Foraminiferal Descendance and its Late Ordovician-Initiated Diversification

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PREFACE

This work comes just over two hundred years after the release of the first classification of foraminifers, which at that time, in 1825, represented a small group of only a few genera included within the cephalopod mollusks. It was the time when organisms were grouped together according to their morphological resemblances, a method that had developed in the early days of science in Antiquity. The classification of the modern and fossilized organisms proved a successful scientific endeavor, and in the specific case of the foraminifers led to the development of about twenty frameworks that accommodated the new data acquired as the scientific advances built up in the study of this group of microorganisms.

A classification framework is a useful tool in practical and fundamental studies. A researcher can figure out the general features of the test architecture simply by knowing the systematic position of the respective organisms and those derived from them, another data set on the distribution in space and geological time, paleobathymetry and paleoecology, etc. A quick look at the classification dynamics shows that the taxonomic principles that formed their foundation changed considerably through time, and they became more and more accurate. There is no doubt that when studying the different classification frameworks they are of a scientific nature, and this explains their success over two centuries of massive development. The first of them was produced before we understood that foraminifers are protistans and at the present, more and more scientists speak of foraminiferology as part of micropaleontology. A scientific story of success, so to speak.

Adding to these developments, a series of studies started implementing the Darwinian principles into the modern classification, which resulted in the grouping of taxa according to inferred ancestor–descendant relationships as recognized in the foraminiferal fossil record. The developments continued in the twentieth century, at a slower pace at first, before accelerating in the last decades of the century. Not only have fundamental advances been made, but the new methodologies also showed their importance in the practical applications of foraminiferology. It was a time when the time-honored grouping based on resemblance started to be replaced by as more refined one, as prefigured in *The Origin of Species*.

A curious turn of events happened in the last decade of the twentieth century, with the onset of a new current of thinking. In general terms, according to this thinking, micropaleontology needed to reinvent itself by migrating towards biology, genetics, and geochemistry, without providing a clear argumentation on why such a colossal shift was necessary. Notably, this came in a period of the extensive development of many branches of micropaleontology, foraminiferology among them. I cannot find a rational explanation for the success of this current of thinking, which led to an obvious fragmentation of the publication topics. One of the most affected domains of study in foraminiferology was that of classification development, which became closer to the neontological sciences (biology and genetics). In other words, the principles of classification of living organisms derived from a small number of taxa were also applied to the fossil record, which is a completely different data set.

But the scientific advances of foraminiferology cannot be stopped. The beginnings of the transition from the resemblance-based to evolutionary classification marks in fact the change towards a high-magnitude conceptual leap, namely the first declassification framework, the topic of this work.

The reader will find this work challenging as almost everything is changed when compared with the classical resemblance-only based classifications. So different as it is, it can be the source of ideas for several hundred articles and more. One common feature of the classifications and declassification is the use for now of the Latin names at the genus level and for lineages respectively. I think of it as evidence that two scientific perspectives on the fossil record cannot exclude each other and are compatible at some point. With the mention that one is conceptually stagnant, whereas the other must move forward.

This work of declassification is significant, and therefore this book is just part of a larger process. It follows *Foraminiferal Descendence and its Early Cambrian-Initiated Diversification* (published in 2026) and will be accompanied eventually by three other companion titles: *Foraminiferal Descendence and its Late Silurian-Initiated Diversification*; *Foraminiferal Descendence and its Early Triassic-Initiated Diversification*; and *Foraminiferal Descendence and its Middle Jurassic- and Early Cretaceous-Initiated Diversifications*.

Calgary, February 3, 2026

CHAPTER 1

INTRODUCTORY CONCEPTS

The Early Paleozoic was a time of major developments in the foraminiferal descendance, one of which was the initiation of the second major diversification in the Late Ordovician times. In contrast with the earliest diversification, which was initiated by single-chambered units, with the formation of a mineralized test, the second one began with multichambered units. Most of the nexuses that form this second diversification consist of units with agglutinated tests, and a transition to a secreted calcitic test is known to have started in the Late Paleozoic, namely in the Late Pennsylvanian.

Foraminiferal declassification is a new perspective on the units recognized in the fossil record and as living representatives, in which the inferred ancestor–descendant relationships play a crucial role. Due to the sheer size of the foraminiferal group, this project will be divided into five books, as mentioned in the Preface, each of them presenting one or more diversifications recognized in the group's history. The general principles and data presentation format were presented in Georgescu (2026), which dealt with the earliest diversification that was initiated in the Early Cambrian with the formation of mineralized tests. Given that both the principles of declassification and the data format remain unchanged, I have considered it useful to include herein two relevant subsections from that work, in order to provide the reader with the relevant data; the two subchapters are "1.2 Foraminifer declassification" and "1.3 Unit presentation format and data significance" from Georgescu (2026) and renumbered herein as sections 1.1 and 1.2. These opening paragraphs will occur in all the four subsequent works.

1.1. Foraminifer declassification

Later developments from the evolutionary classification happened in the Cretaceous planktic foraminifers, when the species started to be grouped according to the ancestor–descendant relationships into lineages rather than genera, emphasizing the dynamic nature of such unit groupings (Georgescu 2009). Notably, in this pioneering study the level of lineage was conferred a formal status within the Linnaean hierarchy. The new and challenging approach was further developed with the definition of the directional and branched lineages, both with a formal status at the same level (Georgescu 2010); this new advance effectively detached the new approach from the classical Aristotelian–Linnean one, where one type of units (i.e., genus) exists at one level of classification. The open system character was further demonstrated afterwards with the development of the iterative lineage and condensed lineage; a review of the four kinds of lineages was given by Georgescu (2014, p. 160–161). Another advance was represented by the definition of the "stage of morphological relative stability" which largely corresponds with the level of species in the Aristotelian–Linnean classification (Georgescu 2014); in parallel, there was developed the first nomenclature system for the stages of morphological relative stability within a lineage. The new approach was further developed for larger groups of foraminifera, both planktics and benthics: rotaliporids (Georgescu 2016), bolivinoidids (Georgescu 2018) and globotruncanids (Georgescu 2020). Only after a continuous development over more than one decade, it became evident that with the lineages of different kinds at the same grouping level, the new method represents a declassification. Such scientific advances led to the possibility of applying the new methodology at the scale of the whole foraminiferal group. As an aspect of terminology, the general term chosen of the different recognized entities within the declassification framework is that of unit; the unit has the equivalent of taxon (pl. taxa) in the Aristotelian–Linnean classification.

The declassification framework for the foraminiferal group is realized by grouping the units through a combination of morphological resemblance, which is given by the common ancestry and differences, which are the result of divergent nature of the descendance process. All the observations that represent the fundament of the declassification are made in stratigraphical order. A description of the units recognized in the fossil record of the foraminiferal group is given below.

The basic unit is that of lineage, which was associated at the time of definition by Georgescu (2014, p. 163) with the evolutionary classification; subsequent observations show that it is equally applicable in declassification. According to the original definition that is followed herein, there are six features that can be used in the description of one lineage: (1) it presents a variable degree of distinctiveness when compared to similar units, (2) is a succession of individuals or groupings of individuals in ancestor–descendant relationships, (3) the similarities between the individuals or groupings of individuals are the result of the common ancestry, (4) the morphological differences individuals or groupings of individuals reflect the descendence or not, (5) consists of one or more stages or morphological relative stability and (6) the descendence history in space and time can be reconstructed from the data from the fossil and rock records, with neontological data available in the cases of the lineages with living representatives. Four kinds of lineages are recognized according to the branching pattern of the component stages of relative morphological stability: directional (DL), ramified (RL), iterative (IL) and condensed (CL) (Georgescu 2014, p. 160) (Fig. 1-1: A). In some cases, the lineage level can be considered equivalent of the genus level in the Aristotelian–Linnean classification; many genera consist of numerous species and are heterogeneous taxa. Such genera are considered groups of lineages (GL) and require further study and splitting in the declassification framework.

Some of the lineages can be grouped and form more complex units termed branches. One branch can consist of two or more lineages, but in general the number of component lineages is small. The branches recognized in this work are directional (DB), ramified (RB) and complexly ramified (CRB) (Fig. 1-1: B).

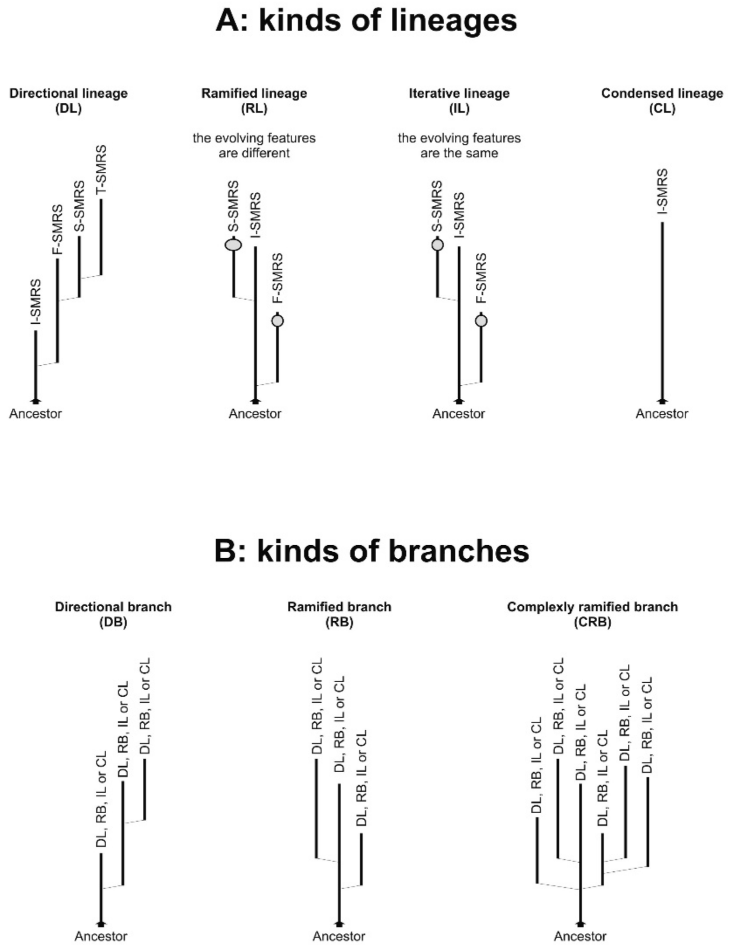

Fig. 1-1. Idealized representation of the kinds of lineages and branches and their terminology used in the foraminiferal declassification framework. Abbreviation: SMRS-stage of morphological relative stability.

The lineages and branches are grouped into a larger entity, herein termed nexus (pl. nexuses); the whole foraminiferal group consists of 203 nexuses. One nexus consists of two to around one hundred lineages and therefore, the branching and diversity varies considerably between the nexuses; in general, one stalk is represented by a group of lineages. The structure of one nexus shows that one lineage emerges from the ancestral unit and in general is a longer ranging one. The stalk can be simple or multiple and in the latter case the component lineages are labelled Stalk 1, Stalk 2 or Stalk 3; maximum three stalk components are recognized in this work (Fig. 1-2). The lineages and branches that derive from the stalk units are considered independent originations from the stalk (IOS) and labelled in stratigraphical order from IOS-1.

The names of the nexuses are formed from the generic name of the stalk unit in the Aristotelian–Linnean classification, which is informalized and in plural form (Fig. 1-3); this system is applied to the branches too. In the case of the stalk units, lineages or groups of lineages, the temporary names are those of the original generic units.

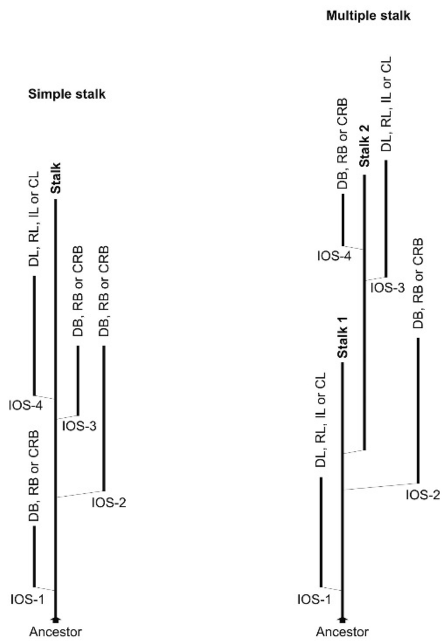

Fig. 1-2. Idealized representation of the two kinds of stalk in foraminiferal declassification. Abbreviations: IOS-independent origination from the stalk, and all the others as in fig. 1-1.

1.2. Unit presentation format and data significance

Five sets of data are presented for each of the units in the descriptive part: the system of reference, synonyms, test morphology, stratigraphical and geographical distribution, and ancestry. Additional data occurs in the case of the units that were already revised in an evolutionary classification framework.

In the classical Aristotelian–Linnean classification, each taxon of a certain level requires the naming of a type from the included taxa of the immediate lower level. The wide acceptation of the designation of types in the modern Aristotelian–Linnean classification led to its renaming as typological classification.

The units described as new in the earlier pioneering works on foraminifers did not have designated types. The word "type" occurs in the sense of "kind" in the Latin text of only one work (Soldani 1789, p. 21). The type-based system was started practically by de Montfort 1808, who designated a type species for the genera of foraminifers he described. This system was widely accepted in France in the 1820s and will be further developed in the typological system.

The modern typological foraminiferal nomenclature is regulated by the International Code of Zoological Nomenclature. The rules of this convention are often rigid, resulting in situations where the so important authorship is changed. For example, and in direct connection with the assigned types, a new genus is not considered valid without the designation of a type species; consequently, such a genus must be renamed and a type species assigned to it to be validated, one act that leads to the change of respective genus's authorship. Another example of a rule that led to nomenclatural instability is that which states that a name of a foraminifer is unique and no other animal or taxon previously considered an animal should bear it; a necessary mention is that foraminifers are protistans, but in the past were often considered unicellular animals. This rule led to the change of name of many foraminifer names, to avoid the confusion with other protistans, invertebrates or vertebrates; notably, such name changes led to the challenge of authorship. The practice and the administrative system that governs such a convention for the nomenclature of the Aristotelian–Linnean classification added further to problems with a reduced chance of being corrected, which are not presented in this work.

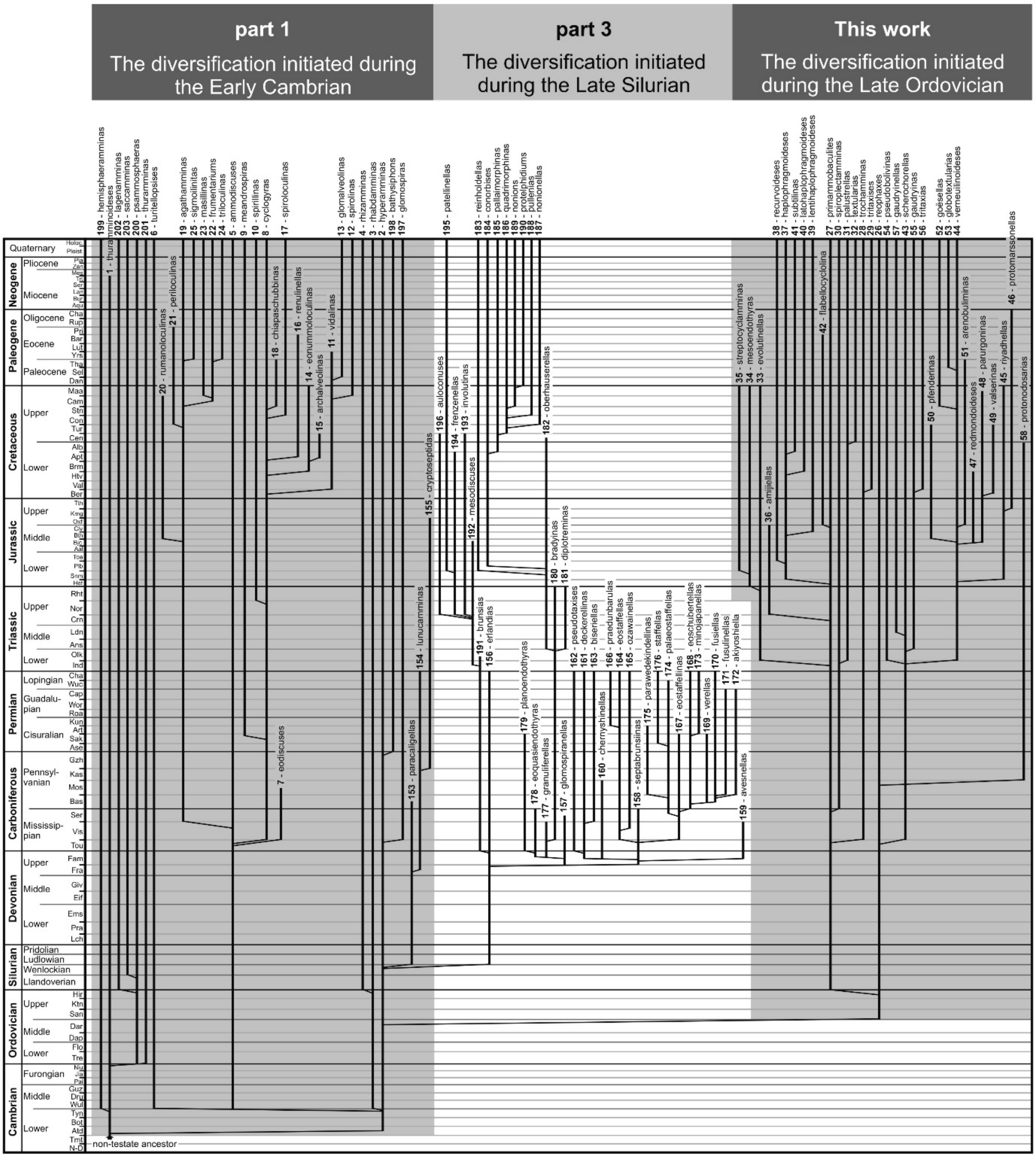

Fig. 1-3. Descendence and stratigraphical distribution of the foraminiferal nexuses recognized in this work. Each of the nexuses is numbered according to the descendence order.

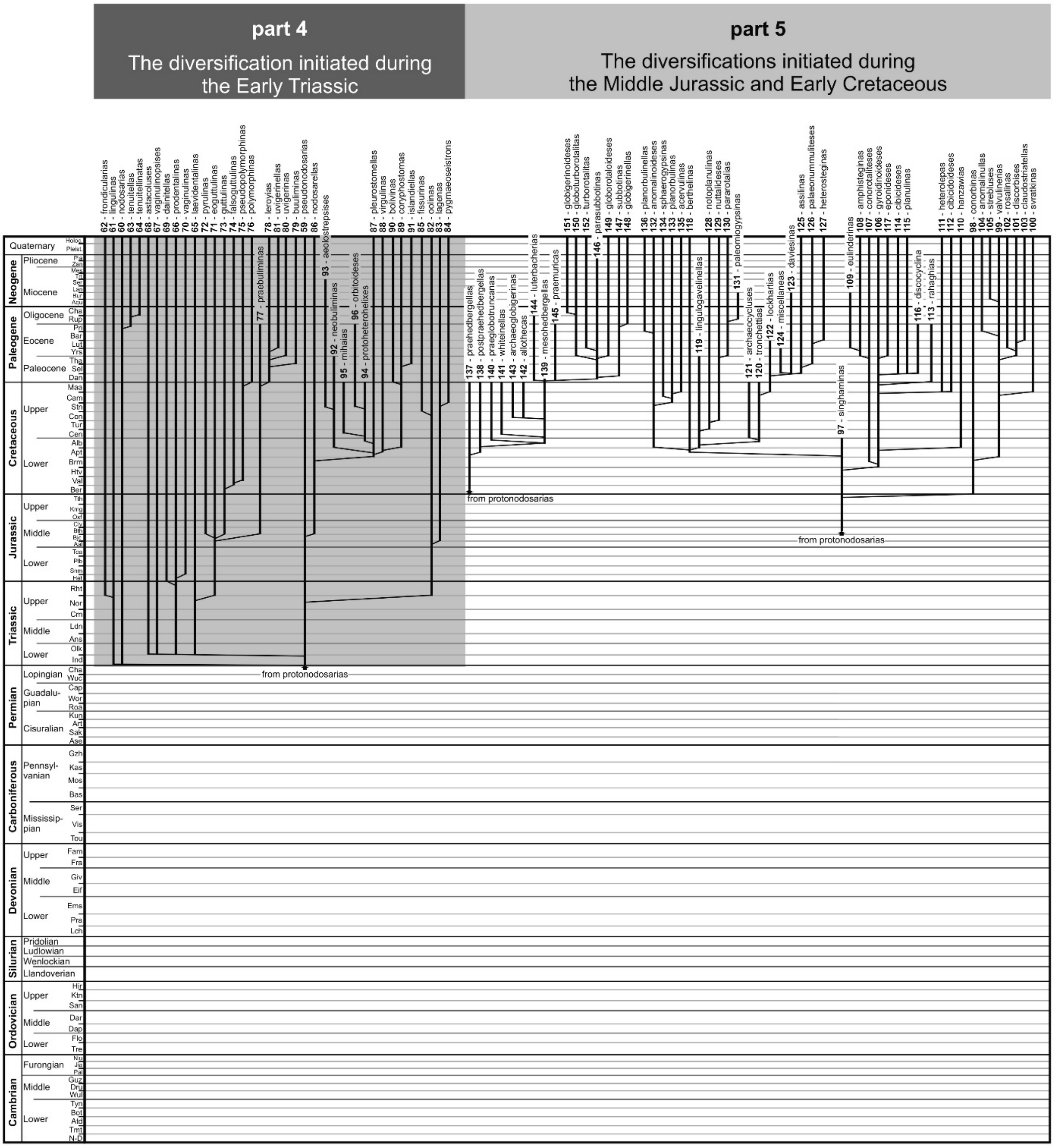

Fig. 1-3. Continued.

A new system of reference is proposed herein to be used in the declassified framework of the foraminiferal units. The unit of reference is one and any stage of relative morphological stability of a lineage; it is defined through the original description and/or figuration, which is termed as first reference. The original material can be further through subsequent studies resulting in a dynamic database. This approach started with the definition of the concept of "hypodigm" by Simpson (1940, p. 417–420) as part of the Aristotelian–Linnean classification, but the separation from the classical typological methodology is evident and most likely prevented its use at a wider scale in the following decades. The system of reference overcomes a major deficiency of the typological classification and nomenclature, namely that the "types" do not exist in nature and they are rather creations of the human minds. This practice had a detrimental effect in the past, which materialized especially in a tendency of many authors to illustrate specimens closer to the holotype, which resulted in a rather artificial impression of a low morphological stability of the genera and species of the Aristotelian–Linnean classification; this is mostly apparent in the opinion that a species is centered around the holotype.

Some of the units presented in this work present synonyms, which are separated into scientific and nomenclatural, according to their nature. Most of the scientific synonyms are mostly objective synonyms, names applied to the same unit. A part of them is the result of attempts by some authors to find units within one unit that present a wide range of morphological stability. In other cases, the units-considered synonyms are based on discrete test morphological features, which are considered trivial. Notably, the possibility that further descendance-based studies are needed to validate these units cannot be ruled out, but probably this will happen at a higher level of detail. A third category of synonyms is generated by errors in the evaluation of the effects of the fossilization process.

The nomenclatural synonyms are those generated by the provisions of the nomenclatural conventions. These are evaluated on a case-by-case basis, and in most instances rejected. A relatively small number of changes are accepted to avoid possible confusion with other foraminiferal units with resembling morphology.

Our data on the foraminiferal tests indicate that they are mineralized (e.g., agglutinated, calcitic, aragonitic) in most cases and that the units with organic tests (proteinaceous, chitinous, pseudochitinous) represent a minority. The foraminiferal tests, fossilized or of living units, provide the most data in the development of the group's declassification framework.

Traditionally, the description of one taxon in the Aristotelian–Linnean classification is the presentation of the morphological data of the test as a sum of features collected from throughout the known stratigraphical range of the respective taxon. The transition to units of significance in the declassified framework shows that the changes of the test morphological features must be followed, resulting in a dynamic morphology (e.g., Georgescu 2013a, 2013b, 2014, 2016, 2018, 2020). Despite these recent advances, most of the data are those from the Aristotelian–Linnean classification, and they require further refinement as the original material is revisited and new material acquired. The dynamic morphology in this work is consistently but briefly apparent in the description of the branches and nexuses.

Every unit or group of units has a definite distribution range in space and time. The concept of stratigraphical range encompasses the known data of such a distribution in the case of every unit. At the fundamental level, the definition of the stratigraphical range as a unifying concept in describing the distribution of one unit in the fossil record, which is used in this work, is that given by Georgescu (2021). The two components of the stratigraphical range are given separately as "stratigraphical interval" and "geographical distribution", following the format used in the past by other authors, such as Loeblich and Tappan (1987).

The stratigraphical interval of the units presented in this work are defined between the best-known evolutionary occurrence (BKEO) event and best-known extinction (BKE) event, as defined by Georgescu (2017). It represents the interval corresponding to the global stratigraphical range of the respective units. It was avoided the use of a terminology that includes the words "appearance" and "datum" for reasons that do not need to be further elaborated upon. The stratigraphical units are primarily those of the Geological Time Scale 2004 by Gradstein et al. (2004) for the reasons already given by Georgescu (2021). Similarly, the geographical distribution is intended to represent the maximum known extension of the respective unit throughout its history.

Inferring the ancestor–descendant relationship between two units is the basic procedure in the development of the foraminiferal declassification framework. This involves the morphological study of the two taxa and the overlapping of their stratigraphical ranges. The result is the identification of the morphological features that do not present changes or show low magnitude modifications, with the potential of demonstrating the ancestry between the two units on one hand, and on the other, those features with conspicuous modifications, which document the divergence between the units.

Due to the large amounts of space required by the presentation of these data for each of the inferred the ancestor–descendant relationships, together with the large number of units included in this work, the ancestry is presented in a somewhat shortened form. The presented morphological features are those that show considerable changes in the descendence from the ancestral unit. Notably, this system was developed by Kaiho (1998), one work that makes the transition from the Aristotelian–Linnean to the evolutionary classification.

The stratigraphical ranges of the ancestral and descendant units overlap in most of the cases. A gap spanning between less than one to maximum two stages was identified only in a small number of inferred ancestor–descendant relationships; such gaps are also mentioned.

One special case is that of the units that do not have yet a stratigraphical record, and therefore, are known only through living representatives or restricted to the Holocene. The methodology applied in such cases is to evaluate the morphology and recognize the development of certain features and stability of others, consider for comparison the changes occurring in other lineages of the respective nexus and the to infer the ancestor–descendent relationship. Practically, this is a situation where additional technological advances are needed for a large-scale investigation of the units with younger stratigraphical ranges.

Most of the illustrations of the specimens presented in the plates come from a variety of works. The largest proportion is represented by specimens illustrated in the original report, but a considerable number include those illustrated in subsequent reports. The name of the author, year of publication and position within the respective work is given for each of these specimens. The plate captions include a full acknowledgment of the work of the respective authors. They are used herein in a fair way and for the creation of a new work of science. Special thanks are for the permission to use photographs from the collections of the United States National Museum, the Smithsonian Institution, Washington, D.C. and The American Museum of Natural History, New York (Dr. B.M. Hussaini). Additional thanks are for the permissions to use illustrated specimens from the Journal for Foraminiferal Research and Micropaleontology and their other publications. Special thanks are for Dr. K. Dewing (Paleontographica Canadiana), Dr. P. Esquier (TOTAL S.A.), Dr. Kroh (NHM Vienna Publishing House) for the permission to use foraminifer illustrations from their publications. I am grateful for the photographs provided by Drs. A. Almogi–Labin, B. Hayward, M. Hesemann, S. Lipson–Benitah, S. Rigaud, F. Schlagintweit, F. Siemensma and M. Septfontaine. I greatly appreciate the help of Dr. J.–P. Debenay, Dr. S. Özcan Altiner, Dr. A. Sabirov, and Dr. I. Yassini for the permission to use relevant illustrations from their publications. Dr. I.I. Bucur, Dr. K. Tanaka and Dr. E. Tesakova kindly helped by providing previously illustrated specimens from some hard-to-get publications.

CHAPTER 2

SYSTEMATIC DESCRIPTIONS AND DESCENDENCE

This part includes the descriptions of the nexuses and component units of the foraminiferal diversification initiated in the Late Ordovician era.

2.1. Nexus reophaxes

(Fig. 2-1)

Description. This nexus was initiated with the development of multilocular tests with chambers with a uniserial arrangement along a straight to slightly curved axis. The tests are mostly free and on rare occasions some of the early representatives adopted an attached mode of life. The diversification is mostly apparent in the development of a calcitic microcrystalline wall, or an agglutinated wall with an alveolar ultrastructure, the degree of chamber overlapping, a chamber interior subdivided by lamellar partitions and the formation of a lens-shaped to slit-like aperture that can be produced on a neck or not.
Stratigraphical interval: Upper Ordovician (Sandbian)–Holocene.

Stalk: group of lineages ***Reophax*** (Plate 1, Figure 1)

First reference: de Montfort 1808, p. 331. Unit of reference: *Reophax scorpiurus* De Montfort 1808, p. 331, fig. 83.
Scientific synonym: *Proteonina*-Williamson 1858, p. 1. Nomenclatural synonyms: *Lituolina*-Goës 1882, p. 136; *Arproteonum*-Rhumbler 1913, p. 348; *Arreophaxum*-Rhumbler 1913, p. 441.
Test morphology. Test is free and multilocular, consisting of uniserially arranged subglobular, oviform or pyriform chambers that increase in size as added; the sutures are distinct to incised. Aperture is small and simple, in terminal position and produced on a neck. Test wall is agglutinated, consisting of fine to coarse particles bounded by variable amounts of cement.
Stratigraphical interval: Upper Ordovician (Sandbian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Reophax* descended from *Hyperammina* of multilocular tests by adding uniserially successive chambers, each having a smaller aperture relative to that of the ancestral unit.

IOS-1: ramified branch-**darjellas**

Description. This ramified branch consists mostly of units with a free test in which the chambers are added along a slightly curved growth axis. A small early coiled stage occurs in the representatives that adopted an attached mode of life. The chambers are pyriform, and the aperture is rounded and terminal. The wall is single layered, consisting of microcrystalline calcite, agglutinated particles or a combination of both.
Stratigraphical interval: Mississippian–Lower Permian (Tournaisian–Artinskian).

Directional lineage ***Darjella*** (Plate 1, Figure 2)

First reference: Malakhova 1964, p. 110. Unit of reference: *Darjella monilis* Malakhova 1964, p. 110, pl. 1, figs. a–g.
Scientific synonym: *Elevenella*-Vachard 1994, p. 70.
Test morphology. Test is free and multilocular, consisting of proloculus followed of several uniserially added chambers along a straight to slightly curved axis. The chambers are pyriform, slightly elongated in the direction of growth. Sutures are distinct and indented. Aperture is relatively small and rounded, in terminal position and produced on a short neck. Test wall is single layered, dominated by microcrystalline calcite and with relatively rare small-sized agglutinated particles.
Stratigraphical interval: Lower–Middle Mississippian (Tournaisian–lower Visean). Geographical distribution: Russia, Iran, EU (France).
Ancestry. *Darjella* descended from *Reophax* through the development of tests in walls that are dominated by microcrystalline calcite.

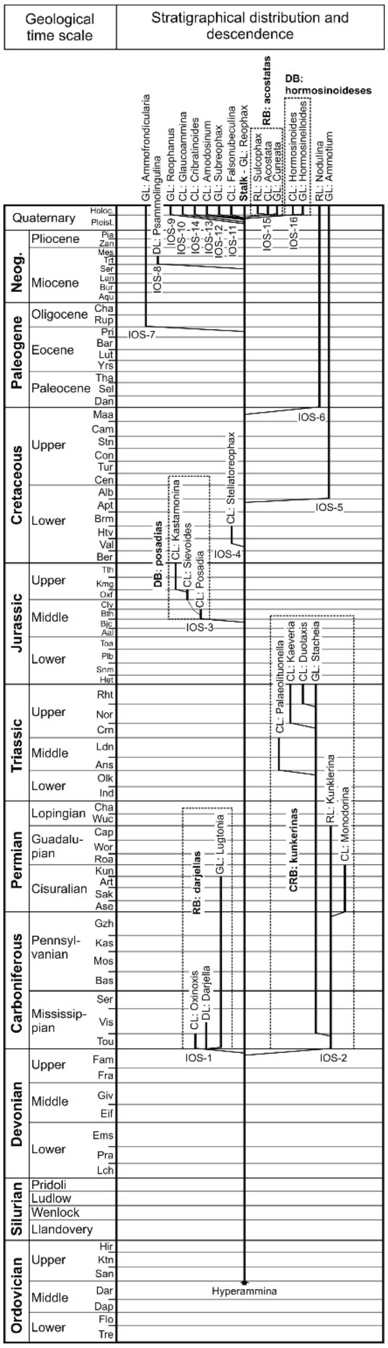

Fig. 2-1. Stratigraphical distribution and descendence of the representatives of the nexus reophaxes.

Condensed lineage ***Oxinoxis*** (Plate 1, Figure 3)

First reference: Gutschick 1962, p. 1299. Unit of reference: *Oxinoxis botrys* Gutschick 1962, p. 1300, pl. 174, figs. 25–26, pl. 175, figs. 1–8, 12, 14, text–fig. 4.

Test morphology. Test is attached and multilocular, consisting of chambers added in two distinct stages: the early stage is gently coiled forming less that one whorl, and the later one has uniserially and somewhat irregularly added pyriform chambers that overlap at a relatively high rate. Sutures are distinct and depressed. Aperture is small and rounded, in terminal position and produced on an elongated neck. Test wall is agglutinated, consisting of particles bounded by cement.

Stratigraphical interval: Lower Mississippian (Tournaisian). Geographical distribution: USA (Illinois, Missouri, Montana).

Ancestry. *Oxinoxis* descended from *Darjella* by adopting an attached mode of life and development of tests with a slightly coiled early stage.

Group of lineages ***Lugtonia*** (Plate 1, Figure 4)

First reference: Cummings 1955, p. 231. Unit of reference: *Nodosinella concinna* Brady 1876, p. 106, pl. 7, figs. 11–15.
Test morphology. Test is free, consisting of proloculus followed of several uniserially added chambers along a straight to slightly curved axis. The chambers are pyriform, slightly elongated in the direction of growth and overlap at various rates. Sutures are deeply indented. Aperture is single, relatively small and rounded, and in terminal position. Test wall is single layered and homogeneous, consisting of microcrystalline calcite.
Stratigraphical interval: Mississippian–Lower Permian (Tournaisian–Artinskian). Geographical distribution: UK (England), USA (Texas), Australia, Egypt, Russia.
Ancestry. *Lugtonia* descended from *Darjella* through the development of tests with a microcrystalline calcitic wall.

IOS-2: complexly ramified branch-**kunklerinas**

Description. The representatives of this complexly ramified branch present a multilocular test with the chambers added along a straight or straightly curved growth axis. The chamber interior is simple or with radial lamellar partitions. Test wall consists of agglutinated particles with considerable amounts of cement.
Stratigraphical interval: Mississippian–Triassic (Tournaisian–Rhaetian).

Ramified lineage ***Kunklerina*** (Plate 1, Figure 5)

First reference: Rauzer–Chernousova and Reytlinger 1986, p. 19. Unit of reference: *Reophax kunklerensis* Conkin 1961, p. 279, pl. 21, figs. 20–23, pl. 26, fig. 14.
Test morphology. Test is free and multilocular, consisting of subglobular chambers that overlap at a high rate and present a uniserial arrangement; sutures are distinct and incised. Aperture is rounded, situated in terminal position on the last-formed chamber and produced on a short neck. Test wall is agglutinated, consisting of fine to medium coarse particles bounded by considerable amounts of cement.
Stratigraphical interval: Mississippian–Middle Permian (Tournaisian–Capitanian). Geographical distribution: USA (Indiana), Australia, China.
Ancestry. *Kunklerina* descended from *Reophax* through the development of subglobular chambers that overlap at a relatively high rate.

Group of lineages ***Stacheia*** (Plate 1, Figure 6)

First reference: Brady 1876, p. 107. Unit of reference: *Stacheia marginulinoides* Brady 1876, p. 112, pl. 7, figs. 16–21.
Test morphology. Test is free and consists of a succession of subglobular chambers aligned uniserially along a gently curved growth axis. The chambers increase in diameter at a relatively high rate. Aperture is small, rounded and can be produced on a short neck. Test wall is agglutinated, consisting of fine to medium coarse particles bounded by much cement.
Stratigraphical interval: Mississippian–Triassic (Visean–Rhaetian). Geographical distribution: UK, USA (Indiana, Kentucky, Ohio, Tennessee), EU (Germany), Australia, Iran.
Ancestry. *Stacheia* descended from *Kunklerina* by developing tests with a slightly curved growth axis and chambers that increase more rapidly in diameter as added.

Condensed lineage ***Monodorina*** (Plate 1, Figure 7)

First reference: Lin and others 1990, p. 121. Unit of reference: *Monodorina longlinensis* Lin and others 1990, p. 122, pl. 2, figs. 17–19.
Test morphology. Test is free and multilocular, consisting of the proloculus followed by chambers that increase rapidly in diameter and are uniserially arranged. Sutures are distinct and incised. Aperture is small and at the top of the last-formed chamber. Test wall consists of small-sized and well-sorted particles bounded by large amounts of cement.
Stratigraphical interval: Lower Permian. Geographical distribution: China.
Ancestry. *Monodorina* descended from *Kunklerina* through the development of tests with a higher rate of chamber diameter increase.

Condensed lineage ***Palaeolituonella*** (Plate 1, Figure 8)

First reference: Bérczi–Makk 1981, p. 390. Unit of reference: *Palaeolituonella majzoni* Bérczi–Makk 1981, p. 390, pl. 1, figs. 1–8.
Test morphology. Test is free and consists of chambers that form two distinct growth stages; in the early stage they are added in a low trochospire with up to five chambers per whorl, whereas the later one is formed of few chambers uniserially added along a straight axis. The chambers of the uniserial stage are wide and low. Sutures are indistinct in the early stage and distinct and depressed in the later one. Test wall is fine to moderately coarse agglutinated. The chambers of the later stage are subdivided by weakly developed lamellar radial partitions that extend from the wall.
Stratigraphical interval: Middle–Upper Triassic (Anisian–Carnian). Geographical distribution: EU (Hungary, Austria, Italy, Bulgaria, Germany), Serbia, Montenegro.
Ancestry. *Palaeolituonella* descended from *Stacheia* through the development of tests with two growth stages (trochospiral–uniserial) and a partitioned chamber interior in the uniserial stage.

Condensed lineage ***Kaeveria*** (Plate 1, Figure 9)

First reference: Senowbari–Daryan 1984, p. 87. Unit of reference: *Palaeolituonella fluegeli* Zaninetti and others 1982, p. 107, pl. 8, figs. 1–2, 4–5.
Test morphology. Test is free and consists of chambers that form two distinct growth stages; in the early stage the chambers are added in a low trochospire with up to five chambers per whorl, whereas in the later stage the chambers are alternately added relative to the test growth axis. The chambers of the uniserial stage are low. Sutures are indistinct in the early stage and depressed between the last-formed chambers. Aperture is single, a low arch at the base of the last-formed chamber. Test wall is fine to moderately coarse agglutinated and simple, with considerable amounts of cement. The chambers of the later stage are subdivided by lamellar radial partitions that present alternating lengths.
Stratigraphical interval: Upper Triassic (Norian–Rhaetian). Geographical distribution: EU (Italy, Austria), Türkiye.
Ancestry. *Kaeveria* descended from *Stacheia* through the development of tests with two growth stages (trochospiral–biserial) and a partitioned chamber interior in the later stage.

Condensed lineage ***Duotaxis*** (Plate 1, Figure 10)

First reference: Kristan 1957, p. 294. Unit of reference: *Duotaxis metula* Kristan 1957, p. 295, pl. 27, figs. 5–6.
Test morphology. Test is free and consists of chambers in a trochospire coil that in general presents three chambers per whorl. Sutures are indistinct between the earlier chambers and distinct and depressed in the later stage. Aperture is single, a low arch at the base of the last-formed chamber and is partly covered by a subtriangular apertural tooth. Test wall is finely and simple, with much cement. Chamber interior is simple, undivided.
Stratigraphical interval: Upper Triassic (Rhaetian). Geographical distribution: EU (Austria).
Ancestry. *Duotaxis* descended from *Stacheia* through the development of tests with chambers added in a trochospiral coil and migrated aperture at the base of the last-formed chamber.

IOS-3: directional branch-**posadias**

Description. This directional branch consists of units with a multilocular test consisting of pyriform to subglobular chambers that overlap at a relatively high rate and are uniserially added. Chamber interior is simple or subdivided by radial lamellar partitions. The wall consists of agglutinated particles and can be simple or with alveolar ultrastructure.
Stratigraphical interval: Middle–Upper Jurassic (Bathonian–Tithonian).

Condensed lineage ***Posadia*** (Plate 1, Figure 11)

First reference: Giusberti and Coccioni 2003, p. 213. Unit of reference: *Posadia feroniensis* Giusberti and Coccioni 2003, p. 213, pl. 1–3, pl. 4, figs. 1, 3–16.
Test morphology. Test is free and multilocular, consisting of uniserially arranged pyriform chambers that overlap at a high rate; the test presents a circular to elliptical outline in transverse section. Chamber rate of size increase is high in the juvenile stage and somewhat reduced in the adult; the gerontic tests present almost parallel sides. Sutures are distinct and depressed. Aperture is small, rounded, in terminal position and produced on a short neck. Test wall is agglutinated and simple, consisting of poorly sorted particles bounded by relatively small amounts of calcitic cement.
Stratigraphical interval: Middle Jurassic (Bathonian). Geographical distribution: EU (Italy).
Ancestry. *Posadia* descended from *Reophax* through the development of tests with a higher rate of chamber overlapping resulting in a somewhat stouter test.

Condensed lineage ***Sievoides*** (Plate 1, Figure 12)

First reference: Farinacci and Ekmekci 2004, p. 65. Unit of reference: *Sievoides kocyigiti* Farinacci and Ekmekci 2004, p. 65, pl. 2, figs. 1–8.
Test morphology. Test is free and multilocular. Chambers are subglobular and uniserially arranged along a straight to slightly curved growth axis; the chambers overlap at a relatively high rate and increase in size as added. Aperture is small, terminal in position and produced on a short neck. Test wall is thick, agglutinated and with an internal alveolar ultrastructure at the interior.
Stratigraphical interval: Upper Jurassic (upper Oxfordian–Kimmeridgian). Geographical distribution: Türkiye, Morocco.
Ancestry. *Sievoides* descended from *Posadia* through the development of a test wall with an internal alveolar ultrastructure; notably, there is a gap between the ranges of two units comprising the Callovian–lower Oxfordian interval.

Condensed lineage ***Kastamonina*** (Plate 1, Figure 13)

First reference: Sirel 1993, p. 2. Unit of reference: *Kastamonina abanica* Sirel 1993, p. 3, pl. 1, figs. 1–12, pl. 2, figs. 1–11.
Test morphology. Test is free, consisting of the small proloculus followed by uniserially added chambers along a growth axis, which at first is slightly curved and becomes straight in the late ontogeny. Chambers increase rapidly in width and overlap at a relatively high rate. Sutures are slightly depressed. Aperture is a small, circular, and in terminal position. Test wall is finely agglutinated and presents an internal alveolar ultrastructure. Chamber interior is subdivided by longitudinal lamellar partitions that originate from wall.

Stratigraphical interval: Upper Jurassic (Kimmeridgian–Tithonian). Geographical distribution: Türkiye.
Ancestry. *Kastamonina* descended from *Sievoides* through the development of tests with the chamber interior partitioned by longitudinal lamellar partitions.

IOS-4: condensed lineage ***Stellatoreophax*** (Plate 1, Figure 14)

First reference: this work; the name translates as "the stellate *Reophax*". Unit of reference: *Reophax stellatus* Neagu 1975, p. 23, pl. 5, figs. 5–23, pl. 6, figs. 1–6.
Test morphology. Test is free, consisting of chambers added uniserially along a straight growth axis; only fragmented tests consisting of a succession of chambers are known. The chambers present a stellate outline in apical view due to the occurrence of shallow groves with a radial display; maximum chamber width occurs at the half distance between the proximal and distal ends. Aperture is rounded, terminal and produced on a high conical neck. Test wall is agglutinated, consisting of fine to medium coarse particles bounded by cement.
Stratigraphical interval: Lower Cretaceous (upper Valanginian–Hauterivian). Geographical distribution: EU (Romania).
Ancestry. *Stellatoreophax* descended from *Reophax* through the development of chambers with shallow radial groves and aperture produced on a long conical neck.

IOS-5: group of lineages ***Ammotium*** (Plate 1, Figure 15)

First reference: Loeblich and Tappan 1953, p. 33. Unit of reference: *Lituola cassis* Dawson and Parker in Dawson 1870, p. 87, fig. 3.
Scientific synonym: *Ammovaginulina*-Nakkady and Eissa 1960, p. 13.
Test morphology. Test is free and multilocular consisting of tightly coiled chambers around the proloculus that forms one whorl, rarely more; chambers become elongated in ontogeny and occasionally cover the proloculus over the periphery. Sutures are often indistinct. Aperture is simple and rounded, situated at the peripheral-anterior angle of the last-formed chamber. Test wall is agglutinated.
Stratigraphical interval: Lower Cretaceous (Albian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Ammotium* descended from *Reophax* through the development of a coiled test, elongated chambers and aperture migration towards an anterior-peripheral position.

IOS-6: ramified lineage ***Nodulina*** (Plate 1, Figure 16)

First reference: Rhumbler 1895, p. 85. Unit of reference: *Reophax dentaliniformis* Brady 1881a, p. 49.
Test morphology. Test is free and multilocular, consisting of subcylindrical chambers added along a straight to slightly curved growth axis; chambers increase in size as added. Sutures are distinct and depressed, straight to slightly oblique to the growth axis. Aperture is small and rounded, in terminal position and produced on a neck. Test wall is agglutinated, consisting of poorly sorted particles bounded by relatively small amounts of cement.
Stratigraphical interval: Lower Paleocene (Danian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Nodulina* differs from *Reophax* from which it descended mainly by the chamber shape which is subcylindrical rather than oviform to pyriform.

IOS-7: group of lineages ***Ammofrondicularia*** (Plate 1, Figure 17)

First reference: Schubert 1902a, p. 24. Unit of reference: *Ammofrondicularia angusta* Schubert 1902a, p. 24, pl. 1, fig. 20.
Test morphology. Test is free and multilocular, laterally compressed and consisting of several chambers uniserially added along a straight growth axis. The chambers are wide and low, anteriorly curved, and increase more rapidly in width conferring the tests a distally flaring aspect. Sutures are often indistinct, especially between the chambers of the early test. Aperture is in terminal position. Test wall is agglutinated, consisting of poorly sorted and large-sized particles bounded by cement.
Stratigraphical interval: Oligocene (upper Rupelian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Ammofrondicularia* descended from *Reophax* through the development of laterally compressed tests with low and anteriorly curved chambers that increase rapidly in width.

IOS-8: directional lineage ***Psammolingulina*** (Plate 1, Figure 18)

First reference: Silvestri 1904, p. 247. Unit of reference: *Lingulina papillosa* Neugeboren 1856, p. 97, pl. 5, fig. 6.
Test morphology. Test is free and multilocular, consisting of the proloculus followed by several uniserially arranged chambers along a straight growth axis; the proloculus can be slightly elevated, nearly at a right angle when compared with the plane defined by the other chambers. Chambers are flattened, with an anteriorly curved shape in lateral view and increase in size as added. Aperture is small, in the shape of an arcuate slit and slightly elevated. Test wall is agglutinated, simple and consists of poorly sorted particles bounded by cement.
Stratigraphical interval: Upper Miocene (Tortonian). Geographical distribution: EU (Italy, Romania).
Ancestry. *Psammolingulina* descended from *Reophax* through the development of laterally compressed tests with elevated proloculus and wider chambers with a curved shape in lateral view.

IOS-9: group of lineages ***Reophanus*** (Plate 1, Figure 19)

First reference: Saidova 1970, p. 148. Unit of reference: *Hormosina ovicula* Brady 1879, p. 61, pl. 4, fig. 6.
Test morphology. Test is free and multilocular, consisting of several pyriform chambers uniserially added along a straight to slightly curved axis; chambers increase slowly in size as added. Sutures are deeply incised. Aperture is rounded, terminal and produced on an elongated neck. Test wall is agglutinated.
Stratigraphical interval: Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Reophanus* descended from *Reophax* through the reduction of the rate of chamber size increase and the evolution of a finely agglutinated test wall.

IOS-10: condensed lineage ***Glaucoammina*** (Plate 1, Figure 20)

First reference: Seiglie and Bermúdez 1969, p. 200. Unit of reference: *Reophax trilateralis* Cushman 1935, p. 2, pl. 1, figs. 1–4.
Test morphology. Test is free and multilocular, consisting of the proloculus followed by several chambers, which are uniserially added along a straight axis; the test presents a subtriangular outline in transverse section. The chambers have a very low rate of size increase resulting in nearly parallel test sides. Sutures are indistinct. Aperture is simple and rounded, with a circular to elliptical outline and situated in terminal position on the last-formed chamber. Test wall is agglutinated, consisting of poorly sorted large-sized particles bounded by cement.
Stratigraphical interval: Holocene. Geographical distribution: Caribbean region, North Atlantic Ocean.
Ancestry. *Glaucoammina* descended from *Reophax* through the development of a test with subtriangular outline in transverse section.

IOS-11: condensed lineage: ***Falsonubeculina*** (Plate 1, Figure 21)

First reference: Amao and Kaminski 2016, p. 82. Unit of reference: *Pseudonubeculina arabica* Amao and Kaminski 2016, p. 83, pl. 1, figs. a–c, pl. 2, figs. 1–3, pl. 3, figs. a–d. Nomenclatural synonym: the name change from *Pseudonubeculina* to *Falsonubeculina* proposed by Amao and Kaminski (2019, p. 544) is accepted to avoid the confusion with the homonym benthic foraminifer.
Test morphology. Test is free and multilocular, consisting of proloculus followed by successive chambers that increase slowly in size and have a rounded outline in transverse section. Sutures are distinct and depressed. Aperture is slit-like, and in terminal position. Test wall is double layered, with an outer layer of agglutinated particles and an inner one of calcite.
Stratigraphical interval: Holocene. Geographical distribution: Persian Gulf.
Ancestry. *Falsonubeculina* descended from *Reophax* through the development of test with a slit-like aperture and a double layered wall.

IOS-12: group of lineages: ***Subreophax*** (Plate 1, Figure 22)

First reference: Saidova 1975, p. 57. Unit of reference: *Reophax adunca* Brady in Tizard and Murray 1882, p. 715.
Test morphology. Test is free and multilocular, consisting of subpyriform chambers that overlap at various rates and are uniserially arranged along an irregular axis; chambers increase slowly in size as added. Aperture is rounded, in terminal position. Test wall is agglutinated consisting of fine to medium coarse agglutinated particles bounded by cement.
Stratigraphical interval: Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Subreophax* descended from *Reophax* through the development of tests with an irregular growth axis.

IOS-13: condensed lineage ***Arnodosinum*** (Plate 1, Figure 23)

First reference: Rhumbler 1913, p. 442. Unit of reference: *Arnodosinum py-gaussicum* Rhumbler 1913, p. 453, text–fig. 163. Nomenclatural synonyms *Nodosinum*-Hofker 1930, p. 121.
Test morphology. Test is free and unilocular, consisting of uniserial subpyriform chambers along a slightly curved growth axis; chambers overlap at a relatively high rate as added. Aperture is small, radiate and produced on a short neck; the apertural rays extend as well-developed ribs on the anterior portion of the chamber interior. Test wall consists of poorly sorted agglutinated particles bounded by cement.
Stratigraphical interval: Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Arnodosinum* descended from *Reophax* through the development of a radiate aperture with ribs extending in the anterior part of the chamber interior.

IOS-14: condensed lineage ***Cribratinoides*** (Plate 1, Figure 24)

First reference: Saidova 1975, p. 68. Unit of reference: *Sulcophax batellinus* Saidova 1961, p. 22, pl. 6, fig. 26.
Test morphology. Test is free and multilocular, consisting of uniserially arranged chambers along a straight growth axis. Chambers are subglobular, appressed and overlap at a high rate. Sutures are distinct and shallow. Aperture is in terminal position on the last-formed chamber; it is small, slit-like and produced on a short neck. Test wall is double layered; the outer one is coarsely agglutinated, whereas the inner one is more fine.
Stratigraphical interval: Holocene. Geographical distribution: Northwest Pacific Ocean.
Ancestry. *Cribratinoides* descended from *Reophax* through the development of larger tests with appressed chambers, a slit-like aperture produced on a neck and a double layered test wall.

IOS-15: ramified branch-**acostatas**

Description. This ramified branch consists of units with uniserially arranged chambers and with an aperture that is lens-shaped to slit-like. The wall is agglutinated.
Stratigraphical interval: Holocene.

Condensed lineage ***Acostata*** (Plate 1, Figure 25)

First reference: Brönnimann and others 1992a, p. 100. Unit of reference: *Reophax mariae* Acosta 1940, p. 270, pl. 49, figs. 4–6.
Test morphology. Test is free and multilocular, consisting of uniserially arranged ovoid chambers that overlap at various rates and increase in size. Sutures are distinct and depressed. Aperture is lens-shaped and situated in terminal position on the last-formed chamber. Test wall is medium coarsely agglutinated.
Stratigraphical interval: Holocene. Geographical distribution: Caribbean region (off Cuba), Mediterranean Sea (off Italy), South Atlantic Ocean (off Brazil).
Ancestry. *Acostata* descended from *Reophax* through the development of a lens-shaped aperture.

Group of lineages ***Cuneata*** (Plate 1, Figure 26)

First reference: Fursenko in Gudina 1979, p. 21. Unit of reference: *Reophax arctica* Brady 1881b, p. 405, pl. 21, fig. 2.
Scientific synonym: *Oblidolina*-Brönnimann and Whittaker 1980, p. 266.
Test morphology. Test is free and unilocular, consisting of uniserially arranged ovoid chambers along a slightly curved growth axis. There are two distinct growth stages: chamber increase faster in diameter in the early stage and in height in the adult one. Sutures are depressed and distinct. Aperture is elongated, lens-shaped, with slightly elevated margins. Test wall is medium coarsely agglutinated.
Stratigraphical interval: Holocene. Geographical distribution: Arctic Ocean, North Pacific Ocean, North Atlantic Ocean.
Ancestry. *Cuneata* descended from *Acostata* through the development of a test with two growth stages.

Ramified lineage ***Sulcophax*** (Plate 1, Figure 27)

First reference: Rhumbler in Wiesner 1931, p. 93. Unit of reference: *Sulcophax claviformis* Rhumbler in Wiesner 1931, p. 93, pl. 13, fig. 148.
Test morphology. Test is free and multilocular, consisting of uniserially arranged chambers that increase in size as added; chambers are subglobular and overlap at various rates along a growth axis that in general is slightly curved. Aperture is slit-like, terminal in position and situated within a shallow transversal sulcus over the anterior face. Test wall is fine to medium coarsely agglutinated.
Stratigraphical interval: Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Sulcophax* descended from *Acostata* by developing a transversal sulcus over the anterior face.

IOS-16: directional branch-**hormosinoideses**

Description. This directional branch consists of free tests with subpyriform to pyriform chambers which are uniserially added. Aperture is single, relatively large and situated on a thick neck. The wall consists of agglutinated particles.
Stratigraphical interval: Holocene.

Condensed lineage ***Hormosinoides*** (Plate 1, Figure 28)

First reference: Saidova 1975, p. 63. Unit of reference: *Hormosinoides perpastus* Saidova 1975, p. 63, pl. 14, fig. 2.
Test morphology. Test is free and multilocular, consisting of the rounded proloculus and few uniserially arranged subpyriform chambers that overlap at a high rate; chambers increase slowly in size as added. Sutures are slightly depressed, occasionally indistinct. Aperture is large, rounded, in terminal position and produced on a short neck. Test wall is agglutinated, consisting of coarse and well-sorted particles bounded by relatively small amounts of cement.
Stratigraphical interval: Holocene. Geographical distribution: Pacific Ocean.
Ancestry. *Hormosinoides* descended from *Reophax* through the development of tests with chambers that overlap at a high rate and a wall consisting of coarse and well-sorted particles.

Group of lineages ***Hormosinelloides*** (Plate 1, Figure 29)

First reference: Zheng in Zheng and Fu 2001, p. 686. Unit of reference: *Reophax guttifera* Brady 1884, p. 295, pl. 31, figs. 10–15.
Test morphology. Test is free and multilocular, consisting of the proloculus followed by a few pyriform chambers that increase slowly in size as added; the chambers are slightly appressed. Aperture is simple and rounded, situated in terminal position and produced on an elongated neck. Test wall is agglutinated, consisting of coarse and well-sorted particles bounded by considerable amounts of cement.
Stratigraphical interval: Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Hormosinelloides* descended from *Hormosinoides* through the development of apertures produced on an elongated neck.

2.2. Nexus primammobaculiteses

(Fig. 2-2)

Description. This nexus was initiated with the development of tests in which the early stage is planispirally coiled while in the later one the chambers are added uniserially. The diversification often happened through the reduction and eventually loss of the later uniserial stage, the development of laterally compressed tests which can have a flaring aspect in the distal part, and a cribrate or elliptical aperture that can be produced on a neck. The wall is primarily agglutinated and single layered, but in some of the later representatives is double layered with the inner layer having an alveolar to canaliculate ultrastructure, and possibly triple layered. Only a relatively small number of units adapted an attached mode of life.
Stratigraphical interval: Lower Silurian (Aeronian)–Holocene.

Stalk 1: group of lineages ***Primammobaculites*** (Plate 2, Figure 1)

First reference: this work; the name translates as "the first *Ammobaculites*". Unit of reference: *Ammobaculites qusaibaensis* Kaminski and Perdana 2019, p. 63, pl. 1, figs. 11–12.
Test morphology. Test is free, consisting of chambers added in two distinct stages: the early stage is planispirally coiled and consists of a few chambers forming one whorl, whereas the adult stage is uncoiled, and chambers are uniserially added along a straight growth axis. The chambers have a somewhat irregular aspect, are circular to slightly flattened in transverse section and present a slow increase in size as added. Sutures are often indistinct in the early stage and distinct and depressed in the adult one. Aperture is small and rounded, situated in terminal position on the last-formed chamber and produced on a short neck. Test wall is agglutinated, consisting of fine to medium coarse grains bounded by considerable amounts of cement.
Stratigraphical interval: Lower Silurian–Lower Mississippian (Aeronian–Tournaisian). Geographical distribution: USA (Missouri, Illinois, Indiana), Saudi Arabia.
Ancestry. *Primammobaculites* descended from *Reophax* through the development of an early planispiral stage, increase of the chamber overlapping rate and a change in the chamber shape to subglobular, occasionally low subcylindrical.

Stalk 2: group of lineages ***Ammobaculites*** (Plate 2, Figure 2)

First reference: Cushman 1910, p. 114. Unit of reference: *Spirolina agglutinans* d'Orbigny 1846, p. 137, pl. 14, figs. 10–12.
Scientific synonym: *Endotriadella*-Vachard and others 1994, p. 553.
Test morphology. Test is free and consists of two distinct growth stages: the early one is planispirally coiled and consists of one whorl, rarely more, and the later one, in which the chambers are uniserially added along a straight or gently curved growth axis. Chambers of the adult stage present a circular outline in transverse section. Aperture in the adult stage is rounded, terminal and can be produced on a short neck. Test wall is agglutinated, consisting of fine to moderately coarse particles bounded by variable amounts of cement.
Stratigraphical interval: Lower Devonian (Emsian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Ammobaculites* descended from *Primammobaculites* through the development of a somewhat more regular test and on the average a more finely agglutinated wall.

IOS-1: directional branch-**rhenothyras**

Description. The units of this directional branch have a planispirally coiled test and was initiated through the loss of the ancestral uniserial stage. The most apparent diversification trend is represented by the development of a wall with small, agglutinated particles in considerable amounts of calcitic cement in the early representatives and completely calcitic and possibly triple layered in the later ones.
Stratigraphical interval: Lower–Upper Devonian (Pragian–Frasnian).

Condensed lineage ***Rhenothyra*** (Plate 2, Figure 3)

First reference: Beckmann 1950, p. 184. Unit of reference: *Rhenothyra refrathiensis* Beckmann 1950, p. 184, text–figs. 1–4, 5: 2.
Test morphology. Test is free and multilocular, consisting of a relatively large and spherical proloculus followed by successively added chambers that form up to two and a half whorls; the chambers are narrow, numerous per whorl. The test is laterally compressed, biumbilicate and with an evolute coil. Sutures are distinct and depressed. The aperture is simple, with a quasi-circular outline, at the base of the anterior face of the last-formed chamber. Test wall consists of rare and small-sized agglutinated particles within considerable amounts of calcitic cement.
Stratigraphical interval: Lower–Upper Devonian (Pragian–Frasnian). Geographical distribution: EU (Germany, Poland), Tunisia.
Ancestry. *Rhenothyra* descended from *Ammobaculites* through the development of tests with a completely planispiral coil and a wall with dominant calcitic cement.

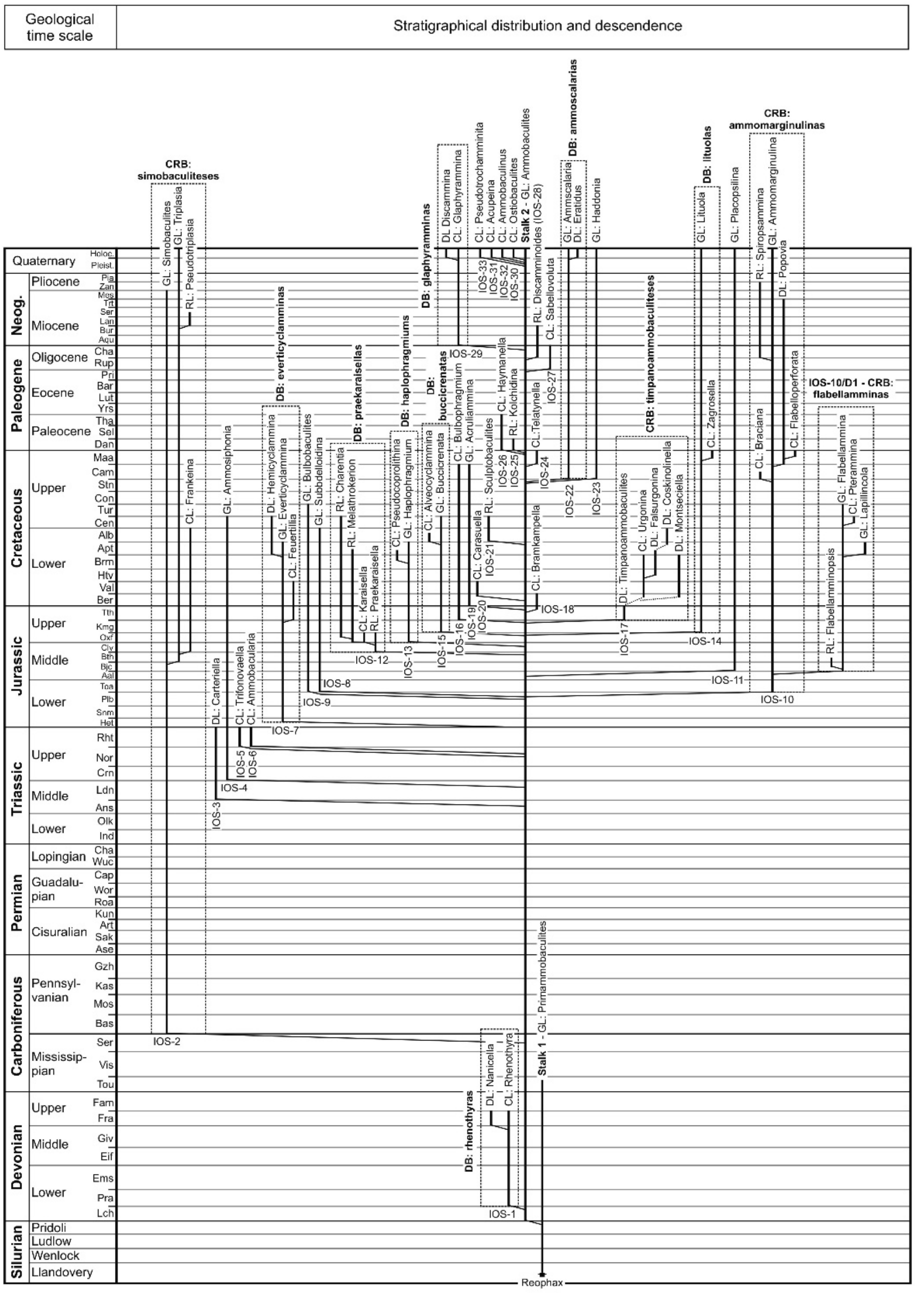

Fig. 2-2. Stratigraphical distribution and descendence of the representatives of the nexus primammobaculiteses.

Directional lineage ***Nanicella*** (Plate 2, Figure 4)

First reference: Henbest 1935, p. 34. Unit of reference: *Endothyra gallowayi* Thomas 1931, p. 40, pl. 7, figs. 1–9.

Test morphology. Test is free and multilocular, consisting of proloculus followed by chambers added in a planispiral coil; the chambers form up to three whorls and increase slowly in size as added. The tests are laterally-compressed, biumbilicate, evolute–involute and with a subrounded and simple periphery. Sutures are distinct and slightly depressed. Aperture is a low arch at the base of the anterior face of the last-formed chamber. Test wall is calcitic, single layered and occasionally triple layered.

Stratigraphical interval: Upper Devonian (Frasnian). Geographical distribution: USA (Iowa), Russia.

Ancestry. *Nanicella* descended from *Rhenothyra* through the development of tests with evolute–involute coil, slit-like aperture at the base of the anterior face of the last-formed chamber and a possibly triple layered test wall.

IOS-2: complexly ramified branch-**simobaculiteses**

Description. The early representatives of this complexly ramified branch present a test with an early planispirally coiled stage and a later laterally compressed uniserial one. The diversification happened through the development of tests in which the later stage has a triangular, triradiate and quadriradiate transverse section. Test wall is simple in most of the units, but some later representatives developed a wall with an alveolar ultrastructure.

Stratigraphical interval: Pennsylvanian (Bashkirian)–Holocene.

Group of lineages ***Simobaculites*** (Plate 2, Figure 5)

First reference: Loeblich and Tappan 1984, p. 1162. Unit of reference: *Ammobaculites cuyleri* Tappan 1940, p. 96, pl. 14, fig. 10.
Test morphology. Test is free and consists of two distinct growth stages: the early one is formed of chambers added in a planispiral coil that form up to two whorls, whereas in the adult stage the chambers are uniserially added along a straight axis. The test is flattened, with subangular periphery. Sutures are flush with the wall in the early stage and distinct and depressed in the later one. Aperture is small and rounded, in terminal position on the last-formed chamber. Test wall is agglutinated and simple, consisting of moderately coarse particles bounded by cement.
Stratigraphical interval: Pennsylvanian–Miocene. Geographical distribution: cosmopolitan.
Ancestry. *Simobaculites* descended from *Ammobaculites* through the development of flattened tests with a subangular periphery and an early stage consisting of chambers that form up to two whorls.

Group of lineages ***Triplasia*** (Plate 2, Figure 6)

First reference: Reuss 1854, p. 65. Unit of reference: *Triplasia murchinsoni* Reuss 1854, p. 65, pl. 25, figs. 1–2.
Scientific synonyms: *Rhabdogonium*-Reuss 1860a, p. 198; *Centenarina*-Majzon 1948, p. 24; *Tetraplasia*-Bartenstein and Brand 1949, p. 672.
Test morphology. Test is free, consisting of two growth stages: the early stage presents chambers added in a planispiral coil that form up to two whorls, whereas the adult one is formed of consists of uniserially added chambers along a straight growth axis. The early stage is laterally compressed, and the uniserial one presents a triradiate to quadriradiate transverse section. The sutures are indistinct, flush with the wall in the early stage and distinct and depressed in the later one. Aperture is small and rounded, in terminal position on the last-formed chamber, and produced on a short neck. Test wall is agglutinated and simple, consisting of moderately coarse particles bounded by cement.
Stratigraphical interval: Middle Jurassic (Bathonian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Triplasia* descended from *Simobaculites* through the development of the adult stage with triradiate to quadriradiate cross section.

Condensed lineage ***Frankeina*** (Plate 2, Figure 7)

First reference: Cushman and Alexander 1929, p. 61. Unit of reference: *Frankeina goodlandensis* Cushman and Alexander 1929, p. 62, pl. 10, figs. 1–2.
Test morphology. Test is free and consists of two distinct stages: the early stage is formed by chambers added in a planispiral coil forming one whorl, rarely more, and the later one has the chambers added uniserially along a straight growth axis. The test is laterally compressed in the early stage and with a triangular to triradiate cross section in adult stage. Sutures are often indistinct in the early stage. Aperture is rounded, situated in the terminal position and can be produced on a short neck. Test wall is agglutinated and simple.
Stratigraphical interval: Middle Jurassic–Lower Cretaceous (Callovian–Albian). Geographical distribution: USA (Texas, South Dakota, Wyoming).
Ancestry. *Frankeina* descended from *Triplasia* through the development of a later stage with triangular to triradiate cross section and later chambers that can be anteriorly curved.

Ramified lineage ***Pseudotriplasia*** (Plate 2, Figure 8)

First reference: Małecki 1954a, p. 499. Unit of reference: *Pseudotriplasia elongata* Małecki 1954a, p. 499, pl. 12, fig. 3.
Test morphology. Test is free, consisting of the proloculus followed by several uniserially arranged chambers along a straight growth axis. Chambers are triradiate in cross section, with concave lateral sides. Sutures are distinct and depressed. Aperture is cribrate and in terminal position. Test wall is agglutinated, consisting or relatively poorly sorted particles bounded by chamber; it is alveolar at the interior, with short lamellar structures between adjacent alveoli.
Stratigraphical interval: Middle Miocene (Langhian–lower Serravallian). Geographical distribution: EU (Poland), Ukraine.
Ancestry. *Pseudotriplasia* descended from *Triplasia* through the loss of the early planispiral stage, development of a cribrate aperture and a test wall with internal alveolar ultrastructure.

IOS-3: ramified lineage ***Carteriella*** (Plate 2, Figure 9)

First reference: Haig and McCartain 2010, p. 376. Unit of reference: *Carteriella manelobasensis* Haig and McCartain 2010, p. 376, fig. 4: 36–47.
Test morphology. Test is free and multilocular, consisting of two growth stages. In the early stage, the chambers are added in a planispiral and evolute coil of about two whorls, of which the outer whorl consists of up to nine chambers; the early stage is laterally compressed, with a rounded periphery. The later stage is formed by uniserially added chambers along a straight or slightly curved growth axis. Sutures are indistinct between the earliest chambers and distinct and depressed between the last-formed ones. The aperture is small and rounded, in terminal position and produced on a short neck. Test wall is agglutinated, consisting of fine to medium coarse particles bounded by organic cement.
Stratigraphical interval: Middle–Upper Triassic (Ladinian–Rhaetian). Geographical distribution: East Timor, EU (Austria).

Ancestry. *Carteriella* descended from *Ammobaculites* through the development of an early planispirally coiled stage that forms most of the test.

IOS-4: group of lineages ***Ammosiphonia*** (Plate 2, Figure 10)

First reference: He in He and Hu 1977, p. 8. Unit of reference: *Ammosiphonia vulgaris* He in He and Hu 1977, p. 9, pl. 2, figs. 5–6, 8.
Test morphology. Test is free and multilocular, with chambers added in a planispiral coil throughout and increasing is size as added. The coiling is involute to evolute–involute and consists of few whorls. Sutures are distinct and slightly depressed. Aperture is rounded and rimmed, produced on a short neck and situated in the central part of the anterior face of the last-formed chamber. Test wall is agglutinated, consisting of medium coarse and well-sorted particles bounded by cement.
Stratigraphical interval: Upper Triassic–Upper Cretaceous (Carnian–Turonian). Geographical distribution: China, Russia.
Ancestry. *Ammosiphonia* descended from *Ammobaculites* through the complete loss of the late uniserial stage and development of a rimmed aperture situated in the central part of the anterior face of the last-formed chamber.

IOS-5: condensed lineage ***Trifonovaella*** (Plate 2, Figure 11)

First reference: this work; the name translates as “the foraminifer of [E.] Trifonova”. Unit of reference: *Reophax tzankovi* Trifonova 1962, p. 145, pl. 1, figs. 1–5.
Test morphology. Test is free and multilocular, consisting of two growth stages; the early stage is planispirally coiled and consists of a few chambers arranged in one whorl, and it is followed by a relatively long adult stage of uniserially arranged chambers along a straight growth axis. Sutures are distinct and depressed throughout. Aperture is small and rounded, in terminal position and produced on a neck with cylindrical aspect. Test wall is finely agglutinated, with particles bounded by considerable amounts of cement.
Stratigraphical interval: Upper Triassic (Rhaetian). Geographical distribution: Cosmopolitan.
Ancestry. *Trifonovaella* descended from *Ammobaculites* through the development of an aperture produced on a neck with cylindrical aspect and a finer test wall.

IOS-6: condensed lineage ***Ammobacularia*** (Plate 2, Figure 12)

First reference: Kristan–Tollmann 1964, p. 40. Unit of reference: *Ammobacularia triloba* Kristan–Tollmann 1964, p. 41, pl. 7, fig. 1.
Test morphology. Test is free, with two distinct growth stages: the early stage consists of chambers added in a planispiral coil forming one whorl, whereas in the adult stage the chambers are added along a straight growth axis. Chambers of the adult stage overlap at a high rate and present a constant diameter. Sutures are distinct and depressed. Aperture is terminal and triradiate. Test wall is agglutinated, consisting of fine to moderately coarse particles bounded by cement.
Stratigraphical interval: Upper Triassic (Rhaetian). Geographical distribution: EU (Austria).
Ancestry. *Ammobacularia* descended from *Ammobaculites* through the development of a triradiate aperture.

IOS-7: ramified branch-**everticyclamminas**

Description. The early units of this ramified branch consist of tests with an early planispiral stage and a later uncoiled one that can be lost in some of the later representatives. The wall is double layered, with a thicker inner layer with an alveolar ultrastructure.
Stratigraphical interval: Lower Jurassic–Upper Cretaceous (upper Hettangian–Cenomanian).

Group of lineages ***Everticyclammina*** (Plate 2, Figure 13)

First reference: Redmond 1964a, p. 407. Unit of reference: *Everticyclammina hensoni* Redmond 1964a, p. 409, pl. 1, figs. 22–25, pl. 2, figs. 17–18.
Scientific synonyms: *Pseudobaculites*-Maync 1965, p. 39; *Mayncella*-Banner 1966, p. 13.
Test morphology. Test is free and consists of the proloculus followed by chambers that form two successive growth stages. The early stage presents the chambers added in a planispiral coil, whereas in the later one the few chambers are added uniserially along a straight axis. The test is slightly laterally compressed and presents a rounded and simple periphery. Sutures are distinct and depressed. Aperture in the later stage is slit-like and situated in terminal position on the last-formed chamber. Test wall is agglutinated and double layered, with an imperforated thin outer layer and a thicker inner one with an alveolar ultrastructure. In longitudinal section, the septa are simple and short, with a subtriangular to subrectangular shape at each junction with the test wall.
Stratigraphical interval: Lower Jurassic–Lower Cretaceous (upper Hettangian–Aptian). Geographical distribution: EU (Croatia, France, Italy, Poland, Portugal, Romania, Slovenia), Iraq, Kuwait, Mexico, Qatar, Serbia, Switzerland, East Timor, Türkiye.
Ancestry. *Everticyclammina* descended from *Ammobaculites* through the development of test with a slit-like aperture in the uniserial stage and a double layered test wall, in which the inner layer presents an alveolar ultrastructure.

Condensed lineage ***Feurtillia*** (Plate 2, Figure 14)

First reference: Maync 1958a, p. 1. Unit of reference: *Feurtillia frequens* Maync 1958a, p. 2, pl. 1, figs. 1-5, pl. 2, figs. 1-10.
Test morphology. Test is free and consists of proloculus followed by chambers that form two growth stages. The early stage is planispiral, whereas in the later one, the chambers are added uniserially along a straight to slightly curved axis. The test is laterally compressed and presents a rounded and simple periphery. In the later stage, the aperture is slit-like and situated in terminal position on the last-formed chamber. Test wall is fine to moderately coarse agglutinated and double layered, consisting of an imperforated outer layer and a thicker inner one that presents an alveolar ultrastructure.
Stratigraphical interval: Upper Jurassic–Lower Cretaceous (Tithonian–Valanginian). Geographical distribution: Switzerland, Morocco, EU (Germany, Portugal, Romania).
Ancestry. *Feurtillia* descended from *Everticyclammina* through the development of tests that present a more accentuated lateral compression and alveoli that often have a subpolygonal outline.

Directional lineage ***Hemicyclammina*** (Plate 2, Figure 15)

First reference: Maync 1953, p. 148. Unit of reference: *Hemicyclammina sigali* Maync 1953, p. 148, text–fig. 1.
Test morphology. Test is free, consisting of the proloculus followed by chambers added in a planispiral coil; chambers increase in size as added. The test is laterally compressed, biumbilicate and involute, with a subrounded and simple periphery. Sutures are distinct and slightly anteriorly arched. Aperture is slit-like and extends from the base up close to the periphery on the anterior face of the last-formed chamber. Test wall is finely agglutinated and double layered, with an outer thin and imperforated layer and an internal one that is thicker. It also has a labyrinthic aspect and presents an alveolar ultrastructure. In median sections, the septa are thin, with well-developed subtriangular bases.
Stratigraphical interval: Cretaceous (Aptian–Cenomanian). Geographical distribution: EU (Croatia), Algeria, Qatar, Iran.
Ancestry. *Hemicyclammina* descended from *Everticyclammina* through the loss of the late uniserial stage and a test wall with relatively thicker and more irregular internal layer.

IOS-8: group of lineages ***Subbdelloidina*** (Plate 2, Figure 16)

First reference: Frentzen 1944, p. 331. Unit of reference: *Subbdelloidina haeussleri* Frentzen 1944, p. 332, pl. 18, figs. 12–22.
Scientific synonym: *Eoplacopsilina*-Payard 1947, p. 63.
Test morphology. Test is completely attached and consists of two distinct growth stages; the early stage is formed by a relatively small number of chambers added in a planispiral coil, whereas the adult stage consists of uniserially added chambers along an irregular axis. Sutures are distinct and depressed. Aperture is small and rounded, situated in terminal position. Test wall is agglutinated.
Stratigraphical interval: Lower Jurassic (Toarcian)–Lower Cretaceous (Albian). Geographical distribution: EU (Germany, France, Spain), Switzerland, Russia.
Ancestry. *Subbdelloidina* descended from *Ammobaculites* by adopting an attached mode of life.

IOS-9: group of lineages ***Bulbobaculites*** (Plate 2, Figure 17)

First reference: Maync 1952a, p. 47. Unit of reference: *Ammobaculites lueckei* Cushman and Hedberg 1941, p. 83, pl. 21, fig. 4.
Test morphology. Test is free and consists of subglobular chambers arranged in two distinct growth stages; the early stage presents the chambers added along a streptospirally coiled axis, whereas the later stage consists of chambers added uniserially along a straight axis. The sutures are distinct and depressed. Aperture is simple, flush with the wall and situated in terminal position. Test wall is agglutinated, consisting of fine to coarse particles bounded by cement.
Stratigraphical interval: Lower Jurassic–Upper Cretaceous (Toarcian–Turonian). Geographical distribution: Colombia, Arctic Canada, EU (Germany), Ukraine.
Ancestry. *Bulbobaculites* descended from *Ammobaculites* through the formation of an early stage with streptospiral coil.

IOS-10: complexly ramified branch-**ammomarginulinas**

Description. The representatives of this complexly ramified branch developed free tests with an early planispiral coil and a later uniserial stage, which is laterally compressed and mostly flaring, rarely with parallel sides. Aperture is single to multiple. The test wall consists of agglutinated particles, simple in the earlier units and developed iteratively a wall with an internal alveolar ultrastructure.
Stratigraphical interval: Lower Jurassic (Toarcian)–Holocene.

Group of lineages ***Ammomarginulina*** (Plate 2, Figure 18)

First reference: Wiesner 1931, p. 97. Unit of reference: *Ammomarginulina ensis* Wiesner 1931, p. 97, pl. 12, fig. 147.
Scientific synonym: *Ammopalmula*-Lindenberg 1966, p. 463.
Test morphology. Test is free and consists of two distinct growth stages: the chambers are added in a planispiral coil in the early stage, evolute to involute, whereas in the adult one they are added along a straight growth axis. The test has a general flattened aspect. The chambers of the adult stage present a variable rate of width increase, and occasionally the

test can have a distally flaring aspect. Sutures are depressed, and in some specimens indistinct especially in the early stage. Aperture is small and rounded, in terminal position or at the peripheral angle on the last-formed chamber and can be produced on a short neck. Test wall consists of a mixture of fine and medium coarse agglutinated particles bounded by variable amounts of cement.
Stratigraphical interval: Lower Jurassic (Toarcian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Ammomarginulina* descended from *Ammobaculites* through the development of a flattened test and the adult stage that occasionally can present a distally flaring aspect.

Condensed lineage ***Braciana*** (Plate 2, Figure 19)

First reference: Schlagintweit and Cvetko Tešcovic 2017, p. 33. Unit of reference: *Braciana jelaskai* Schlagintweit and Cvetko Tešcovic 2017, p. 34, figs. 4: A–K, 5.
Test morphology. Test is free and consists of two distinct growth stages: the chambers are added in a planispiral coil in the early stage, whereas in the later one along a straight growth axis; in the later portion, the chambers can increase in width at a high rate resulting in a peneropline test aspect. The test is laterally compressed, with a rounded and simple periphery. Sutures are distinct and depressed. The chambers of the later stage have multiple apertures, a row of larger pores, which can be rimmed, on the anterior face of the last-formed chamber. Test wall is finely agglutinated, with internal alveolar ultrastructure. Chamber interior presents incipient pillars that emerge from the anterior wall of the last-formed chambers.
Stratigraphical interval: Upper Cretaceous (lower Campanian). Geographical distribution: EU (Croatia, Greece).
Ancestry. *Braciana* descended from *Ammomarginulina* through the development of tests with a cribrate aperture in the later stage, an alveolar wall and chamber interior with pillars in early stage of formation.

Directional lineage ***Popovia*** (Plate 2, Figure 20)

First reference: Suleymanov 1965, p. 48. Unit of reference: *Alveolophragmium planum* Bykova 1939, p. 19, pl. 1, fig. 10, text–fig. 1.
Test morphology. Test is free and consists of successively added chambers that form two distinct stages. The early stage is large and formed of chambers added in a planispiral coil; the coiling is evolute and the chambers form about one and a half whorls. The later stage consists of chamber added uniserially in a rectilinear row. The test is strongly laterally compressed, with parallel sides and rounded and simple periphery. Aperture is single, situated at the base of the anterior face in the early stage and in terminal position in the later one. Test wall is agglutinated, with internal alveolar ultrastructure.
Stratigraphical interval: Upper Cretaceous–Upper Miocene (Maastrichtian–Tortonian). Geographical distribution: Kirghizstan, EU (Romania).
Ancestry. *Popovia* descended from *Ammomarginulina* through the development of a test wall with internal alveolar ultrastructure.

Condensed lineage ***Flabelloperforata*** (Plate 3, Figure 1)

First reference: Schlagintweit and Rashidi 2017a, p. 5. Unit of reference: *Flabelloperforata tarburensis* Schlagintweit and Rashidi 2017a, p. 7, fig. 6: a–m, fig. 7: a–f.
Test morphology. Test is free, consisting of a large proloculus followed by chambers added in a planispiral to low trochospiral coil; the chambers are anteriorly arched and increase rapidly in size resulting in a flaring test. Aperture is multiple, larger pores arranged in rows on the anterior face of the last-formed chamber. Test wall is finely agglutinated and simple, rarely with a fine reticulate network developed on narrow surfaces in the peripheral region of the chambers.
Stratigraphical interval: Upper Cretaceous (upper Maastrichtian). Geographical distribution: Iran, Türkiye.
Ancestry. *Flabelloperforata* descended from *Ammomarginulina* through the development of tests in which the early coil is planispiral to low trochospiral, the chambers increase rapidly in width and there are multiple apertures.

Ramified lineage ***Spiropsammina*** (Plate 3, Figure 2)

First reference: Seiglie and Baker 1983, p. 396. Unit of reference: *Cyclammina uhligi* Schubert 1902a, p. 22, pl. 1, fig. 27.
Test morphology. Test is free and consists of two distinct growth stages; the early stage is formed by proloculus followed by chambers added in a planispiral coil that form up to three whorls, whereas in the later one the chambers are added along a straight to slightly curved growth axis. The early coil is evolute to evolute–involute. The test is laterally compressed, with nearly parallel sides. Sutures are often indistinct. Aperture is single, rounded and in terminal position. Test wall consists of a mixture of fine and medium coarse agglutinated particles bounded by variable amounts of cement; the wall is alveolar at the interior.
Stratigraphical interval: Upper Oligocene-Lower Pliocene (Chattian–Zanclean). Geographical distribution: EU (Austria, France, Poland), Atlantic Ocean (off Cameroon).
Ancestry. *Spiropsammina* descended from *Ammomarginulina* by an evident increase of the relative size of the early planispiral coil, a reduction of the late uniserial stage and the development of a wall with an internal alveolar ultrastructure.

IOS-10/D1: complexly ramified branch-**flabellamminas**

Description. The early representatives of this complexly ramified branch have laterally compressed tests with a later flaring stage or with parallel sides. The diversification is mostly apparent in the development of an early triadiate or quadriradiate stage, chevron-like to anteriorly curved chambers in the later stage, a large aperture or multiple apertures and a wall with an internal alveolar ultrastructure. Most of tests are free and rarely adopted an attached mode of life.
Stratigraphical interval: Middle Jurassic–Upper Cretaceous (Bajocian–Turonian).

Group of lineages ***Flabellammina*** (Plate 3, Figure 3)

First reference: Cushman 1928a, p. 1. Unit of reference: *Flabellammina alexanderi* Cushman 1928a, p. 1, pl. 1, figs. 3–4.
Test morphology. Test is multilocular and consists of two distinct growth stages: the early stage presents the chambers added in a planispiral coil forming one whorl, occasionally more, whereas in the adult one the chambers uniserially added along a straight growth axis. The chambers of the adult stage often have a chevron-like shape. The test has a general flattened aspect, with a subangular periphery. Aperture is small and rounded and is situated in terminal position on the last-formed chamber. Test wall is agglutinated, with fine to moderately coarse particles bounded by cement.
Stratigraphical interval: Middle Jurassic–Upper Cretaceous (Bajocian–Turonian). Geographical distribution: USA, Canada, EU (Germany, Poland, Romania), Russia.
Ancestry. *Flabellammina* descended from *Ammomarginulina* through the development of chevron-like chambers at least in the terminal portion of the adult stage.

Ramified lineage ***Flabellamminopsis*** (Plate 3, Figure 4)

First reference: Małecki 1954b, p. 104. Unit of reference: *Flabellamminopsis variabilis* Małecki 1954b, p. 105, pl. 3, fig. 11, pl. 4, figs. 9–11.
Test morphology. Test is free and with two growth stages; the early stage is formed by chambers added in a planispiral coil, rarely forming more than one whorl, whereas the later one presents uniserially chevron-like or anteriorly curved chambers added along a straight axis. The chambers of the earlier portion can be triradiate or quadriradiate, whereas those of the terminal part are laterally compressed. Aperture is single, rounded, in terminal position on the last-formed chambers and produced on a short neck. Test wall is agglutinated, with an internal alveolar ultrastructure.
Stratigraphical interval: Middle Jurassic (upper Bajocian–lower Bathonian). Geographical distribution: EU (Poland).
Ancestry. *Flabellamminopsis* descended from *Flabellammina* through the reduction of the early planispirally coiled stage and the development of triradiate or quadriradiate chambers in the earlier portion and a wall with internal alveolar ultrastructure.

Condensed lineage ***Lapillincola*** (Plate 3, Figure 5)

First reference: Wilson 1986, p. 3. Unit of reference: *Lapillincola faringdonensis* Wilson 1986, p. 3, pl. 1, fig. 4, pl. 2, figs. 1–2.
Test morphology. Test is attached and multilocular, consisting of the proloculus followed by successive chambers that form two growth stages; the early stage consists of chambers added in a planispiral coil, and the later one with low chambers that are added along a straight growth axis and increase moderately in width resulting in a flabelliform test aspect. Sutures are distinct and weakly depressed. Aperture is multiple, a row of larger pores on the anterior face of the last-formed chamber. Test wall is finely agglutinated.
Stratigraphical interval: Lower Cretaceous (Aptian). Geographical distribution: UK (England).
Ancestry. *Lapillincola* descended from *Flabellammina* by adopting an attached mode of life and the development of tests with multiple apertures on the anterior face of the last-formed chamber.

Condensed lineage ***Pterammina*** (Plate 3, Figure 6)

First reference: Hamaoui 1965, p. 20. Unit of reference: *Pterammina israelensis* Hamaoui 1965, p. 20, pl. 6, figs. 20–24.
Test morphology. Test is free, consisting of the proloculus followed by chambers forming two distinct growth stages. The early stage is relatively small and consists of chambers added in a planispiral coil, and the later stage presents transversally elongated and anteriorly curved chambers uniserially added along a straight axis. The test presents a laterally compressed aspect, is thicker at the center and strongly flattened towards the angular peripheral sides. The sutures are weakly depressed but distinct. Aperture is single, relatively large, elongated and situated in terminal position on the last-formed chamber. The test wall is finely agglutinated, with considerable amounts of cement.
Stratigraphical interval: Upper Cretaceous (upper Cenomanian). Geographical distribution: Israel.
Ancestry. *Pterammina* descended from *Flabellammina* through the development of tests with more numerous chambers and angular periphery.

IOS-11: group of lineages ***Placopsilina*** (Plate 3, Figure 7)

First reference: d'Orbigny 1850, p. 96. Unit of reference: *Placopsilina cenomana* d'Orbigny 1850, p. 185.
Test morphology. Test is attached and multilocular, consisting of two growth stages: the early stage is formed of chambers added in a planispiral coil of one whorl followed by the adult stage in which the chambers are added along an

irregular axis. Sutures are distinct and depressed. Aperture is simple or bordered by a thin lip and rounded, situated in terminal position on the last-formed chamber. Test wall is agglutinated, consisting of fine to moderately coarse particles bounded by cement.
Stratigraphical interval: Middle Jurassic (Bajocian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Placopsilina* descended from *Ammobaculites* by adopting an attached mode of life and through the development of tests with an irregular growth axis.

IOS-12: directional branch-**praekaraisellas**

Description. The representatives of this directional branch present a test with three growth stages: an early streptospiral one, a median stage with planispiral coil and a later uncoiled stage. The streptospiral stage and the uncoiled stage can be lost in the later representatives. The wall is agglutinated and simple in the early representatives and canaliculate in the later ones.
Stratigraphical interval: Middle Jurassic–Upper Cretaceous (Callovian–Cenomanian).

Ramified lineage ***Praekaraisella*** (Plate 3, Figure 8)

First reference: Kurbatov 1972, p. 11. Unit of reference: *Praekaraisella vandobensis* Kurbatov 1972, p. 11, pl. 5, figs. 7-8, pl. 6, figs. 1–7.
Test morphology. Test is free and consists of three growth stages; the earliest stage consists of chambers added along a streptospiral axis, then follows a stage with planispirally added chambers that can form up to three whorls, whereas the later stage is formed of uniserially added chambers along a straight or slightly curved growth line. Together, the early coiled stages are biumbilicate, evolute, slightly laterally compressed and occupy most of the test. Sutures are distinct and depressed throughout. Aperture is a low arch at the base of the last-formed chamber in the planispiral stage and rounded, terminal and produced on a short neck in the uniserial one. Test wall is agglutinated, consisting of fine to moderately coarse particles bounded by considerable amounts of cement. The septal bases are often thickened.
Stratigraphical interval: Middle–Upper Jurassic (Callovian–Oxfordian). Geographical distribution: Uzbekistan.
Ancestry. The evolution from *Ammobaculites* to *Praekaraisella* is marked mostly by the development of a small streptospirally coiled stage following the proloculus and thickened septal bases.

Condensed lineage ***Karaisella*** (Plate 3, Figure 9)

First reference: Kurbatov 1971, p. 121. Unit of reference: *Karaisella uzbekistanica* Kurbatov 1971, p. 123, pl. 2, figs. 1–3, pl. 3, figs. 1–5.
Test morphology. Test is free and consists of the proloculus followed by two growth stages. The first one consists of chambers added along a streptospirally coiled axis and is followed a second one in which the chambers are planispirally added; the planispiral stage occupies the most part of the test. Occasional specimens present a tendency to uncoil of the last-formed chamber. The test presents a general laterally compressed aspect, with involute to involute–evolute coiling and rounded to subrounded periphery. Sutures are distinct, often anteriorly arched and slightly depressed. The aperture is situated in the central part or slightly eccentric of the anterior face of the last-formed chamber. Test wall is agglutinated, consisting of small-sized particles bounded by large amounts of cement. The septal bases are thickened and low.
Stratigraphical interval: Upper Jurassic (Oxfordian). Geographical distribution: Uzbekistan.
Ancestry. *Karaisella* descended from *Praekaraisella* through the increase in size of the streptospirally coiled stage that follows the proloculus, the complete loss of the late uniserial stage and an increase in prominence of the septal thickenings.

Ramified lineage ***Melathrokerion*** (Plate 3, Figure 10)

First reference: Brönnimann and Conrad 1966, p. 132. Unit of reference: *Melathrokerion valserinensis* Brönnimann and Conrad 1966, p. 137, pl. 1–3, text–figs. 1–11.
Test morphology. Test is free and consists of the proloculus followed by a small stage in which chambers are streptospirally added and a second stage consisting of chambers added in a planispiral coil; a tendency to uncoil in the last-formed one or two chamber occurs in occasional specimens. The test has a general lenticular shape with involute coil, is biumbilicate and presents a subangular to subrounded periphery. Sutures are distinct and slightly depressed, resulting in a nearly circular test outline in lateral view. Aperture is single, with a crescent-shaped to subtriangular outline, often situated in a depressional portion on the anterior face of the last-formed chambers. Test wall is finely agglutinated, with considerable amounts of cement; it presents thin transversal canaliculi that confer it a fibrous aspect in thin sections. The septal junctions are thickened.
Stratigraphical interval: Upper Jurassic–Lower Cretaceous (Oxfordian–lower Aptian). Geographical distribution: Switzerland, EU (France, Spain, Bulgaria, Romania), Serbia, Ukraine (Crimea).
Ancestry. *Melathrokerion* descended from *Karaisella* through the development of a crescent-shaped to subtriangular aperture, more prominent septal junction thickenings and a canaliculate wall.

Ramified lineage ***Charentia*** (Plate 3, Figure 11)

First reference: Neumann 1965, p. 93. Unit of reference: *Charentia cuvillieri* Neumann 1965, p. 93, pl. 2, figs. 6–12, text-figs. 6–8.
Scientific synonym: *Tonasia*-Gorbachik 1968, p. 7.
Test morphology. Test is free and consists of two distinct growth stages; the early stage presents chambers added in a planispiral coil that form up to four whorls, whereas the later stage consists of uniserially added chambers along a straight growth line. The test presents a laterally compressed aspect, with biumbilicate and involute early stage and a subangular to subrounded periphery. The chambers increase slowly in size in the planispiral stage and this is often encountered in the later one too, but a higher rate of size increase resulting in distally flaring tests is also known. The aperture is situated on the anterior face of the last-formed chamber, is subtriangular in the early stage and elongated, paralleling the longer chamber sides in the later stage. Test wall is finely agglutinated, with considerable amounts of cement; it presents thin transversal canaliculi. The test interior presents thickened septal junctions.
Stratigraphical interval: Upper Jurassic–Upper Cretaceous (upper Oxfordian–Cenomanian). Geographical distribution: EU (France, Spain, Romania), Algeria, Egypt, Jordan, USA (Texas), Ukraine (Crimea).
Ancestry. *Charentia* descended from *Melathrokerion* as indicated by the general aspect and aperture shape in the early planispiral coil, the wall with canaliculi and the test interior with thickened septal junctions; in addition, there is a complete loss of the early streptospiral coil, development of a later stage with uniserial chamber arrangement and a change of the aperture shape to elongated in the later stage.

IOS-13: directional branch-**haplophragmiums**

Description. This directional branch consists of units with an early streptospiral stage followed by a later uniserial one. Aperture is single or multiple. The wall consists of agglutinated particles with relatively small amounts of cement.
Stratigraphical interval: Upper Jurassic–Lower Cretaceous (Oxfordian–Aptian).

Group of lineages ***Haplophragmium*** (Plate 3, Figure 12)

First reference: Reuss 1860a, p. 217. Unit of reference: *Spirolina aequalis* Roemer 1841, p. 98, pl. 15, fig. 27.
Test morphology. Test is free and consists of subglobular chambers that form two distinct growth stages; the early stage is streptospirally coiled, whereas the later one presents chambers added uniserially along a straight, rarely curved axis. Sutures are distinct and depressed. Aperture is single, simple, rounded and in terminal position on the last-formed chamber; the aperture can be produced on a short neck or not. Test wall is agglutinated, consisting of fine to moderately coarse particles bounded by relatively small amounts of cement; rare alveoli occur in the internal portion of the wall.
Stratigraphical interval: Upper Jurassic–Lower Cretaceous (Oxfordian–Aptian). Geographical distribution: EU (Germany, Austria, Czech Republic, Romania), Switzerland.
Ancestry. *Haplophragmium* descended from *Ammobaculites* through the development of an early stage with streptospiral coil from a planispiral one and a test wall with rare alveoli.

Condensed lineage ***Pseudocoprolithina*** (Plate 3, Figure 13)

First reference: this work; the name translates as "the false *Coprolithina*". Unit of reference: *Coprolithina ebusitana* Colom 1982, p. 442, pl. 1, figs. 1–3.
Test morphology. Test is free consisting of a few chambers that present two growth stages; the early stage is formed of up to five chambers arranged in a tight streptospiral coil and the later one consists of two to three chambers arranged uniserially. The chambers of the early stage increase in size at a high rate and there is no apparent increase in size between those of the later stage. Sutures are weakly marked to indistinct. Aperture is single or double, on the anterior face of the last-formed chamber, and can be surrounded by a prominent rounded rim. Test wall is agglutinated, consisting of fine to moderately coarse particles bounded by cement.
Stratigraphical interval: Lower Cretaceous (upper Barremian–lower Aptian). Geographical distribution: EU (Spain).
Ancestry. *Pseudocoprolithina* descended from *Haplophragmium* through the development of tests consisting of fewer chambers but with an identical succession of growth stages, chambers wider than high in the later stage, a test surface with wrinkled aspect, rimmed anterior face and aperture that in the later stage can be simple or double.

IOS-14: directional branch-**lituolas**

Description. The representatives of this directional branch consist of units with an early planispiral stage and a later uncoiled one. The diversification is mostly apparent in the development of a cribrate aperture and a densely canaliculate agglutinated wall.
Stratigraphical interval: Upper Jurassic (Kimmeridgian)–Holocene.

Group of lineages ***Lituola*** (Plate 3, Figure 14)

First reference: Lamarck 1804, p. 242. Unit of reference: *Lituolites nautiloidea* Lamarck 1804, p. 243.
Scientific synonyms: *Stylolina*-Karrer 1877, p. 371; *Cribrospirella*-Marie 1941, p. 28.
Test morphology. Test is free and consists of two growth stages; the early stage is large and consists of chambers added in a planispiral coil forming up to four whorls, whereas in the later one the chambers are uniserially added along a straight or curved growth axis. The test is laterally compressed, with a rounded and simple periphery. Sutures are distinct

and depressed throughout. Aperture is cribrate and situated in terminal position on the last-formed chamber. Test wall is agglutinated and simple, consisting of fine to medium coarse particles bounded by cement.
Stratigraphical interval: Upper Jurassic (Kimmeridgian)–Holocene. Geographical distribution: cosmopolitan.
Ancestry. *Lituola* descended from *Ammobaculites* through the formation of a well-developed early planispirally coiled stage consisting of up to four chambers and a cribrate aperture.

Condensed lineage ***Zagrosella*** (Plate 3, Figure 15)

First reference: Schlagintweit and Rashidi 2017b, p. 6. Unit of reference: *Zagrosella rigaudii* Schlagintweit and Rashidi 2017b, p. 7, figs. 4: a–b, 5: a–h, 6: a–i, 7: a–l.
Test morphology. Test is free, consisting of the proloculus followed by successively added chambers that form two distinct growth stages; in the early stage, the chambers form a planispiral coil and in the later one, a uniserial coil, along a straight or slightly curved axis. The planispiral stage diameter is larger than the diameter of the chambers of the later stage. Sutures are distinct and depressed. Aperture is single in the earliest chambers, a low arch at the base of the anterior face, then is migrated towards the central portion of the anterior face and finally, cribrate in the last chambers of the early stage and throughout the uniserial stage. Test wall is finely agglutinated and densely canaliculate, with a keriotheca-like aspect.
Stratigraphical interval: Upper Cretaceous (upper Maastrichtian). Geographical distribution: Iran.
Ancestry. *Zagrosella* descended from *Lituola* through the development of tests with a canaliculate wall.

IOS-15: directional branch-**buccicrenatas**

Description. This directional branch consists of units with a planispiral coil that can have a short uncoiled later stage. The wall is agglutinated, with a thicker inner layer with alveolar ultrastructure and alveoli that bifurcate towards the periphery.
Stratigraphical interval: Upper Jurassic–Upper Cretaceous (Kimmeridgian–Cenomanian).

Group of lineages ***Buccicrenata*** (Plate 3, Figure 16)

First reference: Loeblich and Tappan 1949a, p. 252. Unit of reference: *Ammobaculites subgoodlandensis* Vanderpool 1933, p. 407, pl. 49, figs. 1–3.
Test morphology. Test is free and consists of the proloculus followed by chambers added successively and forming two growth stages. The early stage presents the chambers added in a planispiral coil, whereas in the later one they are uniserially added along a slightly irregular axis. The test is laterally compressed, with a rounded and simple periphery. Sutures are distinct and depressed, occasionally incised resulting in a lobate outline. Aperture in the later stage is in terminal position and has the shape of a straight or zigzag slit. Test wall is moderately to coarsely agglutinated and double layered, with an imperforated thin outer layer and a thicker inner one that presents alveoli that can bifurcate.
Stratigraphical interval: Upper Jurassic–Upper Cretaceous (Kimmeridgian–Cenomanian). Geographical distribution: USA (Oklahoma, Texas, Florida), Venezuela, EU (Croatia), Lebanon, United Arab Emirates, Libya.
Ancestry. *Buccicrenata* descended from *Ammobaculites* through the development of tests with a slit-like aperture in the later stage and double layered test wall in which the internal layer presents an alveolar ultrastructure.

Condensed lineage ***Alveocyclammina*** (Plate 3, Figure 17)

First reference: Hillebrandt 1971, p. 14. Unit of reference: *Alveocyclammina andina* Hillebrandt 1971, p. 14, pl. 1, figs. 1–4, pl. 2, figs. 1–6, pl. 3, fig. 1, text–fig. 1.
Test morphology. Test is free, consisting of proloculus followed by chambers added in a planispiral coil throughout the ontogeny. The chambers are subglobular and increase slowly in size as added. The test is laterally compressed, involute and biumbilicate and with a broadly rounded and simple periphery. The aperture is a low arch at the base of the anterior face of the last-formed chamber. Test wall is finely agglutinated and double layered. The outer layer is thin and imperforated whereas the internal one is thicker and presents an alveolar ultrastructure; the alveoli present a complex branching pattern towards the periphery.
Stratigraphical interval: Lower Cretaceous (lower Albian). Geographical distribution: Peru.
Ancestry. *Alveocyclammina* descended from *Buccicrenata* through the development of tests without a later uncoiled, rectilinear stage and test wall in which the internal layer with alveolar ultrastructure presents a complex branching pattern of the alveoli.

IOS-16: condensed lineage ***Bulbophragmium*** (Plate 3, Figure 18)

First reference: Maync 1952a, p. 46. Unit of reference: *Haplophragmium aequale* Reuss 1860a, p. 218, pl. 11, fig. 2.
Test morphology. Test is free and consists of subglobular chambers arranged in two distinct growth stages; the early stage consists of chambers added in a streptospiral coil, whereas the later stage is formed by chambers uniserially added along a straight axis. The aperture is cribrate and situated in terminal position. The wall is agglutinated, consisting of fine to moderately coarse particles bounded by cement. The chamber interior is partitioned by vertical lamellae that present a radial display in transverse section and can bifurcate distally or not.
Stratigraphical interval: Upper Jurassic–Upper Cretaceous (Tithonian–Campanian). Geographical distribution: EU (Austria, France).