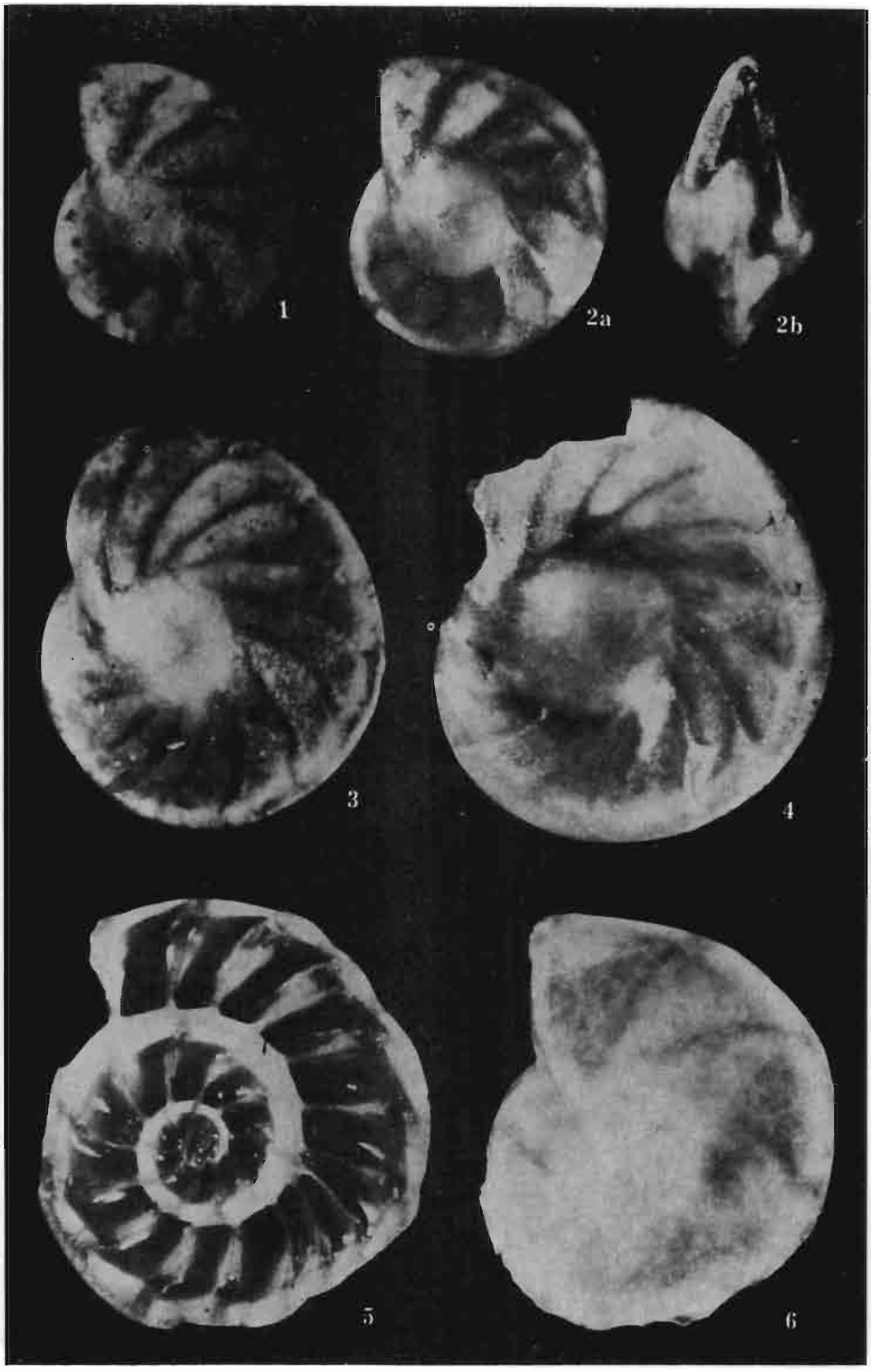


Phot. *M. Wąsak*



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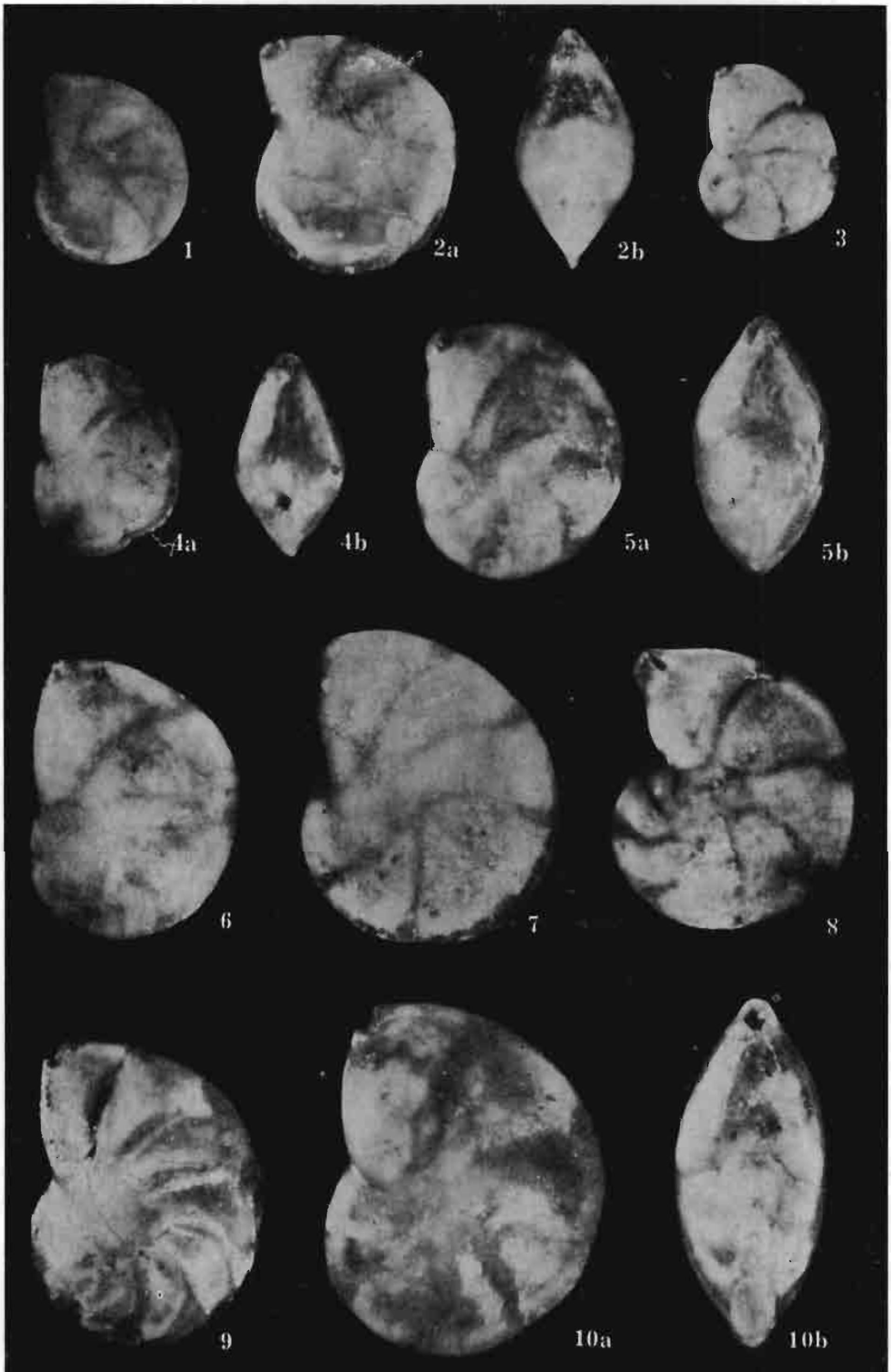

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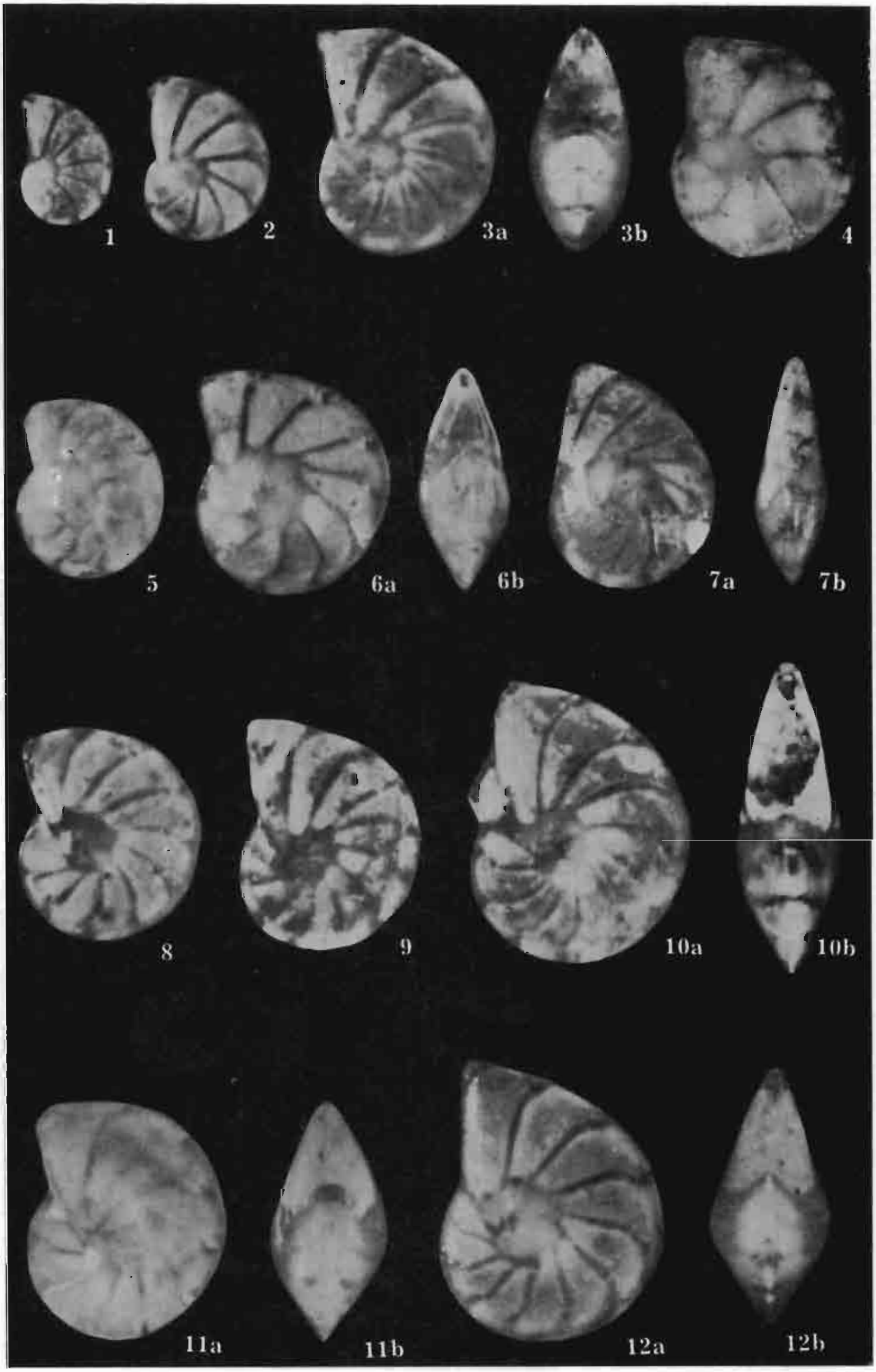

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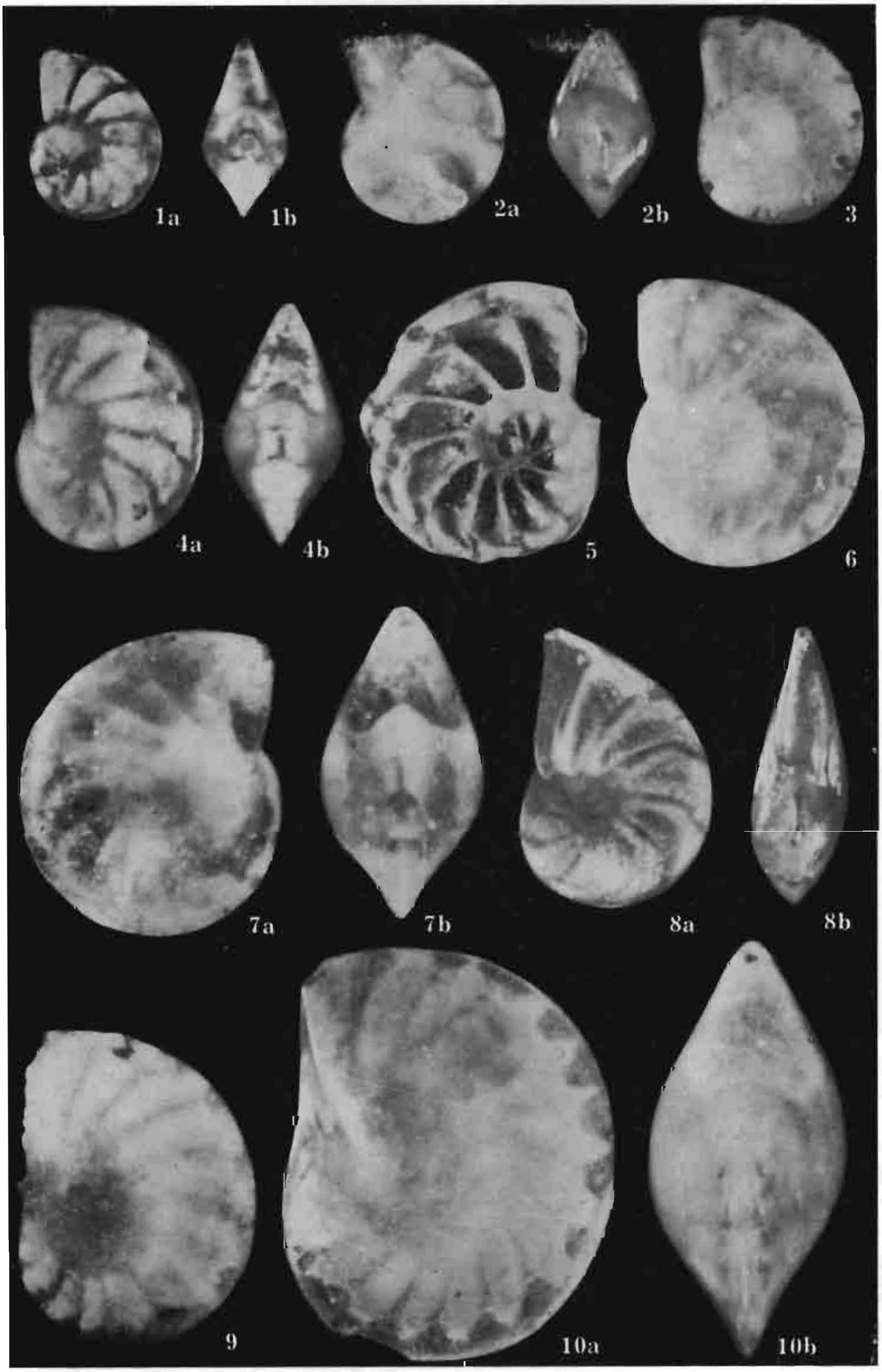

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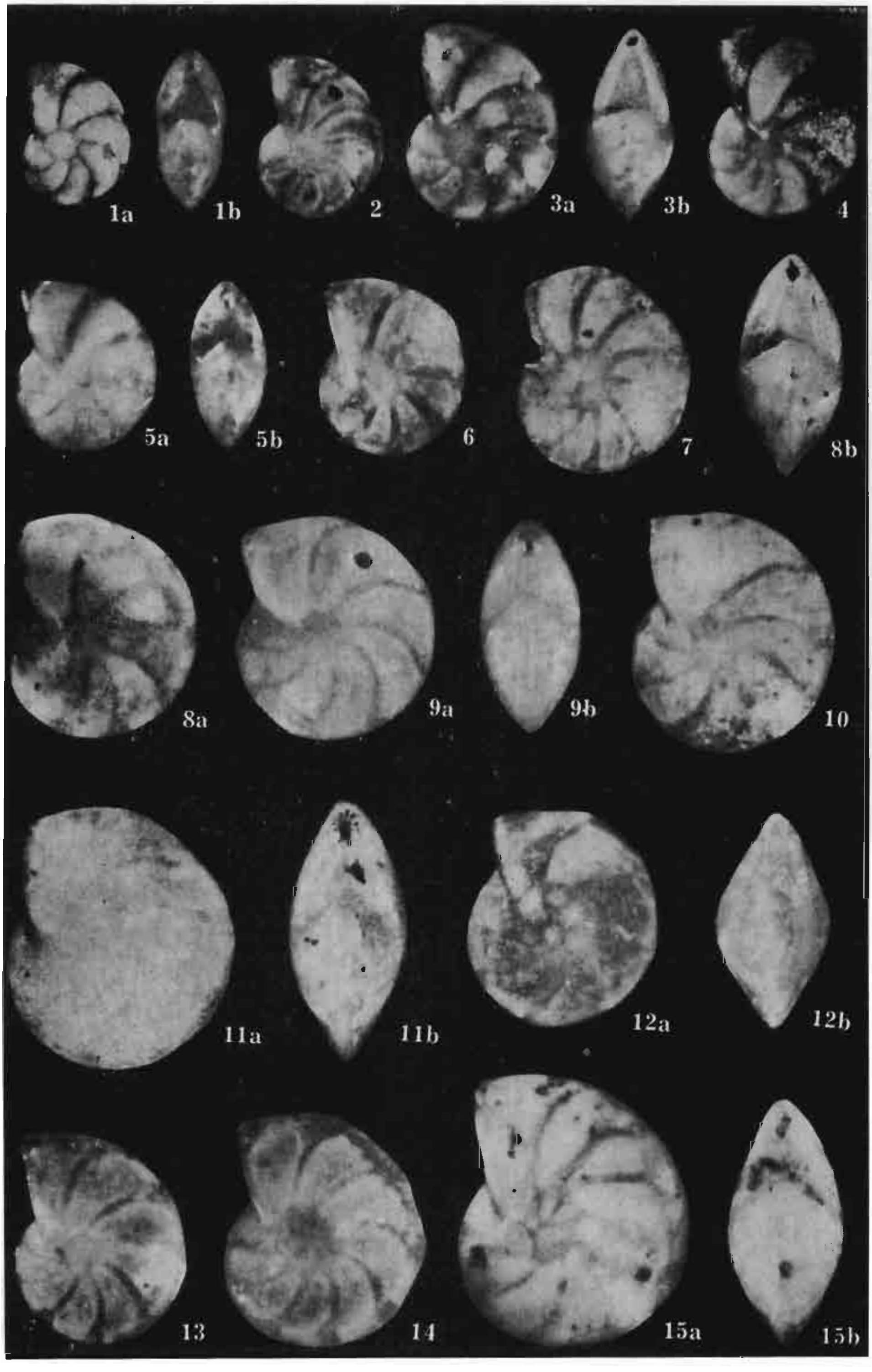

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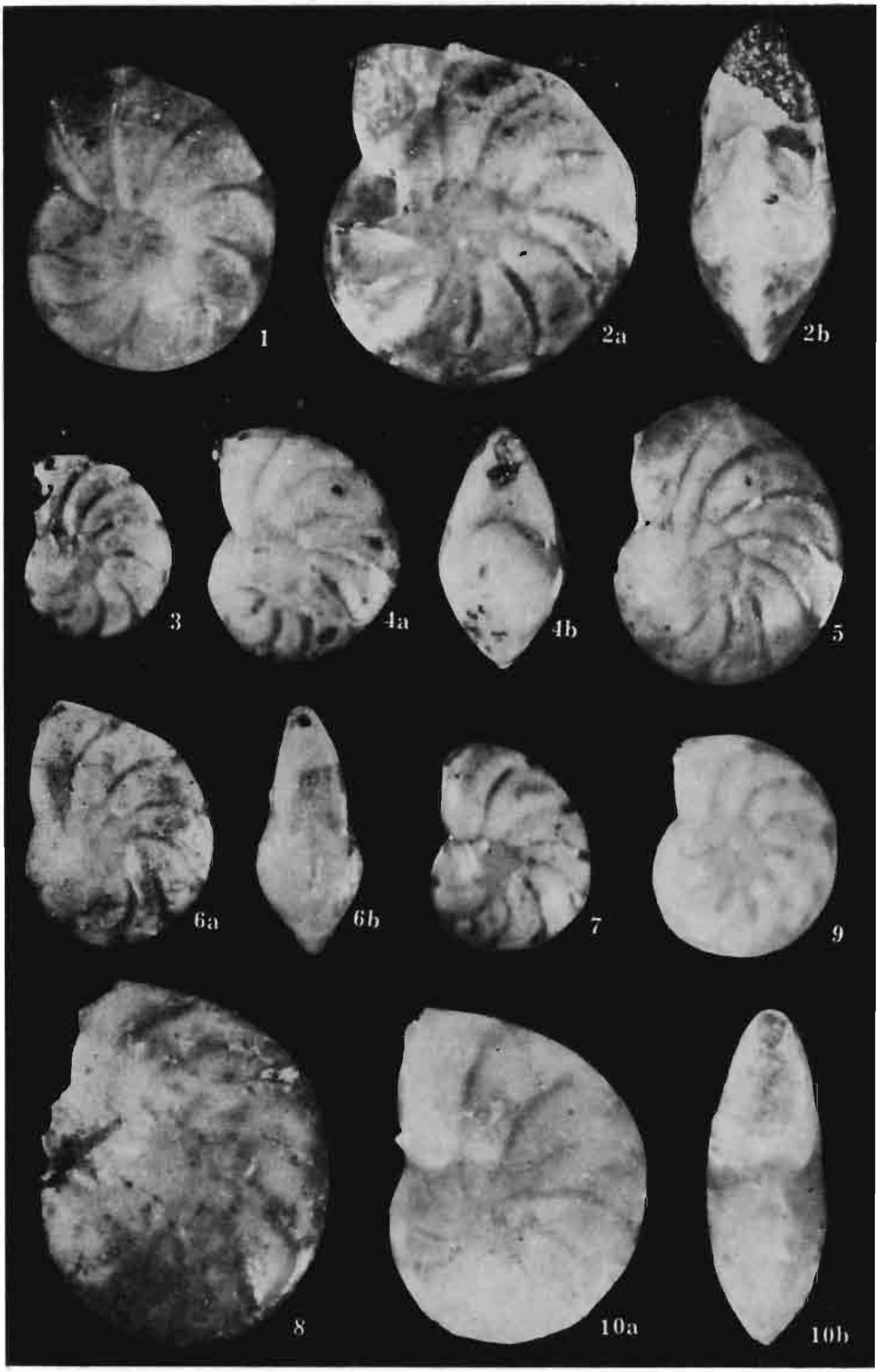

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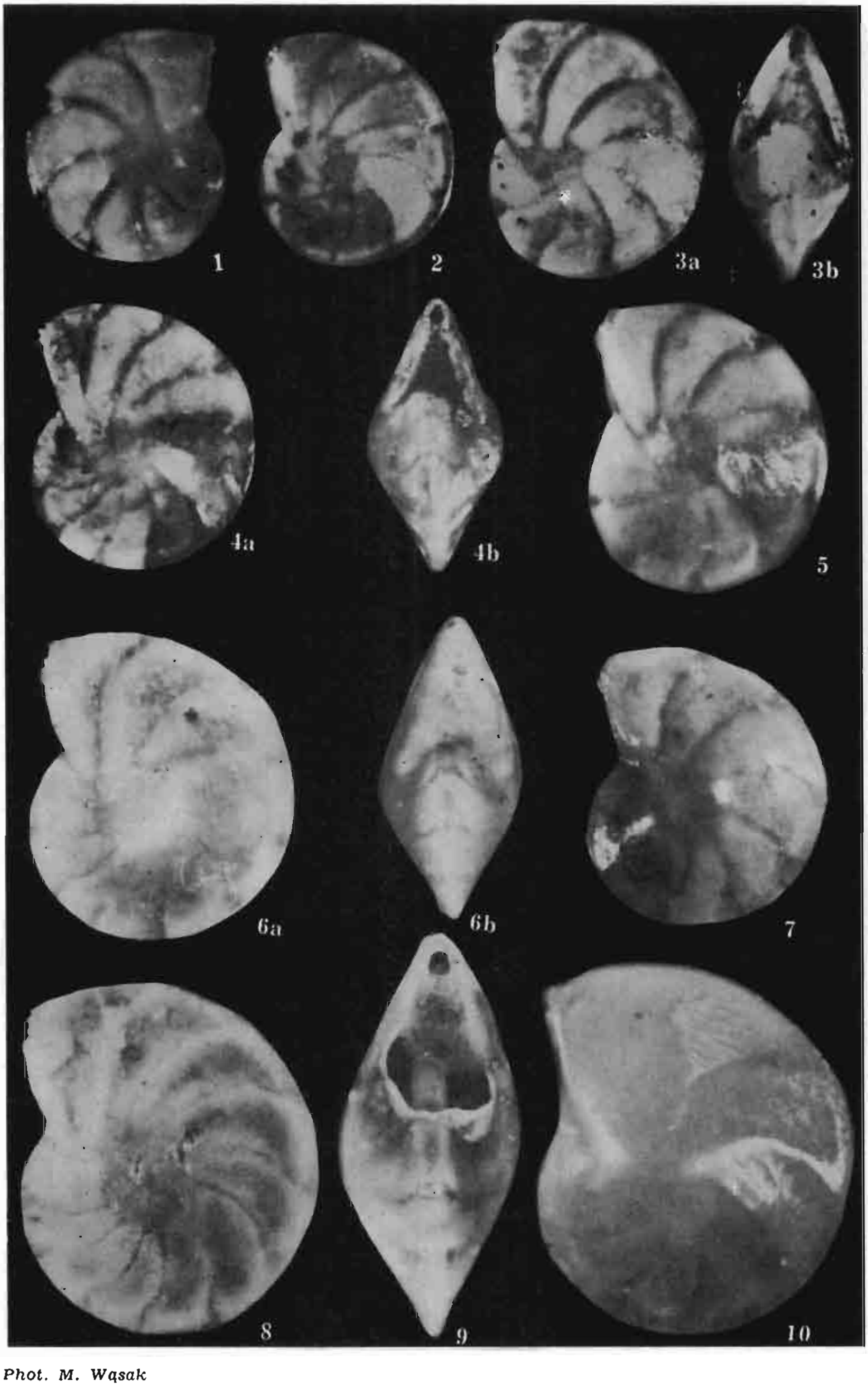

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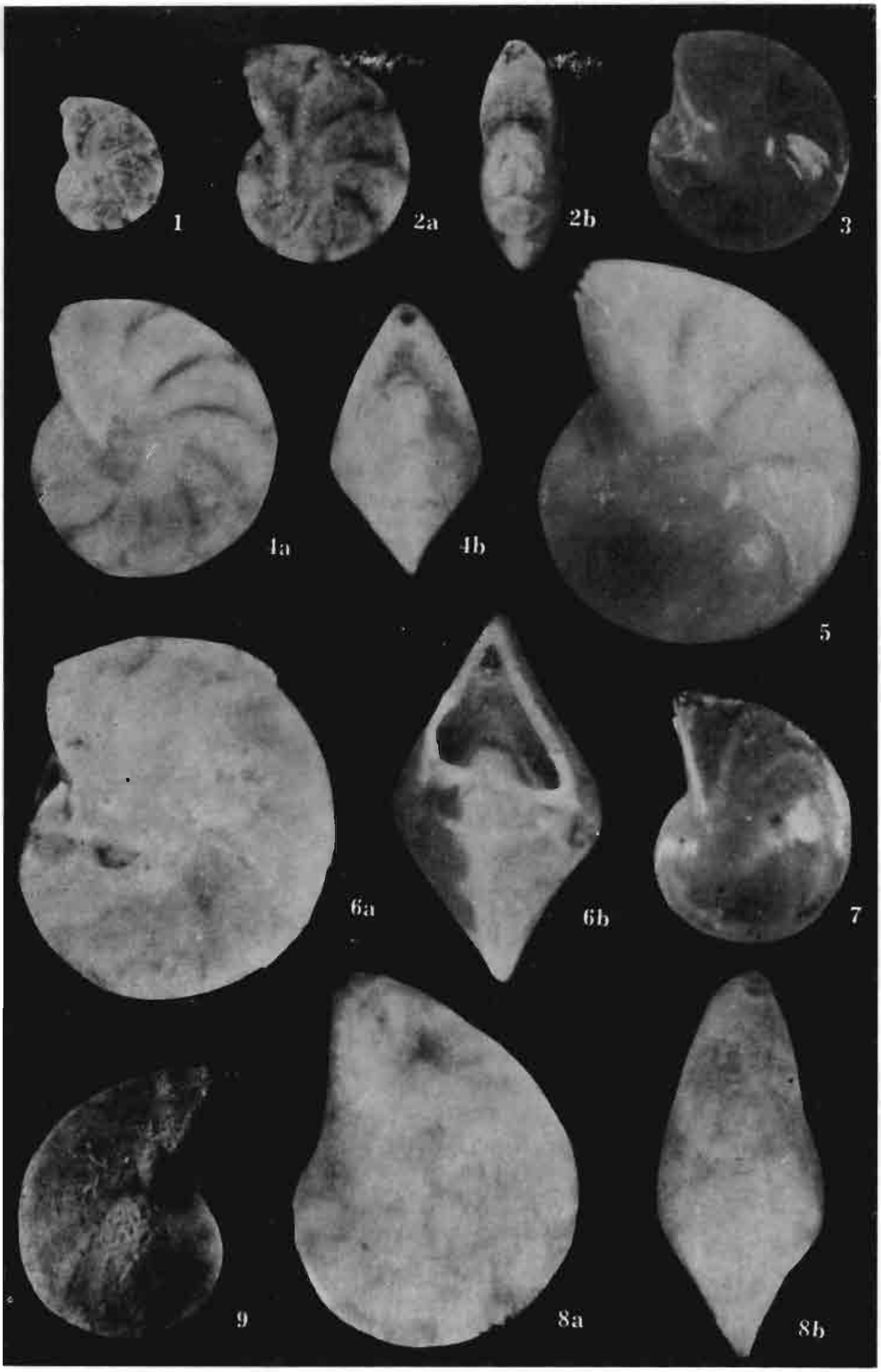

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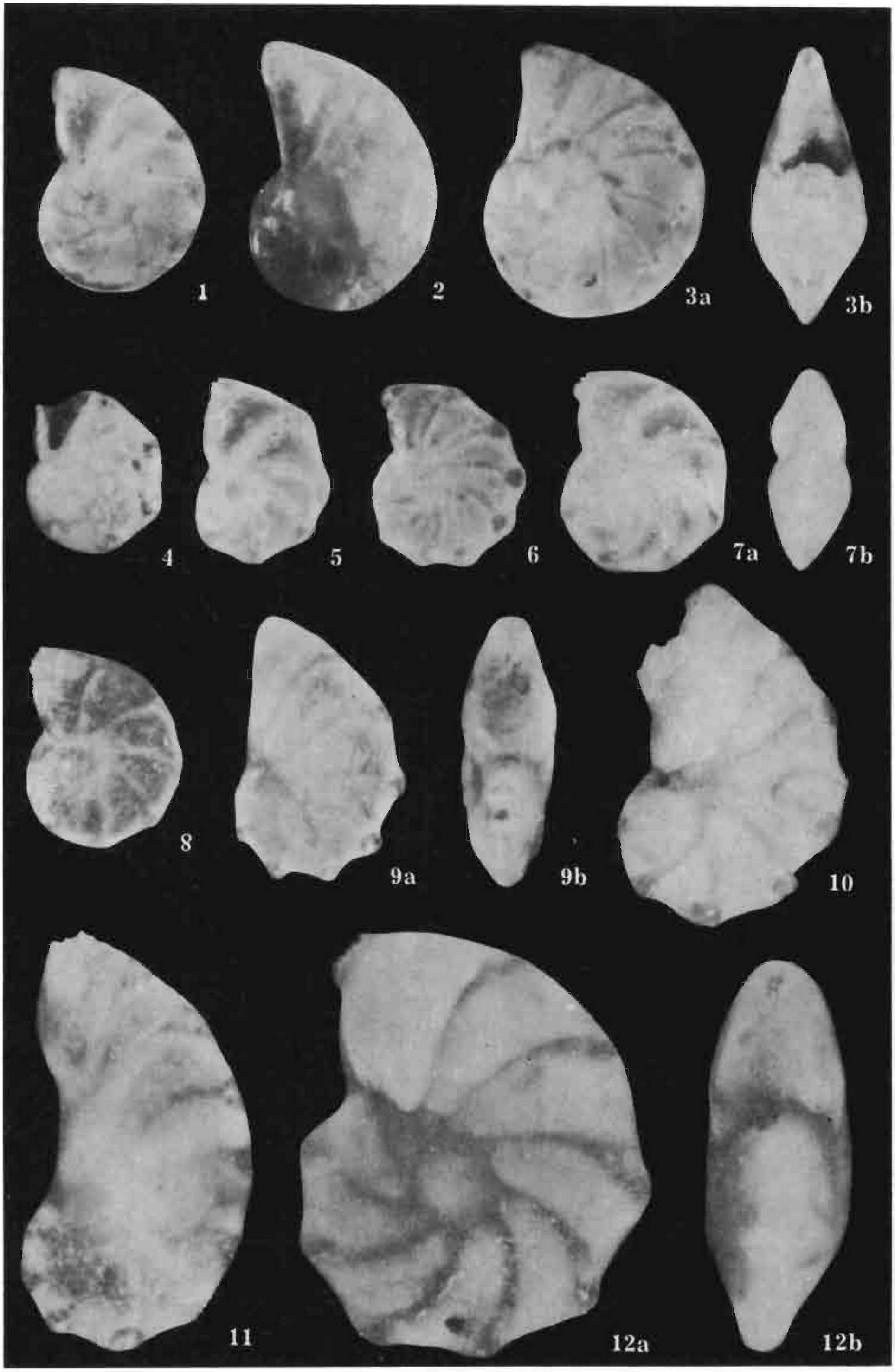

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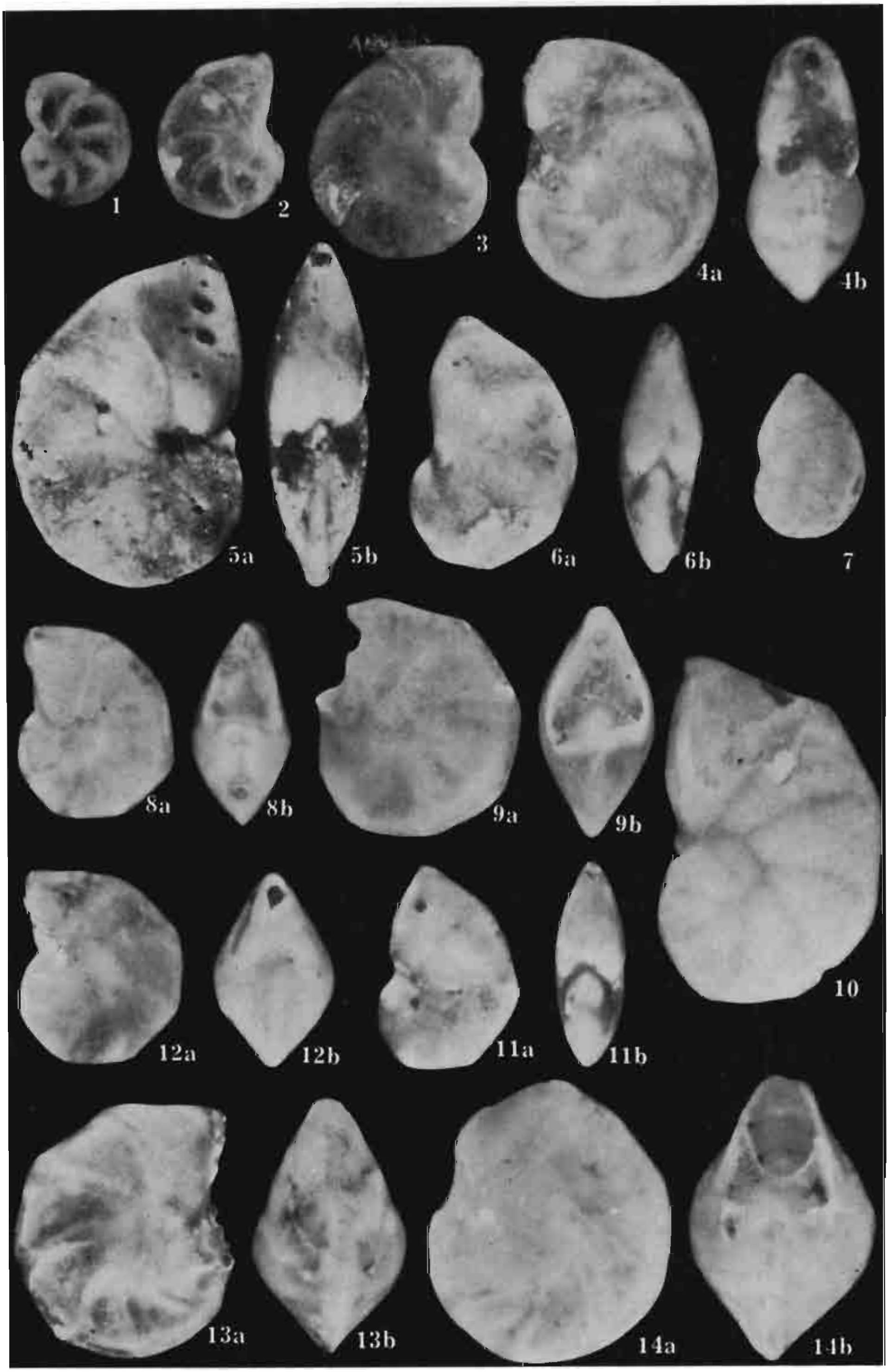
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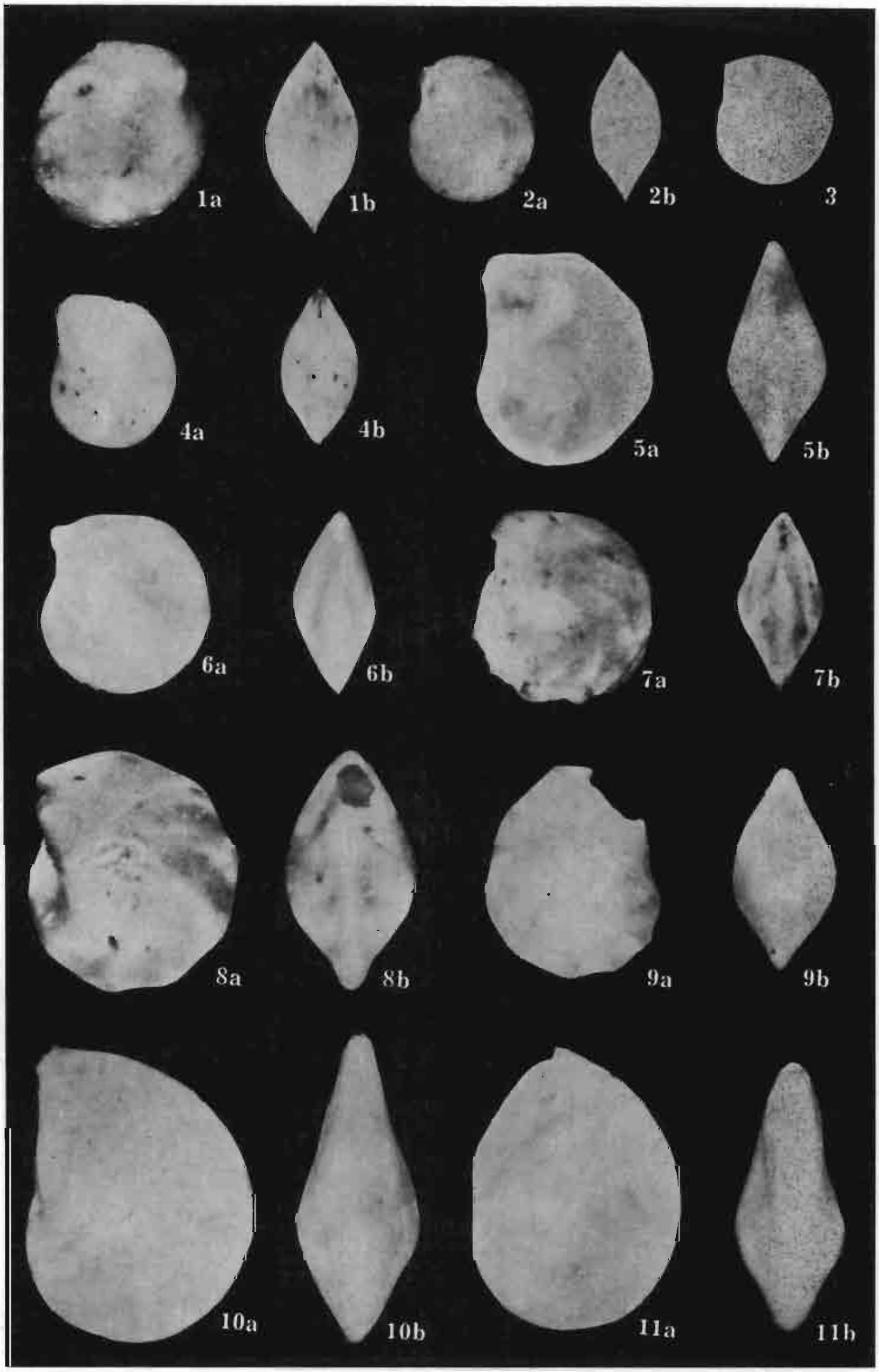

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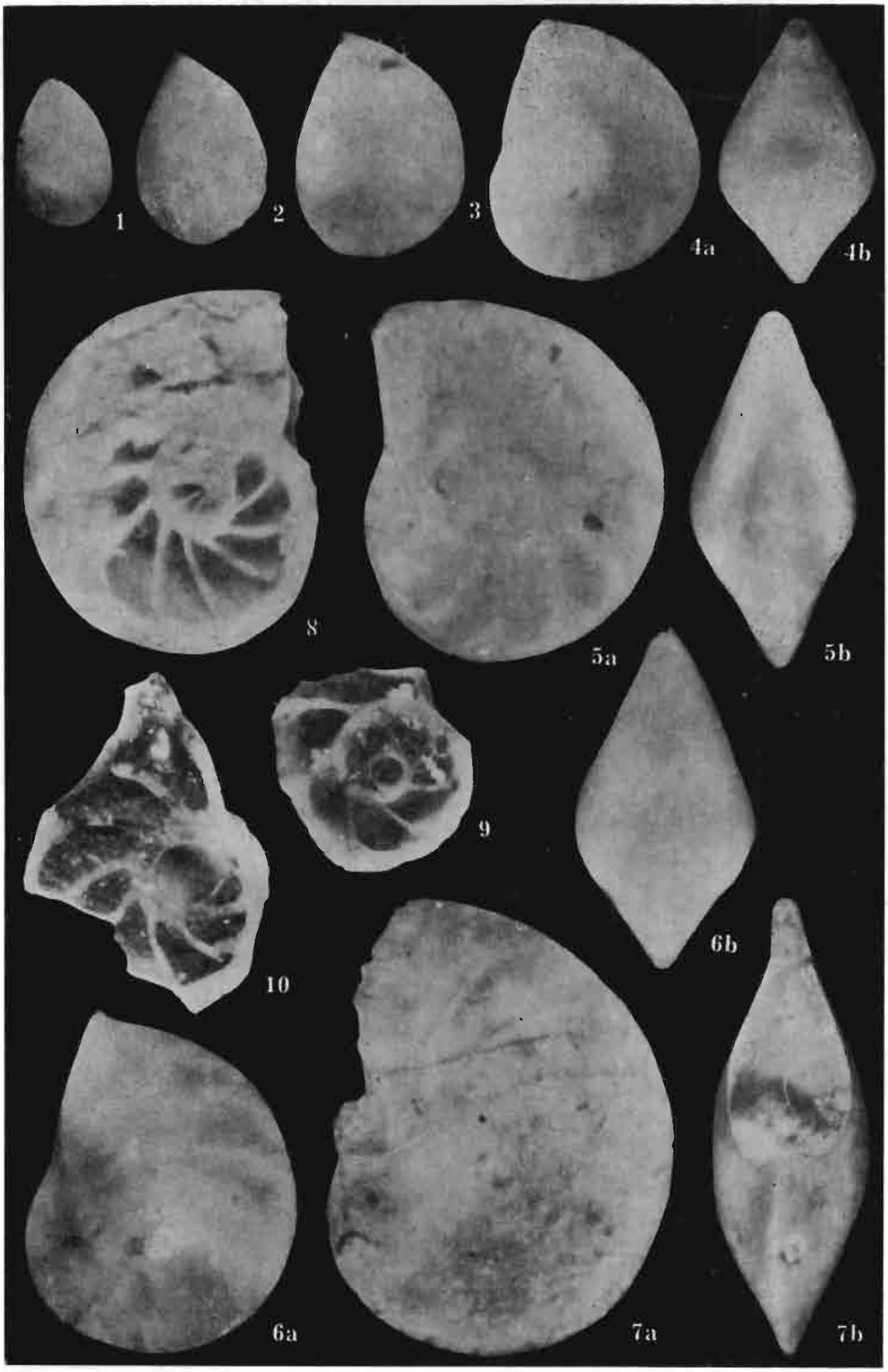

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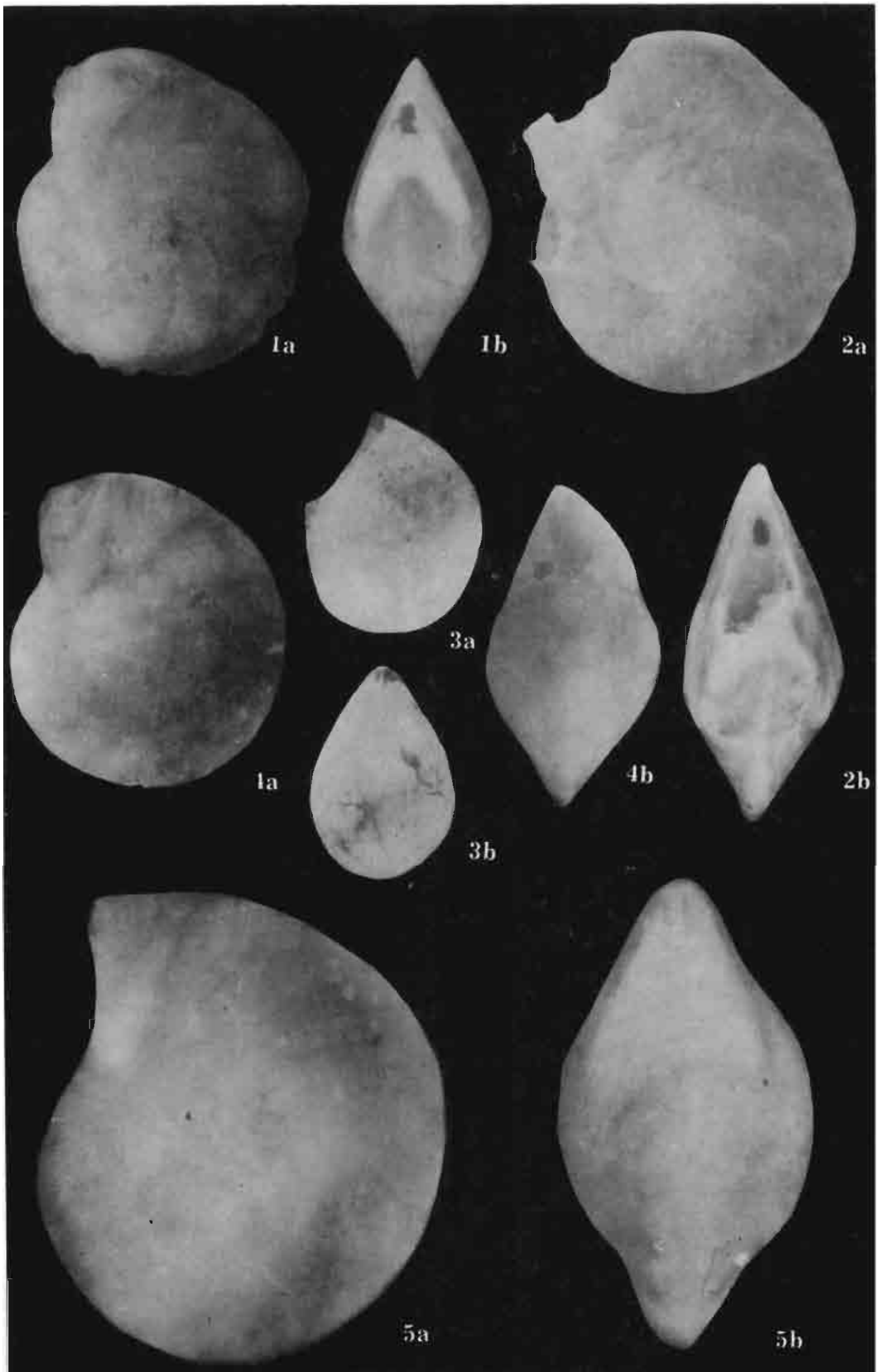

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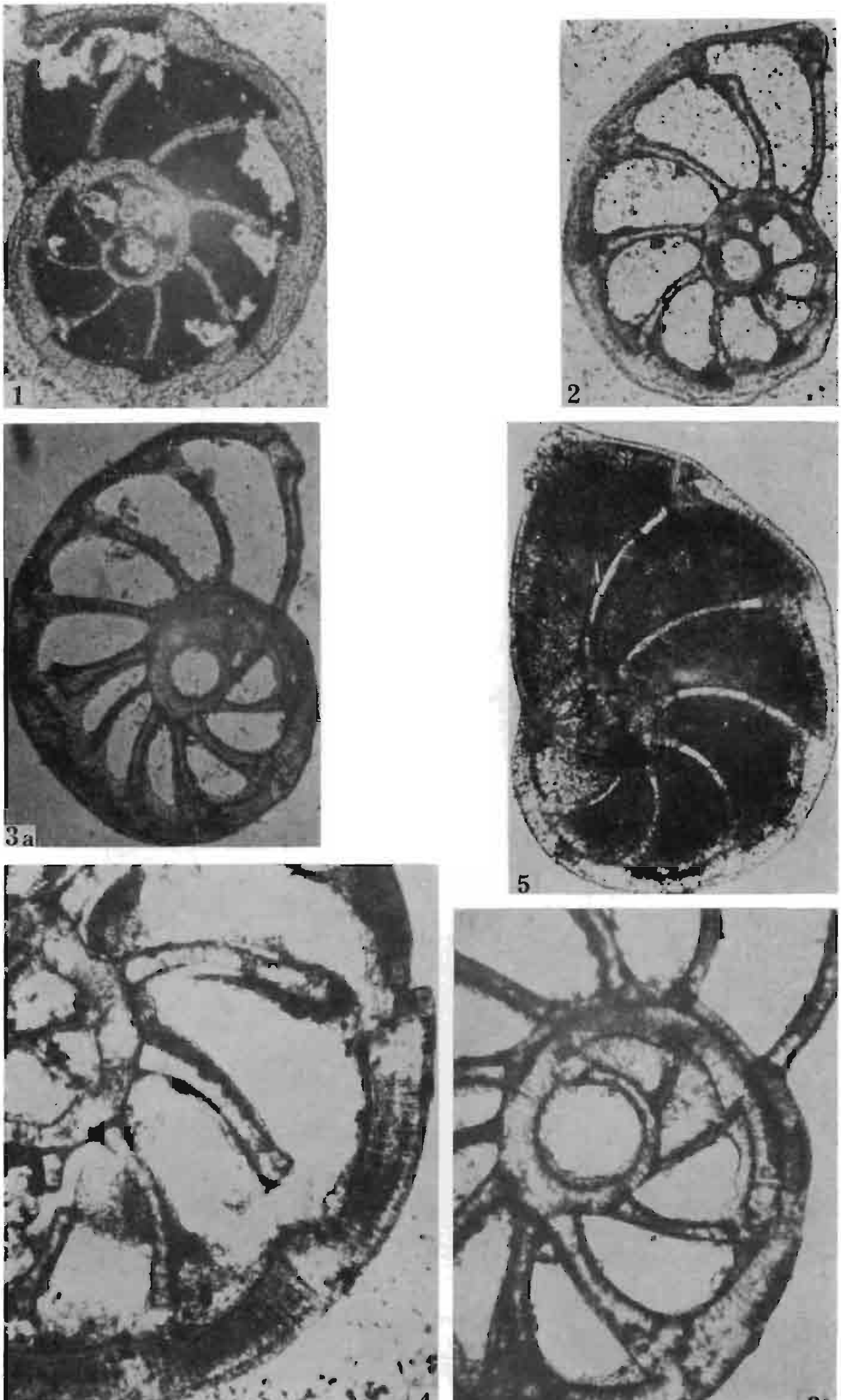

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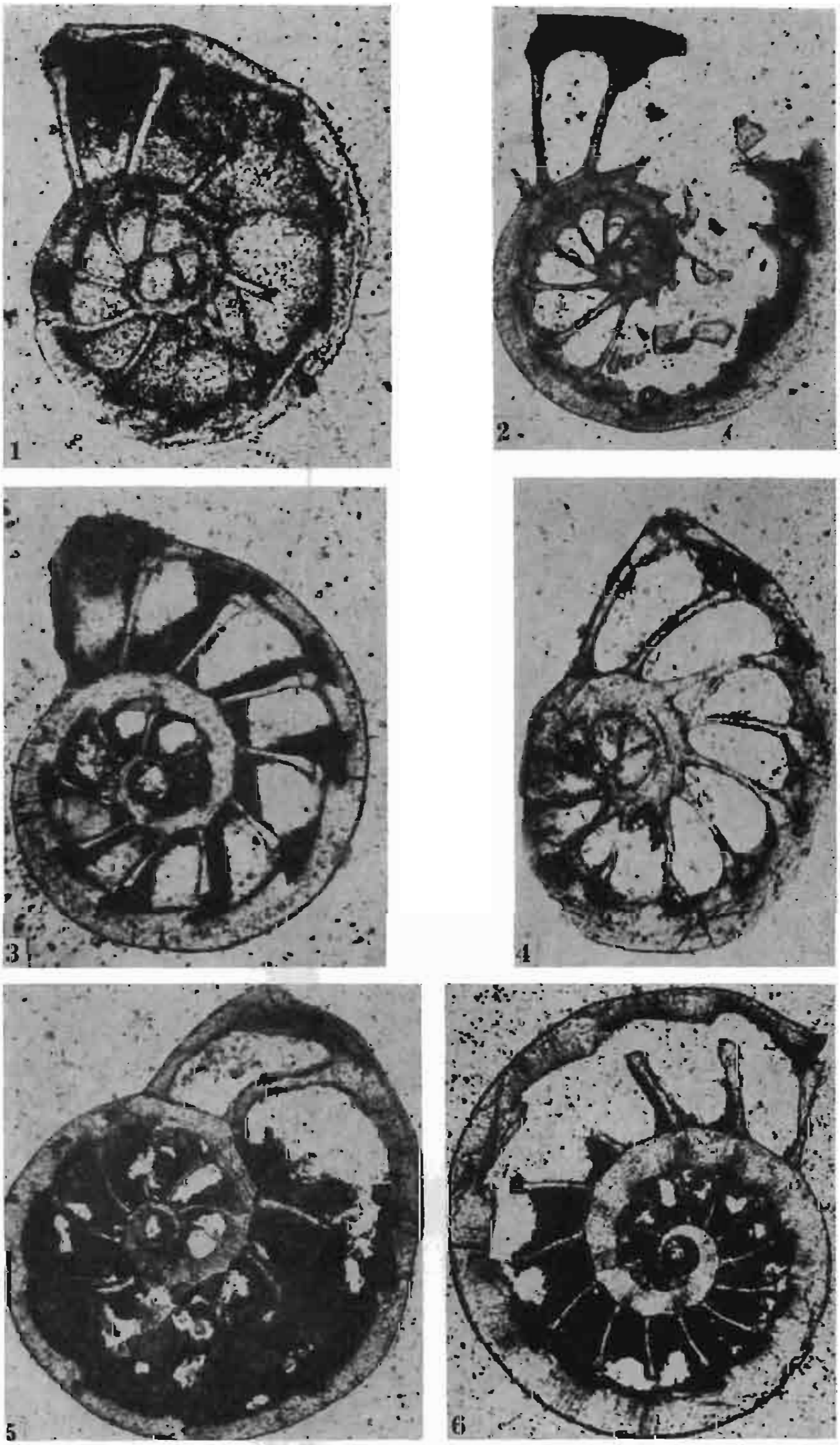

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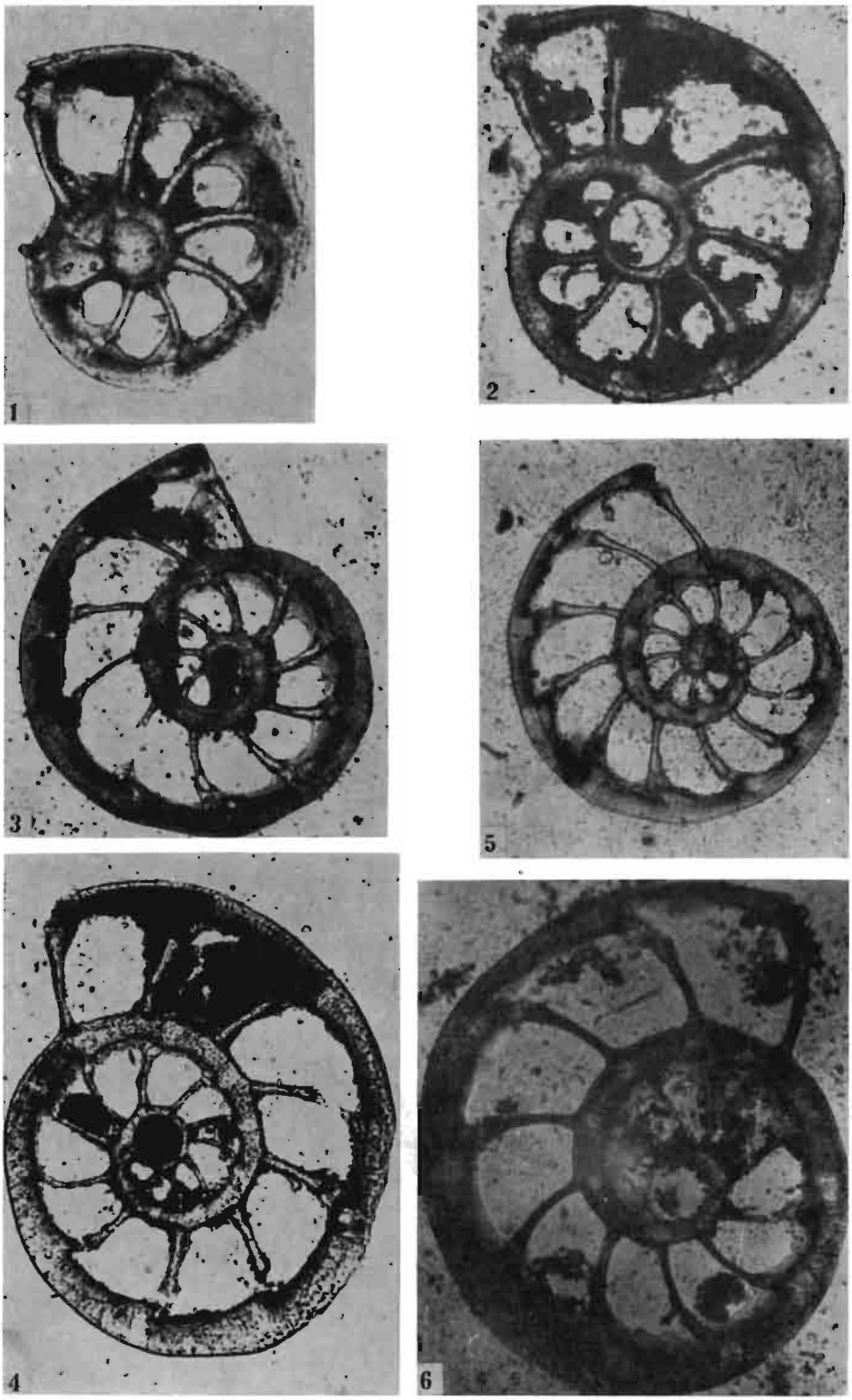

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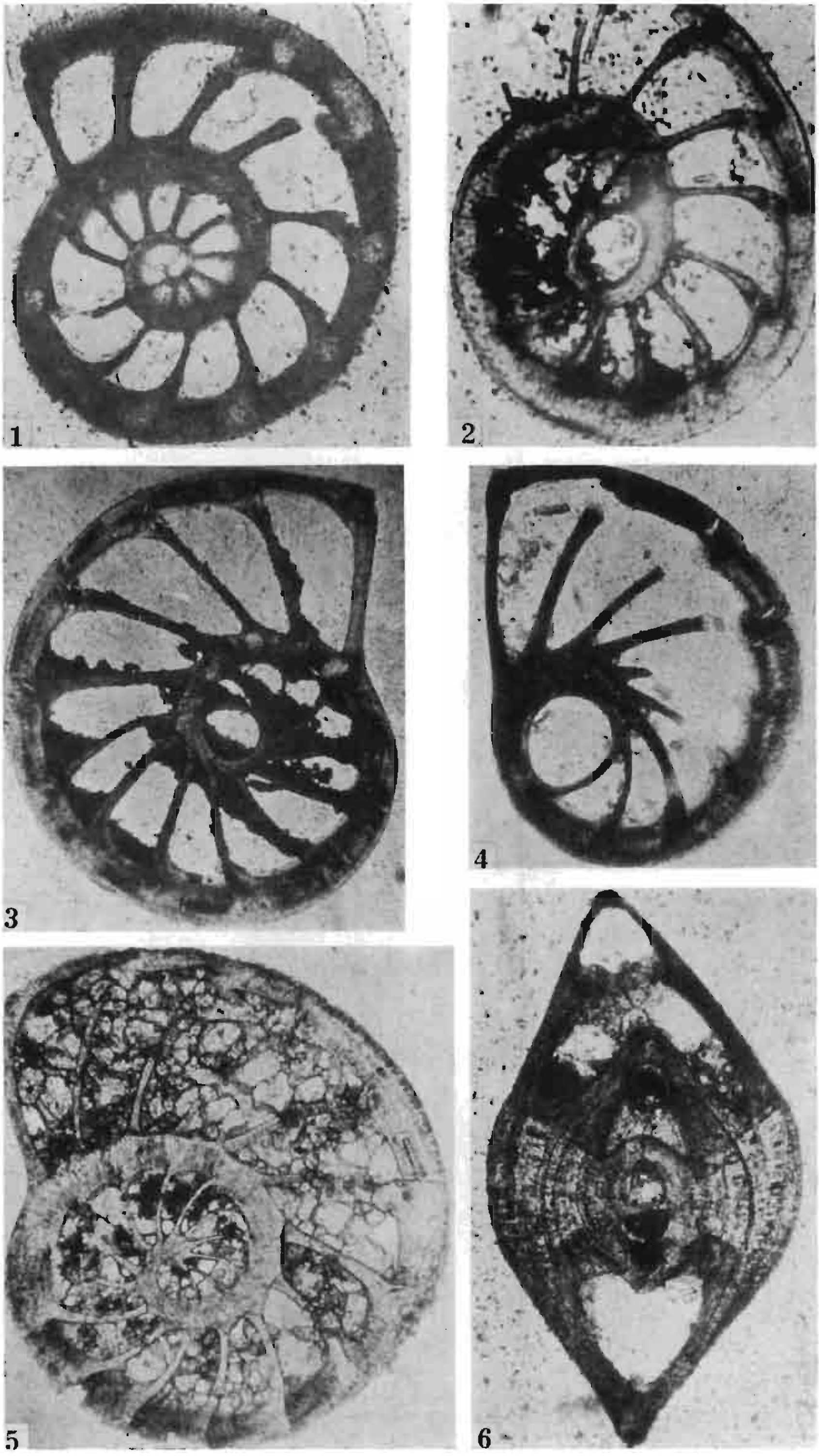

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