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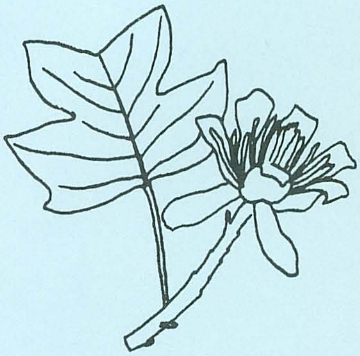

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Miocene—Pleistocene planktic foraminifers from D.S.D.P. Sites 208 and 77, and phylogeny and classification of Cenozoic species

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Editor's Note: The abstract begins on page 5.

PREFACE

The intending reader of this taxonomic work may benefit from warnings regarding the unconventional nature of its methodology, the lack of incorporation of the more recent literature relevant to it, and the context in which the results are submitted.

Peculiarities of the methodology can be highlighted by contrast with a more standard treatment such as Kennett & Srinivasan's (1983) Phylogenetic Atlas of late-Cenozoic planktic foraminifers. The basic taxa of the Atlas were subspecies, species, or monospecific genera which were treated as discrete entities each with a detectable geologic-time range and each capable of morphologic diagnosis. Ancestors of virtually all of the basic taxa were proposed and so led to a completely interconnected phylogenetic tree within the upper-Cenozoic coverage of the Atlas. Selected portions of this tree were designated as 'lineages' and assigned subgenera or genera. These lineages could be defined to include the earliest indication of a (reproductively isolating?) morphologic trend or only its later manifestations. An example of the latter was the evolution of tightly coiled taxa from *Sphaeroidinellopsis seminulina* in the late Miocene. The early part of this trend was assigned to the *Sphaeroidinellopsis* lineage whereas the later part was assigned to the *Sphaeroidinella* lineage. In addition, a single nominal species could be defined so as to successively give rise to other species of its lineage or other lineages. For example, *Globorotalia* (*Globoconella*) *praescitula* was considered to evolve, sequentially in the early to middle Miocene, into *Globorotalia* (*Globoconella*) *miozea*, *Globorotalia* (*Menardelia*) *archeomenardii*, *Globorotalia* (*Hirsutella*) *challengeri*, *Globorotalia* (*Globoconella*) *panda*, and *Globorotalia* (*Hirsutella*) *scitula*, and then to retain its specific identity. Also, within one lineage successive taxa could coexist. For example, in the late Pliocene there were six quite recently evolved nominal species of *Globorotalia* (*Menardella*), five of which were extinct by the early Pleistocene. A suprageneric classification was not used in the Atlas. However, the genera were listed to represent a general phylogenetic arrangement.

Kennett & Srinivasan's (1983) Atlas can be welcomed as a further refinement and synthesis of a variety of previous approaches to the documentation of planktic foraminifers. These approaches reflected different needs of the workers involved: easily recognized taxa for routine biostratigraphy; emphasis on overall morphology for routine classification; detection of anagenetic change for high-resolution biostratigraphy; taxic-distributional analysis for oceanographic and palaeoceanographic application; reconstruction of phylogeny for various reasons; and inclusion of detailed morphology as a set of classificatory criteria to better depict evolutionary history. A critical view of the classifications of the Atlas and its predecessors might, however, consider them to be a series of pragmatic compromises among an accumulating list of newly emphasized aspects of the palaeontology of planktic foraminifers. The reasons for these emphases have usually satisfied the necessary scientific requirement of explanatory relevance but seem to have been unreasonably deficient in the requirement of testability. This assertion can be supported by asking of the Atlas questions such as the following. How can the evolutionary appearance of a taxon be determined? If this depends on the acquisition of distinctive morphology, what level of distinctness from ancestral taxa is required? How distinct should the taxon be from coexisting taxa to be formally recognized? What criteria are required to assign a particular taxonomic category? (Nominal subspecies are permitted to coexist. A nominal genus can arise with or during an anagenetic trend. A generic-group taxon can arise several times from one nominal species even though other generic-group taxa have arisen inbetween.)

Evaluation of the philosophic adequacy of approaches to classification of planktic foraminifers is a nonscientific endeavour. In this pursuit one might prefer to label the strategies of the last few decades as a series of paradigms each fundamentally reexamining its predecessor. Alternatively, they could, as is implied here, be lumped into a single uncritically accepted approach which, though modified with increased information, ignores basic problems of the scientific classification of evolutionary change both spatially and temporally. I have broached this issue here merely to place the methodology presented below into a context more amenable to the reader.

The basic taxa of this work are species. These are detected in a palaeontologic sample as morphologically isolated clusters of intergrading specimens. In sequences of samples a single species would, within the limitations of preservation, accumulation, and sampling, be required to display a continuum of intergradation. Two species with an immediate common ancestor originate after the final indications of intergradation between the respective components in the ancestral species cluster. A corollary is that a species ceased to exist once it had undergone such a splitting event. Terminal extinction is the only other mechanism for species change adopted by this methodology. A subspecies is accepted as a geographically isolated subset of populations within a species. In the fossil record relevant evidence would thus be temporary discontinuities in spatial distribution of species clusters. These operational definitions of those species-group taxa under consideration will imply, by themselves, a reconstruction of the cladogenetic framework of their entire phylogenetic tree. Thus additional concepts, such as the 'lineage' used by the Atlas, are not necessary. Supraspecific taxa are therefore peripheral in this approach and are derived for purely practical purposes. For example, the genus is used herein to group two terminal species with the same immediate common ancestor as well as all ancestral species back through time until a genus-group name is met which was nomenclaturally available earlier.

The methodology used in this work does not suffer from the operational difficulties encountered in Kennett & Srinivasan's (1983) Atlas. For example, the scheme presented herein suggests there to have been one menardiform species, *Globorotalia cultrata*, in the late Pliocene. If corresponding assemblages do not consistently display complete intragradation among menardiform specimens, then this part of the scheme will have been falsified and an appropriate amendment to the scheme will ensure elimination of this error. Alternatively, the Atlas postulates six menardiform species at this time. This presumably predicts that six menardiform entities capable of unique diagnosis were present. The ability to recognize distinctive taxa will depend on the variability of the collections and the detail of observation made. How much detail would be appropriate? To enable testability how could the degree of detail used be proved, in principle, to be wrong? The answer is not readily apparent.

Another contrast between the methodologies of this work and the Atlas is highlighted by the treatment of temporal extent and variability of *Sphaeroidinella dehiscens*. In this work it is proposed that the monospecific genus, *Sphaeroidinella*, appeared in the middle Miocene and crossed the Miocene--Pliocene boundary as a single species. The inclusion of only one species in *Sphaeroidinella* automatically results from the interpretation of a single lineage which arose from a globigeriniform ancestor carrying the earlier-available name, *Globigerina*. Testing of the substantive phylogenetic components of this scheme can be performed as previously discussed. But, once a particular scheme is provisionally accepted, the generic assignment follows according to definition as is appropriate for a nonsubstantive aspect (the appropriateness of such definitions is worthy of debate but not individual implementations of them). With regard to a single sphaeroidinelliform species at the Miocene--Pliocene boundary, if discontinuities in intragradation among specimens from this level were consistently detected, this postulate would be rejected. On the other hand, the Atlas in this case recognizes four species of this kind from this interval and suggests that *S. dehiscens* appeared at this level both as an additional species and an additional genus. How can these assertions be tested? Is the possession of a supplementary opening a sufficient requirement for a different genus? A different species? Why in *S. dehiscens excavata* is the extension of the openings which result in connection of dorsal and ventral openings only a subspecies event?

A final contrast between the methodologies in question is afforded by the supraspecific treatment of lineages. Returning to the Atlas's interpretation of the descendants of *Globorotalia* (*Globoconella*) *praescitula*, it has been noted that the same subgenera arise more than once from this species. This polyphyly in a system which purports to be 'based solely on phylogenetic considerations' (Srinivasan & Kennett, 1981, p. 40) is very confusing. As discussed above, generic assignment in the present work is considered nonsubstantive---it merely follows from the reconstruction of the framework of the phylogeny. Thus semantic debate arising from misleading practices such as mentioned immediately above are avoided.

Leaving methodology, the reader needs to be alerted to the lack of reference in this work to the more recent literature. There are several reasons for not updating the systematic portion of the original manuscript prepared in 1979. Firstly, thorough implementation of the methodology adopted herein requires an enormous amount of coordination and cross-referencing between distribution tables, illustrations, and text. Alterations are thus highly time-consuming. Secondly, as will be apparent from the above discussion, the literature is steeped in a very different taxonomic tradition from that employed here. Thus new publications serve only to add more data on stratigraphic distribution and the like and have no bearing on the method itself. Thirdly, the days of rapid increase in newly discovered species are over. So new publications would add relatively minor details, bearing in mind the broad scope of this work. Their incorporation would not be cost-efficient in the context of the need to publicize an alternative methodology.

Finally, reviews of this work suggest the need for a third warning. The primary purpose of this study is to propose a taxonomic methodology which is scientifically rigorous and operational. Its practical application to a real rather than hypothetical group of organisms is a necessary part of the latter aim. However, this application will be limited by the data available to the author and there is no doubt a significant number of errors in the submitted results. These errors will certainly need to be addressed and their communication is to be welcomed. However, they do not, in themselves, impinge upon the scientific qualities of the taxonomy proposed.

ABSTRACT

Rich assemblages of tropical and subtropical planktic foraminifers from two coarsely sampled upper-Cenozoic deep-sea sequences suggest the need for changes in taxonomic method with a corresponding reclassification which includes all Cenozoic species. This is necessitated by the observation that representative collections of assemblages from phylogenetic lineages exhibit unexpectedly high degrees of variation in test morphology both within assemblages and through sequences of assemblages, and so much more inclusive concepts of many species are required. Also, speciation events in many of these species lineages appear to have been preserved by the appearance of discontinuities in variation within sequences of assemblages. These observations combined with the extensive literature which documents stratigraphic distribution of infraspecific taxa are used to revise the phylogeny of late-Cenozoic species with regard to the branching sequence. This method of phylogeny reconstruction has been termed stratophenetic analysis by P.D. Gingerich. Because the common ancestry of most of these clades appears to lie in the early Cenozoic, the branching sequence is extended to the beginning of the Cenozoic based on the work of W.H. Blow. Two complementary suprageneric classifications of Cenozoic species are offered, each based on this cladogram. Both schemes refer to a revised set of generic and species taxa. The fossil species is defined cladistically: a lineage of populations existing from the splitting event of its immediate ancestor until splitting into its descendants or until terminal extinction. Degree of anagenesis associated with cladogenesis or occurring between cladogenetic events is ignored in species definition. This taxonomy results in 138 nominal Cenozoic species (four new), one for each internodal segment of the cladogram. The genus is defined phylogenetically but is neither cladistic nor, as normally applied, phylic. For primarily practical purposes the genus is used to combine species which form an ancestor--descendant series and so tends to distinguish between sets of evolutionarily conservative and specialized species. The extent of these series is determined by relative times of availability of genus-group names. The method results in fifty nominal Cenozoic genera (eight new). The two suprageneric classifications proposed are phylogenetic. One employs the traditional categories recognized by the International Nomenclatural Codes and emphasizes monophyletic groups of species with broadly similar degrees of diversification while adhering as closely as practicable to established suprageneric concepts. This classification consists of two families, six subfamilies, and twelve tribes (four new). The other classification is strictly cladistic and is expressed by a new nomenclature of seventy-three 'cladegroups'. The two classifications can be broadly compared as follows:

cladophylistic	cladistic
Globerigerinacea	Globigerinivicesimaeseptimae
Heterohelicidae	Heterohelicidecimae
Guembelitriinae	Guembelitriquintae
Heterohelicinae	Heterohelicinonae
Globigerinidae	Globigerinivicesimae
Globigerininae	Globigerinivicesimae (part)
Candeininae	Candeinidecimae
Truncorotaloidinae	Turborotalisextae
Globorotaliinae	Globorotalinonae.

In order to overcome the practical problem of documentation of anagenetic change and population variation useful to stratigraphic and ecologic application within the more inclusive nominal species defined herein, the 'phenon' is used to represent morphologically defined infraspecific taxa. Of these, fifty-three are introduced as new subspecies and two new names are erected.

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INTRODUCTION

The planktic Foraminifera are sexual organisms with a very rich fossil record. More significantly they are one of the most used fossils in applied palaeontology. Thus it is of considerable importance that they be documented as consistently as is practicable by their many students. However, consistency in both classification and nomenclature has been made difficult by the very different practical requirements of the most valuable applications of planktic foraminifers. Mesozoic and Cenozoic high-resolution marine biostratigraphy requires that planktic-foraminiferal taxa be easily recognizable and short-lived. However, for oceanographic application species which are defined biologically (in the modern sense) are required, and in palaeoceanography it is preferred that extant species be found as low as possible in the geologic record.

The very different objectives of biostratigraphy and oceanography did not cause major problems when extensive planktic-foraminiferal biostratigraphic schemes were first proposed in 'Studies in Foraminifera' (Loeblich & others, 1957). In these studies many newly recognized planktic-foraminiferal biozones allowed interpretation of much finer geochronologic subdivisions of the late Cretaceous and Cenozoic than had previous work. However, the emphasis remained pragmatic: broadly based quite variable nominal species, easily recognizable by all students. The dichotomy with oceanographic applications became evident when homotaxic subdivisions of these species, made for finer biostratigraphic resolution and variously designated species, subspecies, and other infraspecific categories, did not concur with reliable observations on variation in living species (for example, Parker, 1962, 1967). Apart from workers who almost exclusively emphasized either biostratigraphic or oceanographic considerations but not both, subsequent students sought a compromise. Thus planktic-foraminiferal classification has neither included all potentially homotaxic variants in diachronous fossil lineages nor attempted to fully describe the synchronous variation of biologic species in the fossil record. In this study a taxonomy is proposed to provide a common framework within which both of these important objectives can be realized.

It is argued below that accurate representation of the fossil record must be compatible with the modern species concept. In particular this requires that nominal fossil species include all specimens which appear, on morphologic or other grounds, to have been potentially interfertile. Thus intuitive subdivision of a morphologically intragrading fossil assemblage (representing interbreeding organisms from a single geologic-time plane) into species taxa which may be used for, say, biostratigraphic zonation seriously misrepresents the fossil record. This is considered the primary cause of inconsistent documentation amongst biostratigraphic studies as well as between these and, for example, oceanographic studies. It is similarly suggested that application of the subspecies category to fossils must be compatible with the modern subspecies concept if confusion is to be avoided. For instance, apparently conspecific variants from the same locality cannot be legitimately placed into different nominal (geographic) subspecies. Rather than use the species and subspecies categories misleadingly, it is proposed that useful subdivisions of these taxa be accorded a different category, the phenon. If this infraspecific category is given the same nomenclatural requirements as other species-group categories, then documentation of synchronous morphologic variation can be accurately and consistently represented by the trivial epithets in species-group names.

It is then argued that the rich record of the planktic Foraminifera allows stratigraphically successive assemblages, each of which exhibits continuous intragradation and which can thus be labelled 'species clusters' (Gingerich, 1979), to be interpreted as remnants of a single lineage of quite diverse populations genealogically continuous through time. Critical in this reasoning is the observation that stratigraphic sequences do not preserve a relatively large number of series which (a) through time contain a quite simple succession of similar but subtly different forms and which (b) in a single time plane contain a somewhat low range of morphologic variation and so are quite distinctive. This notion of many, distinct lineages appears, however, to have been the basis in previous work (including lineage-directed studies) for the recognition of many more species (and higher taxa) in the fossil record than actually existed at any one time or exist today. Rather, it has been observed in this study that the species clusters exhibit an unexpectedly (with regard to the literature) high degree of variation within a single sample interval and typically maintain that degree of variability as a lineage through time. Further, this variability is usually high enough and well enough preserved (at least if the species is quite common in a sampled stratigraphic section) to permit clusters in successive assemblages, even if they are relatively coarsely spaced, to be quite confidently interpreted as parts of a single, variable lineage through time.

Strongly convincing documentation of the above-mentioned sequences of variation would presumably require, for example, numerous illustrations and quantification and this is considered beyond the scope of this study. However, the introduction of the phenon category has enabled qualitative depiction of not only synchronous morphologic variation but also its stratigraphic distribution (via morphologic details conveyed in the 'Phena recorded' sections in the text). For this purpose a new style of presentation of stratigraphic distribution of taxa (Tables 3, 4) is used to enable both explicit documentation of lineage variability and potential testing of these same observations by reinvestigation of these samples. Importantly, the basis of these distribution tables is the assignment of all specimens recorded (>63 µm) in the fully picked, representative collection (RS1) to a phenon and thus to a species. The selection of certain specimens for identification, distinctive because of, say, their size or similarity to available taxa, is deliberately avoided. Further, a considerable number of scanning electron micrographs (of over 1400 specimens; at only two levels of magnification for ease of comparision; arranged in stratigraphic sequence within each section) are presented and some lineages are represented by several illustrated specimens of each phenon.

Given that continuous variation in a single time plane indicative of interbreeding should not be intuitively subdivided into nominal species, it is then argued that the speciation event is the only objective (or nonintuitive) boundary, apart from terminal extinction, available for fossil-species taxa. The nominal fossil species is then a lineage of populations successive through time beginning with those isolated by a splitting event and ending with a subsequent splitting event or with terminal extinction. The nominal living species is the extant end-point of a fossil-species lineage. Thus fossil- and living-species taxa are made compatible and so studies such as oceanography can use the same taxa for fossil and living organisms.

It is further suggested that the application of the above-mentioned species definition is practically possible. In particular, the rich fossil record of the planktic Foraminifera potentially allows speciation events to be confidently placed between ancestral species lineages and their descendants. The method employed for detection of speciation is an extension of that discussed above and used to interpret species lineages through time. It follows from the recognition, at their lowest stratigraphic occurrence, of species clusters additional to those recognized in immediately underlying assemblages. Interpretation of the relationship of these additional species to ancestral and sister-descendant species is based on morphologic similarity, in particular, the sharing of phena with the ancestor, between, and this is very important, stratigraphically successive clusters. This method is then stratophenetic (Gingerich, 1979), not cladistic (Hennig, 1950, 1966). Again, detailed results of this procedure are documented by a new style of presentation (Tables 3, 4) in which the placement of speciation events and their resultant disruption of intergradation between phena are explicitly recorded. By extension of this method all species lineages can be joined into a phylogeny which is located in geologic time.

Implementation of the above conclusions requires a reclassification at the species and infraspecific levels, and this is the primary aim of this study. However, the emphasis on the separation of evolutionary and morphologic information at these lower taxonomic categories has implications for taxonomy at higher levels. It is thus considered appropriate herein to reexamine supraspecific taxonomy as well.

It is suggested below that the long-standing controversy in suprageneric taxonomy is best accommodated in a pluralistic environment where different approaches can be entertained. However, cladistic taxonomy (see Holmes, 1980 for systematic terms and concepts), because of its nonintuitive nature, is considered to occupy a uniquely central position to which other methods can be usefully referred. This approach, based solely on the phylogenetic branching sequence, requires that taxa be holophyletic, that is, they must contain all and only those species which are considered descended from a given stem species. Further, all possible groupings of this type must be able to be named. It is argued that such demands exceed the capacity of traditional nomenclatural systems and so a new system is proposed for their implementation.

All other taxonomies are considered to be significantly intuitive and appropriate to the traditional nomenclatural systems. Of these, a method is proposed which is phylistic in that evolutionary divergence as well as branching sequence are considered. This somewhat new method is still strongly constrained by the branching sequence and is termed cladophylistic.

Finally, the genus category is reexamined. The genus is considered most appropriate to depict ancestor--descendant series and, in so doing, usefully represent an aspect of phylogeny which is rarely described by taxonomy. This is achieved by grouping together back through time all species in ancestor--descendant relationships until an earlier-available genus-group name is encountered. The genus is also used to unite terminal sister species.

In summary, it is the intention of this study to explicitly describe evolutionary history, in particular that of the Cenozoic planktic Foraminifera, in nomenclature. Basic units are species and, potentially, subspecies in evolutionary terms and phena in morphologic terms. Phylogenetic relations are expressed by supraspecific categories. Phylic relationships are expressed nonintuitively by a new cladistic classification and nomenclature and intuitively by a new phylistic classification which uses traditional nomenclature. Ancestor--descendant relationships are represented by the genus.

DISCUSSION OF THE TAXONOMIC PROPOSALS

Species-group categories

The species

Discussion. The modern species concept attributable to Mayr (1940) would seem to provide the only firm basis for taxonomic revision at the species level. Strict application of the criterion of fertility within and sterility between living species to the phylogenetic record requires the extension of living-species taxa through to at least the first population to have separated from the immediately ancestral species. Thus the recognition of successive nominal species within a lineage undergoing significant anagenesis but not splitting cannot be accepted together with the modern species concept. To do so would require an intuitive concept, arbitrarily segmenting the continuity of descent, even though a nonintuitive alternative is available. In detail further problems would arise depending on the type of criterion of lineage segmentation. If a morphologic feature were used, the two nominal species thus distinguished would coexist as long as the ancestral feature persisted and collections of assemblages from this part of the lineage would be misleadingly split into more than one nominal species. If a point in time was chosen to segment the lineage, corresponding taxonomic decisions would be subject to many lines of evidence from diverse disciplines. Thus systematic study would be subject at its basic level to frequent revision merely to establish an arbitrary boundary.

Rejection of segmentation of lineages into nominal species accentuates the problem of delineation of species during geologic time. The modern species concept exacerbates this situation by viewing the phylogenetic tree side-on, as it were, from the present time-plane. Life is from this standpoint a continuum of potential interfertility linking not only ancestors and descendants but also sister descendants (Haldane, 1956). Of course, the time dimension cannot be ignored in this way and its consideration suggests one criterion by which to delimit a species in geologic time. This is the speciation event for it is then, by definition, that interbreeding between descendant sister species breaks down. Thus, because any living species is an end-point of a continuous lineage which arose by speciation, it could be nonarbitrarily delineated only by the speciation event which gave rise to it and its sister species. Similar constraints are applicable to terminally extinct lineages.

The above argument for the splitting event as the only nonintuitive criterion for delineation of terminal (living and extinct) species can be extended to ancestral lineages. Because these are bounded in time both above and below by speciation events, they could be delineated by these limits. An ancestral species in this strict sense could not coexist with its descendants but would be nominally extinct at the later speciation event.

The notion of an ancestral species becoming nominally extinct when giving rise to its immediate descendants is of considerable concern to systematic study of fossils. A lineage may have remained unaffected, within the limits of palaeontologic study, by a speciation event and yet must be labelled a different species if the above-mentioned methodology is pursued. However, of critical consideration is the fact that there is no evidence to suggest that any natural discontinuity exists in the phylogenetic record in a continuum from unaffected lineages to those significantly affected during speciation. Thus, to separately treat these two extremes, an intuitive decision would be required for those lineages affected to an intermediate degree.

Proposal. The species category is herein used to identify each branch of a phylogenetic tree whether it be a terminal branch which is extinct or living, or an ancestral branch. Thus the splitting, or speciation, node and terminal extinction are the only limits of species definition; anagenetic processes are not considered.

The species will carry the name of the first-available species-group name whose primary type is considered to belong to that lineage. All subsequently available names are synonymous at the species level. In the case of a well-studied lineage which underwent considerable anagenesis many species-group taxa may thus be nominally conspecific and this evolutionary information will not be conveyed by species taxa. For a consecutive series of lineages which underwent insignificant anagenesis during one or more splitting events and so had been included in a single nominal species in traditional taxonomies, the valid name will apply to only one lineage segment. Naming of other segments must await and would thus presumably encourage discovery of subtle differences in these segments. It should be noted for this case that loss of any portion of an ancestral set of populations to form a new species must result in some, though not necessarily significant, change in the character of the ancestral species to form its similar descendant. If the cause of speciation is a geographical or related barrier, then the descendant which is similar to the ancestor will have a distribution different from its ancestor by virtue of this barrier. In other cases the populations isolated to form the divergent descendant must be atypical in some manner to remain intact. Such a nonrepresentative sampling of the ancestral species must result in changes to its populations.

A species as defined herein is a lineage which may contain considerable variation at a point in time, owing to the adoption of the modern neontologic species concept, as well as through time, due to the inclusion of anagenesis between speciation events. Its definition is phylogenetic, specifically cladogenetic, but not morphologic. Thus description is merely an adjunct procedure to perform practical identifications especially where evolution approaches convergence. Proposals related to morphologic description are described below under 'The phenon'.

The use of the modern species concept as the basis of the palaeontologic species concept proposed herein results in a consistent approach to distributional analysis between neontologic and palaeobiologic studies. Thus species diversities derived from taxa proposed herein will represent counts of biologic species for any one time-plane under consideration. If, however, variants (phena, see below) arising from anagenesis were given species status, diversity counts would contain a significant influence due to variation within biologic species and interpretation would be spurious.

Genetically based infraspecific categories

Discussion. Infraspecific categories recognized by the International Nomenclatural Codes are generally considered to represent groups of individuals which have distinct genetic identities. Thus the categories accepted by the Botanical Code (Stafleu, 1972) appear to be based on the concept of a biotype, a group of genetically identical individuals, if the definitions of Du Rietz (1930) are generally accepted by botanists (Stace, 1980). It would also seem to be generally accepted, at least in nonmoneran organisms, that this kind of group constitutes a natural population in that it is spatially continuous and is distinct from other similarly defined groups in organismic rather than environmental properties. However, there seems to be considerable disagreement over the distinctness which must be expressed at the boundaries of these populations in order to warrant taxonomic status. Thus the Zoological Code (I.C.Z.N., 1961) accepts only one infraspecific category, the subspecies, and this is apparently generally agreed, following Mayr (1942), to represent geographically isolated populations. The Botanical Code, however, includes the additional categories of variety, subvariety, forma, and subforma. Du Rietz's (1930) definitions of these categories appear to allow the taxonomic recognition of populations which possess relatively indistinct boundaries. Further, Stace (1980) considers the five infraspecific categories adopted by the Botanical Code to be insufficient to adequately describe variation in plants critical to the understanding of their evolutionary properties. Consensus on infraspecific taxonomy is further exacerbated by the needs of marine biologists who deal with changes in populations resulting from a variety of organismic and environmental phenonema which often show gradual rather than distinct geographic boundaries. For instance, van der Spoel (1969, 1971) has selected the category, forma, to taxonomically recognize planktic populations which bear naturally indistinct boundaries such as those in clines (see Endler, 1977). These taxonomic and, therefore, consistently definable entities are apparently needed in order to adequately document phenonema critical to the understanding of speciation in holoplankton. The inflexibility of particularly the Zoological Code with regard to infraspecific taxonomy can thus be understood to result from the dominance of terrestrial biologists in the formulation of the Codes. This would seem to be merely an historical accident (van der Spoel, 1983) and thus unjustifiable.

Proposal. Genetically based infraspecific categories have not been applied in this study. Rather, the taxonomic assessment of population variation would seemingly be most fruitfully postponed until the establishment, proposed herein, of a framework which depicts biologic species in the fossil record. However, it should be noted that such population-based infraspecific concepts are critical to the understanding of evolutionary phenonema and are certainly capable of application to the fossil record in many instances. This is especially likely with future increasingly detailed studies on groups which possess a rich geologic record. Thus, given the priority of the use of the recognized infraspecific categories for population-based groupings in neontologic studies, these categories should be retained exclusively for these purposes.

The phenon

Discussion. The phenon (Camp & Gilly, 1943) was used by Mayr (1969, pp. 5, 144--162; 1982, p. 870) for recognizable entities encountered within a population including 'the sexes (where there is sexual dimorphism), age stages, seasonal variants, and individual variants (morphs, and so on)'. This would appear to correspond to the concept of a phenodeme (Gilmour & Gregor, 1939; Gilmour & Heslop-Harrison, 1954). The concept has been found to be particularly appealing where the species memberships of taxa are not certain, for example, in numerical taxonomy. However, it would seem that generally in biology taxonomic recognition of this concept is considered unnecessary and, often, unscientific. This appears to reflect the view that taxa must represent naturally defined groupings and thus will be considered unsuitable particularly by students who similarly reject genetically based infraspecific categories such as the forma (see above) which are not constrained by naturally distinct boundaries. However, biologic nomenclature was, of course, used long before modern evolutionary concepts of natural groupings and it would therefore seem that the justification for taxonomic status reflects a more basic need. This, I would suggest, is the desire to consistently catalogue the variety of organisms which, because they are living, are in themselves irreducible as entities. They are thus discreet units in nature as opposed to the infinitely varying constructs of matter which constitute the nonliving world.

In palaeontology problems in documentation of variants can encompass those encountered in biology and include further difficulties. Such problems are particularly intrusive in high-resolution biostratigraphy wherein detailed use of homotaxial variants is a routine task. For example, in conodont biostratigraphy such variants are increasingly being labelled with Roman, Latin, or Greek, alphabetic letters and numbers, and termed 'morphotypes'. In addition in this or other fossil groups variants are often recognized by the use of vague references to formal taxa, for example, 'cf.', 'aff.', '?', and '→', as well as by reference to taxa not named at the required level, that is, usually species or subspecies.

A related problem is the need for documentation of disjunct elements of the preservable parts of a fossil organism. This problem is particularly acute when the nature of the organism is unknown or uncertain or when different elements of the preservable parts are subject to very different likelihoods of preservation, environment of deposition, or rates of evolution.

There are then several needs to catalogue variants consistently and precisely, and in applied palaeontology these needs exceed those for genetically based categories. However, the only method which has to date recognized biologic units consistently is the formal nomenclature of the Codes which relies on strict adherence to types. Informal alternatives such as those referred to above have invariably remained idiosyncratic and contributed little to the taxonomic community.

Proposal. The category, phenon, is used herein for a system of names complementary to and, as a system, as equally inclusive as that based on the species category. Whereas the latter system is used to recognize lineages defined solely by their position in the phylogeny, the system of phena is used to segment the morphologic variation, in the broadest sense, through time or space into practically useful units.

Formal recognition of the phenon is identical to that of other species-group categories (see 'Systematic listing' for strategy for introduction of new phena). The formal hierarchical position of the phenon is below species (and infraspecific categories) and any phenon is formally placed in the species which names the lineage (and, if applicable, the infraspecific taxon naming the populations) containing the primary type of the phenon. Synonymy of phena occurs when the primary types of more than one species-group taxon are considered to belong to the same practically useful morphologic unit. Thus all available species-group names are eligible for consideration as species, genetically defined infraspecific taxa, or phena, and an intended comprehensive systematic survey would assign all of these names to each of these categories being considered.

Phena as proposed herein have intuitively defined boundaries. This is because they are deliberately used to segment a continuum of morphologic variation and the degree of detail required will legitimately vary according to the application. Essential stability is maintained by strict adherence to primary-type definition. Communication of the scope of a phenon, if used broadly, can be conveyed by indicating synonymy of phena. Because phena segment a continuum, they will share boundary criteria with morphologically adjacent phena except where they represent extremes of variation. The distinguishing character or characters intuitively limit the phenon and so are the essential diagnosis for it. Description is of secondary importance.

The distribution of a phenon is not necessarily confined to one lineage. In the usual case in which speciation results in morphologic discontinuity, the descendants will not share phena (except in organisms with disjunct elements, see below). However, a phenon may survive a speciation event from the ancestral species into one of its descendants. In these cases the formal placement of the phenon is unchanged and thus so is its full formal name.

With regard to disjunct elements of an organism all can be named separately to the required detail with the phenon category. Where the homology of these elements is uncertain, for example, in organisms of unknown nature, the phenon names could be used to derive a name for the element type. This can be executed by identifying lineages which are considered to possess this type of element and then the first-available phenon name of that type belonging to those lineages may nominally represent that element type. The name can be derived by adding an appropriate suffix (for example, '-iform') to the first-available name and dropping the italic script. Again, such strict nomenclatural usage offers considerably more stability and consistency than informal methods. The use of phena rather than higher-level categories to name element types ensures that the element-type name suggests, by corresponding reference to primary type, that element type. However, if names of higher-level categories are used to assign an element-type name, there is a risk that these names will become misleading when subsequent evidence demands alterations to multielement reconstructions and thus those higher-level names. Once this procedure is completed the disjunct-element phena could be presented within groups of element types where they would be considered to continuously intragrade. The faster-evolving element types will change phena often and tend to distinguish species, and will often be the only available names for the species. The more slowly evolving element types will contain persistent phena throughout successive descendants. Also they may often occupy positions in coeval descendants as they will tend to be retained by both descendants during speciation.

Suprageneric categories

Discussion. Above the genus nomenclatural categories have much less bearing on routine identification than do the genus- and species-group categories. Whereas the genus and species categories are accepted as essential to giving a scientific name to an organism, the suprageneric categories are optional and convey more abstract notions. In some groups of organisms a majority of students have even dispensed with the traditional suprageneric categories for systematic documentation. For example, many fossil groups, especially microfossils, are mostly systematized by alphabetical order of the binomina.

At present, lack of consensus as to what kind of relationship should be conveyed by classification is so marked that a complex terminology is needed to clearly describe the various schools of thought (Holmes, 1980). Broader categories of these schools, phylogenetic, omnispective, and phenetic, differ in the degree to which evolutionary history is considered, respectively from fully to not at all. Phylogenetic schools can be described as cladistic or phylistic. The former considers only the branching sequence in phylogeny whereas the latter also takes into account degrees of evolutionary divergence. Phylistic approaches can be further subdivided according to the relative importance allocated to genotypic similarity, monophyly, or more-loosely defined aspects of practical or intuitive value. These are, respectively, the genophylistic, monophylistic, and homorophylistic schools, all of which include some of these considerations.

The diversity of taxonomic criteria still entertained today despite enormous debate suggests that a natural priority of these criteria may not exist. If this be true, the choice of method must be intuitive or practical and those not chosen cannot be rejected outright. In such a pluralistic environment the most crucial step employed by a systematicist is to explicitly state the approach adopted. Furthermore, it may be considered practicable to employ different systems of nomenclature for each method in order to reduce ambiquity. In the case of the genus and species-group categories, however, it is considered desirable herein that the corresponding concepts be standardized so that scientific names retain their general usage. The proposals for these categories are forwarded independently of those regarding suprageneric taxonomy.

Although the above discussion suggests a need for pluralism in suprageneric taxonomy, one method does seem to be able to provide a framework upon which other methods can be usefully based. Cladistic taxonomy is the only method which lacks arbitrary application given the well-accepted notion of a single phylogeny for all organisms. This is because only the branching sequence of phylogeny is considered and so all information of a relative nature, for example, grade, monophyly, or genotype, is ignored. Problems of definition with regard to the branching sequence appear to be minor and are discussed below. Critical reliance is placed upon the integrity of species through geologic time and, given this axiom, cladogenesis must be considered, on a geologic scale, to be an absolute phenomenon (that is, for a particular species it will have occurred or not occurred). Cases of reticulate evolution can even be accommodated by the method with only minor modification (Wiley, 1979).

Cladistic taxonomy is implemented by dividing the branching sequence of a phylogeny into sections beginning at the top, or most recent, extremity. Specifically, two terminal (living or extinct) species which share an immediate common ancestor are assigned, along with this ancestor, to a taxon of the lowest suprageneric category. These species have been termed sister species (Hennig, 1950, 1966). The concept of sister relationship refers to two taxa of any category which share an immediate common ancestor. The next-higher taxon is constructed by inclusion of the immediate ancestor of the above-mentioned common ancestor as well as all of the former's descendants. Where two sister taxa belong to different categories, the next-higher taxon including both these taxa is assigned a category level one above that of the higher descendant. This requirement for sister taxa can be termed node-coordinate. Further taxa of higher categories are constructed similarly and so the implementation of the taxonomy is nonintuitive.

The regular and comprehensive recognition of suprageneric groups in cladistic classifications would seem to prevent their adoption of traditional categories. Firstly, these categories, from kingdom down, do not nominally express a regular series except within the category group by the use of qualifying prefixes, namely, super- and sub-. Their application to cladistic taxa would thus be terminologically inappropriate. Further, the node-coordinate requirement would, if traditional categories were adopted, dramatically alter the relative levels of groups such as phyla and classes which have long been used outside professional biology. Secondly, the comprehensive subdivision of the branching sequence results in a much larger number of category levels than other methods. Modification of these category levels to accommodate this number by the use of prefixes and suffixes (Farris, 1976) would seem to lead to very cumbersome names. Thus it seems appropriate to use a new system of nomenclature for cladistic classification which, by name, implies a regular series, is not overly cumbersome, and cannot be confused with traditional nomenclature.

Whereas cladistic classifications require special treatment, the intuitive nature of other taxonomies makes them well suited to the traditional nomenclatural system. Although separate recognition of these taxonomies in nomenclature would be welcome, it may misrepresent the overlap in these methods which occurs because their differences are often of emphasis, not necessarily of kind. It would thus seem reasonable to allow each of the noncladistic taxonomies to use the traditional nomenclatural system as long as the concept of relationship is explicitly stated.

With regard to the nonintuitive nature of cladistic taxonomy, its basis is a single order of speciation events. However, all speciation events need not be restricted in time or space. Thus, events which happen gradually through geologic time or through areal extent of the species may not allow the time of speciation to be nonintuitively delineated. In addition, more than one speciation within a species may be in progress at the same time and these may differ variously with regard to degree of development and times of initiation and completion. These problems can be overcome by stating which part of speciation is selected for phylogeny reconstruction. Presumably the first occurrence of complete speciation is that part amenable to most objective delineation.

Proposal. Two complementary systems of suprageneric classifications corresponding to both a cladistic and a noncladistic taxonomy are invoked in this study. For the cladistic scheme all holophyletic groups, called cladegroups, are recognized and given a category level in the manner described above. These taxa are defined by their ancestral species and include all descendants of this species. A new system of nomenclature is introduced to name these taxa. The system is similar to the traditional one ruled by the Nomenclatural Codes in that a genus-group name provides the stem and a suffix indicates the category level. However, the first-available genus-group name is proposed as the stem. To allow an unlimited number of levels the suffix is numerical and indicates, in Latin, the (ordinal) number of speciation events encompassed. For example, a phylogeny containing four splits and with the first-available genus-group name, Globigerina, would be named Cladegroup Globigeriniquartae.

Of the available noncladistic taxonomies a phylistic method is used herein to provide taxa within the traditional nomenclatural system. While attempting to adhere closely to established concepts of suprageneric taxa, these suprageneric groups proposed herein are required to be monophyletic and node-coordinate. Emphasis is placed on groups with broadly similar degrees of diversification. Thus the method is similar to the monophylistic approach but groups are not chosen for genetic homogeneity. An appropriate term may be cladophylistic and, as such, this method provides a traditional classification which intuitively highlights the branching sequence represented by the cladistic classification. At the lowest suprageneric level the tribe is used for paraphyletic groups of genera and is discussed in the next section.

Genus-group categories

Discussion. Genus-group categories have come to serve purposes common to both species-group and suprageneric categories and so are herein discussed after these categories. The genus, with the species, is essential to the scientific name of an organism and this system appears to be manageable and generally accepted in and out of professional biology. The other purpose to which genus-group categories are put is as indicators of close relationship. However, if genus-group taxa are used as the lower levels of the classificatory hierarchy, they must be entirely encompassed by the next-higher taxon. In cladistic classification each speciation event back through time establishes the lower limit of the two taxa containing the descendants of this event. Thus, if the genus is restricted hierarchically, an additional genus-group name is needed for the ancestral species. The overall result of this method would be that every ancestral species beyond the last-one-or-two speciation events would need a unique genus name. The use of genus-group categories for depicting holophyly is patently impractical for the palaeontologist.

The position of the genus between the very different categories of species and suprageneric categories suggests that a similarly intermediate evolutionary concept may be appropriate. The species is used herein to depict continuity of descent without permanent disruption of the gene pool. Suprageneric categories express phylic relationships and combine descendant species which share a discontinuity of descent from a common ancestor after permanent disruption of the gene pool. An aspect not accounted for by either of these categories and yet intermediate in concept is the continuity of descent across splitting events expressed by an ancestor--descendant series. Thus, if the genus category is used to link ancestors to descendants, the branching sequence of phylogeny is fully described in classification. This nonphylic relationship seems to have been uncritically rejected or simply not considered as a taxonomic criterion.

Proposal. The genus category is used herein to unite species in ancestor--descendant relationship and does not indicate any phylic relationship, with one useful exception. This latter case is the inclusion of terminal sister species. Beginning with a pair of living or terminally extinct sister species and their immediate common ancestor, these three species are placed in one genus. Then all previous ancestors back through time are potentially congeneric. A genus name is terminated along this consecutive series when, at a certain ancestral species, an earlier-available genus-group name is encountered either via its type species or as a similar series extending through the sister descendant.

This method is a nonintuitive way of solving the practical problem of competing binomina. Further, it conveys useful phylogenetic information not contained in the lineage-species or phylic-suprageneric-category concepts. Thus, availability of genus-group names permitting, the genus will link species which are in ancestor--descendant relationships and separate species in sister relationships, except where both are terminal. Thus species which diverge from a main line of descent are distinguished. In the Cenozoic planktic Foraminifera this produces many intuitively satisfying generic taxa. Morphologically simple evolutionarily 'conservative' species will usually be thus assigned to a long-ranging genus representing an adaptively basic evolutionary stock. Adaptively specialized species of more complex morphology will usually be assigned to separate genera which diverge off the main evolutionary line.

One of the suprageneric categories, the tribe, is also used in a nonintuitive way within the cladophylistic classification of the Cenozoic planktic Foraminifera proposed herein. However, more general application of this usage of this category is not necessarily intended. The tribe is used in this study for each genus which itself has one or more genera as descendants. It thus serves to nonintuitively group together species which have undergone few splitting events away from a central ancestor--descendant line.

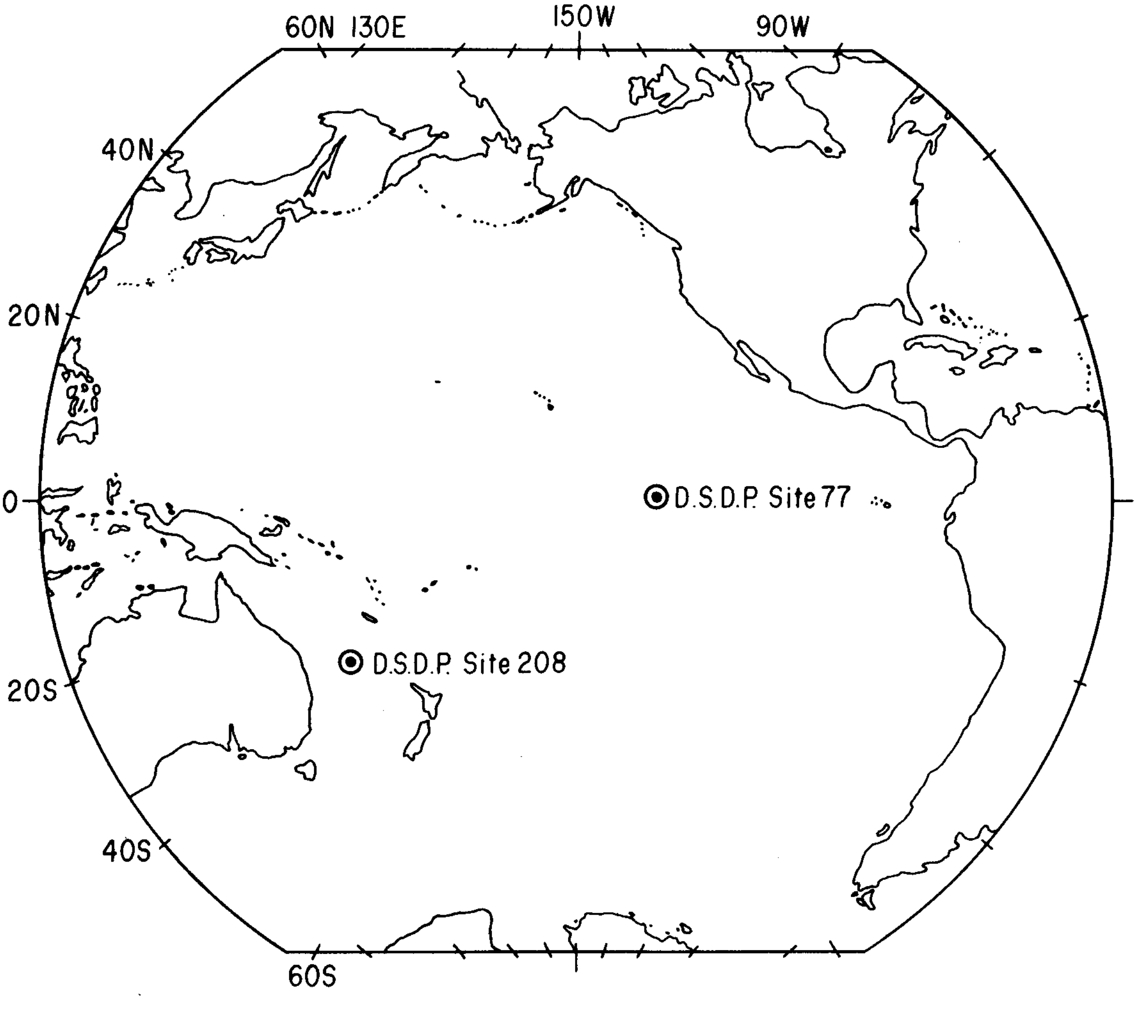
The category, subgenus, is not advocated. This is mainly because the ancestor--descendant series constituting a genus may be very long and is not amenable to logical subdivision except into individual species lineages. If subgeneric subdivision were implemented, the number of monospecific subgenera would, as for the genus, be unwieldy. There are, however, various uses to which the subgenus category could be put. For example, where a genus, as defined above, consists of two terminal species and a series of consecutive ancestral species, two subgenera could be used: one for the terminal species, another for the ancestral species. However, in some cases the ancestral subgenus would include a wide range of species and their grouping into a single subgenus, normally implying very close relationship, would be misleading. On the other hand, combining of the two terminal species of the genus into a subgenus would allow the inclusion within the genus of an additional subgenus if, for example, another two terminal species and a corresponding immediate common ancestor were in a sister relationship with the former subgeneric group. This would then allow up to four terminal species within the genus, a presumably desirable property when applied to living species. On balance, use of the subgenus category would appear to require introduction of too many arbitrary conventions compared to the relatively minor information gained.

The genus category as used herein may prove unacceptable or unwieldy with future application. Its minimal content of sister-group relationships is, of course, at odds with cladistic principles. However, it seems a minor concession when both suprageneric and species categories proposed herein are consistent with such guidelines. With regard to biologic applications, the inclusion of only one or two living species in any genus may seem unreasonably restrictive and would lead to many new nominal genera in some groups. However, the inclusion of many living species in a single genus would presumably imply either lack of interest or considerable uncertainty regarding their relationships. In both cases the corresponding revision of genera could be deferred until appropriate. In the fossil record earlier-available nominal genera will, if defined as here proposed, tend to have very long durations. Further, given the hierarchical nature of traditional classification, the corresponding suprageneric categories will also need to be extended back through time. However, this potentially extremely paraphyletic nature of noncladistic supraspecific taxa could be found useful. Thus the earlier established names would represent long-ranging lineages from which diversification into more adaptively specialised lineages occurred. In addition, at this early stage of detailed phylogenetic reconstruction in palaeontology the nominal extension of genera back through time will often be prevented by significant gaps in knowledge. It seems, therefore, that for the present this nonintuitive method of genus assignment is worthy of trial. Alternatively, the genus could be nominally terminated when a taxon of a stated category level was met as a sister taxon. This would trim the time-range of both the genus and the suprageneric taxa to which it belongs.

PLANKTIC FORAMINIFERS FROM D.S.D.P. SITES 208 AND 77 WITHIN A PHYLOGENY AND CORRESPONDING CLASSIFICATIONS OF CENOZOIC SPECIES

Sampled stratigraphic sections

Two stratigraphic sections, recovered by the Deep Sea Drilling Project, have been chosen for study because of their very rich record of sedimentation since the middle Miocene. Both sections were sampled at coarse intervals. Site 208 (see Burns & others, 1973), situated on the northern Lord Howe Rise, southwest Pacific (Text-fig. 1), was included in a regional biostratigraphic study of Leg 21 by Kennett (1973). Site 77 (see Hays & others, 1972), in the eastern equatorial Pacific, was part of a regional biostratigraphic survey of Leg 9 by Jenkins & Orr (1972). Both sections were important in establishing new biozonal schemes. Site 208 is reference section for eleven warm-subtropical planktic-foraminiferal biozones (Kennett,



Text-figure 1. Locality of Deep-Sea-Drilling-Project Sites 208 and 77.

1973). It is particularly valuable because of the high degree of abundance and preservation of the assemblages and their climatically intermediate nature. Although Leg 9 sites were solution-affected, the continuity of accumulation was high. Site 77 is reference section for eight tropical planktic-foraminiferal biozones (Jenkins & Orr, 1972).

The major biostratigraphic changes in each section were studied by sampling each biozone used by Kennett or Jenkins & Orr for the middle-Miocene--Pleistocene interval (Tables 1, 2). Usually, the middle and boundaries of each zone were sampled and the samples were processed in ascending stratigraphic order. Samples were obtained by horizontal insertion of approximately 2.5-cm-diameter tubes. Assemblages were recovered after disaggregation of 10-cm^3 lumps on a 63-µm sieve. A microsplitter was then used to obtain manageable representative subassemblages. The smallest subassemblage (RS1) was chosen so as to be completely picked in a few hours, usually giving a representative collection of approximately 600 specimens. A larger subassemblage (RS2) was chosen from which all globorotaliform, in the strict sense of Blow (1969), and other specimens of interest could be picked in a few hours, usually giving a collection of about 300 globorotaliform specimens. Usually one of the largest subassemblages (RS3) was used to find rare specimens of interest. Collections are housed in the locality collection of the palaeontologic research collection of the Department of Geology and Mineralogy, University of Queensland. The locality-catalogue numbers are UQL 4500 for D.S.D.P. Site 208 and UQL 4501 for D.S.D.P. Site 77.

Phylogeny and classifications

It remains to describe the procedure by which the above-discussed taxonomies can be applied to the upper-Cenozoic planktic-foraminiferal stratigraphic sequences recovered in this study. Following this, all taxa identified will be treated systematically within the proposed classificatory hierarchy and there reference will be made to the illustrations of specimens which complete this work.

Collections

Samples were obtained from cored sequences of middle-Miocene--Pleistocene deep-sea ooze and chalk and, barring discontinuities, represent, on average, a passage of approximately 1500 years in each column. These samples correspond to insignificant amounts of geologic time within the context of the approximately 14-Ma time-interval of study. The corresponding recovered assemblages are then legitimately representative at least in the sense that they correspond to geochronologically coeval populations of plankton. However, proportional sampling may not have been attained nor are the stratigraphic intervals necessarily representative of the overall palaeoenvironment which persisted between sampling positions. These considerations, however, are not critical to the objectives of this study.

Table 1. Samples examined in this study from Deep-Sea-Drilling-Project Site 208 (UQL 4500). All from unit 1 of Burns & others (1973).

Core	Section	Interval (cm)	Depth below sea-floor (m)	Biozones of Kennett (1973)	Series
1	1	7-9	0.07-0.09	upper Globorotalia truncatulinoides zone	Pleistocene
1	4	74-76	5.24-5.26	middle G. truncatulinoides zone	
2	2	74-76	11.24-11.26	upper G. truncatulinoides-G. tosaensis overlap-zone	
3	2	74-76	24.24-24.26	middle G. truncatulinoides-G. tosaensis overlap-zone	
4	2	74-76	37.24-37.26	lower G. truncatulinoides-G. tosaensis overlap-zone	
4	4	74-76	40.24-40.26	middle G. tosaensis zone	Pliocene
5	4	74-76	50.24-50.26	middle G. inflata zone	
6	1	12-14	53.12-53.14	lower G. inflata zone	
7	4	74-76	67.24-67.26	middle G. crassaformis zone	
9	1	128-130	85.28-85.30	upper G. puncticulata zone	
9	4	2-4	88.52-88.54	middle G. puncticulata zone	
9	6	74-76	92.24-92.26	upper G. margaritae zone	
10	4	74-76	98.24-98.26	middle G. margaritae zone	
11	5	74-76	108.74-108.76	lower G. margaritae zone	
12	4	74-76	125.24-125.26	middle G. conomiozea zone	upper Miocene
13	5	74-76	145.74-145.76	upper Globigerina nepenthes zone	
14	4	74-76	162.24-162.26	middle G. nepenthes zone	
16	1	74-76	194.74-194.76	upper Globorotalia continuosa zone	
17	2	72-74	224.22-224.24	middle G. continuosa zone	
18	2	1-3	232.51-232.53	upper G. mayeri zone	middle Miocene
20	2	64-66	289.14-289.16	middle G. mayeri zone	
21	3	73-75	318.73-318.75	upper Orbulina suturalis zone	

As described above, each assemblage was split into representative subassemblages. The smallest subassemblage was completely picked for a representative collection of planktic foraminifers without regard to size or preservation of specimens. It was only in larger subassemblages that a selection of specimens was made. Even so, these unrepresentative collections of rarer forms were evaluated in terms of the variation observed in their corresponding larger subassemblages to afford comparison with the variation observed in the representative collection.

Species clusters

Each representative collection was studied in detail in order to isolate species clusters (Gingerich, 1979, p. 458). It is this stage that appears to represent the greatest departure from the suite of methodologies currently dominant, at least in terms of the degree of support explicitly argued in the literature, in the practice of identification of palaeontologic taxa. Prior to any deliberate recognition of taxa, specimens from the collections, most importantly all specimens from the representative collection, were grouped according to morphologic similarity. Concurrently, these preliminary clusters were searched for one or more features which might exhibit discontinuities in variation. This is an iterative procedure involving many initial scans of the collections with resultant adjustments of the clusters as well as later checks when more subtle variations in test form were appreciated after similar studies of further collections. Later incorporation of observations made under the scanning electron microscope were also sometimes required. Practical advantages of mineralized microfossils are, of course, fully utilized. In particular, these included typically high abundance, amenability to routine manipulation under the light microscope, and a size small enough to allow accommodation of thousands of specimens of a collection representative with regard to size on a single microslide. Generally, enough specimens were recovered to allow quite confident placement of species boundaries. It must be emphasized that species clusters derived in this way must be objective in what are presumably the majority of cases where reproductive isolation, potential or actual, is reflected, subtly or otherwise, in preserved morphology. (The possibility that sibling species or intraspecific polymorphs were represented was deferred for later consideration.) It is important that objectivity at this stage should not be confused with difficulties in practical application. Correct recognition of morphologic discontinuity may be severely hampered by many factors. These include problems associated with the following: the need to observe subtle morphologic differences in the clusters in some cases when the two species are recently split sister descendants or when they are homeomorphic; collections which are poorly preserved or meagre with respect to the species in question; species showing an unexpectedly high range of variation; collections which are unrepresentative of corresponding living populations due to palaeoenvironmental, preservational, or sampling biases; and lack of experience of the observer in that fossil group.

Table 2. Samples examined in this study from Deep-Sea-Drilling-Project Site 77 (UQL 4501).

Core	Section	Interval (m)	Depth below sea-floor (m)	Biozones of Jenkins & Orr (1972)	Lithostratigraphic units of Hayes & others (1972)		Series
A1	1	0-2	0.00-0.02	upper *Pulleniatina obliqueloculata* zone	Cyclic Unit	Clippertone Oceanic Formation	Pleistocene
B1	3	140-142	13.50-13.52	middle *P. obliqueloculata* zone			
B2	6	138-140	27.18-27.20	lower *P. obliqueloculata* zone			
B4	1	0-2	36.60-36.62	middle *Globigerinoides fistulosus* zone			upper Pliocene
B4	6	146-148	46.56-46.58	lower *G. fistulosus* zone	Varicolored Unit		
B6	1	148-150	56.38-56.40	middle *Sphaeroidinella dehiscens* zone			lower Pliocene
B7	4	147-149	69.97-69.99	lower *S. dehiscens zone*			
B8	3	0-2	76.20-76.22	middle *Globorotalia tumida* zone			
B8	6	145-147	82.15-82.17	lower *G. tumida* zone			
B9	6	140-142	91.20-91.22	upper *G. plesiotumida* zone			upper Miocene
B10	6	143-145	100.33-100.35	upper *G. plesiotumida* zone			
B12	1	5-7	109.85-109.87	middle *G. plesiotumida* zone			
B13	4	6-8	124.46-124.48	middle *G. plesiotumida* zone			
B15	4	22-24	141.92-141.94	lower *G. plesiotumida* zone			
B16	6	22-24	154.02-154.04	lower *G. plesiotumida* zone			
B17	6	144-146	164.44-164.46	middle *Globoquadrina altispira* zone			
B19	2	145-147	173.65-173.67	middle *G. altispira* zone	Gray Unit	Marquesas Oceanic Formation	middle Miocene
B20	4	8-10	184.48-184.50	lower *G. altispira* zone			
B21	5	148-150	196.48-196.50	middle *Globorotalia fohsi lobata* zone			
B22	4	147-149	204.17-204.19	lower *G. fohsi lobata* zone			
B23	4	148-150	213.28-213.30	middle *G. fohsi peripheroacuta* zone			
B24	2	146-148	219.46-219.48	lower *G. fohsi peripheroacuta* zone			

Nonetheless, the specimens in question will be remnants of once living species and will exhibit corresponding morphologic differences which do exist, which are objectively observable. Such observation, however, may require the efforts of more than one study or more than one student. It may also be too difficult for human faculties with only the usual inventory of technologic assistance. For instance, quantitative analysis using sophisticated mathematical manipulation may be required. This would certainly be relevant to many of the problems encountered herein. However, follow-up analyses such as these are considered beyond the scope of this study.

Morphologic documentation

All specimens from the above-discussed collections were assigned to a phenon. Because these taxa are defined to have intuitive boundaries, no attempt was made to assess available species-group taxa for natural distinctness when selecting phena. Rather, it was considered that most available taxa would delineate morphologic variability of some significance, be it temporal or clinal. Taxa were thus evaluated for their practical application, specifically their ability to be identified consistently. They were put into synonymy at the phenon level only when this appeared unreasonably difficult. New phena were introduced for variants intuitively considered to be distinct from primary types of available taxa.

Detailed morphologic description was not attempted. Rather, only the occurrence of phena was noted (Tables 3, 4) and specimens set aside for illustration. This resulted from the decision to place detailed study of anagenesis beyond the scope of this project and to aim for the detection of speciation events. These latter phenomena are critical determinants of the phylogenetic pattern necessary for the application of the taxonomies proposed herein. It should, however, be noted that detailed morphologic observations are necessary for reliable reconstruction of any aspect of evolution. The erection of phylogenetic hypotheses proposed herein would not be possible if not for the wealth of such studies on the planktic Foraminifera already available.

Species lineages, speciation events, and phylogeny

Sampling within successive biozones, although coarse for biostratigraphic application, usually permitted confident assignment of successive species clusters to a lineage. Where two distinct species clusters from the same assemblage appeared to most resemble the same ancestral species cluster, a splitting event in that ancestral species into these two descendant species was interpreted to have occurred in the intervening interval. In some cases the ancestral species cluster maintained its general morphology through to one of its descendants. In these cases the placement of the splitting event was mainly influenced by the lowest occurrence of distinct clusters of the divergent descendant only. Also, there were cases where the ancestral cluster exhibited increased variation, which included forms typical of the divergent descandant, in clusters immediately underlying the interpreted speciation event. The successions of clusters were, in all cases, examined carefully but similar observations on more closely spaced samples from intervening intervals should be performed in the future to test the claims made.

Concatenation of ancestor--descendant relationships within species lineages and between ancestral and descendant species results in a branching pattern (Text-fig. 2, Tables 5, 6), or cladogram (Camin & Sokal, 1965, Tattersall & Eldredge, 1977). Segments are biologic species and nodes are speciation events, also called cladogenetic or splitting events.

Table 3 (pp. 21--30). Phena recovered in this study from Deep-Sea-Drilling-Project Site 208. Occurrence in representative collections (RS1) indicated by 'X', and occurrence in any other collections indicated by '+'. Lineage species indicated by box containing the phena considered to intergrade within each assemblage in which they occur and linked by solid lines where species clusters interpreted to have diverged. Tentative subdivision of multiple-lineage series into individual lineage segments indicated by broken lines. Segments arranged as in Text-fig. 2. Phena ordered within each segment according to the relative stratigraphic position of respective primary types (if positions indistinguishable, ordered alphabetically). Arrows in 'Species' column indicate ascending stratigraphic positions of phena. Phena recorded from segment containing their respective primary types are indicated by an asterisk. Table broken into sections a--j.

Table 3a.

21/3/73-75	20/2/64-66	18/2/1-3	17/2/72-74	16/1/74-76	14/4/74-76	13/5/74-76	12/4/74-76	11/5/74-76	10/4/74-76	9/6/74-76	9/4/2-4	9/1/128-130	7/4/74-76	6/1/12-14	5/4/74-76	4/4/74-76	4/2/74-76	3/2/74-76	2/2/74-76	1/4/74-76	1/1/7-9	Sample Phena	Species
				X	X		+	+				+		X	+		+	+	+			* *tokelauae*	↑ *S. tokelauae*
				+			+											+				* *latum*	
						X								X								* *flexiserialis*	
				X		+		X	X	+	+	X			X							* *globiger*	↓ *S. globiger*
				X		+		X	X	X	X	X		+								* *infirmirugosus*	
																		X		X	X	* *uvula*	↑ *T. uvula*
																			+			* *parkerae*	
																		X	X	X	X	* *glutinata*	
																		X	X	X	X	* *ambitacrena*	
																			X	X	X	* *quasifoliata*	
																		X	X		X	*antarctica*	
																			X			*tripetala*	
																		X	X	X	X	*tetrapetala*	
																		X	X	X	X	*praemonita*	
																			X			*naparimaensis*	
																		X	X	X	X	*incrusta*	
																	X					*parkerae*	↑ *T. antarctica*
																X	X					*glutinata*	
																X	X					*ambitacrena*	
																	X					* *antarctica*	
																	X					* *polypetala*	
																X	+					*tripetala*	
																X	X					*tetrapetala*	
																X	X					*praemonita*	
																X	X					*incrusta*	
																					X	* *evoluta*	↓ *T. evoluta*
							+	+	X		X		X	+								*uvula*	↑ *T. praemonita*
						+							+									*parkerae*	
														X	X							*iota*	
						X	X	X	X	X	X	X	X	X	X							*glutinata*	
						X			X	X	+			X	X							*ambitacrena*	
													X	+	X							* *tripetala*	
													X	+	X							* *tetrapetala*	
												X	X	X	X							* *praemonita*	
						X	X	X		X	X	X	X	X	X							*naparimaensis*	
						X	X	X	X	X	X	X		X	X							*incrusta*	
																X	X	X	X	X	X	* *iota*	↓ *T. iota*
X	X	X	X	X	X																	*uvula*	↑ *C. insueta*
X	X	X	X	X	X																	*glutinata*	
	+	+	X	X	X																	*ambitacrena*	
X	+	X	+	+																		* *naparimaensis*	
X	X	X	X	X	X																	* *incrusta*	
						+																* *praenitida*	↓ *C. nitida*
						+	X		+			X			+					+		* *nitida*	

Table 3b.

21/3/73-75	20/2/64-66	18/2/1-3	17/2/72-74	16/1/74-76	14/4/74-76	13/5/74-76	12/4/74-76	11/5/74-76	10/4/74-76	9/6/74-76	9/4/2-4	9/1/128-130	7/4/74-76	6/1/12-14	5/4/74-76	4/4/74-76	4/2/74-76	3/2/74-76	2/2/74-76	1/4/74-76	1/1/7-9	Sample / Phena	Species
	X	X																				* *clemenciae*	↓ *T. grata*
X	+	X																				* *grata*	
					X	X					+											* *bauerensis*	
														X	X	X	+	+	+	X	X	* *galapagoensis*	
																				X		* *compressa*	
																X		+	X	X	X	* *anfracta*	
																			+	X	X	* *parkerae*	
						?																* *postcretacea*	↓ *T. postcretacea*
+																						* *gemma*	
	X													?								* *pieste*	
					+		X				X		X		X				X			* *praedigitata*	↑ *C. digitata*
+																						* *larmeui*	↑ *N. conglomerata*
X																						* *obesa*	
+																						* *venezuelana*	
+																						* *baroemoensis*	↓ *N. altispira*
	X	+	X	+	+	X			+	X	+	+	+	X	+	+						* *globosa*	
	X			+	+	+			+	+	X	+			+							* *conica*	
X	+	X		X	X	+			+	+		+	+			X						* *pozonensis*	
+	+		X	X	+	+		+	X	+	X	+	X	+	+	+						* *altispira*	
X	X	+	+																			* *dehiscens*	↓ *G. tripartita*
X	X	+	+																			* *advena*	
+	+	X																				* *laxispira*	
			X																			* *tricamerata*	
						X	X	X	X	X	X	X	X	X	X		X		X			* *megastoma*	↑ *G. bulloides*
								+	+	X	X	X	X	X		X	X				+	* *bulloides*	
																			+	X	X	* *extensa*	
											+	+	X	X		X		X		X	X	* *quadrilatera*	
									X			X	+	+	X	+		X	X		X	* *bronnresigorum*	
						X	X	+	+	X	X	X	X	X	X	X	X	X	X	X	X	* *incrusta*	
										X	+	X	+	X	+	X			+			* *pseudobesa*	
						+	+	+	+	+	X	+	+	X	X		X	+	+		+	*anapetes*	
									+	X	+	X	X	X	X	X	X	X	X	X	X	*foliata*	
												+	X		X	X	X		X	X	+	*bulbosa*	
						+	X	X	X	X	X	X	X		X	X		X	X	X		*bollii*	
						+			+		X											*praebulloides*	
						X	+		X	X	X	X	X	X	X	+	X	X	X	+	X	*falconensis*	
						X	X	X	X	X	X	X	X	X	X				X			*occlusa*	

Table 3c.

21/3/73-75	20/2/64-66	18/2/1-3	17/2/72-74	16/1/74-76	14/4/74-76	13/5/74-76	12/4/74-76	11/5/74-76	10/4/74-76	9/6/74-76	9/4/2-4	9/1/128-130	7/4/74-76	6/1/12-14	5/4/74-76	4/4/74-76	4/2/74-76	3/2/74-76	2/2/74-76	1/4/74-76	1/1/7-9	Sample / Phena	Species
					X																	*megastoma*	↑ *G. concinna*
					+																	*bulloides*	
			+	X	+																	*nepenthes*	
			+	+	+																	*delicata*	
			X	+	X																	*incrusta*	
					X																	* *anapetes*	
					X																	* *altihelix*	
			X	X	X																	* *picassiana*	
			+																			* *appenninica*	
			X																			* *columbae*	
			X	X	X																	* *decoraperta*	
				X																		*opsionepenthoides*	
				+	X																	*bollii*	
			+	X	X																	*druryi*	
			X	+	+																	*praebulloides*	
			X	+	X																	*falconensis*	
					+																	*woodi*	
				+	X																	*occlusa*	
						X	X	X	X	X												*druryi*	↓ *G. rubescens*
						X	X	X	X	X	X	X	X	X	X	X	X	X	X			*decoraperta*	
						X	X	X	X	X	X	+			+							*picassiana*	
						X	X	X	X	+	X	X			+		X	X				*altihelix*	
							+	+	+		+	X		+	+		X	+				*apertura*	
							+	+	+													* *delicata*	
						X	+	X	X	+	+	+										* *nepenthes*	
												+	X		X	X	+	X	X	X	X	* *rubescens*	
																					X	* *tenella*	
	X	X																				*nepenthes*	↑ *G. microstoma*
	X	X																				*incrusta*	
		X																				*picassiana*	
	X	X																				*columbae*	
	X	X																				*decoraperta*	
	X																					* *microstoma*	
	X	X																				* *opsionepenthoides*	
	X	X																				*bollii*	
	X	X																				*druryi*	
	+	X																				*praebulloides*	
	X	X																				*falconensis*	
	X																					*extrema*	
	X																					*woodi*	
			X		X	X	+	X	X	X	X		X	X	+	X	X					* *pachydermus*	↓ *E. pachydermus*

Table 3d.

21/3/73-75	20/2/64-66	18/2/1-3	17/2/72-74	16/1/74-76	14/4/74-76	13/5/74-76	12/4/74-76	11/5/74-76	10/4/74-76	9/6/74-76	9/4/2-4	9/1/128-130	7/4/74-76	6/1/12-14	5/4/74-76	4/4/74-76	4/2/74-76	3/2/74-76	2/2/74-76	1/4/74-76	1/1/7-9	Sample / Phena	Species
X																						*incrusta*	↑ *G. bulbosa*
X																						*appenninica*	
X																						*columbae*	
X																						*microstoma*	
+																						* *bollii*	
X																						* *druryi*	
+																						* *trisphaera*	
X																						* *praebulloides*	
X																						* *falconensis*	
X																						* *nepenthoides*	
+																						* *extrema*	
+																						*disjuncta*	
X																						*woodi*	
	+																					*disjuncta*	↓ *S. dehiscens*
		+	X	+				+														* *kochi*	
	+	+	X	X	+	+	+	+	X	X	X	+	+	+								* *seminulina*	
				+			+						+									* *reticulata*	
		+				+	+	+	X	+		+	+	X	+	X	+					* *parkerae*	
					+																	* *paenedehiscens*	
															+	X	+	X	+	+		* *immatura*	
															+		+	+	+	+		* *dehiscens*	
																			+	+		* *excavata*	
				?			?	+					X						?			* *alpha*	↑ *O. quadrilobata*
							+						+	X				+				* *fistulosa*	
			X	X	+	X	X	+	X	+	+	X	X	X	X	X	X	X	+	X	+	* *sacculifera*	
+	+			+	+	+	X	+	+	+	X	+		+	+	+	+	+	X	X	+	* *quadrilobata*	
+				X	X		+		+	X	+	+			+		+	X			+	* *triloba*	
	+							+		X												* *subsacculifera*	
+	X	X	X	X	X	X	X	+	+	X	X	X	X	X	+	+	+	+	X	X	X	* *immatura*	
	+	+			+																	* *irregularis*	
X	X	X		X																		* *bullata*	
+			+			+						+										* *incrusta*	
+	X	+	+	X	+	+		+	X	X		+	X		+					+		* *suturalis*	↓ *O. universa*
	+				+			+	X	+		X										* *bilobata*	
					+			+	+	+		+										* *parkerae*	
	+		+	+	X	X		+	X	X	+	+	X	+	+	X	+	X	+	X		* *universa*	

Table 3e.

21/3/73-75	20/2/64-66	18/2/1-3	17/2/72-74	16/1/74-76	14/4/74-76	13/5/74-76	12/4/74-76	11/5/74-76	10/4/74-76	9/6/74-76	9/4/2-4	9/1/128-130	7/4/74-76	6/1/12-14	5/4/74-76	4/4/74-76	4/2/74-76	3/2/74-76	2/2/74-76	1/4/74-76	1/1/7-9	Sample / Phena	Species
																		+	+	+	+	* *conglobatus*	↑ *G. conglobatus*
																				+		* *altihelix*	
															+	+		+	+	+	+	* *canimaensis*	
																+			+	+	+	*compressus*	
													+									*epityche*	
												+			+				+			*haitiensis*	
											+											*ruber*	↑ *G. haitiensis*
									+	+												*canimaensis*	
								+	+	+												*mitrus*	
									+													* *compressus*	
									+		X											* *anterubra*	
						+	+	+	+													* *epityche*	
					+	+			X	X	X											* *extremus*	
				X	X	X	+			X												* *praerubra*	
					X	X	X	X	+	X	X											* *bollii*	
				+	+	X	X	X	X	X	X											* *obliquus*	
					+			+														* *progomitulus*	
		?	?	X	X	X	X	X	X	X	+											* *compactus*	
+	+	X	X	X	X																	* *bulloideus*	
+																						* *pseudoruber*	
X	X	X																				* *subquadratus*	
												X				X						*compactus*	↓ *G. elongatus*
																X	+	X	+			*progomitulus*	
												X	X	X	X	X	X					*obliquus*	
													X									*bollii*	
												X										*praerubra*	
												X	X	X	X	+						*extremus*	
												+	+	X	X							*anterubra*	
													+		+		X					* *mitrus*	
																+	X	X	X	X	+	* *gomitulus*	
															+	+	+	X	+	+	+	* *elongatus*	
															X	+	+	+	+	+	+	* *pyramidalis*	
														X	X	X	X	X	X	X	X	* *ruber*	
+								?														* *moderiapertura*	↑ *G. aguasayaensis*
	?H.o.										?G.e.									?G.s.			
	+	+	+					+														* *praesiphonifera*	*H. obesa,* ↓ *G. evoluta,* *& G. siphonifera*
+	X	X			+	X	X	+	+			+							+	X	X	* *obesa*	
					+	+	+	+	X	+	X	+	X	+	X		+	X	+	+	+	* *evoluta*	
						+			+	+					+					+	+	* *involuta*	
				+			+	+	+	+	+	+	X	X	+	X		+	+	+	+	* *siphonifera*	

Table 3f.

21/3/ 73- 75	20/2/ 64- 66	18/2/ 1- 3	17/2/ 72- 74	16/1/ 74- 76	14/4/ 74- 76	13/5/ 74- 76	12/4/ 74- 76	11/5/ 74- 76	10/4/ 74- 76	9/6/ 74- 76	9/4/ 2- 4	9/1/128-130	7/4/ 74- 76	6/1/ 12- 14	5/4/ 74- 76	4/4/ 74- 76	4/2/ 74- 76	3/2/ 74- 76	2/2/ 74- 76	1/4/ 74- 76	1/1/ 7- 9	Sample / Phena	Species
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X			X	X	X	* *angustiumbilicata*	↓ *T. detrita*
X	X			X	X	X	X	X														* *primitiva*	
				X	X	X	X	X														* *primoripumilio*	
														X								* *microfoliata*	
													+									* *praepumilio*	
												+				?						* *roglbolliorum*	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	* *clarkei*	
															X	X	X	X	X	X	X	* *atlantisae*	
													+	+								* *cristata*	
									X	X	X	X	X	X	X	X	X	X	X	X	X	* *egelida*	
											?	+	X	X	X	X	X	X	X	X	X	* *guadalupensis*	
												X	+	X	X	X	X	X	X	X	X	* *humilis*	
						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	* *pumilio*	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	* *quinqueloba*	
+	X				?		+															* *extraumbilicatus*	↑ *B. relizensis*
+																						* *relizensis*	
				+																		* *anavenezuelana*	↑ *G. indigena*
				X																		* *redissimilis*	
	X	X	X																			* *lateraliaperturus*	↓ *G. parvulus*
		X	+																			* *variabilis*	
X	X		X																			* *falconarae*	
			+																			* *anasuteri*	
				X	X																	*lateraliaperturus*	↓ *G. hexagonus*
					X		X															*variabilis*	
				X																		*falconarae*	
							+		X	+	X	X	X	+	X		X				X	* *subcretacea*	↑ *P. helicina*
							+															* *polusi*	
											+	X		X				X			X	* *incompta*	
																	+	X	+			* *hybrida*	
										+	X	X	X	X					X		+	* *helicina*	
												+	X									* *eggeriformis*	
																			+	+	+	* *eggeri*	
																			+	+	+	* *dutertrei*	
											X	+	X							+		* *kagaensis*	
							X		X		+		X	X	X	X	X	X	X	X	X	* *pseudopumilio*	
							X		X	X	X	X	X	X	X	X	X	X	X	X	X	* *planispira*	
								+	X		+	+			+							* *praehumerosa*	
												+		+								* *apertura*	
														+							+	* *vincentae*	
										X	X	X	X	X		X						*polygonia*	
										X					+							*humerosa*	
							X	+	X	X	X	X	+									*globorotaloidea*	
							+		+	X												*acostaensis*	
							X	+		+	X	X	X		X							*miniacea*	
							X	+	X	X	X	X	X	X	X	X	X	X	X	X	X	*juvenis*	
										X	+	X	X	X								*pseudopachyderma*	
							X		X	X	+	X										*continuosa*	

Table 3g.

21/3/ 73- 75	20/2/ 64- 66	18/2/ 1- 3	17/2/ 72- 74	16/1/ 74- 76	14/4/ 74- 76	13/5/ 74- 76	12/4/ 74- 76	11/5/ 74- 76	10/4/ 74- 76	9/6/ 74- 76	9/4/ 2- 4	9/1/128-130	7/4/ 74- 76	6/1/ 12- 14	5/4/ 74- 76	4/4/ 74- 76	4/2/ 74- 76	3/2/ 74- 76	2/2/ 74- 76	1/4/ 74- 76	1/1/ 7- 9	Sample / Phena	Species
					X																	*subcretacea*	↑ *P. mayeri*
						+																*planispira*	
					X	+																*praehumerosa*	
				X																		*tegillata*	
						+																* *praepulleniatina*	
					X	X																* *polygonia*	
					+																	* *humerosa*	
				X	X	X																* *globorotaloidea*	
	X	X	X	X	X	+																* *acostaensis*	
					+	+																* *miniacea*	
+	X	X	X	X	X	X																* *juvenis*	
				X	X																	* *pseudopachyderma*	
		X	X	X																		* *plana*	
X	X																					* *nympha*	
+	X	X	X	X	X	X																* *continuosa*	
	X	X																				* *mayeri*	
	X	X																				* *partimlabiata*	
+																						* *umbilicata*	
+	X																					* *siakensis*	
+	X																					* *acrostoma*	
X	X																					* *bella*	
							X	X	X	X	X	X	X	+	+	X		+	X	+	+	* *primalis*	↓ *P. obliqueloculata*
									+	+	+	+	+		+			+	X	X	+	* *praecursor*	
									+	+	+	+										* *praespectabilis*	
									X	X		+	+					+	+	X	X	* *okinawaensis*	
																					+	* *finalis*	
																				+	+	* *obliqueloculata*	
X																						* *birnageae*	↑ *B. birnagene*
+																						*pseudokugleri*	
+																						*kugleri*	
	+																					* *fohsi*	↑ *F. fohsi*
	+																					* *praefohsi*	
+																						* *praescitula*	↓ *G. miozea*
X																						* *quinifalcata*	
+																						* *acumarginata*	
+																						* *archeomenardii*	
+																						* *magnifica*	
X																						*minima*	
?																						*conoidea*	
X																						*bykovae*	
+																						*rifensis*	
X																						*ventriosa*	
+																						*perconigi*	

Table 3h.

21/3/73-75	20/2/64-66	18/2/1-3	17/2/72-74	16/1/74-76	14/4/74-76	13/5/74-76	12/4/74-76	11/5/74-76	10/4/74-76	9/6/74-76	9/4/2-4	9/1/128-130	7/4/74-76	6/1/12-14	5/4/74-76	4/4/74-76	4/2/74-76	3/2/74-76	2/2/74-76	1/4/74-76	1/1/7-9	Sample / Phena	Species
												X	X	+	+	X	X	+	X	+	+	* *scitula*	↑ *O. scitula*
												X	X	X	X	X	X	+	X	X	X	* *subscitula*	
												?	?	?								*evexa*	
												X	X		X	+		+				*praemargaritae*	
						X	X	X	X	X	X											*scitula*	↑ *O. cibaoensis*
								+														*hirsuta*	
								+			X											*praehirsuta*	
						X	X	X	+	X	+											*subscitula*	
						+		+			+											*margaritae*	
						X	+	+			X											*primitiva*	
						+																* *cibaoensis*	
							?	?	?	?	?											*evexa*	
						X	X	+														*astricticamerata*	
						X	X	+	X	X	+											*praemargaritae*	
													X									* *margaritae*	↓ *O. hirsuta*
													X		?							* *praehirsuta*	
																			?			* *hirsuta*	
		X	X	+	+																	*scitula*	↑ *O. ventriosa*
					+																	*subscitula*	
				X																		*margaritae*	
				X	+																	*primitiva*	
					+																	*obturoaperturus*	
				+	+																	* *evexa*	
				X	X																	* *astricticamerata*	
		+	+	X	X																	* *praemargaritae*	
		+		X																		* *ventriosa*	
									+		X	X	X	X		X	X					* *obturoaperturus*	↓ *D. puncticulatus*
											+	+		X	+	+						* *padanus*	
																	+					* *oscitans*	
														+	X	X	X	X	X	X	X	* *inflatus*	
																				X	+	* *nipponicus*	
																			+		+	* *puncticulatus*	
																		X	X	+		* *trigonulus*	
	+																					*acumarginatus*	↓ *G. praemenardii*
	+																					*archeomenardii*	
	+																					*magnifica*	
	+																					* *minima*	
	?																					* *conoidea*	
	+																					* *bykovae*	
	+																					* *gigantea*	
	+																					* *praemenardii*	
	X																					* *rifensis*	
	X																					*ventriosa*	
	+																					*lenguaensis*	
	+																					*merotumida*	
	X																					*suterae*	
	X																					*dallii*	
	+																					*subconomiozea*	

Table 3i.

21/3/ 73- 75	20/2/ 64- 66	18/2/ 1- 3	17/2/ 72- 74	16/1/ 74- 76	14/4/ 74- 76	13/5/ 74- 76	12/4/ 74- 76	11/5/ 74- 76	10/4/ 74- 76	9/6/ 74- 76	9/4/ 2- 4	9/1/128-130	7/4/ 74- 76	6/1/ 12- 14	5/4/ 74- 76	4/4/ 74- 76	4/2/ 74- 76	3/2/ 74- 76	2/2/ 74- 76	1/4/ 74- 76	1/1/ 7- 9	Sample / Phena	Species
																				+	+	* *cultrata*	↑ *G. cultrata*
										X	X	+	X	+	+	+	+	+				*fijiensis*	
										X	X	X	X	X	X	X	X	X				*conferta*	
								+														*praemiocenica*	↑ *G. fijiensis*
									+													*multicamerata*	
									+													*tumida*	
							X	+	X													* *fijiensis*	
							+															*miocenica*	
							X	+	X													*conferta*	
									+													*plesiotumida*	
							+															*pseudomiocenica*	
												+	+	+	+	+	+	+	+	X	X	* *tumida*	↓ *G. tumida*
												X							+	+		* *ungulata*	
		X	+																			*minima*	↓ *G. limbata*
		X	+	X	+	X																*conoidea*	
		+	X	+	X	X																*rifensis*	
		X	X																			* *lenguaensis*	
		X	X	X	+	X																* *pseudomiocenica*	
		X	X	X																		* *saphoae*	
		X	X	X	X	X																* *merotumida*	
				+	X	X																* *miotumida*	
		X	X	X	X	X																* *dalii*	
		?	?	?	?	?																* *plesiotumida*	
			X	+																		* *latiumbilicata*	
			+	+	+																	* *saheliana*	
			+	+	+																	* *mediterranea*	
				+		X																* *conferta*	
				+	+	+																* *oregope*	
					+																	* *miocenica*	
						X																* *consutila*	
		+	+	X	X	+																* *subconomiozea*	
						+																*fijiensis*	
					+																	*multicamerata*	
					X	+																*praemiocenica*	
		X	X		+	+																*cultrata*	

Table 3j.

21/3/ 73- 75	20/2/ 64- 66	18/2/ 1- 3	17/2/ 72- 74	16/1/ 74- 76	14/4/ 74- 76	13/5/ 74- 76	12/4/ 74- 76	11/5/ 74- 76	10/4/ 74- 76	9/6/ 74- 76	9/4/ 2- 4	9/1/128-130	7/4/ 74- 76	6/1/ 12- 14	5/4/ 74- 76	4/4/ 74- 76	4/2/ 74- 76	3/2/ 74- 76	2/2/ 74- 76	1/4/ 74- 76	1/1/ 7- 9	Sample Phena	Species
														+								* *spuritumida*	↑ *F. spuritumida*
							X															*conoidea*	↓ *T. sphericomiozea*
								+	+													*rifensis*	
							+	+	+	+	X											*miotumida*	
								?	?	?												*dalii*	
							+	+	+	+	+											*oregope*	
							X	+	+	X	X											*consutila*	
							+		+	+	X											* *sphericomiozea*	
									X													* *conomiozea*	
											X											* *capitona*	
									+	X	+											*spuritumida*	
															X	+	X	+	+	X	+	* *hessi*	↑ *G. crassaformis*
												X										*miotumida*	↓ *T. crassula*
												+										*oregope*	
												+										*consutila*	
												X	?	?								*sphericomiozea*	
													X	+								* *complanata*	
													X	X								*hessi*	
																	?	X	X	+	X	* *truncatulinoides*	↑ *T. truncatulinoides*
																	X	X	X			*tosaensis*	
															X	+						*complanata*	↓ *T. tosaensis*
															+							*planoconvexa*	
															+							* *ronda*	
																X						* *acrotenes*	
																X						* *tosaensis*	
																			+	+	+	*complanata*	↓ *T. pseudocrassa*
																					+	*ronda*	
																	X	+				* *hybrida*	
																		+		+		* *pseudocrassa*	

In order to produce a more inclusive classification the previous literature has been very tentatively assessed to extend the scheme to the beginning of the Cenozoic. In so doing the primary types of all available phena have been examined from the literature and each has been very tentatively assigned to a lineage species belonging to this branching pattern (Appendix). The listing of phena belonging to species not encountered in the sections sampled in this study is considered necessary in order to avoid confusion about the details of the phylogeny proposed. That this detail far and away transgresses the observations directly available to the author is not disputed. This is especially so with regard to the assignment of phena to their lineage species and also, of course, the placement of splitting events. In justification of this practice the author suggests that even vague and generalized notions of phylogeny influence all systematicists. Rather than leave these notions uncommunicated for fear of encouraging fruitless speculation, it is herein considered that their detailed presentation is likely to alert other workers to problems still unresolved in the literature. Thus the listing presented herein is not meant to imply detailed knowledge but to encourage criticism and refinement of present knowledge by workers with access to appropriate material.

The proposed branching scheme, especially the Palaeocene--lower-Miocene portion not represented by material studied herein, relies very heavily upon the detailed biostratigraphic and phylogenetic documentation by Blow (1969, 1979). The wide scope of Blow's studies allowed the construction of phylogenies depicting ancestor--descendant relationships for the bulk of Cenozoic planktic-foraminiferal taxa. Blow's illustrations of taxa from each biozone then allowed a very tentative assessment of the intergradational relationships of coeval taxa considered by Blow to be connected phylogenetically. Thus, where gradations between taxa appear to be broken, speciation events can be tentatively interpreted allowing the construction of a branching pattern analogous to that constructed in the Miocene-to-Pleistocene material sampled herein. The decision to use Blow's data to provide the basic framework of the branching pattern was taken because of the comprehensiveness of his coverage and its detailed nature, allowing a preliminary pattern to be constructed from a single self-consistent set of studies. It should not need to be stated that Blow's work benefitted enormously from many previous studies, of small and large scale, and the details of his debt to previous work is best sought in Blow's own contributions. The reliance on Blow's results for the lower part of the Cenozoic in this study is a deliberate attempt to build a very tentative branching pattern based on internally consistent data. Further, the author's lack of personal experience in these older collections has prevented an evaluation of Blow's views, in relation to previous work, adequate enough to significantly tamper with them.

The above-discussed cladogenetic information combined with any morphologic observations (phena in Tables 3, 4; corresponding text and illustrations in the sections below; previous literature on these taxa) constitutes a phylogenetic tree. Further hypotheses relating the tree to aspects such as adaptation and environment would constitute a scenario. This latter objective is not pursued in this study.

A cladogram can be derived from a variety of information. The approach used in this study has been called stratophenetic (Gingerich, 1979). A stratophenetically derived cladogram would normally be transferable to a geochronologic scale when biostratigraphic interpretation is included and could then be termed a chronologic cladogram. The cladogram proposed here is of this type. In chronologic cladograms regular spacing of the terminal taxa perpendicular to the time axis allows the chronologic distribution of speciation events, and thus the rates of speciation, to be expressed clearly and is recommended. If this is done, however, addition of noncladogenetic information to a cladogram to depict a phylogenetic tree would be unambiguously expressed only by making use of measures other than variable spacing along vertical or horizontal axes.

Another approach which may provide hypotheses couched in a cladogram is based on the cladistic phylogenetic method of Hennig (1950, 1966). This method notes that phylogeny must produce a unique chronologically ordered hierarchy of theoretically observable morphologic attributes. An older transformation must have at least as many descendants as a younger one and so the relative antiquity of any transformation is expressed by and retrievable from the distribution of its attributes amongst subsequent species. A serious practical problem with the method is that morphologic attributes, depending on their definition within certain limits of observation, may reappear. The genetic code would presumably be normally rich enough to accommodate this problem but phenetic expression may not be. However, this appears to be the only phylogenetic method available for organisms with a fossil record inadequate for the stratophenetic approach. In such cases neither the ancestral and extinct species nor the time of speciation will be known and the cladogram could only be arranged with even spacing along both axes. Where ancestral species, which in the taxonomy accepted herein must be extinct, are included, cladistically derived cladograms usually arrange all species, ancestors or descendants, as end-points presumably to emphasize the uncertainty concerning lineage membership of ancestors. This is often associated with poor understanding of the timing of speciation events. Again, it is important that, whatever information is intended by a cladogram, it be explicitly stated. Useful terms may be 'terminal' for cladograms which place ancestors as end-points and 'nonterminal' when they occupy segments; these correspond to Figures 1b,c and 1a respectively of Hull (1979).

The cladogram referred to above (Text-fig. 2) may thus be termed chronologic, stratophenetically derived, and nonterminal. The cladogram is drawn so that the descendant group containing the most number of splitting events makes the least angle with the ancestral line. This enables the more novel species, in a cladogenetic sense only, to stand out from those species which maintain the general evolutionary line. When the descendant groups contain equal numbers of splits, an intuitive assessment of the relative degrees of anagenesis away from the ancestor is made in order to provide a corresponding nonarbitrary (though intuitive) criterion.

Classifications

The cladistic classification down to species which corresponds (see pp. 14, 15) to the nonchronologic component of the cladogram proposed herein (Text-fig. 2) is presented in Table 7. Fuchs's (1975) phylogeny of Mesozoic planktic foraminifers (Text-fig. 3) is tentatively used to place all Cenozoic species under a single hierarchy and to estimate the category level of the cladegroup containing all planktic foraminifers. Because the cladegroups are holophyletic, they are fully defined by their stem species. For the Cenozoic taxa the stem species in Table 7 is that immediately following the particular taxon and for other taxa the stem species follows in parentheses. In this listing cladegroups are not indented according to their level because the large number of levels would make this impracticable.

The cladophylistic classification down to species is presented in Table 8. The species content of genera in both this and the cladistic classification is identical. For the foraminifers as a whole the classification of Margulis (1974) is used. Margulis's promotion of the Foraminifera to phylum level emphasises that their origin is difficult to place within known protistan groups. Assignment at suborder and superfamily level follows Loeblich & Tappan (1964). Revision of the higher taxa within the Foraminifera necessary to reconcile the differences in these two classifications at phylum level is beyond the scope of this study. A monophyletic redefinition of the Rotaliina could view them as the Duostominacea and their descendants and exclude the Spirillinacea, Nodosariacea, Nonionacea, and Cassidulinacea (see Loeblich & Tappan, 1974). Corresponding revision of the Globigerinacea could presumably place the stem in Diplotremina multifimbriata and include appropriate members of the Robertinacea (see Text-fig. 3).

Not surprisingly the lower levels of classification do not as obviously correspond to grades of organisation, necessary for phylistic classification, as do the higher categories. The Globigerinacea have undergone at least three distinct phases of radiative evolution (Cifelli, 1969) and each phase seems to contain most of the major grades of all morphologic criteria which have been advanced for suprageneric classification. Thus most morphologically defined groups would be polyphyletic. An alternative which accommodates this repetitive evolution is proposed here following the method described above (p. 15). At the family level the phylogeny is divided into blocks of evolutionary radiation. The descendants of Globigerina monmouthensis form a very distinct radiation spanning the Cenozoic and herein are included in the Globigerinidae. Along with similar groups from the Mesozoic and several minor groups with relatively early origins these groups could usefully divide the Globigerinacea into several families. A revision of Mesozoic classification is, however, beyond the scope of this study.

Table 4 (pp. 33--38). Phena recovered in this study from Deep-Sea-Drilling-Project Site 77. Table broken into sections a--f. Otherwise as for Table 3.

Table 4a.

B24/2/146-148	B23/4/148-150	B22/4/147-149	B21/5/148-150	B20/4/ 8- 10	B19/2/145-147	B17/6/144-146	B16/6/ 22- 24	B15/4/ 22- 24	B13/4/ 6- 8	B12/1/ 5- 7	B10/6/143-145	B 9/6/140-142	B 8/6/145-147	B 8/3/ 0- 2	B 7/4/147-149	B 6/1/148-150	B 4/6/146-148	B 4/1/ 0- 2	B 2/6/138-140	B 1/3/140-142	A 1/1/ 0- 2	Sample / Phena	Species
					X						X	+										* *tokelauae*	↑ *S. tokelauae*
															X							* *globiger*	↓ *S. globiger*
							+															* *infirmirugosus*	
		?C.c.									?T.p.							?T.a.			?T.u		
X		X	X	X	X		+		X	X	X	X	+	X	X	+	X			X		* *uvula*	↑ *C. insueta,* *T. praemonita,* *T. antarctica,* *& T. uvula*
X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	* *glutinata*	
													+			X			+			* *ambitacrena*	
X			X		X		X		X					X	X						X	* *naparimaensis*	
X	X		X		X		X	X	X	X	X	X	+	X	X	X	X	X	X	X	X	* *incrusta*	
																					X	* *iota*	↓ *P. iota*
								X														* *clemenciae*	↓ *T. grata*
							X	+		+			X		X		X	+				* *bauerensis*	
																					X	* *anfracta*	
																					X	* *parkerae*	
											?	?										* *pieste*	↓ *T. postcretacea*
								+					+	X			+				+	* *praedigitata*	↑ *C. digitata*
													+									* *eamesi*	
																			+	+		* *pseudofoliata*	↑ *N. conglomerata*
											+	+	X	X	+	+	+		+		X	* *conglomerata*	
	+	+														X						* *eximia*	
				+	+		+	+	X	X	X	X	X	+	+	+						* *ventriosa*	
	+	+	X	X	X		+	+	X	+	X	+	X	+	X	+	?				+	* *larmeui*	
							+	+	+			+	+	+	X		X					* *obesa*	
X	+	+	X	+	+		+	+														* *venezuelana*	
X	+		+		+		+		+	+	X	+	+	X	X	+	+					* *baroemoensis*	↓ *N. altispira*
		+	X	X			X	+	X	X	X		X	X	X	X	X					* *globosa*	
												+					+					* *conica*	
		+	X	+								X	+			+	+					* *pozonensis*	
	+	+	X	+			+		X	X	+	X	+	X	+	X	X					* *altispira*	
			+																			* *dehiscens*	↓ *G. tripartita*

Table 4b.

B24/2/146-148	B23/4/148-150	B22/4/147-149	B21/5/148-150	B20/4/ 8- 10	B19/2/145-147	B17/6/144-146	B16/6/ 22- 24	B15/4/ 22- 24	B13/4/ 6- 8	B12/1/ 5- 7	B10/6/143-145	B 9/6/140-142	B 8/6/145-147	B 8/3/ 0- 2	B 7/4/147-149	B 6/1/148-150	B 4/6/146-148	B 4/1/ 0- 2	B 2/6/138-140	B 1/3/140-142	A 1/1/ 0- 2	Sample Phena	Species
											X				+							* *megastoma*	↑ *G. bulloides*
												+			+		+	+	X		X	* *bulloides*	
																			+			* *extensa*	
																					+	* *quadrilatera*	
																	X				+	* *bronnresigorum*	
																+	+	+	+	X		* *incrusta*	
												+		+		+						* *pseudobesa*	
										+	X	X	+		+	X	+	+	+	+	X	*foliata*	
																	+				+	*bulbosa*	
													X			+	X	X	+	+	X	*bollii*	
										+												*praebulloides*	
									+									+	X	X	X	*falconensis*	
												X	X		+	+		X				*occlusa*	
		?G.m.		?Gc.																			
			X		+																	* *opsionepenthoides*	↑ *G. microstoma* *& G. concinna*
			X		+	X																*druryi*	
				+	?																	*falconensis*	
							X	+	X	X	X		?									*druryi*	↓ *G. rubescens*
											+	+										*opsionepenthoides*	
							+	X		X	+	X	X		X	X	+	+	X			*decoraperta*	
								+														*appenninica*	
										X	X	X	X	X	X							*picassiana*	
											X	X	+		+							*altihelix*	
											+	+	+		+							*apertura*	
										+			+	+								* *delicata*	
							+	+	+	X		X	+	+	X							* *nepenthes*	
														?		+			X	X	X	* *rubescens*	
	+																					* *falconensis*	↑ *G. bulbosa*
X	+	+																				*disjuncta*	
											+											*disjuncta*	↓ *S. dehiscens*
			X	X	X		X	X	X	X	X	X	X	X	X	X	X	X				* *seminulina*	
													+			+						* *reticulata*	
															+	X	X	+	+			* *paenedehiscens*	
																X	X	X	X	+	+	* *immatura*	
																	+	X	+	+	X	* *dehiscens*	
														+	X		+	X			X	* *alpha*	↑ *O. quadrilobata*
							+										+	+				* *fistulosa*	
							+	+	+	+	+	X	X	+	+	+			X	X	+	* *sacculifera*	
X			X	+			+	+		+	+	X	+	+	+	+	+	+	X	+	X	* *quadrilobata*	
			X	+			+	+	X	+	+			+	+	+	X		X			* *triloba*	
		+	X	+			X	X	+	+	X	X	+	+	X	X		+	+	X		* *subsacculifera*	
		+	X	X			X	X	+	X	+	X	+	X	X	X	X	+	+	X	X	* *immatura*	
							+															* *incrusta*	
		+	X				+				+	X	+				+		X		+	* *suturalis*	↓ *O. universa*
			X	X								+										* *bilobata*	
										+		+					X					* *parkerae*	
			X	X		X	+		+	+	+	+	X	+	X	+	+	X	+	+	X	* *universa*	

Table 4c.

B24/2/146-148	B23/4/148-150	B22/4/147-149	B21/5/148-150	B20/4/ 8- 10	B19/2/145-147	B17/6/144-146	B16/6/ 22- 24	B15/4/ 22- 24	B13/4/ 6- 8	B12/1/ 5- 7	B10/6/143-145	B 9/6/140-142	B 8/6/145-147	B 8/3/ 0- 2	B 7/4/147-149	B 6/1/148-150	B 4/6/146-148	B 4/1/ 0- 2	B 2/6/138-140	B 1/3/140-142	A 1/1/ 0- 2	Sample / Phena	Species
																				+	X	* conglobatus	↑ G. conglobatus
											+	+	+		+			+	X		+	* canimarensis	
												+								+	+	compressus	
											+								+			epityche	
																		+	+			haitiensis	
			X	+																		* subquadratus	↓ G. haitiensis
			X	+																		* bulloideus	
					+		X	+	+	X												* obliquus	
										+												* extremus	
											+	+	+	X	+	X	X	X				obliquus	↓ G. elongatus
															+						X	bollii	
											+	X	+	+	+	X	+	+				extremus	
												+			X	X	X	X				anterubra	
																	X	+		X	+	* gomitulus	
																		+	X	+		* elongatus	
																					+	* pyramidalis	
																	+	X	X	X	X	* ruber	
																					+	* adamai	↑ G. adamsi
				?H.o.								?G.e.											
			+																			* praesiphonifera	↓ H. obesa & G. evoluta
												+	+		X	X			+			* evoluta	
													+		+			+				involuta	
												+	+	+	X	X		+				siphonifera	
																					+	obesa	↓ G. siphonifera
																					+	evoluta	
																					+	* involuta	
																					+	* siphonifera	
X		+	X				X	X		X	+			X				X				* angustiumbilicata	↓ T. detrita
			X					X		X			X	X								* primoripumilio	
																			X	X	X	* clarkei	
																					X	* atlantisae	
																					+	* cristata	
																					X	* egelida	
																		X				* quadalupensis	
																X	X	+	X	X	X	* humilis	
														X	X	X	X	X				* pumilio	
X			X							X	+	X	X	X	X	X	X	X	X	X	X	* quinqueloba	
								?														* redissimilis	↑ G. indigena
		?G.p.										?G.h.											
X	X	+	X	X	X		X	X	X	+	X			X								* variabilis	↓ G. parvulus & G. hexagonus
							+		+	+	+	+	+	+	X	X	+	+		X	+	* hexagonus	

Table 4d.

B24/2/146-148	B23/4/148-150	B22/4/147-149	B21/5/148-150	B20/4/ 8- 10	B19/2/145-147	B17/6/144-146	B16/6/ 22- 24	B15/4/ 22- 24	B13/4/ 6- 8	B12/1/ 5- 7	B10/6/143-145	B 9/6/140-142	B 8/6/145-147	B 8/3/ 0- 2	B 7/4/147-149	B 6/1/148-150	B 4/6/146-148	B 4/1/ 0- 2	B 2/6/138-140	B 1/3/140-142	A 1/1/ 0- 2	Sample / Phena	Species
											X	X	X	X	X	X	X	X	X	X	X	* *subcretacea*	↑ *P. helicina*
																	X	X	X	X		* *incompta*	
															+	X		X	X			* *hybrida*	
																	X		X	X	X	* *helicina*	
															X			+				* *eggeriformis*	
																			X	X	X	* *eggeri*	
																			X	+	X	* *dutertrei*	
																			+	+	X	* *kagaensis*	
																			X	X		* *atlantica*	
																					X	* *andamanica*	
												X			+			X	X		X	* *pseudopumilio*	
															+			X	X	X	X	* *planispira*	
																		+				* *pseudopima*	
											X	+	+					+				* *praehumerosa*	
															X		+					* *apertura*	
																+				+		* *vincentae*	
											+	X	+	+								* *tegillata*	
												+										*humerosa*	
														+	X	X		X				*globorotaloidea*	
											X	X	X	X	X							*acostaensis*	
											X		X	X	X	X	+		X	X		*pseudopachyderma*	
											X	X	+	X	X			X				*continuosa*	
								?	X													*subcretacea*	↑ *P. mayeri*
										+												*tegillata*	
			X																			* *polygonia*	
			X			X		X														* *globorotaloidea*	
	?	?	X	X	X		+	+	X	X												* *acostaensis*	
X	X	X	X	X	X																	* *juvenis*	
								X	X	X												* *pseudopachyderma*	
		X	X	X	X		+	+	X	X												* *continuosa*	
			X	X	+		+															* *mayeri*	
?	+	X	X																			* *partimlabiata*	
X		+	X																			* *umbilicata*	
X	X	X	X	X	+																	* *siakensis*	
X	X		X	X	X																	* *acrostoma*	
																+						* *spectabilis*	↓ *P. obliqueloculata*
														+	X	+	X	X				* *primalis*	
											+				+	+	X	+	X	+	X	* *praecursor*	
														+	+	X						* *praespectabilis*	
													+	+	X	+	X	X	X	+	X	* *okinawaensis*	
																			X	X	X	* *finalis*	
																			X	+	X	* *obliqueloculata*	

Table 4e.

B24/2/146-148	B23/4/148-150	B22/4/147-149	B21/5/148-150	B20/4/ 8- 10	B19/2/145-147	B17/6/144-146	B16/6/ 22- 24	B15/4/ 22- 24	B13/4/ 6- 8	B12/1/ 5- 7	B10/6/143-145	B 9/6/140-142	B 8/6/145-147	B 8/3/ 0- 2	B 7/4/147-149	B 6/1/148-150	B 4/6/146-148	B 4/1/ 0- 2	B 2/6/138-140	B 1/3/140-142	A 1/1/ 0- 2	Sample / Phena	Species
			+																			* *lobata*	↑ *F. fohsi*
			+																			* *fohsi*	
		+	+																			* *praefohsi*	
		X																				*peripheroacuta*	
X																						* *quinifalcata*	↓ *G. miozea*
	X																					* *peripheroacuta*	
X	X																					*bykovae*	
	+																					*lenguaensis*	
X																						*perconigi*	
														X	X	+				?	?	* *subscitula*	↑ *O. scitula*
														+								*praemargaritae*	
							? O. v.				? O.c.												
										+		+										*scitula*	↑ *O. ventriosa* & *O. cibaoensis*
											?	+										*hirsuta*	
												+										*evoluta*	
											X											*subscitula*	
											+											*primitiva*	
											X	+										* *cibaoensis*	
											?											* *evexa*	
							+	X		+	X											* *praemargaritae*	
																+						* *primitiva*	↓ *O. hirsuta*
																X	+					* *margaritae*	
															+	+						* *evoluta*	
															+	+						* *praehirsuta*	
															+							* *hirsuta*	

Table 4f.

B24/2/146-148	B23/4/148-150	B22/4/147-149	B21/5/148-150	B20/4/ 8- 10	B19/2/145-147	B17/6/144-146	B16/6/ 22- 24	B15/4/ 22- 24	B13/4/ 6- 8	B12/1/ 5- 7	B10/6/143-145	B 9/6/140-142	B 8/6/145-147	B 8/3/ 0- 2	B 7/4/147-149	B 6/1/148-150	B 4/6/146-148	B 4/1/ 0- 2	B 2/6/138-140	B 1/3/140-142	A 1/1/ 0- 2	Sample / Phena	Species
			+	+																		*praescitula*	↓ *G. praemenardii*
				X																		*quinifalcata*	
			+																			*archeomenardii*	
			+	X	X																	* *minima*	
		?	+																			* *conoidea*	
		+	X																			* *bykovae*	
		+	+	+	+																	* *praemenardii*	
			X																			* *rifensis*	
			+																			*ventriosa*	
				+																		*lenguaensis*	
			+	X	X																	*pseudomiocenica*	
				X	+																	*merotumida*	
			X																			*suterae*	
					+																	*praemargaritae*	
			X																			*perconigi*	
																	+			+	X	* *cultrata*	↑ *G. cultrata*
													?									* *praemiocenica*	
															+							*fijiensis*	
															X							*conferta*	
													X	X	X	X		+	+			*pseudomiocenica*	
								?G.l.			?G.f.												
							X	X	X	X	X	X										* *pseudomiocenica*	↓ *G. limbata* & *G. fijiensis*
							X	+	X		+	+										* *merotumida*	
							+	+	+	X	X	X										* *plesiotumida*	
							+															*tumida*	
										?												*praemiocenica*	
									X	X	+	?										*cultrata*	
														+								*merotumida*	↓ *G. tumida*
														X	X	X	X	X				*plesiotumida*	
													X	X	X	X	X	X	X	X	X	* *tumida*	
													+	X	+	X	X	X	+	+	+	* *flexuosa*	
																				+	+	* *ungulata*	
																+	+	+	X	+		* *hessi*	↑ *G. crassaformis*
														?T.s.									
															?							*mediterranea*	↓ *T. sphericomiozea* & *T. crassula*
																		+	X	X		*tosaensis*	↑ *T. truncatulinoides*
																		?	X			*ronda*	
																		+		+	X	*complanata*	↓ *T. pseudocrassa*
																					+	* *pseudocrassa*	

Thus the family with a Mesozoic stem, the Heterohelicidae, used herein to accommodate the Cenozoic lineages not descended from Globigerina monmouthensis, is only tentatively defined. The Globigerinidae can be usefully divided into four groups of considerable diversification: the Globigerininae, the Globorotaliinae, the Truncorotaloidinae, and the Candeininae. These subfamilies and their constituent tribes are defined in an analogous way (pp. 15, 16). Tribes are erected for those genera which give rise to any other genus, and subfamilies for those tribes which give use to any other tribe. Such usage is, however, not necessarily proposed as a general procedure.

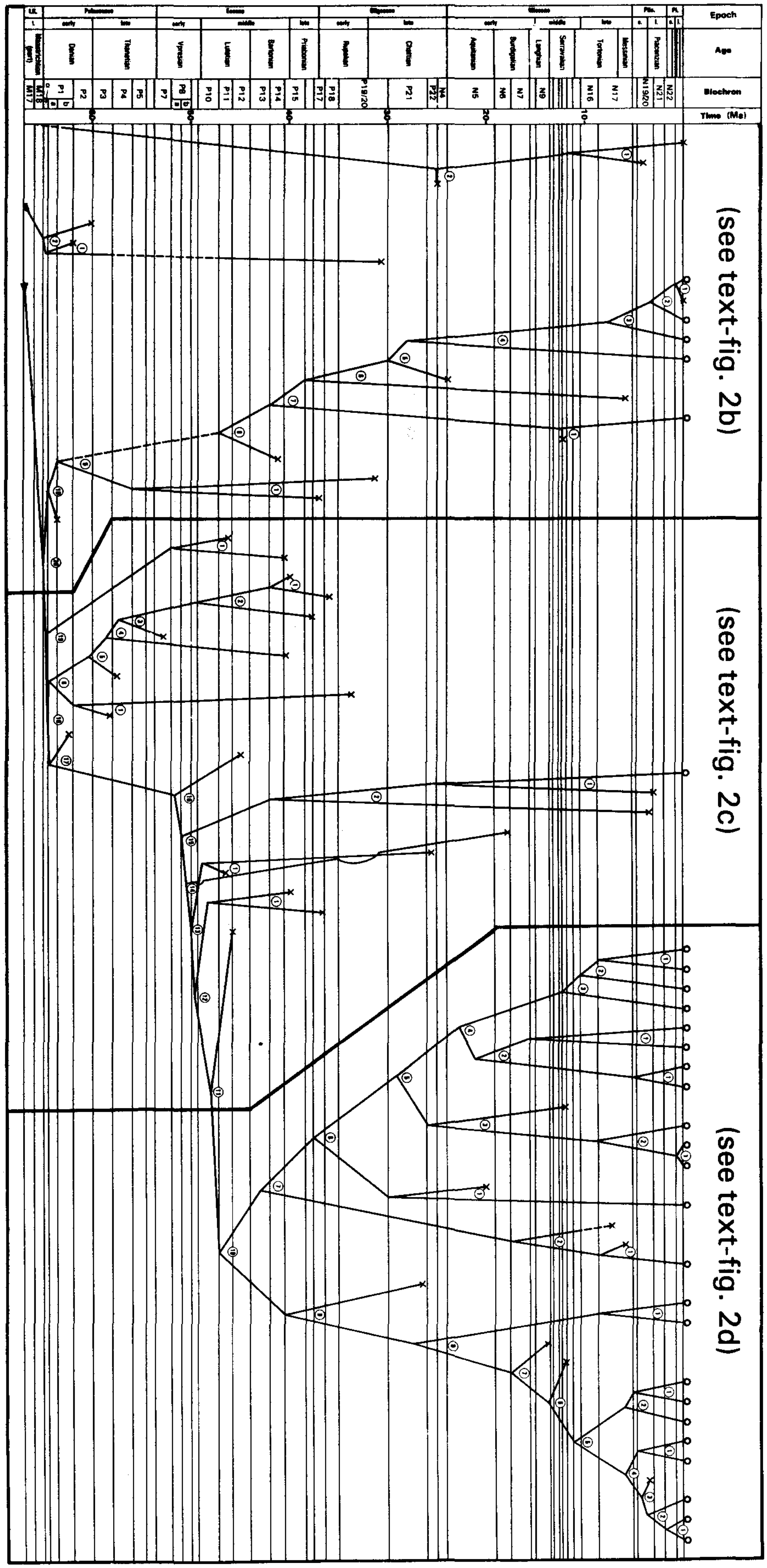
Systematic listing

All Cenozoic species with their constituent phena, as here interpreted, are listed below within the proposed cladistic classification (Table 7). This classification is used because it is uniquely detailed with regard to phylogenetic assignment of species. Both species encountered in the sections sampled in this study as well as those not encountered are listed below (see discussion above). Under each species all species-group taxa considered to belong to the species lineage are listed alphabetically. Reference to illustration, geographic location, and bio-, litho-, and chronostratigraphy (time-scale of Text-fig. 2) of the primary type is given for the species encountered in the material studied herein.

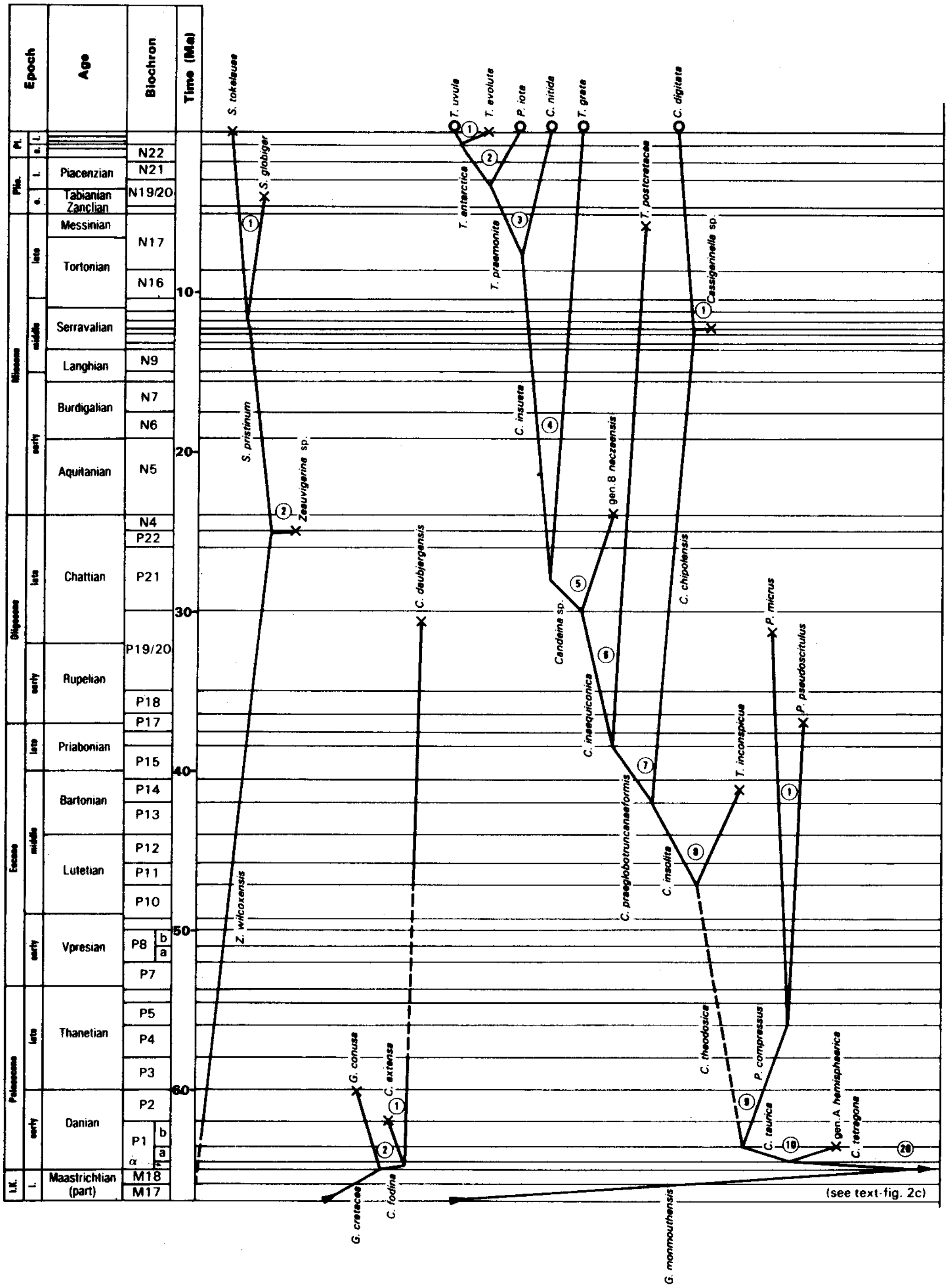
New phena are introduced as new nominal subspecies in order to satisfy formal criteria of availability. Only the holotype is described. In this study, the new nominal subspecies are subsequently relegated to phena when listed with other phena recorded. It is here that boundary criteria used in this study are indicated. All new taxa belonging to categories accepted by the Zoological Code (I.C.Z.N., 1961) are listed in Tables 9 and 10. There, corresponding page references to the systematic listing are given for the species-group taxa, and types, included subordinate taxa, and nomenclatural information are given for supraspecific taxa.

Because proportional composition of taxa is not relevant to the immediate aims of this study, the only distributive documentation given is the occurrence of phena (Tables 3, 4). However, occurrence in the unbiased representative samples (RS1) is also indicated. Throughout the text and tables recorded phena are listed within each species in order of stratigraphic position of respective primary types. When corresponding primary types come from indistinguishable stratigraphic positions, recorded phena are listed in alphabetic order. This ordering of phena is preferred to other possible methods (for example, ordering such that divergence of species is emphasized for the particular section or according to lowest occurrence in the particular section) as it allows a consistent order for different sections and will highlight possible inconsistencies in stratigraphic information (for example, if the stratigraphic and/or phylogenetic position of the primary type is very different from that of the recorded specimens). Thus this method is more likely to lead to uniform use of phena. Where splits, known to occur elsewhere, are not observed in a particular section containing at least one of these species, the resulting multiple-lineage series is designated by the list of those species names involved. In these cases a tentative division of the series into its individual lineage segments is indicated in the corresponding distribution table. Illustrations of specimens from these series are referred to in the text under the species corresponding to this tentative division. There the references to illustrations are placed in parentheses (rather than indicated by a question mark) in order to distinguish them from specimens questionably assigned to a phenon for morphologic reasons. If all occurrences, illustrated or not, recorded herein of a particular phenon in a particular species come from such a tentative subdivision, the entire reference to that phenon is placed in parentheses.

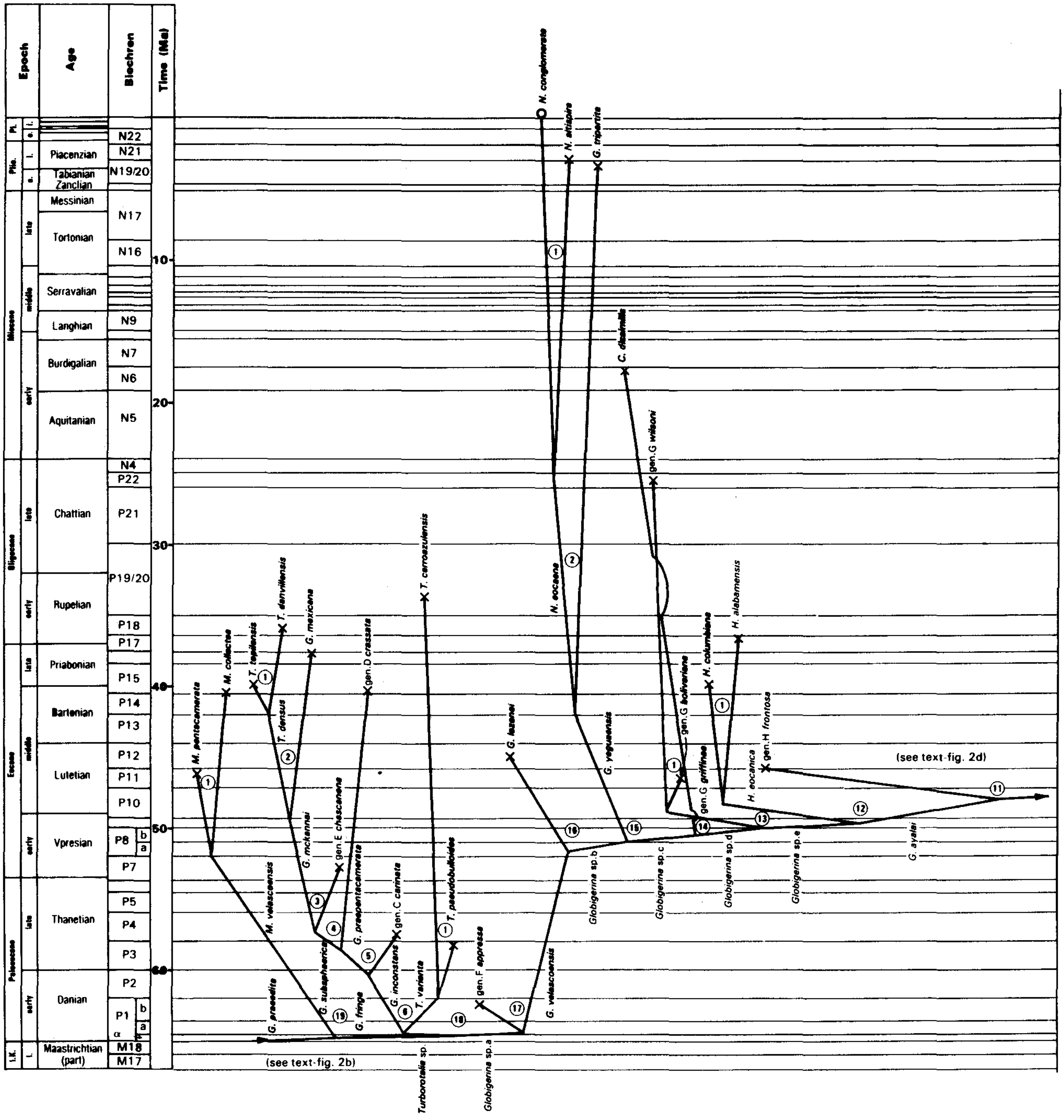
Text-figure 2 (pp. 40--43). A nonterminal chronologic stratophenetically derived cladogram of the Cenozoic planktic Foraminifera, proposed herein. All splitting events which are interpreted to have occurred are drawn at the earliest indication recorded, but clinal effects are not represented. Thus, for example, a particular geographic region may not have experienced a particular splitting event or the event may have occurred significantly later in that region. Terminal open circles indicate living species and terminal crosses indicate extinct species. Time scale of Berggren & Van Couvering (1974) for the Neogene and Hardenbol & Berggren (1978) for the Palaeogene. Figure divided into adjoining parts b--d, with 2a as key.



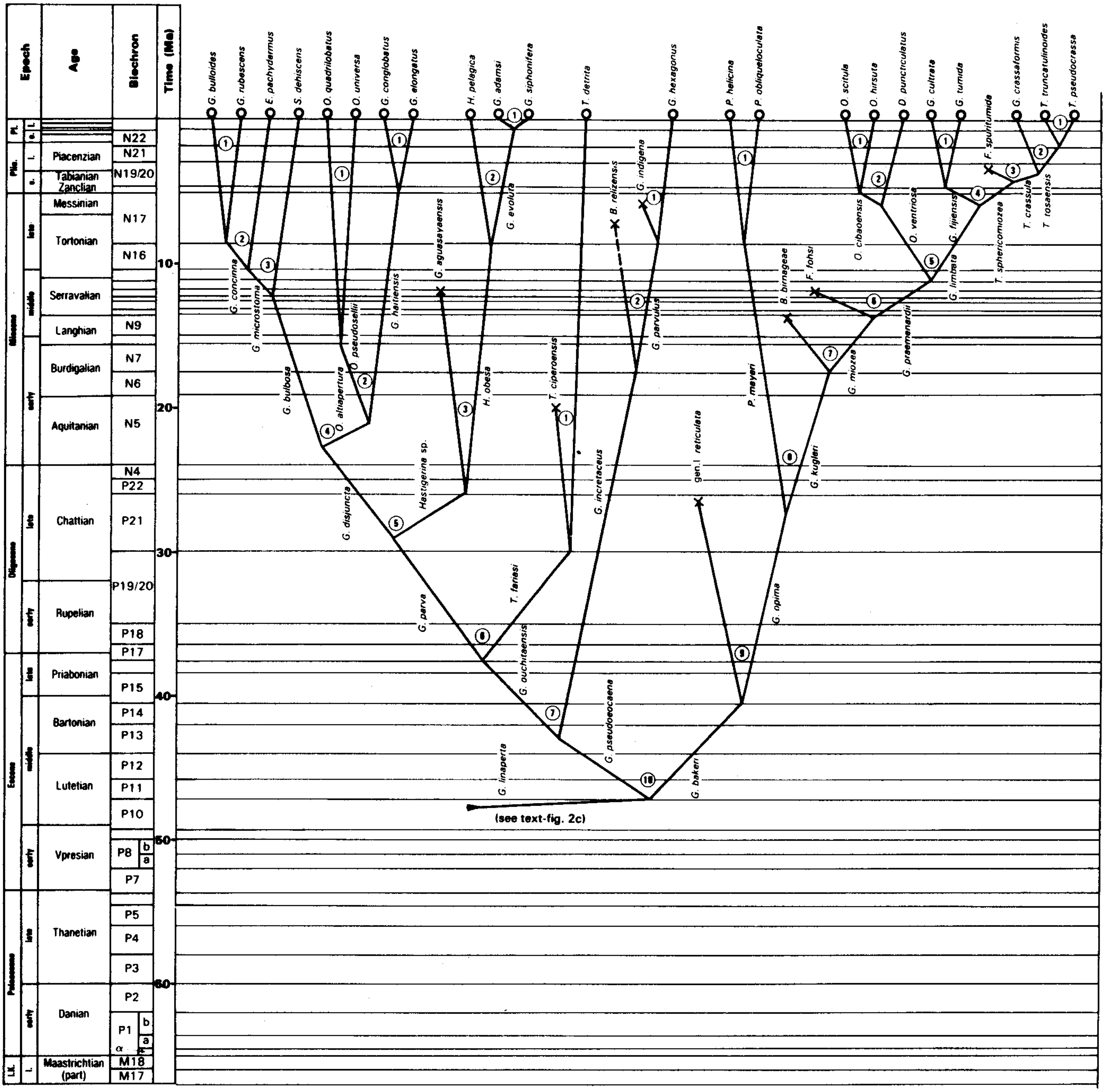
Text-figure 2a.



Text-figure 2b.



Text-figure 2c.



Text-figure 2d.

Even rare phena introduced herein are considered capable of sampling replication subsequent to this study. This likelihood arises from the enormous amount of material potentially available. At the topotypic level, only a minute fraction of the sample supplied was actually picked. Over even the relatively short local stratigraphic ranges of stratigraphically restricted phena, the continuous coring of the sections examined and the richness of the material, relative to the 10-cm^3 samples supplied, ensures abundant material for any phenon. In the light of this richness and also the fact that supplementary picking, after the decision to erect new phena, was not carried out, the actual numbers of specimens recovered of new phena bear little relevance and have not been counted if greater than ten; these are simply indicated as 'common'.

Bio- and lithostratigraphic units are those of the authors of the Initial Reports (see p. 21): Sites 77A and 77B were drilled at 00°28.90'N, 133°13.70'W, water depth 4290.68 m in early 1970; Site 208 was drilled at 26°06.61'S, 161°13.27'E, water depth 2545 m on 23, 24 December 1971; both carried out by the Joint Oceanographic Institutions for Deep Earth Sampling. Samples are indicated thus: site number / core number / section number / interval in cm /representative sample. Biostratigraphic units referred to herein and not named according to the recommendations of the International Stratigraphic Guide (I.S.S.C., 1976) are indicated by category names beginning with lower-case letters. The following abbreviations are used: acc., 'according to'; and vs, 'differs from the following by'. Morphologic terminology follows Blow & Banner (1962). With one exception all recorded phena are illustrated by scanning electron micrographs (Cambridge Stereoscan 500, Electron Microscope Unit, University of Queensland). All photographed specimens are separately housed in the fossil collection of the Department of Geology and Mineralogy, University of Queensland and are given the catalogue numbers UQF 71067 to UQF 72499.

CLADEGROUP(27?) GLOBIGERINIVICESIMAESEPTIMAE

Stem species. 'Diplotremina multifimbriata Fuchs'.

Remarks

Pre-Cenozoic branching sequences of planktic foraminifers have not been investigated by the author. Fuchs's work (see Text-fig. 3) is extremely tentatively used to furnish a rough guide to allow all planktic taxa to be considered under a single hierarchy.

Table 5. List of genera of the Cenozoic planktic Foraminifera which are valid according to the taxonomy proposed herein. Asterisks indicate the type species-group taxa, for which the senior synonym at the species level is indicated where applicable.

Bandyus Fordham n. gen. *Globorotaloides suteri relizensis Bandy, Ingle, & Wright, 1971; =B. relizensis (Bandy, Ingle, & Wright).
Blowellus Fordham n. gen. *Globorotalia birnageae Blow, 1959; =B. birnageae (Blow).
Candeina d'Orbigny, 1839. *Candeina nitida d'Orbigny, 1839.
Cassigerinella Pokorný, 1955. *Cassigerinella boudecensis Pokorný, 1955; =C. chipolensis (Cushman & Ponton).
Cassigerinelloita Stolk, 1965. *Cassigerinelloita amekiensis Stolk, 1965; =C. daubjergensis (Brönnimann).
Catapsydrax Bolli, Loeblich, & Tappan, 1957. *Globigerina dissimilis Cushman & Bermúdez, 1937; =C. dissimilis (Cushman & Bermúdez).
Deshayesulus Fordham n. gen. *Globigerina puncticulata Deshayes, 1832; =D. puncticulatus (Deshayes).
Ehrenbergellus Fordham n. gen. *Aristerospira pachyderma Ehrenberg, 1861; =E. pachydermus (Ehrenberg).
Falsella Fordham n. gen. *F. spuritumida spuritumida Fordham n. subsp.; =F. spuritumida Fordham.
Fohsella Bandy, 1972. *Globorotalia (G.) praefohsi Blow & Banner, 1966; =F. fohsi (Cushman & Ellisor).
Gallerius Fordham n. gen. *Globigerina crassaformis Galloway & Wissler, 1927; =G. crassaformis (Galloway & Wissler).
Globigerina d'Orbigny, 1826. *G. bulloides d'Orbigny, 1826.
Globigerinatheka Brönnimann, 1952. *G. barri Brönnimann, 1952; =G. mexicana (Cushman).
Globigerinella Cushman, 1927. *Globigerina aequilateralis Brady, 1879; =G. siphonifera (d'Orbigny).
Globigerinoides Cushman, 1927. *Globigerina rubra d'Orbigny, 1839; =G. elongatus (d'Orbigny).
Globigerinopsis Bolli, 1962. *G. aguasayaensis Bolli, 1962.
Globoquadrina Finlay, 1947. *Globorotalia dehiscens Chapman, Parr, & Collins, 1934; =G. tripartita (Koch).
Globorotalia Cushman, 1927. *Pulvinulina menardii var. tumida Brady, 1877; =G. tumida (Brady).
Globorotaloides Bolli, 1957. *G. variabilis Bolli, 1957; =G. parvulus (Bolli).
Guembelitria Cushman, 1933. *Gümbelitria cretacea Cushman, 1933; =Guembelitria cretacea Cushman.
Guembelitrioides El-Naggar, 1971. *Globigerinoides higginsi Bolli, 1957; =Guembelitrioides lozanoi (Colom).
Hantkenina Cushman, 1925. *H. alabamensis Cushman, 1925.
Hastigerina Thomson, 1876. *H. murrayi Thomson, 1876; =H. pelagica (d'Orbigny).
Morozovella McGowran, 1968. *Pulvinulina velascoensis Cushman, 1925; =M. velascoensis (Cushman).
Neoacarinina Thompson, 1973. *N. blowi Thompson, 1973; =N. conglomerata (Schwager).
Obandyella Haman, Huddleston, & Donahue, 1980. *Rotalina hirsuta d'Orbigny, 1839; =O. hirsuta (d'Orbigny).
Orbulina d'Orbigny, 1839. *O. universa d'Orbigny, 1839.
Planorotalites Morozova, 1957. *Globorotalia pseudoscitula Glaessner, 1937; =P. pseudoscitulus (Glaessner).
Pulleniatina Cushman, 1927. *Pullenia sphaeroides var. obliqueloculata Parker & Jones, 1865; =Pulleniatina obliqueloculata (Parker & Jones).
Parkerina Fordham n. gen. *Globigerinita iota Parker, 1962; =P. iota (Parker).
Sphaeroidinella Cushman, 1925. *Sphaeroidina bulloides dehiscens Parker & Jones, 1865; =S. dehiscens (Parker & Jones).
Streptochilus Brönnimann & Resig, 1971. *Bolivina tokelauae Boersma, 1969; =S. tokelauae (Boersma).
Tenuitella Fleisher, 1974. *Globorotalia gemma Jenkins, 1966; =T. postcretacea (Myatiuk).
Testacarinata Jenkins, 1971. *Globorotalia inconspicua Howe, 1939; =T. inconspicua (Howe).
Tinophodella Loeblich & Tappan, 1957. *T. ambitacrena Loeblich & Tappan, 1957; =T. uvula (Ehrenberg).
Toddella Fordham n. gen. *Globigerina? grata Todd, 1957; =T. grata (Todd).
Truncorotalia Cushman & Bermúdez, 1949. *Rotalina truncatulinoides d'Orbigny, 1839; =T. truncatulinoides (d'Orbigny).
Truncorotaloides Brönnimann & Bermúdez, 1953. *T. rohri Brönnimann & Bermúdez, 1953; =T. densus (Cushman).
Turborotalia Cushman & Bermúdez, 1949. *Globorotalia centralis Cushman & Bermúdez, 1937; =T. cerroazulensis (Cole).
Turborotalita Blow & Banner, 1962. *Truncatulina humilis Brady, 1884; =T. detrita (Terquem).
Zeauvigerina Finlay, 1939. *Z. zelandica Finlay, 1939; =Z. wilcoxensis (Cushman & Ponton).
unnamed genera A-I.

CLADEGROUP(10?) HETEROHELICIDECIMAE

Stem species. '*Praegubkinella* sp.'

CLADEGROUP(5?) GUEMBELITRIQUINTAE

Stem species. '*Conoglobigerina* sp.'

CLADEGROUP(2) GUEMBELITRISECUNDAE

Stem species. *Guembelitria cretacea* Cushman.

Remarks

The stem species of this group is the only formal multiserial taxon used by Blow (1979) in his range charts and so it is very tentatively chosen as ancestor of similar earliest-Palaeocene species. Because this is a Cretaceous lineage, conspecific phena and the immediate origin of the species have not been studied by the author.

Guembelitria conusa (Chalilov)

Included phena

Globigerina (Eoglobigerina) trifolia Morozova, 1961.
Globocunusa conusa Chalilov, 1956.

Remarks

Although Blow (1979) noted significant differences in wall structure and serial arrangement between the basal-Palaeocene guembelitriform phena, *trifolia* and '*Guembelitria* sp.', and the Danian phenon *conusa*, the thin interval of overlap between these taxa suggests a single lineage of descent may have linked them. The highest occurrence of this lineage is thus defined by that of phenon *conusa*, that is, near the top of Blow's (1979) *Globorotalia (Acarinina) praecursoria* s.s. partial-range zone.

CLADEGROUP(1) CASSIGERINELLOITIPRIMAE

Stem species. *Cassigerinelloita fodina* (Blow).

Remarks

Blow (1979) considered the phena *fodina*, *extensa* (Blow), and *daubjergensis* (Brönnimann) to be quite closely related based on similarities in wall surface, coiling mode, and chamber shape. These phena are thus considered to share an immediate common ancestral lineage.

The stem species of this group is very tentatively considered descended from *G. cretacea*. This is consistent with Bang's (1969) phylogenetic interpretation of similarities in wall between guembelitriform phena and phenon *daubjergensis* as well as the often-reported high spire (for example, Stainforth & others, 1975) of the latter taxon.

Cassigerinelloita fodina (Blow)

Included phenon

Eoglobigerina? *fodina* Blow, 1979.

Remarks

This lineage is considered to appear at the base of Blow's (1979) *Globorotalia (Turborotalia) longiapertura* partial-range zone where it contains '*Eoglobigerina* sp. type I' and phena *fodina* and *extensa*. This level is thus chosen as the upper limit of *G. cretacea*, the interpreted immediate common ancestor of *C. conusa* and *C. fodina*.

Cassigerinelloita extensa (Blow)

Included phenon

Eoglobigerina? *extensa* Blow, 1979.

Remarks

This interpreted lineage is considered to generally retain the morphology of *C. fodina*. The upper limit is determined by the highest occurrence of phenon *extensa*, that is, the top of Blow's (1979) *Globorotalia (Turborotalia) compressa* s.s./*E. eobulloides simplicissima* concurrent-range subzone.

Cassigerinelloita daubjergensis (Brönnimann)

Included phena

Cassigerinelloita amekiensis Stolk, 1963.
Catapsydrax echinatus Bolli, 1957.
Globigerina daubjergensis Brönnimann, 1953.
G. kozlowskii Brotzen & Pozaryska, 1961.
G. (G.) microcellulosa Morozova, 1961.
Globigerinita africana Blow & Banner, 1962.

Table 6. List of species of the Cenozoic planktic foraminifera which are valid according to the taxonomy proposed herein. Each corresponds to a segment in Text-fig. 2. Arrangement is alphabetical by specific epithet.

adamsi (Banner & Blow, 1959); Globigerinella
aguasayaensis Bolli, 1962; Globigerinopsis
alabamensis Cushman, 1925; Hantkenina
altiapertura (Bolli, 1957); Orbulina
altispira (Cushman & Jarvis, 1926); Neoacarinina
antarctica (Keany & Kennett, 1972); Tinophodella
appressa (Blow, 1979); gen.F
ayalai Bermúdez, 1960; Globigerina
bakeri (Cole, 1927); Globorotalia
birnageae (Blow, 1959); Blowellus
bolivariana (Petters, 1954); gen.G
bulbosa LeRoy, 1944; Globigerina
bulloides d'Orbigny, 1826; Globigerina
carinata (El-Naggar, 1966); gen.C
cerroazulensis (Cole, 1928); Turborotalia
chascanona (Loeblich & Tappan, 1957); gen.E
chipolensis (Cushman & Ponton, 1932); Cassigerinella
cibaoensis (Bermúdez, 1949); Obandyella
ciperoensis (Bolli, 1954); Turborotalita
collactea (Finlay, 1939); Morozovella
columbiana (Petters, 1954); Hantkenina
compressus (Plummer, 1926); Planorotalites
concinna Reuss, 1850; Globigerina
conglobatus (Brady, 1879); Globigerinoides
conglomerata (Schwager, 1866); Neoacarinina
conusa (Chalilov, 1956); Guembelitria
crassaformis (Galloway & Wissler, 1927); Gallerius
crassata (Cushman, 1925); gen.D
crassula (Cushman & Stewart, 1939); Truncorotalia
cretacea Cushman, 1933; Guembelitria
cultrata (d'Orbigny, 1839); Globorotalia
danvillensis (Howe & Wallace, 1932); Truncorotaloides
daubjergensis (Brönnimann, 1953); Cassigerinelloita
dehiscens (Parker & Jones, 1865); Sphaeroidinella
densus (Cushman, 1925); Truncorotaloides
detrita (Terquem, 1875); Turborotalita
digitata (Brady, 1879); Cassigerinella
disjuncta (Finlay, 1940); Globigerina
dissimilis (Cushman & Bermúdez, 1937); Catapsydrax
elongatus (d'Orbigny, 1826); Globigerinoides
eocaena (Gümbel, 1868); Neoacarinina
eocanica (Nuttall, 1928); Hantkenina
evoluta Fordham n. sp.; Globigerinella
evoluta Fordham n. sp.; Tinophodella
extensa (Blow, 1979); Cassigerinelloita
fariasi (Bermúdez, 1960); Turborotalita
fijiensis Cushman, 1934; Globorotalia
fodina (Blow, 1979); Cassigerinelloita
fohsi (Cushman & Ellisor, 1939); Fohsella
fringa Subbotina, 1950; Globigerina
frontosa (Subbotina, 1953); gen.H
globiger (Schwager, 1866); Streptochilus
grata (Todd, 1957); Toddella
griffinae (Blow, 1979); gen.G
haitiensis (Coryell & Rivero, 1940); Globigerinoides
helicina (d'Orbigny, 1826); Pulleniatina
hemisphaerica (Morozova, 1961); gen.A
hexagonus (Natland, 1938); Globorotaloides
hirsuta (d'Orbigny, 1839); Obandyella
inaequiconica (Subbotina, 1960); Candeina
inconspicua (Howe, 1939); Testacarinata
inconstans (Subbotina, 1953); Globigerinatheka
incretaceus (Chalilov, 1956); Globorotaloides
indigena (Łuczkowska, 1955); Globorotaloides
insolita (Jenkins, 1966); Candeina
insueta (Cushman & Stainforth, 1945); Candeina
iota (Parker, 1962); Parkerina
kugleri Bolli, 1957; Globorotalia
limbata (d'Orbigny, 1902); Globorotalia
linaperta Finlay, 1939; Globigerina
lozanoi (Colom, 1954); Guembelitrioides
mayeri (Cushman & Ellisor, 1939); Pulleniatina
mckannai (White, 1928); Globigerinatheka
mexicana (Cushman, 1925); Globigerinatheka
microstoma Cita, Premoli Silva, & Rossi, 1965; Globigerina
micrus (Cole, 1927); Planorotalites
miozea Finlay, 1939; Globorotalia
monmouthensis (Olsson, 1960); Globigerina
nazcaensis (Quilty, 1976); gen.B
nitida d'Orbigny, 1839; Candeina
obesa (Bolli, 1957); Hastigerina
obliqueloculata (Parker & Jones, 1865); Pulleniatina
opima Bolli, 1957; Globorotalia
ouchitaensis Howe & Wallace, 1932; Globigerina
pachydermus (Ehrenberg, 1861); Ehrenbergellus
parva Bolli, 1957; Globigerina
parvulus (Bolli, 1957); Globorotaloides
pelagica (d'Orbigny, 1839); Hastigerina
pentacamerata (Subbotina, 1947); Morozovella
postcretacea (Myatiuk, 1950); Tenuitella
praeedita (Blow, 1979); Globigerina
praeglobotruncanaeformis (Bykova, 1960); Candeina
praemenardii Cushman & Stainforth, 1945; Globorotalia
praemonita Fordham n. sp.; Tinophodella
praepentacamerata (Shutskaya, 1956); Globigerinatheka
pristinum Brönnimann & Resig, 1971; Streptochilus
pseudobulloides (Plummer, 1926); Turborotalia
pseudocrassa (Chapman & Parr, 1937); Truncorotalia
pseudoeocaena Subbotina, 1953; Globigerina
pseudosellii (Brönnimann & Resig, 1971); Orbulina
pseudoscitulus (Glaessner, 1937); Planorotalites
puncticulatus (Deshayes, 1832); Deshayesulus
quadrilobata (d'Orbigny, 1846); Orbulina
relizensis (Bandy, Ingle, & Wright, 1971); Bandyus
reticulata (Stache, 1865); gen.I
rubescens Hofker, 1956; Globigerina
scitula (Brady, 1882); Obandyella
siphonifera (d'Orbigny, 1839); Globigerinella
sphericomiozea Walters, 1965; Globorotalia
spuritumida Fordham n. sp.; Falsella
subsphaerica (Subbotina, 1947); Globigerinatheka
taurica (Morozova, 1961); Candeina
tetragona (Morozova, 1961); Candeina
theodosica (Morozova, 1961); Candeina
tokelauae (Boersma, 1969); Streptochilus
topilensis (Cushman, 1925); Truncorotaloides
tosaensis (Takayanagi & Saito, 1962); Truncorotalia
tripartita (Koch, 1926); Globoquadrina
truncatulinoides (d'Orbigny, 1839); Truncorotalia
tumida (Brady, 1877); Globorotalia
universa d'Orbigny, 1839; Orbulina
uvula (Ehrenberg, 1861); Tinophodella
varianta (Subbotina, 1953); Turborotalia
velascoensis Cushman, 1925; Globigerina
velascoensis (Cushman, 1925); Morozovella
ventriosa (Ogniben, 1958); Obandyella
wilcoxensis (Cushman & Ponton, 1932); Chiloguembelina
wilsoni (Cole, 1927); gen.G
yeguaensis (Weinzierl & Applin, 1929); Globoquadrina
sp.; Candeina
sp.; Cassigerinella
sp.a; Globigerina
sp.b; Globigerina
sp.c; Globigerina
sp.d; Globigerina
sp.e; Globigerina
sp.; Turborotalia
sp.; Zeauvigerina

G. hardingae Blow, 1979.
G. martini martini Blow & Banner, 1962.
G. martini scandretti Blow & Banner, 1962.
Globoconusa daubjergensis gigantea Bang, 1969.

Remarks

Despite the above-mentioned morphologic similarities among phena *fodina*, *extensa*, and *daubjergensis*, the latter taxon appears to retain a distinct morphology throughout the variability illustrated by the literature. Thus, because Blow (1979) reports its definite lowest occurrence higher than those of phena *fodina* and *extensa*, *daubjergensis* is considered to split from *C. fodina* and this would occur in the lower part of Blow's (1979) *Globorotalia* (*Turborotalia*) *longiapertura* partial-range zone.

Blow (1979) considered phena *gigantea*, *kozlowskii*, and '*Globastica* sp. type I' to be descendants of phenon *daubjergensis* and, considered as a single lineage, this would extend to at least the top of Blow's (1979) *Globorotalia* (*Morozovella*) *angulata* s.s. partial-range zone. Apart from phenon *amekiensis* which was considered aberrant, Blow (1979) considered the globigerinitiform phena listed above to have possibly descended from phenon *hardingae* and here these are tentatively considered part of a single lineage. This lineage would then range from the upper *Subbotina frontosa* s.s./*G.* (*T.*) *pseudomayeri* concurrent-range zone of Blow (1979) to the upper *Globigerina sellii*--*G. ampliapertura* partial-range zone of Blow (1970).

The two above-mentioned lineages are herein extremely tentatively suggested to be part of a single lineage. This is because the lower sublineage contains the only Cenozoic globigeriniform phena, including the bullate *gigantea*, available as ancestors, once certain considerations reject other possible species. In particular, close relationship of members of the upper sublineage with subbotiniform, dentoglobigeriniform, or catapsydraciform species of the Globigeriniquintaedecimae was rejected by Blow (1979) because of the distinctive spinose and coarsely perforate wall of the former, their lack of portical structures, and their globigeriniform shape. Globigerinitiform and tinophodelliform species which Blow also contrasted with members of the upper sublineage appeared much later.

Anagenesis between the above-mentioned sublineages would have required acquisition of numerous large pores inbetween massive ridges which supported spine bases. This does not appear likely although densely pustulose specimens of phenon *daubjergensis* from the Danian (Blow, 1979, pl. 256, fig. 7) may have allowed such development. A further problem is the large interval between lower and upper sublineages, namely, upper Palaeocene to lower Eocene. However, the small size typical of members of both sublineages suggests that small connecting phena may have been missed.

The inclusion of phenon *amekiensis* establishes the generic name of the above-listed three species supposedly descended from guembelitriform ancestors. However, this decision is very tentative and is based mainly on its small size and apparently thin wall. The other species at this interval to which this phenon could belong, *Catapsydrax dissimilis* (Cushman & Bermúdez), contains much larger phena with thick walls.

CLADEGROUP(9?) HETEROHELICINONAE

Stem species. '*Woletzina* sp.'

CLADEGROUP(2?) ZEAUVIGERINISECUNDAE

Stem species. *Zeauvigerina wilcoxensis* (Cushman & Ponton).

Remarks

Lack of phylogenetic study of Palaeogene biserial taxa prevents corresponding assessment of branching sequences. Thus, because of the seemingly continuous range of variation exhibited by the phena belonging to this Palaeogene group, only a single lineage is extremely tentatively interpreted here. This Palaeogene lineage is tentatively considered to be descended from a member of *Heterohelix* Ehrenberg in agreement with Loeblich & Tappan (1964) and Brönnimann & Resig (1971). However, Reiss (1963) and Jenkins (1971) considered the single-layered wall of chiloguembeliniform species to indicate relationship with the buliminids.

The members of each of the three genera which appear to form a direct line of descent, *Heterohelix* Ehrenberg, *Zeauvigerina* Finlay (including '*Chiloguembelina* Loeblich & Tappan'), and *Streptochilus* Brönnimann & Resig, appear to be quite distinct morphologically. Thus the last two are tentatively considered to arise by cladogenesis rather than anagenesis even though sister species in each case cannot as yet be identified.

Zeauvigerina wilcoxensis (Cushman & Ponton)

Included phena

Bolivina daniana Nakkady & Tallat, 1959.
Chiloguembelina? circumlabiata Hillebrandt, 1962.
C. midwayensis var. *stromiformis* Beckmann, 1957.
C. midwayensis subcylindrica Beckmann, 1957.
C. parallela Beckmann, 1957.
C. subtriangularis Beckmann, 1957.
C. victoriana Beckmann, 1957.
C. waiparaensis Jenkins, 1966.
Chilogümbelina taurica Morozova, 1961.
Guembelina midwayensis var. *nammalensis* Haque, 1956.
G. tenuis Todd, 1957.
Gümbelina barnardi Ansary, 1955.
G. crinita Glaessner, 1937.
G. cubensis Palmer, 1934.
G. cubensis var. *heterostoma* Bermúdez, 1937.
G. garretti Howe, 1939.
G.? marshallana Todd, 1954.
G. mauriciana Howe & Roberts, 1939.
G. micra Subbotina, 1950.
G. midwayensis Cushman, 1940.
G. morsei Kline, 1943.
G. multicellaris Hussey, 1949.
G. ototara Finlay, 1940.
G. pumilia Subbotina, 1950.
G. trinitatensis Cushman & Renz, 1942.
G. venezuelana Nuttal, 1935.
G. venezuelana var. *rugosa* Parr, 1938.
G. wilcoxensis Cushman & Ponton, 1932.
Gümbelitria columbiana Howe, 1939.
G. irregularis Morozova, 1961.
G. oveyi Ansary, 1955.
G. stavensis Bandy, 1949.
G.(?) vivans Cushman, 1934.
Textularia martini Pijpers, 1933.
Zeauvigerina aegyptica Said & Kenawy, 1956.
Z. parri Finlay, 1939.
Z. teuria Finlay, 1947.
Z. zelandica Finlay, 1939.

Zeauvigerina sp.

Remarks

This species represents a hypothetical short-lived sister species of *Streptochilus pristinum*.

CLADEGROUP(1) STREPTOCHILIPRIMAE

Stem species. *Streptochilus pristinum* Brönnimann & Resig.

Remarks

The close similarity between specimens included here and those included in *Bolivina* d'Orbigny and *Brizalina* Costa (see, for example, Sliter, 1970; pl. 1, figs. 1--8 herein) deserves close attention. Ancestry of *Streptochilus* from chiloguembeliniform species is, however, most likely (Brönnimann & Resig, 1971, Fleisher, 1974) and absence of a toothplate may distinguish all members of this genus from morphologically similar benthic individuals. Although

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Table 7 (opposite). Cladistic classification of the Cenozoic planktic Foraminifera down to species corresponding to the cladogram of Text-fig. 2. Higher taxonomic categories tentatively derived from the cladogram of Mesozoic planktic foraminifers of Text-fig. 3.

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transitions between phena belonging to Zeauvigerina and Streptochilus have not been reported (Fleisher, 1974), Blow's (1969) record of the highest occurrence of 'Chiloguembelina ex group cubensis (Palmer)', at the base of his Globigerinoides quadrilobatus primordius/Globorotalia (Turborotalia) kugleri concurrent-range zone, corresponds to the lowest occurrence of S. pristinum given by Brönnimann & Resig (1971). As discussed above, Streptochilus is tentatively considered to arise from Zeauvigerina by cladogenesis.

In the sections studied two separate sets of biserial populations were found from the upper-middle Miocene to lower Pleistocene. These are considered sister species and for the present their split is taken at the lowest occurrence of S. globiger reported by Brönnimann & Resig (1971), that is, the upper Sphaeroidinellopsis subdehiscens s.s.--Globigerina druryi partial-range zone of Blow (1969).

Streptochilus pristinum Brönnimann & Resig

Included phenon

Streptochilus pristinum Brönnimann & Resig, 1971.

Streptochilus globiger (Schwager)

Included phenon

Textilaria globigera Schwager, 1866 (figured syntype: pl. 7, fig. 100; probably Globorotalia tumida flexuosa zone to G. multicamerata--Pulleniatina obliqueloculata s.s. zone of Srinivasan & Sharma, 1973; Nicobar Islands, India, northeast Indian Ocean; lower Pliocene?).

New phenon

Streptochilus globiger infirmirugosus n. subsp.

Holotype. UQF 71195. Pl. 1, fig. 115. Globorotalia puncticulata zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/9/1/128--130/RS2, 85.28--85.30 m below sea-floor; lower Pliocene. Small, fairly fragile; biserial. Equatorial outline oval, lobate; lateral outline acutely conical, moderately lobate. Chambers moderately globular and moderately rectangular, closely appressed, 12 in total; increase moderate and regular. Dorsal view: chambers circular, in a flat plane. Ventral view: aperture interiomarginal, circular but slightly elongated along plane of biseries, moderately wide, one side turned into chamber, other side flaring out, forming a lip. Lateral view: chambers moderately inflated; sutures moderately deeply depressed, straight, slightly sinuous between successive chambers. Wall weakly pustulose to weakly rugose in early chambers; ridges very low, do not form a distinct cross-cutting network. Length, 105 µm; width, 70 µm; height, 180 µm.

Material. Common.

Derivation of name. Latin, infirmus, weak; rugosus, wrinkled.

Phena recorded

Phenon globiger (Schwager). Pl. 1, figs. 42, 43, 45--66, 70--73, 77--82, 90--92, 103--108, 119, 128--130.

Phenon infirmirugosus n. ph. Pl. 1, figs. 44, 67--69, 74--76, 83--89, 93--102, 109--118, 127. Vs ph. globiger: weakly rugose such that last-2 chambers lack distinctive rugae.

Remarks

Both of the recorded phena include specimens with retral processes extending from the posterior portions of chambers.

Although the small Streptochilus individuals could easily be missed in biostratigraphic studies (Brönnimann & Resig, 1971), the highest occurrence of S. globiger is more or less equivalent, in terms of Blow's (1969) biozones, in the two sections studied and in D.S.D.P. Leg 7 (Brönnimann & Resig, 1971). Thus this may be a chronohorizon.

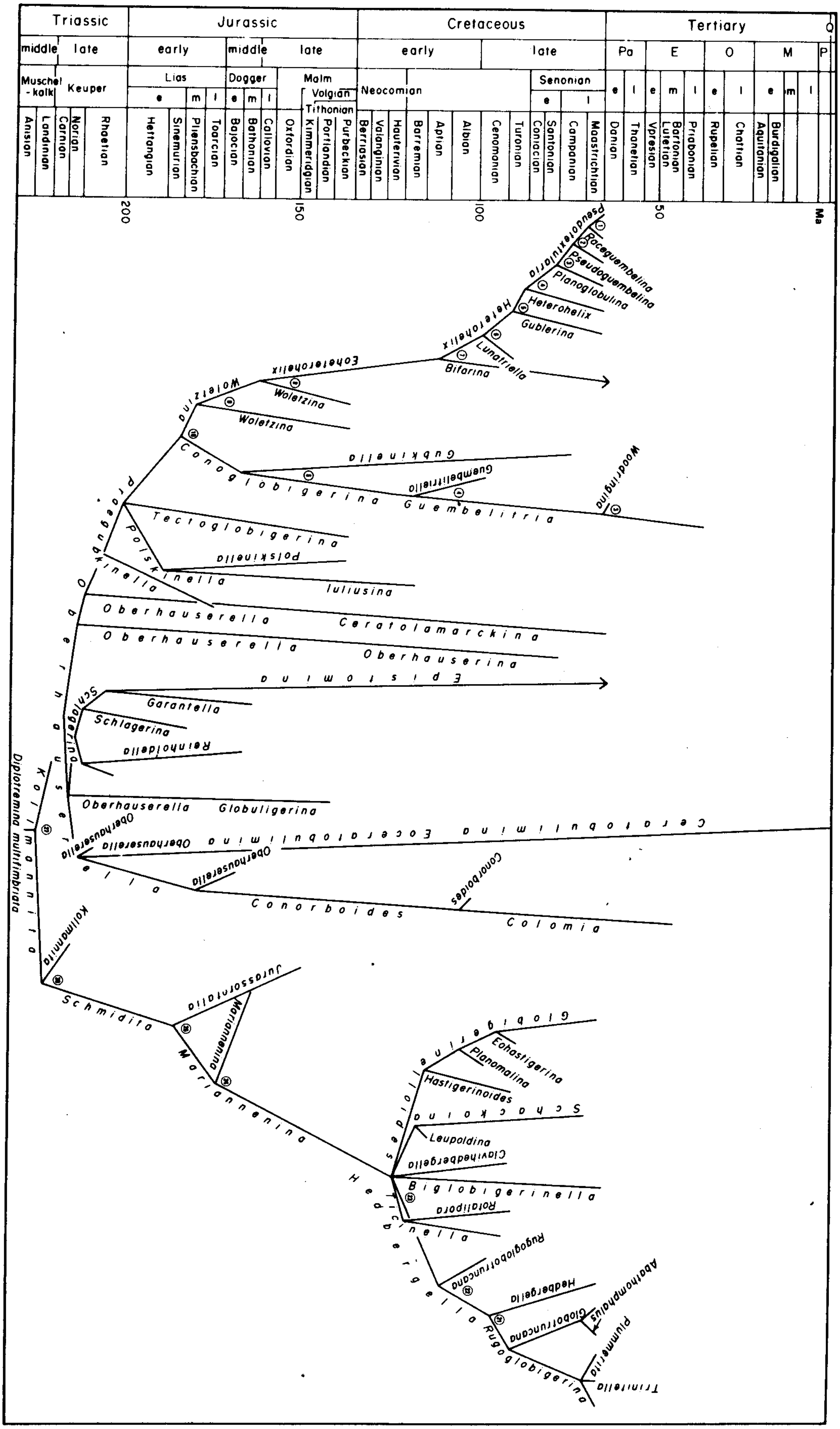
Streptochilus tokelauae (Boersma)

Included phena

Bolivina tokelauae Boersma in Kierstead & others, 1969 (pl. 1, fig. 1; upper B. tokelauae zone; northeast of Suvorov Islands, west South Pacific Ocean; upper Pleistocene).

Streptochilus latum Brönnimann & Resig, 1971 (pl. 51, fig. 3; Globorotalia (G.) tumida plesiotumida consecutive-range zone of Banner & Blow, 1965c; north of Papua New Guinea, west South Pacific Ocean; upper Miocene).

Text-figure 3 (opposite). Phylogeny of genera of Mesozoic planktic and related foraminifers, redrawn after Fuchs (1975, Table 1). Time scale of van Hinte (1976a, b) for the Jurassic and Cretaceous respectively and J.A. Webb (unpublished data) for the Triassic.


Triassic
Jurassic
Cretaceous
Tertiary
Q
middle
late
early
middle
late
early
late
Pa
E
O
M
P
Muschel-kalk
Keuper
Lias
Dogger
Malm
Volgian
Tithonian
Neocomian
Senonian
e
m
l
Anisian
Ladinian
Carnian
Norian
Rhaetian
Hettangian
Sinemurian
Pliensbachian
Toarcian
Bajocian
Bathonian
Callovian
Oxfordian
Kimmeridgian
Portlandian
Purbeckian
Berriasian
Valanginian
Hauterivian
Barremian
Aptian
Albian
Cenomanian
Turonian
Coniacian
Santonian
Campanian
Maastrichtian
Danian
Thanetian
Ypresian
Lutetian
Bartonian
Priabonian
Rupelian
Chattian
Aquitanian
Burdigalian
200
150
100
50
Ma
Pseudotextularia
Racemiguembelina
Pseudoguembelina
Planoglobulina
Heterohelix
Heterohelix
Gublerina
Lunatriella
Bifarina
Eoheterohelix
Woletzina
Woletzina
Woletzina
Conoglobigerina
Gubkinella
Guembelitriella
Guembelitria
Woodringina
Praegubkinella
Tectoglobigerina
Polskinella
Polskinella
Iuliusina
Oberhauserella
Ceratolamarckina
Oberhauserella
Oberhauserina
Epistomina
Schlagerina
Garantella
Schlagerina
Reinholdella
Oberhauserella
Globuligerina
Oberhauserella
Oberhauserella
Eoceratobulimina
Ceratobulimina
Oberhauserella
Conorboides
Conorboides
Colomia
Kollmannita
Kollmannita
Diplotremina multifimbriata
Schmidita
Jurassorotalia
Mariannenina
Mariannenina
Globigerinelloides
Eohastigerina
Planomalina
Hastigerinoides
Schackoina
Leupoldina
Clavihedbergella
Biglobigerinella
Ticinella
Rotalipora
Hedbergella
Rugoglobotruncana
Hedbergella
Globotruncana
Abathomphalus
Rugoglobigerina
Plummerita
Trinitella

New phenon

Stretptochilus tokelauae flexiserialis n. subsp.

Holotype. UQF 71103. Pl. 1, fig. 23. Base of Globorotalia inflata zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/6/1/12--14/RS1, 53.12--53.14 m below sea-floor; upper Pliocene. Small, fairly fragile; biserial. Equatorial outline oval, lobate; lateral outline acutely conical, weakly lobate. Chambers rectangular, closely appressed, 14 in total; increase slow but regular. Dorsal view: chambers weakly compressed in plane of biseries which is gradually twisted through ontogeny such that initial and final planes differ by an angle of 60°. Ventral view: aperture interiomarginal, elongated along plane of biseries, moderately wide, one side turned into chamber, other flaring out, forming a lip. Lateral view: chambers flat to weakly inflated; sutures weakly depressed, straight. Wall smooth, sparsely perforate. Length, 90 µm; width, 50 µm; height, 190 µm.

Material. Two specimens.

Derivation of name. Latin, flexuosus, winding; series (f.), row, succession; -alis, pertaining to.

Phena recorded

Phenon flexiserialis n. ph. Pl. 1, figs. 22, 23.

Phenon latum Brönnimann & Resig. Pl. 1, figs. 9--11, 35, 122, 123.

Phenon tokelauae (Boersma). Pl. 1, figs. 12--14, 15--21, 24--34, 36--41, 120, 121?, 124--126. Vs ph. latum: chamber increase slower. Vs ph. flexiserialis: chamber series in a single plane, not twisted.

Remarks

S. tokelauae has been reported from the Globigerina calida s.s.--Sphaeroidinella dehiscens excavata assemblage-zone of Blow (1969) by Kierstead & others (1969) and Brönnimann & Resig (1971).

CLADEGROUP(26?) GLOBIGERINIVICESIMAESEXTAE

Stem species. 'Kollmannita sp.'

Remarks

This group contains the bulk of planktic foraminifers and compared to the group of 'Oberhauserella sp.' and derivatives, its phylogeny is much better known. Thus it is chosen to estimate the higher taxonomic ranks in this study.

CLADEGROUP(20) GLOBIGERINIVICESIMAE

Stem species. Globigerina monmouthensis (Olsson).

Remarks

Berggren (1962) suggested that, apart from C. daubjergensis and the heterohelicids, the Cenozoic planktic foraminifers descended from G. monmouthensis via Turborotalia pseudobulloides (Plummer). This view has since been upheld by Hillebrandt (1964), McGowran (1968), Berggren (1968), and Steineck (1971). Blow (1979), however, did not consider this group to be necessarily monophyletic. Rather, Blow identified many taxa, formal and informal, at the base of the Palaeocene and few of these could be confidently traced to Cenozoic ancestors. The taxa considered to be the most primitive were either eoglobigeriniform or turborotaliform and Blow very tentatively suggested that these descended from each other or various species, known and unknown, of the Cretaceous genera, Rugoglobigerina Brönnimann, Hedbergella Brönnimann & Brown, and Praeglobotruncana Bermúdez. Further, C. daubjergensis was considered descended from Praeglobotruncana, Rugoglobigerina, Globotruncana Cushman, or eoglobigeriniform species, and so its origin may be with the bulk of Cenozoic planktic foraminifers.

In this study, notwithstanding the much more complicated record implied by Blow's (1979) detailed documentation, a monophyletic origin following Berggren (1962) has been extremely tentatively interpreted. This has been sought to maintain the simplest branching sequence practicable given the immense uncertainties involved. The many phena which Blow recovered from his basal-Palaeocene Globorotalia (Turborotalia) longiapertura partial-range zone have been amalgamated into seven species established by the top of this zone. Also a highly speculative branching sequence has been suggested to connect these seven species with a single species at the base of the zone. Because all of these splits are interpreted to occur

Table 8 (opposite). Cladophylistic classification of the Cenozoic planktic Foraminifera (otherwise as for Table 7).

- Superkingdom Eukaryota
- Kingdom Protista
- Phylum Foraminifera
- Suborder Rotaliina Delage & Hérouard
- Superfamily Globigerinacea Carpenter, Parker, & Jones
  - Family Globigerinidae Carpenter, Parker, & Jones
    - Subfamily Globigerininae Carpenter, Parker, & Jones
      - Tribe Globigerinini Carpenter, Parker, & Jones
        - Genus Globigerina d'Orbigny
          - Globigerina bulloides d'Orbigny
          - Globigerina rubescens Hofker
          - Globigerina concinna Reuss
          - Globigerina microstoma Cita, Premoli Silva, & Rossi
          - Globigerina bulbosa LeRoy
          - Globigerina disjuncta (Finlay)
          - Globigerina parva Bolli
          - Globigerina ouchitaensis Howe & Wallace
          - Globigerina pseudoeocaena Subbotina
          - Globigerina linaperta Finlay
          - Globigerina ayalai Bermúdez
          - Globigerina sp.e
          - Globigerina sp.d
          - Globigerina sp.c
          - Globigerina sp.b
          - Globigerina velascoensis Cushman
          - Globigerina sp.a
          - Globigerina fringa Subbotina
          - Globigerina praeedita (Blow)
          - Globigerina monmouthensis (Olsson)
        - Genus Ehrenbergellus Fordham
          - Ehrenbergellus pachydermus (Ehrenberg)
        - Genus Sphaeroidinella Cushman
          - Sphaeroidinella dehiscens (Parker & Jones)
        - Genus Turborotalita Blow & Banner
          - Turborotalita detrita (Terquem)
          - Turborotalita ciperoensis (Bolli)
          - Turborotalita fariasi (Bermúdez)
        - gen.H
          - gen.H frontosa (Subbotina)
        - Genus Hantkenina Cushman
          - Hantkenina columbiana (Petters)
          - Hantkenina alabamensis Cushman
          - Hantkenina columbiana (Petters)
        - gen.G
          - gen.G wilsoni (Cole)
          - gen.G bolivariana (Petters)
          - gen.G griffinae (Blow)
        - Genus Catapsydrax Bolli, Loeblich, & Tappan
          - Catapsydrax dissimilis (Cushman & Bermúdez)
        - Genus Guembelitrioides El-Naggar
          - Guembelitrioides lozanoi (Colom)
        - gen.F
          - gen.F appressa (Blow)
        - Genus Morozovella McGowran
          - Morozovella pentacamerata (Subbotina)
          - Morozovella collactea (Finlay)
          - Morozovella velascoensis (Cushman)
      - Tribe Orbulinini Schultze
        - Genus Orbulina d'Orbigny
          - Orbulina quadrilobata (d'Orbigny)
          - Orbulina universa d'Orbigny
          - Orbulina pseudosellii (Brönnimann & Resig)
          - Orbulina altiapertura (Bolli)
        - Genus Globigerinoides Cushman
          - Globigerinoides elongatus (d'Orbigny)
          - Globigerinoides conglobatus (Brady)
          - Globigerinoides haitiensis (Coryell & Rivero)
      - Tribe Hastigerinini Bolli, Loeblich, & Tappan
        - Genus Hastigerina Thomson
          - Hastigerina pelagica (d'Orbigny)
          - Hastigerina obesa (Bolli)
          - Hastigerina sp.
        - Genus Globigerinella Cushman
          - Globigerinella siphonifera (d'Orbigny)
          - Globigerinella adamsi (Banner & Blow)
          - Globigerinella evoluta Fordham
        - Genus Globigerinopsis Bolli
          - Globigerinopsis aguasayaensis Bolli
      - Tribe Globorotaloidini Banner & Blow
        - Genus Globorotaloides Bolli
          - Globorotaloides hexagonus (Natland)
          - Globorotaloides indigena (Łuczkowska)
          - Globorotaloides parvulus (Bolli)
          - Globorotaloides incretaceus (Chalilov)
        - Genus Bandyus Fordham
          - Bandyus relizensis (Bandy, Ingle, & Wright)
      - Tribe Globoquadrinini Blow
        - Genus Globoquadrina Finlay
          - Globoquadrina tripartita (Koch)
          - Globoquadrina yeguaensis (Weinzierl & Applin)
        - Genus Neoacarinina
          - Neoacarinina conglomerata (Schwager)
          - Neoacarinina altispira (Karrer)
          - Neoacarinina eocaena (Gümbel)
    - Subfamily Globorotaliinae Cushman
      - Tribe Globorotaliini Cushman
        - Genus Globorotalia Cushman
          - Globorotalia tumida (Brady)
          - Globorotalia cultrata (d'Orbigny)
          - Globorotalia fijiensis Cushman
          - Globorotalia limbata (d'Orbigny)
          - Globorotalia praemenardii Cushman & Stainforth
          - Globorotalia miozea Finlay
          - Globorotalia kugleri Bolli
          - Globorotalia opima Bolli
          - Globorotalia bakeri (Cole)
        - Genus Fohsella Bandy
          - Fohsella fohsi (Cushman & Ellisor)
        - Genus Blowellus Fordham
          - Blowellus birnageae (Blow)
        - Genus Pulleniatina Cushman
          - Pulleniatina helicina (d'Orbigny)
          - Pulleniatina obliqueloculata (Parker & Jones)
          - Pulleniatina mayeri (Cushman & Ellisor)
        - gen.I
          - gen.I reticulata (Stache)
      - Tribe Truncorotaliini Fordham
        - Genus Truncorotalia Cushman & Bermúdez
          - Truncorotalia pseudocrassa (Cushman & Parr)
          - Truncorotalia truncatulinoides (d'Orbigny)
          - Truncorotalia tosaensis (Takayanagi & Saito)
          - Truncorotalia crassula (Cushman & Stewart)
          - Truncorotalia sphericomiozea (Walters)
        - Genus Gallerius Fordham
          - Gallerius crassaformis (Galloway & Wissler)
        - Genus Falsella Fordham
          - Falsella spuritumida Fordham
      - Tribe Obandyellini Fordham
        - Genus Obandyella Haman, Huddleston, & Donahue
          - Obandyella scitula (Brady)
          - Obandyella hirsuta (d'Orbigny)
          - Obandyella cibaoensis (Bermúdez)
          - Obandyella ventriosa (Ogniben)
        - Genus Deshayesulus Fordham
          - Deshayesulus puncticulatus (Deshayes)
    - Subfamily Truncorotaloidinae Loeblich & Tappan
      - Tribe Turborotaliini Fordham
        - Genus Turborotalia Cushman & Bermúdez
          - Turborotalia pseudobulloides (Plummer)
          - Turborotalia cerroazulensis (Cole)
          - Turborotalia varianta (Subbotina)
      - Tribe Truncorotaloidini Loeblich & Tappan
        - Genus Globigerinatheka Brönnimann
          - Globigerinatheka mexicana (Cushman)
          - Globigerinatheka mckannai (White)
          - Globigerinatheka subsphaerica (Subbotina)
          - Globigerinatheka praepentacamerata (Shutskaya)
        - Genus Truncorotaloides Brönnimann & Bermúdez
          - Truncorotaloides topilensis (Cushman)
          - Truncorotaloides danvillensis (Howe & Wallace)
          - Truncorotaloides densus (Cushman)
        - gen.D
          - gen.D crassata (Cushman)
    - Subfamily Candeininae Cushman
      - Tribe Candeinini Cushman
        - Genus Candeina d'Orbigny
          - Candeina nitida d'Orbigny
          - Candeina insueta (Cushman & Stainforth)
          - Candeina sp.
          - Candeina inaequiconica (Subbotina)
          - Candeina praeglobotruncanaeformis (Bykova)
          - Candeina insolita (Jenkins)
          - Candeina theodosica (Morozova)
          - Candeina taurica (Morozova)
          - Candeina tetragona (Morozova)
        - Genus Toddella Fordham
          - Toddella grata (Todd)
        - gen.B
          - gen.B nazcaensis (Quilty)
        - Genus Tenuitella Fleisher
          - Tenuitella postcretacea (Myatiuk)
        - Genus Cassigerinella Pokorný
          - Cassigerinella sp.
          - Cassigerinella digitata (Brady)
          - Cassigerinella chipolensis (Cushman & Ponton)
        - Genus Testacarinata Jenkins
          - Testacarinata inconspicua (Howe)
        - Genus Planorotalites Morozova
          - Planorotalites micrus (Cole)
          - Planorotalites pseudoscitulus (Glaessner)
          - Planorotalites compressus (Plummer)
        - gen.A
          - gen.A hemisphaerica (Morozova)
      - Tribe Tinophodellini Fordham
        - Genus Tinophodella Loeblich & Tappan
          - Tinophodella uvula (Ehrenberg)
          - Tinophodella evoluta Fordham
          - Tinophodella antarctica (Keany & Kennett)
          - Tinophodella praemonita Fordham
        - Genus Parkerina Fordham
          - Parkerina iota (Parker)
  - Family Heterohelicidae Cushman
    - Subfamily Heterohelicinae Cushman
        - Genus Zeauvigerina Finlay
          - Zeauvigerina sp.
          - Zeauvigerina wilcoxensis (Cushman & Parr)
        - Genus Streptochilus Brönnimann & Resig
          - Streptochilus tokelauae (Boersma)
          - Streptochilus globiger (Schwager)
          - Streptochilus pristinum Brönnimann & Resig
    - Subfamily Guembelitriinae Montanaro Gallitelli
        - Genus Guembeltria Cushman
          - Guembelitria conusa (Chalilov)
          - Guembelitria cretacea Cushman
        - Genus Cassigerinelloita Stolk
          - Cassigerinelloita daubjergensis (Brönnimann)
          - Cassigerinelloita extensa (Blow)
          - Cassigerinelloita fodina (Blow)

within a single chron, an usually rapid sequence of events is thus suggested and stratophenetic evidence bearing on the details of this pattern would be beyond the resolution of any present biostratigraphic scheme. This branching sequence is thus presented not as a most probable solution based on evidence but merely as an example of the kind of pattern, with respect to the number of speciation events and the nature of anagenesis, which would be required if a single Cenozoic ancestor for the Globigerinivicesimae is interpreted.

Globigerina monmouthensis (Olsson)

Included phena

Globigerina eugubina Luterbacher & Premoli Silva, 1964.
G. sabina Luterbacher & Premoli Silva, 1964.
G. (Eoglobigerina) pentagona Morozova, 1961.
Globorotalia monmouthensis Olsson, 1960.

Remarks

The extremely tentative choice of G. monmouthensis as the upper-Cretaceous ancestor of the Globigerinivicesimae is based on the simplicity of its morphology which it shares with phena documented by Blow (1979) from his basal-Palaeocene zone. Other available upper-Cretaceous taxa, especially those not normally placed in Hedbergella, possess features which would need to be lost during evolution to produce the basal-Palaeocene phena. In this respect it should be noted that the 'porticus' identified by Blow (1979, pl. 258, fig. 3) in a topotype of G. monmouthensis does not appear to be present in the holotype or another topotype illustrated by Blow (1979, pl. 258, fig. 2). Upper-Cretaceous phena which may have been members of G. monmouthensis have not been investigated in this study.

Further reference to the holotype of G. monmouthensis suggests a possible morphology for the most-primitive Cenozoic globigerinid. This primary type has a thin smooth wall, a low trochospiral coil, five chambers in the final whorl, a narrow unbilicus, a slightly arched, umbilical--extraumbilical aperture, and at least the final chamber showing a late rise in the coil. This is very similar to the phenon called 'Globorotalia (Turborotalia) cf. pentagona' by Blow (1979). This phenon, including the formal taxon to which it was compared by Blow, is thus speculatively suggested to have been a late member of a single late-Cretaceous lineage,

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Table 9. New species-group taxa belonging to categories accepted by the International Code of Zoological Nomenclature (I.C.Z.N., 1961).

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SUBSPECIES	
Bandyus relizensis extraumbilicatus	90
Deshayesulus puncticulatus obturoaperturus	133
Falsella spuritumida spuritumida	142
Globigerina bulbosa trisphaera	110
Globigerina bulloides extensa	117
Globigerina bulloides incrusta	116
Globigerina concinna altihelix	113
Globigerina concinna anapetes	113
Globigerina microstoma opsionepenthoides	112
Globigerinella evoluta evoluta	99
Globigerinoides conglobatus altihelix	107
Globigerinoides haitiensis anterubra	106
Globigerinoides haitiensis compactus	105
Globigerinoides haitiensis compressus	106
Globigerinoides haitiensis epityche	106
Globigerinoides haitiensis praerubra	105
Globigerinoides haitiensis progomitulus	105
Globigerinopsis aguasayaensis moderiapertura	97
Globoquadrina tripartita laxispira	81
Globoquadrina tripartita tricamerata	82
Globorotalia limbata conferta	137
Globorotalia limbata consutila	138
Globorotalia limbata latiumbilicata	137
Globorotalia limbata oregope	138
Globorotalia miozea acuimarginata	129
Globorotaloides indigena anavenezuelana	92
Globorotaloides indigena redissimilis	92
Globorotaloides parvulus anasuteri	91
Globorotaloides parvulus lateraliaperturus	90
Neoacarinina conglomerata ventriosa	84
Obandyella ventriosa astricticamerata	132
Obandyella ventriosa evexa	132
Orbulina quadrilobata alpha	104
Orbulina quadrilobata incrusta	103
Pulleniatina mayeri juvenis	121
Pulleniatina mayeri plana	121
Pulleniatina mayeri polygonia	121
Pulleniatina mayeri umbilicata	120
Sphaeroidinella dehiscens reticulata	111
Streptochilus globiger infirmirugosus	50
Streptochilus tokelauae flexiserialis	52
Tenuitella postcretacea pieste	61
Tinophodella antarctica polypetala	67
Tinophodella evoluta evoluta	68
Tinophodella praemonita praemonita	65
Tinophodella praemonita tetrapetala	66
Tinophodella praemonita tripetala	66
Tinophodella uvula quasifoliata	68
Toddella grata compressa	63
Truncorotalia crassula complanata	143
Truncorotalia pseudocrassa hybrida	145
Truncorotalia sphericomiozea capitona	142
Truncorotalia tosaensis acrotenes	144
Turborotalita detrita primoripumilio	95
NAMES	
Globigerina bulloides bronnresigorum	116
Turborotalita detrita rcglbolliorum	95
SPECIES	
Falsella spuritumida	142
Globigerinella evoluta	99
Tinophodella evoluta	68
Tinophodella praemonita	65

containing phenon *monmouthensis*, which survived the Mesozoic--Cenozoic boundary. Blow's '*Globorotalia* (*Turborotalia*) sp. type VI' is also tentatively included.

The lower limit of this species has not been investigated in this study. The upper limit is the top of Blow's (1979) *Rugoglobigerina hexacamerata* partial-range zone.

CLADEGROUP(10?) CANDEINIDECIMAE

Stem species. *Candeina tetragona* (Morozova).

Remarks

Candeiniform, tinophodelliform, and globigerinitiform taxa are considered to have their origin in tenuitelliform taxa of the middle Eocene (Fleisher, 1974). The origin, however, of the latter group is difficult to place amongst species of that level. The smooth wall surface of tenuitelliform phena would seem to preclude descent from members of the Globigerinundevicesimae, as defined below. The persistent biserial coiling mode of *Zeauvigerina wilcoxensis* appears to be an unlikely ancestral morphology. The remaining Palaeogene groups for consideration are the Guembelitrisecundae and the group preferred herein, the Candeinidecimae.

Of the Guembelitrisecundae the Cassigerinelloitiprimae are of particular interest. Members of this group share with tenuitelliform taxa a small test with a thin apparently microperforate or sparsely perforate wall. Phenon *fodina* is especially suitable as ancestor because of its low coil and extraumbilically trending aperture, and this suggests a possible development toward a globorotaliform coil. Also Blow's (1979) phenon, '*Globastica* sp. type I', is very similar in many respects to members of living *Tinophodella uvula* (Ehrenberg), and phenon *daubjergensis* possesses a pustolose development not dissimilar from phenon *inconspicua* (Howe), a rather atypical member of the Candeinoctavae as here interpreted.

Of the two species of the Candeinidecimae known to occur in the middle Eocene, *Planorotalites micrus* (Cole) would seem to possess a morphology close to that of tenuitelliform taxa. Members of this species have a smooth wall and a planispiral coiling mode which could develop into a low trochospire with relatively minor change. It should be noted that phenon *gemma* (Jenkins) may tend to be 'pseudoplanispiral' (Fleisher, 1974). However, *P. micrus* has a wall distinctly thicker and with larger pores than any tenuitelliform taxa. Increased similarity to tenuitelliform morphology is found in phena considered ancestral to *P. micrus*, that is, *P. compressus* and especially *Candeina taurica* (Morozova). Illustrations of phena *archeocompressa* (Blow) and especially '*Globorotalia* (*Turborotalia*) cf. *archeocompressa*' by Blow (1979) suggest that they are very similar in size, wall surface, chamber shape, and coiling mode to phenon *gemma* (for example, compare pl. 64, fig. 6 with pl. 245, fig. 8). Also Blow's phenon '*Globorotalia* (*Turborotalia*) sp. type I' is reminiscent of several phena occurring in lineages leading to *Toddella grata* (Todd). It is mainly for reasons of similarity of coiling mode that the Candeinidecimae, specifically *Candeina theodosica* (Morozova), are extremely tentatively considered ancestral to tenuitelliform taxa in preference to members of the Guembelitrisecundae.

Candeina tetragona (Morozova)

Included phenon

Globigerina (*Eoglobigerina*) *tetragona* Morozova, 1961.

Remarks

This lineage is considered to continue with minor change the morphology displayed by *G. monmouthensis*. The derivation of the name is based mainly on Blow's (1979) tentative comparison of his phenon '*Globorotalia* (*Turborotalia*) cf. *tetragona*' with the nominate taxon.

This species is entirely confined to Blow's (1979) *Globorotalia* (*Turborotalia*) *longiapertura* partial-range zone.

Gen.A *hemisphaerica* (Morozova)

Included phena

Globigerina (*Eoglobigerina*) *hemisphaerica* Morozova, 1961.
Globorotalia (*Turborotalia*) *longiapertura* Blow, 1979.

Remarks

Blow's (1979) distinctive phenon *longiapertura* seems to show a consistent morphology which could result from reproductive isolation as a species. The adoption of the nominate taxon for this supposed lineage is made very tentatively in accordance with Blow's (1979, p. 1078) view. The species ranges from within the *Globorotalia* (*Turborotalia*) *longiapertura* partial-range

Table 10. New supraspecific taxa belonging to categories accepted by the International Code of Zoological Nomenclature (I.C.Z.N., 1961).

GENERA

Bandyus
Type species. *Globorotaloides suteri relizensis* Bandy, Ingle, & Wright, 1971; = *Bandyus relizensis* (Bandy, Ingle, & Wright).
Etymology. For Orville Lee Bandy; -*ius*, diminutive.
Gender. Masculine.
Included species. Monotypic.

Blowellus
Type species. *Globorotalia birnageae* Blow, 1959; = *Blowellus birnageae* (Blow).
Etymology. For Walter Henry Blow; -*ellus*, diminutive.
Gender. Masculine.
Included species. Monotypic.

Deshayesulus
Type species. *Globigerina puncticulata* Deshayes, 1932; = *Deshayesulus puncticulatus* (Deshayes).
Etymology. For Gérard Paul Deshayes; -*ulus*, diminutive.
Gender. Masculine.
Included species. Monotypic.

Ehrenbergellus
Type species. *Aristerospira pachyderma* Ehrenberg, 1861; = *Ehrenbergellus pachydermus* (Ehrenberg).
Etymology. For Christian Gottfried Ehrenberg; -*ellus*, diminutive.
Gender. Masculine.
Included species. Monotypic.

Falsella
Type species. *Falsella spuritumida* n. sp.
Etymology. Latin, *fallo*, *falsus*, deceive; -*ellus*, diminutive.
Gender. Feminine.
Included species. Monotypic.

Gallerius
Type species. *Globigerina crassaformis* Galloway & Wissler, 1927; = *Gallerius crassaformis* (Galloway & Wissler).
Etymology. For Jesse James Galloway and Stanley Gebhart Wissler; -*ius*, diminutive.
Gender. Masculine.
Included species. Monotypic.

Parkerina
Type species. *Globigerinita iota* Parker, 1962; = *Parkerina iota* (Parker).
Etymology. For Frances Lyman Parker; -*inus*, diminutive.
Gender. Feminine.
Included species. Monotypic.

Toddella
Type species. *Globigerina*? *grata* Todd, 1957; = *Toddella grata* (Todd).
Etymology. For Ruth Todd; -*ellus*, diminutive.
Gender. Feminine.
Included species. Monotypic

TRIBES

Obandyellini
Type genus. *Obandyella* Haman, Huddleston, & Donahue, 1980.
Included genera. *Deshayesulus* n. gen.; *Obandyella* Haman, Huddleston, & Donahue, 1980.

Tinophodellini
Type genus. *Tinophodella* Loeblich & Tappan, 1957.
Included genera. *Parkerina* Fordham n. gen.; *Tinophodella* Loeblich & Tappan, 1957.

Truncorotaliini
Type genus. *Truncorotalia* Cushman & Bermúdez, 1949.
Included genera. *Falsella* n. gen.; *Gallerius* n. gen.; *Truncorotalia* Cushman & Bermúdez, 1949.

Turborotaliini
Type genus. *Turborotalia* Cushman & Bermúdez, 1949.
Included genera. Monotypic.

zone to the top of the G. (T.) pseudobulloides/G. (T.) archeocompressa concurrent-range subzone and possibly into the lowermost part of the G. (T.) compressa s.s./E. eobulloides simplicissima concurrent-range subzone.

CLADEGROUP(9?) CANDEININONAE

Stem species. Candeina taurica (Morozova).

Candeina taurica (Morozova)

Included phena

Globigerina (Eoglobigerina) taurica Morozova, 1961.
Globorotalia (Turborotalia) archeocompressa Blow, 1979.

Remarks

This lineage is interpreted as a continuation of C. tetragona with an increased lateral compression especially with regard to the spiral side. Besides the formal taxa it includes Blow's (1979) 'G. (T.) sp. type I' and the supposed lowest indication of the trend to compression, 'G. (T.) cf. archeocompressa'.

This species ranges from within the G. (T.) longiapertura partial-range zone to the top of G. (T.) pseudobulloides/G. (T.) archeocompressa concurrent-range subzone.

CLADEGROUP(1) PLANOROTALITIPRIMAE

Stem species. Planorotalites compressus (Plummer).

Planorotalites compressus (Plummer)

Included phena

Globigerina compressa Plummer, 1926.
G. compressa var. caucasia Chalilov, 1956.
Globorotalia ehrenbergi Bolli, 1957.
G. emilei El-Naggar, 1966.
G. haunsbergensis Gohrbandt, 1963.
G. kilabiyaensis El-Naggar, 1966.
G. planocompressa evoluta Shutskaya, 1965.
G. planocompressa planocompressa Shutskaya, 1965.
?G. praepseudomenardii Hofker, 1961 (?Cretaceous).
G. pseudomenardii Bolli, 1957.

Remarks

This species represents the lineage of phena recognized by Blow (1979) originating in his 'Globorotalia (Turborotalia) cf. archeocompressa'. The splitting from its supposed ancestor, Candeina taurica, due to increasing size, lateral compression, and thicker more-coarsely perforate walls is herein placed at the lowest occurrence of Blow's 'G. (T.) cf. compressa', that is, at the base of his G. (T.) compressa s.s./Eoglobigerina eobulloides simplicissima concurrent-range subzone.

Planorotalites micrus (Cole)

Included phena

Anomalina luxorensis Nakkady, 1951.
Biglobigerinella kerisensis Suleimanov, 1966.
Globanomalina ovalis Haque, 1956.
G. ovalis var. lakiensis Haque, 1956.
G. simplex Haque, 1956.
G. simplex var. orbicularis Haque, 1956.
G. wilcoxensis globulosa Gohrbandt, 1967.
Globigerina pseudoiota Hornibrook, 1958.
Globigerinella naguewichiensis Myatiuk, 1950.
G. pseudovoluta Bandy, 1949.
Globorotalia chapmani Parr, 1938.
G. planoconica Subbotina, 1953.
G. pseudochapmani Gohrbandt, 1967.
Hastigerina eocenica Berggren, 1960.
Nonion danvillensis Howe & Wallace, 1932.
N. iota Finlay, 1940.
N. micrus Cole, 1927.
N. wilcoxensis Cushman & Ponton, 1932.

Pseudohastigerina barbadoensis Blow, 1969.
P. sharkriverensis Berggren & Olsson, 1967.

Remarks

For this species three separate phenon series recognised by Blow (1979) have been very tentatively amalgamated to form a continuous lineage from the upper Palaeocene to the upper Oligocene. These separate series are phena chapmani--sharkriverensis, planoconicus--'Pseudohastigerina cf. danvillensis', and naguewichensis--barbadoensis. It should be noted, however, that Blow (1979) considered the last-mentioned phena to have possibly descended from a turborotaliform ancestor (Candeina praeglobotruncanaeformis (Bykova)?) and also classified phenon planoconicus within 'Globorotalia (Turborotalia)'.

This species is considered to split from its ancestor, P. compressus, by development of evolute planispirality with the lowest occurrence of phenon chapmani, that is, at the base of Blow's (1979) Muricoglobigerina soldadoensis s.s./G. (Morozovella) velascoensis pasionensis concurrent-range zone. Its highest occurrence is in the upper Globigerina sellii--G. ampliapertura partial-range zone of Blow (1970).

Planorotalites pseudoscitulus (Glaessner)

Included phena

Globanomalina laccadivensis Fleisher, 1974.
Globorotalia australiformis Jenkins, 1971.
G. inflata Hussey, 1949.
G. palmerae Cushman & Bermúdez, 1937.
G. perforataminuta Hussey, 1949.
G. pseudoscitula Glaessner, 1937.
G. pseudoscitula var. elongata Glaessner, 1937.
G. renzi Bolli, 1937.
G. troelseni Loeblich & Tappan, 1957.
G. (Astrorotalia) stellaria Turnovsky, 1958.
G. (G.) capdevilensis Cushman & Bermúdez, 1949.

Remarks

This species results from the amalgamation of phena surviving the split of P. micrus from P. compressus and the phena 'G. (G.) cf. pseudoscitula' of Blow (1979) and pseudoscitulus. Despite Blow's (1979) interpretation of the umbilical plug of phenon palmerae as pararotaliform, the wall surface appears very similar to that of members of this lineage and so phenon palmerae is included. It may also represent a short-lived offshoot.

The species ranges to the middle of Blow's (1979) G. (Morozovella) spinulosa s.s. partial-range zone. If Fleisher's (1974) interpretation of the origin of phenon laccadivensis is considered, then the range can be tentatively extended to the middle of Blow's (1969) Globigerina gortanii s.s.--Globorotalia (Turborotalia) centralis partial-range zone.

CLADEGROUP(8) CANDEINOCTAVAE

Stem species. Candeina theodosica (Morozova).

Candeina theodosica (Morozova)

Included phena

Globigerina danica Bang, 1969.
G. (Eoglobigerina) theodosica Morozova, 1961.

Remarks

This species represents a continuation morphologically of C. tetragona and the less compressed phena of C. taurica.

The highest occurrence of this species as indicated by Blow's (1979) range for phenon danica is the middle Globorotalia (Acarinina) praecursoria s.s. partial-range zone. The large gap between this level and the lowest occurrence of tenuitelliform taxa in the middle Eocene places considerable doubt, as discussed above, on the interpretation of an ancestor--descendant relationship between these groups. However, it seems possible that intermediate specimens have been neglected because of their small size.

Testacarinata inconspicua (Howe)

Included phena

Globorotalia inconspicua Howe, 1939.
G. inconspicua aculeata Jenkins, 1966.

Remarks

These phena are interpreted as a separate lineage because of their very distinctive morphology especially the highly pustulose wall surface. Fleisher (1974) is, however, followed in considering this species to be closely related to other tenuitelliform taxa.

The stratigraphic limits of this species are taken as the range of phenon inconspicua given by Blow (1979), that is, the base of the Globigerapsis kugleri/Subbotina frontosa boweri concurrent-range zone to the middle of the G. (Morozovella) spinulosa s.s. zone. The lower limit, however, is not based, as discussed above, on any positive evidence.

CLADEGROUP(7) CANDEINISEPTIMAE

Stem species. Candeina insolita.

Candeina insolita (Jenkins)

Included phenon

Globorotalia insolita Jenkins, 1966.

Remarks

This species represents the first of the tenuitelliform taxa which can be confidently considered ancestral to the globigerinitiform and related lineages.

CLADEGROUP(1) CASSIGERINELLIPRIMAE

Stem species. Cassigerinella chipolensis (Cushman & Ponton).

Remarks

The only species-group taxon which appears to have been suggested as an ancestor to Cassigerinella is 'Cassigerinelloita amekiensis' (Stolk, 1963). However, this phenon has dubious affinities itself and seems too different from Cassigerinella species in most aspects to warrant consideration. The presence of a toothplate in phenon chipolensis (Cushman & Ponton) (see Fleisher, 1974) may suggest affinity with Islandiella Nørvang (a cassidulinacean according to Hofker, 1963, a buliminacean according to Loeblich & Tappan, 1964, 1974).

In this study C. chipolensis is speculatively considered related to tenuitelliform taxa and is considered descended from C. insolita merely to conform with the lowest occurrence of the former, that is, within Blow's (1979, see p. 1363) Globorotalia (Morozovella) spinulosa s.s. partial-range zone. This interpretation is extremely tentative and is chiefly influenced by the initial planispiral coil, the smooth sparsely perforate wall surface, and the small size of C. chipolensis individuals.

A further speculation is forwarded here concerning the origin of 'Globigerina digitata Brady'. Phena considered to belong to this lineage, namely, digitata (Brady), praedigitata (Parker), and possibly nicobarensis (Srinivasan & Kennett), appear to share a wall structure distinct from members of the Globigerinundevicesimae. The structure appears to be smooth with variable development of pores and pustules (see description in Parker, 1967 and scanning electron micrographs in Blow, 1969, Brönnimann & Resig, 1971, Jenkins & Orr, 1972, Krasheninnikov & Hoskins, 1973, Kennett, 1973, Collin & Vella, 1973, and Srinivasan & Kennett, 1974, 1975). It is because of this distinctive wall structure that this lineage is not considered descended from phenon foliata (Bolli) as suggested by Srinivasan & Kennett (1975). Another possible ancestor is Ehrenbergellus pachydermus phenon pachydermus (Ehrenberg). Representatives of this phenon appear in the middle Globorotalia continuosa zone of Kennett (1973) at D.S.D.P. Site 208 (see below) whereas phenon praedigitata appears somewhat higher in the middle Globigerina nepenthes zone. Thus evolution of the latter from the former could be postulated based on their overall similarity of shape. This would, however, involve reduction of quite prominent interpore ridges, size of pores, and wall thickness in phenon pachydermus and this is considered unlikely.

In preference to the possible ancestors discussed above, the origin of phenon digitata is very tentatively suggested to be in C. chipolensis. This is based mainly on similarity of wall surface and thickness and size. Phena intermediate in stratigraphic occurrence and morphology between these taxa, however, have not been documented. Rather, it is tentatively suggested herein that individuals within C. digitata assemblages which are bulloidiform belong to phenon eamesi (Blow) and Blow's (1969) range for this taxon fills this stratigraphic interval. In addition, because Blow's (1969) ranges for phena chipolensis and eamesi overlap only questionably, cladogenesis is speculatively assumed to have occurred in ancestral populations leaving C. digitata and a short-lived sister species.

Cassigerinella chipolensis (Cushman & Ponton)

Included phena

Cassidulina chipolensis Cushman & Ponton, 1932.

C. winniana Howe, 1939.

Cassigerinella boudecensis Pokorný, 1955.

C. eocaenica Cordey, 1968.

C. globolocula Ivanova, 1958.

C. regularis Iturralde Vincent, 1966.

Globoalternina globolocula Ivanova, 1955.

Cassigerinella digitata (Brady)

Included phena

Beella chathamensis McCulloch, 1977 (pl. 174, figs. 9, 13; off Chatham Island, Galapagos Islands, east central Pacific Ocean; Holocene).

B. guadalupensis McCulloch, 1977 (pl. 174, fig. 11; off Guadalupe Island, off Mexico, east Pacific Ocean; Holocene).

Clavatorella nicobarensis Srinivasan & Kennett, 1974 (pl. 1, figs. 4, 5; *Globorotalia margaritae* zone; Mudstone Member, Sarval Bay Formation; southeast Car Nicobar, Nicobar Islands, India, northeast Indian Ocean; lower Pliocene).

Globigerina digitata Brady, 1879 (1884, pl. 82, fig. 6; Banner & Blow 1959, fig. 4a--c; northeast of Kai Island, Indonesia; Holocene).

G. eamesi Blow, 1959 (pl. 9, fig. 39; *Marginulinopsis basispinosus* zone of Renz, 1948; *Globorotalia menardii* s.s.--*Globigerina nepenthes* zone; Husita Marly-Clay Member, Pozón Formation; northwest Venezuela; upper-middle or lower-upper Miocene).

G. horrida Silvestri, 1898 (figured syntype: pl. 5, fig. 1; Italy; lower Pliocene).

G. praedigitata Parker, 1967 (pl. 19, fig. 5; *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. concurrent-range zone of Banner & Blow, 1965c; South Pacific Ocean; lower Pliocene).

Hastigerinella(?) *frailensis* McCulloch, 1977 (pl. 174, fig. 10; off Los Frailes Point, Mexico, east Pacific Ocean; Holocene).

Phena recorded

Phenon *eamesi* (Blow). Pl. 2, fig. 9. The wall surface, the large initial chambers which increase rapidly, and the high spire are in common with phenon *praedigitata*. The only scanning electron micrographs which are confidently assigned herein to phenon *eamesi* are that of Blow (1969) and possibly Kennett & Vella (1975).

Phenon *praedigitata* (Parker). Pl. 1, figs. 131--136; pl. 2, figs. 1--8, 10--18. Vs ph. *eamesi*: aperture higher arched; usually larger; chambers tend to radial elongation.

Remarks

The lowest occurrence of this living species is taken at that of phenon *eamesi* as recorded by Blow (1969), that is, the base of Banner & Blow's (1965c) *Globigerina nepenthes*/*Globorotalia* (*Turborotalia*) *siakensis* concurrent-range zone.

Cassigerinella sp.

Remarks

This species represents a hypothetical short-lived sister species of *C. digitata*.

CLADEGROUP(6) CANDEINISEXTAE

Stem species. *Candeina praeglobotruncanaeformis* (Bykova).

Candeina praeglobotruncanaeformis (Bykova)

Included phenon

Globigerina praeglobotruncanaeformis Bykova, 1960.

Remarks

This is a general continuation morphologically of its ancestor, *C. insolita*.

Tenuitella postcretacea (Myatiuk)

Included phena

Globigerina khadumica Bykova, 1960 (figured syntypes: pl. 7, figs. 4--7; *Globigerinella liverovskae* zone; basal Khadumian horizon; south Mangyshlak A.S.S.R., Kazakhstan S.S.R., south U.S.S.R.; lower Oligocene).

G. postcretacea Myatiuk, 1950 (pl. 4, fig. 3; Kosmach Series; west Ukrainian S.S.R., west U.S.S.R.; Oligocene).

Globigerinella evoluta Subbotina in Subbotina & others, 1960 (pl. 11, fig. 8; Polyanitsa Formation; Ciscarpathian region, Ukrainian S.S.R., west U.S.S.R.; Oligocene).

G. liverovskae Bykova, 1960 (pl. 7, fig. 3; G. liverovskae zone; basal Khadumian horizon; south Mangyshlak A.S.S.R., southwest Kazakhstan S.S.R., south U.S.S.R.; lower Oligocene).

G. praemicra Subbotina in Subbotina & others, 1960 (pl. 11, fig. 10; Nizhnevorotyshche Formation; Ciscarpathian region, Ukrainian S.S.R., west U.S.S.R.; Oligocene).

Globorotalia denseconnexa Subbotina in Subbotina & others, 1960 (figured syntypes: pl. 7, figs. 5--7; Nizhnevorotyshchenskaya Formation; west Ukrainian S.S.R.; west U.S.S.R.; Oligocene).

Globorotalia gemma Jenkins, 1966 (fig. 11/97--99; 1971, pl. 10, figs. 263--265; Globigerina brevis zone; South Island, New Zealand; lower Whaingaroan, Landonian, lower Oligocene; =G. postcretacea Myatiuk acc. Stainforth & others, 1975).

G. minutissima Bolli, 1957 (pl. 29, fig. 1; G. fohsi s.s. zone; Cipero Formation; Trinidad; middle Miocene).

G. (Turborotalia) cifellii Brönnimann & Resig, 1971 (pl. 42, figs. 2--4; Globigerina angulisuturalis partial-range zone of Blow, 1969; east of New Ireland, Papua New Guinea; upper Oligocene).

G. (T.) nkbrowni Brönnimann & Resig, 1971 (pl. 40, figs. 1, 2, 4; Globigerina angulisuturalis partial-range zone of Blow, 1969; east of New Ireland, Papua New Guinea; upper Oligocene).

G. (T.) transsylvanica Popescu, 1970 (pl. 7, fig. 30; Orbulina suturalis zone; Dej beds, west Romania; Badenian, middle Miocene).

T. bannerblowi Blaicher, 1970 (pl. 4, fig. 1; submenilite Globigerina marls; southeast Poland; lowermost Oligocene).

T. munda franzenaui Sztrákos, 1974 (pl. 4, fig. 1; T. munda zone; north Hungary; middle Oligocene).

New phenon

Tenuitella postcretacea pieste n. subsp.

Holotype. UQF 71240. Pl. 2, fig. 22. Globorotalia mayeri zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/20/2/64--66/RS2, 289.14--289.16 m below sea-floor; middle Miocene. Small, but not very fragile; low dextral trochospire, tight parallel to axis, fairly loose perpendicular to axis. Equatorial outline circular, weakly lobate; lateral outline compressed, weakly umbilicoconvex. Chambers ovate, weakly appressed, at least 12 (16?) in total, 5$\frac{3}{4}$ in final and second-last whorls; increase slow but regular until last 2 or 3 when it is reduced. Dorsal view: chambers longer concentrically, very weakly inflated towards anterior; sutures weakly depressed; intercameral sutures directed anteriorly, smoothly recurved posteriorly. Ventral view: chambers moderately inflated, meet only near coil; intercameral sutures thus smoothly and quickly separate proximally and distally, leaving a wide umbilicus. Lateral view: smoothly rounded; aperture interiomarginal, umbilical--extraumbilical, very low. Wall surface smooth, microperforate?, with small to large, widely and irregularly spaced pores on ventral and, in early whorls, dorsal surfaces. Length, 120 µm; width, 115 µm; height, 50 µm.

Material. Nine specimens.

Derivation of name. Greek, piestos, pressed, compressible.

Phena recorded

Phenon postcretacea (Myatiuk). Pl. 2, fig. 26. Vs ph. minutissima Bolli: aperture does not extend over periphery. The small size of individuals of similar shape to this phenon in Turborotalita detrita (Terquem) assemblages (for example, phena angustiumbilicata (Bolli) and egelida (Cifelli & Smith)) presents difficulties in observing wall surface features which provide the essential morphologic difference between these partial homeomorphs. Rare apparently nonspinose specimens are thus tentatively assigned to phenon postcretacea.

Phenon gemma (Jenkins). Pl. 2, figs. 19, 20. Vs ph. postcretacea: trochospire very low; more, closely appressed chambers in the final whorl. The individuals recorded here are slightly more flattened dorsally with slightly less globular chambers than the primary type.

Phenon pieste n. ph. Pl. 2, figs. 21--25. Vs ph. gemma: distinctly compressed laterally; usually with a wider umbilicus; slower chamber increase tending to result in a reduced final chamber.

Remarks

The large amount of documentation remaining to be performed for this group will probably find it to be more diversified than the single branch interpreted here. The lineage appears to separate from its ancestor, C. praeglobotruncanaeformis, by lateral compression and increase in the number of chambers per whorl.

The holotype of phenon postcretacea appears very similar in shape to Turborotalita detrita phenon angustiumbilicata (Bolli): umbilical aperture, 4½ globular well-separated chambers, no lateral compression. However, it has been interpreted by several authors (see Stainforth & others, 1975) as closely related to phenon gemma whose primary type has an umbilical--extraumbilical aperture, rather closely appressed chambers, and a very low weakly compressed spire. The latter view is tentatively followed here.

The split of Tenuitella postcretacea is taken at the lowest occurrence of phenon gemma as reported by Blow (1979), that is, the base of his (1969) Cribrohantkenina inflata total-range zone. The species can be confidently extended to the upper part of Banner & Blow's (1965c) Globorotalia (G.) tumida plesiotumida--Sphaeroidinellopsis subdehiscens paenedehiscens partial-range zone, the highest occurrence of minutissima as reported by Blow (1969). The records herein in the lower Pliocene are tentative.

CLADEGROUP(5) CANDEINIQUINTAE

Stem species. Candeina inaequiconica (Subbotina).

Candeina inaequiconica (Subbotina)

Included phena

Acarinina inaequiconica Subbotina, 1960.

Globorotalia munda Jenkins, 1965.

G. (Turborotalia) permicra Blow & Banner, 1962.

Remarks

This species represents a general continuation of the morphology of its ancestor, C. praeglobotruncanaeformis.

Gen.B nazcaensis (Quilty)

Included phenon

Clavigerinella nazcaensis Quilty, 1976.

Remarks

The finely perforate delicate test of this species suggests that its affinities lie with tenuitelliform taxa. Specifically, it is very tentatively considered descended from C. inaequiconica, mainly because of the presence of individuals with four chambers in the final (Quilty, 1976, pl. 18, fig. 1) which are similar to phena of C. inaequispira. This lineage is thus interpreted to split from C. inaequiconica by development of planispirality and radially elongate chambers.

The range of this species is taken to correspond to that of its nominate phenon, that is, from the base of the Globigerina angulisuturalis/Globorotalia (Turborotalia) opima s.s. concurrent-range zone to the top of the Globigerinoides quadrilobatus primordius/Globorotalia (T.) kugleri concurrent-range zone of Blow (1969).

CLADEGROUP(4) CANDEINIQUARTAE

Stem species. Candeina sp.

Candeina sp.

Remarks

Apparently there are not any formal taxa available for the continuation of the tenuitelliform lineages which is interpreted to occur between the speciation of gen.B nazcaensis and C. insueta (Cushman & Stainforth).

Toddella grata (Todd)

Included phena

Globigerina brevispira Subbotina in Subbotina & others, 1960 (pl. 11, fig. 4; Verkhnevorotypshche Formation; west Ukrainian S.S.R., west U.S.S.R.; lower Miocene).

G.? grata Todd, 1957 (pl. 74, fig. 4; Globigerinoides sicanus--Globigerinatella insueta partial-range zone of Banner & Blow, 1965c acc. Blow, 1969; Fina-sisu Formation; Saipan, Mariana Islands; upper-lower Miocene).

G. konkensis Agalarova & Pronina, 1975 (pl. 1; Konka horizon; Nakhichevan Azerbaidzhan S.S.R., southwest U.S.S.R.; middle Miocene).

Globorotalia anfracta Parker, 1967 (pl. 28, fig. 3; Gulf of Tehauntepec, south Mexico; Holocene).

G. (*Turborotalia*) *akersi* Quilty, 1976 (pl. 14, figs. 9, 10; *G.* (*G.*) *fohsi* partial-range zone of Banner & Blow, 1965c; east South Pacific Ocean; middle Miocene; junior objective homonym of *G. akersi* Snyder).

G. (*T.*) *bauerensis* Quilty, 1976 (pl. 14, figs., 14, 15; *G.* (*G.*) *fohsi* partial-range zone of Banner & Blow, 1965c; east South Pacific Ocean; middle Miocene).

G. (*T.*) *galapagoensis* Quilty, 1978 (replacement name for *G.* (*T.*) *akersi* Quilty).

G. (*T.*) *parkerae* Brönnimann & Resig, 1971 (pl. 43, fig. 7; northeast of Pitcairn Is., South Pacific Ocean; Holocene).

T. clemenciae Bermúdez, 1960 (pl. 17, fig. 10; southeast Mexico; lower Miocene).

New phenon

Toddella grata compressa n. subsp.

Holotype. UQF 71268. Pl. 2, fig. 50. *Globorotalia truncatulinoides* zone; foraminiferal calcareous-nannofossil ooze; unit 1; D.S.D.P.208/1/4/74--76/RS1; 5.24--5.26 m below sea-floor; Pleistocene. Small, but not very fragile; low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline oval prior to reduced final chamber, then circular, moderately lobate; lateral outline compressed, weakly umbilicoconvex. Chambers ovate, closely appressed, about 12 chambers in total, 5½ in final whorl; increase moderately quick, regular except reduced last chamber. Dorsal view: chambers slightly longer concentrically, later ones slightly inflated; sutures moderately depressed; intercameral sutures directed anteriorly and smoothly but quickly curved posteriorly at distal end. Ventral view: chambers moderately inflated; intercameral sutures depressed, curved, meet at closed umbilicus. Lateral view: smoothly rounded; aperture interiomarginal, umbilical--extraumbilical, very low, with very thin lip. Wall surface smooth, microperforate?; small, widely spaced pustules, more dense on ventral and dorsal surfaces of earlier chambers. Length, 95 µm; width, 90 µm; height, 45 µm.

Material. Nine specimens.

Derivation of name. Latin, *compressus*, pressed together, squeezed.

Phena recorded

Phenon *clemenciae* (Bermúdez). Pl. 2, figs. 29, 30, 35.

Phenon *grata* (Todd). Pl. 2, figs. 27, 28, 31--34, 36, 37. Vs ph. *clemenciae*: more inflated ventrally; usually larger; aperture more extensive; more chambers in the final whorl. The specimens included here follow Poore's (1977) topotypic illustration with which large specimens recorded herein are virtually identical. Specimens of intermediate size are not so inflated ventrally, the dorsal aperture may not be very flattened, the aperture may be more umbilical, and the chambers of the final whorl may number only 4½. These latter individuals resemble *T. postcretacea* phenon *transsylvanica* (Popescu) in chamber shape and arrangement but have fewer chambers in the final whorl and the aperture does not extend as far distally. In D.S.D.P.-Site-208 assemblages specimens with 4 to 4½ chambers in the final whorl are most common. These are difficult to distinguish from *Pulleniatina siakensis* phenon *juvenis* n. ph. Some of the individuals with four chambers in the final whorl are similar to juvenile phenon *anfracta* which are usually more compressed dorsally with more angular features.

Phenon *bauerensis* (Quilty). Pl. 2, figs. 38--40. Vs ph. *clemenciae*: compressed laterally; chambers more inflated.

Phenon *galapagoensis* (Quilty). Pl. 2, figs. 41--44. Vs ph. *bauerensis*: dorsal side of chambers concave; usually more chambers in the final whorl. Quilty's (1976) phena are recorded tentatively herein. The individuals assigned appear to represent a very similar evolutionary trend, though there appear to be stratigraphic and morphologic differences: phenon *bauerensis* was considered by Quilty to be characterized by concave distal ventral surfaces on the chambers and phenon *galapogoensis* by an entirely extraumbilical aperture. Both were restricted to the middle Miocene. Neither of the assemblages of each phenon assigned here appears to have such distinguishing features but they nevertheless appear to undergo a similar increase in the number of chambers per whorl and other changes which result in phenon *anfracta* in the upper Pliocene.

Phenon *compressa* n. ph. Pl. 2, figs. 48--50. Vs ph. *anfracta*: chambers much less inflated ventrally.

Phenon *anfracta* (Parker). Pl. 2, figs. 45, 46. Vs ph. *galapagoensis*: dorsal surfaces of chambers not concave; chambers more inflated; aperture more extensive especially in height; more inflated ventrally.

Phenon *parkerae* (Brönnimann & Resig). Pl. 2, fig. 47. Vs ph. *anfracta*: chambers less closely appressed; less inflated and less angular in shape.

Remarks

The phena *akersi* and *bauerensis*, discovered by Quilty (1976) from the middle Miocene, appear to provide critical connections between the living populations named '*Globorotalia anfracta*' by Parker (1967) and the lower-Miocene phenon *clemenciae* Bermudez. The middle-Miocene assemblages recorded herein of the last-mentioned phenon are meagre and some specimens resemble juvenile specimens of phenon *grata* Todd. The simplest hypothesis, of a single middle-Miocene population including both these phena, is tentatively adopted herein. Thus this species represents a final, living lineage of tenuitelliform assemblages and its level of first appearance is, in the absence of stratophenetic assemblage studies, indicated by changes in its sister species, *C. insueta* (Cushman & Stainforth).

The morphology of phenon *grata* is considered ambiguous in terms of the phylogenetic interpretation adopted herein. The primary type shows a slow chamber increase with 5½ chambers in the final whorl, only moderately inflated chambers, and is moderately compressed laterally, and thus is somewhat similar to the primary type of *Tenuitella postcretacea* phenon *gemma* (Jenkins). However, Poore's (1977) subsequently figured topotype has a much quicker chamber increase, five chambers in the final whorl, and chambers which are highly inflated ventrally and dorsally compressed. The latter morphology is tentatively considered typical pending reillustration of the primary type.

CLADEGROUP(3) CANDEINITERTIAE

Stem species. *Candeina insueta* (Cushman & Stainforth).

Candeina insueta (Cushman & Stainforth)

Included phena

Globigerina juvenilis Bolli, 1957 (pl. 24, fig. 5; *Globorotalia fohsi robusta* zone; uppermost Cipero Formation; Trinidad; middle Miocene; =*Globigerina glutinata* Egger acc. Fleisher, 1974, this study).

G. regina Crescenti, 1966 (text-fig. 4; *Globorotalia menardii* cenozone; Frosolone Formation; Italy; middle Miocene).

G. zealandica Hornibrook, 1961 (pl. 21, fig. 438; Rifle Butts Formation; southeast South Island, New Zealand; Awamoan, lower Miocene).

Globigerinatella insueta Cushman & Stainforth, 1945 (pl. 13, fig. 7; Stainforth & others, 1975, fig. 125/5; zone II, *G. insueta* zone; Cipero Formation; Trinidad; upper-lower Miocene).

Globigerinita boweni Brönnimann & Resig, 1971 (pl. 26, fig. 1; *Globigerina angulisuturalis* partial-range zone of Blow, 1969; east of New Ireland, Papua New Guinea; upper Oligocene).

G. incrusta Akers, 1955 (pl. 65, fig. 2a--c; Stainforth & others, 1975, fig. 124/4; *Cibicides carstensi* var. *opimus* zone; Louisiana, U.S.A.; middle Miocene).

G. naparimaensis Brönnimann, 1951a (text-figs. 1, 2; Bolli & others, 1957, pl. 8, fig. 1; Stainforth & others, 1975, fig. 129/5; *Globorotalia menardii* zone; *Sphaeroidinellopsis subdehiscens* s.s.--*Globigerina druryi* partial-range zone to *Globorotalia* (*Turborotalia*) *continuosa* consecutive-range zone of Banner & Blow, 1965c acc. Blow, 1969; Lengua Formation; Trinidad; upper-middle Miocene).

Globigerinoides parva Hornibrook, 1961 (pl. 28, figs. 544--546; Waitoura Marl Member, Otekaike Limestone; South Island, New Zealand; Waitakian, upper Oligocene; =*Globigerina bradyi* Wiesner acc. Jenkins, 1971).

Globigerinoita morugaensis Brönnimann, 1952 (text-fig. 1a--c; Bolli & others, 1957, pl. 8, fig. 3; *Globorotalia menardii* zone; Lengua Formation; Trinidad; uppermost-middle or lowermost-upper Miocene).

Phena recorded

Phenon *incrusta* (Akers).

Phenon *naparimaensis* (Brönnimann). Vs ph. *incrusta*: very inflated and large bulla.

Tinophodella uvula phenon *ambitacrena* Loeblich & Tappan.

T. uvula phenon *glutinata* (Egger).

T. uvula phenon *uvula* (Ehrenberg).

Remarks

The distinctive morphology of phenon *insueta* is tentatively considered to represent an extreme variant of populations which include more abundant individuals like phena *incrusta* and *glutinata*, rather than a separate offshoot.

C. insueta represents an offshoot from tentuitelliform assemblages by the migration of the aperture to an entirely umbilical position. Its lowest occurrence is taken at that of phenon *juvenilis* as reported by Blow (1979), that is, the middle of Blow's (1969) *Globigerina angulisuturalis*/*Globorotalia* (*Turborotalia*) *opima* s.s. concurrent-range zone. However, the range of variation in phenon *boweni* illustrated by Brönnimann & Resig (1971) suggests that genetic isolation of these from tenuitelliform assemblages may not have occurred until the *Globigerinoides quadrilobatus primordius*/*Globorotalia* (*T.*) *kugleri* concurrent-range chron of Blow (1969).

Candeina nitida d'Orbigny

Included phena

Candeina milletti Dollfus, 1905 (figured syntype: Millett, 1903, pl. 7, fig. 2; west of Kalimantan, Indonesia; Holocene).

C. nitida d'Orbigny, 1839a (figured syntype: pl. 2, figs. 27, 28; Stainforth & others, 1975, fig. 185/1; Cuba or Jamaica; Holocene).

C. nitida praenitida Blow, 1969 (pl. 22, fig. 6; *Globorotalia* (*Turborotalia*) *acostaensis* s.s.--*G.* (*G.*) *merotumida* partial-range zone of Banner & Blow, 1965c; lower Bowden Formation; Jamaica; lower-upper Miocene).

C. nitida var. *triloba* Cushman, 1921 (?pl. 57, fig. 1; Tanon Strait, between Negros and Cebu, Philippines; Holocene).

Phena recorded

Phenon *praenitida* Blow. Pl. 2, fig. 51. Vs *Tinophodella uvula* ph. *parkerae* (Bermudez): several intercameral supplementary apertures present.

Phenon *nitida* d'Orbigny. Pl. 2, figs. 52--55. Vs ph. *praenitida*; intercameral supplementary apertures present in early whorls.

Remarks

Blow's (1969) postulate that this species evolved from *C. insueta* as used herein, via *Tinophodella uvula* phenon *parkerae* (Bermúdez), has been supported by Saito & Thompson (1976) and Fleisher (1974).

The split of *C. nitida* is taken at the lowest occurrence of phenon *nitida* as reported by Blow (1969), that is, the lower part of Banner & Blow's (1965c) *Globorotalia* (*G.*) *tumida plesiotumida*--*Sphaeroidinellopsis subdehiscens paenedehiscens* partial-range zone. The lowest occurrence of *C. nitida* in the sections examined is too abrupt and the assemblages too meagre to estimate the split by stratophenetic divergence.

CLADEGROUP(2) TINOPHODELLISECUNDAE

Stem species. *Tinophodella praemonita* n. sp.

Tinophodella praemonita n. sp.

New phena

Tinophodella praemonita praemonita n. subsp.

Holotype. UQF 71277. Pl. 2, fig. 59. *Globorotalia puncticulata* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/9/1/128--130/RS1, 85.28--85.30 m below sea-floor; lower Pliocene. Small, fragile; low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline highly lobate; lateral outline umbilicoconvex. Chambers globular, weakly appressed, 12 or 13 in total, $3\frac{3}{4}$ in final whorl, $4\frac{1}{2}$ in second-last whorl; increase slow until last whorl when very quick. Dorsal view: chambers circular, weakly inflated; sutures depressed; intercameral sutures radial, and abruptly meeting spiral suture, to smoothly curved. Ventral view: chambers inflated; intercameral sutures radial, meet at tight umbilicus; aperture an umbilical circular arch, pushed peripherally and thus highest anteriorly, with very thin lip. Lateral view: smoothly rounded. Wall surface smooth, with widely spaced and small pores and pustules, denser in earliest chambers; large pores in early sutures on dorsal surface. Length, 180 µm; width, 105 µm; height, 70 µm.

Material. Common.

Derivation of name. Latin, *praemoneo*, *-ictus*, forewarn, foretell; *-itus*, pertaining to.

Tinophodella praemonita tetrapetala n. subsp.

Holotype. UQF 71280. Pl. 2, fig. 62. Globorotalia crassaformis zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/7/4/74--76/RS2, 67.24--67.26 m below seafloor; upper-lower or lower-upper Pliocene. Small, fragile; slightly elevated, sinistral trochospire, moderately tight parallel and perpendicular to axis. Equatorial outline distinctly quadrilobate; lateral outline weakly spiroconvex. Chambers globular and appressed until final whorl when ovate and barely appressed, total of 12 in $2\frac{1}{2}$ whorls, 4 in final whorl, $3\frac{1}{2}$ in second-last whorl; increase rapid then slow by third-last chamber. Dorsal view: chambers weakly oval (longer concentrically), inflated; sutures depressed then deeply incised in final whorl; intercameral sutures radial to curved in early whorls, absent in final whorl. Ventral view: chambers weakly inflated; umbilicus tight. Lateral view: smoothly rounded; aperture interiomarginal, umbilical--extraumbilical, very low. Wall smooth with pustules denser in early chambers. Length, 160 µm; width, 155 µm; height, 90 µm.

Material. Common.

Derivation of name. Greek, tetra, four; petalon (n.), leaf.

Tinophodella praemonita tripetala n. subsp.

Holotype. UQF 72181. Pl. 3, fig. 1. As for T. (T.) praemonita tetrapetala. Small, fragile; very low sinistral trochospire, tight parallel and perpendicular to axis. Equatorial outline distinctly trilobate; lateral outline very weakly compressed. Chambers ovate to globular, closely appressed until final whorl when barely appressed, at least 8 in total, $3\frac{1}{4}$ in final whorl, 4 in second-last whorl; increase rapid then slow by third-last chamber. Dorsal view: chambers extended radially, slightly inflated; sutures slightly depressed; intercameral sutures radial when present. Ventral view: chambers slightly inflated; intercameral sutures radial, nearly meeting at tight umbilicus; aperture an umbilical--extraumbilical low arch. Lateral view: smoothly rounded. Wall smooth with moderately large sparse pores. Length, 115 µm; width, 105 µm; height, 55 µm.

Material. Common.

Derivation of name. Greek treis, tria, three; petalon (n.), leaf.

Phena recovered

Candeina insueta phenon incrusta (Akers). Pl. 2, fig. 56.

C. insueta phenon naparimaensis (Brönnimann). Pl. 2, fig. 57.

Phenon praemonita n. ph. Pl. 2, figs. 59, 60; pl. 3, fig. 2. Vs Tinophodella uvula ph. glutinata (Egger): aperture extended radially; wall surface usually smoother, more transparent.

Phenon tetrapetala n. ph. Pl. 2, figs. 61, 62. Vs ph. praemonita: chambers elongated radially, sometimes with a prominent spire on distal surface; trochospire usually much lower.

Phenon tripetala n. ph. Pl. 3, fig. 1. Vs ph. tetrapetala: 3 chambers in the final whorl.

Tinophodella uvula phenon ambitacrena Loeblich & Tappan. Pl. 3, fig. 4.

T. uvula phenon glutinata (Egger). Pl. 3, fig. 3.

Parkerina iota phenon iota (Parker). Pl. 3, figs. 5, 6.

T. uvula phenon parkerae (Bermúdez).

T. uvula phenon uvula (Ehrenberg). Pl. 2, fig. 58.

Remarks

Assemblages which occur above the separation of C. nitida and below their split into Parkerina iota (Parker) and T. uvula (Ehrenberg) are devoid of available names. The gap is filled by these phena which are early indicators of the increase in variation which resulted in the split to form T. evoluta n. sp. in the Pleistocene.

Parkerina iota (Parker)

Included phenon

Globigerinita iota Parker, 1962 (pl. 10, fig. 26; southeast South Pacific Ocean; Holocene).

Phenon recorded

Phenon iota (Parker). Pl. 3, figs. 7--18. Vs Candeina insueta ph. incrusta (Akers): trochospire distinctly lower in later whorls; chambers more closely appressed, less globular; more chambers in the final whorl; bulla usually more extensive. Bullate and nonbullate specimens vs several phena belonging to Turborotalita detrita (Terquem): pustules (spine bases?) much denser and much smaller.

Remarks

Specimens of phenon incrusta (Akers) with peripherally directed bullae occur throughout the stratigraphic range studied of assemblages of Candeina insueta, Tinophodella praemonita, T. antarctica (Keany & Kennett), and T. uvula (Ehrenberg). However, the lowest occurrence of individuals with a distinctly lower trochospire in the later whorls (phenon iota) is relatively abrupt; a corresponding directional change in lower assemblages (say, a gradual increase of specimens with lower trochospires) was not observed.

The choice of ancestor and the lowest occurrence of P. iota observed herein concurs with that of Parker (1967). The divergence was observed herein to occur in either the upper Globorotalia inflata zone or the lower G. tosaensis zone of Kennett (1973) and is taken as the upper part of the Sphaeroidinella dehiscens s.s.--Globoquadrina altispira s.s. partial-range zone of Blow (1969).

CLADEGROUP(1) TINOPHODELLIPRIMAE

Stem species. Tinophodella antarctica (Keany & Kennett).

Tinophodella antarctica (Keany & Kennett)

Included phenon

Globigerina antarctica Keany & Kennett, 1972 (text-fig. 3/6; south of Tasmania, Australia, South Ocean; lower Pleistocene).

New phenon

Tinophodella antarctica polypetala n. subsp.

Holotype. UQF 71301. Pl. 3, fig. 21. Lower Globorotalia truncatulinoides--G. tosaensis overlap zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/4/2/74--76/RS2, 37.24--37.26 m below sea-floor; lowermost Pleistocene. Small, fragile; very low sinistral trochospire, tight parallel and perpendicular to axis. Equatorial outline highly lobate; lateral outline slightly compressed. Chambers ovate to circular, moderately appressed, about 13 in total, 4½ in final and second-last whorls; increase rapid then slow by third-last chamber. Dorsal view: chambers slightly inflated; sutures deep; intercameral sutures radial, meeting spiral sutures abruptly at distal end. Ventral view: chambers slightly inflated; sutures radial, meeting at tight umbilicus; aperture umbilical--extraumbilical, very low. Lateral view: smoothly rounded; wall smooth with sparse moderately large pores, denser near periphery. Length, 180 µm; width, 165 µm; height, 85 µm.

Material. Six specimens.

Derivation of name. Greek, polys, many; petalon (n.), leaf.

Phena recorded

Candeina insueta phenon incrusta (Akers).

Tinophodella praemonita phenon praemonita n. ph.

T. praemonita phenon tetrapetala n. ph.

T. praemonita phenon tripetala n. ph.

Phenon polypetala n. ph. Pl. 3, figs. 20, 21. Vs T. praemonita ph. tetrapetala: >4 chambers in the final whorl; trochospire very low; more evolute.

Phenon antarctica (Keany & Kennett). Pl. 3, figs. 19, 22, 23. Vs T. uvula ph. glutinata (Egger): aperture a moderately high semicircular arch. Vs Globigerina parva ph. occlusa Blow & Banner: wall much thinner, more transparent; surface smooth with widely spaced pustules.

T. uvula phenon ambitacrena Loeblich & Tappan.

T. uvula phenon glutinata (Egger).

T. uvula phenon parkerae (Bermúdez).

Remarks

Pleistocene assemblages contain abundant bulloidiform individuals which have low-arched rimmed apertures and thin to moderately thin walls. Because most of these appear to intergrade with phena typical of Candeina insueta and Tinophodella species and the remainder appear to result from an ontogenetic trend towards thin walls in Globigerina bulloides d'Orbigny individuals, extreme pseudomorphy is tentatively interpreted. Apparently the former individuals have a smooth wall with very small pores but can develop fairly densely packed pustules and so appear spinose under the light microscope. G. bulloides specimens appear to develop interpore ridges in early chambers of the final whorl by coalescing of pustules, giving a rougher thicker surface. The degree of pseudomorphy and the problems in finding definite distinguishing morphologic criteria to determine intergradational series in these collections prevent confident phylogenetic interpretation. For example, the assignment of the primary type of '*Globigerina antarctica*' to the smoother-walled type must be tentative.

Tinophodella evoluta n. sp.

New phenon

Tinophodella evoluta evoluta n. subsp.

Holotype. UQF 71304. Pl. 3, fig. 24. *Globorotalia truncatulinoides* zone; calcareous-spicule(sponge-spicule?)-bearing foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P. 208/1/1/7--9/RS1, 0.07--0.09 m below sea-floor; Pleistocene. Small, fragile; very low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline distinctly lobate; lateral outline compressed. Chambers ovate, weakly appressed, about 13 in total, 5 in final whorl; increase rapid throughout. Dorsal view: chambers extended radially, barely inflated; sutures weakly depressed; intercameral sutures radial. Ventral view: chambers weakly inflated; intercameral sutures radial; umbilicus wide, exposing part of second-last whorl. Lateral view: smoothly rounded; aperture a low arch, peripheral. Wall smooth with sparse pustules especially peripherally and large (secondary?) pores dorsally. Length, 110 µm; width, 85 µm; height, 45 µm.

Material. Six specimens.

Derivation of name. Latin, *evolvo*, *-utus*, unroll, unfold.

Phenon recorded

Phenon *evoluta* n. ph. Pl. 3, figs. 24--27. Vs *T. antarctica* ph. *polypetala*: early whorls visible both ventrally and dorsally; usually more chambers per whorl; chambers well inflated; smaller.

Remarks

In the highest (Pleistocene) sample studied of Site 208 small evolute individuals, phenon *evoluta*, appear likely to be morphologically discontinuous with phena *praemonita* and *tetrapetala*, these two phena being part of *T. uvula* assemblages at this level. However, their many similarities in coiling, wall structure, and chamber shape permit a reasonably confident interpretation of immediate phylogenetic relationship. Because the intermediate phenon *polypetala* was found in the Pleistocene sample 4/2/74--76, a split into *T. uvula* and *T. evoluta* probably occurred in the Pleistocene, at a time represented between this and the highest sample.

Tinophodella uvula (Ehrenberg)

Included phena

Globigerina bradyi Wiesner, 1931 (Brady 1884, pl. 82, fig. 8; Banner & Blow, 1960b, pl. 3, fig. 1; near Prince Edward Islands, far-southwest Indian Ocean; Holocene; =*Pylodexia uvula* Ehrenberg acc. Banner & Blow, 1960b?, Blow, 1969?, Fleisher, 1974, this study).

G. glutinata Egger, 1893 (figured syntype: pl. 13, figs. 19--21; west of Guinea, east Atlantic Ocean or off central-west Western Australia, east Indian Ocean or northwest of Ceram, Indonesia; Holocene).

Globigerinita glutinata flparkerae Brönnimann & Resig, 1971 (replacement name for *Globigerinoides parkerae* Bermúdez).

Globigerinoides minuta Natland, 1938 (figured syntypes: pl. 7, figs. 2, 3; off south California, U.S.A., west North Atlantic Ocean; Holocene; =*Pylodexia uvula* Ehrenberg acc. Fleisher, 1974, this study, but see Rögl & Bolli, 1973).

G. parkerae Bermudez, 1960 (pl. 10, fig. 10; Nicholas Channel, north of Cuba; Holocene).

Pylodexia uvula Ehrenberg, 1861 (figured syntypes?: Ehrenberg, 1873, pl. 2, figs. 24, 25; Banner & Blow, 1960b, pl. 3, fig. 3a,b; Davis Strait, west of Greenland, Arctic Ocean; Holocene).

Tinophodella ambitacrena Loeblich & Tappan, 1957a (text-fig. 3; Stainforth & others, 1975, fig. 129/6; off southeast Brazil, west South Atlantic Ocean; Holocene; =*Globigerinita naparimaensis* Brönnimann acc. Fleisher, 1974?, Stainforth & others, 1975).

New phenon

Tinophodella uvula quasifoliata n. subsp.

Holotype. UQF 71309. Pl. 3, fig. 29. *Globorotalia truncatulinoides*--*G. tosaensis* overlap zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P. 208/2/2/74--76/RS2, 11.24--11.26 m below sea-floor; Pleistocene. Fairly small, fragile; low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline lobate; lateral outline

umbilicoconvex. Chambers globular, appressed, at least 9 (13?) in total, 3¾ in final whorl, 5 in second-last whorl; increase rapid throughout. Dorsal view: chambers slightly inflated; sutures depressed; intercameral sutures radial. Ventral view: chambers quite highly inflated; intercameral sutures deeply incised, radial but separate quickly especially proximally; umbilicus tight; aperture an umbilical--extraumbilical low arch, highest peripherally. Lateral view: smoothly rounded; successive chambers distinctly different in height. Wall smooth with sparse pustules. Length, 215 µm; width 175 µm; height, 145 µm.
Material. Common.
Derivation of name. Latin, *quasi*, appearing as if; second component refers to '*Globigerina foliata* Bolli'.

Phena recorded

Candeina insueta phenon *incrusta* (Akers). Pl. 3, fig. 33.
C. insueta phenon *naparimaensis* (Brönnimann).
Tinophodella praemonita phenon *praemonita* n. ph.
T. praemonita phenon *tetrapetala* n. ph. Pl. 3, fig. 32.
T. praemonita phenon *tripetala* n. ph.
T. antarctica phenon *antarctica* (Keany & Kennett). Pl. 3, fig. 28.

Phenon *quasifoliata* n. ph. Pl. 3, fig. 29. Vs *T. antarctica* ph. *antarctica* (Keany & Kennett): final chamber part of regular chamber increase, distinctly larger than second-last chamber; aperture lower.

Phenon *ambitacrena* Loeblich & Tappan. Pl. 3, fig. 36. Vs *Candeina insueta* ph. *incrusta*: infralaminal openings occur away from ventral intercameral sutures.

Phenon *glutinata* (Egger). Pl. 3, figs. 34, 35. Vs *C. insueta* ph. *incrusta* (Akers): no bulla.

Phenon *parkerae* (Bermúdez). Pl. 3, figs. 30, 31. Vs ph. *glutinata*: supplementary aperture present.

Phenon *uvula* (Ehrenberg). Vs ph. *glutinata*: highly spired.

CLADEGROUP(19) GLOBIGERINUNDEVICESIMAE

Stem species. *Globigerina praeedita* (Blow).

Globigerina praeedita (Blow)

Included phenon

Eoglobigerina edita praeedita Blow, 1979.

Remarks

The reason for choosing this phenon as representative of the lineage speculatively considered descended from *G. monmouthensis* is its similarity in overall shape to Blow's (1979) '*Globorotalia* (*Turborotalia*) cf. *pentagona*'. It differs most importantly in the presence of distinct pore-pits on the wall surface. Because interpore ridges are weakly developed, this species is thus considered, within the hypothetical scheme presented herein, to possess a perforate cancellate wall surface which is primitive in a phylogenetic sense.

This lineage would be entirely restricted to Blow's (1979) *G.* (*T.*) *longiapertura* partial-range zone.

CLADEGROUP(1) MOROZOVELLIPRIMAE

Stem species. *Morozovella velascoensis* (Cushman).

Morozovella velascoensis (Cushman)

Included phena

Globigerina edita Subbotina, 1953.
G. pauciloculata Jenkins, 1965.
G. spiralis Bolli, 1957.
Globorotalia acutispira Bolli & Cita, 1960.
G. africana El-Naggar, 1966.
G. broedermanni var. *lodoensis* Mallory, 1959.
G. californica Smith, 1957.
G. caylaensis Gartner & Hay, 1962.
G. convexa Subbotina, 1953.
G. crosswicksensis Olsson, 1960.
G. edgari Premoli Silva & Bolli, 1973.
G. hispidicidaris Loeblich & Tappan, 1957.
G. lenticularis Iaccarino, 1964.

G. nicoli Martin, 1943.
G. occlusa Loeblich & Tappan, 1957.
G. pusilla laevigata Bolli, 1957.
G. pusilla pusilla Bolli, 1957.
G. salisburgensis Gohrbandt, 1967.
G. sibaiyaensis El-Naggar, 1966.
G.? traubi Gohrbandt, 1963.
G. trichotrocha Loeblich & Tappan, 1957.
G. velascoensis var. *parva* Rey, 1955.
G. wilcoxensis var. *acuta* Toulmin, 1941.
G. (G.) albeari Cushman & Bermúdez, 1949.
G. (Morozovella) finchi Blow, 1979.
Pseudogloborotalia pasionensis Bermúdez, 1960.
Pulvinulina velascoensis Cushman, 1925.
Truncorotalia marginodentata aperta Gohrbandt, 1963.

Remarks

This species represents the joining of two of Blow's (1979) lineage series. Blow tentatively considered the phenon *edita*--phenon *albeari* series descended from phenon *praeedita*, the primary type of which is interpreted above to belong to *Globigerina praeedita*. This series is considered directly ancestral, without cladogenesis, to the other of Blow's lineage series beginning with phenon *convexa*. This conforms with Berggren's (1968) proposed phenon *laevigata*--phenon *convexa* evolution and is based on the overall similarity in test shape between these two phena especially with regard to the biconvex lateral profile with an angular periphery. The *edita*--*albeari* series may also have included Blow's '*Eoglobigerina edita* cf. *praeedita*'.

The lower limit of this species lies within Blow's (1979) *Globorotalia (Turborotalia) longiapertura* partial-range zone.

Morozovella collactea (Finlay)

Included phena

Acarinina rotundimarginata Subbotina, 1953.
Globorotalia collactea Finlay, 1939.
G. hungarica Samuel, 1972.
G. mattseensis Gohrbandt, 1967.
G. wartsteinensis Gohrbandt, 1967.
G. (Acarinina) broedermanni anapetes Blow, 1979.
G. (Truncorotalia) brodermanni Cushman & Bermúdez, 1949.

Morozovella pentacamerata (Subbotina)

Included phena

Acarinina interposita Subbotina, 1953.
A. pentacamerata var. *acceleratoria* Chalilov, 1956.
A. pentacamerata var. *camerata* Chalilov, 1956.
A. pentacamerata var. *erevanensis* Martirosyan, 1970.
A. subpentacamerata Militsina, 1961.
Globigerina aspensis Colom, 1954.
G. colomi Bermúdez, 1960.
Globorotalia berwaliana Mohan & Soodan, 1969.
G. crassa var. *pentacamerata* Subbotina, 1936.
G. pentacamerata Subbotina, 1947.

Remarks

Within the lower Eocene, *M. velascoensis* assemblages are interpreted by Blow (1979) to form two lineage series: phenon *pentacamerata*--phenon *aspensis* and phenon *lodoensis*--phenon *anepetes*. Herein these are tentatively interpreted as isolated lineages differing mainly in the degree of appression of chambers. Their cladogenesis is taken at the lowest occurrences of phena *broedermanni* and *pentacamerata* at the base of Blow's (1979) *Globorotalia (M.) formosa*-- *G. (M.) lensiformis* partial-range subzone. The upper limit of *M. pentacamerata* is given by that of phenon *aspensis*, that is, the upper part of Blow's (1979) *Globigerapsis kugleri/Subbotina frontosa boweri* concurrent-range zone. Phenon *collactea* is very tentatively considered descended from the phenon lodoensis--phenon anapetes series and so its highest occurrence defines that of M. collactea, that is, the top of Blow's (1979) Globorotalia (M.) spinulosa s.s. partial-range zone.

CLADEGROUP(18) GLOBIGERINIDUODEVICESIMAE

Stem species. Globigerina fringa Subbotina.

Globigerina fringa Subbotina

Included phena

Globigerina fringa Subbotina, 1950.
G. (Eoglobigerina) eobulloides Morozova, 1959.

Remarks

Within the hypothetical scheme alluded to above this lineage is considered to develop from G. praeedita by a lowering of the spire and so also diverges from the lower assemblages of its sister species, M. velascoensis. Blow's (1979) 'Globorotalia (Turborotalia) cf. subquadrata' is tentatively included here.

This species is entirely confined to Blow's G. (T.) longiapertura partial-range zone.

CLADEGROUP(6) TURBOROTALISEXTAE

Stem species. Turborotalia sp.

Turborotalia sp.

Remarks

Enlarging upon the hypothetical branching sequence for earliest-Palaeocene species, Turborotalia sp. represents the development of an extraumbilical aperture from its ancestor, G. fringa, whereas its sister species, Globigerina sp.a, retains this supposedly more primitive feature. Included in Turborotalia sp. are Blow's (1979) 'Globorotalia (Turborotalia) sp. types II, III, and V'.

This species is entirely limited to Blow's G. (T.) longiapertura partial-range zone.

CLADEGROUP(1) TURBOROTALIPRIMAE

Stem species. Turborotalia varianta (Subbotina).

Turborotalia varianta (Subbotina)

Included phenon

Globigerina varianta Subbotina, 1953.

Remarks

This lineage is considered to continue from the general morphology of its ancestor, Turborotalia sp. Included tentatively here are Blow's (1979) 'Eoglobigerina sp. type V' and 'Globorotalia (T.) sp. type VII'.

The lower limit of the species is within Blow's G. (T.) longiapertura partial-range zone.

Turborotalia cerroazulensis (Cole)

Included phena

Acarinina indolensis Morozova, 1959.
Globigerina cerro-azulensis Cole, 1928.
G. pseudoampliapertura Blow & Banner, 1962.
G. subcorpulenta Chalilov, 1956.
Globorotalia bonairensis Pijpers, 1933.
G. centralis Cushman & Bermúdez, 1937.
G. cerroazulensis cunialensis Toumarkine & Bolli, 1970.
G. cerroazulensis pomeroli Tourmarkine & Bolli, 1970.
G. cocoaensis Cushman, 1928.
G. imitata Subbotina, 1953.
G. pseudomayeri Bolli, 1957.
G. reissi Loeblich & Tappan, 1957.
G. (Turborotalia) praecentralis Blow, 1979.
G. (T.) pseudoimitata Blow, 1979.
G. (T.) rainwateri Blow, 1979.
Turborotalia altispiroides Bermúdez, 1960.

Remarks

With this species an attempt is extremely tentatively made to locate the origin of Blow's (1979) phenon praecentralis--phenon pseudoampliapertura series. Reconsideration of the nature of this event is necessitated by Blow's (1979) rejection of Toumarkine & Bolli's (1970) view of a subbotiniform ancestry for this lineage. Blow's revised scheme is tentatively followed here mainly because of his documentation of the supposed lowest-occurring phenon of this series, *praecentralis*, from the base of his *Globorotalia* (*Morozovella*) *aragonensis*/*G*. (*M*.) *formosa* concurrent-range subzone. This is below the lowermost development of a similar test form in subbotiniform assemblages, that is, the lowest occurrence of phenon *ayalai* (Bermúdez) in the upper part of Blow's *G*. (*Acarinina*) *aspensis*/*Globigerina lozanoi prolata* concurrent-range zone.

The origin of phenon *praecentralis* was not indicated by Blow (1979) and there do not appear to be any similar phena at this level which could be confidently considered ancestral. Given this situation the turborotaliform phena, *imitata*, *rainwateri*, and *reissi*, which Blow (1979) tentatively considered related to each other, are speculatively chosen as ancestors. The series linking these phena completes the stratigraphic interval between *T*. *varianta* and phenon *praecentralis*. More importantly the phena of this series share with phenon *praecentralis* a close appression of the chambers. If phenon *pseudoimitata* is included, further morphologic similarities arise by increased ventral inflation (for example, Loeblich & Tappan, 1957b, pl. 59, fig. 5, identified as '*Globorotalia* (*Turborotalia*) cf. *pseudoimitata*' by Blow, 1979). In the lower part of this supposed lineage, phenon *indolensis* is included mainly because of its closely appressed chambers.

The lower limit of the species is taken at that of phenon *imitata*, that is, the base of Blow's (1979) *G*. (*Acarinina*) *praecursoria* s.s. partial-range zone. At this level the lineage is interpreted to diverge from its ancestor, *T*. *varianta*, and its sister species, *T*. *pseudobulloides*, by an increase in the number of chambers per whorl with accompanying appression of the chambers. The highest occurrence is that of phenon *pseudoampliapertura*, that is, the lower part of Blow's (1970) *Globigerina sellii*--*G*. *ampliapertura* partial-range zone.

Turborotalia pseudobulloides (Plummer)

Included phena

Globigerina pseudo-bulloides Plummer, 1926.
G. (*G*.) *pseudobulloides subquadrata* Morozova, 1961.
Globorotalia (*Turborotalia*) *quadrilocula* Blow, 1979.

Remarks

This species continues the general morphology of its ancestor, *Turborotalia* sp. Its upper limit is taken at that of phena *pseudobulloides* and *quadrilocula*, that is, the upper part of Blow's (1979) *Globorotalia* (*Morozovella*) *angulata* s.s. partial-range zone.

CLADEGROUP(5) GLOBIGERINATHEKIQUINTAE

Stem species. *Globigerinatheka inconstans* (Subbotina).

Globigerinatheka inconstans (Subbotina)

Included phena

Acarinina multiloculata Morozova, 1961.
A. *praecursoria* Morozova, 1957.
Globigerina arabica El-Naggar, 1966.
G. *edita* var. *polycamera* Chalilov, 1956.
G. *inconstans* Subbotina, 1953.
G. *scabrosa* Bermúdez, 1960.
G. *schachdagica* Chalilov, 1956.
G. *scobinata* Bermúdez, 1960.
Globorotalia faragi El-Naggar, 1966.
G. *trinidadensis* Bolli, 1957.
G. *uncinata* Bolli, 1957.
G. (*Turborotalia*) *pseudoinconstans* Blow, 1979.

Remarks

This lineage is interpreted in order to isolate phena considered descended from *Turborotalia* sp. and distinguished by the development of a wider umbilicus and a greater number of chambers per whorl. Included here are Blow's (1979) phena '*Globorotalia* (*T*.) aff. *pseudobulloides*', '*G*. (*T*.) cf. *pseudobulloides*', '*G*. (*T*.) cf. *polycamerata*', and '*G*. (*T*.) sp. type IV'.

The lower limit of the species is within Blow's (1979) *G*. (*T*.) *longiapertura* partial-range zone.

Gen.C carinata (El-Naggar)

Included phenon

Globorotalia uncinata carinata El-Naggar, 1966.

Remarks

This species represents a supposed short-lived descendant of G. inconstans wherein the trend towards greater appression of chambers of the ancestor results in truncate chambers separated by straight ventral intercameral sutures. It is considered to include Blow's (1979) 'Globorotalia (Acarinina) cf. carinata'.

The lower limit of the species is taken as that of Blow's (1979) 'G. (A.) cf. carinata', that is, the middle of his G. (A.) praecursoria s.s. partial-range zone. The upper limit corresponds to that of phenon carinata, that is, the lowermost part of Blow's G. (G.) pseudomenardii partial-range zone.

CLADEGROUP(4) GLOBIGERINATHEKIQUARTAE

Stem species. Globigerinatheka praepentacamerata (Shutskaya).

Remarks

This taxon comprises two large groups of phena, gen.D crassata (Cushman) and the Globigerinathekitertiae, within each of which Blow (1979) interpreted fully connected phylogenetic sequences. Gen.D crassata comprises a series of phena the origin of which Blow (1979) traced to his basal-Palaeocene 'Globorotalia (Turborotalia) cf. pseudobulloides'. It ends with phenon spinulosa (Cushman). The Globigerinathekitertiae consist of a series of phena which Blow (1979) considered descended from the upper-Palaeocene phenon acarinata (Subbotina) and ultimately from turborotaliform taxa. Blow (1979, p. 905) tentatively included phenon aquiensis (Loeblich & Tappan) and its descendants as having evolved from phenon acarinata. In this study, following Berggren (1968), phenon subsphaerica (Subbotina) and its descendants are also tentatively included in the Globigerinathekitertiae although Blow (1979) suggested that they may be descended from small nonmuricate turborotaliform assemblages. Both this view of a close relationship between phena subsphaerica and acarinata and that of an immediate common ancestor between the Globigerinathekitertiae and gen.D crassata are herein based mainly on their shared quadrate shape. On morphologic grounds the origin of the Globigerinathekitertiae could lie with Globigerina velascoensis Cushman via its nominate phenon. However, the latter does not occur below the lower part of Blow's (1979) Globorotalia (G.) pseudomenardii partial-range zone whereas phena subsphaerica and acarinata are present in the middle and upper parts, respectively, of the immediately underlying G. (Morozovella) angulata s.s. partial-range zone.

Globigerinatheka praepentacamerata (Shutskaya)

Included phena

Acarinina primitiva Morozova, 1961.
Globorotalia angulata praepentacamerata Shutskaya, 1956.
G. (A.) praeaequa Blow, 1979.

Remarks

The interpretation of branching sequences associated with the origin of the Globigerinathekiquartae is very difficult based mainly, as it is here, on Blow's (1979) sequence of phena rather than on stratophenetic assemblage studies. It is very tentatively suggested that the initial splitting from G. inconstans and its descendant, gen.D carinata, involved a sharpening of the periphery and a tendency toward a quadrate shape with four chambers in the final whorl. However, reduction in chambers per whorl is suggested to have been subsequent and so phena such as praeangulata (Blow), angulata (White), and conicotruncata (Subbotina) are considered part of the lower gen.D crassata assemblages rather than part of a separate offshoot.

This short-lived ancestor is taken to appear as phenon praeaequa in the upper part of Blow's (1979) Globorotalia (Acarinina) praecursoria s.s. partial-range zone. Its upper limit is taken at the lowest occurrence of Globigerinatheka subsphaerica (Subbotina).

Gen.D crassata (Cushman)

Included phena

Acarinina vedica Martirosyan, 1970.
Discorbina simulatilis Schwager, 1883.
Globigerina angulata White, 1928.

Globorotalia aequa bullata Jenkins, 1966.
G. angulata abundocamerata Bolli, 1957.
G. angulata hexacamerata Bolli, 1957.
G. angulata kubanensis Shutskaya, 1956.
G. apanthesma Loeblich & Tappan, 1957.
G. aragonensis Nuttall, 1930.
G. aragonensis var. *caucasica* Glaessner, 1937.
G. aragonensis var. *twisselmanni* Mallory, 1959.
G. bollii El-Naggar, 1966.
G. conicotruncata Subbotina, 1947.
G. crassata var. *aequa* Cushman & Renz, 1942.
G. crater Finlay, 1939.
G. dolabrata Jenkins, 1966.
G. formosa formosa Bolli, 1957.
G. formosa gracilis Bolli, 1957.
G. hadii Aubert, 1963.
G. kolchidica Morozova, 1961.
G. lacerti Cushman & Renz, 1946.
G. lehneri Cushman & Jarvis, 1929.
G. lensiformis Subbotina, 1953.
G. loeblichi El-Naggar, 1966.
G. marginodentata Subbotina, 1953.
G. marksi Martin, 1943.
G. nartanensis Shutskaya, 1956.
G. naussi Martin, 1943.
G. praenartanensis Shutskaya, 1956.
G. pseudospinulosa Samuel, 1972.
G. quadrata Nakkady & Talaat, 1959.
G. rex Martin, 1943.
G. spinulosa Cushman, 1927.
G. subbotinae Morozova, 1939.
G. tadjikistanensis Bykova, 1953.
G. (Acarinina) praeangulata Blow, 1979.
G. (Morozovella) aequa tholiformis Blow, 1979.
G. (M.) spinulosa coronata Blow, 1979.
G. (Turborotalia) hansbollii Blow & Banner, 1962.
Morozovella bandyi Fleisher, 1974.
Pseudogloborotalia guatemalensis Bermúdez, 1960.
Pulvinulina crassata Cushman, 1925.
Turborotalia (Acarinina) istropolitana Samuel, 1972.
T. (A.) vicespinuloinflata Samuel, 1972.

Remarks

Despite the wide range of variation implied by the long list of phena amalgamated above, this species is tentatively considered to represent a single lineage arising from its ancestor, *Globigerinatheka praepentacamerata*. With regard to the considerable variation displayed by this lineage it should be noted that the more distinctive phena such as *caucasica* and *lehneri* occupy different levels and both stratigraphically overlie the suite of basically quadrate phena centred on phenon *aequa*. Thus a single lineage undergoing sequential anagenesis seems a reasonable, albeit provisional, hypothesis.

The upper limit is determined by that of phenon *spinulosa*, that is, the top of Blow's (1979) *Globorotalia (Morozovella) spinulosa* s.s. partial-range zone.

CLADEGROUP(3) GLOBIGERINATHEKITERTIAE

Stem species. *Globigerinatheka subsphaerica* (Subbotina).

Globigerinatheka subsphaerica (Subbotina)

Included phenon

Globigerina subsphaerica Subbotina, 1947.

Remarks

The lower limit of this short-lived ancestor is taken at that of the nominate phenon, that is, the middle of Blow's (1979) Globorotalia (Morozovella) angulata s.s. partial-range zone.

Gen.E chascanona (Loeblich & Tappan)

Included phenon

Globigerina chascanona Loeblich & Tappan, 1957.

Remarks

Blow's (1979) view that this phenon represents an isolated closely knit assemblage by the middle of his Globorotalia (G.) pseudomenardii partial-range zone is tentatively adopted here. The similar range of phenon aquiensis (Loeblich & Tappan) with its high-spired primary type is thus provisionally taken to be mostly represented by lower-spired individuals similar to Loeblich & Tappan's (1957, pl. 51, fig. 4, pl. 56, figs. 4, 5) paratypes.

The upper limit of the species is determined by that of its nominate phenon, that is, the lower part of Blow's (1979) G. (Acarinina) wilcoxensis berggreni partial-range zone.

CLADEGROUP(2) GLOBIGERINATHEKISECUNDAE

Stem species. Globigerinatheka mckannai (White).

Globigerinatheka mckannai (White)

Included phena

Acarinina acarinata Subbotina, 1953.
A. clara Chalilov, 1956.
A. falsospiralis Davidson & Morozova, 1964.
A. intermedia Subbotina, 1953.
A. mattseensis alticonica Fleisher, 1974.
A. pseudotopilensis Subbotina, 1953.
A. quadratoseptata Davidson & Morozova, 1964.
A. subintermedia Chalilov, 1956.
A. triplex Subbotina, 1953.
Globigerina aquiensis Loeblich & Tappan, 1957.
G. cretacea var. esnehensis Nakkady, 1950.
G. dubia var. lakiensis Haque, 1956.
G. esnaensis LeRoy, 1953.
G. gravelli Brönnimann, 1952.
G. mckannai White, 1928.
G. nodosa El-Naggar, 1966.
G. soldadoensis Brönnimann, 1952.
G. soldadoensis angulosa Bolli, 1957.
G. stonei Weiss, 1955.
Globoconusa quadripartitaformis Chalilov, 1956.
Globorotalia berggreni El-Naggar, 1966.
G. irrotata Loeblich & Tappan, 1957.
G. quetra Bolli, 1957.
G. strabocella Loeblich & Tappan, 1957.
G. tribulosa Loeblich & Tappan, 1957.
G. whitei Weiss, 1955.
G. wilcoxensis Cushman & Ponton, 1932.
G. (Acarinina) appressocamerata Blow, 1979.
Subbotina kiersteadae Fleisher, 1974.

Remarks

This species represents an apparent intergradation among a large number of phena considered by Blow (1979) to be descended from phenon subsphaerica, acarinina, or aquiensis. The lower limit of the lineage is determined by the apparent split of gen.E chascanona and the upper limit by the supposed split of G. mexicana (Cushman).

Globigerinatheka mexicana (Cushman)

Included phena

Candeina zeocenica Hornibrook & Jenkins, 1965.
Catapsydrax venzoi Borsetti, 1959.
Globigerapsis indica Singh & Tewari, 1968.

G. kugleri Bolli, Loeblich, & Tappan, 1957.
G. tropicalis Blow & Banner, 1962.
Globigerina baconica Samuel, 1972.
G. mexicana Cushman, 1925.
G. orbiformis Cole, 1927.
Globigerinatheka barri Brönnimann, 1952.
G. curryi Proto Decima & Bolli, 1970.
G. euganea Proto Decima & Bolli, 1970.
G. kutchensis Singh & Tewari, 1968.
G. lindiensis Blow & Banner, 1962.
G. subconglobata luterbacheri Bolli, 1972.
Globigerinita globiformis Blow & Banner, 1962.
G. howei Blow & Banner, 1962.
Globigerinoides index Finlay, 1939.
G. korotkovi Keller, 1946.
G. macrostoma Hagn, 1956.
G. nuttalli Hamilton, 1953.
G. rubriformis Subbotina, 1953.
G. semi-involutus Keijzer, 1945.
G. subconglobatus micra Shutskaya, 1958.
G. subconglobatus var. *subconglobatus* Chalilov, 1958.
Porticulosphaera beckmanni Saito, 1962.
Sphaeroidinella senni Beckmann, 1954.

Remarks

This species represents a tentative amalgamation of the following series of Blow (1979): the phenon *senni*--phenon *beckmanni* series, the phenon *howei*--phenon *semiinvoluta* series, and phenon *barri*. This amalgamation is based mainly on Bolli's (1972) views regarding the monophyletic nature of the globigerinathekiform taxa. However, Blow (1979) apparently regarded these taxa to have at least two distinct origins. He appeared to place most confidence regarding ancestry on phenon *senni* and its descendants which he considered evolved from *G. mckannai* phenon *soldadoensis*. On the other hand Blow suggested that phenon *howei* and its descendants and phenon *barri* evolved from phenon *higginsi* (Bolli). The latter was considered descended from phenon *prolata* (Bolli) via phenon *lozanoi* (Colom) and an origin for these taxa was not indicated. In this study the phenon *prolata*--phenon *higginsi* series is very tentatively considered descended from *Globigerina velascoensis* Cushman and unrelated to globigerinathekiform taxa. Apart from Bolli's (1972) analysis this is suggested by the lack of wall thickening, characteristic of globigerinathekiform taxa, in phenon *prolata* and its descendants. All globigerinathekiform taxa are thus considered monophyletic and, further, tentatively considered entirely intergradational. Apart from the difficulty of distinguishing between various globigerinathekiform phena from illustrations, this is based on the marked differences between the views of Bolli (1972) and Blow (1979) regarding the detailed ancestor--descendant relationships of the various phena involved. These differing points of view would be expected if all belonged to a single highly variable lineage.

The lower limit of the species is placed immediately above the highest occurrence of *G. mckannai* phenon *soldadoensis* as this phenon is considered by Blow (1979) to intergrade with the lowest-occurring individuals of phenon *senni*. This level of speciation is then the middle part of Blow's (1979) *Globorotalia* (*Acarinina*) *aspensis*/*Globigerina lozanoi prolata* concurrent-range zone. The upper limit is set by that of phenon *index*, that is, the upper part of Blow's (1969) *Cribrohantkenina inflata* total-range zone and possibly to the lower part of his *Globigerina gortanii* s.s.--*Globorotalia* (*Turborotalia*) *centralis* partial-range zone.

CLADEGROUP(1) TRUNCOROTALOIDIPRIMAE

Stem species. *Truncorotaloides densus* (Cushman).

Truncorotaloides densus (Cushman)

Included phena

Acarinina boudreauxi Fleisher, 1974.
A. crassaformis simulata Krayeva, 1960.
A. discors Myatiuk, 1970.

A. planodorsalis Fleisher, 1974.
A. punctocarinata Fleisher, 1974.
Globigerina coalingensis Cushman & Hanna, 1927.
G. decepta Martin, 1943.
G. nitida Martin, 1943.
G. spinuloinflata Bandy, 1949.
Globigerinoides pseudodubia Bandy, 1949.
Globoquadrina primitiva Finlay, 1947.
Globorotalia bullbrooki Bolli, 1957.
G. (*Acarinina*) *cuneicamerata* Blow, 1979.
G. (*A.*) *matthewsae* Blow, 1979.
G. (*Truncorotaloides*) *topilensis praetopilensis* Blow, 1979.
Pulvinulina crassata var. *densa* Cushman, 1925.
Truncorotaloides haynesi Samanto, 1970.
T. rohri Brönnimann & Bermúdez, 1953.
T. rohri var. *guaracaraensis* Brönnimann & Bermúdez, 1953.
T. rohri var. *mayoensis* Brönnimann & Bermúdez, 1953.
T. rohri var. *piparoensis* Brönnimann & Bermúdez, 1953.

Remarks

This species represents that part of Blow's (1979) phenon *acarinata*--phenon *mayoensis* series occurring between the speciations of *Globigerinatheka mexicana* and *T. danvillensis*. Blow did not indicate the origin of phenon *spinuloinflatus*. It is placed in this species because of the general similarities displayed in the reillustration of the primary type by Cifelli (1972, text-fig. 2).

Truncorotaloides danvillensis (Howe & Wallace)

Included phena

Acarinina rugosoaculeata Subbotina, 1953.
Globigerina danvillensis Howe & Wallace, 1932.
Subbotina danvillensis karpatica Myatiuk, 1970.
Turborotalia (*Acarinina*) *alteconica* Samuel, 1972.

Remarks

Blow (1979) did not indicate the origin of phenon *rugosoaculeatus*. However, this phenon and other small turborotaliform phena have been thought (Berggren, 1968, Samuel, 1972) to have descended from taxa related to phenon *rohri* by a continuation of a middle-Eocene trend toward increased chambers per whorl. Because they are very different from the quadrate truncorotaloidiform phena at this level, a split is interpreted in the ancestral *T. densus*.

The range of this species is taken to correspond with that of phenon *rugosoaculeatus*, that is, from the base of the *Globorotalia* (*Morozovella*) *spinulosa* s.s. partial-range zone to the lower part of the *Globigerina tapurensis* partial-range zone of Blow (1979).

Truncorotaloides topilensis (Cushman)

Included phenon

Globigerina topilensis Cushman, 1925.

Remarks

This is a continuation of the general morphology of its ancestor, *T. densus*.

The upper limit corresponds to that of phenon *spinuloinflatus*, that is, the *Globorotalia* (*Morozovella*) *spinulosa* s.s. partial-range zone and possibly the lower part of the *Porticulasphaera semiinvolutus* partial-range zone of Blow (1979). If this phenon should prove unreliable in determining the upper range of *T. topilensis*, it could be taken at that of phenon *rohri* or *mayoensis* both of which have highest occurrences probably just below the base of the latter zone.

CLADEGROUP(17) GLOBIGERINISEPTIMAEDECIMAE

Stem species. *Globigerina* sp.a.

Globigerina sp.a

Remarks

This is a continuation of the general morphology of its ancestor, *G. fringa*. Blow's (1979) phenon '*Eoglobigerina eobulloides* cf. *simplicissima*' may belong here.

This species is entirely confined to Blow's *Globorotalia* (*Turborotalia*) *longiapertura* partial-range zone.

Gen.F *appressa* (Blow)

Included phenon

Eoglobigerina appressa Blow, 1979.

Remarks

Blow's (1979) phenon appears distinctly different from apparently related phena suggesting it to be a short-lived offshoot as it is interpreted here. It may also include Blow's (1979) '*Eoglobigerina* sp. type II'. Within the speculative branching sequence presented here it develops from *Globigerina* sp.a by a flattening of the spire. The variation from an umbilical to an extraumbilical aperture may, however, also suggest a closer relationship to *Turborotalia* sp.

The lower limit of the species lies within Blow's (1979) *Globorotalia* (*Turborotalia*) *longiapertura* partial-range zone. The upper limit is taken as that of the nominate phenon, that is, the upper part of Blow's (1979) *G.* (*T.*) *compressa*/*E.* *eobulloides simplicissima* concurrent-range subzone.

CLADEGROUP(16) GLOBIGERINISEXTAEDECIMAE

Stem species. *Globigerina velascoensis* Cushman.

Globigerina velascoensis Cushman

Included phena

Eoglobigerina eobulloides simplicissima Blow, 1979.
?*Globigerina asperula* Gümbel, 1868 (nomen dubium).
G. bacuana Chalilov, 1956.
G. compressaformis Chalilov, 1956.
G. dudrouensis Kavary, 1964.
G. finlayi Brönnimann, 1952.
G. haynesi El-Naggar, 1966.
G. hornibrooki Brönnimann, 1952.
?*G. paratriloculinoides* Hofker, 1956 (nomen dubium).
G. pileata Chalilov, 1956.
G. pseudotriloba White, 1928.
G. quadritriloculinoides Chalilov, 1956.
G. stainforthi Brönnimann, 1952.
G. triangularis White, 1928.
G. triloculinoides Plummer, 1926.
G. triloculinoides var. *nanus* Chalilov, 1956.
G. triloculinoides parva El-Naggar, 1966.
G. trivialis Subbotina, 1953.
G. velascoensis Cushman, 1925.
G. velascoensis var. *compressa* White, 1928.
Globorotalia tortiva Bolli, 1957.
Subbotina triangularis cancellata Blow, 1979.

Remarks

This species represents those phena which Blow (1979) considered descended from phenon *trivialis* and possibly phenon *eobulloides* via phenon *simplicissima*. Phenon *velascoensis* is included with the other subbotiniform taxa even though its quadrate shape is quite distinctive. This is based mainly on the interpretation of intergradation by Samuel (1972). Blow's (1979, pl. 98, fig. 8) '*Subbotina* sp. ex interc *S. triangularis* (s.l.) and *S. hornibrooki* (s.l.)' may represent a transitional specimen. The species may also include Blow's (1979) '*Eoglobigerina* cf. *trivalis*, aff. *trivialis*, and sp. types III and IV'.

The lower limit of this species lies within Blow's (1979) *Globorotalia* (*Turborotalia*) *longiapertura* partial-range zone.

Guembelitroides lozanoi (Colom)

Included phena

Globigerina lozanoi Colom, 1954.
G. prolata Bolli, 1957.
'*Globigerinoides*' *higginsi* Bolli, 1957.
Globorotalia thebaica Said, 1960.

Remarks

Blow's (1979) revision of the stratigraphic distribution and phylogenetic relationships of Palaeogene turborotaliform taxa implies a very different phylogeny of these taxa from that of Berggren (1968) and McGowran (1968). The latter authors were able to explain the origin of the Oligocene and so the living turborotaliform taxa by alluding to a series of similar Palaeogene taxa having a simple, and thus presumably primitive, 'stock' morphology. Thus phena *nana* (Bolli) and *siakensis* (LeRoy), from which all living globorotaliform species, in the broad sense, are generally considered to be descended, were thought to be part of a series of phena extending from the base of the Cenozoic, namely, phena *monmouthensis*, *pseudobulloides*, *varianta*, *prolatus*, *pseudomayeri* (Bolli), *bolivariana* (Petters), and *wilsoni* (Cole). Blow's (1979) interpretations, however, suggested that these phena are, as a group, both highly polyphyletic and, in some cases, much more restricted in stratigraphic distribution. Thus, phena *varianta* and *pseudobulloides* were considered by Blow (1979) to be closely related and possibly descended from *'Hedbergella'* which may have implied phenon *monmouthensis*. However, both of the former were recorded no higher than the lower Thanetian leaving a considerable stratigraphic gap until the next 'stock' turborotaliform taxon, phenon *prolatus*, from the middle Vpresian. The origin of the later was not indicated by Blow (1979) and there were no taxa documented from this interval which could be confidently related to it. Phenon *pseudomayeri*, from the uppermost Vpresian and lower Lutetian, may still be considered on general morphologic grounds to form part of a 'stock' turborotaliform lineage. However, its closely appressed inflated chambers are generally considered to indicate a close relationship to the *T. cerroazulensis* lineage. Further, because this latter species presents an apparently smooth anagenesis from phenon *praecentralis* to phena *cerroazulensis* and *pseudoampliapertura*, the lineage seems most probably to be a specialized offshoot from which morphologically simple 'stock' populations would be unlikely to arise. Phenon *bolivariana*, from a similar interval, is considered by Blow (1979) to descend from subbotiniform taxa and to again represent a specialized offshoot, in this case a short-lived trend toward involute planispirality. Phenon *wilsoni*, the primary type of which probably comes from the upper Lutetian, was used by Berggren (1968) as a vital connection between phenon *nana* and lower-Eocene taxa in his 'stock' turborotaliform lineage. Blow (1979), however, considered the morphology of this phenon to be uncertain and did not record it. Further, Blow suggested that it may be synonymous with phenon *increbescens* (Bandy) and the latter is generally argued to be part of a specialized offshoot ending in phenon *prasaepis* (Blow). Thus Blow's (1979) detailed documentation of Palaeogene turborotaliform phena suggests not a continuous line of descent throughout the Cenozoic but rather several phylogenetically isolated pseudomorphs.

In this study Blow's (1979) suggestion of phenon *angiporoides* (Hornibrook) as ancestor to the Miocene phenon *continuosa* (Blow), and so ultimately to phena *acostaensis* (Blow) and *dutertrei* (d'Orbigny), is tentatively accepted with modifications. With regard to phenon *prolatus* this suggests that its origin need not be sought in 'stock' turborotaliform taxa which may not occur at its level of lowest occurrence. Rather, Blow's revision allows taxa of quite different origins to be considered based on (limited) stratophenetic evidence.

Two unrelated phena are herein considered most likely ancestors of phenon *prolatus*. Phenon *pseudoimitata* is similar in overall shape. Interestingly, the phylogenetic interpretation of the latter phenon tentatively adopted herein, that is, it being a member of the lower *T. cerroazulensis* lineage, a descendant of *T. varianta*, would suggest reconsideration of the 'stock' turborotaliform lineage if its ancestry to phenon *prolatus* was accepted. However, there seem to be major differences between these two phena. Phenon *pseudoimitata* has a tight low coil with closely appressed rapidly increasing chambers, a narrow umbilicus, and a low aperture. On the other hand, phenon *prolatus* has a loose moderately high coil with well-separated slowly increasing chambers, a moderately wide umbilicus, and a slightly arched aperture. Further, the wall surface of the latter could be described as subbotiniform with large densely packed pores separated by prominent ridges whereas the former has small rather widely distributed pores with indistinct interpore ridges. This difference could be mainly a result of secondary encrustation in phenon *pseudoimitata*. The phylogenetic interpretation of these wall surface differences is uncertain but herein is tentatively to indicate separate histories.

The other origin considered for phenon *prolatus*, and that which is favoured, is within *G. velascoensis*. This is based mainly on similarity of wall surface as well as other characters discussed above. It is tentatively suggested that phenon *prolatus*, and ultimately phena *lozanoi* and *higginsi*, resulted from a loosening of the coil in members of *G. velascoensis* assemblages such as the individuals of phenon *hornibrooki* illustrated by Blow (1979, pl. 124, figs. 7, 8).

The lower limit of this species is taken as that of phenon *prolatus*, that is, the lower part of Blow's (1979) *Globorotalia* (*Morozovella*) *formosa*--*G.* (*M.*) *lensiformis* partial-range subzone. The upper limit is determined by that of phenon *higginsi*, that is, the middle of the *G.* (*M.*) *lehneri* partial-range zone.

CLADEGROUP(15) GLOBIGERINIQUINTAEDECIMAE

Stem species. *Globigerina* sp.b.

Remarks

Within the phylogenetic scheme presented here *Globigerina* sp.b is tentatively suggested to ultimately give rise to ten species between its origin, in the lower-Eocene *Globorotalia* (*Morozovella*) *formosa*--*G.* (*M.*) *lensiformis* partial-range subzone, and the middle-Eocene *Globigerapsis kugleri*/*Subbotina frontosa boweri* concurrent-range zone. This interpretation is based on a complex set of lineage series proposed by Blow (1979) all of which originate in either phenon *triangularis* or phenon *linaperta* Finlay. Because of the very rapid sequence of speciation events necessary to account for this diversity and the high degree of similarity of the earlier members of these lineages, the postulation of the details of the corresponding branching sequence must be very uncertain indeed. Difficulties with this interpretation are exacerbated by the need herein to rely on phenon series identified, in the main, with little regard for assemblage variation. The cladogram proposed for these taxa is thus highly speculative. The actual branching sequence has been based on the levels of lowest occurrence of phena interpreted to begin trends which result in apparent genetic separation of a lineage. However, given the considerable variability present in these assemblages, the appearance of phena could probably be accommodated within that variability for a significant length of geologic time before cladogenesis allowed isolation from the ancestral assemblage. There may be little or no relationship between the time of appearance of a phenon and the time when it is taken up into a descendant offshoot species. Thus the above-mentioned procedure of matching branching sequences to lowest occurrences of phena is prone to considerable error.

Globigerina sp.b

Remarks

This is a continuation of the general morphology of *G. velascoensis*.

CLADEGROUP(2) GLOBOQUADRINISECUNDAE

Stem species. *Globoquadrina yeguaensis* (Weinzierl & Applin).

Globoquadrina yeguaensis (Weinzierl & Applin)

Included phena

Globigerina ariakensis Asano, 1962.
G. incisa Hillebrandt, 1962.
G. pseudoeocaena var. *trilobata* Subbotina, 1953.
G. yeguaensis Weinzierl & Applin, 1929.

Remarks

This species represents phenon *galavisi* (Bermúdez) and its nonbullate descendants, as interpreted by Blow (1979), prior to the splitting of *G. tripartita* (Koch). Its lower limit, the development of an umbilical tooth, is taken at the lowest occurrence of Blow's (1979) '*Dentoglobigerina* sp. type I', that is, the base of his *Globorotalia* (*Morozovella*) *aragonensis*/*G.* (*M.*) *formosa* concurrent-range subzone.

Globoquadrina tripartita (Koch)

Included phena

Globigerina? *aspera* Koch, 1926 (figured syntypes: text-figs. 22, 23; Stainforth & others, 1975, fig. 106/7,6; one of these two specimens has disintegrated acc. Bolli in Stainforth & others, 1975, but the latter authors' inconsistent reference leaves the identity ambiguous; lower *Globigerina*-marl; Kalimantan, Indonesia; middle Tertiary; junior objective homonym of *G. aspera* Ehrenberg; =*Globorotalia dehiscens* Chapman, Parr, & Collins acc. Bermúdez, 1960).

G. binaiensis Koch, 1935 (replacement name for *G.*? *aspera* Koch).

G. bulloides var. tripartita Koch, 1926 (text-fig. 21; Blow & Banner, 1962, pl. 10, figs. A--C; Stainforth & others, 1975, fig. 148/3; lower Globigerina-marl; Kalimantan, Indonesia; middle Tertiary).

G. brevis Jenkins, 1966 (fig. 7/58--60; G. brevis zone; South Island, New Zealand; lower Whaingaroan, Landonian, lower Oligocene).

G. clarae Bermúdez, 1960 (pl. 2, figs. 4a--c; Alazan Formation; southeast Mexico; middle Oligocene; =Globoquadrina sellii Borsetti acc. Blow, 1969, Fuenmayor, 1969, Stainforth, 1974, & others, 1975).

G. oligocaenica Blow & Banner, 1962 (pl. 10, figs. L--N; Stainforth & others, 1975, fig. 141/6; G. sellii/Pseudohastigerina barbadoensis concurrent-range zone acc. Blow 1969; southeast Tanzania; Rupelian, upper-lower Oligocene; =Globoquadrina sellii Borsetti acc. Blow & Banner, 1962, Blow, 1969, Fuenmayor, 1969, Postuma, 1971, Fleisher, 1974, Stainforth, 1974, & others, 1975; =Globigerina clarae Bermúdez acc. Jenkins, 1971?).

G. rohri Bolli, 1957 (pl. 23, fig. 1; Stainforth & others, 1975, fig. 148/8; Globorotalia opima s.s. zone; lower Cipero Formation; west Trinidad; upper Oligocene; =G. bulloides var. tripartita Koch acc. Blow & Banner, 1962, Blow, 1969, Soedino, 1970, Jenkins, 1971, Tjalsma, 1971, Fleisher, 1974, Stainforth, 1974, & others, 1975, Toumarkine & Bolli, 1975, Palmieri, 1975).

G. sakitoensis Asano, 1962 (pl. 22, fig. 1; Nakado Formation; west Kyushu, Japan; Oligocene; =G. tripartita tapurensis Blow & Banner acc. Blow, 1979).

G. sastrii Raju, 1971 (pl. 4, fig. 1; G. sastrii zone; southeast India; Oligocene).

G. tripartita tapurensis Blow & Banner, 1962 (pl. 10, figs. H--K; G. oligocaenica zone; G. sellii/Pseudohastigerina barbadoensis concurrent-range zone acc. Blow, 1969; Lower Lukuledi Formation; southeast Tanzania; upper-lower Oligocene).

Globoquadrina dehiscens praedehiscens Blow & Banner, 1962 (pl. 15, figs. Q--S; Globorotalia kugleri zone; Cipero Formation; Trinidad; Aquitanian, uppermost Oligocene or lowermost Miocene; =Globigerina bulloides var. tripartita Koch acc. Jenkins, 1971).

G. palmerae Bermúdez, 1960 (pl. 13, fig. 10; Adelina Marl, Tinguaro Formation; Cuba; middle Oligocene; =G. sellii Borsetti acc. Fuenmayor, 1969?).

G. quadraria var. advena Bermúdez, 1949 (pl. 22, fig. 38; Gurabo Formation; north Dominican Republic; middle Miocene; =Globorotalia dehiscens Chapman, Parr, & Collins acc. Bolli, 1957, Stainforth & others, 1975).

G sellii Borsetti, 1959 (pl. 1, fig. 3a--c; Stainforth & others, 1975, fig. 141/4; north Italy; lower Oligocene; =Globigerina bulloides var. tripartita Koch acc. Jenkins, 1971).

G. subdehiscens Finlay, 1947 (Hornibrook, 1961, pl. 22, figs. 446, 447, 449; Jenkins, 1971, pl. 20, figs. 595--597; New Zealand; Altonian, lower Miocene; =Globorotalia dehiscens Chapman, Parr, & Collins acc. Jenkins, 1971).

Globorotalia dehiscens Chapman, Parr, & Collins, 1934 (pl. 11, fig. 36; Victoria, Australia; Balcombian, lower-middle Miocene).

G. quadraria Cushman & Ellisor, 1939 (pl. 2, fig. 5; Louisiana, U.S.A.; Miocene; =G. dehiscens Chapman, Parr, & Collins acc. Bolli, 1957, Blow, 1959, Jenkins, 1960, Blow & Banner, 1962, Parker, 1967, Lamb & Beard, 1972, Stainforth & others, 1975, Palmieri, 1975).

New phena

Globoquadrina tripartita laxispira n. subsp.

Holotype. UQF 71383. Pl. 4, fig. 9. Orbulina suturalis zone; foraminifer-rich calcareous-nannofossil chalk, unit 1; D.S.D.P.208/21/3/73--75/RS3, 318.73--318.75 m below sea-floor; middle Miocene. Very large, robust; moderately elevated sinistral trochospire, moderately loosely coiled in later whorls, both parallel and perpendicular to axis. Equatorial outline weakly lobate, almost quadrate; lateral outline highly umbilicoconvex. Chambers ovate parallel to axis, extremely closed appressed, about 16 in total, $4\frac{1}{2}$ in final whorl, 4 in second-last whorl; increase moderately rapid until fourth-last chamber when slower. Dorsal view: chambers distinctly longer concentrically, slightly inflated; sutures weakly depressed; intercameral sutures directed anteriorly and recurved halfway to periphery to be strongly curved posteriorly at distal end, thus posterior part of next chamber overlaps at the periphery. Ventral view: chambers vaulted halfway to umbilicus, thus leaving a wide umbilicus and reduced intercameral contact; intercameral sutures radial where present; aperture umbilical, covered by foreign material. Lateral view: dorsoperipheral shoulder and ventral face

smoothly rounded; umbilical shoulder acute; apertural face steep. Wall cancellate with large dense pores. Length, 660 µm; width, 640 µm; height, 600 µm.
Material. Common.
Derivation of name. Latin, *laxus*, loose, slack, unstrung; *spira* (f.), coil, twist.

Globoquadrina tripartita tricamerata n. subsp.
Holotype. UQF 71392. Pl. 4, fig. 18. *Globorotalia mayeri* zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/18/2/1--3/RS3, 232.51--232.53 m below sea-floor; middle Miocene. Very large, robust; moderately elevated sinistral trochospire, moderately loosely coiled in later whorls, both parallel and perpendicular to axis. Equatorial outline weakly trilobate; lateral outline highly umbilicoconvex. Chambers ovate parallel to axis, extremely closely appressed, over 8 (13?), 3 in final whorl, 3¾ in second-last whorl; increase moderately rapid until third-last chamber when much reduced. Dorsal view: chambers much longer concentrically, slightly inflated; sutures weakly depressed; intercameral sutures slightly anteriorly directed, recurved posteriorly close to periphery giving effect of lateral overlap by next chamber; chambers broadest posteriorly, thus increasing lobation. Ventral view: chambers vaulted halfway to umbilicus, thus leaving a wide umbilicus and reduced intercameral contact; intercameral sutures radial where present; aperture umbilical, covered by foreign material. Lateral view: dorsoperipheral shoulder smoothly rounded; ventral face slightly flattened; umbilical shoulder acute; apertural face steep. Wall cancellate with large, dense pores. Length, 460 µm; width, 490 µm; height, 570 µm.
Material. Six specimens.
Derivation of name. Latin. *tres*, three; *camera* (f.), chamber; *-atus*, provided with.

Phena recorded

Phenon *dehiscens* (Chapman, Parr, & Collins). Pl. 3, figs. 80--88; pl. 4, figs. 19--23, 25.

Phenon *advena* Bermúdez. Pl. 3, figs. 91--93; pl. 4, figs. 1--8, 11, 14--16, 24. Vs ph. *dehiscens*: chambers of the final whorl have much slower relative increase in height of the ventral extension; umbilicus surrounded by high umbilical faces of the chambers of the final whorl; tends to larger size and reduction in chamber size in last-1-or-2 chambers; looser coiling along axis; greater number (4½) of chambers in the final whorl; elevation of last whorl above earlier whorl. The primary types of phena *advena* and *dehiscens* are very similar and some of Blow's (1969) distinguishing criteria seem to place the holotype of phenon *advena* in phenon *dehiscens*.

Phenon *laxispira* n. ph. Pl. 4, figs. 9, 10. Vs ph. *advena*: coiling loosens with additional whorls; wider umbilicus; usually more chambers in the final whorl.

Phenon *tricamerata* n. ph. Pl. 4, figs. 12, 13, 17, 18. Vs ph. *advena*, *dehiscens*: <4 chambers in the final whorl.

Remarks

The lower part of this species is represented by phenon *tripartita* (Koch) and its descendants as interpreted by Blow (1979).

The lineage is taken to arise by a reduction in chambers per whorl and associated increased tightness of coiling and appression of chambers as represented by the lowest occurrence of the nominate phenon, that is, the base of Blow's (1979) *Globorotalia* (*Morozovella*) *spinulosa* s.s. partial-range zone. The highest occurrence herein of this species is lower-upper Miocene but Blow (1969) records it as high as the upper part of his *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone. This is consistent with the observation of Kennett & Srinivasan (1975) regarding the oceanographically controlled diachroneity of the extinction of this species.

CLADEGROUP(1) NEOACARININIPRIMAE

Stem species. *Neoacarinina eocaena* (Gümbel).

Neoacarinina eocaena (Gümbel)

Included phena

Catapsydrax gortanii Borsetti, 1959.
Globigerina aequatorialis Hofker & Thalmann, 1959.
G. ampliapertura cancellata Pessagno, 1963.
G. eocaena Gümbel, 1868.
G. galavisi Bermúdez, 1960.
G. haoi Gutierrez Domech, 1966.

G. hofkeri Bermúdez, 1960.
G. ouchitaensis var. *senilis* Bandy, 1949.
G. paravenezuelana Hofker, 1956.
G. pseudocorpulenta Chalilov, 1956.
G. stainforthi Hofker, 1956.
G. tumbili Chalilov, 1956.
G. turritilina praeturritilina Blow & Banner, 1962.
G. turritilina turritilina Blow & Banner, 1962.
G. yeguaensis pseudovenezuelana Blow & Banner, 1962.
Globoquadrina globularis Bermúdez, 1960.

Remarks

This species is a continuation of the general morphology of its ancestor, *G. yeguaensis*, with a loosening of the spire. It represents phenon *galavisi* and its descendants, in Blow's (1979) interpretation, prior to the separation of *Neoacarinina conglomerata* (Schwager).

Neoacarinina altispira (Cushman & Jarvis)

Included phena

Globigerina altispira Cushman & Jarvis, 1936 (pl. 1, fig. 13; Bolli, Loeblich, & Tappan, 1957, pl. 5, fig. 4; Stainforth & others, 1975, fig. 102/5; *Globorotalia* (*G.*) *tumida* s.s.--*Sphaeroidinellopsis subdehiscens paenedehiscens* partial-range zone or *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone acc. Blow, 1969; Bowden Formation; northeast Jamaica; uppermost Miocene or lower Pliocene).

G. baroemoensis LeRoy, 1939 (pl. 6, figs. 1, 2; Telisa Formation; Sumatra, Indonesia; Miocene?; =*G. conglomerata* Schwager acc. Srinivasan, 1975?; =*Globorotalia dehiscens* Chapman, Parr, & Collins acc. Stainforth & others, 1975).

G. baroemoensis var. *quadrata* LeRoy, 1944a (holotype and/or paratypes: pl. 3, figs. 34, 35, pl. 7, figs. 37--39; Telisa or Lower or Middle Palembang Formations; Sumatra, Indonesia; lower or middle Miocene).

?*G. bulloides* var. *quadripartita* Koch, 1926 (figured syntype: text-fig. 20; lower *Globigerina*-marl; Kalimantan, Indonesia; middle Tertiary; nomen dubium acc. Banner & Blow, 1960b, Blow & Banner, 1962).

?*G. carteri* Karrer, 1878 (figured syntype: pl. 5, fig. 23; Luzon, Philippines; Neogene; ?nomen dubium).

G. winkleri Bermúdez 1960 (pl. 6, fig. 4; '*G.*' *dissimilis* zone; Trinidad; middle Oligocene).

Globoquadrina altispira conica Brönnimann & Resig, 1971 (pl. 22, fig. 1; *Globorotalia* (*Turborotalia*) *continuosa* consecutive-range zone of Blow, 1969; north of Papua New Guinea, southwest Pacific Ocean; uppermost-middle or lowermost-upper Miocene).

G. altispira globosa Bolli, 1957 (pl. 24, fig. 9; Stainforth & others, 1975, fig. 101/6; *Catasydrax dissimilis* zone; upper Cipero Formation; Trinidad; lower Miocene; =*Globigerina altispira* Cushman & Jarvis acc. Parker, 1967, Tjalsma, 1971, Zachariasse, 1975).

G. langhiana Cita & Gelati, 1960 (text-fig. 1; *G. langhiana* zone; northwest Italy; lower Langhian, upper-lower or lower-middle Miocene; =*Globorotalia dehiscens* Chapman, Parr, & Collins acc. Tjalsma, 1971, Stainforth & others, 1975; =*Globigerina baroemoensis* LeRoy acc. Blow, 1969?, Berggren & Amdurer, 1973, Srinivasan, 1975).

G. pozonensis Blow, 1959 (pl. 10, fig. 54; upper *Robulus senni* s.l. zone of Renz, 1948; upper *Globigerina bulloides* zone; upper Huso Clay Member, upper Pozón Formation; northwest Venezuela; Vindobonian or higher, upper Miocene; =*G. altispira globosa* Bolli acc. Blow, 1969, Stainforth & others, 1975).

Phena recorded

Phenon *baroemoensis* (LeRoy). Pl. 5, figs. 4, 13, 18, 19, 21, 30. Vs *N. conglomerata* ph. *venezuelana* (Hedberg): umbilicus more open; chambers less rounded; subquadrate equatorial outline; umbilical shoulder more angular.

Phenon *globosa* (Bolli). Pl. 4, figs. 26--29, 33; pl. 5, figs. 1, 2, 5, 6, 20, 22--24, 26, 27, 29, 34. Vs *N. globularis* ph. *globularis* Bermúdez: >4 chambers in the final whorl. Most of the individuals included here have fewer chambers in the final whorl than the holotype.

Phenon *conica* (Brönnimann & Resig). Pl. 5, fig. 14. Vs ph. *baroemoensis*: spire higher and tiered, umbilicus tight.

Phenon *pozonensis* (Blow). Pl. 4, figs. 34--36; pl. 5, figs. 7, 15--17, 28, 31. Vs ph. *globosa*: smaller; fewer chambers; tight umbilicus; usually more coarsely perforate and more distinctly reticulate wall surface.

Phenon *altispira* (Cushman & Jarvis). Pl. 4, figs. 30--32, 37, 38; pl. 5, figs. 3, 8--12, 25, 32, 33. Vs ph. *globosa*: much higher dorsally. Vs ph. *conica*: wider umbilicus, coiling not tiered.

Remarks

The extinction of *N. altispira* is taken as the highest occurrence of the nominate phenon as recorded by Blow (1969) and Berggren and Van Couvering (1974), that is, the top of the *G. altispira*--*Globorotalia exilis* partial-range zone of Berggren (1973).

Neoacarinina conglomerata (Schwager)

Included phena

Globigerina atlantis Bermúdez, 1960 (holotype and/or paratypes: pl. 1, fig. 3; Nicholas Channel, north of Cuba; Holocene).

G. conglomerata Schwager, 1866 (Banner & Blow, 1960b, pl. 2, fig. 3; probably *Globorotalia tumida flexuosa* zone to *G. multicamerata*--*Pulleniatina obliqueloculata* s.s. zone of Srinivasan & Sharma, 1973; Nicobar Islands, India, northeast Indian Ocean; lower Pliocene?).

G. eximia Todd, 1957 (pl. 78, fig. 8; *Globorotalia* (*G.*) *tumida plesiotumida* consecutive-range zone to *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone acc. Blow, 1969; Donni Sandstone; Saipan, Mariana Islands; upper Miocene or lower Pliocene).

G. venezuelana Hedberg, 1937b (pl. 92, fig. 7; middle zone of Hedberg, 1937a; upper member, Carapita formation; northeast Venezuela; upper Oligocene; =*G. conglomerata* Schwager acc. Lamb & Beard, 1972?; =*G. bulloides* var. *quadripartita* Koch acc. Postuma, 1971).

Globoquadrina larmeui Akers, 1955 (pl. 65, fig. 4; *Operculinoides* zone; Louisiana, U.S.A.; middle Miocene; =*Globorotalia dehiscens* Chapman, Parr, & Collins acc. Parker, 1967, Brönnimann & Resig, 1971, Stainforth & others, 1975).

G. obesa Akers, 1955 (pl. 65, fig. 5; *Miogypsina* zone; Louisiana, U.S.A.; lower Miocene; =*Globorotalia dehiscens* Chapman, Parr, & Collins acc. Parker, 1967?, Stainforth & others, 1975).

G. pseudofoliata Parker, 1967 (pl. 27, fig. 1; south of Nausu, west South Pacific Ocean; Pliocene or lower? Pleistocene).

Neoacarinina blowi Thompson, 1973 (pl. 1, fig. 1; northeast of Prince Edward Islands, southwest Indian Ocean; upper Pleistocene).

New phenon

Neoacarinina conglomerata ventriosa n. subsp.

Holotype. UQF 71480. Pl. 6, fig. 13. *Globorotalia plesiotumida* zone; radiolarian calcareous-nannofossil ooze with foraminifers, varicoloured unit, Clipperton Formation; D.S.D.P. 77B/13/4/6--8/RS2, 123.36--123.38 m below sea-floor; upper Miocene. Very large, robust; moderately elevated sinistral trochospire, tight parallel and perpendicular to axis. Equatorial outline weakly quadrilobate; lateral outline highly umbilicoconvex. Chambers ovate parallel to axis, extremely closed appressed, over 11 (18?) in total, 4 in final whorl, 5½ in second-last whorl; increase rapid until third-last chamber when decreases. Dorsal view: chambers distinctly elongated concentrically, weakly elevated proximally; sutures weakly depressed; intercameral sutures radial in final whorl, increasingly directed and curved posteriorly to earlier chambers; chambers broadest posteriorly giving a tangential lobation. Ventral view: chambers vaulted very close to umbilicus; intercameral sutures radial to curved, very deeply incised, adjacent pairs (final--second-last and second-last--third-last; third-last--fourth-last and fourth-last--final) meet at opposite ends of broad umbilical gap which is moderately wide; aperture obscured, umbilical. Lateral view: dorsoperipheral shoulder and ventral face smoothly rounded; umbilical shoulder recurved very close to umbilicus; apertural face reclined. Wall cancellate with large dense pores. Length, 385 µm; width, 405 µm; height, 410 µm.

Material. Common.

Derivation of name. Latin, *ventriosus*, pot-bellied, bulging.

Phena recorded

Phenon venezuelana (Hedberg). Pl. 5, figs. 38, 41--43; pl. 6, fig. 6. This form appears to be characterized by a tight umbilicus and closely appressed compressed chambers.

Phenon obesa (Akers). Pl. 5, fig. 35. Vs ph. venezuelana: flattened dorsal side in early whorls; shallowly inclined apertural face and maximum height of chamber closer to periphery; large final chamber and fewer chambers in the final whorl.

Phenon larmeui (Akers). Pl. 5, figs. 36, 44--47, 52--54; pl. 6, figs. 1, 2, 7, 10, 11, 17. Vs ph. venezuelana: flattened dorsal side in early whorls; shallowly inclined apertural face and maximum height of chamber closer to periphery; chambers better separated and more globular; the open apertural face often results in a small to large bulla or flap covering the umbilicus. Vs ph. obesa: chamber increase slower, final chamber not as large; chambers better separated.

Phenon ventriosa n. ph. Pl. 5, figs. 48--50; pl. 6, figs. 3--5, 8, 9, 12, 13, 18--25, 29. Vs ph. larmeui: chambers extended ventrally to form a more steeply inclined apertural face; more angular umbilical shoulder; more closely appressed chambers; more quadrate equatorial outline. Vs ph. venezuelana: flattened early whorls; ventral vaulting.

Phenon eximia (Todd). Pl. 5, figs. 37, 39, 40, 51. Vs ph. venezuelana: chambers globular, better separated; Vs ph. larmeui, obesa, and ventriosa: dorsal side inflated.

Phenon conglomerata (Schwager). Pl. 6, figs. 26--28, 30--33, 35. Vs ph. venezuelana: usually more open umbilicus and more inflated chambers. Vs ph. eximia: usually more open umbilicus; more inflated chambers (especially ventrally); usually more chambers in the final whorl (>3½ vs 3--3½). Vs ph. ventriosa: chambers more globular; umbilical shoulder more rounded; chambers better separated; umbilicus more open; dorsal side inflated or, at least, not distinctly flattened. Fleisher (1974) has noted Blow's (1969) error in assuming a lack of teeth in this phenon. The chart (Table 4) presented here shows no overlap of this phenon and phenon venezuelana. However, specimens more or less satisfying the above criteria for phenon venezuelana do probably occur in the lower range of phenon conglomerata, but have a somewhat more inflated appearance than definite specimens occurring below the latter phenon. It is therefore possible that a set of characters may be formulated with future work which will show a definite stratigraphic gap between these near-homeomorphs.

Phenon pseudofoliata (Parker). Pl. 6, fig. 34. Vs ph. conglomerata: umbilicus tighter; chambers less appressed and more spherical.

Remarks

'Neoacarinina blowi' was reported by Thompson (1973) from the upper Pleistocene of the southwest Indian Ocean, just outside Bé & Tolderlund's (1971; see also Parker, 1971) mapped distribution of 'Globigerina conglomerata Schwager'. Its gross shape similarities to the latter phenon are here tentatively interpreted to be due to extreme variation and thus it is included in N. conglomerata populations.

N. conglomerata is tentatively considered to split with the lowest occurrence of phenon venezuelana which Blow (1969) placed in the middle of his Globigerina angulisuturalis partial-range zone.

CLADEGROUP(14) GLOBIGERINIQUARTAEDECIMAE

Stem species. Globigerina sp.c.

Globigerina sp.c

Remarks

This species is a continuation of the general morphology of G. velascoensis.

Catapsydrax dissimilis (Cushman & Bermúdez)

Included phena

Globigerina bulloides var. cryptomphala Glaessner, 1937.
G. corpulenta Subbotina, 1953.
G. dissimilis Cushman & Bermúdez, 1937.
G. isahayensis Asano, 1962.
G. linaperta var. turgida Finlay, 1939.
G. pera Todd, 1937.
G. simulans Bermúdez, 1960.
G. taroubaensis Brönnimann, 1952.
Globigerinita dissimilis ciperoensis Blow & Banner, 1962.

G. riveroae Bermudez, 1960.

Remarks

Two phenon series of Blow (1979) are tentatively amalgamated here because of their bullate tests: phenon *taroubaensis*--phenon *turgida* and phenon *simulans*--phenon *ciperoensis*.

The lower limit of this species is taken at that of phenon *taroubaensis*, that is, the lower part of Blow's (1979) *Globorotalia* (*Morozovella*) *aragonensis*/*G.* (*M.*) *formosa* concurrent-range subzone. The upper limit is determined by that of the nominate phenon, that is, the upper part of Blow's (1969) *Globigerinatella insueta*/*Globigerinita dissimilis* concurrent-range zone.

CLADEGROUP(13) GLOBIGERINITERTIAEDECIMAE

Stem species. *Globigerina* sp.d.

Globigerina sp.d

Remarks

This species is a continuation of the general morphology of *G. velascoensis*.

CLADEGROUP(1) UNNAMED

Stem species. Gen.G *griffinae* (Blow).

Remarks

The stem of this group is based on Blow's (1979) phenon *griffinae*--phenon *bolivariana* (Petters) series which he considered descended from phenon *inaequispira* Subbotina. It is tentatively suggested that Blow's phenon *increbescens* (Bandy)--phenon *prasaepis* (Blow) series descended from this stem. This is based on the similarity of phena *griffinae* and *increbescens* which appear to differ significantly only in degrees of rate of increase, height of spire, and distinctness of the apertural lip. This interpretation leaves a stratigraphic gap corresponding to the lower and middle parts of Blow's (1979) *Globorotalia* (*Morozovella*) *lehneri* partial-range zone. However, the ranges of the above phena may need reevaluation given that Blow (1979, p. 1178) indicated that the placing of the lowest occurrence of phenon *increbescens* in the upper part of the above-mentioned zone was questionable and that misidentifications of these phena may have occurred. Also, given that phenon *wilsoni* (Cole), which is tentatively assigned herein to the phenon *increbescens*--phenon *prasaepis* lineage, was not recorded by Blow (1979) and that its primary type may come from the above-mentioned zone, Blow may have missed some members of the lower sections of this lineage.

Gen.G *griffinae* (Blow)

Included phenon

Globorotalia (*Turborotalia*) *griffinae* Blow, 1979.

Remarks

The lower limit of this species is taken at that of the nominate phenon, that is, the base of Blow's (1979) *Globorotalia* (*Acarinina*) *aspensis*/*Globigerina lozanoi prolata* concurrent-range zone. The upper limit is determined by the split of gen.G *bolivariana*.

Gen.G *bolivariana* (Petters)

Included phena

Globigerina? *bolivariana pannonica* Samuel, 1972.
G. pseudocretacea Hofker, 1956.
G. wilsoni bolivariana Petters, 1954.
Globigerinella alexi Haque, 1956.

Remarks

The lower limit of this species corresponds to the break in intergradation between phena *griffinae* and *bolivariana* observed by Blow (1979) in the lower to middle parts of his *Subbotina frontosa* s.s./*Globorotalia* (*Turborotalia*) *pseudomayeri* concurrent-range zone. The upper limit is determined by that of the nominate phenon, that is, the middle of Blow's *Globigerapsis kugleri*/*Subbotina frontosa boweri* concurrent-range zone.

Gen.G *wilsoni* (Cole)

Included phena

Globigerina ampliapertura Bolli, 1957.
G. increbescens Bandy, 1949.
G. prasaepis Blow, 1969.
G. rotundata var. *jacksonensis* Bandy, 1949.
G. wilsoni Cole, 1927.

Remarks

Blow's (1979) observations of a coarsening of the wall surface of phenon griffinae individuals occurring above the apparent isolation of this phenon from phenon bolivariana would be consistent with an anagenesis to phenon increbescens. The upper limit of this species is determined by that of phenon prasaepis, that is, the middle of Blow's (1969) Globigerina angulisuturalis partial-range zone.

CLADEGROUP(12) GLOBIGERINIDUODECIMAE

Stem species. Globigerina sp.e.

Globigerina sp.e

Remarks

This species is a continuation of the general morphology of G. velascoensis.

CLADEGROUP(1) HANTKENINIPRIMAE

Stem species. Hantkenina eocanica (Nuttal).

Remarks

The stem of this group is based on Blow's (1979) phenon eocanica--phenon columbiana (Petters) series which was considered descended from phenon inaequispira Subbotina. Because of their shared planispirality and chamber elongation, this stem lineage is tentatively considered ancestral to Blow's phenon mexicana Cushman--phenon dumblei Weinzierl & Applin series. The development of tubulospines in the latter is taken to represent isolation of the corresponding lineage. For similar reasons this latter lineage is tentatively considered ancestral to Blow's phenon alabamensis Cushman--phenon inflata Howe series. Because of the lack of stratigraphic overlap of these last-two series, it is tentatively assumed that they are related by anagenesis without splitting.

Hantkenina eocanica (Nuttal)

Included phena

Hastigerinella eocanica Nuttal, 1928.
H. eocanica var. aragonensis Nuttal, 1930.
H. caucasica Subbotina, 1958.
H. jarvisi Cushman, 1930.

Remarks

The lower limit of this species is taken at that of the nominate phenon, that is, the middle of Blow's (1979) Globorotalia (Acarinina) aspensis/Globigerina lozanoi prolata concurrent-range zone.

Hantkenina alabamensis Cushman

Included phena

Hantkenina alabamensis Cushman, 1925.
H. alabamensis compressa Parr, 1947.
H. alabamensis var. primitiva Cushman & Jarvis, 1929.
H. australis Finlay, 1939.
H. brevispina Cushman, 1925.
H. danvillensis Howe & Wallace, 1934.
H. dumblei Weinzierl & Applin, 1929.
H. inflata Howe, 1928.
H. lazzarii Pericoli, 1959.
H. lehneri Cushman & Jarvis, 1929.
H. liebusi Shokhina, 1937.
H. longispira Cushman, 1925.
H. mccordi Howe & Wallace, 1932.
H. mexicana Cushman, 1925.
H. mexicana var. aragonensis Nuttal, 1930.
H. nanggulanensis Hartono, 1969.
H. (Applinella) trinitatensis Brönnimann, 1950.
H. (Cribrohantkenina) bermudezi Thalmann, 1942.
H. (H.) suprasuturalis Brönnimann, 1952.
H. (H.) thalmanni Brönnimann, 1950.
?Siderolina kochi Hantken, 1875 (nomen dubium).

Remarks

The lower limit of this species is taken at that of phenon *mexicana*, that is, the middle of Blow's (1979) *Subbotina frontosa* s.s./*Globorotalia* (*Turborotalia*) *pseudomayeri* concurrent-range zone. The upper limit is determined by that of phenon *primitiva*, that is, the middle of Blow's (1969) *Globigerina gortanii* s.s./*Globorotalia* (*T.*) *centralis* partial-range zone.

Hantkenina colombiana (Petters)

Included phena

Clavigerinella akersi Bolli, Loeblich, & Tappan, 1957.
Hastigerinella columbiana Petters, 1954.

Remarks

This species is a continuation of the general morphology of its ancestor, *H. eocanica*. Its upper limit is determined by that of its nominate phenon, that is, the top of Blow's (1979) *Globorotalia* (*Morozovella*) *lehneri* partial-range zone.

CLADEGROUP(11) GLOBIGERINUNDECIMAE

Stem species. *Globigerina ayalai* Bermúdez.

Globigerina ayalai Bermúdez

Included phena

?*Globigerina alpigena* Gümbel, 1868 (nomen dubium).
G. ayalai Bermúdez, 1960.
?*G. eocaenica* Terquem, 1882 (nomen dubium).
G. hagni Gohrbandt, 1967.

Remarks

This species is a continuation of the general morphology of *G. velascoensis* apparently with increased variation. This includes individuals with highly arched extraumbilically directed apertures. The species thus constitutes the lower part of Blow's (1979) phenon '*Subbotina eocanica*?'--phenon *boweri* (Bolli) series. With regard to the nomenclatural status of phenon '*Globigerina eocanica*', Blow's (1979, p. 1260) retention of the name despite his appreciation of the uncertain nature of the primary type was openly expedient and this practice is considered to be unnecessarily conservative.

Gen.H *frontosa* (Subbotina)

Included phena

Globigerina boweri Bolli, 1957.
G. frontosa Subbotina, 1953.

Remarks

It was noted above in the discussion of *T. cerroazulensis* that Blow's (1979) documentation of phenon *praecentralis* necessitated, on stratigraphic grounds, acceptance of his phylogenetic scheme for that species. This is pending detailed reinvestigation of appropriate assemblage sequences which is beyond the scope of this study. Thus Blow's (1979) phenon '*Subbotina eocaenica*?'--phenon *boweri* series is accepted here.

The lower and upper limits of the species are taken at that of phenon *boweri*, that is, the middle of Blow's (1979) *Subbotina frontosa* s.s./*Globorotalia* (*T.*) *pseudomayeri* concurrent-range zone to the top of the *Globigerapsis kugleri*/*S. frontosa boweri* concurrent-range zone.

CLADEGROUP(10) GLOBIGERINIDECIMAE

Stem species. *Globigerina linaperta* Finlay.

Remarks

This group constitutes a large portion of living planktic foraminifers and so the interpretation of its stem species and its immediate descendants is of considerable impact. This objective is, however, hampered because phena such as *officinalis* Subbotina and *opima* Bolli, apparently crucial to the ancestry of living species and treated in Blow's (1969) Neogene synthetic study, were not integrated into his Palaeogene sequel (Blow, 1979). Thus, although stratophenetic evidence derived from Blow (1979) can be brought to bear on the nature of these branching sequences, these data are somewhat fragmentary.

Globigerina linaperta Finlay

Included phena

Globigerina inaequispira Subbotina, 1953.
G. linaperta Finlay, 1939.
G. micropora de Klasz, Le Calvez, & Rerat, 1969.

?G. taminensis Kübler & Zwingli, 1866 (nomen dubium).

Remarks

This species is interpreted to be more variable than its ancestor, G. ayalai, owing mainly to the presence of more compact individuals with closely appressed chambers, namely, phenon minima (Jenkins). This is apparently additional to the presence of individuals with extraumbilically elevated apertures, phenon crociapertura, presumed homeomorphs of members of the sister species, gen.H frontosa. It is very tentatively suggested that this variability breaks down to form descendants, Globigerina pseudoeocaena Subbotina and Globorotalia bakeri (Cole). This has been suggested by the variation allowed by Blow (1979, pl. 163, figs. 4--10) for phenon inaequispira Subbotina in his Subbotina frontosa s.s./Globorotalia (Turborotalia) pseudomayeri concurrent-range zone and its apparently more restricted variation (pl. 177, fig. 3; pl. 180, figs. 1--7; pl. 185, fig. 9) in the overlying zone. In the lower zone phenon-inaequispira individuals vary from compact coarsely surfaced tests with closely appressed chambers resembling phenon linaperta (Blow, 1979, pl. 163, fig. 6) to individuals with well-separated chambers and a surface of smaller pores with depressed interpore ridges (pl. 163, fig. 9). In the higher zone, phenon inaequispira appears restricted to the latter shape and phenon linaperta appears quite distinct (pl. 177, figs. 4--6). Thus a split in G. linaperta assemblages is tentatively suggested to occur at the top of the S. frontosa s.s./G. (T.) pseudomayeri concurrent-range zone into G. pseudoeocaena, typified by more thinly and smoothly walled individuals with better-separated chambers, and G. bakeri with more thickly and coarsely walled individuals with closely appressed chambers.

CLADEGROUP(7) GLOBIGERINISEPTIMAE

Stem species. Globigerina pseudoeocaena Subbotina.

Globigerina pseudoeocaena Subbotina

Included phena

Globigerina achtschaucujmensis Chalilov, 1956.
G. inaequispira transversa Chalilov, 1956.
G. pseudoeocaena var. compacta Subbotina, 1953.
G. pseudoeocaena var. ellipsocamerata Chalilov, 1956.
G. pseudoeocaena var. pseudoeocaena Subbotina, 1953.
Globorotalia cerroazulensis possagnoensis Toumarkine & Bolli, 1970.
Subbotina crociapertura Blow, 1979.

Remarks

Blow (1979) considered phenon suteri (Bolli) to descend from phenon inaequispira and the similarity of apertural position between these phena, if certain ontogenetic stages are compared, is especially convincing. The very coarse wall-surface of the former, however, necessitates a reversal in trend for G. pseudoeocaena and so derivation from G. bakeri, within the scheme proposed herein, cannot be rejected. The appearance of phenon suteri is suggested herein to result from cladogenesis. This is supported by the distinctive morphology of this phenon compared with members of G. pseudoeocaena, the lack of intermediate individuals between phena suteri and inaequispira as reported by Blow (1979), and the maintenance of a sequence of more typically globigeriniform individuals well above the lowest occurrence of phenon suteri. These globigeriniform individuals include phenon officinalis Subbotina which occurs just above phenon suteri and which Fleisher (1974) considered ancestral to the Neogene globigeriniform species.

CLADEGROUP(2) GLOBOROTALOIDISECUNDAE

Stem species. Globorotaloides incretaceus (Chalilov).

Globorotaloides incretaceus (Chalilov)

Included phena

Catapsydrax stainforthi Bolli, Loeblich, & Tappan, 1957.
C. unicavus Bolli, Loeblich, & Tappan, 1957.
Globigerina incretacea Chalilov, 1956.
Globigerinita unicava primitiva Blow & Banner, 1962.
Globorotalia testarugosa Jenkins, 1960.
Globorotaloides suteri Bolli, 1957.
Subbotina vialovi Myatiuk, 1970.
Turborotalia czeczvaensis Myatiuk, 1970.

Remarks

This species represents Blow's (1979) phenon *suteri*--phenon *unicavus* series. Its lower limit is taken at that of phenon *suteri*, that is, the lower part of Blow's (1969) *Orbulinoides beckmanni* total-range zone.

Bandyus relizensis (Bandy, Ingle, & Wright)

Included phena

Globorotaloides suteri relizensis Bandy, Ingle, & Wright, 1971 (pl. 1, fig. 2; *Siphogenerina hughesi* zone of Kleinpell, 1938; west California; Relizian, upper-lower Miocene).

New phenon

Bandyus relizensis extraumbilicatus n. subsp.

Holotype. UQF 71320. Pl. 3, fig. 40. *Orbulina suturalis* zone; foraminifer-rich calcareous-nannofossil chalk, unit 1; D.S.D.P.208/21/3/73--75/RS2, 318.73--318.75 m below sea-floor; lower-middle Miocene. Moderate in size, robust; low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline weakly lobate; lateral outline oval. Chambers globular, moderately appressed, at least 10 in total, 4 in final whorl; increase moderate and regular throughout. Dorsal view: chambers slightly longer concentrically, barely inflated; sutures flush; intercameral sutures radial. Ventral view: chambers inflated; intercameral sutures radial, meet at tight umbilicus; aperture umbilical--extraumbilical, low. Lateral view: smoothly rounded. Wall coarsely and deeply cancellate. Length, 165 µm; width 145 µm; height, 115 µm.

Material. Five specimens.

Derivation of name. Latin, *extra*, on the outside, beyond; *umbilicus* (m.), navel; *-atus*, pertaining to.

Phena recorded

Phenon *relizensis* (Bandy, Ingle, & Wright). Pl. 3, figs. 37, 38.

Phenon *extraumbilicatus* n. ph. Ph. 3, figs. 39, 40. Vs ph. *relizensis*: aperture extraumbilical.

Remarks

The split of *B. relizensis* is considered to have occurred in the late Saucesian. Its upper range is determined by that of phenon *extraumbilicatus* which can be confidently placed in the middle Miocene and tentatively extended to the upper Miocene.

CLADEGROUP(1) GLOBOROTALOIDIPRIMAE

Stem species. *Globorotaloides parvulus* (Bolli).

Globorotaloides parvulus (Bolli)

Included phena

Catapsydrax parvulus Bolli, Loeblich, & Tappan, 1957 (pl. 7, fig. 10; *Globorotalia mayeri* zone; Lengua Formation; Trinidad, middle Miocene).

Globorotaloides falconarae Gianelli & Salvatorini, 1976 (pl. 2, fig. 1; *Globorotalia continuosa* subzone, *G. acostaensis* s.s. zone of D'Onofrio & others, 1976; *G. (Turborotalia) acostaensis* s.s.--*G. (G.) merotumida* partial-range zone of Banner & Blow, 1965; Sicily, Italy; Tortonian, upper Miocene).

G. trema Lipps, 1964 (pl. 4, fig. 3; Monterey Shale; south California; uppermost Luisian, Burdigalian, lower-middle Miocene).

G. variabilis Bolli, 1957 (pl. 27, fig. 20; *Globorotalia menardii* zone; Lengua Formation; uppermost-middle or lowermost-upper Miocene).

Hastigerinella bermudezi Bolli, 1957 (pl. 25, fig. 1; *Globorotalia fohsi barisanensis* zone; Cipero Formation; Trinidad; lower-middle Miocene).

Protentella prolixa Lipps, 1964 (pl. 2, fig. 8; Monterey Shale; south California; uppermost Luisian, Burdigalian, lower Miocene).

New phena

Globorotaloides parvulus lateraliaperturus n. subsp.

Holotype. UQF 71322. Pl. 3, fig. 42. *Orbulina suturalis* zone; foraminifer-rich calcareous-nannofossil chalk, unit 1; D.S.D.P.208/21/3/73--75/RS2, 318.73--318.75 m below sea-floor; lower-middle Miocene. Moderately small, robust; low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline oval, weakly lobate; lateral outline weakly compressed. Chambers ovate, closely appressed, about 13 in total, 4 in final whorl; increase slow but regular. Dorsal view: chambers slightly longer concentrically, barely inflated;

sutures barely depressed; intercameral sutures directed slightly posteriorly, then curved posteriorly. Ventral view: chambers weakly inflated; intercameral sutures radial, meeting at tight umbilicus; aperture umbilical--extraumbilical, very low, with a very thin lip. Lateral view: smoothly rounded. Wall weakly but coarsely cancellate. Length, 150 µm; width, 115 µm; height, 90 µm.

Material. Common.

Derivation of name. Latin, *lateralis*, of the side; *apertura* (f.), opening, hole; -*us*, adjectival termination.

Globorotaloides parvulus anasuteri n. subsp.

Holotype. UQF 71339. Pl. 3, fig. 59. *Globorotalia continuosa* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/17/2/74--76/RS2, 224.24--224.26 m below sea-floor; upper Miocene. Moderate in size, robust; low dextral trochospire, very tight parallel and perpendicular to axis. Equatorial outline very weakly lobate; lateral outline oval. Chambers globular, very closely appressed, at least 12 in total, 4 in final whorl, 4½ in second-last whorl; increase slow but regular except final 'chamber' which is a reduced, umbilical flap. Dorsal view: chambers longer concentrically, slightly inflated; sutures slightly depressed; intercameral sutures slightly directed posteriorly, then curved posteriorly. Ventral view: chambers inflated; intercameral sutures radial; umbilicus tight, covered by flap with a low umbilical opening with a thick lip. Lateral view: smoothly rounded. Wall surface coarsely cancellate. Length, 200 µm; width 195 µm; height, 145 µm.

Material. Two specimens.

Derivation of name. Greek, *ana*, back again; the second component refers to '*Globorotaloides suteri* Bolli'.

Phena recorded

Phenon *lateraliaperturus* n. ph. Pl. 3, figs. 41, 42, 49--51, 54. Vs *G. suteri* ph. *suteri* Bolli: aperture extraumbilical. Vs *Globoquadrina tripartita* ph. *dehiscens* (Chapman, Parr, & Collins): umbilical shoulder rounded and lower; equatorial outline more rounded. Separation of these individuals from juvenile *G. tripartita* ph. *dehiscens* can be quite difficult. This is, however, interpreted as pseudomorphy rather than intergradation.

Phenon *variabilis* Bolli. Pl. 3, figs. 52, 53, 55--57, (71--73). Vs ph. *lateraliaperturus*: more chambers in the final whorl; dorsal intercameral sutures recurved; usually bulla present; chambers not as inflated ventrally. Vs *G. suteri* ph. *suteri*: more chambers in the final whorl; dorsal intercameral sutures more curved; early chambers more compressed.

Phenon *falconarae* Gianelli & Salvatorini. Pl. 3, figs. 43--48. Vs ph. *lateraliaperturus*: aperture umbilical. Vs *G. suteri* ph. *suteri*: chambers more closely appressed, less globose, more elongate concentrically and always 4 in the final whorl; equatorial outline less lobate.

Phenon *anasuteri* n. ph. Pl. 3, figs. 58, 59. Vs *G. suteri* ph. *suteri*: possibly higher trochospire in later whorls (globigeriniform rather than globorotaliform); dorsal surface higher. Vs ph. *lateraliaperturus*: bullate; larger; chambers more globular.

Globorotaloides indigena (Łuczkowska)

Included phena

Candeina amicula Takayanagi & Saito, 1962 (pl. 23, fig. 3; *Globorotalia cultrata* s.s./*Globigerina nepenthes* zone; Nobori Formation; Skikoku, Japan; Tortonian, upper Miocene).

Catapysdrax prahovensis Popescu, 1969 (pl. 2, fig. 7; Spirialis marls horizon; south Romania; upper Tortonian, upper Miocene).

Globigerinoides dinapoli Ogniben, 1958 (pl. 15, fig. 1; Flysch di Moleta; southwest Italy; upper Helvetian, middle Miocene).

G. indigena Łuczkowska, 1955 (pl. 10, figs. 6, 7; Grabowiec beds; south Poland; middle or upper Tortonian, upper Miocene).

Velapertina cingulata Popescu, 1969 (pl. 1, fig. 3; Spirialis marls horizon; Subcarpathians, south Romania; upper Tortonian, upper Miocene).

V. iorgulescui Popescu, 1969 (pl. 2, fig. 5; Spirialis marls horizon; Subcarpathians, Romania; upper Tortonian, upper Miocene).

V. luczkowskae Popescu in Popescu & Cioflica, 1973 (pl. 8, figs. 75--77; upper *V. iorgulescui* zone; Spirialis marls horizon, Mireş beds, Cîmpie series; north Transylvania, Romania; upper Tortonian, upper Miocene).

New phena

Globorotaloides indigena redissimilis n. subsp.

Holotype. UQF 71345. Pl. 3, fig. 65. Upper *Globorotalia continuosa* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/16/1/74--76/RS2, 194.74--194.76 m below sea-floor; upper Miocene. Large, robust; slightly elevated dextral trochospire, very tight parallel and perpendicular to axis. Equatorial outline weakly lobate; lateral outline oval. Chambers globular, very closely appressed, about 12 in total, 4 in last whorl; increase moderate until third-last chamber when it is decreased. Dorsal view: chambers longer concentrically, slightly inflated; sutures flush; intercameral sutures directed and curved posteriorly. Ventral view: chambers inflated; intercameral sutures radial to curved; umbilicus covered by small flap with a low opening and a thick lip. Lateral view: smoothly rounded. Wall weakly cancellate with fairly large dense pores. Length 350 µm; width, 340 µm; height, 290 µm.

Material. Seven specimens.

Derivation of name. Latin, *re*, again; the second component refers to '*Globigerina dissimilis* Cushman & Bermúdez'.

Globorotaloides indigena anavenezuelana n. subsp.

Holotype. UQF 71347. Pl. 3, fig. 67. As for *G. indigena redissimilis*. Large, robust; slightly elevated sinistral trochospire, extremely tight parallel and perpendicular to axis. Equatorial outline barely lobate; lateral outline oval. Chambers globular, extremely closely appressed, over 7 (12?) in total, 3½ in final whorl; increase moderate until third-last chamber when much reduced. Dorsal view: chambers longer concentrically, barely inflated; sutures flush; intercameral sutures directed and curved posteriorly. Ventral view: chambers weakly inflated, mostly proximally; intercameral sutures radial to curved, adjacent pairs of sutures (last--second-last and second-last--third-last; third-last--fourth-last and fourth-last--final) meet at opposite ends of very low slit-like umbilical aperture; umbilicus closed. Lateral view: dorsoperipheral shoulder not quite smoothly rounded; highest part of umbilical shoulder closer to umbilicus than if smoothly rounded, thus apertural face slightly steepened. Wall weakly cancellate with fairly large dense pores. Length, 310 µm; width, 330 µm; height, 255 µm.

Material. Three specimens.

Derivation of name. Greek, *ana*, back again; the second component refers to '*Globigerina venezuelana* Hedberg'.

Phena recorded

Phenon *redissimilis* n. ph. Pl. 3, figs. 60--65. Vs *Catapysdrax dissimilis* ph. *dissimilis* (Cushman & Bermudez): bulla possibly more extensive, similar in shape to *C. dissimilis* ph. *primitiva* (Blow & Banner). Vs *G. parvalus* ph. *anasuteri*: trochospire higher especially in early whorls; chambers more globular.

Phenon *anavenezuelana* n. ph. Pl. 3, figs. 66--68. Vs *Neoacarinina conglomerata* ph. *venezuelana*: possibly tighter umbilicus. Vs ph. *redissimilis*: no bulla.

Remarks

Both phena introduced above differ from the others included in this species by the absence of supplementary sutural apertures. For the present this is tentatively considered merely a clinal difference from the populations documented from the middle?--upper Miocene of Europe and Japan. Phenon *dinapoli* may precede the split which gave rise to the species in question, but presently it is considered part of it owing to its similarities with the other phena listed, which are of definite upper-Miocene age (see Popescu & Cioflica, 1973).

Globorotaloides hexagonus (Natland)

Included phena

Globigerina clippertonensis McCulloch, 1977 (pl. 173, fig. 1; off Clipperton Is., Galapagos Islands, east central Pacific Ocean; Holocene).

G. hexagona Natland, 1938 (pl. 7, fig. 1; off south California, U.S.A.; Holocene).

Globorotalia (Clavatorella) oveyi Buckley, 1973 (pl. 1, figs. 1--6; Indian Ocean; Holocene).

Phena recorded

Globorotaloides parvulus phenon *lateraliaperturus* n. ph.

G. parvulus phenon *variabilis* Bolli. Pl. 3, figs. 69, 70, (74, 78).

G. parvulus phenon *falconarae* Gianelli & Salvatorini.

Phenon *hexagonus* (Natland). Pl. 3, figs. 75--77, 79. Vs *G. parvulus* ph. *variabilis*: larger; more coarsely perforated; wider umbilicus; chambers better separated and more inflated.

Remarks

Although the D.S.D.P.-Site-77 assemblages recovered of this species are too meagre to confidently indicate the style of anagenesis which occurred in this lineage, the lowest occurrence of phenon *hexagonus* in the upper Miocene appears to be quite abrupt, following a rather static succession of assemblages containing phenon *variabilis*.

CLADEGROUP(6) GLOBIGERINISEXTAE

Stem species. *Globigerina ouchitaensis* Howe & Wallace.

Globigerina ouchitaensis Howe & Wallace

Included phena

Globigerina acerbaidjanica Chalilov, 1956.
G. officinalis Subbotina, 1953.
G. ouchitaensis Howe & Wallace, 1932.

Remarks

Phenon *officinalis*, possibly the lowest occurring phenon of this species, is tentatively considered ancestral to the Neogene globigeriniform species (Fleisher, 1974). The suggestion of *G. pseudoeocaena* as ancestor of *G. ouchitaensis* is based mainly on similarities between phena *inaequispira* and *officinalis*, namely, a wall surface with weak interpore ridges and well-separated chambers.

This species has been interpreted herein to correspond with the lower portions of Blow & Banner's (1962) and Blow's (1969) phenon *officinalis*--phenon *ciperoensis* (Bolli) series, phenon *officinalis*--phenon *angustiumbilicata* (Bolli) series, and phenon *occlusa* Blow & Banner--phenon *praebulloides* Blow--phenon *leroyi* Blow & Banner series. However, a few anagenetic trends appear to occur concurrently in these taxa making delineation of branching sequences from the stratigraphic distribution of established phena very difficult. It is very tentatively suggested that the lowest occurrence of phenon *angustiumbilicata* represents the earliest cladogenesis in this group and this involves mainly an increase in the number of chambers per whorl. This corresponds with the base of Blow's (1969) *Cribrohantkenina inflata* total-range zone.

CLADEGROUP(1) TURBOROTALITIPRIMAE

Stem species. *Turborotalita fariasi* (Bermúdez).

Turborotalita fariasi (Bermúdez)

Included phena

Globigerina anguliofficinalis Blow, 1969.
G. fariasi Bermúdez, 1960.
G. officinalis crux Blaicher, 1970.
G. ouchitaensis gnaucki Blow & Banner, 1962.

Remarks

The integrity of this lineage late in the Oligocene is indicated by the gradation, demonstrated by Blow & Banner (1962, fig. 16), from phenon *officinalis* to phenon *angustiumbilicata* in the lower part of Blow's (1970) *Globigerina sellii*--*G. ampliapertura* partial-range zone.

Turborotalita ciperoensis (Bolli)

Included phena

Globigerina ciperoensis Bolli, 1954.
G. ciperoensis angulisuturalis Bolli, 1957.

Remarks

The lower limit of this species, indicated by isolation of individuals with distinctly wide umbilici, is taken at that of phenon *angulisuturalis*, that is, the base of Blow's (1969) *Globigerina angulisuturalis*/*Globorotalia* (*Turborotalia*) *opima* s.s. concurrent-range zone. The upper limit is determined by that of Blow's (1969) '*Globigerina ouchitaensis ciperoensis* forma atypica', that is, the upper part of Blow's (1969) *Globoquadrina dehiscens praedehiscens*--*G. dehiscens* s.s. partial-range zone.

Turborotalita detrita (Turquem)

Included phena

Globanomalina praepumilio Parker, 1967 (pl. 18, fig. 1; *Globorotalia* (*G.*) *tosaensis* consecutive-range zone of Banner & Blow, 1965c; east of Mauritius, west Indian Ocean; upper Pliocene).

Globigerina atlantisae Cifelli & Smith, 1970 (pl. 1, fig. 1; North Atlantic Ocean; Holocene).

G. ciperoensis angustiumbilicata Bolli, 1957 (pl. 22, fig. 13; Stainforth & others, 1975, fig. 105/5; *G. ciperoensis* s.s. zone; lower Cipero Formation; Trinidad; upper-upper Oligocene).

G. clarkei Rögl & Bolli, 1973 (pl. 4, fig. 14; zone Y of Ericson & Wollin, 1968; *G. bermudezi* subzone, *Globorotalia truncatulinoides* s.s. zone; north of Venezuela, Caribbean Sea, upper Pleistocene).

G. cretacea var. *eggeri* Heron-Allen & Earland, 1922 (figured syntype: pl. 7, figs. 6--8; off north North Island, New Zealand, west South Pacific Ocean; Holocene; *G. detrita* Turquem acc. this study?).

G. cristata Heron-Allen & Earland, 1929 (Banner & Blow, 1960b, pl. 7, fig. 5; north of Possession Is., west of Namibia; Holocene).

G.(?) *cristatiformis* McCulloch, 1977 (pl. 175, fig. 12; off Bikini Atoll, Pacific Ocean; Holocene).

G. detrita Terquem, 1875a (figured syntypes: 1875b, pl. 4, fig. 4; north France; Holocene).

G. exumbilicata Herman, 1974 (amongst pls 17--19; phase VI of Herman, 1969; Arctic Ocean; lower Pleistocene; =*G. quinqueloba egelida* acc. Herman, 1980a).

G. gradationis Voloshinova, 1960 (pl. 29, fig. 10; lower Okobykay Formation; Sakhalin, U.S.S.R.; upper Miocene; =*G. ciperoensis angustiumbilicata* Bolli acc. this study).

G. groenlandica Shchedrina, 1946 (figured syntype: pl. 4, fig. 23; Greenland Sea, Arctic Ocean; Holocene; =*G. quinqueloba* Natland acc. Jenkins, 1971, this study).

G.(?) *quadalupensis* McCulloch, 1977 (pl. 175, fig. 10; off Guadalupe Is., off Mexico, east Pacific Ocean; Holocene).

G. microfoliata Brönnimann & Resig, 1971 (pl. 6, fig. 6; 'zone N20 (including N19) of Blow, 1969'; north of Papua New Guinea, southwest Pacific Ocean; lower Pliocene).

G. multiloba Romeo, 1965 (pl. 118, fig. 1; *Orbulina suturalis* zone of Selli, 1960; tripoli beds; south Italy; basal Messinian, upper Miocene).

G. pseudoedita Subbotina in Subbotina & others, 1960 (pl. 1, fig. 1; Nizhnevorotyshchaya Formation; west Ukrainian S.S.R., west U.S.S.R.; Oligocene; =*G. ciperoensis angustiumbilicata* Bolli acc. this study).

G. quinqueloba Natland, 1938 (pl. 6, fig. 7; off south California, U.S.A.; Holocene).

G. quinqueloba egelida Cifelli & Smith, 1970 (pl. 3, fig. 4; North Atlantic Ocean; Holocene).

G. regularis Turquem, 1880 (figured syntype: pl. 16, fig. 2; north France; Holocene; junior objective homonym of *G. regularis* d'Orbigny; =*G. detrita* Terquem acc. this study?).

G. tecta Lipps, 1964 (pl. 1, fig. 6; Monterey Shale; south California, U.S.A.; Luisian, pre?-Burdigalian, lower Miocene; =*G. ciperoensis angustiumbilicata* Bolli acc. this study?).

G. weissi Saito, 1963 (pl. 54, fig. 13; *Globigerinatella insueta*/*Globigerinoides bisphericus* subzone; Saigo Formation, Mikasa Group; Honshu, Japan; uppermost-lower or lowermost-middle Miocene; =*G. quinqueloba* Natland acc. Jenkins, 1971, this study).

Globigerinita bikiniensis McCulloch, 1977 (pl. 175, fig. 13; off Bikini Atoll; Holocene).

G. parkerae Loeblich & Tappan, 1957 (text-fig. 1; south of west Florida, U.S.A., northeast Gulf of Mexico; Holocene).

G. stainforthi praestainforthi Blow, 1969 (pl. 25, figs. 3--5; *Globigerinoides quadrilobatus primordius*--*Globorotalia* (*Turborotalia*) *kugleri* concurrent-range zone of Banner & Blow, 1965c; Trinidad; Aquitanian, lower-lower Miocene).

Globorotalia mohleri Bolli, 1966 (pl. 1, figs. 3--5; *G. fohsi* s.s. zone; east Java, Indonesia; middle Miocene).

G. neominutissima Bermúdez & Bolli, 1969 (pl. 13, figs. 10--12; Cumana Formation; northeast Venezuela; Pliocene).

G. pumilo Parker, 1962 (pl. 6, fig. 2; northeast of Pitcairn, South Pacific Ocean; Holocene; =*Globigerina detrita* Terquem acc. this study?).

G. seigliei Bermúdez & Bolli, 1969 (pl. 18, figs. 1--3; northeast Venezuela; Holocene).

G. (*Turborotalia*) *riedeli* Brönnimann & Resig, 1971 (pl. 41, fig. 4; *Globigerina nepenthes/Globorotalia* (*T.*) *siakensis* concurrent-range zone of Banner & Blow, 1965c; north of Papua New Guinea, southwest Pacific Ocean; middle Miocene).

Hastigerinella riedeli Rögl & Bolli, 1973 (pl. 4, fig. 2; text-fig. 5; zone X of Ericson & Wollin, 1968; *Globigerina calida* s.s. subzone, *Globorotalia truncatulinoides* s.s. zone; north of Venezuela, Caribbean Sea; upper Pleistocene).

Truncatulina humilis Brady, 1884 (Banner & Blow, 1960b, pl. 8, fig. 1; west of south Western Sahara, east North Atlantic Ocean; Holocene).

Turborotalita primitiva Brönnimann & Resig, 1971 (pl. 26, fig. 7; *Globigerina angulisuturalis* partial-range zone of Blow, 1969; east of New Ireland, Papua New Guinea; upper-upper Oligocene).

T. quinqueloba lingulata Collen & Vella, 1973 (pl. 5, fig. 3; North Island, New Zealand; Mangapanian, upper Pliocene; =*Globigerina quinqueloba* Natland acc. this study).

New name

Turborotalita detrita roglbolliorum n. name.

For *Hastigerinella riedeli* Rögl & Bolli. Within the present classification the latter name becomes a junior subjective homonym of '*Globorotalia* (*Turborotalia*) *riedeli* Brönnimann & Resig'.

Derivation of name. For Fred Rögl and Hans Bolli.

New phenon

Turborotalita detrita primoripumilio n. subsp.

Holotype. UQF 71561. Pl. 7, fig. 56. Upper *Globorotalia continuosa* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/16/1/74--76/RS1, 194.74--194.76 m below sea-floor; upper Miocene. Small, but quite robust; slightly elevated dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline slightly oval, weakly lobate; lateral outline weakly compressed, weakly umbilicoconvex. Chambers ovate to globular, closely appressed, over 9 (13?) in total, 5 in final (and second-last?) whorl; increase slow but regular. Dorsal view: chambers slightly longer concentrically, very slightly elevated; sutures very slightly depressed; intercameral sutures radial. Ventral view: chambers moderately inflated; intercameral sutures radial, meet at tight umbilicus; aperture interiomarginal, umbilical--extraumbilical, low, slightly arched near periphery. Lateral view: smoothly rounded. Wall smooth with sparse blunt pustules and fairly large pores, especially peripherally and suturally on dorsal surface. Length, 80 µm; width 70 µm; height, 45 µm.

Material. Common.

Derivation of name. Latin, *primoris*, first, earliest; second component refers to '*Globorotalia pumilio* Parker'.

Phena recorded

Phenon *angustiumbilicata* (Bolli). Pl. 7, figs. 1--18, 35, 36, 42, 43, 58--63, 69, 77, 78, 87, 103, 123, 137--139; pl. 8, figs. 40, 76, 97, 107, 108, 116. The considerable degree of intraassemblage variation in this phenon is typical of the phena of *T. detrita* as used herein: four to seven chambers in the final whorl, thin to heavily encrusted wall, umbilical to umbilical--extraumbilical apertural position, apertural lip absent to present and extending to fuse with earlier chambers of the final whorl, chambers globular to slightly elongate radially, spire low to slightly elevated (chambers of the final whorl displaced), final chamber small to much larger than previous chambers, wall surface finely spinose to pustulose especially on periphery, and up to 190 µm in maximum dimension (average approximately 100 µm). Very rare specimens have an accessory aperture.

Phenon *primitiva* Brönnimann & Resig. Pl. 7, figs. 19--23, 37, 38, 55, 64, 70; pl. 8, figs. 41, 64, 77, 78, 86, 109. Vs ph. *angustiumbilicata*: heavily encrusted; chambers closely appressed; ventral intercameral sutures very shallow to completely infilled; equatorial outline less lobate; usually smaller maximum size.

Phenon *primoripumilio* n. ph. Pl. 7, figs. 56, 71, 79, 80, 88, 96, 97, 140, 141; pl. 8, figs. 42, 65, 117. Vs ph. *angustiumbilicata*: aperture umbilical--extraumbilical and very low; chambers less inflated, more closely appressed; ventral intercameral sutures shallower; thinner walled; chambers more elongated radially.

Phenon microfoliata (Brönnimann & Resig). Pl. 8, fig. 45. Vs ph. clarkei: few chambers in the final whorl; aperture umbilical with lip; no extension of final chamber, leaving aperture open to umbilicus.

Phenon praepumilio (Parker). Pl. 8, figs. 19, 21. Vs ph. primoripumilio: weakly evolute to involute dorsally; more chambers in the final whorl.

Phenon roglbolliorum n. name. Pl. 7, fig. 125. Vs ph. angustiumbilicata: well-developed spines on distal surface of chambers; chambers less spherical, more closely appressed, more elongate radially. Vs ph. guadalupensis: well-developed spines on distal surface of chambers; chambers not pointed distally.

Phenon clarkei (Rögl & Bolli). Pl. 7, figs. 24, 44, 45, 47, 104, 111, 112, 126, 127; pl. 8, figs. 5--12, 46--48, 67--70, 79, 99, 118, 119. Vs ph. primitiva: aperture umbilical--extraumbilical; pores slightly smaller; thickened surface is smoother.

Phenon atlantisae (Cifelli & Smith). Pl. 8, figs. 75, 85, 113--115, 125, 126. Vs ph. egelida: see Cifelli & Smith (1970).

Phenon cristata (Heron-Allen & Earland). Pl. 8, figs. 38, 39, 62, 63. Vs ph. guadalupensis: extension of final chamber to cover umbilicus and proximal surfaces of other chambers of the final whorl and along ventral intercameral sutures. Vs ph. humilis: some chambers are pointed radially.

Phenon egelida (Cifelli & Smith). Pl. 7, figs. 95, 110, 121, 122, 132, 133; pl. 8, figs. 26--35, 74, 83, 90--92, 105, 106, 112, 123, 124. Vs ph. quinqueloba: thinner walled; final chamber does not extend proximally; chambers more spherical and better separated; ventral intercameral sutures deeper. Vs ph. angustiumbilicata: thinner walled; wall surface smooth.

Phenon guadalupensis (McCulloch). Pl. 7, figs. 124, 142--146; pl. 8, figs. 1--4, 43, 44, 66, 98. Vs ph. primoripumilio; some chambers pointed radially.

Phenon humilis (Brady). Pl. 7, figs. 134--136; pl. 8, figs. 36, 37, 55--61, 84. Vs ph. quinqueloba: final chamber extends onto proximal surfaces of other chambers of the final whorl and along the ventral intercameral sutures. Thickened specimens with deeply dissected dorsal intercameral sutures show a more restricted distribution than typical individuals.

Phenon pumilio (Parker). Pl. 7, figs. 84--86, 103, 108, 109, 119, 120; pl. 8, figs. 17, 18, 20, 22--25, 51--54, 80--82. Vs ph. primoripumilio: >6 chambers in the final whorl. Just above its lowest occurrence, this phenon tends to increasing numbers of chambers in the final whorl, greater radial elongation of chambers, and increasing height of aperture.

Phenon quinqueloba (Natland). Pl. 7, figs. 25--34, 39--41, 46, 48--54, 57, 65--68, 72--76, 81--83, 89--94, 98--101, 105--107, 113--118, 128--131; pl. 8, figs. 13--16, 49, 50, 71--73, 87--89, 93--96, 100--104, 110, 111, 120--122. Vs ph. angustiumbilicata: more compressed laterally; chambers more elongate radially, less inflated, and more closely appressed; last ventral intercameral sutures curved; apertural face extends proximally to partially or wholly (ph. lingulata Collen & Vella) cover umbilicus; wall surface smoother and less spinose; aperture lower. Vs ph. primitiva and clarkei: thinner walled; equatorial outline more lobate; chambers more inflated and better separated; ventral intercameral sutures deeper. Vs ph. primoripumilio: aperture umbilical; chambers more inflated; ventral intercameral sutures curved; usually thinner walled; final chamber may extend proximally. Vs ph. roglbolliorum: spines not well developed on distal surface of chambers. Vs ph. clarkei: aperture umbilical. Size is not considered in the definition of this phenon though Asano, Ingle, & Takayanagi (1968) show a subtle change in size during its range. The holotype is much larger than most specimens recovered, especially in the lower assemblages. Rare specimens with elongate final chambers are included; phena guadalupensis and cristata have early chambers of the final whorl pointed.

Remarks

Previously (Asano, Ingle, & Takayanagi, 1968), an interpreted lineage, containing only phena angustiumbilicata and quinqueloba, has been considered to have undergone relatively subtle changes in size and shape from its late-Eocene--early-Oligocene appearance to the present. However, in this study much greater anagenesis of this lineage is interpreted in the late Miocene--Pleistocene when variability increased in features such as chamber shape, wall thickness, development of bullae, chamber arrangement, and mode of coiling.

CLADEGROUP(5) GLOBIGERINIQUINTAE

Stem species. Globigerina parva Bolli.

Globigerina parva Bolli

Included phena

Globigerina kondoi Todd, 1970.
G. parva Bolli, 1957.
G. praebulloides leroyi Blow & Banner, 1962.
G. praebulloides occlusa Blow & Banner, 1962.
G. praebulloides pseudoleroyi Iturralde Vincent, 1967.
G. praebulloides tinguarensis Iturralde Vincent, 1967.

Remarks

This species represents a portion of the lineage of phenon *occlusa* and its descendants as interpreted by Blow (1969).

CLADEGROUP(3) HASTIGERINITERTIAE

Stem species. *Hastigerina* sp.

Remarks

This group is centred around Blow's (1969) phenon *obesa* (Bolli)--phenon *siphonifera* (d'Orbigny) series. The lowest-occurring representative, phenon *obesa*, is tentatively considered to indicate isolation of members of *G. parva* assemblages by the development of low spines and extraumbilical apertures.

Hastigerina sp.

Remarks

Apparently phena have not been erected from the lowermost lineage of the Hastigerinitertiae. The lower limit of this species is taken at that of phenon *obesa*, that is, the lower part of Blow's (1969) *Globigerina angulisuturalis*/*Globorotalia* (*Turborotalia*) *opima* s.s. concurrent-range zone.

Globigeriniopsis aguasayaensis Bolli

Included phena

Globigerinanus bullatus bullatus Ouda, 1978 (pl. 3, fig. 1; upper Ayun Musa Formation; northeast Egypt; lower Langhian, uppermost-lower or lowermost-middle Miocene).

G. bullatus expansus Ouda, 1978 (pl. 2, fig. 8; as for *G. bullatus bullatus*).

G. loxophodellus Ouda, 1978 (pl. 3, fig. 2; as for *G. bullatus bullatus*).

G. multiaperturus Ouda, 1978 (pl. 3, fig. 6; as for *G. bullatus bullatus*).

G. phodoaplatus Ouda, 1978 (pl. 2, fig. 3; as for *G. bullatus bullatus*).

G. sphaeroides Ouda, 1978 (pl. 2, fig. 6; as for *G. bullatus bullatus*).

G. sudri maturus Ouda, 1978 (pl. 1, fig. 5; as for *G. bullatus bullatus*).

G. sudri sudri Ouda, 1978 (pl. 1, fig. 1; lower Ayun Musa Formation; northeast Egypt; upper Burdigalian, upper-lower Miocene).

Globigerinopsis aguasayaensis Bolli, 1962 (pl. 1, fig. 2; *Globorotalia fohsi robusta* zone?; Oficina Formation; northeast Venezuela; middle Miocene).

G. grilli Schmid, 1967 (text-fig. 2; upper Lageniden-zone; Baden Series; northeast Austria, middle? Miocene).

G. guhai Raju, 1971 (pl. 8, fig. 1; *Globorotalia kugleri*--*Globigerinoides primordius* zone; southeast India; Aquitanian, lower Miocene.

G. martinkayei Bolli, 1962 (pl. 1, fig. 10; *Globorotalia fohsi robusta* zone?; Oficina Formation; northeast Venezuela; middle Miocene).

New phena

Globigerinopsis aguasayaensis moderiapertura n. subsp.

Holotype. UQF 71782. Pl. 8, fig. 127. *Orbulina suturalis* zone; foraminifer-rich calcareous-nannofossil chalk, unit 1; D.S.D.P.208/21/3/73--75/RS2, 318.73--318.75 m below sea-floor; middle Miocene. Moderate in size, robust; moderately elevated dextral trochospire, loose parallel to axis, tight perpendicular to axis. Equatorial outline weakly lobate; lateral outline highly spired, globular. Chambers ovate to globular, at least 9 in total, $4\frac{1}{2}$ in final whorl; increase moderately rapid then slow after third-last chamber. Dorsal view: chambers longer concentrically, slightly inflated; sutures slightly depressed; intercameral sutures directed and curved posteriorly. Ventral view: chambers highly inflated; sutures moderately incised, weakly curved; umbilicus open; aperture an umbilical wide fairly low arch; aperture of second-last chamber arched distally; final chamber (subsequent chamber probably removed)

partially covers umbilicus, very inflated. Lateral view: smoothly rounded. Length 270 µm; width 255 µm; height, 310 µm.
Material. Two specimens.
Derivation of name. Latin, *modero*, *-atus*, keep within bounds; *apertura* (f.), opening, hole.

Phena recorded

Phenon *moderiapertura* n. ph. Pl. 8, figs. 127, 128? Vs ph. *aguasayaensis*, *grilli*, *guhai*, & *martinkayei*: aperture restricted to base of final chamber.

Remarks

Blow's (1969) tentative synonymy of Bolli's (1962) two simultaneously published nominal species presumably constitutes the first revision and thus *G. aguasayaensis* has priority over *G. martinkayei*.

G. aguasayaensis is considered to have split with the lowest occurrence of phenon *guhai* Raju from the *Globorotalia kugleri*--*Globigerinoides primordius* zone. Its extinction is placed at the highest occurrence of the nominate phenon as recorded by Blow (1969), that is, the middle of his *Sphaeroidinellopsis subdehiscens* s.s.--*Globigerina druryi* partial-range zone.

CLADEGROUP(2) HASTIGERINISECUNDAE

Stem species. *Hastigerina obesa* (Bolli).

Remarks

There appear to be three living species constituting a monophyletic group: *H. pelagica* (d'Orbigny), *Globigerinella adamsi* Banner & Blow, and *G. siphonifera* (d'Orbigny). However, their validity in the present oceans and in the fossil record has yet to be supported by documented population studies.

Hastigerina obesa (Bolli)

Included phena

Globorotalia obesa Bolli, 1957 (pl. 29, fig. 2; Stainforth & others, 1975, fig. 130/4; *G. fohsi robusta* zone; uppermost Cipero Formation; Trinidad; middle Miocene).

G. saginata Jenkins, 1966 (pl. 2, fig. 11; southwest France; upper Burdigalian; lower Miocene).

Hastigerina klampisensis Kadar, 1975 (pl. 7, fig. 52; *Globigerinoides sicanus*--*Globorotalia peripheroronda* assemblage; *Orbulina suturalis*--*G. (Turborotalia) peripheroronda* partial-range zone of Banner & Blow, 1965c; lower Sentolo Formation; Java, Indonesia; lower-middle Miocene).

H. (H.) siphonifera praesiphonifera Blow, 1969 (pl. 54, figs. 7--9; *Globigerinoides sicanus*--*Globigerinatella insueta* partial-range zone; northwest Venezuela, upper Burdigalian, uppermost-lower Miocene).

Phena recorded

(Phenon *praesiphonifera* (Blow). Pl. 8, figs. 133, 134.)

(Phenon *obesa* (Bolli). Pl. 8, figs. 129--132. Vs ph. *praesiphonifera*: trochospiral throughout; chamber increase quicker; aperture higher but more restricted extraumbilically; chambers better separated; ventral intercameral sutures deeper. The holotype has a distinctly high aperture and well-separated inflated chambers. However, most workers also include individuals with low apertures and closely appressed chambers, that is, four-chambered *Globigerinella siphonifera* phenon *siphonifera* (d'Orbigny). This usage is followed here but further study of the types involved may suggest the need for additional names for such individuals.)

Hastigerina pelagica (d'Orbigny)

Included phena

?*Hastigerina digitata* var. *acuminata* Rhumbler via O. Wetzel in Ellis & Messina, 1949 (figured syntype: Rhumbler, 1911, pl. 37, fig. 10; Atlantic Ocean; Holocene; nomen dubium acc. Ellis & Messina, 1949).

?*H. digitata* var. *digitifera* Rhumbler via O. Wetzel in Ellis & Messina, 1949 (figured syntype: Rhumbler, 1911, pl. 37, fig. 9; Atlantic Ocean; Holocene; nomen dubium acc. Ellis & Messina, 1949).

H. murrayi Thomson, 1876 (as for *Nonionina pelagica* d'Orbigny; junior objective synonym of *N. pelagica* d'Orbigny; *H. murrayi* Thomson non emended Banner & Blow =*N. pelagica* d'Orbigny non emended Banner & Blow acc. Parker & Jones, 1865, Brady, 1884).

H. parapelagica Saito & Thompson in Saito & others, 1976 (pl. 2, fig. 2; pl. 6, fig. 6; southwest of Cuba, Caribbean Sea; Pleistocene).

?*Hastigerinella rhumbleri* Galloway, 1933 (replacement name for '*Hastigerina digitata* Rhumbler'; *nomen dubium*, see Saito & others, 1976).

Hastigerinopsis digitiformans Saito & Thompson in Saito & others, 1976 (Banner & Blow, 1960b, text-fig. 8; North Atlantic Ocean; Holocene).

Nonionina pelagica d'Orbigny, 1839c (C. Wyville Thomson in Murray 1876, pl. 22, lower illustration; Brady, 1884, pl. 83, fig. 4; see Banner & Blow, 1960a; southwest of Saint Helena, South Atlantic Ocean; Holocene).

Remarks

Assemblages of this species were not encountered in this study. To consider the considerable variation (Bé, 1965) indicative of more than one species (Saito & others, 1976) would require rapid speciation as at least two of the end-forms have lowest occurrences at similar levels: phenon *pelagica* (d'Orbigny) or possibly phenon *parapelagica* Saito & Thompson was reported by Blow (1969) from as low as the middle of the *Globorotalia* (*Turborotalia*) *acostaensis* s.s.--*G.* (*G.*) *merotumida* partial-range zone of Banner & Blow (1965c) and phenon *digitiformans* Saito & Thompson was reported by Gianelli & others (1976) from the middle *G. mediterranea* subzone, *G. conomiozea* zone of D'Onofrio & others (1976). The above-mentioned record of Blow's (1969) is taken as the lower limit of the species.

CLADEGROUP(1) GLOBIGERINELLIPRIMAE

Stem species. *Globigerinella evoluta* n. sp.

Globigerinella evoluta n. sp.

New phenon

Globigerinella evoluta evoluta n. subsp.

Holotype. UQF 71791. Pl. 9, fig. 1. *Globigerina nepenthes* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/14/4/74--76/RS3, 162.24--162.26 m below sea-floor; upper Miocene. Large, fairly robust; barely elevated dextral trochospire, tight parallel to axis, increasingly loose perpendicular to axis. Equatorial outline moderately lobate; lateral outline not quite symmetrical. Chambers spherical, slightly appressed, at least 11 (15?) in total, 4½ in final whorl. Dorsal view: chambers circular, moderately inflated; sutures moderately incised; intercameral sutures radial. Ventral view: chambers very inflated; sutures radial; umbilicus very wide. Lateral view: smoothly rounded; aperture an umbilical--extraumbilical arch of consistent moderate height. Wall densely perforate and pustulose, smooth between. Length, 535 µm; width, 435 µm; height, 310 µm.

Material. Common.

Derivation of name. Latin, *evolvo*, *-utus*, unroll, unfold.

Phenon recorded

(*Hastigerina obesa* phenon *praesiphonifera* (Blow).)

(*H. obesa* phenon *obesa* (Bolli).)

(Phenon *evoluta* n. ph. Pl. 9, figs. 1, 3. Vs *Hastigerina obesa* ph. *praesiphonifera* Blow and *obesa* (Bolli): umbilicus open; aperture extensive extraumbilically and usually high.)

(*Globigerinella siphonifera* phenon *involuta* (Cushman). Pl. 9, figs. 2, 4.)

(*G. siphonifera* phenon *siphonifera* (d'Orbigny). Pl. 8, fig. 135; pl. 9, fig. 5.)

Globigerinella adamsi (Banner & Blow)

Included phena

Beella discors McCulloch, 1977 (pl. 174, fig. 15; off Bikini Atoll, Pacific Ocean; Holocene).

Hastigerina (*Bolliella*) *adamsi* Banner & Blow, 1959 (text-fig. 4; Brady, 1884, pl. 82, fig. 6; northeast of Ki Islands, Indonesia; Holocene).

Phenon recorded

Phenon *adamsi* (Banner & Blow). Pl. 9, fig. 6.

Remarks

The split of *G. adamsi* Banner & Blow is placed at the lowest occurrence of its nominate phenon as recorded by Blow (1969), that is, the base of his *Globigerina calida* s.s.--*Sphaeroidinella dehiscens excavata* assemblage-zone.

Globigerinella siphonifera (d'Orbigny)

Included phena

Globigerina aequilateralis Brady, 1879 (Banner & Blow, 1960a, text-fig. 3; Caroline Is., southwest Pacific Ocean; Holocene; ≠*G. siphonifera* d'Orbigny non emended Banner & Blow acc. Saito & others, 1976; =*G. siphonifera* d'Orbigny acc. Banner & Blow, 1960a, Saito & others, 1976).

G. aequilateralis var. *involuta* Cushman, 1917 (figured syntype: text-fig. 11; off east Mindanao, Philippines; Holocene).

G. hirsuta d'Orbigny, 1839b (figured syntype: lost acc. Le Calvez, 1974; =*G. siphonifera* d'Orbigny acc. Le Calvez, 1974).

G. radians Egger, 1893 (figured syntype: pl. 13, figs. 22--24; off central west Western Australia, east Indian Ocean or southwest of Samoa, west South Pacific Ocean; Holocene).

G. siphonifera d'Orbigny, 1839a (Banner & Blow, 1960a, text-fig. 2; Cuba; Holocene?).

Phena recorded

(*Hastigerina obesa* phenon *obesa* (Bolli).)

(*Globigerinella evoluta* phenon *evoluta* n. ph.)

(Phenon *involuta* (Cushman). Vs ph. *siphonifera*: chambers very inflated axially, producing a (weakly) angled umbilical shoulder; chambers usually more closely appressed; coiling tends to be more involute.)

Phenon *siphonifera* (d'Orbigny). Vs *G. evoluta* ph. *evoluta*: planispiral throughout, though slight divergences are allowed; early whorls usually involute.

CLADEGROUP(4) GLOBIGERINIQUARTAE

Stem species. *Globigerina disjuncta* (Finlay).

Remarks

This group is a good example of the need for a phylogeny of (population-defined) species in addition to that of morphologically defined taxa. Different successions of phena leading to *Orbulina quadrilobata* phenon *triloba* (Reuss) occur in tropical (Blow, 1956) and cool-subtropical (Jenkins, 1965) areas. Unless each phenon in these series is recognised as such, not as a genetically isolated set of populations, controversy is the unfortunate result (ignoring the possibility of reticulate evolution). However, such regional differences can be interpreted as the result of clinal variation in a single set of interbreeding populations. Although some workers occasionally hint at such interpretation to fossil sequences (see, for example, Jenkins's, 1965 illustration of the origin of phenon *triloba* (Reuss)), studies such as those by Scott (1969, 1972), Chaproniere (1973), and Srinivasan & Kennett (1976), which explicitly applied this model, have been only rarely published and the implications usually not implemented.

Globigerina disjuncta (Finlay)

Included phena

Globigerina brazieri Jenkins, 1966.
G. euapertura Jenkins, 1960.
?*G. globularis* Roemer, 1838 (nomen dubium).
G. grimsdalei Keijzer, 1945.
G. labiacrassata Jenkins, 1966.
G. woodi Jenkins, 1960.
G. woodi connecta Jenkins, 1964.
Globigerinoides apertasuturalis Jenkins, 1960.
G. inusitatus Jenkins, 1966.
G. quadrilobatus primordius Blow & Banner, 1962.
Sphaeroidinella disjuncta Finlay, 1940.

Remarks

This species represents a continuation of the general morphology of *G. parva* with an increased variation to include the lowest globigerinoidiform taxa.

CLADEGROUP(2) ORBULINISECUNDAE

Stem species. *Orbulina altiapertura* (Bolli).

Remarks

This group refers to phenon *quadrilobata* (d'Orbigny) and its descendants as interpreted by Blow (1969).

Orbulina altiapertura (Bolli)

Included phena

Globigerina butti Popescu, 1972.

Globigerinoides triloba altiapertura Bolli, 1957.

Remarks

The lower limit of this species is taken just above the lowest occurrence of phenon *altiapertura* (Bolli) and just below that of phenon *subquadrata* Brönnimann, that is, the lower to middle part of Banner & Blow's (1965c) *Globoquadrina dehiscens praedehiscens* partial-range zone.

CLADEGROUP(1) ORBULINIPRIMAE

Stem species. *Orbulina pseudosellii* (Brönnimann & Resig).

Orbulina pseudosellii (Brönnimann & Resig)

Included phena

Globigerinoides pseudosellii Brönnimann & Resig, 1971.

G. quadrilobatus praeimmaturus Brönnimann & Resig, 1971.

G. sicanus praesicanus Brönnimann & Resig, 1971.

Orbulina universa d'Orbigny

Included phena

Candeina biloba Jedlitschka, 1934 (figured syntypes: text-figs. 8--12; Czechoslovakia; Miocene).

C. triloba Jedlitschka, 1934 (figured syntypes: text-figs. 13--18, 20; Czechoslovakia; Miocene; =*Orbulina suturalis* Brönnimann acc. Blow, 1956; junior subjective homonym of *Globigerina triloba* Reuss acc. this study).

Canorbulina universa Jedlitschka, 1934 (figured syntypes: text-figs. 1--7, 19, 21--23; Czechoslovakia; Miocene; junior subjective homonym of *Orbulina universa* d'Orbigny acc. this study).

Cosinosphaera ciliosa Stuart, 1866 (figured syntypes: pl. 18, figs. 1, 2, 3, 4; Italy; Holocene; =*Orbulina universa* d'Orbigny acc. this study).

Globigerina bilobata d'Orbigny, 1846 (Banner & Blow, 1960b, pl. 3, fig. 9; northeast Austria; Tortonian, upper Miocene).

G. ovoidea Seguenza, 1880 (pl. 17, fig. 39; southeast Italy; Sicilian, Pliocene; =*G. bilobata* d'Orbigny acc. Blow, 1956).

G. (*Orbulina*) *acerosa* Owen, 1868 (pl. 5, fig. 2; Holocene).

G. (*O.*) *continens* Owen, 1868 (figured syntypes: pl. 5, figs. 3, 4; Holocene).

Globigerinoides bispherica Todd in Brönnimann & Todd, 1954 (pl. 1, fig. 1; *G. sicanus*--*Globigerinatella insueta* partial-range zone of Banner & Blow, 1965 acc. Blow, 1969; Fina-sisu Formation; Saipan, Mariana Islands, northwest Pacific Ocean; upper-lower Miocene; =*Globigerinoides sicana* de Stefani acc. Banner & Blow, 1965a, Blow, 1969, Stainforth & others, 1975; junior subjective homonym of *Orbulina universa* var. *bisphaerica* LeRoy acc. this study).

G. glomerosa circularis Blow, 1956 (text-fig. 2/3,4; *Siphogenerina transversa* zone of Renz, 1948; upper *Globigerinatella insueta*/*Globigerinoides bisphaerica* subzone of Blow, 1959; lower Husito Marly-Clay Member; Pozón Formation; north Venezuela; upper-lower or lower-middle Miocene).

G. glomerosa curva Blow, 1956 (text-fig. 1/10,11; as for *G. glomerosa circularis* Blow).

G. glomerosa glomerosa Blow, 1956 (text-fig. 1/18,19; as for *G. glomerosa circularis* Blow).

G. sicana de Stefani, 1952 (Cushman & Stainforth, 1945, pl. 13, fig. 6; Blow, 1969, pl. 3, figs. 10, 11; Stainforth & others, 1975, fig. 144/4; middle zone II of Cushman & Stainforth, 1945; *G. sicanus*--*Globigerinatella insueta* partial-range zone of Banner & Blow, 1965c acc. Blow, 1969; Cipero Marl Formation; Trinidad; uppermost-lower Miocene).

G. transitoria Blow, 1956 (text-fig. 2/12,13; *Siphogenerina transversa* zone of Renz, 1948; *Globigerinatella insueta*/*Globigerinoides bisphaerica* subzone, upper *Globigerinatella insueta* zone s.l.; Husito Marly-Clay Member, Pozón Formation; Trinidad; uppermost-lower or lowermost-middle Miocene).

Orbulina cornwallisi McLean, 1956 (pl. 53, fig. 3; Yorktown Formation; southeast Virginia, U.S.A.; upper Miocene).

O. gemina Terrigi, 1891 (=*G. bilobata* d'Orbigny acc. Blow, 1956).

O. imperfecta Rhumbler, 1911 (figured syntypes: pl. 34, figs. 4, 6; Atlantic Ocean; Holocene).

O. parva Rhumbler via O. Wetzel in Ellis & Messina, 1949 (figured syntypes: Rhumbler, 1911, pl. 34, figs. 7, 8, 11, 12; Atlantic Ocean; Holocene).

O. petraea Giebel, 1852 (d'Orbigny, 1846, pl. 1, fig. 1; northeast Austria; Miocene).

O. suturalis Brönnimann, 1951b (text-fig. 4/15,16,20; *Globorotalia menardii* zone; Trinidad; upper-lower Miocene or ?lower-middle Miocene; =*Canorbulina universa* Jedlitschka acc. Brönnimann, 1951b, Blow, 1956, Jenkins, 1971, Stainforth & others, 1975, this study).

O. universa d'Orbigny, 1839a (Le Calvez, 1974, lectotype not illustrated; Cuba; Holocene).

O. universa var. *bisphaerica* LeRoy, 1941 (pl. 1, fig. 3; Sangkoelirang Marls; east Borneo, Indonesia; uppermost Miocene or lower Pliocene; =*O. bilobata* d'Orbigny acc. Blow, 1956, this study).

O. universa parkerae Brönnimann & Resig, 1971 (pl. 45, figs. 2--4; *Globorotalia* (*G.*) *tumida* s.s.--*Sphaeroidinellopsis subdehiscens paenedehiscens* partial-range zone of Banner & Blow, 1965c; southwest Pacific Ocean; uppermost Miocene or lowermost Pliocene).

Phena recorded

Phenon *suturalis* Brönnimann. Pl. 11, figs. 21--23.

Phenon *bilobata* d'Orbigny. Pl. 11, fig. 24.

Phenon *parkerae* Brönnimann & Resig. Pl. 11, fig. 25. Vs ph. *bilobata*: last-2 chambers differ in size. Vs ph. *suturalis*: only 2 chambers visible.

Phenon *universa* d'Orbigny. Pl. 11, figs. 20, 26.

Remarks

The variable ontogeny of *O. universa*, especially in terms of wall structure, has resulted in doubt about a monophyletic origin, as assumed herein, for this species (Parker, 1962, 1967, Bandy, 1966, Bandy, Vincent, & Wright, 1969). However, there is as yet no fossil evidence for an origin other than that documented by Blow (1956, Scott, 1973). Blow's (1956) two-branched phylogeny of phena belonging to this group is here interpreted as a single lineage of populations, mainly due to the presence of individuals morphologically intermediate between phenon *bilobata* and phenon *universa*; these have recently been named as '*O. universa parkerae*' by Brönnimann & Resig (1971).

This species is considered to have split with the lowest occurrence of phenon *sicana* as recorded by Blow (1969), that is, the base of Banner & Blow's (1965c) *Globigerinoides sicanus*--*Globigerinatella insueta* partial-range zone.

Orbulina quadrilobata (d'Orbigny)

Included phena

Globigerina affinis Silvestri, 1898 (north Italy; Pliocene).

G. bulliformis Mayer-Eymar, 1887 (figured syntype: d'Orbigny, 1846, pl. 9, figs. 4--6; Bronn, 1856, pl. 35^{2}, fig. 19; northeast Austria; Miocene).

G. bulloides var. *recumbens* Rhumbler, 1901 (figured syntype: text-fig. 27; Banner & Blow, 1965a, text-fig. 17; Holocene).

G. fistulosa Schubert, 1910 (figured syntype: text-fig. 2; Banner & Blow, 1965a, text-fig. 4; figured ideotypes: Schubert, 1911, text-figs. 13a--c; Stainforth & others, 1975, fig. 201/1; Sandwich Is., northeast of Papua New Guinea; uppermost Pliocene).

G. intermedia Silvestri, 1898 (figured syntype: pl. 4, fig. 13; north Italy; lower Pliocene).

G. panormensis de Stefani, 1952 (Sicily, Italy; Miocene).

G. quadrilobata d'Orbigny, 1846 (Banner & Blow, 1960b, pl. 4, fig. 3; 1965a, text-fig. 11; northeast Austria; Tortonian, upper Miocene; ≠*G. quadrilobata* d'Orbigny non emended Banner & Blow acc. Bandy, 1964, Jenkins, 1971).

G. sacculifera Brady, 1877 (Banner & Blow, 1960b, pl. 4, fig. 1; 1965a, text-fig. 3; Stainforth & others, 1975, fig. 137/6; New Ireland, Papua New Guinea; upper Miocene or Pliocene; =*G. quadrilobata* d'Orbigny acc. Todd, 1961).

G. sacculifera var. *galeata* Rhumbler via O. Wetzel in Ellis & Messina, 1949 (figured syntypes; Rhumbler, 1911, pl. 31, figs. 14, 15; Banner & Blow, 1965a, text-fig. 18).

G. sacculifera var. *recumbens* Rhumbler via O. Wetzel in Ellis & Messina, 1949 (figured syntypes: Rhumbler, 1911, pl. 31, figs. 11, 12, 13; Banner & Blow, 1965a, text-fig. 19; Atlantic Ocean; Holocene; junior objective homonym of *G. bulloides* var. *recumbens* Rhumbler).

G. tricamerata Tolmachoff, 1934 (figured syntype: pl. 41, fig. 21; Banner & Blow, 1965a, text-fig. 7; west Colombia; Miocene).

G. triloba Reuss, 1850 (figured syntype; pl. 47, fig. 11; Banner & Blow, 1965a, text-fig. 2; southeast Poland; Tertiary; =*G. quadrilobata* d'Orbigny acc. Bandy, 1964, Jenkins, 1971).

?*G. trilocularis* d'Orbigny in Deshayes, 1832 (figured syntype: Fornasini, 1897, pl. 12, text-fig.; France; pre-Holocene; nomen dubium acc. Banner & Blow, 1965a).

Globigerinoides bannerblowi Popescu in Popescu & Cioflica, 1973 (replacement name for *Globigerina quadrilobata* d'Orbigny).

G. cancellata Copeland, 1964 (pl. 42, fig. 3; Duplin Marl; North Carolina, U.S.A.; upper Miocene).

G. quadrilobatus hystricosus Belford, 1962 (pl. 4, figs. 11--13; Banner & Blow, 1965a, text-fig. 1; northwest Papua New Guinea; uppermost Miocene or Pliocene).

G. sacculifer brachysacculifer Christodoulou, 1960 (figured syntype: pl. 1, figs. 31, 32; Banner & Blow, 1965a, text-fig. 12; Kărpathos, Dodecanese Islands, Greece; lower Pliocene; =*Globigerina sacculifera* Brady acc. Banner & Blow, 1965a?).

G. sacculifer minimus Christodoulou, 1960 (figured syntype: pl. 1, figs. 27, 28; Banner & Blow, 1965a, text-fig. 13; Kărpathos, Dodecanese Islands, Greece; lower Pliocene; =*G. sacculifera* Brady acc. Banner & Blow, 1965a?).

G. sacculifer spinulosus Christodoulou, 1960 (figured syntype: pl. 1, figs. 25, 26; Banner & Blow, 1965a, text-fig. 14; Kărpathos, Dodecanese Islands, Greece; lower Pliocene; =*G. sacculifera* Brady acc. Banner & Blow, 1965a?).

G. sacculifera subsacculifera Cita, Premoli Silva, & Rossi, 1965 (pl. 31, fig. 3; *Globorotalia mayeri*/*Globigerina nepenthes* zone; Rio Mazzapiedi Series, north Italy; type Tortonian, upper Miocene).

G. sacculiferoides Christodoulou, 1960 (pl. 1, fig. 18; Kărpathos, Dodecanese Islands, Greece; lower Pliocene).

G. sacculiferus immatura LeRoy, 1939 (pl. 3, figs. 19--21; Banner & Blow, 1965a, text-fig. 8; transitional zone, lower Palembang Formation acc. Blow & Banner, 1966; central Sumatra, Indonesia; middle Miocene; =*G. trilocularis* d'Orbigny acc. Le Roy, 1944a,b; =*G. tricamerata* Tolmachoff acc. Banner & Blow, 1965a?).

G. sacculiferus irregularis LeRoy, 1944a (figured syntypes: pl. 3, figs. 42 & 43, 45 & 46; Banner & Blow, 1965a, text-fig. 6; Telisa or Lower Palembang Formations; central Sumatra, Indonesia; lower or middle Miocene).

G. suleki Bermŭdez, 1960 (pl. 10, fig. 9; Nicholas Channel, north of Cuba; Holocene).

G. triloba var. *aspera* Petri, 1954 (pl. 12, figs. 12, 13; Banner & Blow, 1965a, text-fig. 15; *Bolivina plicatella* zone; northeast Brazil; Miocene; *G. sacculiferus immaturus* LeRoy acc. Banner & Blow, 1965a?).

G. trilobus bullatus L.-S. & Y.-M. Chang in Chang, 1962 (pl. 2, fig. 2; Banner & Blow, 1965a, text-fig. 16; upper *Globigerinatella insueta*/*Globigerinoides bisphaericus* subzone or lower *Globorotalia fohsi barisanensis* zone of Blow, 1959; Sogo Formation equivalent; central Taiwan; upper Aquitanian or lowermost Burdigalian, lower Miocene).

New phena

Orbulina quadrilobata incrusta n. subsp.

Holotype. UQF 71872. Pl. 11, fig. 5. *O. suturalis* zone; foraminifer-rich calcareous-nannofossil chalk, unit 1; D.S.D.P.208/21/3/73--75/RS3, 318.73--318.75 m below sea-floor; lower-middle Miocene. Moderate in size, robust; low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline weakly trilobate; lateral outline oval. Chambers globular, weakly appressed, at least 7 in total, 3 in final whorl; increase moderate. Dorsal view: chambers slightly longer concentrically, barely inflated; sutures barely depressed; intercameral sutures radial. Ventral view: chambers inflated; intercameral sutures radial, meeting at closed umbilicus; aperture umbilical, almost closed. Lateral view: smoothly rounded. Wall cancellate on dorsal side of final chamber, covered-in elsewhere. Length, 325 µm; width 270 µm; height, 220 µm.

Material. Common.

Derivation of name. Latin, *incrusto*, *-atus*, cover with a coating of some substance.

Orbulina quadrilobata alpha n. subsp.

Holotype. British Museum Natural History no. 1959/4/13/8. Brady, 1884, pl. 80, fig. 11; Banner & Blow, 1960b, pl. 4, fig. 2. 'Challenger' station 224, north of Papua New Guinea, west North Pacific Ocean; Holocene. A preliminary description from Banner & Blow's (1960b) illustration is given, pending a redescription direct from the specimen. Very large, fairly robust; moderately elevated dextral trochospire, loose perpendicular to axis. Equatorial outline lobate. Chambers globular, except final chamber which is elongated radially and terminated in two points, barely appressed, 3½ in final whorl. Dorsal view: chambers circular, moderately inflated; sutures deeply depressed; very large apertures at spiral--intercameral junctions. Ventral view: chambers inflated; sutures very deep; umbilicus wide; aperture umbilical, moderately high and wide. Wall densely and coarsely perforate. Length, 1040 µm; width, 350 µm.

Material. Common.

Derivation of name. Full spelling of Greek letter, following informal usage by Blow (1969).

Phena recorded

Phenon *incrusta* n. ph. Pl. 11, figs. 5--7. These thickened specimens are otherwise identical to phenon *immatura*. The lack of supplementary apertures and the compact thickened shape give similarity to *Globigerina disjuncta* phenon *connecta* Jenkins.

Phenon *bullata* (Chang). Pl. 11, fig. 11.

Phenon *irregularis* (LeRoy). Pl. 11, fig. 8.

Phenon *immatura* (LeRoy). Pl. 11, fig. 16. Vs ph. *incrusta*: thinner walled; supplementary apertures not infilled. Vs ph. *bullata*: no bulla. Vs ph. *irregularis*: restricted umbilicus.

Phenon *subsacculifera* (Cita, Premoli Silva, & Rossi). Pl. 11, fig. 9. Vs ph. *immatura*: elongated but rounded final chamber.

Phenon *triloba* (Reuss). Pl. 11, fig. 14. Vs ph. *immatura*: in umbilical view, the size of the final chamber is greater than the combined size of the earlier chambers of the final whorl. The decision taken here not to use apertural distinctions (for example, Jenkins 1971) stems from the rather high primary aperture of the illustrated syntype of phenon *triloba* which, however, has an inflated final chamber.

Phenon *quadrilobata* (d'Orbigny). Pl. 11, figs. 10, 12. Vs ph. *immatura*: coiling looser both parallel and perpendicular to axis, giving 3½--4 chambers in the final whorl; higher spire; chambers well separated; usually larger in size and with a higher aperture.

Phenon *sacculifera* (Brady). Pl. 11, figs. 15, 17. Vs ph. *subsacculifera*: final chamber angular, not rounded.

Phenon *fistulosa* (Schubert). Pl. 11, fig. 19. Vs ph. *sacculifera*: radially directed extensions on chambers of the final whorl.

Phenon *alpha* n. ph. Pl. 11, figs. 13, 18. Vs ph. *sacculifera*: final chamber extended further radially.

CLADEGROUP(1) GLOBIGERINOIDIPRIMAE

Stem species. *Globigerinoides haitiensis* (Coryell & Rivero).

Globigerinoides haitiensis (Coryell & Rivero)

Included phena

Globigerina haitiensis Coryell & Rivero, 1940 (figured syntypes: pl. 42, figs. 29, 30; see Bermúdez & Farias, 1971; Port-au-Prince, Haiti; upper-middle Miocene; =*G. venezuelana* Hedberg acc. Bermúdez, 1960, Stainforth & others, 1975).

Globigerinoides bollii Blow, 1959 (pl. 10, fig. 65; *Marginulinopsis basispinosus* zone of Renz, 1948; lower *Globorotalia menardii* s.s./*Globigerina nepenthes* zone; Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; Vindobonian or higher, upper-middle Miocene).

G. bulloideus Crescenti, 1966 (text-fig. 9; *Globorotalia menardii* zone; Fontanelice Formation; north Italy; Tortonian, upper Miocene).

G. diminuta Bolli, 1957 (pl. 25, fig. 11; lower? *Globigerinatella insueta* zone; upper Cipero Formation; Trinidad, upper-lower Miocene).

G. emeisi Bolli, 1966 (pl. 1, figs. 11--13; *Globorotalia margaritae* zone; Kalibeng beds; Java, Indonesia; upper Miocene).

G. obliqua Bolli, 1957 (pl. 25, fig. 10; Stainforth & others, 1975, fig. 118/1; *Globorotalia mayeri* zone; lowermost Lengua Formation; Trinidad; middle Miocene).

G. obliquus amplus Perconig, 1968 (pl. 7, fig. 20; southwest Spain; upper Tortonian, upper Miocene).

G. obliquus extremus Bolli & Bermúdez, 1965 (pl. 1, figs. 10--12; Stainforth & others, 1975, fig. 165/1; *Globorotalia margaritae* zone; Cubagua Is., northeast Venezuela; upper Miocene; =*Globigerina adriatica* Fornasini acc. Blow, 1969?).

G. pseudoruber Todd, 1957 (Poore, 1977, figs. 1--3; *G. sicanus*--*Globigerinatella insueta* partial-range zone of Banner & Blow, 1956c acc. Blow, 1969; Fina-sisu Formation; Saipan, Mariana Islands, northwest Pacific Ocean; uppermost-lower or lowermost-middle Miocene).

G. ruber seigliei Bermúdez & Bolli, 1969 (pl. 8, figs. 10--12; *Globoquadrina altispira* s.s. zone; Cerro Negro Member, Cubagua Formation; northeast Venezuela; upper Miocene).

G. subquadrata Brönnimann in Brönnimann & Todd, 1954 (pl. 1, fig. 8; *G. sicanus*--*Globigerinatella insueta* partial-range zone of Banner & Blow, 1965c acc. Blow, 1969; Fina-sisu Formation; Saipan, Mariana Islands, northwest Pacific Ocean; uppermost-lower or lowermost-middle Miocene; =*Globigerina rubra* d'Orbigny acc. Stainforth & others, 1975).

G. subquadratus subelongatus Brönnimann & Resig, 1971 (pl. 13, fig. 1; 'zone N7/N8 of Banner & Blow, 1965c'; east of New Ireland, Papua New Guinea; upper-lower or lower-middle Miocene; =*G. pseudoruber* Todd acc. Poore, 1977, this study).

G. tapiesi Perconig, 1968 (pl. 7, fig. 23; southwest Spain; uppermost Tortonian or lowermost Andalusian, upper Miocene).

New phena

Globigerinoides haitiensis compactus n. subsp.

Holotype. UQF 71819. Pl. 9, fig. 29. *Globigerina nepenthes* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/14/4/74--76/RS3, 162.24--162.26 m below sea-floor; upper Miocene. Small robust; low sinistral trochospire, very tight parallel and perpendicular to axis. Equatorial outline very weakly lobate; lateral outline oval. Chambers globular, closely appressed, at least 10 chambers, $3\frac{1}{2}$ in the final whorl; increase slow. Dorsal view: chambers longer concentrically, barely inflated; sutures barely depressed; intercameral sutures directed and curved posteriorly. Ventral view: chambers inflated; intercameral sutures radial to curved, almost meeting at closed umbilicus; aperture an umbilical moderate circular arch, slightly pushed distally, with a distinct wide lip. Lateral view: smoothly rounded. Wall regularly perforate but considerably thickened by coalescing of interpore ridges. Length, 175 µm; width, 165 µm; height, 150 µm.

Material. Common.

Derivation of name. Latin, *compatus*, thick, firm.

Globigerinoides haitiensis progomitulus n. subsp.

Holotype. UQF 71820. Pl. 9, fig. 30. As for *G. haitiensis compacta* except RS2. Small, robust; very slightly elevated dextral trochospire, very tight parallel and perpendicular to axis. Equatorial outline weakly trilobate; lateral outline oval. Chambers ovate parallel to axis, weakly appressed, 13 in total in 3 whorls, 3 in final, 4 in second-last, 5 in initial (not including proloculus) whorls; increase moderate. Dorsal view: chambers longer concentrically, slightly inflated; sutures barely depressed; intercameral sutures directed and curved posteriorly where present. Ventral view: chambers inflated; intercameral sutures slightly depressed, meeting at tight umbilicus; aperture umbilical, opposite second-last--third-last intercameral suture, tear-shaped, with thick lip. Lateral view: smoothly rounded. Wall moderately densely perforate, thickened, weakly cancellate in some parts. Length, 120 µm; width, 110 µm; height, 100 µm.

Material. Common.

Derivation of name. Greek, *pro*, before; second component refers to '*Globigerina gomitulus* Seguenza'.

Globigerinoides haitiensis praerubra n. subsp.

Holotype. UQF 71831. Pl. 9, fig. 41. Upper *Globigerina nepenthes* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/13/5/74--76/RS2, 145.74--145.76 m below sea-floor; upper Miocene. Moderate in size, robust; slightly elevated sinistral trochospire, tight parallel and perpendicular to axis. Equatorial outline weakly trilobate; lateral outline weakly spiroconvex. Chambers globular, slightly appressed, at least 8 in total, 3 in final whorl, 4 in second-last whorl; increase moderately rapid. Dorsal view: chambers longer concentrically, slightly inflated; sutures slightly depressed; intercameral sutures directed and curved posteriorly where present. Ventral view: chambers inflated; intercameral sutures curved, meeting at tight umbilicus; aperture umbilical, opposite second-last--third-last intercameral suture, a high broad arch with a thick lip. Lateral view: smoothly rounded. Wall densely perforate with connected interpore ridges producing a cancellate surface. Length, 285 µm; width, 245 µm; height, 225 µm.

Material. Common.

Derivation of name. Latin, prae, before; second component refers to 'Globigerina rubra d'Orbigny'.

Globigerinoides haitiensis epityche n. subsp.

Holotype. UQF 71835. Pl. 9, fig. 45. Globorotalia conomiozea zone; foraminifer-bearing calcareous-nannofossil ooze, unit 1; D.S.D.P.208/12/4/74--76/RS3, 125.24--125.26 m below sea-floor; upper Miocene. Moderate in size, robust; moderately elevated dextral trochospire, fairly loose parallel to axis, tight perpendicular to axis. Equatorial outline barely lobate; lateral outline highly spiroconvex. chambers ovate parallel to axis, weakly appressed, at least 9 (13?) in total, 3¼ in final whorl, 3¾ in second-last whorl; increase moderate. Dorsal view: chambers much longer concentrically, slightly inflated; sutures fairly deeply incised; intercameral sutures directed and curved posteriorly. Ventral view: chambers inflated; intercameral sutures curved; umbilicus tight, covered by flap with a very small, lipped opening on the second-last--third-last intercameral suture. Lateral view: dorsoperipheral shoulder rounded; ventral face very slightly flattened; umbilical shoulder recurved, not smoothly curved. Wall densely perforate, but partially covered by thickening, including joining of interpore ridges. Length, 350 µm; width 360 µm; height, 350 µm.

Material. Common.

Derivation of name. Greek, epityche (f.), flap.

Globigerinoides haitiensis anterubra n. subsp.

Holotype. UQF 71840. Pl. 9, fig. 50. Globorotalia margaritae zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/10/4/74--76/RS3, 98.74--98.76 m below sea-floor; lower Pliocene. Moderate in size, robust; moderately elevated sinistral trochospire, fairly loose parallel to axis, tight perpendicular to axis. Equatorial outline weakly trilobate; lateral outline spiroconvex. Chambers ovate parallel to axis, weakly appressed, at least 9 in total, 3 in final whorl, 3½ in second-last whorl; increase moderate. Dorsal view: chambers much longer concentrically, weakly inflated; sutures fairly deeply incised; intercameral sutures directed and curved posteriorly where present; apertures on posterior proximal spiral sutures of final, second-last, and third-last chambers. Ventral view: chambers inflated; intercameral sutures curved; umbilicus tight; large apertures opposite second-last--third-last and third-last--fourth-last intercameral sutures. Lateral view: smoothly rounded. Wall densely perforate, deeply cancellate. Length, 390 µm; width 375 µm; height, 405 µm.

Material. Common.

Derivation of name. Latin, ante, before; second component refers to 'Globigerina rubra d'Orbigny'.

Globigerinoides haitiensis compressus n. subsp.

Holotype. UQF 71841. Pl. 9, fig. 51. As for G. haitiensis anterubra. Large, robust; moderately elevated sinistral trochospire, fairly tight parallel and perpendicular to axis. Equatorial outline weakly trilobate; lateral outline spiroconvex. Chambers ovate parallel to axis, weakly appressed, at least 9 in total, 3 in final whorl, 3¾ in second-last whorl; increase moderately rapid. Dorsal view: chambers much longer concentrically, barely inflated; moderately depressed sutures; intercameral sutures curved where present; apertures obscured. Ventral view: chambers inflated to vaulted; sutures curved, incised; umbilicus tight; aperture umbilical. Lateral view: dorsoperipheral shoulder and ventral face smoothly rounded; umbilical shoulder recurved; apertural face very steep. Wall densely perforate with high interpore ridges. Length 565 µm; width, 525 µm; height, 490 µm.

Material. Common.

Derivation of name. Latin, compressus, pressed together, squeezed.

Phena recorded

Phenon subquadratus Brönnimann. Pl. 9, fig. 8. This phenon and its probable pseudomorphy with G. elongatus phenon ruber (d'Orbigny) are described by Banner & Blow (1960b), Cordey (1967), and Blow (1969). To these I would add possible apertural differences: phenon subquadratus appears to possess a smaller circular primary aperture which is higher but more constricted laterally, whereas phenon ruber shows an aperture which is widest at the base and much lower in comparison with the base; secondary apertures in phenon subquadratus appear smaller on average. Most specimens of phenon subquadratus encountered in this study have two supplementary apertures (see text-fig. 2/6 of Cordey, 1967). Cordey's proposed evolution from an ancestor with one supplementary aperture seems supported by the restriction of such individuals to the lowest sample studied of D.S.D.P. Site 208. These latter specimens are more loosely coiled parallel to the axis than typical individuals.

Phenon pseudoruber Todd. Pl. 9, figs. 9, 10. Vs ph. subquadratus: high spire.

Phenon bulloideus Crescenti. Pl. 9, figs. 7, 11--17, 19, 26, 27, 38. Vs ph. subquadratus: 3½--4 chambers in the final whorl; aperture opposite the third-last chamber. The affinity of the holotype of this phenon is considered doubtful as the original illustration and description hint at a globigeriniform wall surface (smooth, spinose). However, subsequent workers (for example, Parker, 1973) appear to have interpreted it as having a coarse reticulate surface. This view is tentatively followed here. Individuals without a supplementary aperture are included.

Phenon compactus n. ph. Pl. 9, figs. 18, 20--23, 28, 29, 39. Vs ph. bulloideus: wall thickened; more compact shape; no supplementary aperture.

Phenon progomitulus n. ph. Pl. 9, figs. 30, 47. Vs ph. praerubra: primary aperture very small and circular; wall usually thicker; compact shape.

Phenon obliquus Bolli. Pl. 9, figs. 24, 25, 31, 32, 40. Vs ph. bulloideus: chambers compressed; wide primary aperture; subquadrate overall form; less lobate.

Phenon bollii Blow. Pl. 9, figs. 33--35, 44. Vs ph. compactus: a very small sometimes slit-like supplementary aperture.

Phenon praerubra n. ph. Pl. 9, figs. 36, 41. Vs ph. bulloideus: 3 chambers in the final whorl; primary aperture opposite ventral intercameral suture between second- and third-last chambers. Boltovskoy's (1974b) informal 'Globigerina "praerubra" ' is formalised here.

Phenon extremus Bolli & Bermúdez. Pl. 9, figs. 37, 42, 48. Vs ph. obliquus: final chamber distinctly flattened.

Phenon epityche n. ph. Pl. 9, figs. 43, 45, 46, 49. Vs ph. haitiensis: final chamber reduced.

Phenon anterubra n. ph. Pl. 9, fig. 50. Vs ph. praerubra: supplementary aperture present.

Phenon compressus n. ph. Pl. 9, fig. 51. Vs ph. extremus: chambers much broader concentrically, much more inflated and appressed. Vs G. conglobatus ph. canimarensis: primary aperture more restricted; chambers more inflated and appressed. Vs ph. epityche: final chamber not distinctly reduced; usually 4 chambers in the final whorl with the primary aperture opposite the third-last chamber; the latter usually has 3 chambers in the final whorl with a very restricted aperture opposite the ventral intercameral suture between the second- and third-last chambers.

Globigerinoides elongatus phenon mitrus Todd. Pl. 9, fig. 52.

G. conglobatus phenon canimarensis Bermúdez. Pl. 10, fig. 1.

G. elongatus phenon ruber (d'Orbigny). Pl. 10, fig. 2.

Globigerinoides conglobatus (Brady)

Included phena

Globigerina conglobata Brady, 1879 (Banner & Blow, 1960b, pl. 4, fig. 4; Stainforth & others, 1975, fig. 158/1; South Atlantic Ocean; Holocene).

Globigerinoides canimarensis Bermúdez, 1960 (pl. 10, fig. 5; Matanzas Formation; northwest Cuba; Pliocene).

New phena

Globigerinoides conglobatus altihelix n. subsp.

Holotype. UQF 71859. Pl. 10, fig. 17. Globorotalia truncatulinoides zone, foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/1/4/74--76/RS3, 5.24--5.26 m below sea-floor; Pleistocene. Very large, robust; very high sinistral trochospire, loose parallel to axis but very tight perpendicular to axis. Equatorial outline very weakly lobate; lateral outline highly spiroconvex. Chambers ovate parallel to axis, barely appressed, at least 14 in total, 3¾ in final, 3½ in second-last, 3¾ in third-last whorls; increase moderate. Dorsal view: chambers much longer concentrically, weakly inflated; sutures deeply but narrowly incised; intercameral sutures radial where present; supplementary apertures on proximal spiral

sutures, later ones higher. Ventral view: chambers highly inflated; intercameral sutures radial, meeting at closed umbilicus which is partially covered by final chamber; aperture umbilical, low. Lateral view: smoothly rounded. Wall densely perforate with well-developed interpore ridges. Length, 735 µm; width 670 µm; height, 755 µm.
Material. Two specimens.
Derivation of name. Latin, *altus*, high; *helix*, *icis* (f.), whorl, spiral.

Phena recorded

Globigerinoides haitiensis phenon *haitiensis* (Coryell & Rivero). Pl. 10, figs. 3, 6, 9--11. The holotype of this phenon appears to come from the upper-middle Miocene and thus presumably precedes the split giving rise to *G. conglobatus* (d'Orbigny). However, in both sections studied herein, it was found only in the latter species clusters.

G. haitiensis phenon *epityche* n. ph. Pl. 10, fig. 4.

G. haitiensis phenon *compressus* n. ph. Pl. 10, figs. 5, 7, 14--16.

Phenon *canimarensis* Bermúdez. Pl. 10, fig. 12. Vs *G. haitiensis* ph. *extremus*: chambers much broader concentrically; primary aperture larger and wider; larger; final chamber rounded at top, not flattened; chambers much more inflated and appressed.

Phenon *altihelix* n. ph. Pl. 10, fig. 17. Vs ph. *canimarensis* and *conglobatus*: high spired.

Phenon *conglobatus* (Brady). Pl. 10, figs. 8, 13, 18. Vs *G. haitiensis* ph. *haitiensis*: 4 chambers in the final whorl with primary aperture opposite third-last chamber whereas the latter has 3 and the aperture is opposite the ventral intercameral suture between the second- and third-last chambers. Vs ph. *canimarensis*: chambers much more inflated and appressed. Vs ph. *compressus*: primary aperture more open.

Remarks

Divergence of assemblages of *G. conglobatus* from *G. haitiensis* was estimated at Site 208 to occur in the upper *Globorotalia puncticulata* zone.

Globigerinoides elongatus (d'Orbigny)

Included phena

Globigerina adriatica Fornasini, 1899a (figured syntypes: pl. 3, figs. 6, 7; northeast Italy; Holocene).

G. bulloides var. *rubra* subvar. *pyramidalis* van den Broeck, 1876 (pl. 3, figs. 9, 10; Bay of Biscay, France; Holocene).

G. canariensis d'Orbigny, 1839b (syntypes lost acc. Le Calvez, 1974; =*G. elongata* d'Orbigny acc. Le Calvez, 1974).

G. cyclostoma Galloway & Wissler, 1927 (pl. 7, fig. 8; lower bed, Lower San Pedro Group; California, U.S.A.; Pleistocene; =*G. elongata* d'Orbigny acc. Rögl & Bolli, 1973?; =*G. gomitulus* Seguenza acc. Blow, 1969).

G.(?) *dubiata* McCulloch, 1977 (pl. 173, fig. 9; Catalina Is., off California, U.S.A., northeast Pacific Ocean; Holocene).

G. elongata d'Orbigny, 1826 (Banner & Blow, 1960b, pl. 3, fig. 10; northeast Italy; Holocene).

G. gomitulus Seguenza, 1880 (Minstretta, 1962, text-fig. 1; south Italy; upper Pliocene or Pleistocene).

G. helicina? var. *aculeata* Silvestri, 1898 (figured syntype: pl. 5, fig. 7; Italy; lower Pliocene).

G. rubra d'Orbigny, 1839a (Banner & Blow, 1960b, pl. 3, fig. 8; Stainforth & others, 1975, fig. 139/5; Cuba; Holocene; =*G. elongata* d'Orbigny acc. Parker, 1962?, Fleisher, 1974; =*G. helicina* d'Orbigny non emended Banner & Blow acc. Fleisher, 1974).

Globigerinoides elongata bikiniensis McCulloch, 1977 (pl. 174, fig. 2; off Bikini Atoll, Pacific Ocean; Holocene).

G. elongata cedrosensis McCulloch, 1977 (pl. 174, fig. 1; off Cedros Is., off Mexico, east Pacific Ocean; Holocene).

G. italicus Mosna & Vercesi, 1975 (pl. 3, fig. 1; *Globorotalia puncticulata* subzone, *G. margaritae* zone; northwest Italy; lower Pliocene).

G. mitra Todd, 1957 (pl. 78, fig. 3; lower *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone acc. Blow, 1969; Donni Sandstone; Saipan, Mariana Islands, northwest Pacific Ocean; lower Pliocene).

G. ruber parkerae Borsetti & Cati, 1975 (pl. 7, fig. 4; *Globorotalia puncticulata* subzone, *G. margaritae* zone; northeast Italy; lower Pliocene; junior subjective homonym of *Orbulina universa parkerae* Brönnimann & Resig acc. this study).

G. tyrrhenicus Borsetti & Cati, 1974 (pl. 35, fig. 1; *Sphaeroidinellopsis* spp. subzone, *Globorotalia margaritae* zone; Ventotene Is., west of Italy, east Tyrrhenian Sea; lowermost Pliocene).

Phena recorded

Globigerinoides haitiensis phenon *compactus* n. ph.

G. haitiensis phenon *progomitulus* n. ph. Pl. 11, fig. 1.

G. haitiensis phenon *obliquus* Bolli. Pl. 10, fig. 19.

G. haitiensis phenon *bollii* Blow.

G. haitiensis phenon *praerubra* n. ph.

G. haitiensis phenon *extremus* Bolli & Bermúdez.

G. haitiensis phenon *anterubra* n. ph.

Phenon *mitrus* Todd. Vs *G. haitiensis* ph. *obliquus* & *extremus*: high spire.

Phenon *gomitulus* (Seguenza). Pl. 11, figs. 3, 4. Vs *G. haitiensis* ph. *progomitulus*: supplementary aperture present.

Phenon *elongatus* (d'Orbigny). Pl. 10, figs. 23, 24. Vs ph. *ruber*: final chamber compressed.

Phenon *pyramidalis* (van den Broeck). Pl. 10, figs. 22, 25, pl. 11, fig. 2. Vs ph. *ruber*: high spired.

Phenon *ruber* (d'Orbigny). Pl. 10, figs. 20, 21. Vs *G. haitiensis* ph. *praerubra*: supplementary aperture present. Vs *G. haitiensis* ph. *anterubra*: 3 chambers in second-last whorl. Vs ph. *gomitulus*: large primary aperture.

CLADEGROUP(3) GLOBIGERINITERTIAE

Stem species. *Globigerina bulbosa* LeRoy.

Globigerina bulbosa LeRoy

Included phena

Globigerina bollii Cita & Premoli Silva, 1960 (text-fig. 1; pl. 13, fig. 12; *G. bollii* zone; northwest Italy; middle Langhian, middle? Miocene; =*G. falconensis* Blow acc. Blow, 1969).

G. bulbosa LeRoy, 1944a (figured syntype: pl. 3, figs. 26, 27; Lower Palembang Formation; central Sumatra, Indonesia; middle Miocene).

G. druryi Akers, 1955 (pl. 65, fig. 1; *Cibicides carstensi* var. *opimus* zone; Louisiana, U.S.A.; middle Miocene).

G. falconensis Blow, 1959 (pl. 9, fig. 40; *Siphogenerina transversa* zone of Renz, 1948; upper *Globigerinatella insueta*/*Globigerinoides bisphaerica* subzone, upper *Globigerinatella insueta* zone s.l.; lower Husito Marly-Clay Member, Pozón Formation, northwest Venezuela; Aquitanian, upper-lower or lower-middle Miocene).

G. foliata Bolli, 1957 (pl. 24, fig. 1; *Globorotalia fohsi robusta* zone; uppermost Cipero Formation; Trinidad; middle Miocene).

G. marialuisae Bermúdez, 1960 (pl. 4, fig. 6; south Mexico; middle Miocene).

G. nepenthoides Brönnimann & Resig, 1971 (pl. 7, fig. 6; 'zone N7/N8 of Banner & Blow, 1965c'; east of New Ireland, Papua New Guinea; upper-lower Miocene; =*G. nepenthes* Todd acc. Stainforth & others, 1975?).

G. nilotica Viotti & Mansour, 1969 (pl. 6, fig. 1; northeast Egypt; middle Miocene; =*G. falconensis* acc. Brönnimann & Resig, 1971).

G. praebulloides Blow, 1959 (pl. 8, fig. 47; *Siphogenerina transversa* zone of Renz, 1948; upper *Globigerinatella insueta*/*Globigerinoides bisphaerica* subzone, upper *Globigerinatella insueta* zone s.l.; Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; Aquitanian, upper-lower or lower-middle Miocene).

G. praebulloides pseudociperoensis Blow, 1969 (pl. 17, figs. 8, 9; *Globorotalia* (*G.*) *praefohsi* consecutive-range zone of Banner & Blow, 1965c; lower Palembang Formation; central Sumatra; Indonesia; Langhian, middle Miocene).

G. pseudodruryi Brönnimann & Resig, 1971 (pl. 7, figs. 1, 2; 'N6 (including N5?) of Banner & Blow, 1965c'; east of New Ireland, Papua New Guinea, lower Miocene; =*G. nepenthes* Todd acc. Stainforth & others, 1975?).

G. tecta Lipps, 1964 (pl. 1, fig. 6; Monterey Shale; California, U.S.A.; Luisian, Burdigalian, lower Miocene).

G. woodi extrema Cati, 1974 (pl. 45, fig. 4; *Globigerinoides altiaperturus*/*G. trilobus* s.l. zone, upper *Globigerinita dissimilis* zone; north Italy; lower Miocene).

Sphaeroidinella cellata Subbotina in Bykova & others, 1958 (pl. 11, fig. 4; Banner & Blow, 1965a, text-fig. 5; Balichskaya Series; west Ukrainian S.S.R.; Helvetian, middle Miocene).

Sphaeroidinellopsis ovalis Dremel, 1970 (text-fig. 88; *Globigerinatella insueta* zone; Kephallinia, Ionian Islands, west Greece; Aquitanian, upper-lower Miocene).

New phenon

Globigerina bulbosa trisphaera n. subsp.

Holotype. UQF 71901. Pl. 11, fig. 36. *Orbulina suturalis* zone; foraminifer-rich calcareous-nannofossil chalk, unit 1; D.S.D.P.208/21/3/73--75/RS2, 318.73--318.75 m below sea-floor; middle Miocene. Moderate in size, robust; low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline weakly trilobate; lateral outline oval. Chambers globular, closely appressed, at least 7 in total, 3¼ in final whorl; increase rapid. Dorsal view: chambers weakly inflated; sutures weakly depressed; intercameral sutures radial. Ventral view: chambers moderately inflated; intercameral sutures radial, meeting at tight umbilicus; aperture an umbilical very restricted low arch with a thin lip; final chamber extends anteriorly onto third-last chamber. Lateral view: smoothly rounded. Wall densely perforate and thickly pustulose especially in early chambers of the final whorl. Length, 330 µm; width, 320 µm; height, 250 µm.

Material. Two specimens.

Derivation of name. Latin, *tres*, three; *sphaera* (f.), ball.

Phena recorded

Globigerina disjuncta phenon *woodi* Jenkins. Pl. 11, fig. 27. Rare specimens have 3½ chambers in the final whorl, fairly closely appressed chambers, a moderately high aperture, and a thick wall.

G. disjuncta phenon *disjuncta* (Finlay). Pl. 11, figs. 28, 29; pl. 14, fig. 101.

Phenon *extrema* Cati. Pl. 11, fig. 30. Vs *G. disjuncta* ph. *woodi*: 4 chambers in the final whorl; slow chamber increase; aperture more open; chambers less closely appressed.

Phenon *nepenthoides* Brönnimann & Resig. Pl. 11, fig. 31, 32. Moderately highly spired; aperture low and umbilical, extending extraumbilically; chambers closely appressed; ventral intercameral sutures shallow.

Phenon *falconensis* Blow. Pl. 11, figs. 33, 34. Aperture low; chamber increase slow, especially in last chambers, to moderate; umbilicus tight; chambers closely appressed; essentially spinose, otherwise smooth, wall surface, typically thickened and pustulose, grading into reticulate surface. Rare large specimens, intergrading to phenon *trisphaera*, are included here, though intermediate-sized specimens appear rare.

Phenon *praebulloides* Blow. Pl. 11, fig. 35. Vs *G. disjuncta* ph. *woodi*: thin spinose wall; usually better separated chambers. Vs ph. *falconensis*: aperture highly arched, tending to be peripherally directed; chambers show quicker chamber increase, better separated; deeper ventral intercameral sutures.

Phenon *trisphaera* n. ph. Pl. 11, figs. 36, 37. Vs large specimens of ph. *falconensis*: 3 chambers in the final whorl.

Phenon *druryi* Akers. Pl. 11, fig. 38; pl. 14, fig. 102. Vs ph. *falconensis*: aperture higher; wall thicker, reticulose. Vs ph. *nepenthoides*: spire lower; aperture higher and restricted to umbilicus; chambers better separated.

Phenon *bollii* Cita & Premoli Silva. Pl. 11, fig. 39. Vs ph. *falconensis*: last chamber reduced; umbilicus wider.

Globigerina microstoma phenon *microstoma* Cita, Premoli Silva, & Rossi.

G. concinna phenon *columbae* Martínez Díaz.

G. concinna phenon *appenninica* (Pezzani).

G. bulloides phenon *incrusta* n. ph. Pl. 11, fig. 40.

Sphaeroidinella dehiscens (Parker & Jones)

Included phena

Globigerina kochi Caudri, 1934 (Koch, 1923, text-fig. 8; clay-marl or sand-marl of Rutten, 1916; northeast Java, Indonesia; Neogene).

G. seminulina Schwager, 1886 (Banner & Blow, 1960b, pl. 7, fig. 2; Stainforth & others, 1975, fig. 142/7; Nicobar Islands, India; Sarmatian acc. Banner & Blow, 1960?; Pliocene?).

Prosphaeroidinella challengerae Ujiié, 1975 (nomen nudum).

P. parkerae Ujiié, 1976 (pl. 4, figs. 1, 2; pl. 5, figs. 1, 2; *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone of Blow, 1969; north Philippine Sea, west North Pacific Ocean; lower Pliocene).

P. philippinensis Ujiié, 1976 (nomen nudum; =*Sphaeroidinella disjuncta* Finlay acc. Ujiié, 1976).

Sphaeroidina bulloides var. *dehiscens* Parker & Jones, 1865 (Banner & Blow, 1960b, pl. 7, fig. 3; Stainforth & others, 1975, fig. 161/1; northeast of Brazil, central Atlantic Ocean; Holocene; =*Globigerina sacculifera* Brady acc. Bé, 1965, Bé, Jongebloed, & McIntyre, 1969, Bé & Hemleben, 1970, Bé & van Donk, 1971).

S. dehiscens var. *immatura* Cushman, 1919 (figured syntype: pl. 14, fig. 2; *Globorotalia (Turborotalia) acostaensis* s.s.--*G. (G.) merotumida* partial-range zone of Banner & Blow, 1965c to *G. (G.) multicamerata*--*Pulleniatina obliqueloculata* s.s. partial-range zone of Blow, 1969; Bowden Formation; Jamaica; upper Miocene or Pliocene; =*S. bulloides* var. *dehiscens* Parker & Jones acc. Parker, 1967, Lamb & Beard, 1972).

Sphaeroidinella dehiscens excavata Banner & Blow, 1965c (Banner & Blow, 1967, pl. 4, fig. 5; Blow, 1969, pl. 10, fig. 14; Stainforth & others 1975, fig. 161/2; near Ifalik Is., Caroline Islands, west Pacific Ocean; Holocene; =*Sphaeroidina bulloides* var. *dehiscens* Parker & Jones acc. Lamb & Beard, 1972, Stainforth & others, 1975).

S. dehiscens subdehiscens Blow, 1959 (pl. 12, fig. 71; Stainforth & others, 1975, fig. 205/1; *Valvulineria herricki* zone of Renz, 1948; *Globorotalia mayeri*/*G. lenguaensis* subzone, *G. mayeri* zone s.l.; Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; Vindobonian, middle Miocene; =*Globigerina seminulina* Schwager acc. this study).

S. ionica evoluta Cita & Ciaranfi, 1972 (pl. 76, figs. 1, 2; *Globorotalia truncatalinoides* total-range zone; southeast Ionian Sea, Mediterranean Sea; lower Pleistocene; =*S. dehiscens excavata* Banner & Blow acc. this study).

S. ionica ionica Cita & Ciaranfi, 1972 (pl. 74, fig. 1; *Globorotalia inflata* interval-zone; southeast Ionian Sea, Mediterranean Sea; uppermost Pliocene; =*Sphaeroidina dehiscens* var. *immatura* Cushman acc. this study).

S. missionis Carter, 1963 (pl. 25, figs. 16--18; Portland Limestone; west Victoria, Australia; upper Miocene).

S. multiloba LeRoy, 1944b (figured syntype: pl. 4, figs. 7--9; southwest Java, Indonesia; Miocene or Pliocene; =*Globigerina seminulina* Schwager acc. LeRoy, 1944?, Parker, 1967, Ujiié, 1976).

S. rutschi Cushman & Renz, 1941 (pl. 4, fig. 5; *Marginulina basispinosa* and *Robulus senni* zone; zone 4, Upper Agua Salada Formation; northwest Venezuela; middle or upper Miocene; =*Globigerina seminulina* Schwager acc. Parker, 1967; =*G. kochi* acc. Banner & Blow, 1960b?; =*S. disjuncta* Finlay acc. Ujiié, 1976).

S. spinulosa Subbotina in Bykova & others, 1958 (pl. 11, fig. 6; west Albania; lower Pliocene; =*S. dehiscens subdehiscens* Blow acc. Parker, 1967?).

S. transiens Carter, 1963 (pl. 25, figs. 13--15; Portland Limestone; west Victoria, Australia; upper Miocene).

Sphaeroidinellopsis quadrangularis Bermúdez, 1960 (figured syntypes: Rhumbler, 1911, pl. 30, figs. 18--21; Atlantic Ocean; Holocene).

S. sphaeroides Lamb, 1969 (pl. 1, fig. 1; pl. 2, figs. 1--3; Stainforth & others, 1975, fig. 189/3; Gulf of Mexico; upper Pliocene; =*S. subdehiscens paenedehiscens* Blow acc. Stainforth & others, 1975, this study).

S. subdehiscens paenedhiscens Blow, 1969 (pl. 30, figs. 4, 9; Stainforth & others, 1975, fig. 189/1; *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone; Bowden Formation; Jamaica; lower Pliocene).

New phenon

Sphaeroidinella dehiscens reticulata n. subsp.

Holotype. UQF 71930. Pl. 12, fig. 16. *Globorotalia crassaformis* zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/7/4/74--76/RS4, 67.24--67.26 m below sea-floor; upper-lower or lower-upper Pliocene. Moderate in size, robust; low dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline very weakly trilobate; lateral outline oval. Chambers globular, very closely appressed, at least 6 in total, 3½ in final whorl; increase moderate. Dorsal view: chambers slightly inflated; sutures barely depressed; intercameral sutures radial. Ventral view: chambers weakly inflated; intercameral sutures radial; umbilicus very tight; narrow umbilical--extraumbilical opening along final--third-last intercameral suture, widest proximally. Lateral view: smoothly rounded. Wall coarsely but shallowly cancellate, not developed near sutures. Length, 300 μm; width 260 μm; height, 215 μm.

Material. Common.

Derivation of name. Latin, *reticulatus*, netted, net-like.

Remarks

The phenon found by Reiss & Gvirtzmann (1966) from the Tortonian of Israel, '*Sphaeroidinellopsis grimsdalei "reticulata"* ', is considered informal. Their illustrated specimens are probably equivalent to *Sphaeroidinella dehiscens* phenon *parkerae* (Ujiié).

Phena recorded

Globigerina disjuncta phenon *disjuncta* (Finlay). Pl. 11, fig. 41; Pl. 15, fig. 21.

Phenon *kochi* (Caudri). Pl. 11, figs. 43, 44; pl. 12, figs. 4, 10, 15; pl. 15, fig. 6. Vs *Globigerina disjuncta* ph. *disjuncta*: >4½ chambers in the final whorl. This is the accepted concept of this phenon although the illustration of the holotype is ambiguous in this character.

Phenon *seminulina* (Schwager). Pl. 11, fig. 42; pl. 12, figs. 1, 2, 7, 12, 13, 17; pl. 14, figs. 103--111; pl. 15, figs. 1--5, 7--20, 22--40; pl. 16, figs. 1, 2, 4, 8, 13. Vs *G. disjuncta* ph. *disjuncta*: extra, shiny wall-layer.

Phenon *reticulata* n. ph. Pl. 12, figs. 3, 8, 9, 16. Vs ph. *seminulina*: wall surface distinctly reticulate, at least in some parts.

Phenon *parkerae* (Ujiié). Pl. 12, figs. 6, 11, 14, 18--22. Vs ph. *reticulata*: deep pore pits.

Phenon *paenedehiscens* (Blow). Pl. 12, fig. 5; pl. 16, figs. 3, 6, 7, 14, 17. Vs ph. *seminulina*: ventral incision longer; more tightly coiled; chambers more embracing; outline more spherical without clearly defined externally visible suture commissures.

Phenon *immatura* (Cushman). Pl. 13, fig. 1; pl. 16, figs. 5, 9--11, 15, 16, 18--20; pl. 17, figs. 1--3, 5. Vs ph. *paenedehiscens*: small incision in outer dorsal layer.

Phenon *dehiscens* (Parker & Jones). Pl. 12, fig. 23; pl. 13, figs. 2, 3; pl. 16, figs. 12, 21, 22; pl. 17, figs. 4, 6--9. Vs ph. *immatura*: dorsal opening distinctly wide.

Phenon *excavata* Banner & Blow. Pl. 13, fig. 4. Vs ph. *dehiscens*: dorsal and ventral openings connected and open widely to reveal earlier chambers; chambers less closely appressed.

Remarks

The split in *Globigerina disjuncta* which gave rise to this species was sampled too coarsely herein to allow estimation of assemblage divergence. *S. dehiscens* is tentatively considered to have split with the lowest occurrence of phenon *seminulina*, reported by Blow (1969) as *Sphaeroidinellopsis subdehiscens* s.s. at the base of his *S. subdehiscens* s.s.--*Globigerina druryi* partial-range zone.

CLADEGROUP(2) GLOBIGERINISECUNDAE

Stem species. *Globigerina microstoma* Cita, Premoli Silva, & Rossi.

Globigerina microstoma Cita, Premoli Silva, & Rossi

Included phenon

G. microstoma Cita, Premoli Silva, & Rossi, 1965 (pl. 31, fig. 1; top of *Globorotalia mayeri*/*Globigerina nepenthes* zone or *Globorotalia menardii*/*Globigerina nepenthes* zone; Rio Mazzapiedi Series; north Italy; Tortonian, upper-middle Miocene).

New phenon

Globigerina microstoma opsionepenthoides n. subsp.

Holotype. UQF 71966. Pl. 13, fig. 28. *Globorotalia mayeri* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/20/2/64--66/RS2, 289.14--289.16 m below sea-floor; middle Miocene. Small, robust; weakly elevated trochospire, tight parallel and perpendicular to axis. Equatorial outline moderately lobate; lateral outline oval. Chambers ovate, moderately compressed, at least 9 (13?) in total, 4 in final and second-last whorls; increase slow. Dorsal view: chambers slightly longer concentrically, weakly inflated; sutures slightly depressed; intercameral sutures directed and curved posteriorly. Ventral view: chambers weakly inflated; intercameral sutures radial, meeting at tight umbilicus; aperture umbilical, highly arched, pushed distally, with a thick lip. Lateral view: smoothly rounded.

Wall surface thickened, fairly densely perforate, weakly cancellate prior to final chamber. Length, 145 µm; width 130 µm; height, 95 µm.

Material. Common.

Derivation of name. Greek, *opsios*, late; last components refer to '*G.* *nepenthoides* Brönnimann & Resig'.

Phena recorded

Globigerina *disjuncta* phenon *woodi* Jenkins. Pl. 13, figs. 5--12, 42.

G. *bulbosa* phenon *extrema* Cati. Pl. 13, fig. 13.

G. *bulbosa* phenon *falconensis* Blow. Pl. 13, figs. 14--16.

G. *bulbosa* phenon *praebulloides* Blow. Pl. 13, fig. 17.

G. *bulbosa* phenon *druryi* Akers. Pl. 13, figs. 18--21, 43--45; pl. 17, figs. 10?, 11.

G. *bulbosa* phenon *bollii* Cita & Premoli Silva. Pl. 13, figs. 22--25.

Phenon *opsionepenthoides* n. ph. Pl. 13, figs. 26--30. Vs *G.* *bulbosa* ph. *nepenthoides*: coil much lower and tighter. Vs *G.* *bulbosa* ph. *druryi*: aperture directed peripherally; chambers closely appressed.

Phenon *microstoma* Cita, Premoli Silva, & Rossi. Pl. 13, fig. 31. Vs *G.* *disjuncta* ph. *woodi*: 4 chambers in the final whorl; small circular aperture. Vs *G.* *bulbosa* ph. *extrema*: small circular aperture; chambers more closely appressed.

G. *concinna* phenon *decoraperta* Takayanagi & Saito. Pl. 13, figs. 32, 33, 46.

G. *concinna* phenon *columbae* Martínez Díaz. Pl. 13, figs. 34--37.

G. *concinna* phenon *picassiana* Perconig.

G. *bulloides* phenon *incrusta* n. ph. Pl. 13, figs. 38--40, 47.

G. *rubescens* phenon *nepenthes* Todd. Pl. 13, figs. 41, 48, 49.

Ehrenbergellus *pachydermus* (Ehrenberg)

Included phena

Aristerospira *pachyderma* Ehrenberg, 1861 (figured syntype?: 1873, pl. 1, fig. 4; Davis Strait, Arctic Ocean; Holocene).

Globigerina *bramlettei* Lipps, 1964 (pl. 1, fig. 4; Monterey Shale; south California, U.S.A., upper Mohnian, Helvetian?, middle Miocene).

G. *bulloides* var. *borealis* Brady, 1881 (Banner & Blow, 1960b, pl. 3, fig. 4; Arctic Ocean; Holocene; =*Aristerospira* *pachyderma* Ehrenberg acc. Fleisher, 1974, Jenkins, 1971).

Phena recorded

Phenon *pachydermus* (Ehrenberg). Pl. 13, figs. 50--62. Vs *Pulleniatina* *siakensis* ph. *pseudopachyderma* (Cita, Premoli Silva, & Rossi): see Olsson (1976).

Remarks

The split giving rise to this species is taken below the lowest occurrence of the nominate phenon at Site 208, that is, the lower *Globorotalia* *continuosa* zone of Kennett (1973). In this part of the section the nominate phenon is similar to phena *druryi* (Akers), *opsionepenthoides* n. ph., and *columbae* Martínez Díaz. However, the rarity of phenon *pachydermus* precludes a confident assessment of intergradation. The phylogenetic interpretation adopted herein for *E.* *pachydermus* concurs with the general conclusions reached by Olsson (1976), based mainly on detailed ultrastructural wall-surface studies on Holocene individuals. However, the present study proposes a much earlier origin for this species, near the middle--late-Miocene boundary, rather than in the Pleistocene as suggested by Olsson. This species pseudomorphs phenon *pseudopachyderma* Cita, Premoli Silva, & Rossi which has been shown (for example, Srinivasan & Kennett, 1976) to be part of *Pulleniatina* *siakensis* (LeRoy) and *P.* *helicina* (d'Orbigny), as defined below.

CLADEGROUP(1) GLOBIGERINIPRIMAE

Stem species. *Globigerina* *concinna* Reuss.

Globigerina *concinna* Reuss

Included phena

Catapsydrax *appenninicus* Pezzani, 1963 (pl. 29, fig. 1; pl. 31, fig. 1; north Italy; Messinian; upper Miocene or lower Pliocene; =*Globigerina* *druryi* *decoraperta* Takayanagi & Saito acc. Jenkins, 1971).

Globigerina *apertura* Cushman, 1918 (figured syntype: pl. 12, fig. 8; Yorktown Formation; Virginia, U.S.A.: Miocene).

G. columbae Martínez Díaz, 1970 (pl. 1, fig. 1; southeast Spain; Andalusian, upper Miocene).

G. concinna Reuss, 1850 (figured syntype: pl. 47, fig. 8, ?lost acc. Grill in Bolli, 1954; northeast Austria; Tortonian, upper Miocene acc. Grill in Bolli, 1954).

G. diplostoma Reuss, 1850 (figured syntypes: pl. 47, figs. 9, 10; pl. 48, fig. 1; south Poland, Tertiary).

G. druryi decoraperta Takayanagi & Saito, 1962 (pl. 28, fig. 10; *Globorotalia cultrata* s.s./*Globigerina nepenthes* zone; Nobori Formation; Shikoku, Japan; Tortonian, upper-middle or lower-upper Miocene?).

G. parabulloides Blow, 1959 (pl. 10, fig. 46; upper *Marginulinopsis basispinosus* zone of Renz, 1948; top of *Globorotalia menardii* s.s./*Globigerina nepenthes* zone; Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; Vindobonian or higher, lower-upper Miocene).

G. picassiana Perconig, 1968 (pl. 7, fig. 19; southwest Spain; upper Tortonian, upper Miocene; =*G. nepenthes* Todd acc. Stainforth & others, 1975?).

G. ridenda Voloshinova, 1960 (pl. 29, fig. 8; upper Okobykay Formation; Sakhalin, U.S.S.R.; upper Miocene).

G. riveroae Bolli & Bermúdez, 1965 (pl. 1, figs. 1--3; *Globorotalia* (*G.*) *tumida plesiotumida* zone of Banner & Blow, 1965c to lower *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* partial-range zone acc. Blow, 1969; Cerro Negro member, Cubagua Formation; northeast Venezuela; upper Miocene or lower Pliocene).

G. rudis Voloshinova, 1960 (pl. 29, fig. 9; lower Okobykay Formation; Sakhalin, U.S.S.R.; upper Miocene).

Globigerinopsoides algeriana Cita & Mazzola, 1970 (pl. 38, fig. 1; *Globigerina nepenthes* zone; northeast Algeria; lower Tortonian; upper Miocene).

Sphaeroidinellopsis nepenthes var. *constricta* Bermúdez, 1960 (pl. 10, fig. 2; east Cuba, middle Miocene?).

New phena

Globigerina concinna altihelix n. subsp.

Holotype. UQF 72039. Pl. 14, fig. 29. *G. nepenthes* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/14/4/74--76/RS2, 162.24--162.26 m below sea-floor; upper Miocene. Moderate in size, robust; moderately highly elevated dextral trochospire, moderately loose parallel to axis, tight perpendicular to axis. Equatorial outline weakly lobate; lateral outline spiroconvex. Chambers globular, weakly to moderately closely appressed, at least 10 in total, $3\frac{1}{2}$ in final whorl; increase slow. Dorsal view: chambers slightly longer concentrically, weakly inflated; sutures barely depressed; intercameral sutures directed and curved posteriorly. Ventral view: chambers inflated; sutures radial to curved; umbilicus tight; aperture umbilical, opposite second-last--third-last intercameral suture, a high arch with a thick lip. Lateral view: smoothly rounded. Wall densely perforate with elevated interpore ridges. Length, 205 µm; width, 200 µm; height, 240 µm.

Material. Common.

Derivation of name. Latin, *altus*, high; *helix*, *-icis* (f.), whorl, spiral.

Globigerina concinna anapetes n. subsp.

Holotype. UQF 72041. Pl. 14, fig. 31. As for *G. concinna altihelix* except RS1. Moderate in size, fairly robust; moderately elevated dextral trochospire, fairly loose parallel and especially perpendicular to axis. Equatorial outline moderately lobate; lateral outline weakly biconvex. Chambers globular, weakly appressed, at least 9 (13?) in total, 4 in final whorl; increase moderate until second-last chamber when slowed. Dorsal view: chambers slightly longer concentrically, weakly inflated; sutures moderately depressed; intercameral sutures radial. Ventral view: chambers moderately highly inflated, intercameral sutures radial; umbilicus moderately wide; aperture a high arch, umbilical--extraumbilical, highest near periphery. Lateral view: smoothly rounded. Wall densely perforate with pustules on elevated interpore ridges. Length, 290 µm; width 270 µm; height, 235 µm.

Material. Common.

Derivation of name. Greek, *anapetes*, wide open, expanded.

Phena recorded

Globigerina parva phenon *occlusa* Blow & Banner. Pl. 14, figs. 13--16, 59, 82, 83. Using Blow & Banner's (1962) distinguishing criteria, this phenon was assigned to specimens in *G. concinna* and *G. bulloides* clusters. Blow (1969) gives a long range to this phenon which includes the upper-Miocene--Pliocene occurrences observed herein. However, its absence from middle-Miocene assemblages in this study suggests potential nominal separation from typical (lower-Oligocene) individuals.

G. disjuncta phenon *woodi* Jenkins. Pl. 14, fig. 17.

G. bulbosa phenon *falconensis* Blow. Pl. 13, fig. 63; pl. 14, figs. 1, 2.

G. bulbosa phenon *praebulloides* Blow. Pl. 14, figs. 3, 4, 18--20.

G. bulbosa phenon *druryi* Akers. Pl. 14, figs. 5, 6, 21, 22.

G. bulbosa phenon *bollii* Cita & Premoli Silva. Pl. 14, figs. 7, 23--25.

G. microstoma phenon *opsionepenthoides* n. ph.

Phenon *decoraperta* Takayanagi & Saito. Pl. 13, figs. 64, 65; pl. 14, figs. 8, 26. Vs *G. bulbosa* ph. *extrema*: well-developed lip; higher dorsal side. Vs ph. *opsionepenthoides*: aperture higher, not usually as distinctly peripherally vaulted; chambers less closely appressed. Vs *G. microstoma* ph. *microstoma*: aperture higher and wider with lip; chambers less closely appressed. Vs *G. bulbosa* ph. *druryi*: aperture higher and wider; chambers better separated.

Phenon *columbae* Martínez Díaz. Pl. 14, fig. 27. Vs *G. bulbosa* ph. *bollii*: umbilicus much tighter.

Phenon *appenninica* (Pezzani). Pl. 13, fig. 66. Vs ph. *decoraperta*: bullate.

Phenon *picassiana* Perconig. Pl. 13, fig. 67; pl. 14, figs. 9, 41, 50; pl. 17, fig. 15. Vs *G. bulbosa* ph. *druryi*: narrower very restricted aperture; higher spire.

Phenon *altihelix* n. ph. Pl. 14, figs. 28, 29. Vs ph. *decoraperta*: high spire.

Phenon *anapetes* n. ph. Pl. 14, figs. 30--32. Inflated; moderately highly trochospiral; aperture umbilical--extraumbilical.

G. bulloides phenon *incrusta* n. ph. Pl. 14, figs. 10, 11, 33, 34.

G. rubescens phenon *delicata* Brönnimann & Resig. Pl. 14, figs. 35, 36.

G. rubescens phenon *nepenthes* Todd. Pl. 13, figs. 68--71, pl. 14, figs. 12, 37.

G. bulloides phenon *bulloides* d'Orbigny. Pl. 14, figs. 38--40.

G. bulloides phenon *megastoma* Earland.

Globigerina rubescens Hofker

Included phena

Globigerina nepenthes Todd, 1957 (pl. 78, fig. 7; Stainforth & others, 1975, fig. 183/1; lower *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone acc. Blow, 1969; Donni Sandstone; Saipan, Mariana Islands, northwest Pacific Ocean; lower Pliocene).

G. nepenthes delicata Brönnimann & Resig, 1971 (pl. 1, fig. 7; *Globorotalia* (*G.*) *tumida* s.s.--*Sphaeroidinellopsis subdehiscens paenedehiscens* partial-range zone of Blow, 1969; southwest Pacific Ocean; uppermost Miocene or lowermost Pliocene; =*G. nepenthes* Todd acc. Stainforth & others, 1975?).

G. rosacea Bermúdez & Seiglie, 1963 (pl. 29, fig. 1; north of Venezuela, Caribbean Sea; Holocene).

G. rubescens Hofker, 1956 (figured syntypes: pl. 32, fig. 26; pl. 35, figs. 18 & 19, 20 & 21; Malaysia--Indonesia archipelago; Holocene).

G. sallentina Dallan, Gianelli, & Salvatorini, 1968 (text-fig. 1; pl. 1, fig. 1; *Globorotalia puncticulata* subzone, *G. margaritae* cenozone; southeast Italy; lower Pliocene).

G. vignalii Bermúdez & Bolli, 1969 (pl. 4, figs. 10--12; Cerro Negro Member, Cubagua Formation; northeast Venezuela; upper Miocene or ?lower Pliocene).

Globigerinoides fragilis Borsetti & Cati, 1972 (text-fig. 1; pl. 79, fig. 1; pl. 80, fig. 2; *Globorotalia margaritae* zone; west of Italy, east Tyrrhenian Sea; lower Pliocene).

G. tenellus Parker, 1958 (pl. 6, fig. 7; north of Libya, Mediterranean Sea; Holocene).

Phena recorded

Globigerina bulbosa phenon *druryi* Akers. Pl. 17, fig. 16.

G. microstoma phenon *opsionepenthoides* n. ph. Pl. 17, figs. 12--14.

G. concinna phenon *decoraperta* Takayanagi & Saito. Pl. 14, fig. 53.

G. concinna phenon *appenninica* Pezzani.

G. concinna phenon *picassiana* Perconig.

G. concinna phenon *altihelix* n. ph. Pl. 14, fig. 55.

G. concinna phenon *apertura* Cushman. Pl. 14, figs. 42, 46, 47. Vs ph. *decoraperta*: aperture much wider and higher. Vs ph. *altihelix*: lower spire.

Phenon *delicata* Brönnimann & Resig. Pl. 14, figs. 43--45, 51, 52.

Phenon *nepenthes* Todd. Pl. 14, figs. 48, 49. Vs ph. *delicata*: final chamber thick walled with low to only moderately high aperture. Vs *G. bulbosa* ph. *druryi*: higher coil; aperture higher or wider; more chambers per whorl, more closely appressed and obliquely directed.

Phenon *rubescens* Hofker. Pl. 14, figs. 54, 56, 57. Vs ph. *decoraperta*: aperture more restricted, especially narrower; chambers better separated; wall thinner but distinctly cancellate; smaller.

Phenon *tenella* (Parker). Pl. 14, fig. 58. Vs ph. *rubescens*: supplementary aperture present.

Remarks

The split of *G. concinna* which gives rise to this species and *G. bulloides* is estimated by successive species-cluster divergence at Site 208 to occur in the upper *G. nepenthes* zone of Kennett (1973).

Globigerina bulloides d'Orbigny

Included phena

Globigerina bermudezi Seiglie, 1963 (pl. 1, figs. 6--8; eastern Venezuela; Holocene).

G. bulloides d'Orbigny, 1826 (Banner & Blow, 1960b, pl. 1, fig. 1; northeast Italy; Holocene).

G. calida Parker, 1962 (pl. 1, fig. 9; South Pacific Ocean; Holocene).

G. calida praecalida Blow, 1969 (pl. 13, figs. 7, 8; *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone; south of Ocean Is., Gilbert and Ellice Islands, west Pacific Ocean; lower Pliocene).

G. megastoma Earland, 1934 (pl. 8, fig. 9; Banner & Blow, 1960b, pl. 1, fig. 3; south of Chile, Southern Ocean; Holocene).

G. megastoma cariacoensis Rögl & Bolli, 1973 (pl. 2, fig. 2; text-fig. 4; *Globorotalia fimbriata* subzone, *G. truncatulinoides* s.s. zone; zone Z of Ericson & Wollin, 1968; north of Venezuela; Holocene).

G. quadrilatera Galloway & Wissler, 1927 (pl. 7, fig. 11; middle bed, Lower San Pedro Group; California, U.S.A.; Pleistocene).

G. santamariaensis McCulloch, 1977 (pl. 172, fig. 7; Santa Maria Bay, Mexico, east Pacific Ocean; Holocene).

G. tetracamerata Bolli & Bermúdez, 1965 (pl. 1, figs. 7--9; *Globorotalia truncatulinoides*/*G. inflata* zone; *G. (Turborotalia) tosaensis tenuitheca* consecutive-range zone or *G. (G.) truncatulinoides* s.s. partial-range zone of Banner & Blow, 1965c acc. Blow, 1969; Cumana Formation; northeast Venezuela; upper Pliocene or lower Pleistocene; =*G. parabulloides* Blow acc. Blow, 1969).

G. umbilicata Orr & Zaitzeff, 1971 (pl. 1, fig. 2; Rio Del Formation; north California, U.S.A.; upper Pliocene).

Globorotalia (Turborotalia) incisa Brönnimann & Resig, 1971 (pl. 45, fig. 1; 'zone N20 (including N19) of Blow, 1969'; north of Papua New Guinea, southwest Pacific Ocean; lower Pliocene).

G. (T.) palpebra Brönnimann & Resig, 1971 (pl. 3, fig. 3; *G. (T.) tosaensis tenuitheca* consecutive-range zone of Banner & Blow, 1965c; north of New Guinea, southwest Pacific Ocean; upper Pliocene).

T. pseudobesa Salvatorini, 1967 (pl. 2, fig. 6; Italy; Messinian, upper Miocene).

New name

Globigerina bulloides bronnresigorum n. name.

For *Globorotalia (Turborotalia) incisa* Brönnimann & Resig. Within the present classification the latter name becomes a junior subjective homonym of '*Globigerina incisa* Hillebrandt'.

Derivation of name. For Paul Brönnimann & Johanna Resig.

New phena

Globigerina bulloides incrusta n. subsp.

Holotype. UQF 72077. Pl. 14, fig. 67. Upper *G. nepenthes* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/13/5/74--76/RS1, 145.74--145.76 m below sea-floor; upper Miocene. Small, robust; slightly elevated dextral trochospire, tight parallel and perpendicular to axis. Equatorial outline weakly lobate; lateral outline oval. Chambers ovate, weakly appressed, at least 12 in total, 3¾ in final whorl, 4½ in second-last whorl; increase moderate then slow after third-last chamber. Dorsal view: chambers weakly inflated; sutures weakly incised; intercameral sutures directed and curved posteriorly. Ventral view: chambers slightly longer concentrically, weakly inflated; intercameral sutures radial or curved, moderately incised, and slit-like. Lateral view: smoothly rounded. Wall densely perforate but covered by thickening; elevated interpore ridges especially near periphery. Length, 145 µm; width, 130 µm; height, 105 µm.

Material. Common.

Derivation of name. Latin, incrusto, -atus, cover with a coating of some substance.

Globigerina bulloides extensa n. subsp.

Holotype. UQF 72109. Pl. 14, fig. 99. Globorotalia truncatulinoides zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/1/4/74--76/RS2, 5.24--5.26 m below sea-floor; Pleistocene. Moderate in size, robust; slightly elevated dextral trochospire, slightly loose parallel and perpendicular to axis. Equatorial outline distinctly quadrilobate; lateral outline slightly spiroconvex. Chambers globular to ovate, barely appressed, at least 11 in total, 4 in final whorl; chamber increase moderate until last, reduced chamber. Dorsal view: chambers circular, last few extended radially, slighty inflated; sutures weakly depressed; intercameral sutures radial if present. Ventral view: chambers inflated; intercameral sutures radial; chambers quickly separate proximally, leaving umbilicus open; aperture an umbilical low arch with a thick lip. Lateral view: smoothly rounded. Wall densely perforate with moderately developed interpore ridges. Length, 270 µm; width, 300 µm; height, 180 µm.

Material. Common.

Derivation of name. Latin, extensus, stretched out, spread out.

Phena recorded

Globigerina parva phenon occlusa Blow & Banner.

G. bulbosa phenon falconensis Blow. Pl. 14, figs. 60--63, 69--71, 79, 87, 90, 95.

G. bulbosa phenon praebulloides Blow. Pl. 14, fig. 72.

G. bulbosa phenon bollii Cita & Premoli Silva. Pl. 14, figs. 64, 73, 74.

G. bulbosa phenon bulbosa LeRoy. Pl. 14, fig. 100. Vs ph. falconensis: chambers, especially final chamber, extremely elongated radially; chambers better separated; usually thinner walled. Vs ph. praebulloides: chambers, especially final chamber, extremely elongated radially; aperture very low.

G. bulbosa phenon foliata Bolli. Pl. 14, figs. 65, 77, 84, 85. Vs ph. bulbosa: elongation of chambers not as marked, especially final chamber compared to earlier chambers. Vs ph. falconensis and praebulloides: chambers elongated radially, much better separated, with deeply incised ventral intercameral sutures.

G. concinna phenon anapetes n. ph.

Phenon pseudobesa (Salvatorini). Pl. 14, figs. 75, 81, 94. Vs G. bulbosa ph. praebulloides: aperture highest closer to periphery. The phena 'G. calida Parker' and 'G. calida praecalida Blow' were not recorded herein and thus their phylogenetic positions can be only tentatively interpreted. For the moment they are included within the G. bulloides lineage, showing most similarity to phenon pseudobesa. However, boundary criteria between these phena and similar individuals belonging to coeval Globigerinella species are difficult to define. For instance, both the trochospiral G. bulloides and the planispiral Globigerinella species show a tendency to a low trochospiral coil. Low trochospiral individuals of Globigerinella are assigned above to a new phenon. Further study will be needed to establish essential morphological features to separate these pseudomorphs.

Phenon incrusta n. ph. Pl. 14, figs. 66, 67, 76, 78, 88, 89, 91, 98. Vs G. bulbosa ph. falconensis: wall thickened, ventral intercameral sutures correspondingly shallower; aperture very low; chambers appear closely appressed.

Phenon bronnresigorum n. name. Pl. 14, figs. 80, 86, 96, 97. Vs ph. incrusta: wall more thickened so that ventral intercameral sutures are surrounded by high walls, giving a distinctly incised appearance; aperture tends to extraumbilical extension.

Phenon quadrilatera Galloway & Wissler. Pl. 14, fig. 68. Vs G. bulbosa ph. bollii: aperture higher; umbilicus wider.

Phenon extensa n. ph. Pl. 14, fig. 99. Vs G. bulbosa ph. bollii: chambers radially elongated.

Phenon *bulloides* d'Orbigny. Pl. 14, fig. 93. Vs *G. bulbosa* ph. *praebulloides*: chambers better separated; deeper ventral intercameral sutures; larger; aperture broader; chambers more inflated.

Phenon *megastoma* Earland. Pl. 14, fig. 92. Vs ph. *bulloides*: higher spired; usually thinner walled; tighter umbilicus.

CLADEGROUP(9) GLOBOROTALINONAE

Stem species. *Globorotalia bakeri* (Cole).

Globorotalia bakeri (Cole)

Included phena

Globigerina angiporoides minima Jenkins, 1966.
G. bakeri Cole, 1927.
G. kyushuensis Asano & Murata, 1958.
G. posttriloculinoides Chalilov, 1956.
G. turcmenica Chalilov, 1956.
Subbotina inflatiformis Myatiuk, 1970.

Remarks

This species is a continuation of the general morphology of its ancestor, *G. linaperta*, with increasing appression of chambers. It corresponds to an amalgamation of those phena considered by Blow (1979) to be descended from phenon *linapera*, excluding phena *inaequispira* and *ayalai* and their descendants, and also includes the highest occurrences of phena *finlayi* and *hornibrooki*.

Gen.I *reticulata* (Stache)

Included phena

?*Globigerina angipora* Stache, 1865 (nomen dubium).
G. angiporoides Hornibrook, 1965.
G. bulloides var. *compacta* Subbotina, 1953.
G. eocaenica var. *irregularis* Subbotina, 1953.
G. patagonica Todd & Kniker, 1952.
G. linaperta transdanubica Samuel, 1972.
G. planoexilis Blaicher, 1970.
G. posttriloculinoides var. *clinata* Chalilov, 1956.
G. protoreticulata Hofker, 1956.
G. reticulata Stache, 1865.
G. subtriloculinoides Chalilov, 1956.
G. utilisindex Jenkins & Orr, 1973.
Subbotina angiporoides lindiensis Blow, 1979.
S. droogeri Myatiuk, 1970.

Remarks

This species represents phenon *linaperta* and those descendants, as interpreted by Blow (1979), which occur above the split with *Globorotalia opima* Bolli from their immediate common ancestor, *G. bakeri*. It exhibits a continuation of the general morphology of the ancestor with a further tightening of the coil.

The upper limit of the species is determined by that of phenon *angiporoides*, that is, the middle part of Banner & Blow's (1965c) *Globigerina angulisuturalis*/*Globorotalia* (*Turborotalia*) *opima* s.s. concurrent-range zone.

CLADEGROUP(8) GLOBOROTALIOCTAVAE

Stem species. *Globorotalia opima* Bolli.

Remarks

As discussed above in remarks given for *Guembelitrioides lozanoi*, Blow's (1979) view of a phenon *angiporoides* ancestry for Neogene globorotaliform species is tentatively accepted with modifications. Blow (1979) suggested the phenon series, *angiporoides*--*continuosa* (Blow)--*acostaensis* (Blow)--*dutertrei* (d'Orbigny). However, the highest occurrence of phenon *angiporoides*, the middle of Banner & Blow's (1965c) *Globigerina angulisuturalis*/*Globorotalia* (*Turborotalia*) *opima* s.s. concurrent-range zone, is well below the lowest occurrence of phenon *continuosa* in the lower part of their *Globigerinatella insueta*/*Globigerinita dissimilis* concurrent-range zone. This gap was filled by small turborotaliform individuals unnamed by Blow (1969) and considered by him to be unrelated to the similar phenon *nana* Bolli. Thus

Blow's final published views on the origin of the Neogene turborotaliform species would seem to envisage an origin in phenon angiporoides via these unnamed individuals.

In this study Blow's (1969, 1979) suggested origin of Neogene turborotaliform species is tentatively adopted with the modification that phenon nana and its descendants of late-Oligocene--early-Miocene age are considered part of a highly variable lineage originating in G. bakeri via phenon angiporoides and leading to phenon continuosa. These descendants of phenon nana include, in probable order of occurrence, phena opima Bolli, semivera (Hornibrook), siakensis (LeRoy), pseudocontinuosa (Jenkins), extans (Jenkins), bella (Jenkins), and acrostoma (Wezel). Such phena may include the unnamed individuals considered by Blow (1969) to be ancestral to phenon continuosa. This suggested amalgamation of several phena into a single species-cluster-defined lineage is encouraged by the large range of variation observed in Pulleniatina mayeri (Cushman & Ellisor) assemblages recovered in this study. Derivation of phenon nana from phenon angiporoides seems to involve relatively minor, mainly apertural, changes especially if phenon nana individuals found below the lowest occurrence of phenon opima are considered (compare fig. 103/1--3 with fig. 131/5--7 in Stainforth & others, 1975).

As a cautionary note with regard to the phylogeny adopted here, the gross similarity of T. cerroazulensis phenon pseudoimitata to members of the G. opima lineage should be noted. Consideration of a close relationship of these taxa would entail the validity of the turborotaliform 'stock' lineage view forwarded by Berggren (1968) and McGowran (1968).

Globorotalia opima Bolli

Included phena

Globigerina krosniensis Blaicher, 1970.
Globorotalia opima nana Bolli, 1957.
G. opima opima Bolli, 1957.

Remarks

The lower limit of this species is taken as that of phenon nana, that is, the base of Blow's (1979) Porticulasphaera semiinvoluta partial-range zone.

CLADEGROUP(1) PULLENIATINIPRIMAE

Stem species. Pulleniatina mayeri (Cushman & Ellisor)

Pulleniatina mayeri (Cushman & Ellisor)

Included phena

Globigerina globorotaloidea Colom, 1954 (figured syntypes: pl. 17, figs. 1--25; southeast Spain; Vindobonian, Helvetian or Tortonian, middle Miocene; =G. dutertrei d'Orbigny acc. Stainforth & others, 1975).

G. macrostoma Copeland, 1964 (pl. 41, fig. 5; Duplin Marl; North Carolina, U.S.A.; upper Miocene).

G. semivera Hornibrook, 1961 (pl. 23, figs. 455--457; Jenkins, 1971, pl. 12, figs. 342--344; Globigerinoides trilobus s.s. zone acc. Jenkins, 1971; Rifle Butts Formation; South Island, New Zealand; Awamoan, lower Miocene).

G. siakensis LeRoy, (month not given) 1939 (pl. 4, figs. 20--22; Blow, 1969, pl. 10, figs. 7--9; Stainforth & others, 1975, fig. 143/3; transitional zone, sand and clay series; central Sumatra, Indonesia; lower or middle Miocene).

G. subtarchanensis Agalarova & Pronina, 1975 (pl. 3; salt-bearing series; Nakhichevan Azerbaidzhan S.S.R., southwest U.S.S.R.; middle Sarmatian, upper Miocene).

G. tarchanensis Subbotina & Khutsieva in Bogdanovich, 1950 (pl. 10, fig. 5; Tarkhan horizon; southwest U.S.S.R.; Miocene).

Globorotalia acostaensis Blow, 1959 (pl. 17, fig. 106; Banner & Blow, 1967, pl. 3, fig. 1; Blow, 1969, pl. 9, figs. 13--15; Stainforth & others, 1975, fig. 152/1; Marginulinopsis basispinosus zone of Renz, 1948; top of G. menardii s.s./Globigerina nepenthes zone; Globorotalia (Turborotalia) acostaensis s.s.--G. (G.) merotumida partial-range zone of Banner & Blow, 1965c acc. Blow, 1969; upper Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; lower-upper Miocene.

G. acostaensis trochoidea Bizon & Bizon, 1965 (pl. 4, fig. 12; northwest Greece; Tortonian, upper Miocene).

'G.' acrostoma Wezel, 1966 (text-fig. 1; Ruggieri & Sprovieri, 1970, fig. 4a; upper Globigerinoides trilobus cenozone; zone a scagile tettoniche; Sicily, Italy; upper-lower Miocene).

G. acrostoma partimlabiata Ruggieri & Sprovieri, 1970 (Fig. 3; G. miozea zone; Orbulina s.l. zone, Globoquadrina altispira/Globorotalia miozea subzone of Cati & others, 1968; G. mayeri/G. praemenardii zone of Cita & Premoli Silva, 1968; lower Sphaeroidinellopsis subdehiscens s.s.--Globigerina druryi partial-range zone of Banner & Blow, 1965c; S. Cipirello Marl; Sicily, Italy; Serravallian, middle Miocene).

G. adamantea Saito, 1963 (pl. 54, fig. 4; G. fohsi s.s. zone; lower Numazawa Formation; Honshu, Japan; Burdigalian, lower Miocene).

G. bella Jenkins, 1967 (fig. 3/1--3; 1971, pl. 10, figs. 257--259; Globigerinoides trilobus s.s. zone; north North Island, New Zealand; Awamoan, Pareoran, lower Miocene).

G. extans Jenkins, 1960 (pl. 4, fig. 5; Globoquadrina dehiscens s.s. zone; Victoria, Australia; upper-upper Oligocene or lower-lower Miocene).

G. humerosa Takayanagi & Saito, 1962 (p. 28, fig. 1; Stainforth & others, 1975, fig. 170/1; G. cultrata s.s./Globigerina nepenthes zone; Nobori Formation; Skikoku, Japan; Tortonian, upper Miocene; =Globigerina dutertrei d'Orbigny acc. Jenkins, 1971).

G. involuta Pezzani, 1963 (pl. 32, fig. 11; north Italy; Messinian, upper Miocene).

G. lupeae Martínez Díaz, 1970 (pl. 1, fig. 3 acc. Martínez Díaz in Saito & others, 1973; southeast Spain; Andalusian, upper Miocene).

G. mayeri Cushman & Ellisor, (March) 1939 (pl. 2, fig. 4; Blow, 1969, pl. 3, figs. 7--9; Louisiana, U.S.A.; middle Miocene; =Globigerina siakensis LeRoy acc. Stainforth & others, 1975).

G. mayeri nympha Jenkins, 1967 (fig. 3/7--9; 1971, pl. 12, figs. 318--320; G. mayeri s.s. zone; southwest South Island, New Zealand; Waiauan, Southland, upper-middle Miocene).

G. miniacea Bermúdez & Bolli, 1969 (pl. 11, figs. 10--12; G. (Turborotalia) acostaensis s.s.--G. (G.) merotumida partial-range zone or G. (G.) tumida plesiotumida consecutive-range zone of Banner & Blow, 1965c acc. Blow, 1969; Cerro Verde Member, Cubagua Formation; northeast Venezuela; upper Miocene).

G. nana pseudocontinuosa Jenkins, 1967 (fig. 4/20--22; 1971, pl. 12, figs. 336--338; Globigerina woodi connecta zone; north North Island, New Zealand; Otaian, Pareoran, lower-lower Miocene).

G. opima continuosa Blow, 1959 (pl. 19, fig. 125; Blow, 1969, pl. 3, figs. 4--6; Valvulineria herricki zone of Renz, 1948; base of G. mayeri/Globigerina nepenthes subzone, Globorotalia mayeri s.l.; base of Globigerina nepenthes/Globorotalia (Turborotalia) siakensis concurrent-range zone of Banner & Blow, 1965c acc. Blow, 1969; Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; Vindobonian, upper-middle Miocene).

G. pseudopachyderma Cita, Premoli Silva, & Rossi, 1965 (pl. 31, fig. 6; G. menardii/Globigerina nepenthes zone; Rio Mazzapiedi Series; north Italy; type Tortonian, upper Miocene).

G. (Turborotalia) rikuchuensis Takayanagi & Oda in Takayanagi & others, 1976 (pl. 1, fig. 4; Ichinoseki II zone; Globigerina nepenthes/Globorotalia (Turborotalia) siakensis concurrent-range zone of Banner & Blow, 1965c; upper Shimokurosawa Formation; Japan; middle Miocene).

Pulleniatina praepulleniatina Brönnimann & Resig, 1971 (pl. 20, figs. 2, 3; Globorotalia (G.) tumida plesiotumida consecutive-range zone of Banner & Blow, 1965c; southwest Pacific Ocean; upper Miocene).

New phena

Pulleniatina mayeri umbilicata n. subsp.

Holotype. UQF 72218. Pl. 17, fig. 26. Orbulina suturalis zone; foraminifer-rich calcareous-nannofossil chalk, unit 1; D.S.D.P.208/21/3/73--75/RS3, 318.73--318.75 m below sea-floor; lower-middle Miocene. Moderate in size, robust; elevated sinistral trochospire, slightly loose parallel to axis, tight perpendicular to axis. Equatorial outline circular, very weakly lobate; lateral outline spiroconvex. Chambers ovate, closely appressed, about 13 in total, 4¾ in final whorl; increase moderate then very slow after fifth-last chamber. Dorsal view: chambers longer concentrically, moderately inflated; sutures weakly depressed; intercameral sutures radial. Ventral view: chambers weakly inflated; intercameral sutures radial, meeting at tight umbilicus; aperture umbilical, low, pushed distally, with a thick lip. Lateral view: dorsoperipheral shoulder weakly compressed, otherwise moderately smoothly rounded. Wall densely perforate, heavily encrusted in early chambers of the final whorl. Length, 280 µm; width, 270 µm; height, 180 µm.

Material. Common.

Derivation of name. Latin, umbilicatus, navel-like, umbilical.

Pulleniatina mayeri plana n. subsp.

Holotype. UQF 72241. Pl. 18, fig. 3. Upper G. mayeri zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/18/2/1--3/RS2, 232.51--232.53 m below sea-floor; upper-middle Miocene. Small, robust; low sinistral trochospire, tight parallel and perpendicular to axis. Equatorial outline circular, weakly lobate; lateral outline umbilicoconvex. Chambers ovate, closely compressed, about 14 in total, 5½ in final whorl; increase moderate; last chamber reduced. Dorsal view: chambers longer concentrically, barely inflated; sutures barely depressed; intercameral sutures radial to directed and curved posteriorly. Ventral view: chambers inflated; intercameral sutures radial, some curved posteriorly at distal end, meeting at slightly open umbilicus. Lateral view: smoothly rounded, though umbilical shoulder slightly acute in final chamber; aperture umbilical--extraumbilical, low. Wall smooth with moderately dense pores especially towards periphery; dorsal side thickened, obscuring early chambers. Length, 180 µm; width, 160 µm; height, 105 µm.

Material. Common.

Derivation of name. Latin, planus, flat.

Pulleniatina mayeri juvenis n. subsp.

Holotype. UQF 72245. Pl. 18, fig. 7. G. continuosa zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/17/2/74--76/RS1, 224.24--224.26 m below sea-floor; upper Miocene. Small, fairly robust; low sinistral trochospire, tight parallel and perpendicular to axis. Equatorial outline oval, weakly lobate; lateral outline compressed, weakly umbilicoconvex. Chambers ovate, closely appressed, at least 8 in total, 4½ in final whorl; increase moderate. Dorsal view: chambers slightly longer concentrically, barely inflated; sutures slightly depressed; intercameral sutures radial. Ventral view: chambers moderately inflated; intercameral sutures radial meeting at slightly open umbilicus. Lateral view: smoothly rounded; aperture umbilical--extraumbilical, comma shaped, highest peripherally. Wall smooth; sparse small pores; very minor development of interpore ridges ventrally. Length, 115 µm; width, 95 µm; height, 60 µm.

Material. Common.

Derivation of name. Latin, juvenis, young.

Pulleniatina mayeri polygonia n. subsp.

Holotype. UQF 72258. Pl. 18, fig. 20. Globigerina nepenthes zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/14/4/74--76/RS1, 162.24--162.26 m below sea-floor; upper Miocene. Small, fairly robust; low sinistral trochospire, tight parallel and perpendicular to axis. Equatorial outline oval, moderately lobate; lateral outline compressed, weakly umbilicoconvex. Chambers ovate, moderately closely appressed, about 14? in total, 4¼ in final whorl; increase moderate. Dorsal view: chambers slightly longer concentrically, barely inflated; sutures barely depressed; intercameral sutures radial. Ventral view: chambers inflated; intercameral sutures radial, meeting at slightly open umbilicus. Lateral view: smoothly rounded. Wall coarsely and deeply reticulose. Length, 160 µm; width, 140 µm; height, 110 µm.

Material. Common.

Derivation of name. Greek. polys, many; gonia (f.), angle, corner.

Phena recorded

Phenon bella (Jenkins). Pl. 17, figs. 17, 18. This phenon partially pseudomorphs the smoother-walled Globorotalia praemenardii phenon bykovae (Aisenstadt) in its faintly sinuous ventral intercameral sutures and moderately flattened spiral side.

Phenon acrostoma (Wezel). Pl. 17, figs. 19, 20. Vs ph. bella: aperture very distinctly comma shaped. The holotypes of phena acrostoma and semivera (Hornibrook) are very similar. If the specimens of the latter figured by Berggren & Amdurer (1973, pl. 27, figs. 16--19) are correctly assigned, phenon semivera is much more inflated, has shallower ventral intercameral sutures, more-closely-appressed chambers, and an aperture which is moderately high throughout its extension from the umbilicus toward the periphery. These two phena may be separated stratigraphically (that is, not linked by intergrading stratigraphically intermediate specimens assignable to either phenon).

Phenon *siakensis* (LeRoy). Pl. 17, figs. 21--23, 32, 33. Vs ph. *bella*: ventral intercameral sutures straight; umbilicus open; chambers less closely appressed; usually larger with more chambers in the final whorl; aperture sometimes higher and lip not as well developed.

Phenon *umbilicata* n. ph. Pl. 17, figs. 24--27. Vs ph. *siakensis*: aperture umbilical. These specimens typically have 4½ to 5 chambers in the final whorl, a low aperture, tight to weakly open umbilicus, small to moderate size, and commonly a flattened spire of the initial whorls. Intermediates to ph. *siakensis* have a final chamber which is displaced slightly ventrally with an umbilical aperture closing off the umbilical--extraumbilical aperture of the previous chamber.

Phenon *partimlabiata* (Ruggieri & Sprovieri). Pl. 17, figs. 34--36. Vs ph. *acrostoma*: dorsal side flatter; chambers more closely appressed; ventral intercameral sutures shallower and slightly sinuous; exterior surface smoother; umbilicus tighter; chamber increase quicker and more regular. The authors of this phenon appear to place primary distinction for its identity on the development distally of an inversion of the apertural lip. It is used here, however, to document intermediates between phena *acrostoma* and *mayeri*.

Phenon *mayeri* (Cushman & Ellisor). Pl. 17, figs. 37, 38, 44--46; pl. 18, fig. 1. Vs ph. *partimlabiata*: aperture much lower though still can be weakly comma shaped as in the holotype; usually more chambers (>5½) in the final whorl; chamber increase quicker; chambers longer radially. Vs ph. *siakensis*: aperture weakly to moderately elevated but elevation laterally restricted, often producing a weak comma shape; dorsal intercameral sutures distinctly curved; chambers more closely appressed; ventral intercameral sutures slightly sinuous; dorsal side flatter; chamber increase quicker and more regular.

Phenon *continuosa* (Blow). Pl. 17, figs. 28--30. Vs ph. *bella*: fewer (4) chambers in the final whorl; ventral intercameral sutures straight. Vs ph. *acrostoma*: fewer chambers in the final whorl; chambers more closely appressed; aperture lower. Specimens from middle- and upper-Miocene parts of the sections examined have weakly comma-shaped apertures and moderately well-separated chambers like the holotype. Lowermost-Pliocene individuals, however, have more-inflated more-closely-appressed chambers with quite low apertures; also some specimens have a higher-than-normal aperture, though not as high as *P. helicina* phenon *nigriniae* (Fleisher).

Phenon *nympha* (Jenkins). Pl. 17, fig. 31. Vs ph. *bella*: final chamber reduced; smaller; straight ventral intercameral sutures.

Phenon *plana* n. ph. Pl. 18, figs. 2--4, 6. Vs ph. *mayeri*: dorsal surface of chambers distinctly flattened; aperture very low and slit-like; chamber increase slow; final chamber small; chambers closely appressed; moderately inflated ventrally. Vs ph. *nympha*: dorsal surface of chambers distinctly flattened; chambers moderately inflated ventrally; ventral intercameral sutures slightly sinuous. This phenon serves as an intermediate between phena *mayeri* and *acostaensis*.

Phenon *pseudopachyderma* (Cita, Premoli Silva & Rossi). Pl. 18, fig. 13. Vs ph. *nympha*: ventral intercameral sutures straight; chambers more closely appressed and usually few in the final whorl (4 vs 4½); aperture extends to umbilicus which is slightly wider; in ph. *nympha* the umbilicus is tight, the aperture begins proximally as a very low slit, and ventral intercameral sutures are shallower.

Phenon *juvenis* n. ph. Pl. 17, fig. 39; pl. 18, figs. 5, 7--10, 14, 15. Vs juvenile ph. *mayeri*: chambers well separated and more spherical; ventral intercameral sutures deeper. Morphologic variation of *P. mayeri* and *P. helicina* assemblages is particularly difficult to document by a set of strictly defined phena. Various morphologic criteria appear to show trends in both space and time which are less correlated than is typical of foraminiferal plankton. Also, unidirectional trends do not operate for long periods of time or over large geographic distances but show minor and major reversals quite frequently. There is also less than typical relationship between adult and juvenile morphology shown by the minor change in juvenile morphology with time and space. Moreover, not only are juveniles of *P. mayeri* and *P. helicina* very similar to each other, but also they show little difference in shape and size from various ontogenetic stages of other species which do retain their general shape through life (for example, *Toddella grata* (Todd) and *Tenuitella postcretacea* (Myatiuk)). Juvenile

Globorotaloides variabilis Bolli and *Neoacarinina altispira* (Cushman & Jarvis) can also be very similar.

The observations necessary to overcome misidentification of small specimens are more likely to be made if they are separately documented. Phenon *juvenis* is used here for most of the juveniles of *P. mayeri* and *P. helicina* and the following variation is allowed: small; thin walled; 4 to 5½ chambers in the final whorl; aperture usually umbilical--extraumbilical, low to moderately high, sometimes with a weak lip; spiral side moderately inflated to flattened; umbilicus closed to moderately wide; wall surface smooth to weakly polygonal around pores. Increase in the number of chambers per whorl results in a wider umbilicus, better-separated chambers, deeper ventral intercameral sutures, slow chamber increase, more flattened spiral side. Separation from various ontogenetic stages of *Toddella grata* and *Tenuitella postcretacea* can be difficult and is usually achieved by noting the complete lack of polygonal development on the wall surface of these latter species.

Phenon *miniacea* (Bermúdez & Bolli). Pl. 18, fig. 19. Vs ph. *continuosa*: aperture low, slit-like; chambers more closely appressed; ventral intercameral sutures shallower; wall usually more thickened; chambers usually more inflated ventrally; usually smaller. The size of the holotype seems in doubt: maximum dimension given by the authors is 160 µm, but magnification given with illustration suggests 440 µm.

Phenon *acostaensis* (Blow). Pl. 17, figs. 40--43; pl. 18, figs. 11, 12, 16. Vs ph. *plana*: ventral side at least slightly inflated. Vs ph. *pseudopachyderma*: more chambers in the final whorl; usually larger. Vs ph. *continuosa*: more chambers in the final whorl; aperture a low slit, usually with a lip; usually larger. Vs ph. *siakensis*: umbilicus closed; chambers closely appressed, more inflated; aperture not elevated. Vs ph. *nympha*: ventral intercameral sutures straight; usually larger; usually more chambers in the final whorl.

Phenon *globorotaloidea* (Colom). Vs ph. *acostaensis*: coil slightly looser allowing chambers which are more spherical, show a slightly increased progression in spiral height, and are more inflated ventrally; higher aperture tending to be more restricted to umbilicus; final chamber often displaced ventrally; umbilicus more open. Use of this phenon is difficult as no primary type has been designated or illustrated in detail; the illustrated syntypes show considerable variation. It is used here for individuals occurring above the lowest occurrence of phenon *acostaensis* and apparently in the same sense as Tjalsma (1971) and Brönnimann & Resig (1971).

Phenon *humerosa* (Takayanagi & Saito). Vs ph. *acostaensis*: umbilicus open and wide; aperture more extensive and connects with relict aperture of previous chamber; more chambers in the final whorl; chambers are more radially elongate.

Phenon *polygonia* n. ph. Pl. 18, figs. 20, 21, 26, 27. Vs ph. *juvenis*: wall surface with well-developed polygonal rims around pores. These distinctive individuals are rarer than phenon *juvenis*. They were at first thought to be juvenile *Globorotaloides* species or *Neoacarinina altispira* (Cushman & Jarvis). However, juveniles of *Globorotaloides* species are very similar in shape to their adults (wide umbilicus, flatened dorsal side, low umbilical--extraumbilical aperture) and *N. altispira* juveniles have an umbilical aperture, loose coil, and wide umbilicus.

Phenon *praepulleniatina* Brönnimann & Resig. Pl. 18, fig. 28. Vs ph. *humerosa*: last chambers show distinct inflation and extension, both dorsally and especially ventrally, concealing the umbilical opening.

Pulleniatina helicina phenon *tegillata* (Brönnimann & Resig). Pl. 18, figs. 17, 18.

P. helicina phenon *praehumerosa* (Natori). Pl. 18, fig. 22.

P. helicina phenon *planispira* (Brönnimann & Resig). Pl. 18, fig. 29.

P. helicina phenon *subcretacea* (Łomnicki). Pl. 18, figs. 23--25.

Pulleniatina obliqueloculata (Parker & Jones)

Included phena

Globigerina antillensis Bermúdez, 1960 (pl. 1, fig. 1; Nicholas Channel, north of Cuba; Holocene; =*Pullenia sphaeroides* var. *obliqueloculata* Parker & Jones acc. Stainforth & others, 1975).

Pullenia sphaeroides var. *obliqueloculata* Parker & Jones, 1865 (see Bolli & others, 1957; Banner & Blow, 1960b, pl. 7, fig. 4; 1967, pl. 3, fig. 4; Stainforth & others, 1975, fig. 186/1; off southeast Brazil, west South Atlantic Ocean; Holocene).

Pulleniatina obliqueloculata finalis Banner & Blow, 1967 (pl. 3, fig. 5; Stainforth & others, 1975, fig. 166/1, near Ascension Is., South Atlantic Ocean; Holocene).

P. obliqueloculata praecursor Banner & Blow, 1967 (pl. 3, fig. 3; upper *Sphaeroidinella dehiscens* s.s./*Globoquadrina altispira* s.s. concurrent-range zone of Banner & Blow, 1965c; unit 59 of Cushman & Stainforth, 1951, Borbón Formation; Ecuador; lower Pliocene).

P. obliqueloculata trochospira Hartono, 1964 (text-fig. 8; Bali, Indonesia; upper Miocene or Pliocene; =*Pullenia sphaeroides* var. *obliqueloculata* Parker & Jones acc. Stainforth & others, 1975).

P. okinawaensis Natori, 1976 (pl. 5, fig. 5; *Globorotalia* (*G.*) *truncatulinoides* s.s. Partial-range Zone; Chinen Sand, Ryukyu Group; Ryukyu Islands, Japan; lower Pleistocene).

P. primalis Banner & Blow, 1967 (pl. 3, fig. 2; Stainforth & others, 1975, fig. 197/1; upper *Globorotalia* (*G.*) *tumida* s.s.--*Sphaeroidinellopsis subdehiscens paenedehiscens* partial-range zone; Bowden Formation; Jamaica; lowermost Pliocene).

P. spectabilis Parker, 1965 (text-fig. 1; *Sphaeroidinella dehiscens* s.s./*Globoquadrina altispira* s.s. concurrent-range zone of Banner & Blow, 1965c; south of Nauru, west South Pacific Ocean; lower Pliocene).

P. spectabilis praespectabilis Brönnimann & Resig, 1971 (pl. 19, figs. 4, 7; 'N20 (including N19) of Blow, 1969'; north of Papua New Guinea, southwest Pacific Ocean; lower Pliocene).

Phena recorded

Phenon *spectabilis* Parker. Pl. 19, figs. 26, 27.

Phenon *primalis* Banner & Blow. Pl. 19, figs. 9--11, 13--16, 28, 34--38, 42; pl. 20, figs. 13, 15. Vs *P. mayeri* ph. *praepulleniatina*: smooth surface in all chambers of the final whorl.

Phenon *praecursor* Banner & Blow. Pl. 19, figs. 17--21, 30, 32, 39, 40, 43--45; pl. 20, figs. 5--7, 14. Vs ph. *primalis*: primary aperture reaches periphery.

Phenon *praespectabilis* Brönnimann & Resig. Pl. 19, figs. 22, 31. Vs ph. *primalis*: dorsoperipheral shoulder angular, not smoothly rounded.

Phenon *okinawaensis* Natori. Pl. 19, figs. 12, 23--25, 29, 33, 41, 46; pl. 20, figs. 1, 8--10, 16--19. Vs ph. *primalis*: aperture restricted distally, better developed umbilically; chambers more globular, better separated, less laterally compressed; smaller; deeper ventral intercameral sutures; smooth outer wall thin or absent; usually fewer chambers in the final whorl.

Phenon *finalis* Banner & Blow. Pl. 20, figs. 24--27. Vs ph. *obliqueloculata*: dorsally involute.

Phenon *obliqueloculata* (Parker & Jones). Pl. 20, figs. 2--4, 11, 12, 20--22, ?23. Vs ph. *praecursor*: proximal ventral suture between last and opposite chambers of the final whorl is straight.

Remarks

The appearance of *P. obliqueloculata* at both sites examined is rather abrupt. However, at Site 208 the divergence of assemblages would appear to occur near the boundary of the *Globigerina nepenthes* and *Globorotalia conomiozea* zones of Kennett (1973).

Pulleniatina helicina (d'Orbigny)

Included phena

Globigerina atlantica Berggren, 1972 (pl. 2, fig. 8; lower *Globorotalia inflata* zone; west of U.K., North Atlantic Ocean; upper Pliocene).

G. cryophila Herman, 1980b (replacement name for *G. occlusa* Herman).

G. dubia Egger, 1857 (figured syntype: pl. 9, figs. 7--9; southwest West Germany; Miocene).

G. dutertrei d'Orbigny, 1839a (Banner & Blow, 1960b, pl. 2, fig. 1; Stainforth & others, 1975, fig. 163/1; Cuba; Holocene).

G. eggeri Rhumbler, 1901 (Brady, 1884, pl. 79, fig. 17a; Banner & Blow, 1960b, pl. 2, fig. 4; northeast of Juan Fernández Is., east South Pacific Ocean; Holocene; =*G. dutertrei* d'Orbigny acc. Cifelli, 1961, Fleisher, 1974, Stainforth & others, 1975).

G. eggeriformis McCulloch, 1977 (pl. 171, fig. 9; off San Clemente Is., off California, U.S.A., northeast Pacific Ocean; Holocene).

G. flosculus Voloshinova, 1960 (pl. 29, fig. 12; lower Nutovo Formation; Sakhalin, U.S.S.R.; lower Pliocene).

G. galapagoensis McCulloch, 1977 (pl. 171, fig. 8; off Hood Is., Galapagos Islands, east central Pacific Ocean; Holocene).

G. hancocki McCulloch, 1977 (pl. 172, fig. 6; James Is., Galapagos Islands, east central Pacific Ocean; Holocene).

G. helicina d'Orbigny, 1826 (Banner & Blow, 1960b, pl. 2, fig. 5; northeast Italy; Holocene).

G. hybrida McCulloch, 1977 (pl. 175, fig. 7; off San Nicolas Is., off California, U.S.A., northeast Pacific Ocean; Holocene).

G. incompta Cifelli, 1961 (pl. 4, fig. 1; east of U.S.A., west North Atlantic Ocean; Holocene; =G. dutertrei d'Orbigny non emended Banner & Blow acc. Cifelli, 1961).

G. occlusa Herman, 1974 (pl. 3, fig. 5; phase I of Herman, 1969; Arctic Ocean; Pleistocene; junior objective homonym of G. praebulloides occlusa Blow & Banner).

G. paraobesa Herman, 1974 (pl. 3, fig. 10; phase III of Herman, 1969; Arctic Ocean; Pleistocene).

G. partidiana McCulloch, 1977 (pl. 173, fig. 3; off Los Islets, North Isla Partida, Mexico, east Pacific Ocean; Holocene).

G. polusi Androsova, 1962 (text-fig. 15; Arctic Ocean; Holocene).

G. pyriporosa Rhumbler, 1911 (figured syntypes: pl. 31, figs. 1--4; Atlantic Ocean; Holocene).

G. rotundata d'Orbigny in Fornasini, 1899a (Banner & Blow 1960b, pl. 2, fig. 2; St Helena, South Atlantic Ocean; Holocene; =G. dutertrei d'Orbigny acc. Banner & Blow, 1960b).

G. subcretacea Chapman, 1902 (figured syntype: pl. 36, fig. 16; Tutanga Is., near Funafuti Is., South Pacific Ocean; Holocene; junior objective homonym of G. subcretacea Łomnicki).

G. subcretacea Łomnicki, 1901 (Brady, 1884, pl. 82, fig. 10?; Blow, 1969, pl. 4, figs. 18--20; northeast of Ki Islands, Indonesia; Holocene).

Globoquadrina asanoi Maiya, Saito, & Sato, 1976 (pl. 3, fig. 1; Globigerina pachyderma (dextral)/Globorotalia orientalis zone; Nomura Mudstone, Funakawa Formation; north Honshu, Japan; upper Pliocene).

G. himiensis Maiya, Saito, & Sato, 1976 (pl. 4, fig. 1; Globigerina pachyderma (dextral)/Globorotalia orientalis zone; lower Yabuta Formation; Honshu, Japan; basal Pleistocene).

G. kagaensis Maiya, Saito, & Sato, 1976 (pl. 3, fig. 6; Globigerina pachyderma (dextral)/Globorotalia orientalis zone; lower Yabuta Formation; Honshu, Japan; basal Pleistocene).

Globorotalia apertura Pezzani, 1963 (pl. 30, fig. 1; north Italy; Messinian, upper Miocene or lower Pliocene; =Globigerina dutertrei d'Orbigny acc. Jenkins, 1971).

G. ikebei Maiya, Saito, & Sato, 1976 (pl. 1, fig. 4; G. ikebei/O. universa zone; Shiiya Formation; Honshu, Japan; upper Pliocene).

G. seigliei Bermúdez & Bolli, 1969 (pl. 18, figs. 1--3; northeast Venezuela; Holocene).

G. (Turborotalia) acostaensis pseudopima Blow, 1969 (pl. 35, figs. 1--3; G. (T.) tosaensis tenuitheca consecutive-range zone of Banner & Blow, 1965c; Sarmi Formation; north Irian Jaya; upper Pliocene).

G. (T.) acostaensis tegillata Brönnimann & Resig, 1971 (pl. 33, fig. 3; G. (G.) tumida s.s.--Sphaeroidinellopsis subdehiscens paenedehiscens partial-range zone of Banner & Blow, 1965c; southwest Pacific Ocean; basal Pliocene; =G. acostaensis Blow acc. Stainforth & others, 1975).

G. (T.) humerosa praehumerosa Natori, 1976 (pl. 2, fig. 1; G. (T.) humerosa s.s.--G. (T.) tosaensis Interval Zone; G. (G.) multicamerata--Pulleniatina obliqueloculata s.s. partial-range zone of Blow, 1969; Yonabaru Formation, Shimajiri Group; Okinawa, Ryukyu Islands, Japan, west North Pacific Ocean; Pliocene).

G. (T.) planispira Brönnimann & Resig, 1971 (pl. 44, fig. 4; Stainforth & others, 1975, fig. 193/1; G. (T.) tosaensis tenuitheca consecutive-range zone of Banner & Blow, 1965c; southwest Pacific Ocean; upper Pliocene).

G. (T.) pliocenica Minstretta, 1962 (pl. 9, fig. 6; Sicily, Italy; lower Pliocene).

G. (T.) pseudopumilio Brönnimann & Resig, 1971 (pl. 43, fig. 4; G. (T.) tosaensis tenuitheca consecutive-range zone of Banner & Blow, 1965c; north of Papua New Guinea, southwest Pacific Ocean; upper Pliocene).

Neogloboquadrina dutertrei andamanica Srinivasan & Azmi, 1976 (pl. 2, fig. 4; Globorotalia tosaensis tenuitheca zone; Silty Mudstone Member, Neill West Coast Formation; Neill Is., Andaman Islands, northeast Indian Ocean; upper Pliocene).

N. dutertrei blowi Rögl & Bolli, 1973 (replacement name for Globigerina subcretacea).

Turborotalia (T.) nigriniae Fleisher, 1974 (pl. 20, figs. 1--3; upper Globorotalia (G.) tumida s.s.--Sphaeroidinellopsis subdehiscens paenedehiscens partial-range zone of Banner & Blow, 1965c; Laccadive Sea, north Indian Ocean; basal Pliocene).

T. (T.) vincentae Fleisher, 1974 (pl. 21, figs. 1--3; Globorotalia (G.) tumida s.s.--Sphaeroidinellopsis subdehiscens paenedehiscens partial-range zone of Banner & Blow, 1965c; Laccadive Sea, north Indian Ocean; basal Pliocene).

Phena recorded

Pulleniatina mayeri phenon continuosa (Blow). Pl. 18, figs. 39, 40, 50.

P. mayeri phenon pseudopachyderma (Cita, Premoli Silva, & Rossi).

P. mayeri phenon juvenis n. ph. Pl. 18, figs. 30, 38, 51, 52.

P. mayeri phenon miniacea (Bermúdez & Bolli). Pl. 18, fig. 41.

P. mayeri phenon acostaensis (Blow). Pl. 18, figs. 42, 43.

P. mayeri phenon globorotaloidea (Colom). Pl. 18, figs. 31, 44, 45, 69.

P. mayeri phenon humerosa (Takayanagi & Saito). Pl. 18, fig. 78?

P. mayeri phenon polygonia n. ph. Pl. 18, figs. 46, 53, 59, 79.

Phenon tegillata (Brönnimann & Resig). Vs P. mayeri ph. acostaensis: apertural flap present which is a relatively thin-walled extension covering the umbilicus and distinct from the thicker and less extensive lip or flap developed in ph. acostaensis.

Phenon vincentae (Fleisher). Pl. 18, figs. 74, 101; pl. 19, fig. 1. Vs P. mayeri ph. miniacea: much more inflated closely appressed chambers (ventrally and dorsally); larger. Vs P. mayeri ph. continuosa: much more inflated closely appressed chambers; larger; aperture a very low but extensive slit; ventral intercameral sutures shallower. Vs P. mayeri ph. acostaensis: much more inflated closely appressed chambers; usually larger size and fewer chambers in the final whorl. The specimens assigned here do not possess the flange of the holotype but their dorsal and ventral inflation is typical.

Phenon apertura (Pezzani). Pl. 18, figs. 60, 61. Vs P. mayeri ph. humerosa: chambers much more inflated, spherical, well separated; aperture much higher throughout its extent; fewer chambers in the final whorl; more rapid chamber increase; ventral intercameral sutures deeper.

Phenon praehumerosa (Natori). Pl. 18, fig. 63. Vs P. mayeri ph. acostaensis: aperture more extensive (higher and longer, highest near periphery); wider umbilicus; usually more chambers in the final whorl and these are fairly equal in size, including the last chamber. Vs P. mayeri ph. humerosa: umbilicus tighter; chambers of the final whorl not bunched up like the latter which thus has more chambers per whorl with greater radial elongation.

Phenon pseudopima (Blow). Pl. 21, fig. 1. Vs all other related phena: aperture extends over periphery and is almost symmetrical; highly inflated.

Phenon planispira (Brönnimann & Resig). Pl. 18, figs. 32, 64, 71, 72, 80, 81, 88, 89; pl. 19, fig. 2. Vs P. mayeri ph. globorotaloidea: dorsal side distinctly flattened; aperture usually lower, more extraumbilical; chambers usually more closely appressed; coiling usually tighter. Vs P. mayeri ph. plana: larger; umbilicus wider; chambers not as closely appressed; ventral intercameral sutures straight. Stratigraphically lower specimens tend to have a somewhat looser coil axially than the stratigraphically higher more-holotypical specimens; the lowest specimens have more-globular chambers with the final chamber displaced and an aperture which is moderately high and umbilical like P. mayeri ph. globorotaloidea.

Phenon pseudopumilio (Brönnimann & Resig). Pl. 18, figs. 33, 54, 75, 82. Vs ph. planispira: dorsal side not flattened; chambers in a lower regular coil (including final chamber); aperture usually higher especially near periphery; usually more chambers in the final whorl; chambers more elongate radially. Vs P. mayeri ph. juvenis: larger; wider umbilicus; aperture higher and more extensive distally.

Phenon andamanica (Srinivasan & Azmi). Pl. 21, fig. 2. Vs ph. dutertrei: umbilical shoulder elevated and angular.

Phenon atlantica (Berggren). Pl. 19, fig. 3. Vs ph. helicina: more inflated; umbilicus wider.

Phenon kagaensis (Maiya, Saito, & Sato). Pl. 18, figs. 55, 65, 73, 96. Vs P. mayeri phena continuosa and miniacea: chambers much more inflated; umbilicus wider; larger. Vs ph. miniacea and vincentae: aperture higher. Vs ph. nigriniae (Fleisher): aperture lower, extends onto wider umbilicus. The specimens assigned here have a tighter umbilicus than the holotype.

Phenon dutertrei (d'Orbigny). Pl. 18, figs. 95, 100; pl. 19, figs. 7, 8. Vs ph. helicina: wider umbilicus; usually much larger with much more inflated chambers. Vs ph. eggeri: fewer chambers in the final whorl; chambers not as radially elongate; umbilicus not as wide; no tendency to distal extension of aperture.

Phenon eggeri (Rhumbler). Pl. 18, figs. 94, 97--99; pl. 19, fig. 6. Vs ph. congesta: more chambers in the final whorl; much wider umbilicus; chambers better separated with deeper ventral intercameral sutures; aperture tends to be umbilical.

Phenon eggeriformis (McCulloch). Pl. 18, figs. 62, 68, 70. Vs ph. nigriniae (Fleisher): greater number of chambers in the final whorl (5 vs 4); chambers better separated, more spherical; ventral intercameral sutures deeper; aperture more extensive. These specimens resemble juvenile P. obliqueloculata which, however, attain their distinctive wall surface even at early ontogenetic stages.

Phenon helicina (d'Orbigny). Pl. 18, figs. 47, 48, 56, 66, 76, 93; pl. 19, figs. 4, 5. Vs P. mayeri ph. globorotaloidea: aperture umbilical, sometimes has tooth-shaped apertural flap; coiling loose. Vs P. mayeri ph. umbilicata: wider umbilicus; looser coiling; chambers better separated and more inflated; larger. These individuals were found to be very difficult to assign to commonly used phena. Stratigraphically lower specimens are early representatives of a trend to the umbilically apertured highly inflated living phena dutertrei and eggeri. Juveniles of these living phena also fit the morphologic criteria used here for phenon helicina. The primary type is only slightly less inflated and more tightly coiled perpendicular to the axis than that of phenon dutertrei; it is slightly longer in maximum dimension. The very large holotype of phenon atlantica seems to represent a larger more inflated phenon. At the other end of variation, phenon involuta (Pezzani) may be included within the criteria used herein, though it more likely represents smaller less inflated specimens with a low more extensive aperture.

Phenon hybrida (McCulloch). Pl. 18, figs. 83--87, 90--92. Vs ph. vincentae: more chambers in the final whorl; usually umbilicus wider and aperture higher; chamber increase slower (early chambers of the final whorl often larger than the later ones); larger. Vs ph. apertura: chambers closely appressed; ventral intercameral sutures very shallow; chamber increase slower; usually larger.

Phenon incompta (Cifelli). Pl. 18, figs. 57, 58, 67. Vs P. mayeri ph. juvenis: larger. Vs P. mayeri ph. globorotaloidea: thinner walled; fewer chambers in the final whorl. Vs ph. helicina: thinner walled; umbilicus tight; aperture lower and tends to be more extensive distally; tends to fewer chambers in the final whorl. This phenon is difficult to set limits for as some of its characteristic features (thin wall, tight umbilicus, few chambers per whorl) are encountered in juveniles and preadults of other phena.

Phenon polusi (Androsova). Pl. 18, fig. 37.

Phenon subcretacea (Łomnicki). Pl. 18, figs. 34--36, 49, 77. Vs ph. praehumerosa: fewer chambers in the final whorl; chambers better separated, more spherical; ventral intercameral sutures deeper; chamber increase regular and quicker. Vs ph. planispira: chambers spherical (including dorsally), better separated; aperture higher. Vs ph. apertura: umbilicus tight; aperture lower and more restricted, especially proximally; regular chamber increase; less inflated chambers.

CLADEGROUP(7) GLOBOROTALISEPTIMAE

Stem species. Globorotalia kugleri Bolli.

Globorotalia kugleri Bolli

Included phena

Globorotalia kugleri Bolli, 1957.
G. platispira de Klasz, Le Calvez, & Rerat, 1969.
G. (Turborotalia) mendacis Blow, 1969.
G. (T.) pseudokugleri Blow, 1969.

Remarks

This species represents the lower part of an amalgamation (Fleisher, 1974) of two of Blow's (1969) series: phenon mendacis--phenon pseudokugleri--phenon kugleri and 'Globorotalia (Turborotalia) peripheroronda forma α' and its descendants. Following Berggren (1968) it is considered descended from phenon siakensis individuals interpreted herein to have been part of G. opima assemblages. The lower limit of the species is taken at that of phenon mendacis, that is, the middle of Banner & Blow's (1965c) *Globigerina angulisuturalis*/*Globorotalia (Turborotalia) opima* s.s. concurrent-range zone.

Blowellus birnageae (Blow)

Included phenon

Globorotalia birnageae Blow, 1959 (pl. 17, fig. 108; *Siphogenerina transversa* zone of Renz, 1948; upper *Globigerinatella insueta*/*Globigerinoides bispherica* subzone, upper *Globigerinatella insueta* zone s.l.; lower Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; Aquitanian, upper-lower or lower-middle Miocene).

Phena recorded

Globorotalia kugleri phenon *kugleri* Bolli. Pl. 21, fig. 4. A single specimen with a flattened dorsal side and strongly recurved dorsal intercameral sutures is very tentatively assigned.

G. kugleri phenon *pseudokugleri* Blow. Pl. 21, fig. 3. Vs f. *kugleri*: straighter dorsal intercameral sutures; chambers more inflated, especially dorsally. A single specimen is very tentatively assigned.

Phenon *birnageae* (Blow). Pl. 21, fig. 5. Vs *G. kugleri* ph. *kugleri*: dorsal intercameral sutures not strongly recurved; very tight umbilicus; well-developed lip. Vs *G. kugleri* ph. *pseudokugleri*: very tight umbilicus; well-developed lip. The rarity of this and the other phena included in the *B. birnageae* assemblage recovered precludes any definite statement on variation. They appear distinct from *P. mayeri* individuals.

CLADEGROUP(6) GLOBOROTALISEXTAE

Stem species. *Globorotalia miozea* Finlay.

Globorotalia miozea Finlay

Included phena

Globorotalia archeomenardii Bolli, 1957 (pl. 28, fig. 11; *G. fohsi barisanensis* zone; middle Cipero Formation; Trinidad; middle Miocene; =*G. praemenardii* Cushman & Stainforth acc. Jenkins, 1971).

G. conica Jenkins, 1960 (pl. 4, fig. 3; *Canorbulina glomerosa circularis* zone; *Globigerinoides sicanus*--*Globigerinatella insueta* partial-range zone of Banner & Blow, 1965c; Victoria, Australia; upper-lower Miocene).

G. magnifica Bizon & Glaçon, 1978 (pl. 3, fig. 1; *Orbulina suturalis*--*G. (Turborotalia) peripheroronda* partial-range zone of Banner & Blow, 1965c; *G. peripheroronda*/*O. suturalis* zone of Bizon & others, 1972; *G. fohsi peripheroronda* zone; east of Menorca, Balearic Islands, Spain, west Mediterranean Sea; Langhian, lower-middle Miocene).

G. miozea Finlay, 1939 (fig. 159; Hornibrook, 1958, pl. 1, figs. 6--8; Jenkins, 1971, pl. 6, figs. 144--146; South Island, New Zealand; Clifdenian, upper-lower Miocene).

G. quinifalcata Saito & Maiya, 1973 (pl. 18, fig. 5; *Orbulina suturalis*--*G. (Turborotalia) peripheroronda* partial-range zone of Banner & Blow, 1965c; middle Hojuji Formation; Japan; lower-middle Miocene).

G. scitula praescitula Blow, 1959 (pl. 19, fig. 128; Saito & Maiya, 1973, pl. 18, fig. 7; Stainforth & others, 1975, fig. 140/4; *Robulus wallacei* zone of Renz, 1948; lower *Globigerinatella insueta*/*Globigerinoides trilobus* subzone, lower *Globigerinatella insueta* zone s.l.; *G. insueta*--*Globigerinoides quadrilobatus trilobus* partial-range zone of Banner & Blow, 1965c acc. Blow, 1969; Menicito Clay Member, Tocuyo Formation; northwest Venezuela; Aquitanian, lower Miocene; =*Pulvinulina scitula* Brady acc. Stainforth & others, 1975; =*Globorotalia scitula ventriosa* Ogniben acc. Parker, 1964?).

G. zealandica Hornibrook, 1958 (figs. 18, 19, 30; Jenkins, 1971, pl. 14, figs. 395--397; *Globigerinoides trilobus* s.s. zone; South Island, New Zealand; Awamoan, lower Miocene).

G. zealandica incognita Walters, 1965 (text-fig. 6a--c; east North Island, New Zealand; Awamoan, lower Miocene).

G. zealandica pseudomiozea Walters, 1965 (text-fig. 6p--r; east North Island, New Zealand; upper Awamoan, lower Miocene; =*G. zealandica* Hornibrook acc. Jenkins, 1971).

G. (*Turborotalia*) *peripheroacuta* Blow & Banner, 1966 (pl. 1, fig. 2; Blow, 1959, pl. 17, fig. 112; *Siphogenerina transversa* zone of Renz, 1948; *G. fohsi fohsi* zone, *G. fohsi* zone s.l. of Blow, 1959; lower Husito Marly-Clay Member, San Lorenzo Formation; northwest Venezuela; middle Miocene; =*G. fohsi* Cushman & Ellisor acc. Huang, 1976).

G. (*T.*) *peripheroronda* Blow & Banner, 1966 (pl. 1, fig. 1; Stainforth & others, 1975, fig. 119/1; *Siphogenerina transversa* zone of Renz, 1948; *G. fohsi barisanensis* subzone, *G. fohsi* zone s.l. of Blow, 1959; Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; lower Miocene; =*T. bykovae* Aisenstadt acc. Popescu, 1970, Popescu & Cioflica, 1973, this study).

T. lata Lipps, 1964 (pl. 3, fig. 3; Monterey Shale; California, U.S.A.; Luisian, Burdigalian, lower Miocene).

New phenon

Globorotalia miozea acumarginata n. subsp.

Holotype. UQF 72424. Pl. 21, fig. 8. *O. suturalis* zone; foraminifer-rich calcareous-nannofossil chalk; D.S.D.P.208/21/3/73--75/RS4, 318.73--318.75 m below sea-floor; lower-middle Miocene. Moderate in size, fairly robust; low dextral trochospire, very tight. Equatorial outline circular, weakly lobate; lateral outline biconvex, slightly higher umbilically. Chambers angular-rhomboid, strongly appressed, about 14 in total, 5 in final whorl; increase moderate. Dorsal view: chambers longer concentrically, flat; sutures flush, nonlimbate or very weakly limbate; intercameral sutures directed and smoothly curved posteriorly. Ventral view: chambers weakly inflated; intercameral sutures radial tending to curve posteriorly at distal end, moderately depressed, meeting at tight umbilicus; aperture umbilical--extraumbilical, interiomarginal, very low, slit-like, with thick lip. Lateral view: dorsoperipheral shoulder sharply angular; ventral face and umbilical shoulder gently and smoothly rounded; terminal face and apertural face weakly concave. Wall smooth with dense small pores. Length, 325 µm; width, 280 µm; height, 140 µm.

Material. Common.

Derivation of name. Latin, *acuo*, make pointed, sharpen; *margo*, *-inis*, border, edge; *-atus*, pertaining to.

Phena recorded

Phenon *praescitula* Blow. Pl. 21, fig. 6.

Phenon *quinifalcata* Saito & Maiya. Pl. 21, fig. 7. This phenon is used for distinctive abundant (at Site 208) intermediates between phenon *praescitula* or *Globorotalia praemenardii* phenon *minima* Akers and *G. praemenardii* phenon *bykovae* (Aisenstadt). Larger specimens are probably early representatives of a trend resulting in *Obandyella ventriosa* phenon *suterae* (Catalano & Sprovieri). The very similar phena, '*Globorotalia* (*Turborotalia*) *rikuchuensis* Takayanagi & Oda' and '*G. ikebei* Maiya, Saito, & Sato', are very tentatively considered pseudomorphs belonging to *Pulleniatina* species.

Phenon *acumarginata* n. ph. Pl. 21, fig. 8. Vs ph. *praescitula*: very sharply angled periphery. Vs ph. *archeomenardii* & *G. praemenardii* ph. *praemenardii*: without distinct imperforate thickening. Blow's (1959) hypothesis of the gradual acquisition of a thick keel in *G. cultrata* phenon *cultrata* (d'Orbigny), found in assemblages of *G. limbata* (d'Orbigny) herein, from unkeeled phenon *praescitula* still seems tenable. However, the holotypes of both phenon *archeomenardii* and *G. praemenardii* phenon *praemenardii*, Blow's intermediate phena in this trend, each have a well-developed keel in the outer whorl; Blow's observation of a lack of limbation in earlier whorls is accepted here, pending further investigation of the types.

Phenon *archeomenardii* Bolli. Pl. 21, fig. 9. Vs ph. *acumarginata*: keeled periphery.

Phenon *magnifica* Bizon & Glaçon. Pl. 21, fig. 10. Vs ph. *archeomenardii*: circular less lobate equatorial outline; chambers concentrically longer.

Phenon *peripheroacuta* Blow & Banner.

Globorotalia praemenardii phenon *minima* Akers.

G. praemenardii phenon *conoidea* Walters. Pl. 21, fig. 11.

G. praemenardii phenon *bykovae* (Aisenstadt).

G. praemenardii phenon *rifensis* Feinberg & Lorenz.

G. limbata phenon *lenguaensis* Bolli.

Obandyella ventriosa phenon *ventriosa* (Ogniben).

O. ventriosa phenon *perconigi* (Martínez Díaz).

Fohsella fohsi (Cushman & Ellisor)

Included phena

Globorotalia barisanensis LeRoy 1939 (pl. 1, figs. 8--10; Blow & Banner 1966, pl. 1, fig. 7; transitional zone; lower Palembang Formation acc. Blow & Banner, 1966; Sumatra, Indonesia; middle Miocene; =*G. fohsi* Cushman & Ellisor acc. Blow & Banner, 1966).

G. dominicana Bermúdez in Thalmann, 1950 (replacement name for *G. lobata* Bermúdez).

G. fohsi Cushman & Ellisor, 1939 (pl. 2, fig. 6; Blow & Banner, 1966, pl. 1, fig. 5; lower Bigenerina nodosaria directa--Cibicides carstensi zone; Lousiana, U.S.A.: middle Miocene).

G. fohsi robusta Bolli, 1950 (pl. 15, fig. 2; upper G. fohsi zone; upper Cipero Formation; Trinidad; middle Miocene).

G. lobata Bermúdez, 1949 (pl. 22, fig. 17; Blow & Banner, 1966, text-fig. 4/1; Stainforth & others, 1975, fig. 118/1; Trinchera Formation; Dominican Republic; middle Miocene).

G. (G.) praefohsi Blow & Banner, 1966 (pl. 1, fig. 4; G. fohsi zone of Renz, 1948; G. fohsi lobata zone, G. fohsi zone s.l. of Blow, 1959; Husito Marly-Clay Member, Pozon Formation; northwest Venezuela; middle Miocene; =G. fohsi Cushman & Ellisor acc. Huang, 1976).

Phena recorded

Globorotalia miozea phenon peripheroacuta Blow & Banner.

Phenon praefohsi (Blow & Banner). Pl. 21, fig. 13. Vs Globorotalia miozea ph. peripheroacuta: last chambers have keeled periphery.

Phenon fohsi (Cushman & Ellisor). Pl. 21, fig. 14. Vs ph. praefohsi: all chambers of final whorl keeled.

Phenon lobata (Bermúdez). Pl. 25, fig. 3. Vs ph. fohsi: equatorial outline distinctly lobate due to greater radial elongation of chambers.

Remarks

The split of this species at Site 77B is estimated to occur in the upper Globorotalia fohsi peripheroronda zone of Jenkins & Orr (1972) and appears to coincide with the lowest occurrence of phenon praefohsi, which defines the base of Banner & Blow's (1965c) G. (G.) praefohsi consecutive-range zone.

CLADEGROUP(5) GLOBOROTALIQUINTAE

Stem species. Globorotalia praemenardii Cushman & Stainforth.

Globorotalia praemenardii Cushman & Stainforth

Included phena

Globorotalia canariensis var. minima Akers, 1955 (pl. 65, figs. 3a--c; Saito & Maiya, 1973, pl. 18, fig. 8; Cibicides carstensi var. opimus zone; Louisiana, U.S.A.: middle Miocene).

G. miozea conoidea Walters, 1965 (text-fig. 8j--l; east North Island, New Zealand; Lillburnian or Waiauan, middle Miocene).

G. miozea rifensis Feinberg & Lorenz, 1973 (pl. 1, figs. 1--3; G. miozea rifensis subzone, Orbulina s.l. zone; northern Morocco; middle Miocene).

G. petaliformis Boltovskoy, 1974 (pl. 14, fig. 1; Orbulina suturalis--G. (Turborotalia) peripheroronda partial-range zone to G. (G.) fohsi partial-range zone of Banner & Blow, 1965c; central Indian ocean; middle Miocene).

G. praemenardii Cushman & Stainforth, 1945 (pl. 13, fig. 14; Blow, 1969, pl. 6, figs. 1--3; Stainforth & others, 1975, fig. 134/6; zone III, G. fohsi zone; Cipero Formation; Trinidad; middle Miocene).

G. scitula gigantea Blow, 1959 (pl. 16, fig. 127; Valvulineria herricki zone of Renz, 1948; base of G. mayeri/G. lenguaensis subzone, base of G. mayeri zone s.l.; Sphaeroidinellopsis subdehiscens s.s.--Globigerina druryi partial-range zone of Banner & Blow, 1965c; Husito Marly-Clay Member, Pozón Formation; northwest Venezuela; Vindobonian, middle Miocene; =Pulvinulina scitula Brady acc. Jenkins, 1971, Stainforth & others, 1975).

G. (G.) ichinosekiensis Takayanagi & Oda in Takayanagi & others, 1976 (pl. 1, fig. 1; Ichinoseki II zone, Globigerina nepenthes/Globorotalia (Turborotalia) siakensis concurrent-range zone of Banner & Blow, 1965c; upper Shimokurosawa Formation, Japan; middle Miocene; =G. archeomenardii Bolli acc. this study).

G. (G.) iwaiensis Takayanagi & Oda in Takayanagi & others, 1976 (pl. 1, fig. 2; Ichinoseki I zone; Sphaeroidinellopsis subdehiscens s.s.--Globigerina druryi partial-range zone of Banner & Blow, 1965c; upper Shimokurosawa Formation, Japan; middle Miocene; =Globorotalia dalii Perconig acc. this study).

Turborotalia bykovae Ira Markovia Aisenstadt in Subbotina & others, 1960 (pl. 13, fig. 7; Bogorodchan Formation; Ukrainian S.S.R.; Helvetian ?or lower Tortonian, middle Miocene).

Phena recorded

Globorotalia miozea phenon praescitula Blow.

G. miozea phenon quinifalcata Saito & Maiya.

G. miozea phenon acumarginata n. ph.

G. miozea phenon archeomenardii Bolli.

G. miozea phenon magnifica Bizon & Glaçon.

Phenon minima Akers. Pl. 21, fig. 15. Vs G. miozea ph. quinifalcata: chambers concentrically shorter. In terms of shape only, this name can be applied to juveniles of several other phena. In G. miozea assemblages specimens are included which are transitional in shape to Obandyella ventriosa phenon ventriosa and resemble O. scitula phenon subscitula but which do not possess as open an umbilicus as the latter.

Phenon conoidea Walters. Low-occurring specimens (Site-208 lowest-two samples studied herein) have quite low umbilical sides compared to the holotype and are weakly keeled. A wide range of variation is, however, allowed as the characteristic thickening reduces the number of features available for finer division.

Phenon bykovae (Aisenstadt). Pl. 21, fig. 16. Vs G. miozea ph. peripheracuta: periphery rounded (not acutely compressed) in last chambers.

Phenon gigantea Blow. Pl. 21, fig. 17. Vs G. miozea ph. praescitula: larger; periphery more rounded; usually more chambers in the final whorl.

Phenon praemenardii Cushman & Stainforth. Pl. 21, fig. 18. Vs G. miozea ph. archeomenardii: chamber arrangement within coil not flexed like latter, that is, chambers inclined umbilically away from coiling axis; usually larger. Vs G. miozea ph. magnifica: equatorial outline lobate, ovoid rather than circular.

Phenon rifensis Feinberg & Lorenz. Pl. 21, fig. 19. Vs ph. conoidea: not as thickened; larger; more chambers per whorl; less inflated ventrally and thus more bioconvex; chambers concentrically shorter.

Obandyella ventriosa phenon ventriosa (Ogniben). Pl. 21, fig. 20.

Globorotalia limbata phenon lenguaensis Bolli.

G. limbata phenon pseudomiocenica Bolli & Bermúdez.

G. limbata phenon merotumida Blow & Banner.

O. ventriosa phenon suterae (Catalano & Sprovieri). Pl. 21, fig. 23. Vs ph. gigantea, distinctly rounded periphery and inflated chambers. Most of the individuals assigned here seem intermediate to 'G. nicolae Catalano & Sprovieri' which is included within O. ventriosa phenon suterae.

O. ventriosa phenon praemargaritae (Catalano & Sprovieri).

O. ventriosa phenon perconigi (Martínez Díaz). Pl. 21, fig. 12. Vs Obandyella ventriosa ph. ventriosa: tight umbilicus, more chambers in final whorl, usually slower chamber increase. Vs Blowellus birnageae ph. birnageae: latter has smoothly rounded periphery. The type level (Andalusian) of this phenon is correlated with the upper Miocene and is thus much higher than its occurrence herein.

G. limbata phenon dalii Perconig. Pl. 21, fig. 21.

G. limbata phenon subconomiozea Bandy. Pl. 21, fig. 22.

CLADEGROUP(2) OBANDYELLISECUNDAE

Obandyella ventriosa (Ogniben)

Included phena

Globorotalia juanae Bermúdez & Bolli, 1969 (pl. 14, figs. 4--6; Stainforth & others, 1975, fig. 173/1; Globigerina nepenthes/Globorotalia (Turborotalia) siakensis concurrent-range zone or G. (T.) continuosa consecutive-range zone of Banner & Blow, 1965c acc. Blow, 1969; Carenero Formation; Venezuela; upper-middle or lower-upper Miocene).

G. nicolae Catalano & Sprovieri, 1971 (pl. 2, fig. 1; G. tumida plesiotumida zone?; gessoso-solififera formation; Sicily, Italy; Sahelian, lower Messinian, lower-upper Miocene).

G. perconigi Martínez Díaz, 1970 (pl. 1, fig. 2; southeast Spain; Andulusian, upper Miocene).

G. praemargaritae Catalano & Sprovieri, 1969 (pl. 1, fig. 5; G. tumida plesiotumida zone; Sicily, Italy; Sahelian, lower-upper Miocene; =G. juanai Bermúdez & Bolli acc. Stainforth & others, 1975).

G. scitula ventriosa Ogniben, 1958 (pl. 15, fig. 4; lower Flysch di Moleta; southwest Italy; upper Helvetian, upper-middle Miocene; =Pulvinulina scitula Brady acc. Stainforth & others, 1975).

G. suterae Catalano & Sprovieri, 1971 (pl. 1, fig. 1; G. acostaensis--G. merotumida zone or lower G. tumida plesiotumida zone; Sicily, Italy; Sahelian, lower Messinian, lower-upper Miocene).

G. (Turborotalia) exserta Romeo, 1969 (pl. 1, fig. 1; Sicily, Italy; upper Tortonian, upper Miocene).

New phena

Obandyella ventriosa astricticamerata n. subsp.

Holotype. UQF 72442. Pl. 21, fig. 26. Globigerina nepenthes zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/14/4/74--76/RS3, 162.24--162.26 m below sea-floor; upper Miocene. Moderate in size, robust; low sinistral trochospire, very tight. Equatorial outline oval, barely lobate; lateral outline biconvex. Chambers rhomboid, extremely appressed, at least 13 in total, 6 in final whorl, 5 in second-last whorl; increase slow, regular. Dorsal view: chambers nearly circular, slightly longer concentrically, flat; sutures flush; spiral sutures limbate to second-last chamber; intercameral sutures nonlimbate, directed and smoothly curved posteriorly. Ventral view: chambers weakly inflated; sutures slightly depressed, curved posteriorly, meet at closed umbilicus; aperture umbilical--extraumbilical, interiomarginal, low, slit-like, with thick lip. Lateral view: dorsoperipheral shoulder compressed, rounded; dorsal and ventral surfaces of final chamber rounded; earlier chambers keeled. Wall smooth, densely and finely perforate; pustules near aperture. Length, 275 µm; width, 235 µm; height, 140 µm.

Material. Common.

Derivation of name. Latin, astrictus, tight; camera, chamber; -atus, provided with.

Obandyella ventriosa evexa n. subsp.

Holotype. UQF 72443. Pl. 21, fig. 27. As for O. ventriosa astricticamerata. Moderate in size, fairly robust; slightly elevated sinistral trochospire, tight. Equatorial outline circular though slightly oval, weakly lobate; lateral outline moderately convex dorsally, moderately truncated ventrally. Chambers angular-truncate, closely appressed, at least 11 in total, $4\frac{3}{4}$ in final whorl; increase moderate; final chamber reduced. Dorsal view: chambers longer concentrically, barely inflated; sutures generally flush; intercameral sutures directed anteriorly then recurved posteriorly 1/3 toward periphery, nonlimbate, tend to be depressed distally as posterior portion of next chamber is inclined below anterior portion of previous chamber. Ventral view: chambers moderately highly inflated; intercameral sutures depressed, curved posteriorly and then may be recurved anteriorly, producing a slightly sinuous shape, meet at tight umbilicus; aperture umbilical--extraumbilical, interiomarginal, low, with a thin lip. Lateral view: dorsal side of final chamber flat, slightly concave; dorsoperipheral shoulder rounded but compressed; ventral face and terminal face concave; umbilical shoulder smoothly rounded. Wall smooth, densely and finely perforate; pustules near aperture. Length, 360 µm; width 350 µm; height, 250 µm.

Material. Nine specimens.

Derivation of name. Latin, evexus, rounded at the top.

Phena recorded

Phenon ventriosa (Ogniben). Vs Globorotalia miozea ph. praescitula: ventrally inflated. These specimens are most common at Site 208 in clusters of G. praemenardii where rare forms approach a morphology virtually identical to the holotype: moderate size, fairly angular periphery, approximately 5 chambers in the final whorl. However, most specimens recovered have 4 to $4\frac{1}{2}$ chambers in the final whorl, a rather rounded periphery, and a small size, and are generally similar to G. miozea phenon conica Jenkins.

Phenon praemargaritae (Catalano & Sprovieri). Pl. 21, fig. 24.

Phenon astricticamerata n. ph. Pl. 21, fig. 26. Vs ph. praemargaritae & G. limbata ph. lenguanensis: chambers more closely appressed (especially spirally), less inflated; periphery more acute.

Phenon evexa n. ph. Pl. 21, fig. 27. Vs ph. praemargaritae: specimens with $4\frac{1}{2}$--5 chambers in the final whorl have concentrically longer chambers; anterior spiral face of each chamber distinctly raised above posterior spiral face of next chamber at their common dorsal intercameral suture. These phena are presumably early members of a trend eventually giving rise to Deshayesulus puncticulatus (Deshayes).

Deshayesulus puncticulatus phenon obturoaperturus n. ph. Pl. 21, fig. 25.

Obandyella hirsuta phenon *primitiva* (Cita). Pl. 21, fig. 29.
O. hirsuta phenon *margaritae* (Bolli & Bermúdez).
O scitula phenon *subscitula* (Conato).
O. scitula phenon *scitula* (Brady). Pl. 21, fig. 28.

Remarks

O. ventriosa and *G. limbata* clusters appear to separate in the upper *Globorotalia mayeri* zone of Kennett (1973) at Site 208 and in the middle *Globoquadrina altispira* zone of Jenkins & Orr (1972) at Site 77B.

Deshayesulus puncticulatus (Deshayes)

Included phena

Globigerina inflata d'Orbigny, 1839b (Banner & Blow, 1967, pl. 4, fig. 1; Stainforth & others, 1975, fig. 171/1; west of Western Sahara, North Atlantic Ocean; Holocene).

G. nipponica Asano, 1957 (pl. 1, figs. 1--3; Kii Channel between Shikoku and Honshu, Japan; Holocene).

G. puncticulata Deshayes, 1832 (Banner & Blow, 1960b, pl. 5, fig. 7; Stainforth & others, 1975, fig. 199/1; northeast Italy; Holocene).

G. punctulata d'Orbigny in Fornasini, 1899a (lectotype as for *G. puncticulata* Deshayes).

G. trigonula d'Orbigny in Fornasini, 1903 (figured syntype: pl. 1, fig. 2; Saint Helena, South Atlantic Ocean; Holocene).

Globorotalia bononiensis Dondi, 1963 (fig. 41/1; Stainforth & others, 1975, fig. 156/1; north Italy; middle Pliocene).

G. inflata praeinflata Maiya, Saito, & Sato, 1976 (pl. 2, fig. 7; north-North Pacific Ocean; lower Pleistocene).

G. inflata triangula Theyer, 1973 (pl. 1, fig. 1; Stainforth & others, 1975, fig. 208/1, Tasman Sea, southwest Pacific Ocean; Pleistocene; =*G. trigonula* d'Orbigny acc. this study).

G. orientalis Maiya, Saito, & Sato, 1976 (pl. 1, fig. 5; *G. pachyderma* (dextral)/*Globorotalia orientalis* zone; Nishiyama Formation; Honshu, Japan; lower Pleistocene).

G. oscitans Todd, 1958 (pl. 1, fig. 23; southeast of Sardinia, Mediterranean Sea; Quaternary).

G. puncticulata padana Dondi & Papetti, 1968 (pl. 3, fig. 1; north Italy; Pliocene).

G. (Turborotalia) praeoscitans Akers, 1972 (pl. 50, fig. 2; *G. (G.) tumida* s.s.--*Sphaeroidinellopsis subdehiscens paenedehiscens* partial-range zone or *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone of Blow, 1969; Yorktown Formation; Virginia, U.S.A.; Zanclian or Astian, lower Pliocene).

New phenon

Deshayesulus puncticulatus obturoaperturus n. subsp.

Holotype. UQF 72447. Pl. 21, fig. 30. *Globorotalia margaritae* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/10/4/74--76/RS2, 98.24--98.26 m below seafloor; lower Pliocene. Moderate in size, robust; elevated sinistral trochospire, tight. Equatorial outline weakly quadrilobate; lateral outline slightly convex dorsally, moderately truncate ventrally. Chambers globular-truncate, moderately closely appressed, about 13 in total, 4 in final whorl. Dorsal view: chambers much longer concentrically, weakly inflated; sutures slightly depressed; intercameral sutures directly posteriorly but close to radial, quickly curved posteriorly near periphery. Ventral view: chambers highly inflated, sutures radial to curved posteriorly, meet at slightly open umbilicus; aperture an umbilical--extraumbilical interiomarginal very low slit. Lateral view: dorsoperipheral shoulder rounded; dorsal side of final chamber slightly concave; ventral face, umbilical shoulder, and apertural face smoothly rounded, convex, and high. Wall smooth but densely pustulose. Length, 295 µm; width, 275 µm; height, 195 µm.

Material. Common.

Derivation of name. Latin, *obturo*, *-atus*, close up; *apertura*, an opening; *-us*, adjectival termination.

Phena recorded

Phenon *obturoaperturus* n. ph. Pl. 21, fig. 30. The origin of this phenon was poorly sampled at Site 208 in this study. However, small rare individuals in the *Globigerina nepenthes* zone of Kennett (1973) are very close to specimens of *Obandyella ventriosa* and are included within this species at that level. The gradual increase in height of the aperture and a trend toward a more planoconical shape results in phenon padanus. Nomenclaturally these phena have produced considerable disagreement among workers, especially from one region to another. Those that use phenon puncticulatus for individuals preceding phenon inflatus probably refer to phenon obturoaperturus or phenon padanus. Berggren's (1977b, fig. 19) 'Globorotalia cibaoensis to G. puncticulata' lineage was probably part of the same species as that preserved at the Sites studied here, though there would seem to be differences in the phena involved.

Phenon padanus (Dondi & Papetti). Pl. 21, fig. 31. Vs ph. obturoaperturus: aperture higher; planoconvex; axial profile more angular; highest part of umbilical face close to umbilicus (not halfway to periphery); in the latter the umbilical face is proximal to the highest part and is inclined regularly toward the umbilicus, producing a similar feature to that in Globoquadrina tripartita ph. dehiscens.

Phenon oscitans (Todd). Pl. 22, fig. 2. Vs ph. padanus: larger more circular aperture; periphery more rounded.

Phenon inflatus (d'Orbigny). Pl. 22, fig. 1. Vs ph. padanus: periphery more angular (latter is more rounded though still compressed); less planoconvex; larger. Vs ph. oscitans: much larger; aperture not circular or as relatively high; latter has only 3½ chambers in the final whorl.

Phenon nipponicus (Asano). Pl. 22, fig. 5. Vs ph. puncticulatus and inflatus: last chamber very small.

Phenon puncticulatus (Deshayes). Pl. 22, fig. 4. Vs ph. inflatus: last few chambers smaller than expected from previous chamber increase.

Phenon trigonulus (d'Orbigny). Pl. 22, fig. 3. Vs ph. inflatus: 3 chambers in the final whorl; more planoconvex; flatter spiral side; periphery more angular; low slit-like aperture.

Remarks

The phylogeny of this species and similar phena belonging to the Truncorotalitertiae has been interpreted variously. Differences of opinion appear to reflect mainly the regions where these species have been examined and so different schemes exist for New Zealand, the Mediterranean, and tropical areas. Although much of the variation is the result of past clines (see Chaproniere, 1973), it is tentatively considered herein that these phena belong to species of quite different origins. The difficulties produced by this pseudomorphy are exemplified by the change of interpretation of these phena from the work of Berggren & Amdurer (1973) to the more recent proposals of Berggren (1977a, b).

The strongest but not conclusive evidence presented herein for the proposed evolution of Obandyella ventriosa to D. puncticulatus is the occurrence, in the middle Globigerina nepenthes zone of Kennett (1973) at Site 208, of rare individuals, phenon obturoaperturus, with a crassiform shape. These are similar to ventrally inflated O. ventriosa specimens at the same level. However, more importantly, they occur well below the lowest occurrence of pseudomorphic specimens, which result from reduction of the keel, occurring in assemblages of Truncorotalia crassula (Cushman & Stewart) and Gallerius crassaformis (Galloway & Wissler). This interpretation of a late-Miocene crassaform lineage seems to have been supported subsequently, with regard to availability to the writer, by Blow's (1979, p. 220) revised identification of taxa belonging to his 'Globorotalia (Turborotalia) crassaformis stock'.

At Site 208 D. puncticulatus appears to separate from O. ventriosa between the top of the Globigerina nepenthes zone and the middle of the G. margaritae zone of Kennett (1973).

CLADEGROUP(1) OBANDYELLIPRIMAE

Stem species. Obandyella cibaoensis (Bermúdez).

Obandyella cibaoensis (Bermúdez)

Included phena

Globorotalia cibaoensis Bermúdez, 1949 (pl. 22, fig. 23; Mao Formation; Dominican Republic, upper Miocene).

G. martinezi Perconig, 1968 (pl. 6, fig. 10; Spain; upper Tortonian, upper Miocene).

G. miroensis Perconig, 1968 (pl. 7, fig. 14; Spain; upper Tortonian, upper Miocene).

Phenon recorded

Obandyella ventriosa phenon praemargaritae (Catalano & Sprovieri).

O. ventriosa phenon astricticamerata n. ph.

O. ventriosa phenon evexa n. ph.

Phenon cibaoensis (Bermúdez). Pl. 22, fig. 6. Vs O. ventriosa ph. praemargaritae: acute periphery in last few chambers.

O. hirsuta phenon primitiva (Cita).
O. hirsuta phenon margaritae (Bolli & Bermúdez).
(O. hirsuta phenon evoluta (Cita). Pl. 25, fig. 4.)
O. scitula phenon subscitula (Conato).
O. hirsuta phenon praehirsuta (Blow).
O. hirsuta phenon hirsuta (d'Orbigny).
O. scitula phenon scitula (Brady).

Remarks

The phylogenetic occurrences and morphologic affinities of Perconig's (1968) two phena included in this species are difficult to estimate mainly because of their morphologic similarity to phena of the Globorotaliquartae. However, Perconig appears to consider them both close to phena of Obandyella.

Obandyella hirsuta (d'Orbigny)

Included phena

Globoquadrina patriciae McCulloch, 1977 (pl. 193, fig. 9; off Funchal, Madeira, east central North Atlantic Ocean; Holocene).

Globorotalia hirsuta eastropacia Boltovskoy, 1974a (pl. 1, fig. 1; west of Colombia, east Indian Ocean; Holocene).

G. margaritae Bolli & Bermúdez, 1965 (1978, pl. 1, fig. 1; G. margaritae zone; upper G. (Turborotalia) acostaensis s.s.--G. (G.) merotumida partial-range zone to Sphaeroidinella dehiscens s.s.--Globoquadrina altispira s.s. partial-range zone of Banner & Blow, 1965c acc. Blow, 1969; Las Hernandez bed, Cubagua Formation; Venezuela; upper Miocene or lower Pliocene).

G. margaritae evoluta Cita, 1973 (pl. 1, fig. 1; G. margaritae evoluta lineage-zone; west Mediterranean Sea; Pliocene).

G. margaritae primitiva Cita, 1973 (pl. 2, figs. 2, 3; Stainforth & others, 1975, fig. 173/7; G. margaritae evoluta lineage-zone; west Mediterranean Sea; Pliocene; =G. juanai Bermúdez & Bolli acc. Stainforth & others, 1975).

G. (G.) hirsuta praehirsuta Blow, 1969 (pl. 43, figs. 4, 5; Stainforth & others, 1975, fig. 195/1; Sphaeroidinella dehiscens s.s.--Globoquadrina altispira s.s. partial-range zone of Banner & Blow, 1965c; west Italy; lower Pliocene).

G. (Hirsutella) theyeri Fleisher, 1974 (pl. 13, figs. 1, 2; ?Globigerina calida s.s.--Sphaeroidinella dehiscens excavata assemblage-zone of Blow, 1969; Laccadive Sea, north Indian Ocean; upper Quaternary).

Rotalina hirsuta d'Orbigny, 1839b (Blow, 1969, pl. 8, figs. 1--3; Stainforth & others, 1975, fig. 169/1; west of Western Sahara, North Atlantic Ocean; Holocene).

Phena recorded

Phenon primitiva (Cita). Vs O. ventriosa ph. astricticamerata: chambers better separated, fewer in the final whorl. Vs O. cibaoensis ph. cibaoensis: periphery angular in early chambers of the final whorl. Vs O. ventriosa ph. praemargaritae: periphery more acute; chambers less inflated; tends to more elongate equatorial outline and axial flexure. Vs ph. margaritae: slower more regular chamber increase (for example, final chamber only just larger than second-last chamber); keel very weak or absent; flexing much weaker; fewer chambers in the final whorl. Specimens intermediate from phenon astricticamerata pseudomorph Globorotalia limbata phenon panda Jenkins.

Phenon margaritae (Bolli & Bermúdez). Pl. 22, fig. 7. Some assemblages, mostly of Pliocene age, contain specimens typical in all respects except for the loss of a keel; these may prove useful as separate phena.

Phenon evoluta (Cita). Vs ph. margaritae: less elongated equatorial outline; slow chamber increase; not distinctly flexed. Vs ph. primitiva: distinctly keeled.

Phenon praehirsuta (Blow). Pl. 22, fig. 8. Vs ph. margaritae: much less flexure. Vs ph. praemargaritae: fewer chambers in the final whorl; quicker chamber increase; stronger keel. Vs ph. evoluta: more elongate equatorial outline. Vs ph. hirsuta: tight umbilicus.

Phenon hirsuta (d'Orbigny). Pl. 22, fig. 9.

Remarks

O. hirsuta appears to separate from *O. cibaoensis* between the middle *Globorotalia puncticulata* zone and the middle *G. crassaformis* zone of Kennett (1973) at Site 208.

Obandyella scitula (Brady)

Included phena

Globigerina? depressa d'Orbigny in Fornasini, 1903 (only remaining syntype: Banner & Blow, 1960b, pl. 5, fig. 6; Saint Helena, South Atlantic Ocean; Holocene; junior objective homonym of *G. depressa* Ehrenberg).

Globorotalia bermudezi Rögl & Bolli, 1973 (pl. 6, fig. 17; pl. 16, figs. 2, 3; text-fig. 6; zone Z of Ericson & Wollin, 1968; *G. fimbriata* subzone, *G. truncatulinoides* s.s. zone; north of Venezuela; Holocene; =*G. scitula subscitula* Conato acc. this study).

G. nicobarica Srinivasan & Sharma, 1969 (text-figs. 1--3; *G.* (*G.*) *tumida* s.s.--*Sphaeroidinellopsis subdehiscens* partial-range zone or *Sphaeroidinella dehiscens* s.s./*Globoquadrina altispira* s.s. concurrent-range zone; Sawai Bay Formation; Car Nicobar Is., Bay of Bengal, north Indian Ocean; lower Pliocene).

G. scitula subscitula Conato, 1964 (pl. 2, fig. 16; Torrente Savena sequence; north Italy; lower Pliocene).

Pulvinulina scitula Brady, 1882 (Banner & Blow, 1960b, pl. 5, fig. 5; Stainforth & others, 1975, fig. 140/6; Faeroe Channel, North Atlantic Ocean; Holocene).

Rotalina canariensis d'Orbigny, 1839b (Banner & Blow, 1960b, pl. 5, fig. 4; Canary Islands, North Atlantic Ocean; Holocene).

Phena recorded

Obandyella ventriosa phenon *praemargaritae* (Catalano & Sprovieri).

O. ventriosa phenon *evexa* n. ph.

Phenon *subscitula* (Conato). Pl. 22, fig. 10. Vs *O. ventriosa* ph. *praemargaritae*: smaller; more open umbilicus; chambers less inflated both spirally and ventrally; dorsal side lower; chambers better separated. The interpretation of this phenon by Blow (1969: pl. 3, figs. 1--3, maximum diameter 405 µm; pl. 39, fig. 8, maximum diameter 530 µm) would appear to be in error and included moderately large specimens tending to greater than four chambers in the final whorl (here included in *O. ventriosa* phena *praemargaritae* and *scitula*). The holotype is only about 240 µm in maximum diameter. There is a tendency to flattened spiral sides and correspondingly inflated umbilical sides, especially in the upper Miocene and lower Pliocene.

Phenon *scitula* (Brady). Vs *Globorotalia praemenardii* ph. *gigantea*: more lobate; concentrically longer chambers; looser coiling. Vs *O. ventriosa* ph. *ventriosa*: not as ventrally inflated. Vs *O. ventriosa* ph. *praemargaritae*: fewer chambers in the final whorl; concentrically longer chambers. Vs *O. ventriosa* ph. *evexa*: in the latter the umbilical faces of the chambers (especially the last few) meet the periphery almost at right angles, whereas the spiral faces are only slightly inflated (periphery still angular). Vs ph. *subscitula*: larger; thicker walled; fewer chambers in the final whorl; usually slightly lower umbilically and higher spirally; concentrically longer chambers.

CLADEGROUP(4) GLOBOROTALIQUARTAE

Stem species. *Globorotalia limbata* (d'Orbigny).

Globorotalia limbata (d'Orbigny)

Included phena

Globorotalia dalii Perconig, 1968 (pl. 6, fig. 1; Spain; Andalusian, upper Miocene).

G. hemisphaerica Bizon & Bizon, 1971 (pl. 5, fig. 1; *G.* cf. *humerosa* zone; south Spain; upper Tortonian or Messinian, upper Miocene).

G. lenguaensis Bolli, 1957 (pl. 29, fig. 5; Stainforth & others, 1975, fig. 127/2; *G. menardii* zone; Lengua Formation; Trinidad; upper-middle Miocene).

G. menardii var. *miocenica* Palmer, 1945 (pl. 1, fig. 10; Stainforth & others, 1975, fig. 180/1; upper *G.* (*Turborotalia*) *acostaensis* s.s.--*G.* (*G.*) *merotumida* partial-range zone to *G.* (*G.*) *multicamerata*--*Pulleniatina obliqueloculata* s.s. partial-range zone acc. Blow, 1969; Bowden Formation; Jamaica; Vindobonian, upper-middle or lower-upper Miocene?).

G. menardii miotumida Jenkins, 1960 (pl. 4, fig. 9; *G. menardii miotumida* zone; Victoria, Australia; upper-middle or lower-upper Miocene).

G. menardii panda Jenkins, 1960 (pl. 4, fig. 10; base of *G. menardii miotumida* zone; Victoria, Australia; upper-middle or lower-upper Miocene).

G. miocenica mediterranea Catalano & Sprovieri, 1969 (pl. 2, fig. 6; G. tumida plesiotumida zone; Sicily, Italy; Sahelian, upper Miocene).

G. miotumida explicationis Jenkins, 1967 (fig. 4/4--16; 1971, pl. 5, figs. 129--131; G. miotumida s.s. zone; North Island, New Zealand; Tongaporutuan, Taranakian, upper-middle or upper Miocene).

G. pseudomiocenica Bolli & Bermúdez, 1965 (pl. 1, figs. 13--15; G. menardii zone; G. (Turborotalia) continuosa consecutive-range zone of Banner & Blow, 1965c acc. Blow, 1969; Carenero Formation, Venezuela; upper-middle or lower-upper Miocene).

G. saheliana Catalano & Sprovieri, 1971 (pl. 1, fig. 3; Sicily, Italy; Sahelian, Messinian, upper Miocene).

G. saphoae Bizon & Bizon, 1965 (pl. 4, fig 9; northwest Greece; Tortonian, middle Miocene?; =G. miozea sphericomiozea Walters acc. Jenkins, 1971).

G. (Globoconella) conomiozea subconomiozea Bandy, 1975 (pl. 1, fig. 1; east Indian Ocean; upper Messinian, ?Kapitean, upper-upper Miocene or lower Pliocene).

G. (Globorotalia) merotumida Blow & Banner in Banner & Blow, 1965b (text-fig. 1; 1967, pl. 4, fig. 4; Blow, 1969, pl. 9, figs. 4--6; G. menardii s.s./Globigerina nepenthes zone of Blow, 1959; Cubagua Formation; Venezuela; upper-middle or lower-upper Miocene).

G. (G.) paralenguaensis Blow, 1969 (pl. 46, figs. 3--6; basal G. (Turborotalia) acostaensis s.s.--G. (G.) merotumida partial-range zone: lower Muruan Formation; Papua New Guinea; upper Miocene).

G. (G.) tumida plesiotumida Blow & Banner in Banner & Blow, 1965b (text-fig. 2; 1967, pl. 4, fig. 3; Blow, 1969, pl. 9, figs. 7--9; Stainforth & others, 1975, fig. 194/1; Sphaeroidinella seminulina zone of Blow, 1959; Cubagua Formation; Venezuela; upper Miocene).

Rotalia limbata d'Orbigny in Fornasini, 1902 (Banner & Blow, 1960b, pl. 5, fig. 3; northeast Italy; ?Tortonian, upper Miocene).

New phena

Globorotalia limbata latiumbilicata n. subsp.

Holotype. UQF 72466. Pl. 22, fig. 17. Globorotalia continuosa zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/17/2/74--76/RS3, 224.24--224.26 m below sea-floor; upper Miocene. Very large, robust; low sinistral trochospire, very tight. Equatorial outline circular, very weakly lobate; lateral outline biconvex, umbilical side higher. Chambers angular-rhomboid, very closely appressed, about 17 in total, 6½ in final whorl; increase slow. Dorsal view: chambers much longer concentrically, flat; sutures flush; intercameral sutures strongly directed anteriorly then recurved posteriorly 1/3 way to periphery, leaving posterior portion of next chamber extending along peripheral border; distal spiral suture and distal portion of intercameral sutures of final whorl limbate. Ventral view: chambers moderately inflated; sutures radial or curved posteriorly, not meeting because of wide umbilicus. Lateral view: periphery keeled; dorsal side of final chamber weakly convex; ventral face weakly and irregularly convex; umbilical shoulder subacutely recurved close to umbilicus; aperture an umbilical--extraumbilical interiomarginal low slit except weakly raised near periphery; keel thick in early chambers of the final whorl. Wall densely perforate, smooth, but heavily pustulose in early chambers of the final whorl. Length, 750 μm; width, 625 μm; height, 360 μm.

Material. Eight specimens.

Derivation of name. Latin, latus, broad, wide; umbilicatus (m.), navel; -us, adjectival termination .

Globorotalia limbata conferta n. subsp.

Holotype. UQF 72468. Pl. 23, fig. 2. Upper Globorotalia continuosa zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/16/1/74--76/RS3, 194.74--194.76 m below sea-floor; upper Miocene. Moderately large, robust; low dextral trochospire, very tight. Equatorial outline circular, virtually nonlobate; lateral outline biconvex, umbilical side more convex. Chambers angular-truncate, very closely appressed, about 17 in total, 7 in final whorl; increase very slow. Dorsal view: chambers slightly longer concentrically, flat; sutures flush; intercameral sutures directed anteriorly or radially, recurved posteriorly halfway to periphery; spiral suture of last-1½ whorls and last-3 intercameral sutures strongly limbate and thus raised. Ventral view: chambers moderately inflated; intercameral sutures radial then curved posteriorly at distal end, nearly meet at moderately open umbilicus. Lateral view: periphery keeled, thick in early chambers of final whorl; dorsal face slightly convex; ventral face slightly concave; umbilical shoulder smoothly rounded; aperture an umbilical--extraumbilical interiomarginal low slit with thick lip. Wall densely and finely perforate, pustulose near aperture. Length, 300 µm; width, 275 µm; height, 150 µm.

Material. Common.

Derivation of name. Latin, *confertus*, dense, crowded.

Globorotalia limbata oregope n. subsp.

Holotype. UQF 72469. Pl. 23, fig. 3. *Globigerina nepenthes* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/14/4/74--76/RS3, 162.24--162.26 m below sea-floor; upper Miocene. Moderately large, robust; slightly elevated sinistral trochospire, tight. Equatorial outline circular, very weakly lobate; lateral outline moderately convex dorsally, moderately vaulted ventrally. Chambers angular-truncate, closely appressed, at least 10 in total, 5 in final whorl; increase moderate. Dorsal view: chambers longer concentrically, flat; sutures flush; intercameral sutures directed and smoothly curved posteriorly; spiral suture and last-2 intercameral sutures of final whorl limbate. Ventral view: chambers highly inflated; intercameral sutures shallow, sinuous, meet at slightly open umbilicus; aperture umbilical--extraumbilical, interiomarginal, low. Lateral view: periphery keeled, fairly thick in early chambers of final whorl; dorsal face slightly convex; ventral face concave adjacent to keel, then smoothly convex; umbilical shoulder smoothly rounded; final chamber reduced. Wall finely and densely perforate, pustulose near aperture. Length, 335 µm; width 335 µm; height, 225 µm.

Material. Common.

Derivation of name. Greek, *orego*, stretch out; *ope* (f.), opening, hole.

Globorotalia limbata consutila n. subsp.

Holotype. UQF 72472. Pl. 23, fig. 6. Top of *Globigerina nepenthes* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/13/5/74--76/RS2, 145.74--145.76 m below sea-floor; upper Miocene. Moderate in size, robust; slightly elevated sinistral trochospire, tight. Equatorial outline barely lobate; lateral outline biconvex, more convex ventrally. Chambers angular-truncate, closely appressed, 3¾ in final whorl; increase slow. Dorsal view: chambers longer concentrically, flat; last intercameral suture directed and curved posteriorly, limbate; all other features obscured by thickening. Ventral view: chambers inflated; intercameral sutures shallow, curved, meeting at nearly closed umbilicus; aperture an extensive umbilical--extraumbilical interiomarginal slit, slightly raised near periphery. Lateral view: heavily keeled periphery; dorsal face slightly concave; ventral face nearly flat; umbilical shoulder smoothly rounded, highest close to umbilicus. Wall finely and densely perforate, heavily encrusted. Length, 385 µm; width, 360 µm; height, 330 µm.

Material. Common.

Derivation of name. Latin, *consutilis*, sewed together.

Phena recorded

Globorotalia praemenardii phenon *minima* Akers.

G. praemenardii phenon *conoidea* Walters.

G. praemenardii phenon *rifensis* Feinberg & Lorenz.

Phenon *lenguaensis* Bolli. Pl. 22, fig. 11. Vs *Hirsutella ventriosa* ph. *perconigi*: concentrically shorter chambers. This is used for specimens with a tight umbilicus, noncarinate but acute periphery, and a circular equatorial outline. Assignment to this phenon must remain doubtful until the type assemblage is better understood. For example, the small size and numerous chambers in the final whorl of the holotype appear to be quite rare features if previously figured and the present material are considered. Also, the drawing of the umbilical view suggests a (poorly developed) keel.

The fairly large suite of specimens recovered here shows considerable variation. In particular, rare forms approach *Hirsutella hirsuta* phenon *primitiva* and thus cast doubt on morphological discontinuity between *H. ventriosa* and *G. limbata* in the lower-upper Miocene. Although alternative interpretations of the phylogeny of phenon *lenguaensis* cannot be ruled out, individuals so identified and considered by previous workers to be closely related to *H. ventriosa* are presumed, for the present, to be *H. ventriosa* phenon *primitiva* or *praemargaritae* (see, for example, Fleisher, 1974, Steineck & Fleisher, 1978).

Phenon pseudomiocenica Bolli & Bermúdez. Pl. 22, fig. 12. The illustration of the holotype of this phenon does not seem consistent with its interpretation by its authors and subsequent workers. The holotype is drawn with a moderately convex spiral side and appears to be characterized by a generally inflated shape, mainly ventrally. This is how it is interpreted here, that is, for specimens similar to G. cultrata phenon cultrata (d'Orbigny) but inflated more umbilically than spirally, sometimes resulting in specimens with low spiral sides.

Phenon saphoae Bizon & Bizon. Pl. 22, fig. 13. Vs G. praemenardii ph. conoidea: ≥5 chambers in the final whorl. Vs G. praemenardii ph. rifensis: distinctly thickened, giving a rounded lower-lateral profile.

Phenon merotumida Blow & Banner. Pl. 22, fig. 14. Vs G. praemenardii ph. minima & lenguaensis: keeled. This is also used to include more-planoconvex forms which do not attain the vaulted shape of ph. hemisphaerica Bizon & Bizon.

Phenon miotumida Jenkins. This phenon is restricted to those individuals closely resembling the holotype in, especially, size and number of chambers in the final whorl.

Phenon dalii Perconig. Vs ph. merotumida: concentrically more-elongate chambers; less closely appressed chambers; fewer chambers in the final whorl. Vs ph. miotumida: >4¾ chambers in the final whorl.

Phenon plesiotumida Blow & Banner. Pl. 22, fig. 15. Vs ph. merotumida: last chamber/s show distinct size increase; larger. Blow's (1969) most important criteria for distinguishing phena merotumida and plesiotumida were shape aspects, though the original description also emphasized size. At Site 208, specimens apparently satisfying the shape characteristics of phenon plesiotumida but much smaller than the holotype occur as low as the middle Miocene and are tentatively included here. However, specimens which would have been included within this phenon by Blow are probably absent from the Miocene of this section.

Phenon latiumbilicata n. ph. Pl. 22, fig. 17. Vs G. praemenardii ph. rifensis: wider umbilicus; larger; more highly vaulted; more chambers in the final whorl on average. The relatively fine subdivision of individuals which have concentrically fairly long chambers (as opposed to menardiform) is not applied to thickened specimens, the phena of which are allowed greater variation.

Phenon saheliana Catalano & Sprovieri. Pl. 22, fig. 18. Vs ph. saphoae: higher and vaulted conical angle.

Phenon mediterranea Catalano & Sprovieri. Pl. 23, fig. 1; pl. 25, fig. 1. Vs ph. saheliana: concentrically shorter chambers; usually more chambers in the final whorl; unthickened, especially noticeable by the sutures. Vs ph. latiumbilicata: higher conical angle.

Phenon conferta n. ph. Pl. 23, fig. 2. Vs ph. merotumida, plesiotumida, & pseudomiocenica: much slower chamber increase; chambers more closely appressed; outline distinctly less lobate. Vs ph. merotumida: larger; more chambers in the final whorl. Vs ph. pseudomiocenica: thinner walled; more chambers in the final whorl. This phenon is used to document the early part of a trend towards increased appression which resulted in G. fijiensis phenon fijiensis Cushman. It serves as a subtropical clinal analogue of phenon plesiotumida.

Phenon oregope n. ph. Pl. 23, fig. 3. Vs ph. subconomoizea & G. praemenardii ph. rifensis: wider umbilicus into which opens an extensive aperture; spiral side moderately flat; ventral side moderately vaulted; final chamber usually small. Vs ph. latiumbilicata: extensive aperture; fewer chambers in the final whorl; more planoconvex (latter is more biconvex); concentrically longer chambers. This is used to document the changes in morphology associated with increasing planoconvexity and concentric length of chambers occurring in portions of G. limbata which eventually split off into Truncorotalia sphericomiozea (Walters). In the upper part of its range (lowest Pliocene) at Site 208, this phenon is larger with a wide umbilicus and thickened by secondary calcification, resulting in an aperture which is restricted in length.

Phenon miocenica Palmer. Pl. 23, fig. 4. Vs ph. mediterranea: conical angle smaller and umbilical side less vaulted; aperture very low. Vs ph. pseudomiocenica and conferta: dorsal side flat.

Phenon consutila n. ph. Pl. 23, fig. 6. Vs ph. miotumida & T. sphericomiozea ph. conomiozea (Kennett): shallow ventral intercameral sutures and larger and sometimes higher aperture caused by increased appression of chambers and secondary thickening; usually larger than ph. miotumida. These individuals are early representatives of a trend resulting in T.

sphericomiozea phenon sphericomiozea. They are typically only moderately inflated but specimens with vaulted umbilical sides are included.

Phenon subconomiozea Bandy. Pl. 21, fig. 22. Vs G. praemenardii ph. rifensis: different chamber increase; relatively larger final chamber; deeper ventral intercameral sutures; more lobate outline; more rapid increase in ventral chamber height; usually less thickened; more thinly walled and keeled; usually fairly straightly keeled laterally, not flexed; fewer chambers in the final whorl and smaller size on average. Vs ph. dalii: chambers more concentrically elongate; chambers less closely appressed and more inflated ventrally; oval more lobate outline; fewer chambers in the final whorl.

Globorotalia fijiensis phenon fijiensis Cushman. Pl. 23, fig. 7.

(G. tumida phenon tumida (Brady). This unexpected occurrence in the lower G. plesiotumida zone at Site 77B, as delineated by Jenkins & Orr (1972), is not due to laboratory contamination as the samples were processed in ascending stratigraphic order.)

G. cultrata phenon multicamerata Cushman & Jarvis. Pl. 23, fig. 5.

G. cultrata phenon praemiocenica Lamb & Beard.

G. cultrata phenon cultrata (d'Orbigny). Pl. 22, fig. 16.

CLADEGROUP(1) GLOBOROTALIPRIMAE

Stem species. Globorotalia fijiensis Cushman.

Globorotalia fijiensis Cushman

Included phenon

Globorotalia menardii var. fijiensis Cushman, 1934 (pl. 17, fig. 5; G. (G.) tumida plesiotumida consecutive-range zone to Sphaeroidinella dehiscens s.s.--Globoquadrina altispira s.s. partial-range zone acc. Blow, 1969; Suva Formation; Viti-levu, Fiji; upper-upper Miocene--lower Pliocene; =G. menardii var. multicamerata Cushman & Jarvis acc. Stainforth & others, 1975).

Phena recorded

Globorotalia limbata phenon pseudomiocenica Bolli & Bermúdez.

G. limbata phenon merotumida Blow & Banner.

G. limbata phenon plesiotumida Blow & Banner.

G. limbata phenon conferta n. ph.

G. limbata phenon miocenica Palmer.

Phenon fijiensis Cushman. Vs G. limbata ph. conferta: wider umbilicus; more lobate; larger. Vs G. cultrata ph. pertenuis Beard: more inflated; wider umbilicus. Vs G. cultrata ph. exilis Blow: wider umbilicus; more chambers in the final whorl. This phenon would appear to have been a Pacific clinal analogue of the central-American G. cultrata phena pertenuis Beard and exilis Blow, both of which were probably absent from the Pacific Ocean (Fleisher, 1974).

G. tumida phenon tumida (Brady). Pl. 23, fig. 8.

G. cultrata phenon multicamerata Cushman & Jarvis.

G. cultrata phenon praemiocenica Lamb & Beard.

(G. cultrata phenon cultrata (d'Orbigny).)

Remarks

Presently it is nomenclaturally convenient to consider the primary type of Cushman's phenon to come from this phylogenetic branch. Certainly, it is most distinctive in this part of Site 208.

Globorotalia tumida (Brady)

Included phena

Globorotalia ungulata Bermúdez, 1960 (pl. 15, fig. 6; Stainforth & others, 1975, fig. 213/1; northwest of Cuba; Holocene).

G. (G.) tumida lata Brönnimann & Resig, 1971 (pl. 29, fig. 3; lower G. (G.) truncatulinoides s.s. partial-range zone of Banner & Blow, 1965c; southwest Pacific Ocean; lower Pleistocene).

Pulvinulina menardii var. tumida Brady, 1877 (Banner & Blow, 1960b, pl. 5, fig. 1; Stainforth & others, 1975, fig. 212/1; New Ireland, Papua New Guinea; upper Miocene or Pliocene).

P. tumida var. flexuosa Koch, 1923 (figured syntypes: text-figs. 9, 10; Stainforth & others, 1975, fig. 168/4; M_2 stage of Verbeek & Fennema, 1896; clay-marl of Rutten, 1916; northeast Java, Indonesia; Neogene).

Phena recorded

Globorotalia limbata phenon merotumida Blow & Banner.

G. limbata phenon plesiotumida Blow & Banner.

Phenon tumida (Brady). Vs G. limbata ph. plesiotumida: much more inflated both ventrally and dorsally; much more rapid increase in radial length of chambers; much more massive carina; much thicker; usually larger.

Phenon flexuosa (Koch). Pl. 25, fig. 6. Vs ph. tumida: last chamber/s twisted ventrally.

Phenon ungulata Bermúdez. Pl. 23, fig. 9. Vs ph. tumida: thin walled and much less strongly keeled.

Remarks

This species appears to split from G. fijiensis assemblages at Site 208 between the middle G. margaritae zone and the top of the G. puncticulata zone of Kennett (1973).

Globorotalia cultrata (d'Orbigny)

Included phena

Globorotalia akersi Snyder, 1975 (pl. 1, figs. 4--6; Gulf of Mexico; Holocene).

G. cavernula Bé, 1967 (pl. 10, fig. 1; subantarctic South Pacific Ocean; Holocene).

G. menardii antarctica McCulloch, 1977 (pl. 177, fig. 4; north of King George V Land, Antarctica, Southern Ocean; Holocene).

G. menardii jamesbayensis McCulloch, 1977 (pl. 177, fig. 6; James Is., Galapagos Islands, east-central Pacific Ocean, Holocene).

G. menardii var. multicamerata Cushman & Jarvis, 1930 (pl. 34, fig. 8; Stainforth & others, 1975, fig. 181/1; G. (G.) tumida s.s.--Sphaeroidinellopsis subdehiscens paenedehiscens partial-range zone or Sphaeroidinella dehiscens s.s.--Globoquadrina altispira s.s. partial-range zone acc. Blow, 1969?; Bowden Formation acc. Blow, 1969?; Jamaica; lower Pliocene?).

G. menardii neoflexuosa Srinivasan, Kennett, & Bé, 1974 (pl. 1, fig. 1; northwest Indian Ocean; Holocene).

G. pertenuis Beard, 1969 (pl. 1, fig. 1; Stainforth & others, 1975, fig. 191/1; Gulf of Mexico; Nebraskan, Pleistocene).

G. praemiocenica Lamb & Beard, 1972 (pl. 17, fig. 1; Stainforth & others, 1975, fig. 196/1; Pulleniatina obliqueloculata zone; Gulf of Mexico; Pliocene).

G. (G.) cultrata exilis Blow, 1969 (pl. 7, figs. 1--3; Stainforth & others, 1975, fig. 164/1; Sphaeroidinella dehiscens s.s.--Globoquadrina altispira s.s. partial-range zone; Bowden Formation; Jamaica; lower Pliocene).

Pulvinulina menardii var. fimbriata Brady, 1884 (pl. 103, fig. 3; Banner & Blow, 1960b, pl. 5, fig. 2; off Culebra Is., Puerto Rico; Holocene).

Rotalia menardii Parker, Jones, & Brady, 1865 (Banner & Blow, 1960b, pl. 6, fig. 2; Stainforth & others, 1975, fig. 177/3; Irish Sea; Holocene; =Rotalina cultrata d'Orbigny acc. Parker, 1964, this study).

R. nitida d'Orbigny in Fornasini, 1906 (pl. 3, fig. 4; Banner & Blow, 1960b, pl. 6, fig. 3; Saint Helena, South Atlantic Ocean; Holocene; =Rotalina cultrata d'Orbigny acc. Banner & Blow, 1960b, this study).

Rotalina cultrata d'Orbigny, 1839a (Banner & Blow, 1960b, pl. 6, fig. 1; southwest of Cuba, Caribbean sea; Holocene).

Phena recorded

Globorotalia limbata phenon pseudomiocenica Bolli & Bermúdez.

G. limbata phenon conferta n. ph.

G. fijiensis phenon fijiensis Cushman.

Phenon multicamerata Cushman & Jarvis. Vs G. fijiensis ph. fijiensis: less inflated relative to size; more thickly walled and keeled. Both this phenon and ph. praemiocenica occur only in G. limbata and G. fijiensis clusters at Site 208.

Phenon praemiocenica Lamb & Beard. Pl. 23, fig. 10. Vs G. limbata ph. pseudomiocenica: more thinly walled and keeled; usually more inflated. Vs G. limbata ph. conferta: fewer less-appressed chambers in the final whorl; thinner walled; more inflated; chambers more circular.

Phenon cultrata (d'Orbigny). Vs G. limbata ph. pseudomiocenica: weakly inflated chambers; compressed biconvex axially; slight flexure of coiling; wide umbilicus; larger; deeper and wider ventral intercameral sutures.

CLADEGROUP(3) TRUNCOROTALITERTIAE

Stem species. Truncorotalia sphericomiozea (Walters).

Truncorotalia sphericomiozea (Walters)

Included phena

Globorotalia conomiozea Kennett, 1966 (text-fig. 10; west South Island, New Zealand; Kapitean, upper-upper Miocene or lower Pliocene).

G. miozea sphericomiozea Walters, 1965 (text-fig. 8n--p; east North Island, New Zealand; upper Tongaporutuan or Kapitean, upper Miocene or lower Pliocene).

New phenon

Truncorotalia sphericomiozea capitona n. subsp.

Holotype. UQF 72480. Pl. 23, fig. 14. Globorotalia puncticulata zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/9/4/2--4/RS1, 88.52--88.54 m below sea-floor; lower Pliocene. Moderate in size, fairly robust; slightly elevated sinistral trochospire, tight. Equatorial outline oval, barely lobate; lateral outline biconvex, more convex ventrally. Chambers angular-truncate, closely appressed, about 9 in total, 3½ in final whorl; increase rapid. Dorsal view: chambers much longer concentrically, flat; sutures flush; intercameral sutures directed and smoothly curved posteriorly; spiral suture and last-3 intercameral sutures of final whorl limbate. Ventral view: chambers moderately inflated, undergo rapid height increase; intercameral sutures curved, depressed, meeting at closed umbilicus; aperture umbilical--extraumbilical, interiomarginal, low, slightly higher near periphery. Lateral view: periphery keeled; dorsal face flat; ventral face and umbilical shoulder smoothly and gently convex. Wall densely and finely perforate; sparse pustules. Length, 335 µm; width, 270 µm; height, 180 µm.

Material. Two specimens.

Derivation of name. Latin, capito, -onis, one with a large head.

Phena recorded

Globorotalia praemenardii phenon conoidea Walters.

G. praemenardii phenon rifensis Feinberg & Lorenz.

G. limbata phenon miotumida Jenkins. Pl. 23, fig. 11.

G. limbata phenon dalii Perconig.

(G. limbata phenon mediterranea Catalano & Sprovieri. Pl. 25, fig. 5?)

G. limbata phenon oregope n. ph.

G. limbata phenon consutila n. ph.

Phenon sphericomiozea (Walters). Pl. 23, fig. 12. Vs Globorotalia limbata ph. consutila: more thickened and thus chambers appear more closely appressed; less quadrate equatorial outline; periphery rounded; keel virtually completely covered; usually smaller in size and higher ventrally.

Phenon conomiozea (Kennett). Pl. 23, fig. 13. Usage herein is restricted to distinct individuals close to the holotype: conical angle greater than 60° (see Chaproniere, 1973); four chambers in the final whorl; very highly vaulted ventrally; highest point of chambers close to umbilicus; keel in axial view slightly flexed and early chambers slightly elevated spirally.

Phenon capitona n. ph. Pl. 23, fig. 14. Vs G. limbata ph. miotumida & conomiozea, & Truncorotalia crassula ph. viola (Blow): last-few chambers show a rapid increase in size in all 3 dimensions. Vs G. limbata ph. miotumida: more planoconvex, ventral side more inflated, spiral side only slightly inflated.

Falsella spuritumida phenon spuritumida n. ph.

Remarks

This species is considered to split from G. limbata in the lower Globorotalia conomiozea zone of Kennett (1973).

Falsella spuritumida n. sp.

New phenon

Falsella spuritumida spuritumida n. subsp.

Holotype. UQF 72481. Pl. 23, fig. 15. Base of Globorotalia inflata zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/6/1/12--14/RS2, 53.12--53.14 m below sea-floor; upper Pliocene. Large, robust; low sinistral trochospire, tight. Equatorial outline oval, barely lobate; lateral outline equally biconvex. Chambers angular-truncate, closely appressed, 4½ in final whorl; increase moderate. Dorsal view: chambers longer concentrically, flat; sutures flush; last intercameral suture directed and curved posteriorly, limbate; other features obscured by thickening. Ventral view: chambers moderately inflated; intercameral sutures radial, narrow but deeply incised, meet at closed umbilicus. Lateral view: keeled periphery, very thick on early chambers of final whorl; dorsal face slightly concave; ventral face concave adjacent to periphery, inflecting to weakly convex, continuing to umbilical shoulder which covers umbilicus; aperture an umbilical--extraumbilical interiomarginal low slit, slightly higher near periphery; keel distinctly flexed axially. Wall finely and densely perforate, smooth, but heavily encrusted. Length, 650 µm; width, 565 µm; height, 320 µm.

Material. Common.

Derivation of name. Latin, spurius, false; second component refers to 'Pulvinulina menardii var. tumida Brady'.

Phena recorded

Phenon spuritumida n. ph. Pl. 23, fig. 15. Vs Globorotalia limbata ph. oregope: more biconvex (latter is more planoconvex); chamber increase regular (latter typically with reduced final chamber at the level where these phena occur together); usually larger. Vs G. limbata ph. consutila: $>4\frac{1}{2}$ chambers in the final whorl; larger; wider umbilicus. Vs G. tumida ph. tumida: concentrically longer chambers; fewer chambers in the final whorl; more lobate outline; not as inflated or tumid but more compressed biconvex.

Remarks

Some individuals in lowest-Pliocene Truncorotalia sphericomiozea assemblages sampled at Site 208 do not follow the dominant trend (towards fewer chambers in the final whorl, increased thickening, and increased planoconvexity) which results in Truncorotalia crassula. On the other hand, they tend toward large specimens with about five chambers in the final whorl, biconvex shape, and a thick keel and wall, thus pseudomorphing Globorotalia tumida phenon tumida. Rare specimens found in the upper Pliocene are vastly different from coexisting T. crassula individuals and thus are considered morphologically isolated. This species is considered to have split from G. sphericomiozea assemblages at Site 208 between the middle Globorotalia puncticulata zone and the basal G. inflata zone of Kennett (1973).

CLADEGROUP(2) TRUNCOROTALISECUNDAE

Stem species. Truncorotalia crassula (Cushman & Stewart).

Truncorotalia crassula (Cushman & Stewart)

Included phena

Globorotalia crassacrotonensis Conato & Follador, 1967 (text-fig. 4/3; southeast Italy; Pliocene; =Globigerina crassaformis Galloway & Wissler acc. Stainforth & others, 1975; =Globorotalia hirsuta aemiliana Colalongo & Sartoni acc. Conato & Follador, 1967).

G. crassula Cushman & R.E. Stewart in Cushman & others, 1930 (pl. 7, fig. 1b; Blow, 1969, pl. 9, figs. 1--3; California, U.S.A.; Pliocene).

G. crotonensis Conato & Follador, 1967 (text-fig. 4/1; southeast Italy; Pliocene; =G. hirsuta aemiliana Colalongo & Sartoni acc. Stainforth & others, 1975).

G. hirsuta aemiliana Colalongo & Sartoni, 1967 (pl. 30, fig. 1; Stainforth & others, 1975, fig. 154/1; north Italy; Pliocene).

G. planoconvexa Hug, 1970 (text-fig. 29; G. planoconvexa zone; west Greece; middle Pliocene).

G. (Globorotalia) crassula viola Blow, 1969 (pl. 5, figs. 4--6; G. (G.) tumida s.s.--Sphaeroidinellopsis subdehiscens paenedehiscens partial-range zone; Buff Bay Beds of Cushman & Jarvis, 1930, Bowden Formation; Jamaica; upper Messinian or lower Zanclian, upper-upper Miocene or lower-lower Pliocene).

New phenon

Truncorotalia crassula complanata n. subsp.

Holotype. UQF 72482. Pl. 24, fig. 1. Globorotalia crassaformis zone; foraminiferal calcareous-nannofossil ooze, unit 1; D.S.D.P.208/7/4/74--76/RS2, 67.24--67.26 m below sea-floor; upper-lower or lower-upper Pliocene. Moderate in size, robust; low sinistral trochospire, tight. Equatorial outline oval, weakly lobate; lateral outline umbilicoconvex, dorsal side flat, ventral side moderately vaulted. Chambers angular-conical, closely appressed, 4 in final whorl; increase moderate. Dorsal view: chambers distinctly longer concentrically, flat; sutures flush; intercameral sutures directed radially or posteriorly and quickly curved posteriorly close to periphery. Ventral view: chambers vaulted; intercameral sutures shallow, sinuous to radial, meeting at slightly open umbilicus. Lateral view: keeled periphery; ventral face slightly convex; umbilical shoulder high, quickly recurved, but rounded; apertural face reclined; aperture an umbilical--extraumbilical interiomarginal low slit, slightly higher near periphery. Wall densely and finely perforate, sparsely to densely pustulose, early chambers obscured dorsally by thickening. Length, 470 µm; width, 425 µm; height, 300 µm.

Material. Common.

Derivation of name. Latin, *complanatus*, flattened.

Phena recorded

Globorotalia limbata phenon *miotumida* Jenkins.

G. limbata phenon *oregope* n. ph.

G. limbata phenon *consutila* n. ph.

Truncorotalia sphericomiozea phenon *sphericomiozea* (Walters).

Phenon *complanata* n. ph. Pl. 24, fig. 1. Vs *T. sphericomiozea* ph. *conomiozea*: early chambers of spiral side flat; keel relatively straight as viewed laterally; more highly vaulted on earlier chambers of final whorl.

Gallerius crassaformis phenon *hessi* (Bolli & Premoli Silva). Pl. 24, figs. 2, 3.

Gallerius crassaformis (Galloway & Wissler)

Included phena

Globigerina crassaformis Galloway & Wissler, 1927 (pl. 7, fig. 12; Stainforth & others, 1975, fig. 159/1; middle bed, Lower San Pedro Group; California, U.S.A.; Pleistocene).

Globorotalia hessi Bolli & Premoli Silva, 1973 (Bolli, 1970, pl. 4, one of figs. 13--16; *G. truncatulinoides* s.s. zone; Caribbean Sea; Pleistocene).

G. (*Turborotalia*) *oceanica* Cushman & Bermúdez, 1949 (pl. 8, fig. 15; north of Cuba, North Atlantic Ocean; Holocene).

Phenon recorded

Phenon *hessi* (Bolli & Premoli Silva). Low-occurring individuals vs *Truncorotalia crassula* ph. *complanata*: final chamber often reduced; umbilical shoulder distinctly rounded; weakly keeled to unkeeled; slightly more loosely coiled; ventral intercameral sutures shallower due to secondary thickening; less lobate outline. This phenon is used for a relatively large range of variation. The most distinctive type is unencrusted, rather loosely coiled with a wide umbilicus, angular but unthickened dorsoperipheral shoulder, steep apertural face with a thin lip which sometimes forms a weak tooth, and fairly well-separated chambers producing a distinctly lobate equatorial outline. This may be the closest type to the holotype of phenon *crassaformis* which, however, is not used because its exact morphology is ambiguous. A gradation exists to encrusted specimens, typical phenon *hessi*, with infilled ventral intercameral sutures, weakly keeled peripheries, and slightly concave dorsal sides. Both phena show a trend to final chambers which are reduced in all three dimensions.

CLADEGROUP(1) TRUNCOROTALIPRIMAE

Stem species. *Truncorotalia tosaensis* (Takayanagi & Saito).

Truncorotalia tosaensis (Takayanagai & Saito)

Included phena

Globorotalia tosaensis Takayanagi & Saito, 1962 (pl. 28, fig. 11; Stainforth & others, 1975, fig. 206/1; *G. cultrata* s.s./*Globigerina nepenthes* zone of Blow, 1959; Nobori Formation; Skikoku, Japan; Tortonian, upper Miocene?).

G. (*Turborotalia*) *crassaformis ronda* Blow, 1969 (pl. 4, figs. 4--6; Stainforth & others, 1975, fig. 202/1; *Sphaeroidinella dehiscens* s.s.--*Globoquadrina altispira* s.s. partial-range zone; Buff Bay Beds; Jamaica; lower Pliocene).

G. (*T.*) *tosaensis tenuitheca* Blow, 1969 (pl. 4, figs. 13--15; lower *G.* (*T.*) *tosaensis tenuitheca* consecutive-range zone; pteropod sandstone, Suva Beds?; Vanua-levu, Fiji; Zanclian, lower Pliocene; =*G. tosaensis* Takayanagi & Saito acc. Stainforth & others, 1975).

New phenon

Truncorotalia tosaensis acrotenes n. subsp.

Holotype. UQF 72487. Pl. 24, fig. 6. *Globorotalia tosaensis* zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P.208/4/4/74--76/RS2, 40.24--40.26 m below seafloor; upper Pliocene. Very large, robust; low dextral trochospire, tight. Equatorial outline

circular, virtually nonlobate; lateral outline highly umbilicoconvex, dorsal side flat, ventral side highly vaulted. Chambers angular-conical, closely appressed, 4 in final whorl; increase moderate. Dorsal view: chambers very long concentrically, flat to concave; sutures flush; intercameral sutures radial but may be quickly curved posteriorly on periphery; last intercameral suture limbate; other features obscured by thickening. Ventral view: chambers vaulted; intercameral sutures curved anteriorly then radial, flush; umbilicus wide, square. Lateral view: weakly keeled periphery; ventral face strongly convex; umbilical shoulder subacutely recurved, very high, very close to umbilicus; terminal and apertural faces reclined; aperture an umbilical--extraumbilical interiomarginal very low slit, very slightly raised adjacent to periphery. Wall densely and finely perforate, smooth but heavily encrusted. Length, 635 µm; width, 600 µm; height, 485 µm.
Material. Seven specimens.
Derivation of name. Greek, *akrotenes*, stretching high.

Phena recorded

Truncorotalia crassula phenon *complanata* n. ph.

T. crassula phenon *planoconvexa* (Hug). Pl. 24, fig. 4. Vs ph. *complanata*: aperture high; weakly keeled to unkeeled periphery; umbilical shoulder rounded. Vs *Deshayesulus puncticulatus* ph. *inflatus*: wall surface pustulose.

Phenon *ronda* (Blow). Pl. 24, fig. 5. Vs *T. crassula* ph. *complanata*: dorsoperipheral shoulder rounded.

Phenon *acrotenes* n. ph. Pl. 24, figs. 6, 7. Vs *T. crassula* ph. *complanata*: ventrally vaulted, say, ventral height at least $\frac{3}{4}$ of maximum diameter; dorsal intercameral sutures straighter; last chamber usually relatively larger; umbilicus wider in large specimens. Both small thin-walled ?juveniles and large thickened specimens are included.

Phenon *tosaensis* (Takayanagi & Saito). Pl. 24, fig. 8. Vs ph. *ronda*: $>4\frac{1}{2}$ chambers in the final whorl; nonlobate equatorial outline; dorsal intercameral sutures straighter; chambers concentrically shorter. Vs *T. truncatulinoides* ph. *truncatulinoides* (d'Orbigny): unkeeled to very weakly keeled. The phena proposed by Blow (1969), *tenuitheca* and *pachytheca*, are not used herein. Distinction between encrusted and unencrusted individuals was found difficult to apply consistently and the transition to keeled individuals was rather coarsely sampled at Site 208.

Remarks

This species appears to split from *T. crassula* assemblages at Site 208 in the lower *Globorotalia inflata* zone of Kennett (1973).

Truncorotalia truncatulinoides (d'Orbigny)

Included phena

Globorotalia (*Globorotalia*) *truncatulinoides pachytheca* Blow, 1969 (pl. 5, figs. 13--15; *G.* (*G.*) *truncatulinoides* s.s. partial-range zone; Manchioneal Formation s.l.; Jamaica; lower Pleistocene; =*Rotalina truncatulinoides* d'Orbigny acc. Stainforth & others, 1975).

Rotalina truncatulinoides d'Orbigny, 1839b (Blow, 1969, pl. 5, figs. 10--12; Stainforth & others, 1975, fig. 209/1; off Gomera, Canary Islands, east North Atlantic Ocean; Holocene).

Phena recorded

Truncorotalia tosaensis phenon *ronda* (Blow).

T. tosaensis phenon *tosaensis* (Takayanagi & Saito).

Phenon *truncatulinoides* (d'Orbigny). Pl. 24, fig. 9. Vs *T. tosaensis* ph. *acrotenes*: >4 chambers in the final whorl; strongly keeled; strongly limbate dorsal intercameral sutures recurved near periphery; concentrically shorter chambers; higher ventrally with straight ventral face and sharper umbilical shoulder; terminal face closer to vertical.

Remarks

At Site 208 this species and *T. pseudocrassa* appear to separate from *T. tosaensis* in the upper *Globorotalia tosaensis* zone of Kennett (1973).

Truncorotalia pseudocrassa (Chapman & Parr)

Included phena

Globorotalia crozetensis Thompson, 1973 (pl. 2, fig. 1; southwest of Indian Ocean; upper Pleistocene).

G. pseudocrassa Chapman & Parr, 1937 (pl. 9, fig. 25; south of Tasmania, Australia, Southern Ocean; Holocene).

New phenon

Truncorotalia pseudocrassa hybrida n. subsp.

Holotype. UQF 72491. Pl. 24, fig. 10. Base of *Globorotalia truncatulinoides*--*G. tosaensis* overlap zone; foraminifer-rich calcareous-nannofossil ooze, unit 1; D.S.D.P. 208/4/2/74--76/RS2, 37.24--37.26 m below sea-floor; lowermost Pleistocene. Moderate in size, fairly robust; low sinistral trochospire, tight. Equatorial outline slightly lobate; lateral outline highly umbilicoconvex, dorsal side slightly elevated, ventral side moderately vaulted. Chambers angular-conical, closely appressed, 4 in final whorl; increase moderate. Dorsal view: chambers distinctly longer concentrically, flat; sutures flush, directed almost radially, curved posteriorly, quickly near periphery, nonlimbate. Ventral view: chambers vaulted; intercameral sutures slightly depressed, strongly curved posteriorly; umbilicus tight. Lateral view: dorsal face very slightly convex; periphery very sharp, very weakly keeled; ventral face strongly convex; umbilical shoulder subacutely recurved and very high; apertural and terminal faces slightly concave; aperture umbilical--extraumbilical, interiomarginal, moderately highly arched, circular. Wall densely and finely perforate, smooth; pustules sparse. Length, 280 µm; width, 250 µm; height, 210 µm.

Material. Common.

Derivation of name. Latin, *hybrida* (f.), mongrel.

Phena recorded

Truncorotalia crassula phenon *complanata* n. ph. Pl. 24, fig. 11; Pl. 25, fig. 1.

T. tosaensis phenon *ronda* (Blow). Pl. 25, fig. 2.

Phenon *hybrida* n. ph. Pl. 24, fig. 10. Vs *T. crassula* ph. *planoconvexa*: very sharp to weakly keeled dorsoperipheral shoulder; angular umbilical shoulder. Vs *T. crassula* ph. *complanata*: aperture high, circular. At Site 208 this phenon occurs exclusively of the phena contrasted above but is morphologically a blend of both.

Phenon *pseudocrassa* (Chapman & Parr). Pl. 24, fig. 12. Vs *T. crassula* ph. *complanata*: more biconvex (lower ventrally, slightly inflated dorsally).

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APPENDIX. LIST OF AVAILABLE SPECIES-GROUP NAMES OF THE CENOZOIC PLANKTIC FORAMINIFERA

(with tentative species assignment)

abundocamerata Bolli, 1957; Globorotalia angulata	gen.D crassata
acarinata Subbotina, 1953; Acarinina	G. mckannai
acceleratoria Chalilov, 1956; Acarinina pentacamerata	M. pentacametata
acerosa Owen, 1868; Globigerina (Orbulina)	O. universa
achtschaucujmensis Chalilov, 1956; Globigerina	gen.I reticulata
acostaensis Blow, 1959; Globorotalia	P. mayeri
acrostoma Wezel, 1966; 'Globorotalia'	P. mayeri
acrotenes Fordham n. subsp.; Truncorotalia tosaensis	T. tosaensis
acuimarginata Fordham n. subsp.; Globorotalia miozea	G. miozea
aculeata Jenkins, 1966; Globorotalia inconspicua	T. inconspicua
aculeata Silvestri, 1898; Globigerina helicina? var.	G. elongatus
acuminata Rhumbler, 1949; Hastigerina digitata var.	H. pelagica
acuta Toulmin, 1941; Globorotalia wilcoxensis var.	M. velascoensis
acutispira Bolli & Cita, 1960; Globorotalia	M. velascoensis
adamanica Srinivasan & Azmi, 1976; Neogloboquadrina dutertrei	P. helicina
adamantea Saito, 1963; Globorotalia	P. mayeri
adamsi Banner & Blow, 1959; Hastigerina (Bolliella)	G. adamsi
adriatica Fornasini, 1899; Globigerina	G. elongatus
advena Bermúdez, 1949; Globoquadrina quadraria	G. tripartita
aegyptica Said & Kenawy, 1956; Zeauvigerina	Z. wilcoxensis
aemiliana Colalongo & Sartoni, 1967; Globorotalia hirsuta	T. crassula
aequa Cushman & Renz, 1942; Globorotalia crassata var.	gen.D crassata
aequatorialis Hofker & Thalmann, 1959; Globigerina	N. eocaena
aequilateralis Brady, 1879; Globigerina	G. siphonifera
affinis Silvestri, 1898; Globigerina	O. quadrilobata
africana Blow & Banner, 1962; Globigerinita	C. daubjergensis
africana El-Naggar, 1966; Globorotalia	M. velascoensis
akersi Bolli, Loeblich, & Tappan, 1957; Clavigerinella	H. columbiana
akersi Quilty, 1976; Globorotalia (Turborotalia)	T. grata
akersi Snyder, 1975; Globorotalia	G. cultrata
alabamensis Cushman, 1925; Hantkenina	H. alabamensis
albeari Cushman & Bermúdez, 1949; Globorotalia (G.)	M. velascoensis
alexi Haque, 1956; Globigerinella	H. bolivariana
algeriana Cita & Mazzola, 1970; Globigerinopsoides	G. concinna
alpha Fordham n. subsp.; Orbulina quadrilobata	O. quadrilobata
alpigena Gümbel, 1868; Globigerina	G. ayalai
alteconica Samuel, 1972; Turborotalia (Acarinina)	T. danvillensis
altiapertura Bolli, 1957; Globigerinoides triloba	O. altiapertura
alticonica Fleisher, 1974; Acarinina mattseensis	G. mckannai
altihelix Fordham n. subsp.; Globigerina concinna	G. concinna
altihelix Fordham n. subsp.; Globigerinoides conglobatus	G. conglobatus
altispira Cushman & Jarvis, 1926; Globigerina	N. altispira
altispiroides Bermúdez, 1960; Turborotalia	T. cerroazulensis
ambitacrena Loeblich & Tappan, 1957; Tinophodella	T. uvula
amekiensis Stolk, 1963; Cassigerinelloita	C. daubjergensis
amicula Takayanagi & Saito, 1962; Candeina	G. indigena
ampliapertura Bolli, 1957; Globigerina	gen.G wilsoni
amplus Perconig, 1968; Globigerinoides obliquus	G. haitiensis
anapetes Blow, 1979; Globorotalia (Acarinina) broedermanni	M. collactea
anapetes Fordham n. subsp.; Globigerina concinna	G. concinna
anasuteri Fordham n. subsp.; Globorotaloides parvulus	G. parvulus
anavenezuelana Fordham n. subsp.; Globorotaloides indigena	G. indigena
anfracta Parker, 1967; Globorotalia	T. grata
angipora Stache, 1865; Globigerina	gen.I reticulata

angiporoides Hornibrook, 1965; Globigerina	gen.I reticulata
anguliofficinalis Blow, 1969; Globigerina	T. fariasi
angulisuturalis Bolli, 1957; Globigerina ciperoensis	T. ciperoensis
angulata White, 1928; Globigerina	gen.D crassata
angulosa Bolli, 1957; Globigerina soldadoensis	G. mckannai
angustiumbilicata Bolli, 1957; Globigerina ciperoensis	T. detrita
antarctica Keany & Kennett, 1972; Globigerina	T. antarctica
antarctica McCulloch, 1977; Globorotalia menardii	G. cultrata
anterubra Fordham n. subsp.; Globigerinoides haitiensis	G. haitiensis
antillensis Bermúdez, 1960; Globigerina	P. obliqueloculata
apanthesma Loeblich & Tappan, 1957; Globorotalia	gen.D crassata
aperta Gohrbandt, 1963; Truncorotalia marginodentata	M. velascoensis
appenninicus Pezzani, 1963; Catapsydrax	G. concinna
apertasuturalis Jenkins, 1960; Globigerinoides	G. disjuncta
apertura Cushman, 1918; Globigerina	G. concinna
apertura Pezzani, 1963; Globorotalia	P. helicina
appressa Blow, 1979; Eoglobigerina	gen.F appressa
appressocamerata Blow, 1979; Globorotalia (Acarinina)	G. mckannai
aguasayaensis Bolli, 1962; Globigerinopsis	G. aguasayaensis
aquiensis Loeblich & Tappan, 1957; Globigerina	G. mckannai
arabica El-Naggar, 1966; Globigerina	G. inconstans
aragonensis Nuttall, 1930; Globorotalia	gen.D crassata
aragonensis Nuttall, 1930; Hantkenina mexicana var.	H. alabamensis
aragonensis Nuttall, 1930; Hastigerinella eocanica var.	H. eocanica
archeocompressa Blow, 1979; Globorotalia (Turborotalia)	C. taurica
archeomenardii Bolli, 1957; Globorotalia	G. miozea
ariakensis Asano, 1962; Globigerina	G. yeguaensis
asanoi Maiya, Saito, & Sato, 1976; Globoquadrina	P. helicina
aspensis Colom, 1954; Globigerina	M. pentacamerata
aspera Koch, 1926; Globigerina?	G. tripartita
aspera Petri, 1954; Globigerinoides triloba	O. quadrilobata
asperula Gümbel, 1868; Globigerina	G. velascoensis
astricticamerata Fordham n. subsp.; Obandyella ventriosa	O. ventriosa
atlantica Berggren, 1972; Globigerina	P. helicina
atlantis Bermúdez, 1960; Globigerina	N. conglomerata
atlantisae Cifelli & Smith, 1970; Globigerina	T. detrita
australiformis Jenkins, 1971; Globorotalia	P. pseudoscitulus
australis Finlay, 1939; Hantkenina	H. alabamensis
ayalai Bermúdez, 1960; Globigerina	G. ayalai
azerbaidjanica Chalilov, 1956; Globigerina	G. ouchitaensis
baconica Samuel, 1972; Globigerina	G. mexicana
bacuana Chalilov, 1956; Globigerina	G. velascoensis
bakeri Cole, 1927; Globigerina	G. bakeri
bandyi Fleisher, 1974; Morozovella	gen.D crassata
bannerblowi Blaicher, 1970; Turborotalia	T. postcretacea
bannerblowi Popescu, 1973; Globigerinoides	O. quadrilobata
barbadoensis Blow, 1969; Pseudohastigerina	P. micrus
barisanensis LeRoy, 1939; Globorotalia	F. fohsi
barnardi Ansary, 1955, Gümbelina	Z. wilcoxensis
baroemoensis LeRoy, 1939; Globigerina	N. altispira
barri Brönniman, 1952; Globigerinatheka	G. mexicana
bauerensis Quilty, 1976; Globorotalia (Turborotalia)	T. grata
beckmanni Saito, 1962; Porticulasphaera	G. mexicana
bella Jenkins, 1967; Globorotalia	P. mayeri
berggreni El-Naggar, 1966; Globorotalia	G. mckannai
bermudezi Bolli, 1957; Hastigerinella	G. parvulus
bermudezi Rögl & Bolli, 1969; Globorotalia	O. scitula

bermudezi Seiglie, 1963; *Globigerina*	*G. bulloides*
bermudezi Thalmann, 1942; *Hantkenina* (*Cribrohantkenina*)	*H. alabamensis*
berwaliana Mohan & Soodan, 1969; *Globorotalia*	*M. pentacamerata*
bikiniensis McCulloch, 1977; *Globigerinita*	*T. detrita*
bikiniensis McCulloch, 1977; *Globigerinoides elongata*	*G. elongatus*
biloba Jedlitschka, 1934; *Candeina*	*O. universa*
bilobata d'Orbigny, 1846; *Globigerina*	*O. universa*
binaiensis Koch, 1935; *Globigerina*	*G. tripartita*
birnageae Blow, 1959; *Globorotalia*	*B. birnageae*
bisphaerica LeRoy, 1941; *Orbulina universa* var.	*O. universa*
bispherica Todd, 1954; *Globigerinoides*	*O. universa*
blowi Rögl & Bolli, 1973; *Neogloboquadrina dutertrei*	*P. helicina*
blowi Thompson, 1973; *Neoacarinina*	*N. conglomerata*
bolivariana Petters, 1954; *Globigerina wilsoni*	gen.G *bolivariana*
bollii Blow, 1959; *Globigerinoides*	*G. haitiensis*
bollii Cita & Premoli Silva, 1960; *Globigerina*	*G. bulbosa*
bollii El-Naggar, 1966; *Globorotalia*	gen.D *crassata*
bonairensis Pijpers, 1933; *Globorotalia*	*T. cerroazulensis*
bononiensis Dondi, 1963; *Globorotalia*	*D. puncticulatus*
borealis Brady, 1881; *Globigerina bulloides* var.	*E. pachydermus*
boudecensis Pokorný, 1955; *Cassigerinella*	*C. chipolensis*
boudreauxi Fleisher, 1974; *Acarinina*	*T. densus*
boweni Brönnimann & Resig, 1971; *Globigerinita*	*C. insueta*
boweri Bolli, 1957; *Globigerina*	gen.H *frontosa*
brachysacculifer Christodoulou, 1960; *Globigerinoides sacculifer*	*O. quadrilobata*
bradyi Wiesner, 1931; *Globigerina*	*T. uvula*
bramelettei Lipps, 1964; *Globigerina*	*E. pachydermus*
brazieri Jenkins, 1966; *Globigerina*	*G. disjuncta*
brevis Jenkins, 1966; *Globigerina*	*G. tripartita*
brevispina Cushman, 1925; *Hantkenina*	*H. alabamensis*
brevispira Subbotina, 1960; *Globigerina*	*T. grata*
brödermanni Cushman & Bermúdez, 1949; *Globorotalia* (*Truncorotalia*)	*M. collactea*
bronnresigi Fordham n. name; *Globigerina bulloides*	*G. bulloides*
bulbosa LeRoy, 1944; *Globigerina*	*G. bulbosa*
bullata Jenkins, 1966; *Globorotalia aequa*	gen.D *crassata*
bullatus Chang, 1962; *Globigerinoides trilobus*	*O. quadrilobata*
bullatus Ouda, 1978; *Globigerinanus bullatus*	*G. aguasayaensis*
bullbrooki Bolli, 1957; *Globorotalia*	*T. densus*
bulliformis Mayer-Eymar, 1887; *Globigerina*	*O. quadrilobata*
bulloides d'Orbigny, 1826; *Globigerina*	*G. bulloides*
bulloideus Crescenti, 1966; *Globigerinoides*	*G. haitiensis*
butti Popescu, 1972; *Globigerina*	*O. altiapertura*
bykovae Aisenstadt, 1960; *Turborotalia*	*G. praemenardii*
calida Parker, 1962; *Globigerina*	*G. bulloides*
californica Smith, 1957; *Globorotalia*	*M. velascoensis*
camerata Chalilov, 1956; *Acarinina pentacamerata* var.	*M. pentacamerata*
canariensis d'Orbigny, 1839; *Globigerina*	*G. elongatus*
canariensis d'Orbigny, 1839; *Rotalina*	*O. scitula*
cancellata Blow, 1979; *Subbotina triangularis*	*G. velascoensis*
cancellata Copeland, 1964; *Globigerinoides*	*O. quadrilobata*
cancellata Pessagno, 1963; *Globigerina ampliapertura*	*N. eocaena*
canimarensis Bermúdez, 1960; *Globigerinoides*	*G. conglobatus*
capitona Fordham n. subsp.; *Globorotalia sphericomiozea*	*G. sphericomiozea*
capdevilensis Cushman & Bermúdez, 1949; *Globorotalia* (*G.*)	*P. pseudoscitulus*
cariacoensis Rögl & Bolli, 1973; *Globigerina megastoma*	*G. bulloides*
carinata El-Naggar, 1966; *Globorotalia uncinata*	gen.C *carinata*
carteri Karrer, 1878; *Globigerina*	*N. altispira*

caucasia Chalilov, 1956; Globigerina compressa	P. compressus
caucasica Glaessner, 1937; Globorotalia aragonensis var.	gen.D crassata
caucasica Subbotina, 1958; Hastigerinella	H. eocanica
cavernula Bé, 1967; Globorotalia	G. cultrata
caylaensis Gartner & Hay, 1962; Globorotalia	M. velascoensis
cedroensis McCulloch, 1977; Globigerinoides elongata	G. elongata
cellata Subbotina, 1958; Sphaeroidinella	G. bulbosa
centralis Cushman & Bermúdez, 1937; Globorotalia	T. cerroazulensis
cerro-azulensis Cole, 1928; Globigerina	T. cerroazulensis
challengerae Ujiié, 1975; Prosphaeroidinella	S. dehiscens
chapmani Parr, 1938; Globorotalia	P. micrus
chascanona Loeblich & Tappan, 1957; Globigerina	C. daubjergensis
chathamensis McCulloch, 1977; Beella	C. digitata
chipolensis Cushman & Ponton, 1932; Cassidulina	C. chipolensis
cibaoensis Bermúdez, 1949; Globorotalia	O. cibaoensis
cifellii Brönnimann & Resig, 1971; Globorotalia (Turborotalia)	T. postcretacea
ciliosa Stuart, 1866; Coscinosphaera	O. universa
cingulata Popescu, 1969; Velapertina	G. indigena
ciperoensis Blow & Banner, 1962; Globigerinita dissimilis	C. dissimilis
ciperoensis Bolli, 1954; Globigerina	T. ciperoensis
circularis Blow, 1956; Globigerinoides glomerosa	O. universa
circumlabiata Hillebrandt, 1962; Chiloguembelina?	Z. wilcoxensis
clara Chalilov, 1956; Acarinina	G. mckannai
clarae Bermúdez, 1960; Globigerina	G. tripartita
clarkei Rögl & Bolli, 1973; Globigerina	T. detrita
clemenciae Bermúdez, 1960; Turborotalia	T. grata
clinata Chalilov, 1956; Globigerina posttriloculinoides var.	gen.I reticulata
clippertonensis McCulloch, 1977; Globigerina	G. hexagonus
coalingensis Cushman & Hanna, 1927; Globigerina	T. densus
cocoaensis Cushman, 1928; Globorotalia	T. cerroazulensis
collactea Finlay, 1939; Globorotalia	M. collactea
colombiana Petters, 1954; Hastigerinella	H. colombiana
colomi Bermúdez, 1960; Globigerina	M. pentacamerata
columbae Martínez Díaz, 1970; Globigerina	G. concinna
columbiana Howe, 1939; Gümbelitria	Z. wilcoxensis
compacta Subbotina, 1953; Globigerina bulloides var.	gen.I reticulata
compacta Subbotina, 1953; Globigerina pseudoeocaena var.	G. pseudoeocaena
compactus Fordham n. subsp.; Globigerinoides haitiensis	G. haitiensis
complanata Fordham n. subsp.; Truncorotalia crassula	T. crassula
compressa Fordham n. subsp.; Todella grata	T. grata
compressa Parr, 1947; Hantkenina alabamensis	H. alabamensis
compressa Plummer, 1926; Globigerina	P. compressus
compressa White, 1928; Globigerina velascoensis var.	G. velascoensis
compressaformis Chalilov, 1956; Globigerina	G. velascoensis
compressus Fordham n. subsp.; Globigerinoides haitiensis	G. haitiensis
concinna Reuss, 1850; Globigerina	G. concinna
conferta Fordham n. subsp.; Globorotalia limbata	G. limbata
conglobata Brady, 1879; Globigerina	G. conglobatus
conglomerata Schwager, 1866; Globigerina	N. conglomerata
conica Brönnimann & Resig, 1971; Globoquadrina altispira	N. altispira
conica Jenkins, 1960; Globorotalia	G. miozea
conicotruncata Subbotina, 1947; Globorotalia	gen.D crassata
connecta Jenkins, 1964; Globigerina woodi	G. disjuncta
conoidea Walters, 1965; Globorotalia miozea	G. praemenardii
conomiozea Kennett, 1966; Globorotalia	G. sphericomiozea
constricta Bermúdez, 1960; Sphaeroidinellopsis nepenthes var.	G. concinna
consutila Fordham n. subsp.; Globorotalia limbata	G. limbata

continens Owen, 1868; Globigerina (Orbulina)	O. universa
continuosa Blow, 1959; Globorotalia opima	P. mayeri
conusa Chalilov, 1956; Globoconusa	G. conusa
convexa Subbotina, 1953; Globorotalia	M. velascoensis
coronata Blow, 1979; Globorotalia (Morozovella) spinulosa	gen.D crassata
corpulenta Subbotina, 1953; Globigerina	C. dissimilis
cornwallisi McLean, 1956; Orbulina	O. universa
crassacrotonensis Conato & Follador, 1967; Globorotalia	T. crassula
crassaformis Galloway & Wissler, 1927; Globigerina	G. crassaformis
crassata Cushman, 1925; Pulvinulina	gen.D crassata
crassula Cushman & Stewart, 1939; Globorotalia	T. crassula
crater Finlay, 1939; Globorotalia	gen.D crassata
crinita Glaessner, 1937; Gümbelina	Z. wilcoxensis
cristata Heron-Allen & Earland, 1929; Globigerina	T. detrita
cristatiformis McCulloch, 1977; Globigerina(?)	T. detrita
crociapertura Blow, 1979; Subbotina	G. pseudoeocaena
crosswicksensis Olsson, 1960; Globorotalia	M. velascoensis
crotonensis Conato & Follador, 1967; Globorotalia	T. crassula
crozetensis Thompson, 1973; Globorotalia	T. pseudocrassa
crux Blaicher, 1970; Globigerina officinalis	T. fariasi
cryophila Herman, 1980; Globigerina	P. helicina
cryptomphala Glaessner, 1937; Globigerina bulloides var.	C. dissimilis
cubensis Palmer, 1934; Gümbelina	Z. wilcoxensis
cultrata d'Orbigny, 1839; Rotalina	G. cultrata
cuneicamerata Blow, 1979; Globorotalia (Acarinina)	T. densus
cunialensis Toumarkine & Bolli, 1970; Globorotalia cerroazulensis	T. cerroazulensis
curryi Proto Decima & Bolli, 1970; Globigerinatheka	G. mexicana
curva Blow, 1956; Globigerinoides glomerosa	O. universa
cyclostoma Galloway & Wissler, 1927; Globigerina	G. elongatus
czeczvaensis Myatiuk, 1970; Turborotalia	G. incretaceus
dalii Perconig, 1968; Globorotalia	G. limbata
daniana Nakkady & Tallat, 1959; Bolivina	Z. wilcoxensis
danica Bang, 1969; Globigerina	C. theodosica
danvillensis Howe & Wallace, 1932; Globigerina	T. danvillensis
danvillensis Howe & Wallace, 1932; Nonion	P. micrus
danvillensis Howe & Wallace, 1934; Hantkenina	H. alabamensis
daubjergensis Brönnimann, 1953; Globigerina	C. daubjergensis
decepta Martin, 1943; Globigerina	T. densus
decorapertura Takayanagi & Saito, 1962; Globigerina druryi	G. concinna
dehiscens Chapman, Parr, & Collins, 1934; Globorotalia	G. tripartita
dehiscens Parker & Jones, 1865; Sphaeroidina bulloides var.	S. dehiscens
delicata Bronnimann & Resig, 1971; Globigerina nepenthes	G. rubescens
densa Cushman, 1925; Pulvinulina crassata var.	T. densus
denseconnexa Subbotina, 1960; Globorotalia	T. postcretacea
depressa d'Orbigny, 1903; Globigerina?	O. scitula
detrita Terquem, 1875; Globigerina	T. detrita
digitata Brady, 1879; Globigerina	C. digitata
digitifera Rhumbler, 1949; Hastigerina digitata var.	H. pelagica
digitiformans Saito & Thompson, 1976; Hastigerinopsis digitiformans	H. pelagica
diminuta Bolli, 1957; Globigerinoides	G. haitiensis
dinapoli Ogniben, 1958; Globigerinoides	G. indigena
diplostoma Reuss, 1850; Globigerina	G. concinna
discors McCulloch, 1977; Beella	G. adamsi
discors Myatiuk, 1970; Acarinina	T. densus
disjuncta Finlay, 1940; Sphaeroidinella	G. disjuncta
dissimilis Cushman & Bermúdez, 1937; Globigerina	C. dissimilis
dolabrata Jenkins, 1966; Globorotalia	gen.D crassata

dominicana Bermúdez, 1950; Globorotalia	F. fohsi
droogeri Myatiuk, 1970; Subbotina	gen.I reticulata
druryi Akers, 1955; Globigerina	G. bulbosa
dubia Egger, 1857; Globigerina	P. helicina
dubiata McCulloch, 1977; Globigerina(?)	G. elongatus
dudroensis Kavary, 1964; Globigerina	G. velascoensis
dumblei Weinzierl & Applin, 1929; Hantkenina	H. alabamensis
dutertrei d'Orbigny, 1839; Globigerina	P. helicina
eamesi Blow, 1959; Globigerina	C. digitata
eastropacia Boltovskoy, 1974; Globorotalia hirsuta	O. hirsuta
echinatus Bolli, 1957; Catapsydrax	C. daubjergensis
edgari Premoli Silva & Bolli, 1973; Globorotalia	M. velascoensis
edita Subbotina, 1953; Globigerina	M. velascoensis
egelida Cifelli & Smith, 1970; Globigerina quinqueloba	T. detrita
eggeri Heron-Allen & Earland, 1922; Globigerina cretacea var.	T. detrita
eggeri Rhumbler, 1901; Globigerina	P. helicina
eggeriformis McCulloch, 1977; Globigerina	P. helicina
ehrenbergi Bolli, 1957; Globorotalia	P. compressus
ellipsocamera Chalilov, 1956; Globigerina pseudoeocaena var.	G. pseudoeocaena
elongata Glaessner, 1937; Globorotalia pseudoscitula var.	P. pseudoscitulus
elongata d'Orbigny, 1826; Globigerina	G. elongatus
emeisi Bolli, 1966; Globigerinoides	G. haitiensis
emilei El-Naggar, 1966; Globorotalia	P. compressus
eobulloides Morozova, 1959; Globigerina (Eoglobigerina)	G. fringa
eocaena Gümbel, 1868; Globigerina	N. eocaena
eocaenica Cordey, 1968; Cassigerinella	C. chipolensis
eocaenica Terquem, 1882; Globigerina	G. ayalai
eocanica Nuttall, 1928; Hastigerinella	H. eocanica
eocenica Berggren, 1960; Hastigerina	P. micrus
epityche Fordham n. subsp.; Globigerinoides haitiensis	G. haitiensis
erevanensis Martirosyan, 1970; Acarinina pentacamerata var.	M. pentacamerata
esnaensis LeRoy, 1953; Globigerina	G. mckannai
esnehensis Nakkady, 1950; Globigerina cretacea var.	G. mckannai
euapertura Jenkins, 1960; Globigerina	G. disjuncta
euganea Proto Decima & Bolli, 1970; Globigerinatheka	G. mexicana
evexa Fordham n. subsp.; Obandyella ventriosa	O. ventriosa
evoluta Cita, 1973; Globorotalia margaritae	O. hirsuta
evoluta Cita & Ciaranfi, 1972; Sphaeroidinella ionica	S. dehiscens
evoluta Fordham n. subsp.; Globigerinella evoluta	G. evoluta
evoluta Fordham n. subsp.; Tinophodella evoluta	T. evoluta
evoluta Shutskaya, 1965; Globorotalia planocompressa	P. compressus
evoluta Subbotina, 1960; Globigerinella	T. postcretacea
excavata Banner & Blow, 1965; Sphaeroidinella dehiscens	S. dehiscens
exilis Blow, 1969; Globorotalia (G.) cultrata	G. cultrata
eximia Todd, 1957; Globigerina	N. conglomerata
expansus Ouda, 1978; Globigerinanus bullatus	G. aguasayaensis
explicationis Jenkins, 1967; Globorotalia miotumida	G. limbata
exserta Romeo, 1969; Globorotalia (Turborotalia)	O. ventriosa
extans Jenkins, 1960; Globorotalia	P. mayeri
extensa Blow, 1979; Eoglobigerina?	C. extensa
extensa Fordham n. subsp.; Globigerina bulloides	G. bulloides
extraumbilicatus Fordham n.subsp.; Bandyus relizensis	B. relizensis
extrema Cita, 1974; Globigerina woodi	G. bulbosa
extremus Bolli & Bermúdez, 1965; Globigerinoides obliquus	G. hiatiensis
exumbilicata Herman, 1974; Globigerina	T. detrita
falconarae Gianelli & Salvatorini, 1976; Globorotaloides	G. parvulus
falconensis Blow, 1959; Globigerina	G. bulbosa

falsospiralis Davidson & Morozova, 1964; Acarinina	G. mckannai
faragi El-Naggar, 1966; Globorotalia	G. inconstans
fariasi Bermúdez, 1960; Globigerina	T. fariasi
fijiensis Cushman, 1934; Globorotalia menardii var.	G. fijiensis
fimbriata Brady, 1884; Pulvinulina menardii var.	G. cultrata
finalis Banner & Blow, 1967; Pulleniatina obliqueloculata	P. obliqueloculata
finchi Blow, 1979; Globorotalia (Morozovella)	M. velascoensis
finlayi Brönnimann, 1952; Globigerina	G. velascoensis
fistulosa Schubert, 1910; Globigerina	O. quadrilobata
flexiserialis Fordham n. subsp.; Streptochilus tokelauae	S. tokelauae
flexuosa Koch, 1923; Pulvinulina tumida var.	G. tumida
flosculus Voloshinova, 1960; Globigerina	P. helicina
flparkerae Brönnimann & Resig, 1971; Globigerinita glutinata	T. uvula
fodina Blow, 1979; Eoglobigerina?	C. fodina
fohsi Cushman & Ellisor, 1939; Globorotalia	F. fohsi
foliata Bolli, 1957; Globigerina	G. bulbosa
formosa Bolli, 1957; Globorotalia formosa	gen.D crassata
fragilis Borsetti & Cati, 1972; Globigerinoides	G. rubescens
frailensis McCulloch, 1977; Hastigerinella(?)	T. detrita
franzenaui Sztrákos, 1974; Turborotalia munda	T. postcretacea
fringa Subbotina, 1950; Globigerina	G. fringa
frontosa Subbotina, 1953; Globigerina	gen.H frontosa
galapagoensis McCulloch, 1977; Globigerina	P. helicina
galavisi Bermúdez, 1960; Globigerina	N. eocaena
galeata Rhumbler, 1949; Globigerina sacculifera var.	O. quadrilobata
garretti Howe, 1939; Gümbelina	Z. wilcoxensis
gemina Terrigi, 1891; Orbulina	O. universa
gemma Jenkins, 1966; Globorotalia	T. postcretacea
gigantea Bang, 1969; Globoconusa daubjergensis	C. daubjergensis
gigantea Blow, 1959; Globorotalia scitula	G. praemenardii
globiformis Blow & Banner, 1962; Globigerinita	G. mexicana
globigera Schwager, 1866; Textilaria	S. globiger
globolocula Ivanova, 1958; Cassigerinella	C. chipolensis
globorotaloidea Colom, 1954; Globigerina	P. mayeri
globosa Bolli, 1957; Globoquadrina altispira	N. altispira
globularis Bermúdez, 1960; Globoquadrina	N. eocaena
globularis Roemer, 1838; Globigerina	G. disjuncta
globulosa Gohrbandt, 1967; Globanomalina wilcoxensis	P. micrus
glomerosa Blow, 1956; Globigerinoides glomerosa	O. universa
glutinata Egger, 1893; Globigerina	T. uvula
gnaucki Blow & Banner, 1962; Globigerina ouchitaensis	T. fariasi
gomitulus Sequenza, 1880; Globigerina	G. elongatus
gortanii Borsetti, 1959; Catapsydrax	N. eocaena
gracilis Bolli, 1957; Globorotalia formosa	gen.D crassata
gradationis Voloshinova, 1960; Globigerina	T. detrita
grata Todd, 1957; Globigerina?	T. grata
gravelli Brönnimann, 1952; Globigerina	G. mckannai
griffinae Blow, 1979; Globorotalia (Turborotalia)	gen.G griffinae
grilli Schmid, 1967; Globigerinopsis	G. aguasayaensis
grimsdalei Keijzer, 1945; Globigerina	G. disjuncta
groenlandica Shchedrina, 1946; Globigerina	T. detrita
guadalupensis McCulloch, 1977; Beella	C. digitata
guadalupensis McCulloch, 1977, Globigerina(?)	T. detrita
guaracaraensis Brönnimann & Bermúdez, 1953; Truncorotaloides rohri	T. densus
guatemalensis Bermúdez, 1960; Pseudogloborotalia	gen.D crassata
guhai Raju, 1971; Globigerinopsis	G. aguasayaensis
hadii Aubert, 1963; Globorotalia	gen.D crassata

hagni Gohrbandt, 1967; *Globigerina*	*G. ayalai*
haitiensis Coryell & Rivero, 1940; *Globigerina*	*G. haitiensis*
hancocki McCulloch, 1977; *Globigerina*	*P. helicina*
hansbollii Blow & Banner, 1962; *Globorotalia* (*Turborotalia*)	gen.D *crassata*
haoi Gutiérrez Domech, 1966; *Globigerina*	*N. eocaena*
hardingae Blow, 1979; *Globigerinita*	*C. daubjergensis*
haunsbergensis Gohrbandt, 1963; *Globorotalia*	*P. compressus*
haynesi El-Naggar, 1966; *Globigerina*	*G. velascoensis*
haynesi Samanta, 1970; *Truncorotaloides*	*T. densus*
helicina d'Orbigny, 1826; *Globigerina*	*P. helicina*
hemisphaerica Bizon & Bizon, 1971; *Globorotalia*	*G. limbata*
hemisphaerica Morozova, 1961; *Globigerina* (*Eoglobigerina*)	gen.A *hemisphaerica*
hessi Bolli & Premoli Silva, 1973; *Globorotalia*	*G. crassaformis*
heterostoma Bermúdez, 1937; *Gümbelina cubensis* var.	*Z. wilcoxensis*
hexacamerata Bolli, 1957; *Globorotalia angulata*	gen.D *crassata*
hexagona Natland, 1938; *Globigerina*	*G. hexagonus*
higginsi Bolli, 1957; '*Globigerinoides*'	*G. lozanoi*
himiensis Maiya, Saito, & Sato, 1976; *Globoquadrina*	*P. helicina*
hirsuta d'Orbigny, 1839; *Globigerina*	*G. siphonifera*
hirsuta d'Orbigny, 1839; *Rotalina*	*O. hirsuta*
hispidicidaris Loeblich & Tappan, 1957; *Globorotalia*	*M. velascoensis*
hofkeri Bermúdez, 1960; *Globigerina*	*N. eocaena*
hornibrooki Brönnimann, 1952; *Globigerina*	*G. velascoensis*
horrida Silvestri, 1898; *Globigerina*	*T. detrita*
howei Blow & Banner, 1962; *Globigerinita*	*G. mexicana*
humerosa Takayanagi & Saito, 1962; *Globorotalia*	*P. mayeri*
humilis Brady, 1884; *Truncatulina*	*T. detrita*
hungarica Samuel, 1972; *Globorotalia*	*M. collactea*
hybrida Fordham n. subsp.; *Truncorotalia pseudocrassa*	*T. pseudocrassa*
hybrida McCulloch, 1977; *Globigerina*	*P. helicina*
hystricosus Belford, 1962; *Globigerinoides quadrilobatus*	*O. quadrilobata*
ichinosekiensis Takayanagi & Oda, 1976; *Globorotalia* (*G.*)	*G. praemenardii*
ikebei Maiya, Saito, & Sato, 1976; *Globorotalia*	*P. helicina*
immatura Cushman, 1919; *Sphaeroidina dehiscens* var.	*S. dehiscens*
immatura LeRoy, 1939; *Globigerinoides sacculiferus*	*O. quadrilobata*
imitata Subbotina, 1953; *Globorotalia*	*T. cerroazulensis*
imperfecta Rhumber, 1911; *Orbulina*	*O. universa*
inaequiconica Subbotina, 1960; *Acarinina*	*C. inaequiconica*
inaequispira Subbotina, 1953; *Globigerina*	*G. linaperta*
incisa Brönnimann & Resig, 1971; *Globorotalia* (*Turborotalia*)	*G. bulloides*
incisa Hillebrandt, 1962; *Globigerina*	*G. yeguaensis*
incognita Walters, 1965; *Globorotalia zealandica*	*G. miozea*
incompta Cifelli, 1961; *Globigerina*	*P. helicina*
inconspicua Howe, 1939; *Globorotalia*	*T. inconspicua*
inconstans Subbotina, 1953; *Globigerina*	*G. inconstans*
increbescens Bandy, 1949; *Globigerina*	gen.G *wilsoni*
incretacea Chalilov, 1956; *Globigerina*	*G. incretaceus*
incrusta Akers, 1955; *Globigerinita*	*C. insueta*
incrusta Fordham n. subsp.; *Globigerina bulloides*	*G. bulloides*
incrusta Fordham n. subsp.; *Orbulina quadrilobata*	*O. quadrilobata*
index Finlay, 1939; *Globigerinoides*	*G. mexicana*
indica Singh & Tewari, 1968; *Globigerapsis*	*G. mexicana*
indigena Łuczkowska, 1955; *Globigerinoides*	*G. indigena*
indolensis Morozova, 1959; *Acarinina*	*T. cerroazulensis*
infirmirugosus Fordham n. subsp.; *Streptochilus globiger*	*S. globiger*
inflata Howe, 1928; *Hantkenina*	*H. alabamensis*
inflata Hussey, 1949; *Globorotalia*	*P. pseudoscitulus*

inflata d'Orbigny, 1839; *Globigerina*	*D. puncticulatus*
inflatiformis Myatiuk, 1970; *Subbotina*	*G. bakeri*
insolita Jenkins, 1966; *Globorotalia*	*C. insolita*
insueta Cushman & Stainforth, 1945; *Globigerinatella*	*C. insueta*
intermedia Silvestri, 1898; *Globigerina*	*O. quadrilobata*
intermedia Subbotina, 1953; *Acarinina*	*G. mckannai*
interposita Subbotina, 1953; *Acarinina*	*M. pentacamerata*
inusitatus Jenkins, 1966; *Globigerinoides*	*G. disjuncta*
involuta Cushman, 1917; *Globigerina aequilateralis* var.	*G. siphonifera*
involuta Pezzani, 1963; *Globorotalia*	*P. mayeri*
ionica Cita & Ciaranfi, 1972; *Sphaeroidinella ionica*	*S. dehiscens*
iorgulescui Popescu, 1969; *Velapertina*	*G. indigena*
iota Finlay, 1940; *Nonion*	*P. micrus*
iota Parker, 1962; *Globigerinita*	*P. iota*
irregularis LeRoy, 1944; *Globigerinoides sacculiferus*	*O. quadrilobata*
irregularis Morozova, 1961; *Gumbelitria*	*Z. wilcoxensis*
irregularis Subbotina, 1953; *Globigerina eocaenica* var.	gen.I *reticulata*
irrotata Loeblich & Tappan, 1957; *Globorotalia*	*G. mckannai*
isahayensis Asano, 1962; *Globigerina*	*C. dissimilis*
istropolitana Samuel, 1972; *Turborotalia* (*Acarinina*)	gen.D *crassata*
italicus Mosna & Vercesi, 1975; *Globigerinoides*	*G. elongatus*
iwaiensis Takayanagi & Oda, 1976; *Globorotalia* (*G.*)	*G. praemenardii*
jacksonensis Bandy, 1949; *Globigerina rotundata* var.	gen.G *wilsoni*
jamesbayensis McCulloch, 1977; *Globorotalia menardii*	*G. cultrata*
jarvisi Cushman, 1930; *Hastigerinella*	*H. eocanica*
juanai Bermúdez & Bolli, 1969; *Globorotalia*	*O. ventriosa*
juvenilis Bolli, 1957; *Globigerina*	*C. insueta*
juvenis Fordham n. subsp.; *Pulleniatina mayeri*	*P. mayeri*
kagaensis Maiya, Saito, & Sato, 1976; *Globoquadrina*	*P. helicina*
karpatica Myatiuk, 1970; *Subbotina danvillensis*	*T. danvillensis*
kerisensis Suleimanov, 1966; *Biglobigerinella*	*P. micrus*
khadumica Bykova, 1960; *Globigerina*	*T. postcretacea*
kiersteadae Fleisher, 1974; *Subbotina*	*G. mckannai*
kilabiyaensis El-Naggar, 1966; *Globorotalia*	*P. compressus*
klampisensis Kadar, 1975; *Hastigerina*	*H. obesa*
kochi Caudri, 1934; *Globigerina*	*S. dehiscens*
kochi Hantken, 1875; *Siderolina*	*H. alabamensis*
kolchidica Morozova, 1961; *Globorotalia*	gen.D *crassata*
kondoi Todd, 1970; *Globigerina*	*G. parva*
konkiensis Agalarova & Pronina, 1975; *Globigerina*	*T. grata*
korotkovi Keller, 1946; *Globigerinoides*	*G. mexicana*
kozlowskii Brotzen & Pozaryska, 1961; *Globigerina*	*C. daubjergensis*
krosniensis Blaicher, 1970; *Globigerina*	*G. opima*
kubanensis Shutskaya, 1956; *Globorotalia angulata*	gen.D *crassata*
kugleri Bolli, 1957; *Globorotalia*	*G. kugleri*
kugleri Bolli, Loeblich, & Tappan, 1957; *Globigerapsis*	*G. mexicana*
kutchensis Singh & Tewari, 1968; *Globigerinatheka*	*G. mexicana*
kyushuensis Asano & Murata, 1958; *Globigerina*	*G. bakeri*
labiacrassata Jenkins, 1966; *Globigerina*	*G. disjuncta*
laccadivensis Fleisher, 1974; *Globanomalina*	*P. pseudoscitulus*
lacerti Cushman & Renz, 1946; *Globorotalia*	gen.D *crassata*
laevigata Bolli, 1957; *Globorotalia pusilla*	*M. velascoensis*
lakiensis Haque, 1956; *Globanomalina ovalis* var.	*P. micrus*
lakiensis Haque, 1956; *Globigerina dubia* var.	*G. mckannai*
langhiana Cita & Gelati, 1960; *Globoquadrina*	*N. altispira*
larmeui Akers, 1955; *Globoquadrina*	*N. conglomerata*
lata Brönnimann & Resig, 1971; *Globorotalia* (*G.*) *tumida*	*G. tumida*

lata Lipps, 1964; *Turborotalia*	*G. miozea*
lateraliaperturus Fordham n. subsp.; *Globorotaloides parvulus*	*G. parvulus*
latiumbilicata Fordham n. subsp.; *Globorotalia limbata*	*G. limbata*
latum Brönnimann & Resig, 1971; *Streptochilus*	*S. tokelauae*
laxispira Fordham n. subsp.; *Globoquadrina tripartita*	*G. tripartita*
lazzarii Pericoli, 1959; *Hantkenina*	*H. alabamensis*
lehneri Cushman & Jarvis, 1929; *Globorotalia*	gen.D *crassata*
lehneri Cushman & Jarvis, 1929; *Hantkenina*	*H. alabamensis*
lenguaensis Bolli, 1957; *Globorotalia*	*G. limbata*
lensiformis Subbotina, 1953; *Globorotalia*	gen.D *crassata*
lenticularis Iaccarino, 1964; *Globorotalia*	*M. velascoensis*
leroyi Blow & Banner, 1962; *Globigerina praebulloides*	*G. parva*
limbata d'Orbigny, 1902; *Rotalia*	*G. limbata*
liebusi Shokhina, 1937; *Hantkenina*	*H. alabamensis*
linaperta Finlay, 1939; *Globigerina*	*G. linaperta*
lindiensis Blow, 1979; *Subbotina angiporoides*	gen.I *reticulata*
lindiensis Blow & Banner, 1962; *Globigerinatheka*	*G. mexicana*
lingulata Collen & Vella, 1973; *Turborotalita quinqueloba*	*T. detrita*
liverovskae Bykova, 1960; *Globigerinella*	*T. postcretacea*
lobata Bermúdez, 1949; *Globorotalia*	*F. fohsi*
lodoensis Mallory, 1959; *Globorotalia broedermanni* var.	*M. velascoensis*
loeblichi El-Naggar, 1966; *Globorotalia*	gen.D *crassata*
longiapertura Blow, 1979; *Globorotalia* (*Turborotalia*)	gen.A *hemisphaerica*
longispina Cushman, 1925; *Hantkenina*	*H. alabamensis*
loxophodellus Ouda, 1978; *Globigerinanus*	*G. aguasayaensis*
lozanoi Colom, 1954; *Globigerina*	*G. lozanoi*
luczkowskae Popescu, 1973; *Velapertina*	*G. indigena*
lupeae Martínez Díaz, 1970; *Globorotalia*	*P. mayeri*
luterbacheri Bolli, 1972; *Globigerinatheka subconglobata*	*G. mexicana*
luxorensis Nakkady, 1951; *Anomalina*	*P. micrus*
macrostoma Copeland, 1964; *Globigerina*	*P. mayeri*
macrostoma Hagn, 1956; *Globigerinoides*	*G. mexicana*
magnifica Bizon & Glaçon, 1978; *Globorotalia*	*G. miozea*
margaritae Bolli & Bermúdez, 1965; *Globorotalia*	*O. hirsuta*
marginodentata Subbotina, 1953; *Globorotalia*	gen.D *crassata*
marialuisae Bermúdez, 1960; *Globigerina*	*G. bulbosa*
marksi Martin, 1943; *Globorotalia*	gen.D *crassata*
marshallana Todd, 1954; *Gümbelina?*	*Z. wilcoxensis*
martinezi Perconig, 1968; *Globorotalia*	*O. cibaoensis*
martini Blow & Banner, 1962; *Globigerinita martini*	*C. daubjergensis*
martini Pijpers, 1933; *Textularia*	*Z. wilcoxensis*
martinkayei Bolli, 1962; *Globigerinopsis*	*G. aguasayaensis*
matthewsae Blow, 1979; *Globorotalia* (*Acarinina*)	*T. densus*
mattseenensis Gohrbandt, 1967; *Globorotalia*	*M. collactea*
maturus Ouda, 1978; *Globigerinanus sudri*	*G. aguasayaensis*
mauriciana Howe & Roberts, 1939; *Gümbelina*	*Z. wilcoxensis*
mayeri Cushman & Ellisor, 1939; *Globorotalia*	*P. mayeri*
mayoensis Brönnimann & Bermúdez, 1953; *Truncorotaloides rohri* var.	*T. densus*
mccordi Howe & Wallace, 1932; *Hantkenina*	*H. alabamensis*
mckannai White, 1928; *Globigerina*	*G. mckannai*
mediterranea Catalano & Sprovieri, 1969; *Globorotalia miocenica*	*G. limbata*
megastoma Earland, 1934; *Globigerina*	*G. bulloides*
menardii Parker, Jones, & Brady, 1865; *Rotalia*	*G. cultrata*
mendacis Blow, 1969; *Globorotalia* (*Turborotalia*)	*G. kugleri*
merotumida Blow & Banner, 1965; *Globorotalia* (*G.*)	*G. limbata*
mexicana Cushman, 1925; *Globigerina*	*G. mexicana*
mexicana Cushman, 1925; *Hantkenina*	*H. alabamensis*

micra Shutskaya, 1958; Globigerinoides subconglobatus	G. mexicana
micra Subbotina, 1950; Gümbelina	Z. wilcoxensis
microcellulosa Morozova, 1961; Globigerina (G.)	C. daubjergensis
microfoliata Brönnimann & Resig, 1971; Globigerina	T. detrita
micropora de Klasz, Le Calvez, & Rerat, 1969; Globigerina	G. linaperta
microstoma Cita, Premoli Silva, & Rossi, 1965; Globigerina	G. microstoma
micrus Cole, 1927; Nonion	P. micrus
midwayensis Cushman, 1940; Gümbelina	Z. wilcoxensis
milletti Dollfus, 1905; Candeina	C. nitida
mineacea Bermúdez & Bolli, 1969; Globorotalia	P. mayeri
minima Akers, 1955; Globorotalia canariensis var.	G. praemenardii
minima Jenkins, 1966; Globigerina angiporoides	G. bakeri
minimus Christodoulou, 1960; Globigerinoides sacculifer	O. quadrilobata
minuta Natland, 1938; Globigerinoides	T. uvula
minutissima Bolli, 1957; Globorotalia	T. postcretacea
miocenica Palmer, 1945; Globorotalia menardii var.	G. limbata
miotumida Jenkins, 1960; Globorotalia menardii	G. limbata
miozea Finlay, 1939; Globorotalia	G. miozea
mirorensis Perconig, 1968; Globorotalia	O. cibaoensis
missionis Carter, 1963; Sphaeroidinella	S. dehiscens
mitra Todd, 1957; Globigerinoides	G. elongatus
moderiapertura Fordham n. subsp.; Globigerinopsis aguasayaensis	G. aguasayaensis
mohleri Bolli, 1966; Globorotalia	T. detrita
morsei Kline, 1943; Gümbelina	Z. wilcoxensis
morugaensis Brönnimann, 1952; Globigerinoita	C. insueta
multiaperturus Ouda, 1978; Globigerinanus	G. aguasayaensis
multicamerata Cushman & Jarvis, 1930; Globorotalia menardii var.	G. cultrata
multicellaris Hussey, 1949; Gümbelina	Z. wilcoxensis
*multiloba Romeo, 1965; Globigerina	T. detrita
multiloculata Morozova, 1961; Acarinina	G. inconstans
munda Jenkins, 1965; Globorotalia	C. inaequiconica
murrayi Thomson, 1876; Hastigerina	H. pelagica
naguewichiensis Myatiuk, 1950; Globigerinella	P. micrus
nammalensis Haque, 1956; Guembelina midwayensis var.	Z. wilcoxensis
nana Bolli, 1957; Globorotalia opima	G. opima
nanggulanensis Hartono, 1969; Hantkenina	H. alabamensis
nanus Chalilov, 1956; Globigerina triloculinoides var.	G. velascoensis
naparimaensis Brönnimann, 1951; Globigerinita	C. insueta
nartanensis Shutskaya, 1956; Globorotalia	gen.D crassata
naussi Martin, 1943; Globorotalia	gen.D crassata
nazcaensis Quilty, 1976; Clavigerinella	H. eocanica
neoflexuosa Srinivasan, Kennett, & Bé, 1974; Globorotalia menardii	G. cultrata
neominutissima Bermúdez & Bolli, 1969; Globorotalia	T. detrita
nepenthes Todd, 1957; Globigerina	G. rubescens
nepenthoides Brönnimann & Resig, 1971; Globigerina	G. bulbosa
nicobarensis Srinivasan & Kennett, 1974; Clavatorella	C. digitata
nicobarica Srinivasan & Sharma, 1969; Globorotalia	O. scitula
nicolae Catalano & Sprovieri, 1971; Globorotalia	O. ventriosa
nicoli Martin, 1943; Globorotalia	M. velascoensis
nigrinae Fleisher, 1974; Turborotalia (T.)	P. helicina
nilotica Viotti & Mansour, 1969; Globigerina	G. bulbosa
nipponica Asano, 1957; Globigerina	D. puncticulatus
nitida Martin, 1943; Globigerina	T. densus
nitida d'Orbigny, 1839; Candeina	C. nitida
nitida d'Orbigny, 1906; Rotalia	G. cultrata
nkbrowni Brönnimann & Resig, 1971; Globorotalia (Turborotalia)	T. postcretacea
nodosa El-Naggar, 1966; Globigerina	G. mckannai

* multiloba LeRoy, 1944; Sphaeroidinella — S. dehiscens

nuttalli Hamilton, 1953; Globigerinoides	G. mexicana
nympha Jenkins, 1967; Globorotalia mayeri	P. mayeri
obesa Akers, 1955; Globoquadrina	N. conglomerata
obesa Bolli, 1957; Globorotalia	H. obesa
obliqua Bolli, 1957; Globigerinoides	G. haitiensis
obliqueloculata Parker & Jones, 1865; Pullenia sphaeroides var.	P. obliqueloculata
obturoaperturus Fordham n.subsp.; Deshayesulus puncticulatus	D. puncticulatus
occlusa Blow & Banner, 1962; Globigerina praebulloides	G. parva
occlusa Herman, 1974; Globigerina	P. helicina
occlusa Loeblich & Tappan, 1957; Globorotalia	M. velascoensis
oceanica Cushman & Bermúdez, 1949; Globorotalia (Turborotalia)	G. crassaformis
officinalis Subbotina, 1953; Globigerina	G. ouchitaensis
okinawaensis Natori, 1976; Pulleniatina	P. obliqueloculata
oligocaenica Blow & Banner, 1962; Globigerina	G. tripartita
opima Bolli, 1957; Globorotalia opima	G. opima
opsionepenthoides Fordham n. subsp.; Globigerina microstoma	G. microstoma
orbicularis Haque, 1956; Globanomalina simplex var.	P. micrus
orbiformis Cole, 1927; Globigerina	G. mexicana
oregope Fordham n. subsp.; Globorotalia limbata	G. limbata
orientalis Maiya, Saito, & Sato, 1976; Globorotalia	D. puncticulatus
oscitans Todd, 1958; Globorotalia	D. puncticulatus
ototara Finlay, 1940; Gumbelina	Z. wilcoxensis
ouchitaensis Howe & Wallace, 1932; Globigerina	G. ouchitaensis
ovalis Dremel, 1970; Sphaeroidinellopsis	G. bulbosa
ovalis Haque, 1956; Globanomalina	P. micrus
oveyi Ansary, 1955; Gümbelitria	Z. wilcoxensis
oveyi Buckley, 1973; Globorotalia (Clavatorella)	G. hexagonus
ovoidea Sequenza, 1880; Globigerina	O. universa
pachyderma Ehrenberg, 1861; Aristerospira	E. pachydermus
pachytheca Blow, 1969; Globorotalia (G.) truncatulinoides	T. truncatulinoides
padana Dondi & Papetti, 1968; Globorotalia puncticulata	D. puncticulatus
paenedehiscens Blow, 1969; Sphaeroidinella subdehiscens	S. dehiscens
palmerae Bermúdez, 1960; Globoquadrina	G. tripartita
palmerae Cushman & Bermúdez, 1937; Globorotalia	P. pseudoscitulus
palpebra Brönnimann & Resig, 1971; Globorotalia (Turborotalia)	G. bulloides
panda Jenkins, 1960; Globorotalia menardii	G. limbata
pannonica Samuel, 1972; Globigerina? bolivariana	gen.G bolivariana
panormensis de Stefani, 1952; Globigerina	O. quadrilobata
parabulloides Blow, 1959; Globigerina	G. parabulloides
paralenguaensis Blow, 1969; Globorotalia (G.)	G. limbata
parallela Beckmann, 1957; Chiloguembelina	Z. wilcoxensis
paraobesa Herman, 1974; Globigerina	P. helicina
parapelagica Saito & Thompson, 1976; Hastigerina	H. pelagica
paratriloculinoides Hofker, 1956; Globigerina	G. velascoensis
paravenezuelana Hofker, 1956; Globigerina	N. eocaena
parkerae Bermúdez, 1960; Globigerinoides	T. uvula
parkerae Borsetti & Cati, 1975; Globigerinoides ruber	G. elongatus
parkerae Brönnimann & Resig, 1971; Globorotalia (Turborotalia)	T. grata
parkerae Brönnimann & Resig, 1971; Orbulina universa	O. universa
parkerae Loeblich & Tappan, 1957; Globigerinita	T. detrita
parkerae Ujiié, 1976; Prosphaeroidinella	S. dehiscens
parri Finlay, 1939; Zeauvigerina	Z. wilcoxensis
partidiana McCulloch, 1977; Globigerina	P. helicina
partimlabiata Ruggieri & Sprovieri, 1970; Globorotalia acrostoma	P. mayeri
parva Bolli, 1957; Globigerina	G. parva
parva El-Naggar, 1966; Globigerina triloculinoides	G. velascoensis
parva Hornibrook, 1961; Globigerinoides	C. insueta

parva Rey, 1955; *Globorotalia velascoensis* var.	*M. velascoensis*
parva Rhumbler, 1949; *Orbulina*	*O. universa*
parvulus Bolli, Loeblich, & Tappan, 1957; *Catapsydrax*	*G. parvulus*
pasionensis Bermúdez, 1960; *Pseudogloborotalia*	*M. velascoensis*
patagonica Todd & Kniker, 1952; *Globigerina*	gen.I *reticulata*
patriciae McCulloch, 1977; *Globoquadrina*	*O. hirsuta*
pauciloculata Jenkins, 1966; *Globigerina*	*M. velascoensis*
pelagica d'Orbigny, 1839; *Nonionina*	*H. pelagica*
pentacamerata Subbotina, 1947; *Globorotalia*	*M. pentacamerata*
pentagona Morozova, 1961; *Globigerina* (*Eoglobigerina*)	*G. monmouthensis*
pera Todd, 1957; *Globigerina*	*C. dissimilis*
perconigi Martínez Díaz, 1970; *Globorotalia*	*O. ventriosa*
perforataminuta Hussey, 1949; *Globorotalia*	*P. pseudoscitulus*
peripheroacuta Blow & Banner, 1966; *Globorotalia* (*Turborotalia*)	*G. miozea*
peripheroronda Blow & Banner, 1966; *Globorotalia* (*Turborotalia*)	*G. miozea*
permicra Blow & Banner, 1962; *Globorotalia* (*Turborotalia*)	*C. inaequiconica*
pertenuis Beard, 1969; *Globorotalia*	*G. cultrata*
petaliformis Boltovskoy, 1974; *Globorotalia*	*G. praemenardii*
petraea Giebel, 1852; *Orbulina*	*O. universa*
philippinensis Ujiié, 1976; *Prosphaeroidinella*	*S. dehiscens*
phodoaplatus Ouda, 1978; *Globigerinanus*	*G. aguasayaensis*
picassiana Perconig, 1968; *Globigerina*	*G. concinna*
pieste Fordham n. subsp.; *Tenuitella postcretacea*	*T. postcretacea*
pileata Chalilov, 1956; *Globigerina*	*G. velascoensis*
piparoensis Brönnimann & Bermúdez, 1953; *Truncorotaloides rohri* var.	*T. densus*
plana Fordham n. subsp.; *Pulleniatina mayeri*	*P. mayeri*
planispira Brönnimann & Resig, 1971; *Globorotalia* (*Turborotalia*)	*P. helicina*
planocompressa Shutskaya, 1965; *Globorotalia planocompressa*	*P. compressus*
planoconica Subbotina, 1953; *Globorotalia*	*P. micrus*
planoconvexa Hug, 1970; *Globorotalia*	*T. crassula*
planodorsalis Fleisher, 1974; *Acarinina*	*T. densus*
planoexilis Blaicher, 1970; *Globigerina*	gen.I *reticulata*
platispira de Klasz, Le Calvez, & Rerat, 1969; *Globorotalia*	*G. kugleri*
plesiotumida Blow & Banner, 1965; *Globorotalia* (*G.*) *tumida*	*G. limbata*
pliocenica Minstretta, 1962; *Globorotalia* (*Turborotalia*)	*P. helicina*
polusi Androsova, 1962; *Globigerina*	*P. helicina*
polycamera Chalilov, 1956; *Globigerina edita* var.	*G. inconstans*
polygonia Fordham n. subsp.; *Pulleniatina mayeri*	*P. mayeri*
polypetala Fordham n. subsp.; *Tinophodella antarctica*	*T. antarctica*
pomeroli Toumarkine & Bolli, 1970; *Globorotalia cerroazulensis*	*T. cerroazulensis*
possagnoensis Toumarkine & Bolli, 1970; *Globorotalia cerroazulensis*	*T. cerroazulensis*
postcretacea Myatiuk, 1950; *Globigerina*	*T. postcretacea*
posttriloculinodes Chalilov, 1956; *Globigerina*	*G. bakeri*
pozonensis Blow, 1959; *Globoquadrina*	*N. altispira*
praeaequa Blow, 1979; *Globorotalia* (*Acarinina*)	*G. praepentacamerata*
praeangulata Blow, 1979; *Globorotalia* (*Acarinina*)	gen.D *crassata*
praebulloides Blow, 1959; *Globigerina*	*G. bulbosa*
praecalida Blow, 1969; *Globigerina calida*	*G. bulloides*
praecentralis Blow, 1979; *Globorotalia* (*Turborotalia*)	*T. cerroazulensis*
praecursor Banner & Blow, 1967; *Pulleniatina obliqueloculata*	*P. obliqueloculata*
praecursoria Morozova, 1957; *Acarinina*	*G. inconstans*
praedehiscens Blow & Banner, 1962; *Globoquadrina dehiscens*	*G. tripartita*
praedigitata Parker, 1967; *Globigerina*	*C. digitata*
praeedita Blow, 1979; *Eoglobigerina edita*	*G. praeedita*
praefohsi Blow & Banner, 1966; *Globorotalia* (*G.*)	*F. fohsi*
praeglobotruncanaeformis Bykova, 1960; *Globigerina*	*C. praeglobotruncanaeformis*
praehirsuta Blow, 1969; *Globorotalia* (*G.*)	*O. hirsuta*

praehumerosa Natori, 1976; Globorotalia (Turborotalia) humerosa	P. helicina
praeimmaturus Brönnimann & Resig, 1971; Globigerinoides quadrilobatus	O. pseudosellii
praeinflata Maiya, Saito, & Sato, 1976; Globorotalia inflata	D. puncticulatus
praemargaritae Catalano & Sprovieri, 1969; Globorotalia	O. ventriosa
praemenardii Cushman & Stainforth, 1945; Globorotalia	G. praemenardii
praemicra Subbotina, 1960; Globigerinella	T. postcretacea
praemiocenica Lamb & Beard, 1972; Globorotalia	G. cultrata
praemonita Fordham n. subsp.; Tinophodella praemonita	T. praemonita
praenartanensis Shutskaya, 1956; Globorotalia	gen.D crassata
praenitida Blow, 1969; Candeina nitida	C. nitida
praeoscitans Akers, 1972; Globorotalia (Turborotalia)	D. puncticulatus
praepentacamerata Shutskaya, 1956; Globorotalia angulata	G. praepentacamerata
praepseudomenardii Hofker, 1961; Globorotalia	P. compressus
praepulleniatina Brönnimann & Resig, 1971; Pulleniatina	P. mayeri
praepumilio Parker, 1967; Globanomalina	T. detrita
praerubra Fordham n. subsp.; Globigerinoides haitiensis	G. haitiensis
praescitula Blow, 1959; Globorotalia scitula	G. miozea
praesicanus Brönnimann & Resig, 1971; Globigerinoides sicanus	O. pseudosellii
praesiphonifera Blow, 1969; Hastigerina (H.) siphonifera	H. obesa
praespectabilis Brönnimann & Resig, 1971; Pullentiana spectabilis	P. obliqueloculata
praestainforthi Blow, 1969; Globigerinita stainforthi	T. detrita
praetopilensis Blow, 1979; Globorotalia (Truncorotaloides) topilensis	T. densus
praeturritilina Blow & Banner, 1962; Globigerina turritilina	N. eocaena
prahovensis Popescu, 1969; Catapsydrax	G. indigena
prasaepis Blow, 1969; Globigerina	gen.G wilsoni
primalis Banner & Blow, 1967; Pulleniatina	P. obliqueloculata
primitiva Blow & Banner, 1962; Globigerinita unicava	G. incretaceus
primitiva Brönnimann & Resig, 1971; Turborotalita	T. detrita
primitiva Cita, 1973; Globorotalia margaritae	O. hirsuta
primitiva Cushman & Jarvis, 1929; Hantkenina alabamensis var.	H. alabamensis
primitiva Finlay, 1947; Globoquadrina	T. densus
primitiva Morozova, 1961; Acarinina	G. praepentacamerata
primordius Blow & Banner, 1962; Globigerinoides quadrilobatus	G. disjuncta
primoripumilio Fordham n. subsp.; Turborotalita detrita	T. detrita
pristinum Brönnimann & Resig, 1971; Streptochilus	S. pristinum
progomitulus Fordham n. subsp.; Globigerinoides haitiensis	G. haitiensis
prolata Bolli, 1957; Globigerina	G. lozanoi
prolixa Lipps, 1964; Protentella	G. parvulus
protoreticulata Hofker, 1956; Globigerina	gen.I reticulata
pseudoampliapertura Blow & Banner, 1962; Globigerina	T. cerroazulensis
pseudobesa Salvatorini, 1967; Turborotalia	G. bulloides
pseudo-bulloides Plummer, 1926; Globigerina	T. pseudobulloides
pseudochapmani Gohrbandt, 1967; Globorotalia	P. micrus
pseudociperoensis Blow, 1969; Globigerina praebulloides	G. bulbosa
pseudocontinuosa Jenkins, 1967; Globorotalia nana	P. mayeri
pseudocorpulenta Chalilov, 1956; Globigerina	N. eocaena
pseudocrassa Chapman & Parr, 1937; Globorotalia	T. pseudocrassa
pseudocretacea Hofker, 1956; Globigerina	gen.G bolivariana
pseudodruryi Brönnimann & Resig, 1971; Globigerina	G. bulbosa
pseudodubia Bandy, 1949; Globigerinoides	T. densus
pseudoedita Subbotina, 1960; Globigerina	T. detrita
pseudoeocaena Subbotina, 1953; Globigerina pseudoeocaena var.	G. pseudoeocaena
pseudofoliata Parker, 1967; Globoquadrina	N. conglomerata
pseudoimitata Blow, 1979; Globorotalia (Turborotalia)	T. cerroazulensis
pseudoinconstans Blow, 1979; Globorotalia (Turborotalia)	G. inconstans
pseudoiota Hornibrook, 1958; Globigerina	P. micrus
pseudokugleri Blow, 1969; Globorotalia (Turborotalia)	G. kugleri

pseudoleroyi Iturralde Vincent, 1967; Globigerina praebulloides	G. parva
pseudomayeri Bolli, 1957; Globorotalia	T. cerroazulensis
pseudomenardii Bolli, 1957; Globorotalia	P. compressus
pseudomiocenica Bolli & Bermúdez, 1965; Globorotalia	G. limbata
pseudomiozea Walters, 1965; Globorotalia zealandica	G. miozea
pseudopachyderma Cita, Premoli Silva, & Rossi, 1965; Globigerina	P. mayeri
pseudopima Blow, 1969; Globorotalia (Turborotalia) acostaensis	P. helicina
pseudopumilio Brönnimann & Resig, 1971; Globorotalia (Turborotalia)	P. helicina
pseudoruber Todd, 1957; Globigerinoides	G. haitiensis
pseudoscitula Glaessner, 1937; Globorotalia	P. pseudoscitulus
pseudosellii Brönnimann & Resig, 1971; Globigerinoides	O. pseudosellii
pseudospinulosa Samuel, 1972; Globorotalia	gen.D crassata
pseudotopilensis Subbotina, 1953; Acarinina	G. mckannai
pseudotriloba White, 1928; Globigerina	G. velascoensis
pseudovenezuelana Blow & Banner, 1962; Globigerina yeguaensis	N. eocaena
pseudovoluta Bandy, 1949; Globigerinella	P. micrus
pumilia Subbotina, 1950; Gümbelina	Z. wilcoxensis
pumilio Parker, 1962; Globorotalia	T. detrita
puncticulata Deshayes, 1832; Globigerina	D. puncticulatus
punctocarinata Fleisher, 1974; Acarinina	T. densus
punctulata d'Orbigny, 1899; Globigerina	D. puncticulatus
pusilla Bolli, 1957; Globorotalia pusilla	M. velascoensis
pyramidalis van den Broeck, 1876; Globigerina bulloides var. rubra subvar.	G. elongatus
pyriporosa Rhumbler, 1911; Globigerina	P. helicina
quadrangularis Bermúdez, 1960; Sphaeroidinellopsis	S. dehiscens
quadraria Cushman & Ellisor, 1939; Globorotalia	G. tripartita
quadrata LeRoy, 1944; Globorotalia baroemoensis var.	N. altispira
quadrata Nakkady & Talaat, 1959; Globorotalia	gen.D crassata
quadratoseptata Davidson & Morozova, 1964; Acarinina	G. mckannai
quadrilatera Galloway & Wissler, 1927; Globigerina	G. bulloides
quadrilobata d'Orbigny, 1846; Globigerina	O. quadrilobata
quadrilocula Blow, 1979; Globorotalia (Turborotalia)	T. pseudobulloides
quadripartita Koch, 1926; Globigerina bulloides var.	N. altispira
quadripartitaformis Chalilov, 1956; Globoconusa	G. mckannai
quadritriloculinoides Chalilov, 1956; Globigerina	G. velascoensis
quasifoliata Fordham n. subsp.; Tinophodella uvula	T. uvula
quetra Bolli, 1957; Globorotalia	G. mckannai
quinifalcata Saito & Maiya, 1973; Globorotalia	G. miozea
quinqueloba Natland, 1938; Globigerina	T. detrita
radians Egger, 1893; Globigerina	G. siphonifera
rainwateri Blow, 1979; Globorotalia (Turborotalia)	T. cerroazulensis
recumbens Rhumbler, 1901; Globigerina bulloides var.	O. quadrilobata
recumbens Rhumbler, 1949; Globigerina sacculifera var.	O. quadrilobata
redissimilis Fordham n. subsp.; Globorotaloides indigena	G. indigena
regina Crescenti, 1966; Globigerina	C. insueta
regularis Iturralde Vincent, 1966; Cassigerinella	C. chipolensis
regularis Terquem, 1880; Globigerina	T. detrita
reissi Loeblich & Tappan, 1957; Globorotalia	T. cerroazulensis
relizensis Bandy, Ingle, & Wright, 1971; Globorotaloides suteri	B. relizensis
renzi Bolli, 1957; Globorotalia	P. pseudoscitulus
reticulata Fordham n. subsp.; Sphaeroidinella dehiscens	S. dehiscens
reticulata Stache, 1865; Globigerina	gen.I reticulata
rex Martin, 1943; Globorotalia	gen.D crassata
rhumbleri Galloway, 1933; Hastigerinella	H. pelagica
ridenda Voloshinova, 1960; Globigerina	G. concinna
riedeli Brönnimann & Resig, 1971; Globorotalia (Turborotalia)	T. detrita

riedeli Rögl & Bolli, 1973; Hastigerinella	T. detrita
rifensis Feinberg & Lorenz, 1973; Globorotalia miozea	G. praemenardii
rikuchuensis Takayanagi & Oda, 1976; Globorotalia (Turborotalia)	P. mayeri
riveroae Bermúdez, 1960; Globigerinita	C. dissimilis
riveroae Bolli & Bermúdez, 1965; Globigerina	G. concinna
robusta Bolli, 1950; Globorotalia fohsi	F. fohsi
roglbollii Fordham n. name; Turborotalita detrita	T. detrita
rohri Bolli, 1957; Globigerina	G. tripartita
rohri Brönnimann & Bermúdez, 1953; Truncorotaloides	T. densus
ronda Blow, 1969; Globorotalia (Turborotalia) crassaformis	T. tosaensis
rosacea Bermúdez & Seiglie, 1963; Globigerina	G. rubescens
rotundata d'Orbigny, 1898; Globigerina	P. helicina
rotundimarginata Subbotina, 1953; Acarinina	M. collactea
rubescens Hofker, 1956; Globigerina	G. rubescens
rubra d'Orbigny, 1839; Globigerina	G. elongatus
rubriformis Subbotina, 1953; Globigerinoides	G. mexicana
rudis Voloshinova, 1960; Globigerina	G. concinna
rugosa Parr, 1938; Gümbelina venezuelana var.	Z. wilcoxensis
rugosoaculeata Subbotina, 1953; Acarinina	T. danvillensis
rutschi Cushman & Renz, 1941; Sphaeroidinella	S. dehiscens
sacculifera Brady, 1877; Globigerina	O. quadrilobata
sacculiferoides Christodoulou, 1960; Globigerinoides	O. quadrilobata
saginata Jenkins, 1966; Globorotalia	H. obesa
saheliana Catalano & Sprovieri, 1971; Globorotalia	G. limbata
sakitoensis Asano, 1962; Globigerina	G. tripartita
salisburgensis Gohrbandt, 1967; Globorotalia	M. velascoensis
sallentina Dallan, Gianelli, & Salvatorini, 1968; Globigerina	G. rubescens
santamariaensis McCulloch, 1977; Globigerina	G. bulloides
saphoae Bizon & Bizon, 1965; Globorotalia	G. limbata
sastrii Raju, 1971; Globigerina	G. tripartita
scabrosa Bermúdez, 1960; Globigerina	G. inconstans
scandretti Blow & Banner, 1962; Globigerinita martini	C. daubjergensis
schachdagica Chalilov, 1956; Globigerina	G. inconstans
scitula Brady, 1882; Pulvinulina	O. scitula
scobinata Bermúdez, 1960; Globigerina	G. inconstans
seigliei Bermúdez & Bolli, 1969; Globigerinoides ruber	G. haitiensis
seigliei Bermúdez & Bolli, 1969; Globorotalia	P. helicina
sellii Borsetti, 1959; Globoquadrina	G. tripartita
semi-involutus Keijzer, 1945; Globigerinoides	G. mexicana
seminulina Schwager, 1866; Globigerina	S. dehiscens
semivera Hornibrook, 1961; Globigerina	P. mayeri
senilis Bandy, 1949; Globigerina ouchitaensis var.	N. eocaena
senni Beckmann, 1954; Sphaeroidinella	G. mexicana
sharkriverensis Berggren & Olsson, 1967; Pseudohastigerina	P. micrus
siakensis LeRoy, 1939; Globigerina	P. mayeri
sibaiyaensis El-Naggar, 1966; Globorotalia	M. velascoensis
sicana de Stefani, 1952; Globigerinoides	O. universa
simplex Haque, 1956; Globanomalina	P. micrus
simplicissima Blow, 1979; Eoglobigerina eobulloides	G. velascoensis
simulans Bermúdez, 1960; Globigerina	C. dissimilis
simulata Krayeva, 1960; Acarinina crassaformis	T. densus
simulatilis Schwager, 1883; Discorbina	gen.D crassata
siphonifera d'Orbigny, 1839; Globigerina	G. siphonifera
soldadoensis Brönnimann, 1952; Globigerina	G. mckannai
spectabilis Parker, 1965; Pulleniatina	P. obliqueloculata
sphaeroides Lamb, 1969; Sphaeroidinellopsis	S. dehiscens
sphaeroides Ouda, 1978; Globigerinanus	G. aguasayaensis

sphericomiozea Walters, 1965; Globorotalia miozea	T. sphericomiozea
spinuloinflata Bandy, 1949; Globigerina	T. densus
spinulosa Cushman, 1927; Globorotalia	gen.D crassata
spinulosa Subbotina, 1958; Sphaeroidinella	S. dehiscens
spinulosus Christodoulou, 1960; Globigerinoides sacculifer	O. quadrilobata
spiralis Bolli, 1957; Globigerina	M. velascoensis
spuritumida Fordham n. subsp.; Falsella spuritumida	F. spuritumida
stainforthi Bolli, Loeblich, & Tappan, 1957; Catapsydrax	G. incretaceus
stainforthi Brönnimann, 1952; Globigerina	G. velascoensis
stainforthi Hofker, 1956; Globigerina	N. eocaena
stavensis Bandy, 1949; Gümbelitria	Z. wilcoxensis
stellaria Turnovsky, 1958; Globorotalia (Astrorotalia)	P. pseudoscitulus
stonei Weiss, 1955; Globigerina	G. mckannai
strabocella Loeblich & Tappan, 1957; Globorotalia	G. mckannai
strombiformis Beckmann, 1957; Chiloguembelina midwayensis var.	Z. wilcoxensis
subbotinae Morozova, 1939; Globorotalia	gen.D crassata
subconglobatus Chalilov, 1958; Globigerinoides subconglobatus var.	G. mexicana
subconomiozea Bandy, 1975; Globorotalia (Globoconella) conomiozea	G. limbata
subcorpulenta Chalilov, 1956; Globigerina	T. cerroazulensis
subcretacea Chapman, 1902; Globigerina	P. helicina
subcretacea Łomnicki, 1901; Globigerina	P. helicina
subcylindrica Beckmann, 1957; Chiloguembelina midwayensis	Z. wilcoxensis
subdehiscens Blow, 1959; Sphaeroidinella dehiscens	S. dehiscens
subdehiscens Finlay, 1947; Globoquadrina	G. tripartita
subelongatus Brönnimann & Resig, 1971; Globigerinoides	G. haitiensis
subintermedia Chalilov, 1956; Acarinina	G. mckannai
subpentacamerata Militsina, 1961; Acarinina	M. pentacamerata
subquadrata Brönnimann, 1954; Globigerinoides	G. haitiensis
subquadrata Morozova, 1961; Globigerina (G.) pseudobulloides	T. pseudobulloides
subsacculifera Cita, Premoli Silva, & Rossi, 1965; Globigerinoides sacculifera	O. quadrilobata
subscitula Conato, 1964; Globorotalia scitula	O. scitula
subsphaerica Subbotina, 1947; Globigerina	G. subsphaerica
subtarchanensis Agalarova & Pronina, 1975; Globigerina	P. mayeri
subtriangularis Beckmann, 1957; Chiloguembelina	Z. wilcoxensis
subtriloculinoides Chalilov, 1956; Globigerina	gen.I reticulata
sudri Ouda, 1978; Globigerinanus sudri	G. aguasayaensis
suleki Bermúdez, 1960; Globigerinoides	O. quadrilobata
suprasuturalis Brönnimann, 1952; Hantkenina (H.)	H. alabamensis
suterae Catalano & Sprovieri, 1971; Globorotalia	O. ventriosa
suteri Bolli, 1957; Globorotaloides	G. incretaceus
suturalis Brönnimann, 1952; Orbulina	O. universa
tadjikistanensis Bykova, 1953; Globorotalia	gen.D crassata
taminensis Kübler & Zwingli, 1866; Globigerina	G. linaperta
tapiesi Perconig, 1968; Globigerinoides	G. haitiensis
tapurensis Blow & Banner, 1962; Globigerina tripartita	G. tripartita
tarchanensis Subbotina & Khutsieva, 1950; Globigerina	P. mayeri
taroubaensis Brönnimann, 1952; Globigerina	C. dissimilis
taurica Morozova, 1961; Chilogümbelina	Z. wilcoxensis
taurica Morozova, 1961; Globigerina (Eoglobigerina)	C. taurica
tecta Lipps, 1964; Globigerina	T. detrita
tegillata Brönnimann & Resig, 1971; Globorotalia (Turborotalia) acostaensis	P. helicina
tenuitheca Blow, 1969; Globorotalia (Turborotalia) tosaensis	T. tosaensis
tenellus Parker, 1958; Globigerinoides	G. rubescens
tenuis Todd, 1957; Guembelina	Z. wilcoxensis
testarugosa Jenkins, 1960; Globorotalia	G. incretaceus

tetracamerata Bolli & Bermúdez, 1965; Globigerina	G. bulloides
tetragona Morozova, 1961; Globigerina (Eoglobigerina)	C. tetragona
tetrapetala Fordham n. subsp.; Tinophodella praemonita	T. praemonita
teuria Finlay, 1947; Zeauvigerina	Z. wilcoxensis
thalmanni Brönnimann, 1950; Hantkenina (H.)	H. alabamensis
thebaica Said, 1960; Globorotalia	G. lozanoi
theodosica Morozova, 1961; Globigerina (Eoglobigerina)	C. theodosica
theyeri Fleisher, 1974; Globorotalia (Hirsutella)	O. hirsuta
tholiformis Blow, 1979; Globorotalia (Morovella) aequa	gen.D crassata
tinguarensis Iturralde Vincent, 1967; Globigerina praebulloides	G. parva
tokelauae Boersma, 1969; Bolivina	S. tokelauae
topilensis Cushman, 1925; Globigerina	T. topilensis
tortiva Bolli, 1957; Globorotalia	G. velascoensis
tosaensis Takayanagi & Saito, 1962; Globorotalia	T. tosaensis
transdanubica Samuel, 1972; Globigerina linaperta	gen.I reticulata
transiens Carter, 1963; Sphaeroidinella	S. dehiscens
transitoria Blow, 1956; Globigerinoides	O. universa
transsylvanica Popescu, 1970; Globorotalia (Turborotalia)	T. postcretacea
transversa Chalilov, 1956; Globigerina inaequispira	G. pseudoeocaena
traubi Gohrbandt, 1963; Globorotalia?	M. velascoensis
trema Lipps, 1964; Globorotaloides	G. parvulus
triangula Theyer, 1973; Globorotalia inflata	D. puncticulatus
triangularis White, 1928; Globigerina	G. velascoensis
tribulosa Loeblich & Tappan, 1957; Globorotalia	G. mckannai
trichotrocha Loeblich & Tappan, 1957; Globorotalia	M. velascoensis
tricamerata Fordham n. subsp.; Globoquadrina tripartita	G. tripartita
tricamerata Tolmachoff, 1934; Globigerina	O. quadrilobata
trifolia Morozova, 1961; Globigerina (Eoglobigerina)	G. conusa
trigonula d'Orbigny, 1903; Globigerina	D. puncticulatus
triloba Cushman, 1921; Candeina nitida var.	C. nitida
triloba Jedlitschka, 1934; Candeina	O. universa
triloba Reuss, 1850; Globigerina	O. quadrilobata
trilobata Subbotina, 1953; Globigerina pseudoeocaena var.	G. yeguaensis
trilocularis d'Orbigny, 1832; Globigerina	O. quadrilobata
triloculinoides Plummer, 1926; Globigerina	G. velascoensis
trinidadensis Bolli, 1957; Globorotalia	G. inconstans
trinitatensis Brönnimann, 1950; Hantkenina (Applinella)	H. alabamensis
trinitatensis Cushman & Renz, 1942; Gümbelina	Z. wilcoxensis
tripartita Koch, 1926; Globigerina bulloides var.	G. tripartita
tripetala Fordham n. subsp.; Tinophodella praemonita	T. praemonita
triplex Subbotina, 1953; Acarinina	G. mckannai
trisphaera Fordham n. subsp.; Globigerina bulbosa	G. bulbosa
trivialis Subbotina, 1953; Globigerina	G. velascoensis
trochoidea Bizon & Bizon, 1965; Globorotalia acostaensis	P. mayeri
trochospira Hartono, 1964; Pulleniatina obliqueloculata	P. obliqueloculata
troelseni Loeblich & Tappan, 1957; Globortalia	P. pseudoscitulus
tropicalis Blow & Banner, 1962; Globigerapsis	G. mexicana
truncatulinoides d'Orbigny, 1839; Rotalina	T. truncatulinoides
tumbili Chalilov, 1956; Globigerina	N. eocaena
tumida Brady, 1877; Pulvinulina menardii var.	G. tumida
turcmenica Chalilov, 1956; Globigerina	G. bakeri
turgida Finlay, 1939; Globigerina linaperta var.	C. dissimilis
turritilina Blow & Banner, 1962; Globigerina turritilina	N. eocaena
twisselmanni Mallory, 1959; Globorotalia aragonensis var.	gen.D crassata
tyrrhenicus Borsetti & Cati, 1974; Globigerinoides	G. elongatus
umbilicata Fordham n. subsp.; Pulleniatina mayeri	P. mayeri
umbilicata Orr & Zaitzeff, 1971; Globigerina	G. bulloides

uncinata Bolli, 1957; *Globorotalia*	*G. inconstans*
ungulata Bermúdez, 1960; *Globorotalia*	*G. tumida*
unicavus Bolli, Loeblich, & Tappan, 1957; *Catapsydrax*	*G. incretaceus*
universa Jedlitschka, 1934; *Canorbulina*	*O. universa*
universa d'Orbigny, 1839; *Orbulina*	*O. universa*
utilisindex Jenkins & Orr, 1973; *Globigerina*	gen.I *reticulata*
uvula Ehrenberg, 1861; *Pylodexia*	*T. uvula*
variabilis Bolli, 1957; *Globorotaloides*	*G. parvulus*
varianta Subbotina, 1953; *Globigerina*	*T. varianta*
vedica Martirosyan, 1970; *Acarinina*	gen.D *crassata*
velascoensis Cushman, 1925; *Globigerina*	*G. velascoensis*
velascoensis Cushman, 1925; *Pulvinulina*	*M. velascoensis*
venezuelana Hedberg, 1937; *Globigerina*	*N. conglomerata*
venezuelana Nuttall, 1935; *Gümbelina*	*Z. wilcoxensis*
ventriosa Fordham n. subsp.; *Neoacarinina conglomerata*	*N. conglomerata*
ventriosa Ogniben, 1958; *Globorotalia scitula*	*O. ventriosa*
venzoi Borsetti, 1959; *Catapsydrax*	*G. mexicana*
vialovi Myatiuk, 1970; *Subbotina*	*G. incretaceus*
vicespinuloinflata Samuel, 1972; *Turborotalia* (*Acarinina*)	gen.D *crassata*
victoriana Beckmann, 1957; *Chiloguembelina*	*Z. wilcoxensis*
vignalii Bermúdez & Bolli, 1969; *Globigerina*	*G. rubescens*
vincentae Fleisher, 1974; *Turborotalia* (*T.*)	*P. helicina*
viola Blow, 1969; *Globorotalia* (*G.*) *crassula*	*T. crassula*
vivans Cushman, 1934; *Gümbelitria*(?)	*Z. wilcoxensis*
waiparaensis Jenkins, 1966; *Chiloguembelina*	*Z. wilcoxensis*
wartsteinensis Gohrbandt, 1967; *Globorotalia*	*M. collactea*
weissi Saito, 1963; *Globigerina*	*T. detrita*
whitei Weiss, 1955; *Globorotalia*	*G. mckannai*
wilcoxensis Cushman & Ponton, 1932; *Globorotalia*	*G. mckannai*
wilcoxensis Cushman & Ponton, 1932; *Gümbelina*	*Z. wilcoxensis*
wilcoxensis Cushman & Ponton, 1932; *Nonion*	*P. micrus*
wilsoni Cole, 1927; *Globigerina*	gen.G *wilsoni*
winkleri Bermúdez, 1960; *Globigerina*	*N. altispira*
winniana Howe, 1939; *Cassidulina*	*C. chipolensis*
woodi Jenkins, 1960; *Globigerina*	*G. disjuncta*
yeguaensis Weinzierl & Applin, 1929; *Globigerina*	*G. yeguaensis*
zealandica Hornibrook, 1958; *Globorotalia*	*G. miozea*
zealandica Hornibrook, 1961; *Globigerina*	*C. insueta*
zelandica Finlay, 1939; *Zeauvigerina*	*Z. wilcoxensis*
zeocenica Hornibrook & Jenkins, 1965; *Candeina*	*G. mexicana*

EXPLANATION OF PLATES

Unless otherwise stated: where figure identification includes an alphabetic character, a is umbilical view, b is lateral view, c is spiral view; figures without alphabetic characters are umbilical views; and magnifications are X70.

PLATE 1

All magnifications X140; where figure identifications include an alphabetic character, a is inner lateral view, b is apertural view, c is serial view.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Brizalina sp.

Figures without alphabetic characters are inner lateral views.

Middle *Globorotalia conomiozea* zone. Figs. 1--3; UQF 71081--71083.

Lower *G. margaritae* zone. Figs. 4--6; UQF 71084--71086.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Fig. 7; UQF 71087.

Middle *G. truncatulinoides*--*G. tosaensis* overlap-zone. Fig. 8; UQF 71088.

Streptochilus tokelauae (Boersma)

Figures without alphabetic characters are inner lateral views.

Upper *G. continuosa* zone. Phenon *latum* Brönnimann & Resig: figs. 9--11; UQF 71089--71091. Phenon *tokelauae* (Boersma): figs. 12--14; UQF 71092--71094.

Middle *Globigerina nepenthes* zone. Phenon *tokelauae* (Boersma): figs. 15--20; UQF 71095--71100.

Upper *Globorotalia puncticulata* zone. Phenon *tokelauae* (Boersma): fig. 21; UQF 71101.

Lower *G. inflata* zone. Phenon *flexiserialis* n. ph.: figs. 22, 23 (holotype); UQF 71102, 71103. Phenon *tokelauae* (Boersma): figs. 24--32; UQF 71104--71112.

Middle *G. inflata* zone. Phenon *tokelauae* (Boersma): fig. 33; UQF 71113.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *tokelauae* (Boersma): fig. 34; UQF 71114.

Middle *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *latum* Brönnimann & Resig: fig. 35; UQF 71115. Phenon *tokelauae* (Boersma): figs. 36, 37; UQF 71116, 71117.

Upper *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *tokelauae* (Boersma): figs. 38--41; UQF 71118--71121.

Streptochilus globiger (Schwager)

Figures without alphabetic characters are inner lateral views.

Upper *G. continuosa* zone. Phenon *globiger* (Schwager): figs. 42, 43; UQF 71122, 71123. Phenon *infirmirugosus* n. ph.: fig. 44; UQF 71124.

Lower *G. margaritae* zone. Phenon *globiger* (Schwager): figs. 45--66; UQF 71125--71146. Phenon *infirmirugosus* n. ph.: figs. 67--69; UQF 71147--71149.

Middle *G. margaritae* zone. Phenon *globiger* (Schwager): figs. 70--73; UQF 71150--71153. Phenon *infirmirugosus* n. ph.: figs. 74--76; UQF 71154--71156.

Upper *G. margaritae* zone. Phenon *globiger* (Schwager): figs. 77--82; UQF 71157--71162. Phenon *infirmirugosus* n. ph.: figs. 83--89; UQF 71163--71169.

Middle *G. puncticulata* zone. Phenon *globiger* (Schwager): figs. 90--92; UQF 71170--71172. Phenon *infirmirugosus* n. ph.: figs. 93--102; UQF 71173--71182.

Upper *G. puncticulata* zone. Phenon *globiger* (Schwager): figs. 103--108; UQF 71183--71188. Phenon *infirmirugosus* n. ph.: figs. 109--114, 115 (holotype), 116, 117; UQF 71189--71197.

Lower *G. inflata* zone. Phenon *infirmirugosus* n. ph.: fig. 118; UQF 71198.

Middle *G. inflata* zone. Phenon *globiger* (Schwager): fig. 119; UQF 71199.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Streptochilus tokelauae (Boersma)

Figures without alphabetic characters are inner lateral views.

Marquesas Oceanic Formation, Gray Unit

Middle *Globoquadrina altispira* zone (19/2/145--147). Phenon *tokelauae* (Boersma): fig. 120; UQF 71200.

Clipperton Oceanic Formation, Varicolored Unit

Middle *Globoquadrina altispira* zone (17/6/144--146). Phenon *tokelauae* (Boersma): fig. 121?; UQF 71201.

Upper *Globorotalia plesiotumida* zone (10/6/143--145). Phenon *latum* Brönnimann & Resig: figs. 122, 123; UQF 71202, 71203. Phenon *tokelauae* (Boersma): fig. 124; UQF 71204.

Upper G. plesiotumida zone (9/6/140--142). Phenon tokelauae (Boersma): figs. 125, 126; UQF 71205, 71206.

Streptochilus globiger (Schwager)

All inner lateral views.

Clipperton Oceanic Formation, Varicolored Unit

Lower G. plesiotumida zone (16/6/22--24). Phenon infirmirugosus n. ph.: fig. 127; UQF 71207.

Lower Sphaeroidinella dehiscens zone. Phenon globiger (Schwager): figs. 128--130; UQF 71208--71210.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Cassigerinella digitata (Brady)

Middle Globigerina nepenthes zone. Phenon praedigitata (Parker): figs. 131, 132; UQF 71211, 71212.

Middle Globorotalia conomiozea zone. Phenon praedigitata (Parker): figs. 133, 134; UQF 71213, 71214.

Middle G. puncticulata zone. Phenon praedigitata (Parker): fig. 135; UQF 71215.

Upper G. puncticulata zone. Phenon praedigitata (Parker): fig. 136; UQF 71216.

PLATE 2

All magnifications X140.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Cassigerinella digitata (Brady)

Upper Globorotalia crassaformis zone. Phenon praedigitata (Parker): figs. 1--3; UQF 71217-- 71219.

Middle G. inflata zone. Phenon praedigitata (Parker): fig. 4; UQF 71220.

Middle G. tosaensis zone. Phenon praedigitata (Parker): figs. 5, 6; UQF 71221, 71222.

Upper G. truncatulinoides--G. tosaensis overlap-zone. Phenon praedigitata (Parker): fig. 6; UQF 71223.

D.S.D.P. Site 77B, east equatorial Pacific Ocean, Clipperton Formation

Cassigerinella digitata (Brady)

Varicolored Unit

Middle G. plesiotumida zone (13/4/6--8). Phenon praedigitata (Parker): fig. 8; UQF 71225.

Lower G. tumida zone. Phenon eamesi (Blow): fig. 9; UQF 71226. Phenon praedigitata (Parker): figs. 10--12; UQF 71227--71229.

Middle G. tumida zone. Phenon praedigitata (Parker): fig. 13; UQF 71230.

Lower Globigerinoides fistulosus zone. Phenon praedigitata (Parker): fig. 14; UQF 71231.

Cyclic Unit

Lower Pulleniatina obliqueloculata zone. Phenon praedigitata (Parker): fig. 15; UQF 71232.

Upper P. obliqueloculata zone. Phenon praedigitata (Parker): figs. 16--18; UQF 71234--71236.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Tenuitella postcretacea (Myatiuk)

Upper Orbulina suturalis zone. Phenon gemma (Jenkins): figs. 19, 20; UQF 71237, 71238.

Middle Globorotalia mayeri zone. Phenon pieste n. ph.: figs. 21, 22 (holotype), 23--25; UQF 71239--71243.

Upper Globigerina nepenthes zone. Phenon postcretacea (Myatiuk): fig. 26; UQF 71244.

Toddella grata (Todd)

Upper Orbulina suturalis zone. Phenon grata (Todd): figs. 27, 28; UQF 71245, 71246.

Middle Globorotalia mayeri zone. Phenon clemenciae (Bermúdez): figs. 29, 30; UQF 71247, 71248. Phenon grata (Todd): figs. 31--34; UQF 71249--71252.

Upper G. mayeri zone. Phenon clemenciae (Bermúdez): fig. 35; UQF 71253. Phenon grata (Todd): figs. 36, 37; UQF 71254, 71255.

Middle Globigerina nepenthes zone. Phenon bauerensis (Quilty): figs. 38, 39; UQF 71256, 71257.

Upper G. nepenthes zone. Phenon bauerensis (Quilty): fig. 40; UQF 71258.

Middle Globorotalia inflata zone. Phenon galapagoensis (Quilty): figs. 41, 42; UQF 71259, 71260.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *galapagoensis* (Quilty): figs. 43, 44; UQF 71261, 71262.

Middle *G. truncatulinoides* zone. Phenon *anfracta* (Parker): figs. 45, 46; UQF 71263, 71264. Phenon *parkerae* (Brönnimann & Resig): fig. 47; UQF 71265. Phenon *compressa* n. ph.: figs. 48, 49, 50 (holotype); UQF 71266--71268.

Candeina nitida d'Orbigny

Upper *Globigerina nepenthes* zone. Phenon *praenitida* Blow: fig. 51; spiral view; UQF 71269.

Middle *Globorotalia margaritae* zone. Phenon *nitida* d'Orbigny: figs. 52, 53; spiral views; UQF 71270, 71271.

Upper *G. margaritae* zone. Phenon *nitida* d'Orbigny: fig. 54; lateral view; UQF 71272.

Middle *G. truncatulinoides* zone. Phenon *nitida* d'Orbigny: fig. 55; lateral view; UQF 71273.

Tinophodella praemonita n. sp.

Upper *Globigerina nepenthes* zone. Phenon *incrusta* (Akers): fig. 56; UQF 71274.

Middle *Globorotalia puncticulata* zone. Phenon *naparimaensis* (Brönnimann): fig. 57; UQF 71275. Phenon *uvula* (Ehrenberg): fig. 58; lateral view; UQF 71276.

Upper *G. puncticulata* zone. Phenon *praemonita* n. ph.: figs. 59 (holotype), 60; UQF 71277, 71278.

Middle *G. crassaformis* zone. Phenon *tetrapetala* n. ph.: figs. 61, 62 (holotype); UQF 71279, 71280.

PLATE 3

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Tinophodella praemonita n. sp.

All magnifications X140.

Middle *Globorotalia crassaformis* zone. Phenon *tripetala* n. ph.: fig. 1 (holotype); UQF 71281.

Lower *G. inflata* zone. Phenon *praemonita* n. ph.: fig. 2; UQF 71282. Phenon *glutinata* (Egger): fig. 3; UQF 71283. Phenon *ambitacrena* Loeblich & Tappan: fig. 4; UQF 71284. Phenon *iota* (Parker): figs. 5, 6; UQF 71285, 71286.

Parkerina iota (Parker)

All magnifications X140.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *iota* (Parker): figs. 7--9; UQF 71287--71289.

Upper *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *iota* (Parker): figs. 10--13; UQF 71290--71293.

Middle *G. truncatulinoides* zone. Phenon *iota* (Parker): fig. 14; UQF 71294.

Upper *G. truncatulinoides* zone. Phenon *iota* (Parker): figs. 15--18; UQF 71295--71298.

Tinophodella antarctica (Keany & Kennett)

All magnifications X140.

Middle *G. tosaensis* zone. Phenon *antarctica* (Keany & Kennett): fig. 19; UQF 71299.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *polypetala* n. ph.: figs. 20, 21 (holotype); UQF 71300, 71301. Phenon *antarctica* (Keany & Kennett): figs. 22, 23; UQF 71302, 71303.

Tinophodella evoluta n. sp.

All magnifications X140.

Upper *G. truncatulinoides* zone. Phenon *evoluta* n. ph.: figs. 24 (holotype), 25--27; UQF 71304--71307.

Tinophodella uvula (Ehrenberg)

All magnifications X140.

Upper *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *antarctica* (Keany & Kennett): fig. 28; UQF 71308. Phenon *quasifoliata* n. ph.: fig. 29 (holotype); UQF 71309. Phenon *parkerae* (Bermúdez): figs. 30, spiral view; 31, oblique spiral view; UQF 71310, 71311.

Middle *G. truncatulinoides* zone. Phenon *tetrapetala* n. ph.: fig. 32; UQF 71312.

Upper *G. truncatulinoides* zone. Phenon *incrusta* (Akers): fig. 33; UQF 71313. Phenon *glutinata* (Egger): figs. 34, 35; UQF 71314, 71515. Phenon *ambitacrena* Loeblich & Tappan: fig. 36; UQF 71316.

Bandyus relizensis (Bandy, Ingle, & Wright)

Upper *Orbulina suturalis* zone. Phenon *relizensis* (Bandy, Ingle, & Wright): figs. 37, 38; UQF 71317, 71318. Phenon *extraumbilicatus* n. ph.: figs. 39, 40 (holotype); UQF 71319, 71320.

Globorotaloides parvulus (Bolli)

Upper *O. suturalis* zone. Phenon *lateraliaperturus* n. ph.: figs. 41, 42 (holotype); UQF 71321, 71322. Phenon *falconarae* Gianelli & Salvatorini: figs. 43--48; UQF 71323--71328.

Upper *Globorotalia mayeri* zone. Phenon *lateraliaperturus* n. ph.: figs. 49--51; UQF 71329--71331. Phenon *variabilis* Bolli: figs. 52, 53; UQF 71332, 71333.

Middle *G. continuosa* zone. Phenon *lateraliaperturus* n. ph.: fig. 54; UQF 71334. Phenon *variabilis* Bolli: figs. 55--57; UQF 71335--71337. Phenon *anasuteri* n. ph.: figs. 58, 59 (holotype); UQF 71338, 71339.

Globorotaloides indigena (Łuczkowska)

Upper *Globorotalia continuosa* zone. Phenon *redissimilis* n. ph.: figs. 60--64, 65 (holotype); UQF 71340--71345. Phenon *anavenezuelanus* n. ph.: figs. 66, 67 (holotype), 68; UQF 71346-- 71348.

Globorotaloides hexagonus (Natland)

Upper *Globorotalia continuosa* zone. Phenon *variabilis* Bolli: fig. 69; UQF 71349.

Middle *G. conomiozea* zone. Phenon *variabilis* Bolli: fig. 70; UQF 71350.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Globorotaloides parvulus (Bolli) and *G. hexagonus* (Natland)

Marquesas Oceanic Formation, Gray Unit

Lower *Globorotalia fohsi peripheracuta* zone. Phenon *variabilis* Bolli: figs. 71--73; UQF 71351--71353.

Clipperton Oceanic Formation, Varicolored Unit

Lower *G. plesiotumida* zone (16/6/22--24). Phenon *variabilis* Bolli: fig. 74; UQF 71354. Phenon *hexagonus* (Natland): figs. 75--77; UQF 71355--71357.

Upper *G. plesiotumida* zone (10/6/143--145). Phenon *variabilis* Bolli: fig. 78; UQF 71358. Phenon *hexagonus* (Natland): fig. 79; UQF 71359.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Globoquadrina tripartita (Koch)

Upper *Orbulina suturalis* zone. Phenon *dehiscens* (Chapman, Parr & Collins): fig. 80; UQF 71360.

Middle *Globorotalia mayeri* zone. Phenon *dehiscens* (Chapman, Parr & Collins): figs. 81--88; 89, 90, X140; UQF 71361--71370. Phenon *advena* Bermúdez: figs. 91, 92; 93, X140; UQF 71371--71373.

PLATE 4

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Globoquadrina tripartita (Koch)

Middle *Globorotalia mayeri* zone. Phenon *advena* Bermúdez: figs. 1--8; UQF 71374--71381. Phenon *laxispira* n. ph.: figs. 9 (holotype), 10; UQF 71383, 71384.

Upper *G. mayeri* zone. Phenon *advena* Bermúdez: fig. 11; UQF 71385. Phenon *tricamerata* n. ph.: figs. 12, 13; UQF 71386, 71387.

Middle *G. continuosa* zone. Phenon *advena* Bermúdez: figs. 14--16; UQF 71388--71390. Phenon *tricamerata* n. ph.: figs. 17, 18 (holotype); UQF 71391, 71392.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Globoquadrina tripartita (Koch)

Marquesas Oceanic Formation, Gray Unit

Middle *Globorotalia fohsi lobata* zone. Phenon *dehiscens* (Chapman, Parr, & Collins): figs. 19, 20, X140; 21--23; UQF 71393--71397. Phenon *advena* Bermúdez: fig. 24; UQF 71398.

Clipperton Oceanic Formation, Varicolored Unit

Upper *G. plesiotumida* zone (9/6/140--142). Phenon *dehiscens* (Chapman, Parr, & Collins): fig. 25; UQF 71399.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Neoacarinina altispira (Cushman & Jarvis)

Middle *Globigerina nepenthes* zone. Phenon *globosa* (Bolli): figs. 26--29; UQF 71401--71404. Phenon *altispira* (Cushman & Jarvis): figs. 30--32; UQF 71405--71407.

Upper *G. nepenthes* zone. Phenon *globosa* (Bolli): fig. 33; UQF 71408. Phenon *pozonensis* (Blow): figs. 34--36; UQF 71409--71411. Phenon *altispira* (Cushman & Jarvis): figs. 37, 38; UQF 71412, 71413.

PLATE 5

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Neoacarinina altispira (Cushman & Jarvis)

Lower *Globorotalia margaritae* zone. Phenon *globosa* (Bolli): figs. 1, 2; UQF 71414, 71415. Phenon *altispira* (Cushman & Jarvis): fig. 3; UQF 71416.

Middle *G. margaritae* zone. Phenon *baroemoensis* (LeRoy): fig. 4; UQF 71417. Phenon *globosa* (Bolli): figs. 5, 6; UQF 71418, 71419. Phenon *pozonensis* (Blow): fig. 7; UQF 71420. Phenon *altispira* (Cushman & Jarvis): figs. 8--12; UQF 71421--71425.

Upper *G. margaritae* zone. Phenon *baroemoensis* (LeRoy): fig. 13; UQF 71426. Phenon *conica* (Brönnimann & Resig): fig. 14, lateral view; UQF 71427. Phenon *pozonensis* (Blow): figs. 15, 16; UQF 71428, 71429.

Middle *G. puncticulata* zone. Phenon *pozonensis* (Blow): fig. 17; UQF 71430.

Upper *G. puncticulata* zone. Phenon *baroemoensis* (LeRoy): figs. 18, 19; UQF 71431, 71432. Phenon *globosa* (Bolli): fig. 20; UQF 71433.

Middle *G. crassaformis* zone. Phenon *baroemoensis* (LeRoy): fig. 21; UQF 71434. Phenon *globosa* (Bolli): figs. 22--24; UQF 71435--71437.

Lower *G. inflata* zone. Phenon *altispira* (Cushman & Jarvis): fig. 25; UQF 71438.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Neoacarinina altispira (Cushman & Jarvis)

Marquesas Oceanic Formation, Gray Unit

Lower *Globorotalia fohsi lobata* zone. Phenon *globosa* (Bolli): fig. 26; UQF 71439.

Middle *G. fohsi lobata* zone. Phenon *globosa* (Bolli): fig. 27; UQF 71440. Phenon *pozonensis* (Blow): fig. 28; UQF 71441.

Clipperton Oceanic Formation, Varicolored Unit

Lower *G. plesiotumida* zone (16/6/22--24). Phenon *globosa* (Bolli): fig. 29; UQF 71442.

Middle *G. plesiotumida* zone (12/1/5--7). Phenon *baroemoensis* (LeRoy): fig. 30; UQF 71443.

Upper *G. plesiotumida* zone (9/6/140--142). Phenon *pozonensis* (Blow): fig. 31; UQF 71444. Phenon *altispira* (Cushman & Jarvis): fig. 32; UQF 71445.

Lower *Sphaeroidinella dehiscens* zone. Phenon *altispira* (Cushman & Jarvis): fig. 33; UQF 71446.

Lower *Globigerinoides fistulosus* zone. Phenon *globosa* (Bolli): fig. 34; UQF 71447.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Neoacarinina conglomerata (Schwager)

Upper *Globigerina nepenthes* zone. Phenon *obesa* (Akers): fig. 35; UQF 71448.

Middle *Globorotalia margaritae* zone. Phenon *larmeui* (Akers): fig. 36; UQF 71449.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Marquesas Oceanic Formation, Gray Unit

Neoacarinina conglomerata (Schwager)

Lower *Globorotalia fohsi lobata* zone. Phenon *eximia* (Todd): fig. 37; UQF 71450.

Middle *G. fohsi lobata* zone. Phenon *venezuelana* (Hedberg): fig. 38; UQF 71451. Phenon *eximia* (Todd): figs. 39, 40; UQF 71452, 71453.

Lower *Globoquadrina altispira* zone. Phenon *venezuelana* (Hedberg): figs. 41--43; UQF 71454--71456. Phenon *larmeui* (Akers): figs. 44--47; UQF 71457--71460. Phenon *ventriosa* n. ph.: figs. 48--50; UQF 71461--71463. Phenon *eximia* (Todd): fig. 51; UQF 71464.

Middle *G. altispira* zone (19/2/145--147). Phenon *larmeui* (Akers): figs. 52--54; UQF 71465--71467.

PLATE 6

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Neoacarinina conglomerata (Schwager)

Marquesas Oceanic Formation, Gray Unit

Middle *G. altispira* zone (19/2/145--147). Phenon *larmeui* (Akers): figs. 1, 2; UQF 71468, 71469. Phenon *ventriosa* n. ph.: figs. 3--5; UQF 71470--71472.

Clipperton Oceanic Formation, Varicolored Unit

Lower *Globorotalia plesiotumida* zone (16/6/22--24). Phenon *venezuelana* (Hedberg): fig. 6; UQF 71473. Phenon *larmeui* (Akers): fig. 7; UQF 71474. Phenon *ventriosa* n. ph.: fig. 8; UQF 71475.

Lower *G. plesiotumida* zone (15/4/22--24). Phenon *ventriosa* n. ph.: fig. 9; UQF 71476.

Middle *G. plesiotumida* zone (13/4/6--8). Phenon *larmeui* (Akers): figs. 10, 11; UQF 71477, 71478. Phenon *ventriosa* n. ph.: figs. 12, 13 (holotype), 14--16; UQF 71479--71483.

Middle *G. plesiotumida* zone (12/1/5--7). Phenon *larmeui* (Akers): fig. 17; UQF 71484. Phenon *ventriosa* n. ph.: figs. 18--22; UQF 71485--71489.

Upper *G. plesiotumida* zone (10/6/143--145). Phenon *ventriosa* n. ph.: figs. 23--25; UQF 71490--71492. Phenon *conglomerata* (Schwager): figs. 26, 27; UQF 71494, 71495.

Upper *G. plesiotumida* zone (9/6/140--142). Phenon *conglomerata* (Schwager): fig. 28; UQF 71496.

Lower *G. tumida* zone. Phenon *ventriosa* n. ph.: fig. 29; UQF 71497. Phenon *conglomerata* (Schwager): fig. 30; UQF 71498.

Middle *G. tumida* zone. Phenon *conglomerata* (Schwager): fig. 31; UQF 71499.

Lower *Sphaeroidinella dehiscens* zone. Phenon *conglomerata* (Schwager): figs. 32, 33; UQF 71500, 71501. Phenon *pseudofoliata* (Parker): fig. 34; UQF 71503.

D.S.D.P. Site 77A, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit

Neoacarinina conglomerata (Schwager)

Upper *P. obliqueloculata* zone. Phenon *conglomerata* (Schwager): fig. 35; UQF 71505.

PLATE 7

All magnifications X140.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Turborotalita detrita (Terquem)

Upper *Orbulina suturalis* zone. Phenon *angustiumbilicata* (Bolli): figs. 1--18; UQF 71506--71523. Phenon *primitiva* Brönnimann & Resig: figs. 19--23; UQF 71524--71528. Phenon *clarkei* (Rögl & Bolli): fig. 24; UQF 71529. Phenon *quinqueloba* (Natland): figs. 25--34; UQF 71530--71539.

Middle *Globorotalia mayeri* zone. Phenon *angustiumbilicata* (Bolli): figs. 35, 36; UQF 71540, 71541. Phenon *primitiva* Brönnimann & Resig: figs. 37, 38; UQF 71542, 71543. Phenon *quinqueloba* (Natland): figs. 39--41; UQF 71544--71546.

Upper *G. mayeri* zone. Phenon *angustiumbilicata* (Bolli): figs. 42, 43; UQF 71547, 71548. Phenon *clarkei* (Rögl & Bolli): figs. 44, 45; UQF 71549, 71550. Phenon *quinqueloba* (Natland): fig. 46; UQF 71551.

Middle *G. continuosa* zone. Phenon *clarkei* (Rögl & Bolli): fig. 47; UQF 71552. Phenon *quinqueloba* (Natland): figs. 48--54; UQF 71553--71559.

Upper *G. continuosa* zone. Phenon *primitiva* Brönnimann & Resig: fig. 55; UQF 71560. Phenon *primoripumilio* n. ph.: fig. 56 (Holotype); UQF 71561. Phenon *quinqueloba* (Natland): fig. 57; UQF 71562.

Middle *Globigerina nepenthes* zone. Phenon *angustiumbilicata* (Bolli): figs. 58--63; UQF 71563--71568. Phenon *primitiva* Brönnimann & Resig: fig. 64; UQF 71569. Phenon *quinqueloba* (Natland): figs. 65--68; UQF 71570--71573.

Upper *G. nepenthes* zone. Phenon *angustiumbilicata* (Bolli): fig. 69; UQF 71574. Phenon *primitiva* Brönnimann & Resig: fig. 70; UQF 71575. Phenon *primoripumilio* n. ph.: fig. 71; UQF 71576. Phenon *quinqueloba* (Natland): figs. 72--76; UQF 71577--71581.

Middle *Globorotalia conomiozea* zone. Phenon *angustiumbilicata* (Bolli): figs. 77, 78; UQF 71582, 71583. Phenon *primoripumilio* n. ph.: figs. 79, 80; UQF 71584, 71585. Phenon *quinqueloba* (Natland): figs. 81--83; UQF 71586--71588. Phenon *pumilio* (Parker): figs. 84-- 86; UQF 71589--71591.

Lower *G. margaritae* zone. Phenon *angustiumbilicata* (Bolli): fig. 87; UQF 71592. Phenon *primoripumilio* n. ph.: fig. 88; UQF 71593. Phenon *quinqueloba* (Natland): figs. 89--94; UQF 71594--71599. Phenon *egelida* (Cifelli & Smith): fig. 95; UQF 71600.

Middle *G. margaritae* zone. Phenon *primoripumilio* n. ph.: figs. 96, 97; UQF 71601, 71602. Phenon *quinqueloba* (Natland): figs. 98--101; UQF 71603--71606. Phenon *pumilio* (Parker): fig. 102; UQF 71607.

Upper *G. margaritae* zone. Phenon *angustiumbilicata* (Bolli): fig. 103; UQF 71608. Phenon *clarkei* (Rögl & Bolli): fig. 104; UQF 71609. Phenon *quinqueloba* (Natland): figs. 105--107; UQF 71610--71612. Phenon *pumilio* (Parker): figs. 108, 109; UQF 71613, 71614. Phenon *egelida* (Cifelli & Smith): fig. 110; UQF 71615.

Middle *G. puncticulata* zone. Phenon *clarkei* (Rögl & Bolli): figs. 111, 112; UQF 71616, 71617. Phenon *quinqueloba* (Natland): figs. 113--118; UQF 71618--71623. Phenon *pumilio* (Parker): figs. 119, 120; UQF 71624, 71625. Phenon *egelida* (Cifelli & Smith): figs. 121, 122; UQF 71626, 71627.

Upper *G. puncticulata* zone. Phenon *angustiumbilicata* (Bolli): fig. 123; UQF 71629. Phenon *guadalupensis* (McCulloch): fig. 124; UQF 71630. Phenon *roglbolliorum* n. name: fig. 125; UQF 71631. Phenon *clarkei* (Rögl & Bolli): figs. 126, 127; UQF 71632, 71633. Phenon *quinqueloba* (Natland): figs. 128--131; UQF 71634--71637. Phenon *egelida* (Cifelli & Smith): figs. 132, 133; UQF 71638, 71639. Phenon *humilis* (Brady): figs. 134--136; UQF 71640--71642.

Middle *G. crassaformis* zone. Phenon *angustiumbilicata* (Bolli): figs. 137--139; UQF 71643--71645. Phenon *primoripumilio* n. ph.: figs. 140, 141; UQF 71647, 71648. Phenon *guadalupensis* (McCulloch): figs. 142--146; UQF 71649--71653.

PLATE 8

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Turborotalita detrita (Terquem)

All magnifications X140.

Middle *Globorotalia crassaformis* zone. Phenon *guadalupensis* (McCulloch): figs. 1--4; UQF 71654--71657. Phenon *praepumilio* (Parker): figs. 19, 21; UQF 71673, 71675. Phenon *clarkei* (Rögl & Bolli): figs. 5--12; UQF 71658--71665. Phenon *quinqueloba* (Natland): figs. 13--16; UQF 71667--71670. Phenon *pumilio* (Parker): figs. 17, 18; 20, oblique umbilical view; 22--25; UQF 71671, 71672, 71674, 71676--71679. Phenon *egelida* (Cifelli & Smith): figs. 26--35; UQF 71680--71689. Phenon *humilis* (Brady): figs. 36, 37; UQF 71690, 71691. Phenon *cristata* (Heron-Allen & Earland): figs. 38, 39; UQF 71692, 71693.

Lower *G. inflata* zone. Phenon *angustiumbilicata* (Bolli): fig. 40; UQF 71694. Phenon *primitiva* Brönnimann & Resig: fig. 41; UQF 71695. Phenon *primoripumilio* n. ph.: fig. 42; UQF 71696. Phenon *guadalupensis* (McCulloch): figs. 43, 44; UQF 71697, 71698. Phenon *microfoliata* (Brönnimann & Resig): fig. 45; UQF 71699. Phenon *clarkei* (Rögl & Bolli): figs. 46--48; UQF 71700--71702. Phenon *quinqueloba* (Natland): figs. 49, 50; UQF 71703, 71704. Phenon *pumilio* (Parker): figs. 51--54; UQF 71705--71708. Phenon *humilis* (Brady): figs. 55-- 61; UQF 71709--71715. Phenon *cristata* (Heron-Allen & Earland): figs. 62, 63; UQF 71716, 71717.

Middle *G. inflata* zone. Phenon *primitiva* Brönnimann & Resig: fig. 64; UQF 71718. Phenon *primoripumilio* n. ph.: fig. 65; UQF 71719. Phenon *guadalupensis* (McCulloch): fig. 66; UQF 71720. Phenon *clarkei* (Rögl & Bolli): figs. 67--70; UQF 71721--71724. Phenon *quinqueloba* (Natland): figs. 71--73; UQF 71725--71727. Phenon *egelida* (Cifelli & Smith): fig. 74; UQF 71729. Phenon *atlantisae* (Cifelli & Smith): fig. 75; UQF 71730.

Middle *G. tosaensis* zone. Phenon *angustiumbilicata* (Bolli): fig. 76; UQF 71731. Phenon *primoripumilio* n. ph.: figs. 77, 78; UQF 71732, 71733. Phenon *clarkei* (Rögl & Bolli): fig. 79; UQF 71734. Phenon *pumilio* (Parker): figs. 80--82; UQF 71735--71737. Phenon *egelida* (Cifelli & Smith): fig. 83; UQF 71738. Phenon *humilis* (Brady): fig. 84; UQF 71739. Phenon *atlantisae* (Cifelli & Smith): fig. 85; UQF 71740.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *primoripumilio* n. ph.: fig. 86; UQF 71741. Phenon *quinqueloba* (Natland): figs. 87--89; UQF 71742--71744. Phenon *egelida* (Cifelli & Smith): figs. 90--92; UQF 71745--71747.

Middle *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *quinqueloba* (Natland): figs. 93--96; UQF 71748--71751.

Upper *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *angustiumbilicata* (Bolli): fig. 97; UQF 71752. Phenon *guadalupensis* (McCulloch): fig. 98; UQF 71753. Phenon *clarkei* (Rögl & Bolli): fig. 99; UQF 71754. Phenon *quinqueloba* (Natland): figs. 100--104; UQF 71755--71759. Phenon *egelida* (Cifelli & Smith): figs. 105, 106; UQF 71760, 71761.

Middle *G. truncatulinoides* zone. Phenon *angustiumbilicata* (Bolli): figs. 107, 108; UQF 71762, 71763. Phenon *primitiva* Brönnimann & Resig: fig. 109; UQF 71764. Phenon *quinqueloba* (Natland): figs. 110, 111; UQF 71765, 71766. Phenon *egelida* (Cifelli & Smith): fig. 112; UQF 71767. Phenon *atlantisae* (Cifelli & Smith): figs. 113--115; UQF 71768--71770.

Upper *G. truncatulinoides* zone. Phenon *angustiumbilicata* (Bolli): fig. 116; UQF 71771. Phenon *primoripumilio* n. ph.: fig. 117; UQF 71772. Phenon *clarkei* (Rögl & Bolli): figs.

118, 119; UQF 71773, 71774. Phenon *quinqueloba* (Natland): figs. 120--122; UQF 71775--71777. Phenon *egelida* (Cifelli & Smith): figs. 123, 124; UQF 71778, 71779. Phenon *atlantisae* (Cifelli & Smith): figs. 125, 126; UQF 71780, 71781.

Globigerinopsis aguasayaensis Bolli

Upper *Orbulina suturalis* zone. Phenon *moderiapertura* n. ph.: fig. 127 (holotype); UQF 71782.

Lower *Globorotalia margaritae* zone. Phenon *moderiapertura* n. ph.: fig. 128?, lateral view; UQF 71783.

Hastigerina obesa (Bolli), *Globigerinella evoluta* n. sp., and *G. siphonifera* (d'Orbigny)

Upper *Orbulina suturalis* zone. Phenon *obesa* (Bolli): fig. 129; UQF 71784.

Middle *Globorotalia mayeri* zone. Phenon *obesa* (Bolli): figs. 130, 131; 132, spiral view; UQF 71785--71787.

Upper *G. mayeri* zone. Phenon *praesiphonifera* Blow: fig. 133, spiral view; UQF 71788.

Middle *G. continuosa* zone. Phenon *praesiphonifera* Blow: fig. 134, lateral view; UQF 71789.

Upper *G. continuosa* zone. Phenon *siphonifera* (d'Orbigny): fig. 135, lateral view; UQF 71790.

PLATE 9

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Hastigerina obesa (Bolli), *Globigerinella evoluta* n. sp., and *G. siphonifera* (d'Orbigny)

Middle *Globigerina nepenthes* zone. Phenon *evoluta* n. ph.: fig. 1 (holotype); UQF 71791.

Upper *G. nepenthes* zone. Phenon *involuta* (Cushman): fig. 2, lateral view; UQF 71792.

Middle *Globorotalia margaritae* zone. Phenon *evoluta* n. ph.: fig. 3; UQF 71793. Phenon *involuta* (Cushman): fig. 4; UQF 71794.

Lower *G. inflata* zone. Phenon *siphonifera* (d'Orbigny): fig. 5, lateral view; UQF 71795.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit

Globigerinella adamsi (Banner & Blow)

Lower *Pulleniatina obliqueloculata* zone. Phenon *adamsi* (Banner & Blow): fig. 6; UQF 71796.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Globigerinoides haitiensis (Coryell & Rivero)

Upper *O. suturalis* zone. Phenon *bulloideus* Crescenti: fig. 7; UQF 71797.

Middle *Globorotalia mayeri* zone. Phenon *subquadratus* Brönnimann: fig. 8; UQF 71798. Phenon *pseudoruber* Todd: figs. 9; 10, lateral view; UQF 71799, 71800. Phenon *bulloideus* Crescenti: figs. 11--15; UQF 71801--71805.

Upper *G. mayeri* zone. Phenon *bulloideus* Crescenti: figs. 16, 17; UQF 71806, 71807. Phenon *compactus* n. ph.: fig. 18; UQF 71808.

Upper *G. continuosa* zone. Phenon *bulloideus* Crescenti: fig. 19; UQF 71809. Phenon *compactus* n. ph.: figs. 20--23; UQF 71810--71813. Phenon *obliquus* Bolli: figs. 24, 25; UQF 71814, 71815.

Middle *Globigerina nepenthes* zone. Phenon *bulloideus* Crescenti: figs. 26; 27, X140; UQF 71816, 71817. Phenon *compactus* n. ph.: figs. 28, 29 (holotype); UQF 71818, 71819. Phenon *progomitulus* n. ph.: fig. 30 (holotype), X140; UQF 71820. Phenon *obliquus* Bolli: figs. 31, 32, lateral views; UQF 71821, 71822. Phenon *bollii* Blow: figs. 33--35; UQF 71823--71825. Phenon *praeruber* n. ph.: fig. 36; UQF 71826. Phenon *extremus* Bolli & Bermúdez: fig. 37; UQF 71827.

Upper *G. nepenthes* zone. Phenon *bulloideus* Crescenti: fig. 38, X140; UQF 71828. Phenon *compactus* n. ph.: fig. 39; UQF 71829. Phenon *obliquus* Bolli: fig. 40; UQF 71830. Phenon *praeruber* n. ph.: fig. 41 (holotype); UQF 71831. Phenon *extremus* Bolli & Bermúdez: fig. 42, lateral view; UQF 71832. Phenon *epityche* n. ph.: fig. 43, lateral view; UQF 71833.

Middle *Globorotalia conomiozea* zone. Phenon *bollii* Blow: fig. 44; UQF 71834. Phenon *epityche* n. ph.: fig. 45 (holotype); UQF 71835.

Lower *G. margaritae* zone. Phenon *epityche* n. ph.: fig. 46, lateral view; UQF 71836. Phenon *progomitulus* n. ph.: fig. 47; UQF 71837.

Middle G. margaritae zone. Phenon extremus Bolli & Bermúdez: fig. 48, umbilicolateral view; UQF 71838. Phenon epityche n. ph.: fig. 49, lateral view; UQF 71839. Phenon anteruber n. ph.: fig. 50 (holotype); UQF 71840. Phenon compressus n. ph.: fig. 51 (holotype); UQF 71841. Phenon mitrus Todd: fig. 52, lateral view; UQF 71842.

PLATE 10

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Globigerinoides haitiensis (Coryell & Rivero)

Upper Globorotalia margaritae zone. Phenon canimarensis Bermúdez: fig. 1; UQF 71843.

Middle G. puncticulata zone. Phenon ruber (d'Orbigny): fig. 2; lateral view; UQF 71844.

Globigerinoides conglobatus (Brady)

Upper Globorotalia puncticulata zone. Phenon haitiensis (Coryell & Rivero): fig. 3, lateral view; UQF 71845.

Middle G. crassaformis zone. Phenon epityche n. ph.: fig. 4; UQF 71846.

Middle G. inflata zone. Phenon compressus n. ph.: fig. 5, umbilicolateral view; UQF 71847.

Middle G. tosaensis zone. Phenon compressus n. ph.: fig. 7, lateral view; UQF 71848.

Lower G. truncatulinoides--G. tosaensis overlap-zone. Phenon haitiensis (Coryell & Rivero): fig. 6; UQF 71849.

Middle G. truncatulinoides--G. tosaensis overlap-zone. Phenon conglobatus (Brady): fig. 8; UQF 71850.

Upper G. truncatulinoides--G. tosaensis overlap-zone. Phenon haitiensis (Coryell & Rivero): figs. 9, 10; 11, umbilicolateral view; UQF 71851--71853. Phenon canimarensis Bermúdez: fig. 12; UQF 71854. Phenon conglobatus (Brady): fig. 13; UQF 71855.

Middle G. truncatulinoides zone. Phenon compressus n. ph.: figs. 14--16, umbilicolateral views; UQF 71856--71858. Phenon altihelix n. ph.: fig. 17 (holotype); UQF 71859. Phenon conglobatus (Brady): fig. 18, umbilicolateral view; UQF 71860.

Globigerinoides elongatus (d'Orbigny)

Upper Globorotalia puncticulata zone. Phenon obliquus Bolli: fig. 19, lateral view; UQF 71861.

Middle G. crassaformis zone. Phenon ruber (d'Orbigny): fig. 20, umbilicolateral view; UQF 71862.

Lower G. inflata zone. Phenon ruber (d'Orbigny): fig. 21, umbilicolateral view; UQF 71863. Phenon pyramidalis (van den Broeck): fig. 22, lateral view; UQF 71864.

Middle G. inflata zone. Phenon elongatus (d'Orbigny): figs. 23, 24, umbilicolateral views; UQF 71865, 71866.

Middle G. tosaensis zone. Phenon pyramidalis (van den Broeck): fig. 25, lateral view; UQF 71867.

PLATE 11

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Globigerinoides elongatus (d'Orbigny)

Middle Globorotalia tosaensis zone. Phenon progomitulus n. ph.: fig. 1; UQF 71868.

Upper G. truncatulinoides--G. tosaensis overlap-zone. Phenon pyramidalis (van den Broeck): fig. 2, lateral view; UQF 71869.

Middle G. truncatulinoides zone. Phenon gomitulus (Seguenza): fig. 3; UQF 71870.

D.S.D.P. Site 77A, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit

Globigerinoides elongatus (d'Orbigny)

Upper Pulleniatina obliqueloculata zone. Phenon gomitulus (Seguenza): fig. 4, umbilicolateral view; UQF 71871.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Orbulina quadrilobata (d'Orbigny)

Upper O. suturalis zone. Phenon incrusta n.ph: figs. 5 (holotype), 6, 7; UQF 71872--71874.

Middle Globorotalia mayeri zone. Phenon irregularis (LeRoy): fig. 8; UQF 71875. Phenon subsacculifera (Cita, Premoli Silva, & Rossi): fig. 9; UQF 71876. Phenon quadrilobata (d'Orbigny): fig. 10; UQF 71877.

Upper G. continuosa zone. Phenon bullata (Chang): fig. 11; UQF 71878.

Middle G. conomiozea zone. Phenon quadrilobata (d'Orbigny): fig. 12?; UQF 71879.

Lower G. margaritae zone. Phenon alpha n. ph.: fig. 13; UQF 71880.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *triloba* (Reuss): fig. 14; UQF 71882.

Middle *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *sacculifera* (Brady): fig. 15; UQF 71883.

Middle *G. truncatulinoides* zone. Phenon *immatura* (LeRoy): fig. 16; UQF 71884. Phenon *sacculifera* (Brady): fig. 17; UQF 71885.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Orbulina quadrilobata (d'Orbigny)

Clipperton Oceanic Formation, Varicolored Unit

Middle *G. tumida* zone. Phenon *alpha* n. ph.: fig. 18; UQF 71886.

Clipperton Oceanic Formation, Cyclic Unit

Middle *Globigerinoides fistulosus* zone. Phenon *fistulosa* (Schubert): fig. 19; UQF 71887.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Orbulina universa d'Orbigny

Middle *Globigerina nepenthes* zone. Phenon *universa* d'Orbigny: fig. 20; UQF 71888.

Lower *Globorotalia margaritae* zone. Phenon *suturalis* Brönnimann: figs. 21--23, lateral views; UQF 71889--71891. Phenon *bilobata* d'Orbigny: fig. 24, lateral view; UQF 71892. Phenon *parkerae* Brönnimann & Resig: fig. 25, lateral view; UQF 71893.

Middle *G. truncatulinoides* zone. Phenon *universa* d'Orbigny: fig. 26, undetermined view; UQF 71894.

Globigerina bulbosa LeRoy

Upper *O. suturalis* zone. Phenon *woodi* Jenkins: fig. 27; UQF 71895. Phenon *disjuncta* (Finlay): figs. 28, 29; UQF 71896, 71897. Phenon *extrema* Cati: fig. 30; UQF 71898. Phenon *nepenthoides* Brönnimann & Resig: figs. 31, 32; UQF 71899, 71900. Phenon *falconensis* Blow: figs. 33, 34; UQF 71901, 71902. Phenon *praebulloides* Blow: fig. 35; UQF 71903. Phenon *trisphaera* n. ph.: fig. 36 (holotype), 37; UQF 71904, 71905. Phenon *druryi* Akers: fig. 38; UQF 71906. Phenon *bollii* Cita & Premoli Silva: fig. 39; UQF 71907. Phenon *incrusta* n. ph.: fig. 40; UQF 71908.

Sphaeroidinella dehiscens (Parker & Jones)

Middle *G. mayeri* zone. Phenon *disjuncta* (Finlay): fig. 41; UQF 71909. Phenon *seminulina* (Schwager): fig. 42; UQF 71910.

Middle *G. continuosa* zone. Phenon *kochi* (Caudri): fig. 43; UQF 71911.

Upper *G. continuosa* zone. Phenon *kochi* (Caudri): fig. 44; UQF 71912.

PLATE 12

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Sphaeroidinella dehiscens (Parker & Jones)

Upper *Globorotalia continuosa* zone. Phenon *seminulina* (Schwager): figs. 1, 2; UQF 71913, 71914. Phenon *reticulata* n. ph.: fig. 3; UQF 71915.

Middle *Globigerina nepenthes* zone. Phenon *kochi* (Caudri): fig. 4; UQF 71916. Phenon *paenedehiscens* (Blow): fig. 5; UQF 71917.

Upper *G. nepenthes* zone. Phenon *parkerae* (Ujiié): fig. 6; UQF 71918.

Middle *Globorotalia conomiozea* zone. Phenon *seminulina* (Schwager): fig. 7; UQF 71919. Phenon *reticulata* n. ph.: figs. 8, 9; UQF 71920, 71921.

Middle *G. margaritae* zone. Phenon *kochi* (Caudri): fig. 10; UQF 71922. Phenon *parkerae* (Ujiié): fig. 11; UQF 71923.

Upper *G. margaritae* zone. Phenon *seminulina* (Schwager): fig. 12; UQF 71925.

Upper *G. puncticulata* zone. Phenon *seminulina* (Schwager): fig. 13; UQF 71926. Phenon *parkerae* (Ujiié): fig. 14; UQF 71927.

Middle *G. crassaformis* zone. Phenon *kochi* (Caudri): fig. 15; UQF 71929. Phenon *reticulata* n. ph.: fig. 16 (holotype); UQF 71930.

Lower *G. inflata* zone. Phenon *seminulina* (Schwager): fig. 17; UQF 71931. Phenon *parkerae* (Ujiié): figs. 18--20; UQF 71932--71934.

Middle *G. inflata* zone. Phenon *parkerae* (Ujiié): figs. 21, 22; UQF 71935, 71936. Phenon *dehiscens* (Parker & Jones): fig. 23; UQF 71937.

PLATE 13

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Sphaeroidinella dehiscens (Parker & Jones)

Middle Globorotalia tosaensis zone. Phenon immatura (Cushman): fig. 1; UQF 71939.

Upper G. truncatulinoides--G. tosaensis overlap-zone. Phenon dehiscens (Parker & Jones): fig. 2; UQF 71940.

Middle G. truncatulinoides zone. Phenon dehiscens (Parker & Jones): fig. 3; UQF 71941.

Upper G. truncatulinoides zone. Phenon excavata Banner & Blow: fig. 4; UQF 71942.

Globigerina microstoma Cita, Premoli Silva, & Rossi

Middle Globorotalia mayeri zone. Phenon woodi Jenkins: figs. 5--12; UQF 71943--71950. Phenon extrema Cati: fig. 13; UQF 71951. Phenon falconensis Blow: figs. 14--16; UQF 71952--71954. Phenon praebulloides Blow: fig. 17; UQF 71955. Phenon druryi Akers: figs. 18, X140; 19, 20; 21, X140; UQF 71956--71959. Phenon bollii Cita & Premoli Silva: figs. 22--25; UQF 71960--71963. Phenon opsionepenthoides n. ph.: figs. 26, 27, X140; 28 (holotype), 29, 30; UQF 71964--71968. Phenon microstoma Cita, Premoli Silva, & Rossi: fig. 31; UQF 71969. Phenon decoraperta Takayanagi & Saito: figs. 32, 33; UQF 71970, 71971. Phenon columbae Martínez Díaz: figs. 34--37; UQF 71972--71975. Phenon incrusta n. ph.: figs. 38, X140; 39, 40; UQF 71976--71978. Phenon nepenthes Todd: fig. 41; UQF 71979.

Upper G. mayeri zone. Phenon woodi Jenkins: fig. 42; UQF 71980. Phenon druryi Akers: figs. 43, 44, X140; 45; UQF 71981--71983. Phenon decoraperta Takayanagi & Saito: fig. 46; UQF 71984. Phenon incrusta n. ph.: fig. 47; UQF 71985. Phenon nepenthes Todd: figs. 48, 49; UQF 71986, 71987.

Ehrenbergellus pachydermus (Ehrenberg)

All magnifications X140.

Middle Globorotalia continuosa zone. Phenon pachydermus (Ehrenberg): fig. 50; UQF 71988.

Middle Globigerina nepenthes zone. Phenon pachydermus (Ehrenberg): figs. 51--54; UQF 71989--71992.

Upper G. nepenthes zone. Phenon pachydermus (Ehrenberg): figs. 55, 56; UQF 71993, 71994.

Middle Globorotalia margaritae zone. Phenon pachydermus (Ehrenberg): fig. 57; UQF 71995.

Upper G. margaritae zone. Phenon pachydermus (Ehrenberg): fig. 58; UQF 71996.

Middle G. crassaformis zone. Phenon pachydermus (Ehrenberg): fig. 59; UQF 71997.

Middle G. inflata zone. Phenon pachydermus (Ehrenberg): fig. 60; UQF 71998.

Lower G. truncatulinoides--G. tosaensis overlap-zone. Phenon pachydermus (Ehrenberg): figs. 61, 62; UQF 71999, 72000.

Globigerina concinna Reuss

Middle Globorotalia continuosa zone. Phenon falconensis Blow: fig. 63; UQF 72001. Phenon decoraperta Takayanagi & Saito: figs. 64, 65; UQF 72002, 72003. Phenon appenninica (Pezzani): fig. 66; UQF 72004. Phenon picassiana Perconig: fig. 67; UQF 72005. Phenon nepenthes Todd: figs. 68--71; UQF 72006--72009.

PLATE 14

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Globigerina concinna Reuss

Upper Globorotalia continuosa zone. Phenon falconensis Blow: figs. 1, 2; UQF 72010, 72011. Phenon praebulloides Blow: figs. 3, 4; UQF 72012, 72013. Phenon druryi Akers: figs. 5, 6; UQF 72014, 72015. Phenon bollii Cita & Premoli Silva: fig. 7; UQF 72016. Phenon decoraperta Takayanagi & Saito: fig. 8; UQF 72017. Phenon picassiana Perconig: fig. 9; UQF 72018. Phenon incrusta n. ph.: figs. 10, 11; UQF 72019, 72020. Phenon nepenthes Todd: fig. 12, final chamber removed; UQF 72021.

Middle Globigerina nepenthes zone. Phenon occlusa Blow & Banner: figs. 13--15; 16, X140; UQF 72023--72026. Phenon woodi Jenkins: fig. 17; UQF 72027. Phenon praebulloides Blow: figs. 18--20; UQF 72028--72030. Phenon druryi Akers: figs. 21, 22; UQF 72031, 72032. Phenon bollii Cita & Premoli Silva: figs 23--25; UQF 72033--72035. Phenon decoraperta Takayanagi & Saito: fig. 26; UQF 72036. Phenon columbae Martínez Díaz: fig. 27; UQF 72037. Phenon altihelix n. ph.: figs 28, 29 (holotype); UQF 72038, 72039. Phenon anapetes n. ph.: figs 30, 31 (holotype), 32; UQF 72040--72042. Phenon incrusta n. ph.: figs 33, 34; UQF 72043, 72044. Phenon delicata Brönnimann & Resig: figs 35, 36; UQF

72045, 72046. Phenon *nepenthes* Todd: fig. 37; UQF 72047. Phenon *bulloides* d'Orbigny: figs. 38--40; UQF 72048--72050.

Globigerina rubescens Hofker

Upper *G. nepenthes* zone. Phenon *picassiana* Perconig: fig. 41; UQF 72051. Phenon *apertura* Cushman: fig. 42; UQF 72052. Phenon *delicata* Brönnimann & Resig: figs. 43 (this specimen has a supplementary aperture on the spiral side), 44, 45; UQF 72053--72055.

Middle *Globorotalia conomiozea* zone. Phenon *apertura* Cushman: figs. 46, 47; UQF 72056, 72057. Phenon *nepenthes* Todd: figs. 48, 49; UQF 72058, 72059.

Middle *G. margaritae* zone. Phenon *picassiana* Perconig: fig. 50; UQF 72060. Phenon *delicata* Brönnimann & Resig: figs. 51, 52; UQF 72061, 72062.

Upper *G. margaritae* zone. Phenon *decoraperta* Takayanagi & Saito: fig. 53; UQF 72063.

Middle *G. inflata* zone. Phenon *rubescens* Hofker: fig. 54; UQF 72064.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *altihelix* n. ph.: fig. 55; UQF 72065.

Middle *G. truncatulinoides* zone. Phenon *rubescens* Hofker: figs. 56; 57, X140; UQF 72066, 72067.

Upper *G. truncatulinoides* zone. Phenon *tenella* (Parker): fig. 58; UQF 72068.

Globigerina bulloides d'Orbigny

Upper *G. nepenthes* zone. Phenon *occlusa* Blow & Banner: fig. 59; UQF 72069. Phenon *falconensis* Blow: figs. 60--63; UQF 72070--72073. Phenon *bollii* Cita & Premoli Silva: fig. 64; UQF 72074. Phenon *foliata* Bolli: fig. 65; UQF 72075. Phenon *incrusta* n. ph.: figs. 66, 67 (holotype); UQF 72076, 72077. Phenon *quadrilatera* Galloway & Wissler: fig. 68; UQF 72078.

Middle *Globorotalia conomiozea* zone. Phenon *falconensis* Blow: figs. 69--71; UQF 72079--72081. Phenon *praebulloides* Blow: fig. 72; UQF 72082. Phenon *bollii* Cita & Premoli Silva: figs. 73, 74; UQF 72083, 72084. Phenon *pseudobesa* (Salvatorini): fig. 75; UQF 72085. Phenon *incrusta* n. ph.: fig. 76; UQF 72086.

Lower *G. margaritae* zone. Phenon *foliata* Bolli: fig. 77; UQF 72087. Phenon *incrusta* n. ph.: fig. 78; UQF 72088.

Middle *G. margaritae* zone. Phenon *falconensis* Blow: fig. 79; UQF 72089. Phenon *bronnresigorum* n. name: fig. 80; UQF 72090.

Middle *G. puncticulata* zone. Phenon *pseudobesa* (Salvatorini): fig. 81; UQF 72091.

Upper *G. puncticulata* zone. Phenon *occlusa* Blow & Banner: figs. 82, 83; UQF 72092, 72093. Phenon *foliata* Bolli: figs. 84, 85; UQF 72094, 72095. Phenon *bronnresigorum* n. name: fig. 86; UQF 72096.

Middle *G. crassaformis* zone. Phenon *falconensis* Blow: fig. 87; UQF 72097. Phenon *incrusta* n. ph.: figs. 88, 89; UQF 72098, 72099.

Lower *G. inflata* zone. Phenon *falconensis* Blow: fig. 90; UQF 72100. Phenon *incrusta* n. ph.: fig. 91; UQF 72101. Phenon *megastoma* Earland: fig. 92; UQF 72102. Phenon *bulloides* d'Orbigny: fig. 93; UQF 72103.

Middle *G. inflata* zone. Phenon *pseudobesa* (Salvatorini): fig. 94; UQF 72104.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *falconensis* Blow: fig. 95; UQF 72105.

Middle *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *bronnresigorum* n. name: figs. 96, 97; UQF 72106, 72107.

Middle *G. truncatulinoides* zone. Phenon *incrusta* n. ph.: fig. 98; UQF 72108. Phenon *extensa* n. ph.: fig. 99 (holotype); UQF 72109.

Upper *G. truncatulinoides* zone. Phenon *bulbosa* LeRoy: fig. 100; UQF 72110.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Marquesas Oceanic Formation, Gray Unit

Globigerina bulbosa LeRoy

Lower *G. fohsi lobata* zone. Phenon *disjuncta* (Finlay): fig. 101; UQF 72111. Phenon *druryi* Akers: fig. 102; UQF 72112.

Sphaeroidinella dehiscens (Parker & Jones)

Middle *G. fohsi lobata* zone. Phenon *seminulina* (Schwager): figs. 103--108; UQF 72113--72118.

Lower *Globoquadrina altispira* zone. Phenon *seminulina* (Schwager): figs. 109--111; UQF 72119--72121.

PLATE 15

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Sphaeroidinella dehiscens (Parker & Jones)

Marquesas Oceanic Formation, Gray Unit

Middle *Globoquadrina altispira* zone (19/2/145--147). Phenon *seminulina* (Schwager): figs. 1--5; UQF 72122--72126.

Clipperton Oceanic Formation, Varicolored Unit

Lower *Globorotalia plesiotumida* zone (16/6/22--24). Phenon *kochi* (Caudri): fig. 6; UQF 72127. Phenon *seminulina* (Schwager): figs. 7--13; UQF 72128--72134.

Lower *G. plesiotumida* zone (15/4/22--24). Phenon *seminulina* (Schwager): figs. 14--17; UQF 72135--72138.

Middle *G. plesiotumida* zone (12/1/5--7). Phenon *seminulina* (Schwager): figs. 18--20; UQF 72139--72141.

Upper *G. plesiotumida* zone (10/6/143--145). Phenon *disjuncta* (Finlay): fig. 21; UQF 72142. Phenon *seminulina* (Schwager): figs. 22--28; UQF 72143--72149.

Upper *G. plesiotumida* zone (9/6/140--142). Phenon *seminulina* (Schwager): figs. 29--34; UQF 72150--72155.

Lower *G. tumida* zone. Phenon *seminulina* (Schwager): figs. 35, 36; UQF 72156, 72157.

Middle *G. tumida* zone. Phenon *seminulina* (Schwager): figs. 37--40; UQF 72158--72161.

PLATE 16

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Sphaeroidinella dehiscens (Parker & Jones)

Clipperton Oceanic Formation, Varicolored Unit

Lower *S. dehiscens* zone. Phenon *seminulina* (Schwager): figs. 1, 2; UQF 72162, 72163.

Middle *S. dehiscens* zone. Phenon *seminulina* (Schwager): fig. 4; UQF 72164. Phenon *paenedehiscens* (Blow): fig. 3; UQF 72165. Phenon *immatura* (Cushman): fig. 5; UQF 72166.

Lower *Globigerinoides fistulosus* zone. Phenon *seminulina* (Schwager): fig. 8; UQF 72167. Phenon *paenedehiscens* (Blow): figs. 6, 7; UQF 72168, 72169. Phenon *immatura* (Cushman): figs. 9--11; UQF 72170--72172. Phenon *dehiscens* (Parker & Jones): fig. 12; UQF 72173.

Clipperton Oceanic Formation, Cyclic Unit

Middle *G. fistulosus* zone. Phenon *seminulina* (Schwager): fig. 13; UQF 72174. Phenon *paenedehiscens* (Blow): fig. 14; UQF 72175. Phenon *immatura* (Cushman): fig. 15; UQF 72176.

Lower *Pulleniatina obliqueloculata* zone. Phenon *paenedehiscens* (Blow): fig. 17; UQF 72177. Phenon *immatura* (Cushman): figs. 16, 18--20; UQF 72178--72181. Phenon *dehiscens* (Parker & Jones): figs. 21, 22; UQF 72182, 72183.

PLATE 17

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit

Sphaeroidinella dehiscens (Parker & Jones)

Middle *Pulleniatina obliqueloculata* zone. Phenon *immatura* (Cushman): figs. 1--3; UQF 72184--72186. Phenon *dehiscens* (Parker & Jones): fig. 4; UQF 72187.

D.S.D.P. Site 77A, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit.

Sphaeroidinella dehiscens (Parker & Jones)

Upper *P. obliqueloculata* zone. Phenon *immatura* (Cushman): fig. 5; UQF 72188. Phenon *dehiscens* (Parker & Jones): figs. 6--9; UQF 72189--72192.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Globigerina bulbosa LeRoy and

Globigerina microstoma Cita, Premoli Silva, & Rossi

Marquesas Oceanic Formation, Gray Unit

Middle *Globoquadrina altispira* zone (19/2/145--147). Phenon *druryi* Akers: figs. 10?, X140; 11; UQF 72194, 72195.

Globigerina rubescens Hofker

Clipperton Oceanic Formation, Varicolored Unit

Upper Globorotalia plesiotumida zone (10/6/143--145). Phenon opsionepenthoides n. ph.: fig. 12; UQF 72196.

Upper G. plesiotumida zone (9/6/140--142). Phenon opsionepenthoides n. ph.: figs. 13, 14; UQF 72197, 72198. Phenon picassiana Perconig: fig. 15, X140; UQF 72199.

Lower G. tumida zone. Phenon druryi Akers: fig. 16; UQF 72200.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Pulleniatina mayeri (Cushman & Ellisor)

Lower Orbulina suturalis zone. Phenon bella (Jenkins): figs. 17, 18; UQF 72209, 72210. Phenon acrostoma (Wezel): figs. 19, 20; UQF 72211, 72212. Phenon siakensis (LeRoy): figs. 21--23; UQF 72213--72215. Phenon umbilicata n. ph.: figs. 24, X140; 25, 26 (holotype), 27; UQF 72216--72219. Phenon continuosa (Blow): figs. 28--30; UQF 72220--72222. Phenon nympha (Jenkins): fig. 31; UQF 72223.

Middle Globorotalia mayeri zone. Phenon siakensis (LeRoy): figs. 32, 33; UQF 72224, 72225. Phenon partimlabiata (Ruggieri & Sprovieri): figs. 34--36; UQF 72226--72228. Phenon mayeri (Cushman & Ellisor): figs. 37, X140; 38; UQF 72229, 72230. Phenon juvenis n. ph.: fig. 39, X140; UQF 72231. Phenon acostaensis (Blow): figs. 40--43; UQF 722232--722235.

Upper G. mayeri zone. Phenon mayeri (Cushman & Ellisor): figs. 44, 45, X140; 46; UQF 72236--72238.

PLATE 18

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Pulleniatina mayeri (Cushman & Ellisor)

Upper Globorotalia mayeri zone. Phenon mayeri (Cushman & Ellisor): fig. 1; UQF 72239. Phenon plana n. ph.: figs. 2, X140; 3 (holotype), 4; UQF 72240--72242. Phenon juvenis n. ph.: fig. 5, X140; UQF 72243.

Middle G. continuosa zone. Phenon plana n. ph.: fig. 6; UQF 72244. Phenon juvenis n. ph.: figs. 7 (holotype), 8--10, X140; UQF 72245--72248. Phenon acostaensis (Blow): figs. 11, 12; UQF 72249, 72250.

Upper G. continuosa zone. Phenon pseudopachyderma (Cita, Premoli Silva, & Rossi): fig. 13; UQF 72251. Phenon juvenis n. ph.: figs. 14, 15; UQF 72252, 72253. Phenon acostaensis (Blow): fig. 16; UQF 72254. Phenon tegiliata (Brönnimann & Resig): figs. 17, 18; UQF 72255, 72256.

Middle Globigerina nepenthes zone. Phenon mineacea (Bermúdez & Bolli): fig. 19; UQF 72257. Phenon polygonia n. ph.: figs. 20 (holotype), 21; UQF 72258, 72259. Phenon praehumerosa (Natori): fig. 22; UQF 72260. Phenon subcretacea (Łomnicki): figs. 23--25; UQF 72261--72263.

Upper G. nepenthes zone. Phenon polygonia n. ph.: figs. 26, X140; 27; UQF 72264, 72265. Phenon praepulleniatina Brönnimann & Resig: fig. 28; UQF 72266. Phenon planispira Brönnimann & Resig: fig. 29; UQF 72267.

Pulleniatina helicina (d'Orbigny)

Middle Globorotalia conomiozea zone. Phenon juvenis n. ph.: fig. 30; UQF 72268. Phenon globorotaloidea (Colom): fig. 31; UQF 72269. Phenon planispira (Brönnimann & Resig): fig. 32; UQF 72270. Phenon pseudopumilio (Brönnimann & Resig): fig. 33; UQF 72271. Phenon subcretacea (Łomnicki): figs. 34--36; UQF 72272--72274. Phenon polusi (Androsova): fig. 37; UQF 72275.

Lower G. margaritae zone. Phenon juvenis n. ph.: fig. 38; UQF 72276.

Middle G. margaritae zone. Phenon continuosa (Blow): figs. 39, 40; UQF 72277, 72278. Phenon miniacea (Bermúdez & Bolli): fig. 41; UQF 72279. Phenon acostaensis (Blow): figs. 42, 43; UQF 72280, 72281. Phenon globorotaloidea (Colom): figs. 44, 45; UQF 72282, 72283. Phenon polygonia n. ph.: fig. 46; UQF 72284. Phenon helicina (d'Orbigny): figs. 47, 48; UQF 72285, 72286. Phenon subcretacea (Łomnicki): fig. 49; UQF 72287.

Middle G. puncticulata zone. Phenon continuosa (Blow): fig. 50; UQF 72288. Phenon juvenis n. ph.: figs. 51, 52, X140; UQF 72289, 72290. Phenon polygonia n. ph.: fig. 53, X140; UQF 72291. Phenon pseudopumilio (Brönnimann & Resig): fig. 54, X140; UQF 72292. Phenon kagaensis (Maiya, Saito, & Sato): fig. 55; UQF 72293. Phenon helicina (d'Orbigny): fig. 56; UQF 72294. Phenon incompta (Cifelii): figs. 57, X140; 58; UQF 72295, 72296.

Upper G. puncticulata zone. Phenon polygonia n. ph.: fig. 59; UQF 72297. Phenon apertura (Pezzani): figs. 60, 61; UQF 72298, 72299. Phenon eggeriformis (McCulloch): fig. 62; UQF 72300. Phenon praehumerosa (Natori): fig. 63; UQF 72301. Phenon planispira (Brönnimann & Resig): fig. 64; UQF 72302. Phenon kagaensis (Maiya, Saito, & Sato): fig. 65; UQF 72303. Phenon helicina (d'Orbigny): fig. 66; UQF 72304. Phenon incompta (Cifelli): fig. 67; UQF 72305. Phenon eggeriformis (McCulloch): fig. 68; UQF 72306.

Middle G. crassaformis zone. Phenon globorotaloidea (Colom): fig. 69; UQF 72307. Phenon eggeriformis (McCulloch): fig. 70; UQF 72308. Phenon planispira (Brönnimann & Resig): figs. 71, 72; UQF 72309, 72310. Phenon kagaensis (Maiya, Saito, & Sato): fig. 73; UQF 72311.

Lower G. inflata zone. Phenon vincentae (Fleisher): fig. 74; UQF 72312. Phenon pseudopumilio (Brönnimann & Resig): fig. 75; UQF 72313. Phenon helicina (d'Orbigny): fig. 76; UQF 72315. Phenon subcretacea (Łomnicki): fig. 77; UQF 72316.

Middle G. inflata zone. Phenon humerosa (Takayanagi & Saito): fig. 78?; UQF 72318. Phenon polygonia n. ph.: fig. 79, X140; UQF 72317. Phenon planispira (Brönnimann & Resig); fig. 80; UQF 72319.

Middle G. tosaensis zone. Phenon planispira (Brönnimann & Resig): fig. 81; UQF 72320.

Lower G. truncatulinoides--G. tosaensis overlap-zone. Phenon pseudopumilio Brönnimann & Resig): fig. 82; UQF 72321.

Middle G. truncatulinoides--G. tosaensis overlap-zone. Phenon hybrida (McCulloch): figs. 83--87; UQF 72322--72326.

Upper G. truncatulinoides--G. tosaensis overlap-zone. Phenon planispira (Brönnimann & Resig): figs. 88, 89; UQF 72327, 72328. Phenon hybrida (McCulloch): figs. 90--92; UQF 72329--72331. Phenon helicina (d'Orbigny): fig. 93; UQF 72332. Phenon eggeri (Rhumbler): fig. 94; UQF 72333. Phenon dutertrei (d'Orbigny): fig. 95; UQF 72334.

Middle G. truncatulinoides zone. Phenon kagaensis (Maiya, Saito, & Sato): fig. 96; UQF 72335. Phenon eggeri (Rhumbler): figs. 97--99; UQF 72336--72338. Phenon dutertrei (d'Orbigny): fig. 100; UQF 72339.

Upper G. truncatulinoides zone. Phenon vincentae (Fleisher): fig. 101; UQF 72340.

PLATE 19

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Pulleniatina helicina (d'Orbigny)

Upper Globorotalia truncatulinoides zone. Phenon vincentae (Fleisher): fig. 1; UQF 72341. Phenon planispira (Brönnimann & Resig): fig. 2; UQF 72342. Phenon atlantica (Berggren): fig. 3; UQF 72343. Phenon helicina (d'Orbigny): figs. 4, 5; UQF 72344, 72345. Phenon eggeri (Rhumbler): fig. 6; UQF 72346. Phenon dutertrei (d'Orbigny): figs. 7, 8; UQF 72347, 72348.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Pulleniatina obliqueloculata (Parker & Jones)

Clipperton Oceanic Formation, Varicolored Unit

Lower G. tumida zone. Phenon primalis Banner & Blow: figs. 9, 10; UQF 72349, 72350.

Middle G. tumida zone. Phenon primalis Banner & Blow: fig. 11; UQF 72351. Phenon okinawaensis Natori: fig. 12; UQF 72352.

Lower Sphaeroidinella dehiscens zone. Phenon primalis Banner & Blow: figs. 13--16; UQF 72353--72356. Phenon praecursor Banner & Blow: figs. 17--21; UQF 72357--72361. Phenon praespectabilis Brönnimann & Resig: fig. 22; UQF 72362. Phenon okinawaensis Natori: figs. 23--25; UQF 72363--72365.

Middle S. dehiscens zone. Phenon spectabilis Parker: figs. 26, 27; UQF 72366, 72367. Phenon primalis Banner & Blow: fig. 28; UQF 72368. Phenon praecursor Banner & Blow: fig. 30; UQF 72369. Phenon praespectabilis Brönnimann & Resig: fig. 31; UQF 72370. Phenon okinawaensis Natori: fig. 29; UQF 72371.

Lower Globigerinoides fistulosus zone. Phenon praecursor Banner & Blow: fig. 32; UQF 72373. Phenon okinawaensis Natori: fig. 33; UQF 72374.

Clipperton Oceanic Formation, Cyclic Unit

Middle G. fistulosus zone. Phenon primalis Banner & Blow: figs. 34--38; UQF 72375--72379. Phenon praecursor Banner & Blow: figs. 39, 40; UQF 72381, 72382. Phenon okinawaensis Natori: fig. 41; UQF 72383.

Lower *P. obliqueloculata* zone. Phenon *primalis* Banner & Blow: fig. 42; UQF 72384. Phenon *praecursor* Banner & Blow: figs. 43--45; UQF 72385--72387. Phenon *okinawaensis* Natori: fig. 46; UQF 72388.

PLATE 20

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit

Pulleniatina obliqueloculata (Parker & Jones)

Lower *P. obliqueloculata* zone. Phenon *okinawaensis* Natori: fig. 1; UQF 72389. Phenon *obliqueloculata* (Parker & Jones): figs. 2--4; UQF 72390--72392.

Middle *P. obliqueloculata* zone. Phenon *praecursor* Banner & Blow: figs. 5--7; UQF 72393--72395. Phenon *okinawaensis* Natori: figs. 8--10; UQF 72396--72398. Phenon *obliqueloculata* (Parker & Jones): figs. 11, 12; UQF 72399, 72400.

D.S.D.P. Site 77A, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit

Pulleniatina obliqueloculata (Parker & Jones)

Upper *P. obliqueloculata* zone. Phenon *primalis* Banner & Blow: figs. 13, 15; UQF 72401, 72402. Phenon *praecursor* Banner & Blow: fig. 14; UQF 72403. Phenon *okinawaensis* Natori: figs. 16--19; UQF 72404--72407. Phenon *obliqueloculata* (Parker & Jones): figs. 20--22, ?23; UQF 72408--72411. Phenon *finalis* Banner & Blow: figs. 24--27; UQF 72413--72416.

PLATE 21

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit

Pulleniatina helicina (d'Orbigny)

Middle *Globigerinoides fistulosus* zone. Phenon *pseudopima* (Blow): fig. 1, lateral view; UQF 72417.

D.S.D.P. Site 77A, east equatorial Pacific Ocean

Clipperton Oceanic Formation, Cyclic Unit

Pulleniatina helicina (d'Orbigny)

Upper *P. obliqueloculata* zone. Phenon *andamanica* (Srinivasan & Azmi): fig. 2; UQF 72418.

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Blowellus birnageae (Blow)

All magnifications X140.

Upper *Orbulina suturalis* zone. Phenon *kugleri* Bolli: fig. 4; UQF 72419. Phenon *pseudokugleri* Blow: fig. 3; UQF 72420. Phenon *birnageae* (Blow): fig. 5; UQF 72421.

Globorotalia miozea Finlay

Upper *O. suturalis* zone. Phenon *praescitula* Blow: fig. 6; UQF 72422. Phenon *quinifalcata* Saito & Maiya: fig. 7; UQF 72423. Phenon *acumarginata* n. ph.: fig. 8 (holotype); UQF 72424. Phenon *archeomenardii* Bolli: fig. 9; UQF 72475. Phenon *magnifica* Bizon & Glaçon: fig. 10; UQF 72476. Phenon *conoidea* Walters: fig. 11; UQF 72427. Phenon *perconigi* (Martínez Díaz): fig. 12; UQF 72428.

Fohsella fohsi (Cushman & Ellisor)

Middle *Globorotalia mayeri* zone. Phenon *praefohsi* (Blow & Banner): fig. 13; UQF 72429. Phenon *fohsi* (Cushman & Ellisor): fig. 14; UQF 72430.

Globorotalia praemenardii Cushman & Stainforth

Middle *G. mayeri* zone. Phenon *minima* Akers: fig. 15; UQF 72431. Phenon *bykovae* (Aisenstadt): fig. 16; UQF 72432. Phenon *gigantea* (Blow): fig. 17; UQF 72434. Phenon *praemenardii* Cushman & Stainforth: fig. 18; UQF 72435. Phenon *rifensis* Feinberg & Lorenz: fig. 19; UQF 72436. Phenon *ventriosa* (Ogniben): fig. 20; UQF 72437. Phenon *suterae* (Catalano & Sprovieri): fig. 23; UQF 72438. Phenon *dalii* Perconig: fig. 21; UQF 72439. Phenon *subconomiozea* Bandy: fig. 22; UQF 72440.

Obandyella ventriosa (Ogniben)

Middle *Globigerina nepenthes* zone. Phenon *praemargaritae* (Catalano & Sprovieri): fig. 24; UQF 72441. Phenon *astricticamerata* n. ph.: fig. 26 (holotype); UQF 72442. Phenon *evexa* n. ph.: fig. 27 (holotype); UQF 72443. Phenon *primitiva* (Cita): fig. 29; UQF 72444. Phenon *obturoaperturus* n. ph.: fig. 25; UQF 72445. Phenon *scitula* (Brady): fig. 28; UQF 72446.

Deshayesulus puncticulatus (Deshayes)

Middle *Globorotalia margaritae* zone. Phenon *obturoaperturus* n. ph.: fig. 30 (holotype); UQF 72447.

Lower *G. inflata* zone. Phenon *padanus* (Dondi & Papetti): fig. 31; UQF 72448.

PLATE 22

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Deshayesulus puncticulatus (Deshayes)

Middle *Globorotalia toseansis* zone. Phenon *inflatus* (d'Orbigny): fig. 1; UQF 72449.

Lower *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *oscitans* (Todd): fig. 2; UQF 72450.

Middle *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *trigonulus* (d'Orbigny): fig. 3; UQF 72451.

Upper *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *puncticulatus* (Deshayes): fig. 4; UQF 72452.

Middle *G. truncatulinoides* zone. Phenon *nipponicus* (Asano): fig. 5; UQF 72453.

Obandyella cibaoensis (Bermúdez)

Upper *Globigerina nepenthes* zone. Phenon *cibaoensis* (Bermúdez): fig. 6; UQF 72454.

Obandyella hirsuta (d'Orbigny)

Middle *Globorotalia crassaformis* zone. Phenon *margaritae* (Bolli & Bermúdez): fig. 7; UQF 72455. Phenon *praehirsuta* (Blow): fig. 8; UQF 72456. Phenon *hirsuta* (d'Orbigny): fig. 9; UQF 72457.

Obandyella scitula (Brady)

Lower *G. inflata* zone. Phenon *subscitula* (Conato): fig. 10; UQF 72458.

Globorotalia limbata (d'Orbigny)

Upper *G. mayeri* zone. Phenon *lenguaensis* Bolli: fig. 11; UQF 72459. Phenon *pseudomiocenica* Bolli & Bermúdez: fig. 12; UQF 72460. Phenon *saphoae* Bizon & Bizon: fig. 13; UQF 72461. Phenon *merotumida* Blow & Banner: fig. 14; UQF 72462. Phenon *plesiotumida* Blow & Banner: fig. 15; UQF 72463. Phenon *cultrata* (d'Orbigny): fig. 16; UQF 72464.

Middle *G. continuosa* zone. Phenon *latiumbilicata* n. ph.: fig. 17 (holotype); UQF 72465. Phenon *saheliana* Catalano & Sprovieri: fig. 18; UQF 72466.

PLATE 23

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Globorotalia limbata (d'Orbigny)

Upper *Globorotalia continuosa* zone. Phenon *mediterranea* Catalano & Sprovieri: fig. 1; UQF 72467. Phenon *conferta* n. ph.: fig. 2 (holotype); UQF 72468.

Middle *Globigerina nepenthes* zone. Phenon *oregope* n. ph.: fig. 3 (holotype); UQF 72469. Phenon *miocenica* Palmer: fig. 4; UQF 72470. Phenon *multicamerata* Cushman & Jarvis: fig. 5; UQF 72471.

Upper *G. nepenthes* zone. Phenon *consutila* n. ph.: fig. 6 (holotype); UQF 72472. Phenon *fijiensis* Cushman: fig. 7; UQF 72473.

Globorotalia fijiensis Cushman

Middle *G. margaritae* zone. Phenon *tumida* (Brady): fig. 8; UQF 72474.

Globorotalia tumida (Brady)

Upper *G. truncatulinoides*--*G. tosaensis* overlap-zone. Phenon *ungulata* Bermúdez: fig. 9; UQF 72475.

Globorotalia cultrata (d'Orbigny)

Middle *G. crassaformis* zone. Phenon *praemiocenica* Lamb & Beard: fig. 10; UQF 72476.

Truncorotalia sphericomiozea (Walters)

Middle *Globorotalia margaritae* zone. Phenon *miotumida* Jenkins: fig. 17; UQF 72477. Phenon *sphericomiozea* (Walters): fig. 12; UQF 72478. Phenon *conomiozea* (Kennett): fig. 13; UQF 72479.

Middle *G. puncticulata* zone. Phenon *capitona* n. ph.: fig. 14 (holotype); UQF 72480.

Falsella spuritumida n. sp.

Lower *G. inflata* zone. Phenon *spuritumida* n. ph.: fig. 15 (holotype); UQF 72481.

PLATE 24

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Truncorotalia crassula (Cushman & Stewart)

Middle Globorotalia crassaformis zone. Phenon complanata n. ph.: fig. 1 (holotype); UQF 72482.

Lower G. inflata zone. Phenon hessi (Bolli & Premoli Silva): figs. 2, 3; UQF 72483, 72484.

Truncorotalia tosaensis (Takayanagi & Saito)

Middle G. inflata zone. Phenon planoconvexa (Hug): fig. 4; UQF 72485. Phenon ronda (Blow): fig. 5; UQF 72486.

Middle G. tosaensis zone. Phenon acrotenes n. ph.: figs. 6 (holotype), 7; UQF 72487, 72488. Phenon tosaensis (Takayanagi & Saito): fig. 8; UQF 72489.

Truncorotalia truncatulinoides (d'Orbigny)

Middle G. truncatulinoides--G. tosaensis overlap-zone. Phenon truncatulinoides (d'Orbigny): fig. 9; UQF 72490.

Truncorotalia pseudocrassa (Chapman & Parr)

Lower G. truncatulinoides--G. tosaensis overlap-zone. Phenon hybrida n. ph.: fig. 10 (holotype); UQF 72491.

Middle G. truncatulinoides--G. tosaensis overlap-zone. Phenon complanata n. ph.: fig. 11; UQF 72492.

Middle G. truncatulinoides zone. Phenon pseudocrassa (Chapman & Parr): fig. 12; UQF 72493.

PLATE 25

D.S.D.P. Site 208, north Lord Howe Rise, unit 1

Truncorotalia pseudocrassa (Chapman & Parr)

Upper Globorotalia truncatulinoides zone. Phenon complanata n. ph.: fig. 1; UQF 72494. Phenon ronda (Blow): fig. 2; UQF 72495.

D.S.D.P. Site 77B, east equatorial Pacific Ocean

Fohsella fohsi (Cushman & Ellisor)

Marquesas Oceanic Formation, Gray Unit

Middle G. fohsi lobata zone. Phenon lobata (Bermúdez): fig. 3; UQF 72496.

Obandyella ventriosa (Ogniben) & Obandyella cibaoensis (Bermúdez)

Clipperton Oceanic Formation, Varicolored Unit

Upper G. plesiotumida zone (9/6/140--142). Phenon evoluta (Cita): fig. 4; UQF 72497.

Globorotalia tumida (Brady)

Clipperton Oceanic Formation, Varicolored Unit

Upper S. dehiscens zone. Phenon flexuosa (Koch): fig. 6; UQF 72499.

?Truncorotalia sphericomiozea (Walters) and
Truncorotalia crassula (Cushman & Stewart)

Clipperton Oceanic Formation, Varicolored Unit

Lower Sphaeroidinella dehiscens zone. Phenon mediterranea Catalano & Sprovieri: fig. 5?; UQF 72498.

Plate I

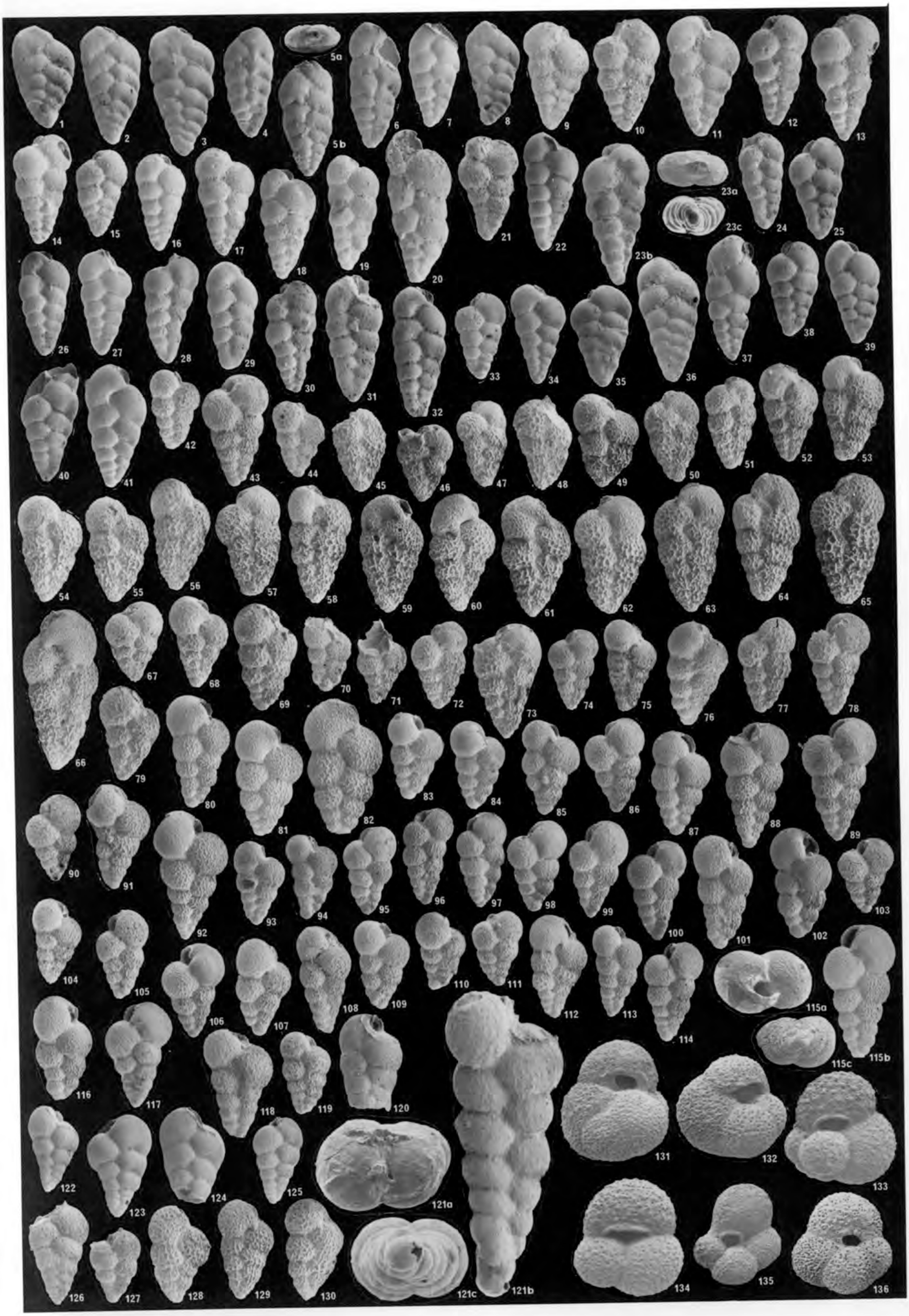
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Plate 2

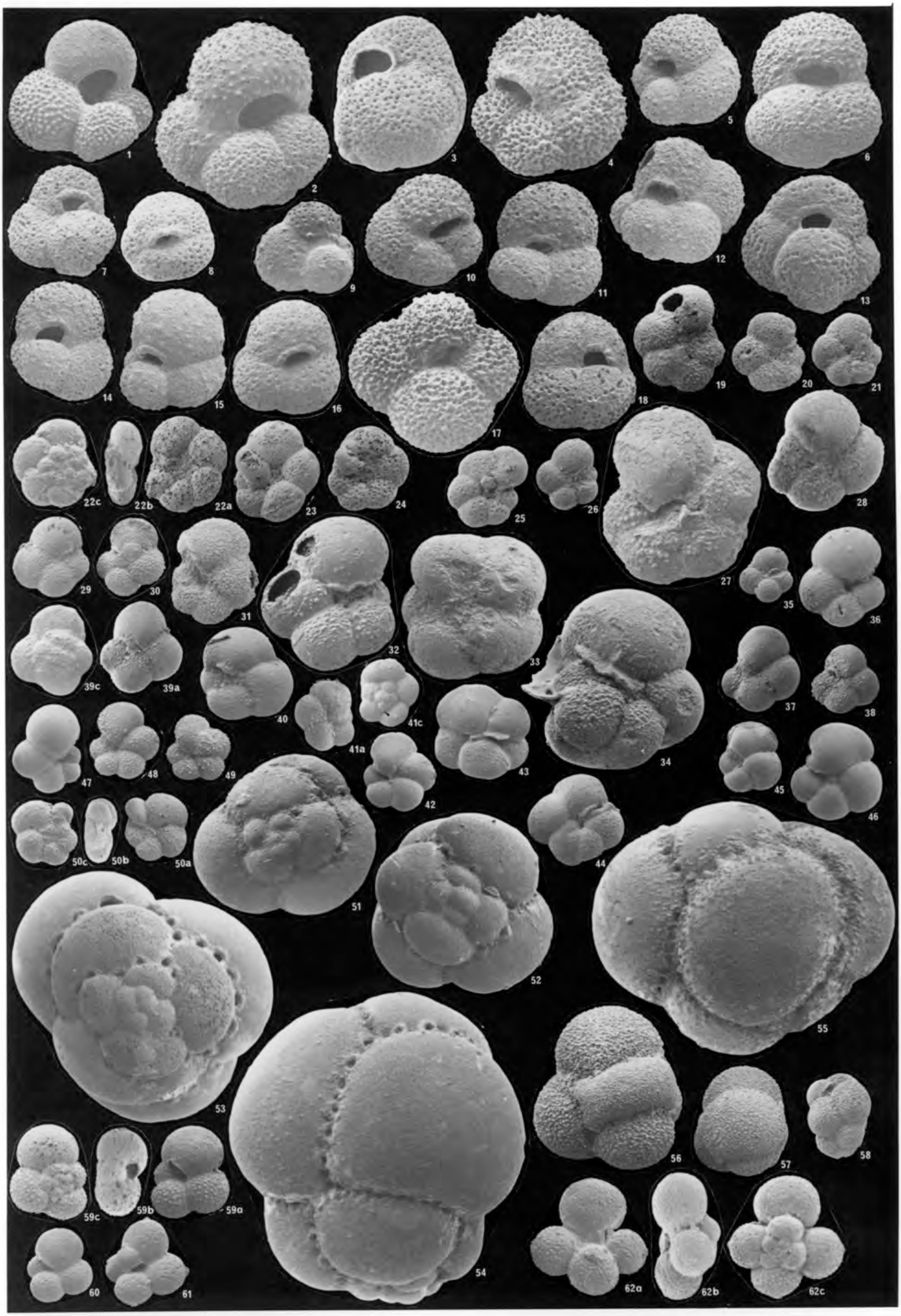
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Plate 3

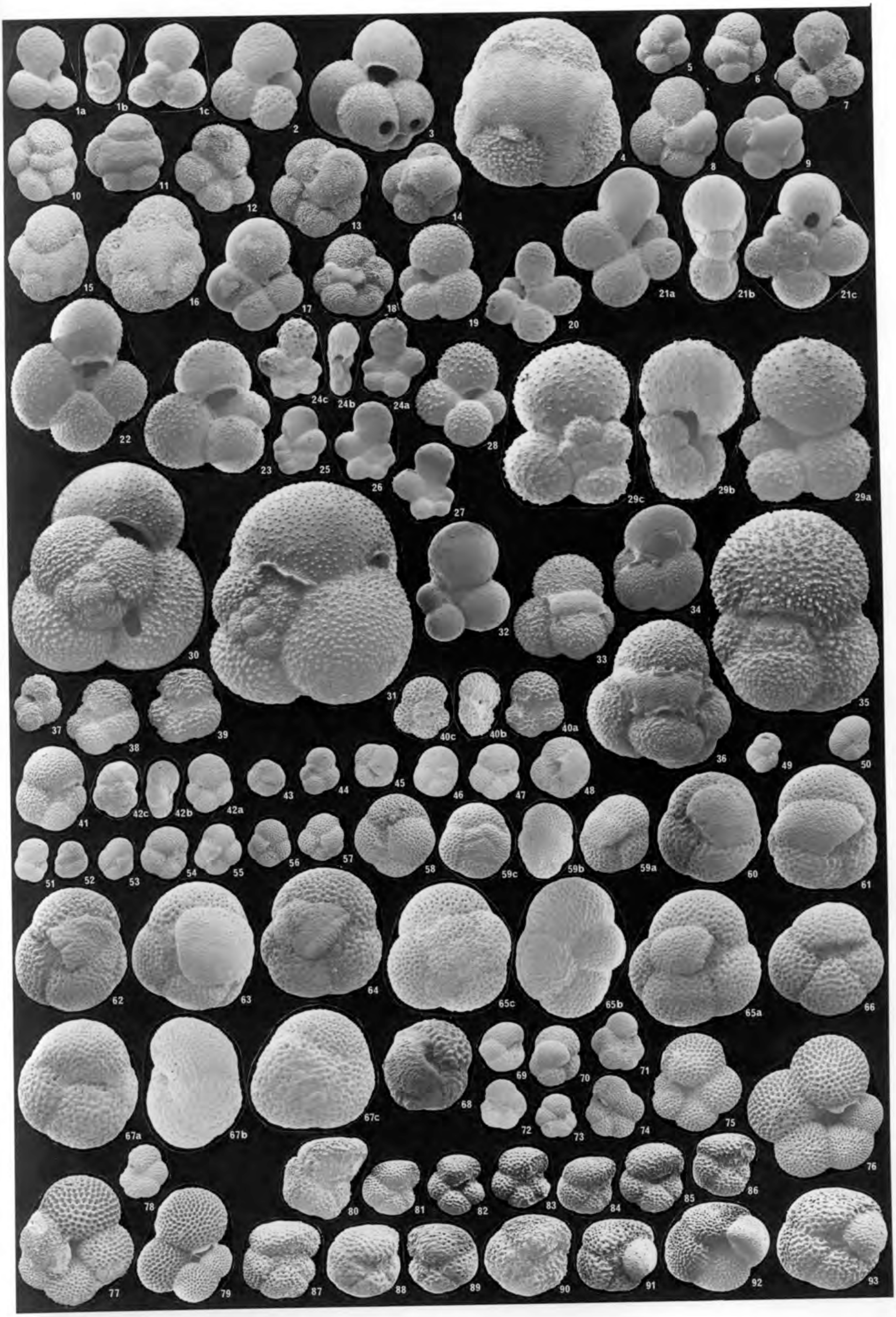
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Plate 4

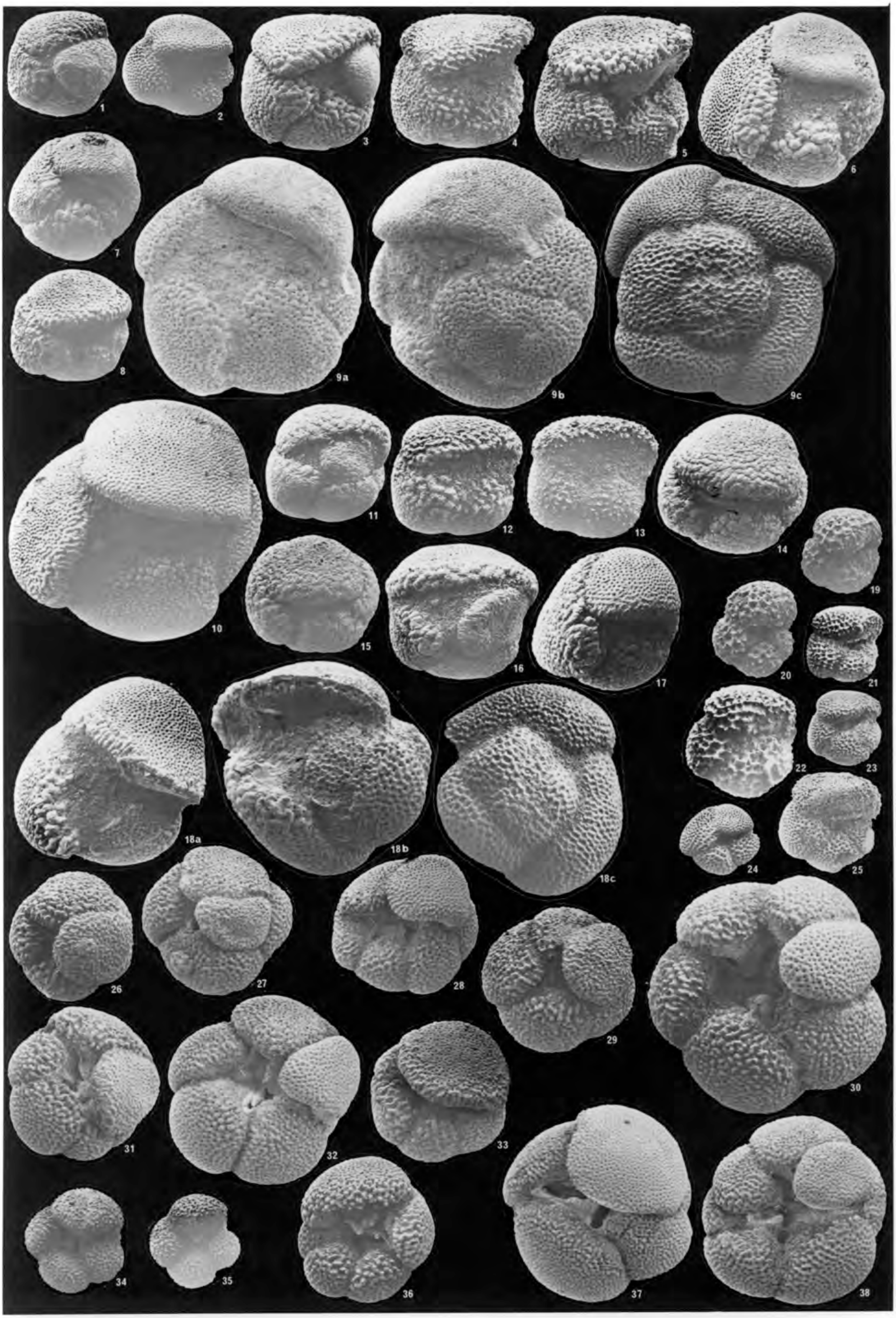
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Plate 5

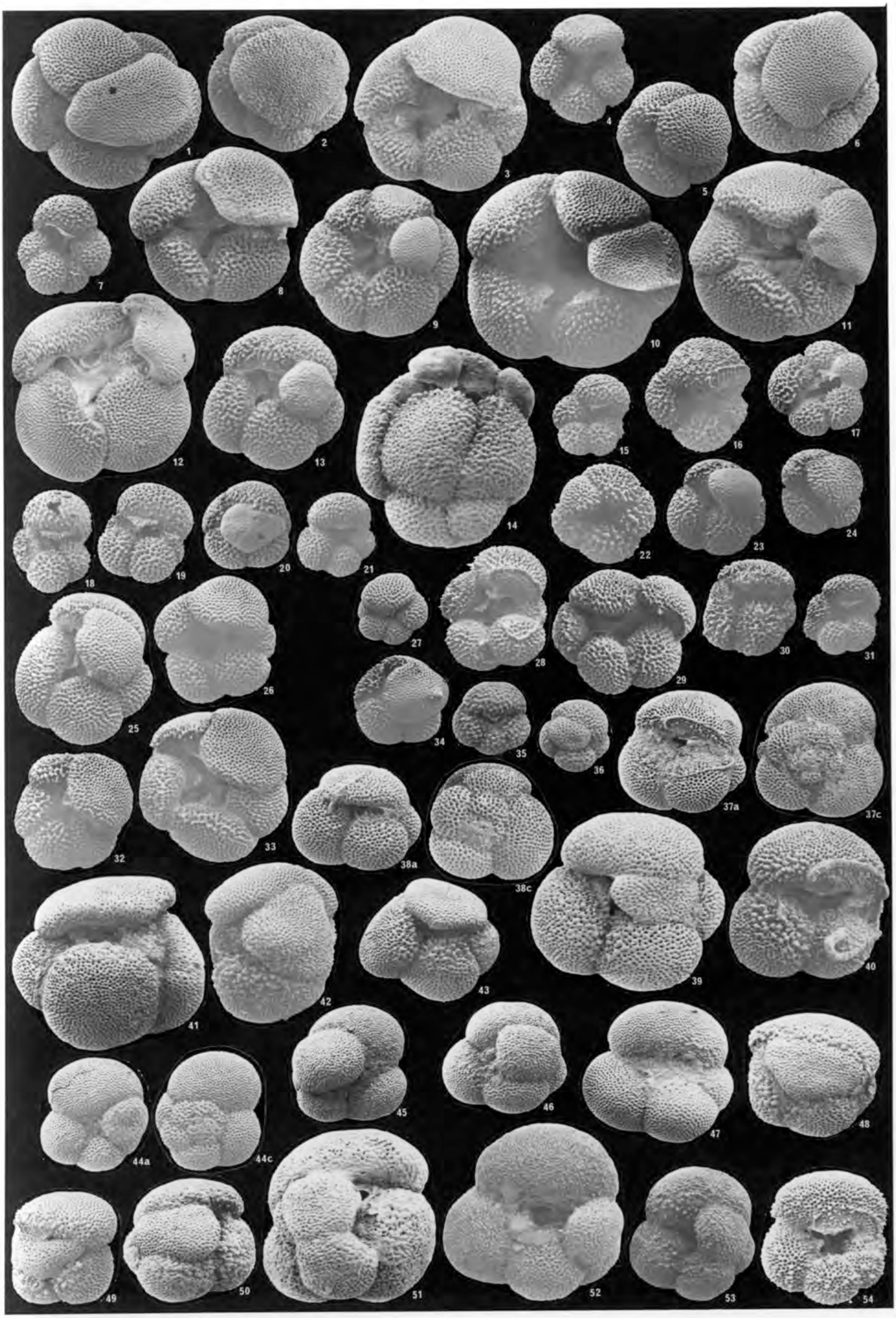
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Plate 6

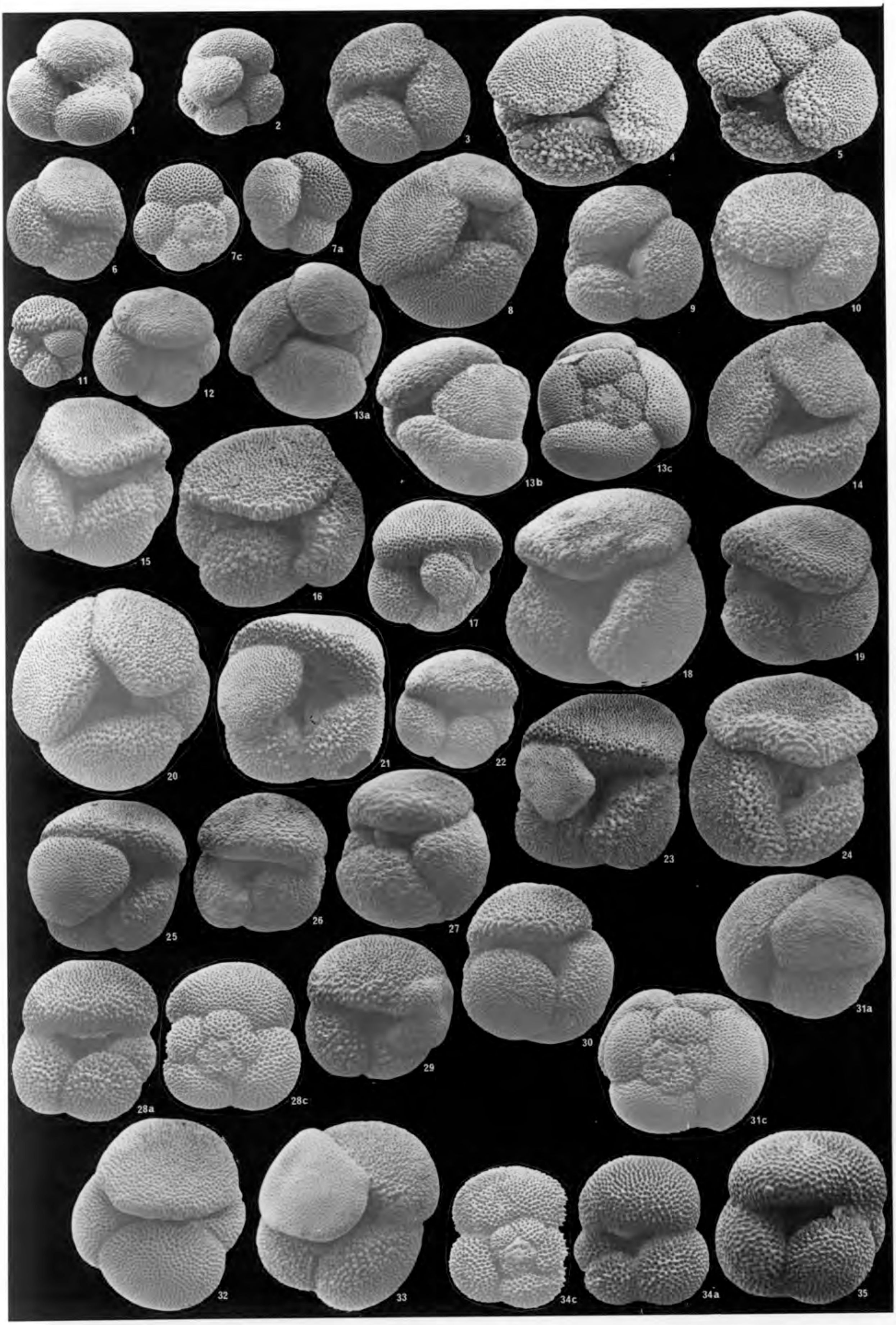
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Plate 7

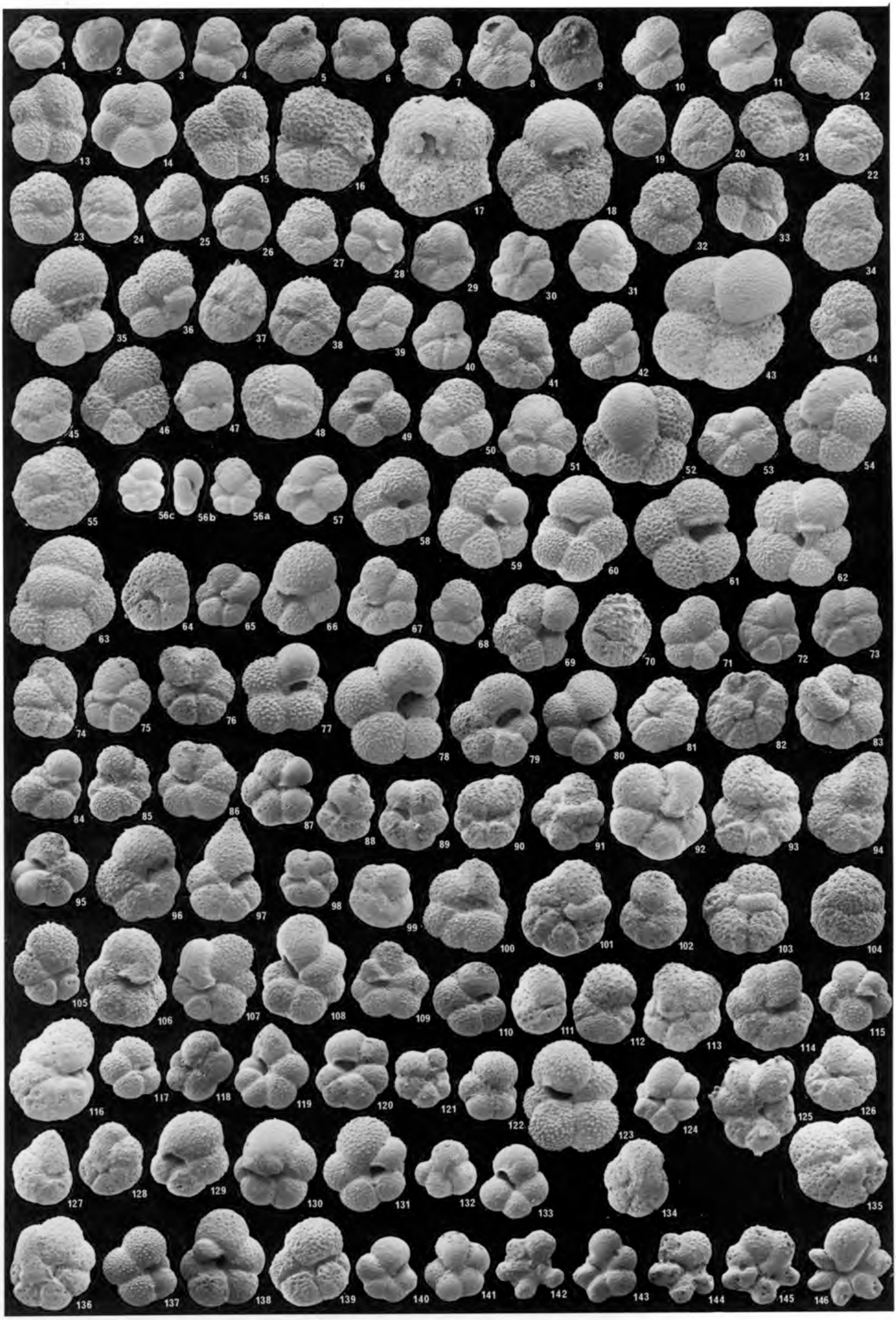
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Plate 8

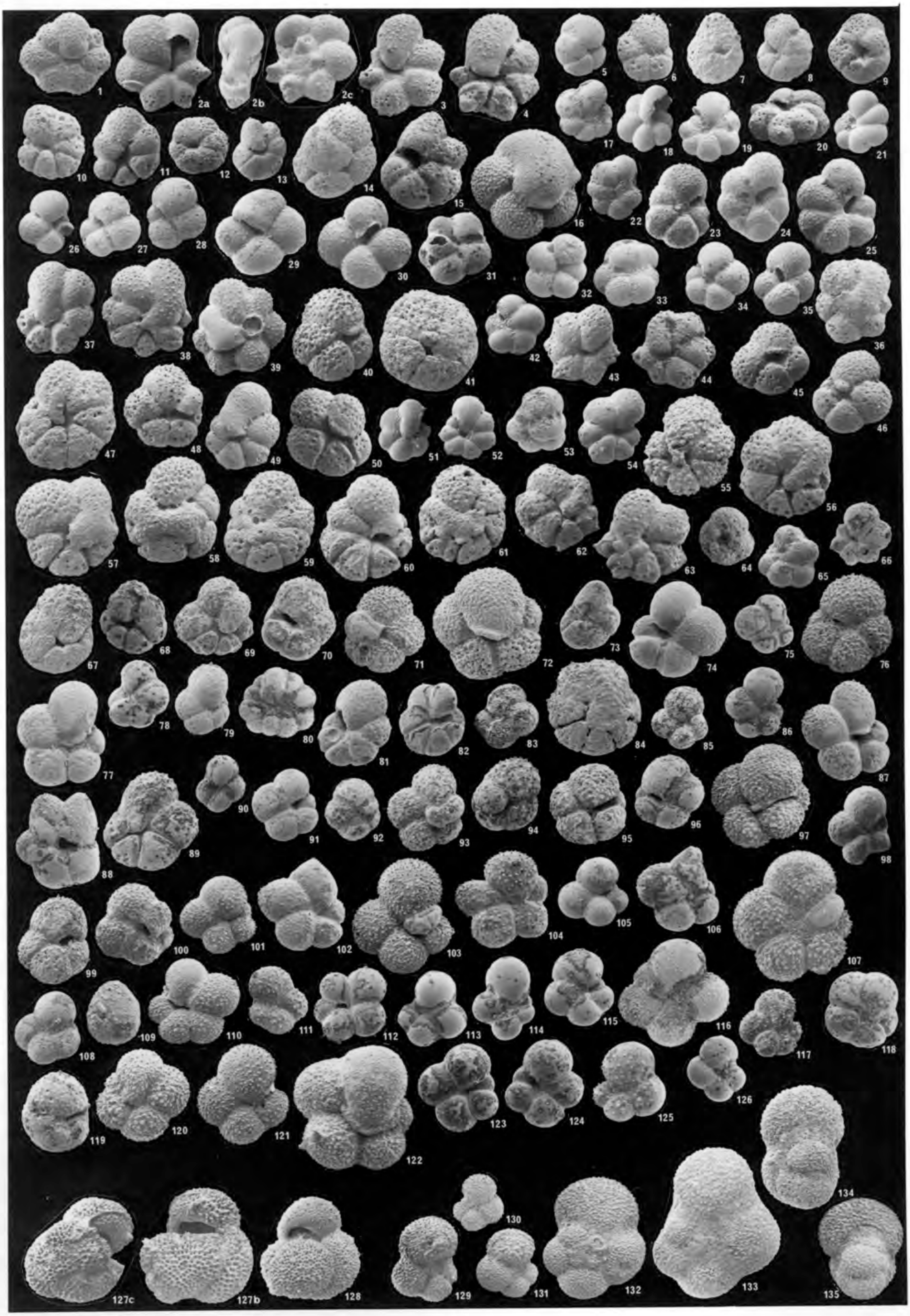
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Plate 9

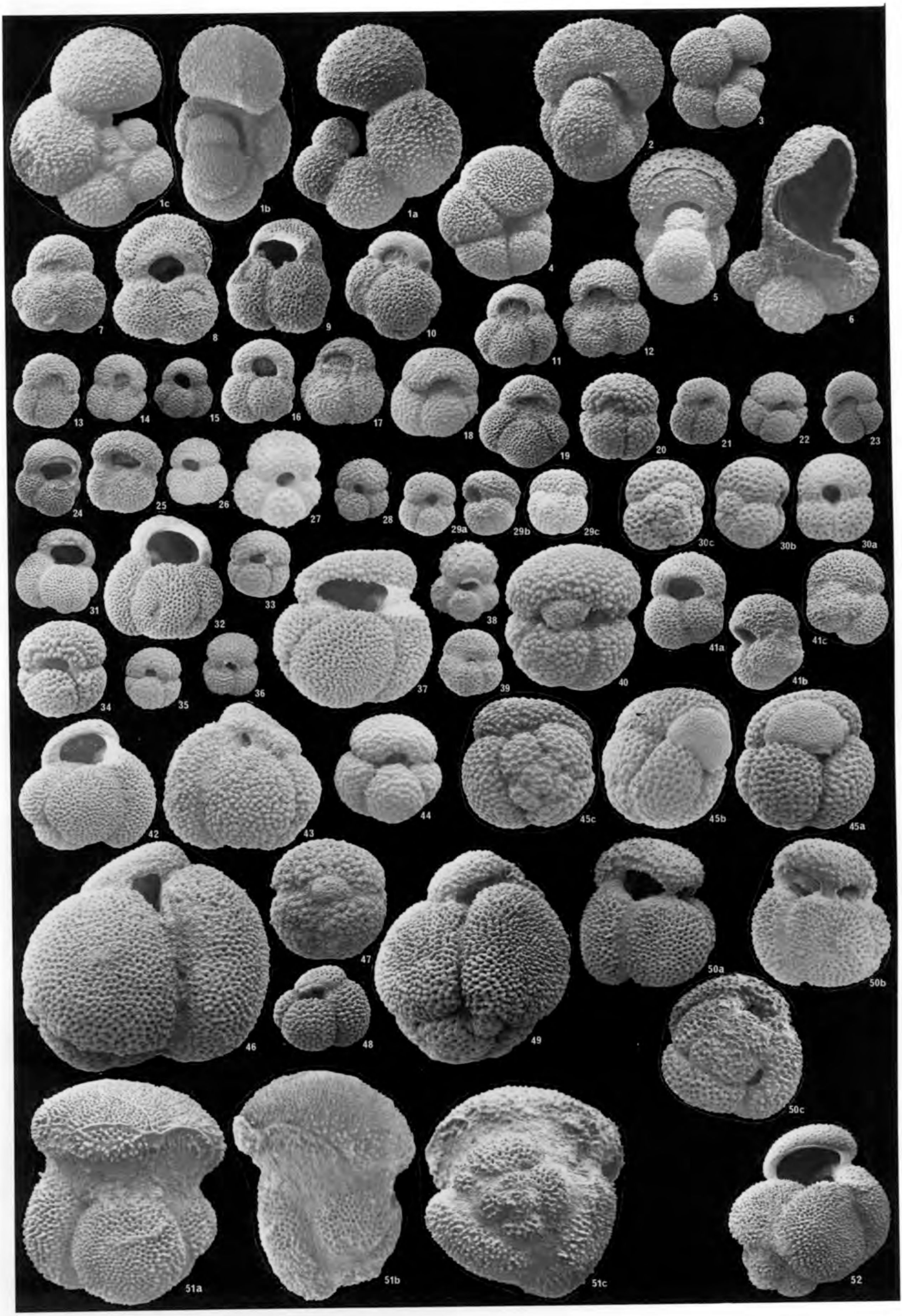
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Plate 10


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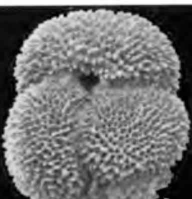
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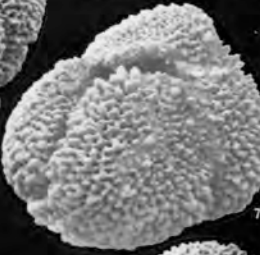
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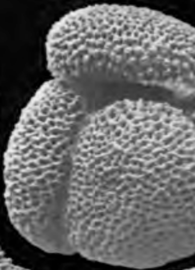
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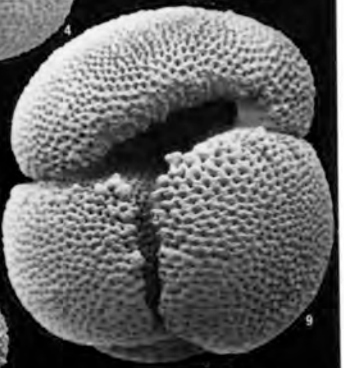
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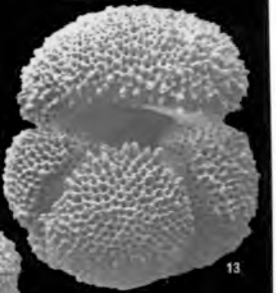
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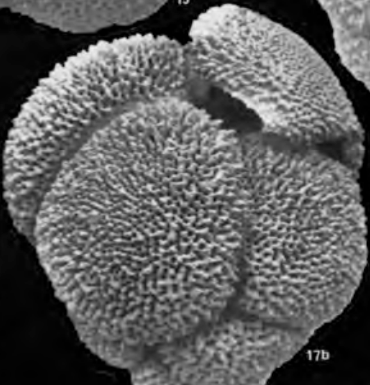
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Plate II

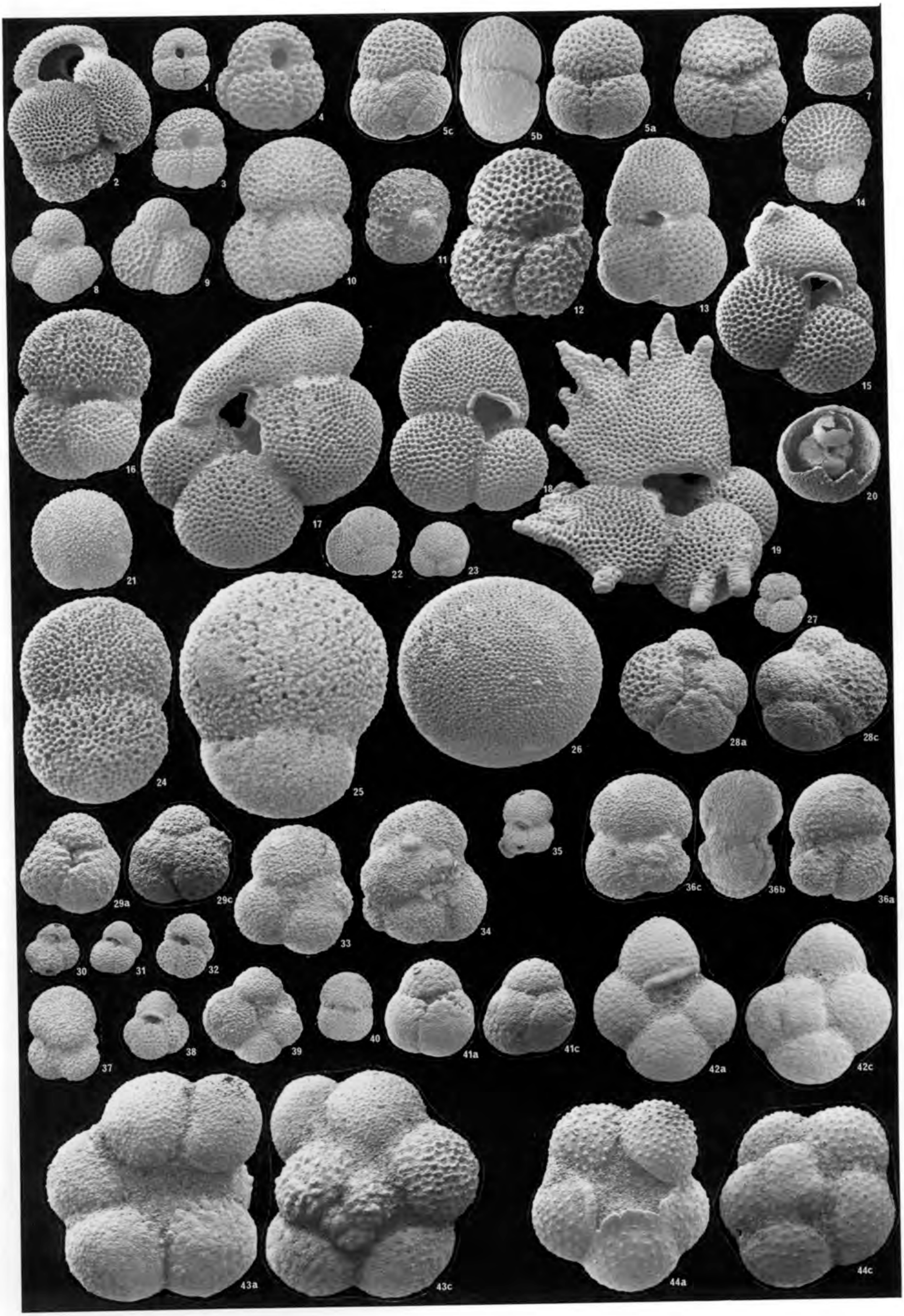

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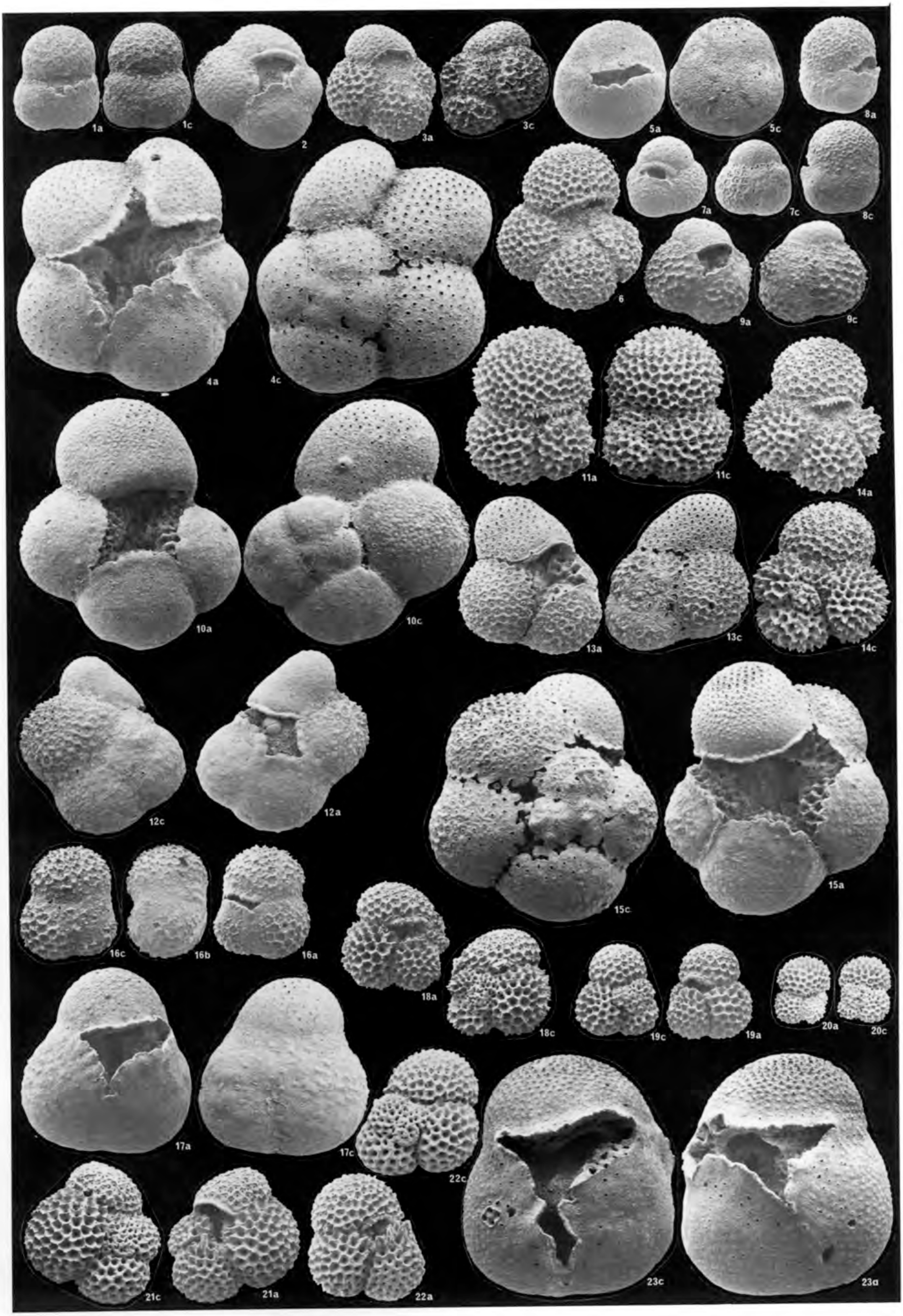
Plate 12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16c
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Plate 13

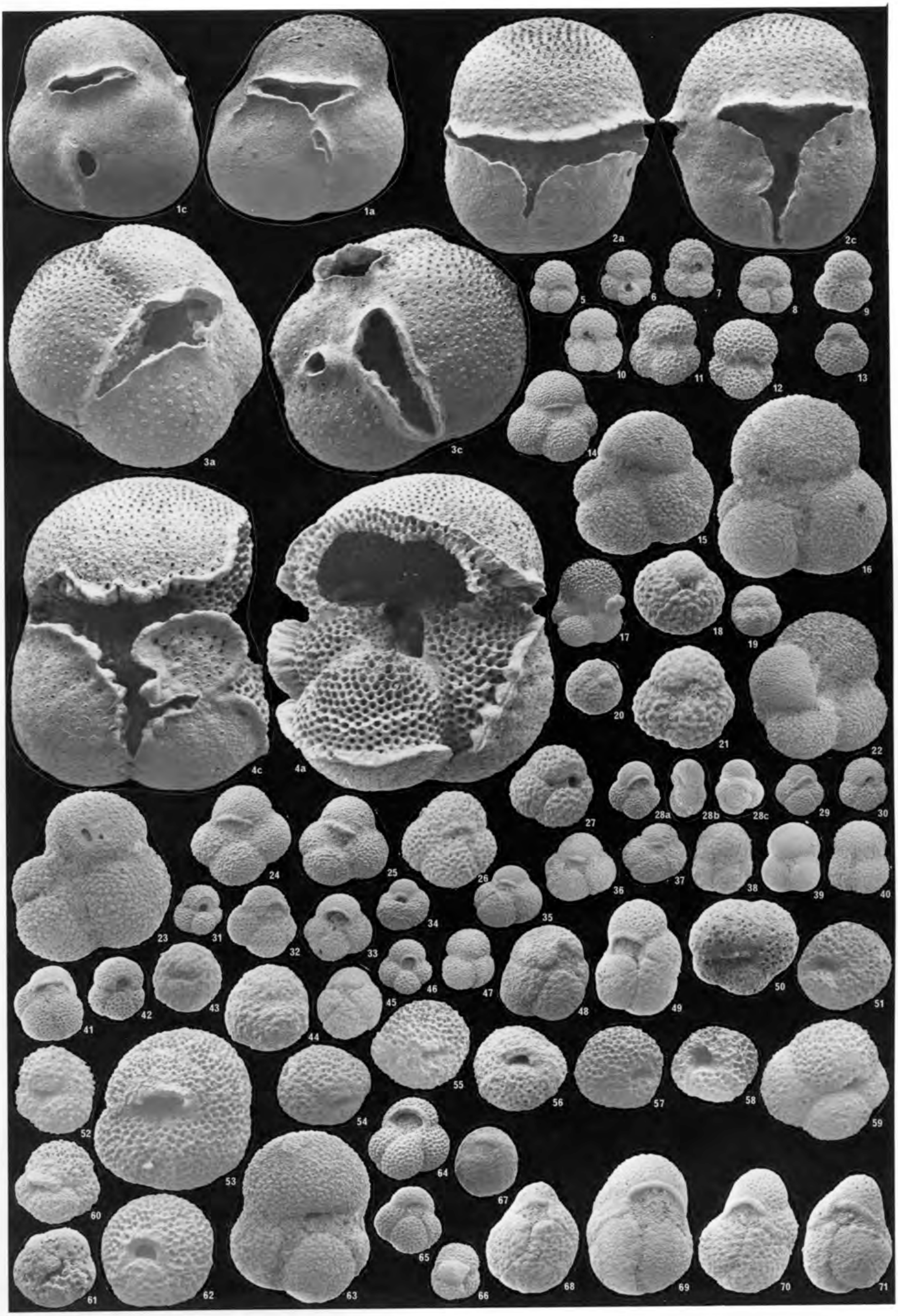
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Plate 14

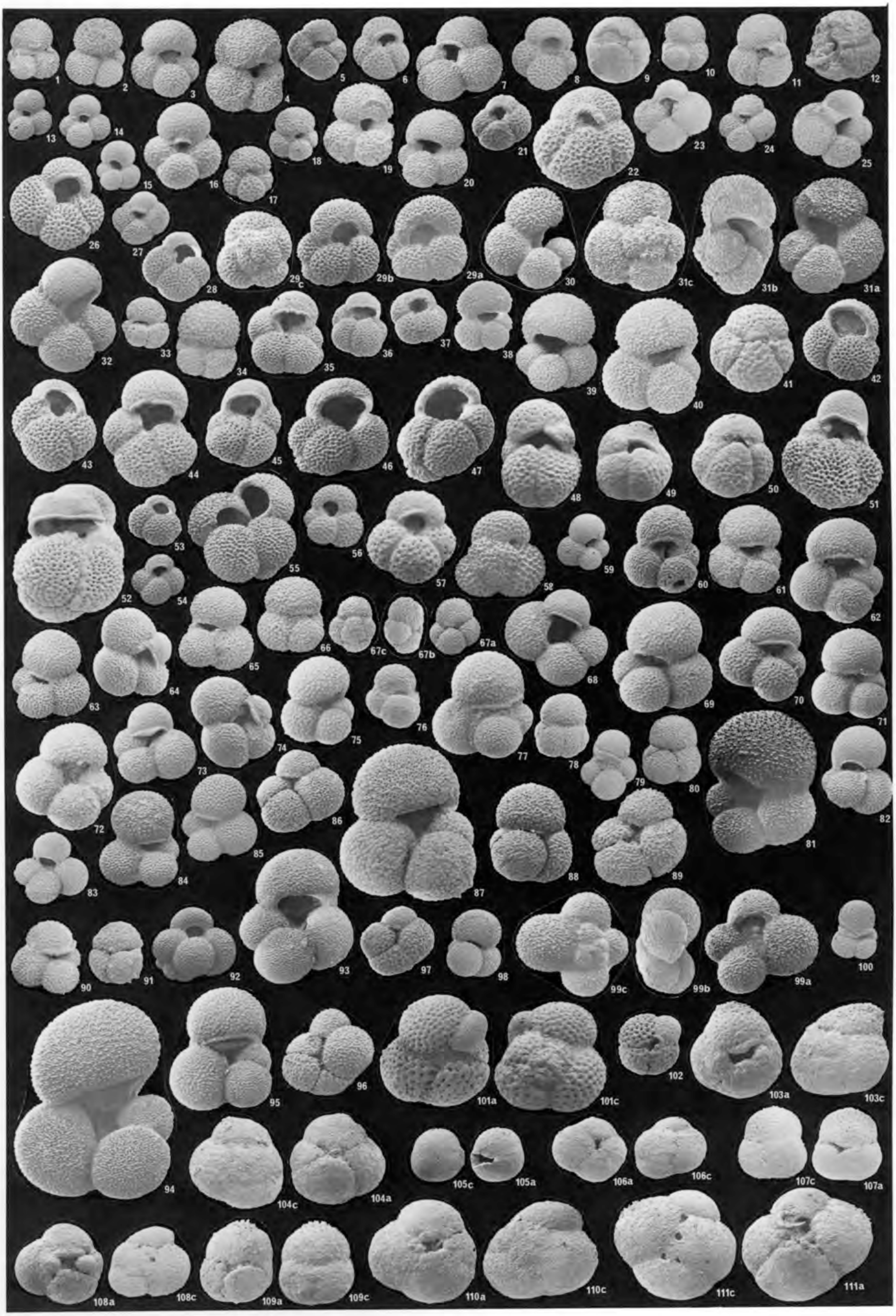
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Plate 15

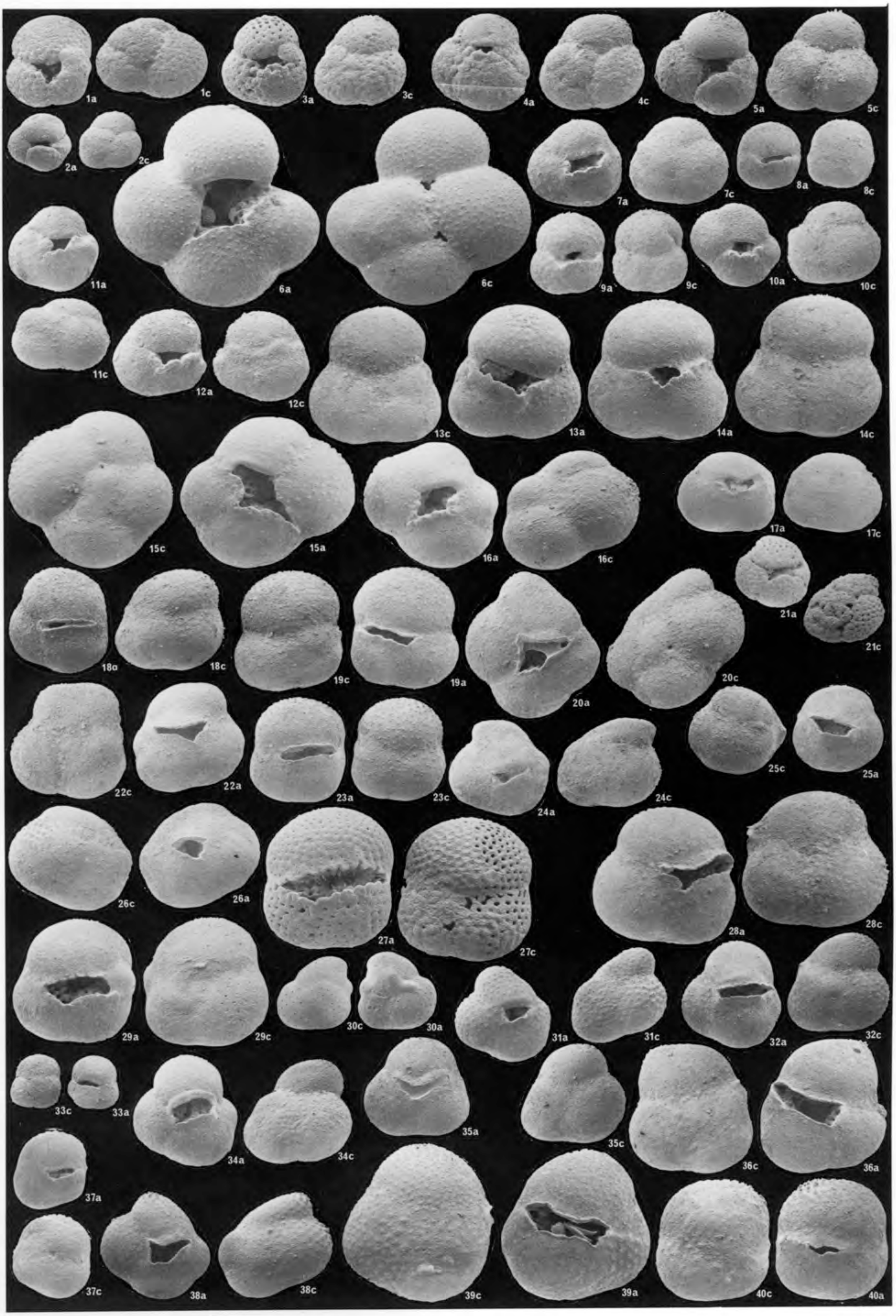
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Plate 16

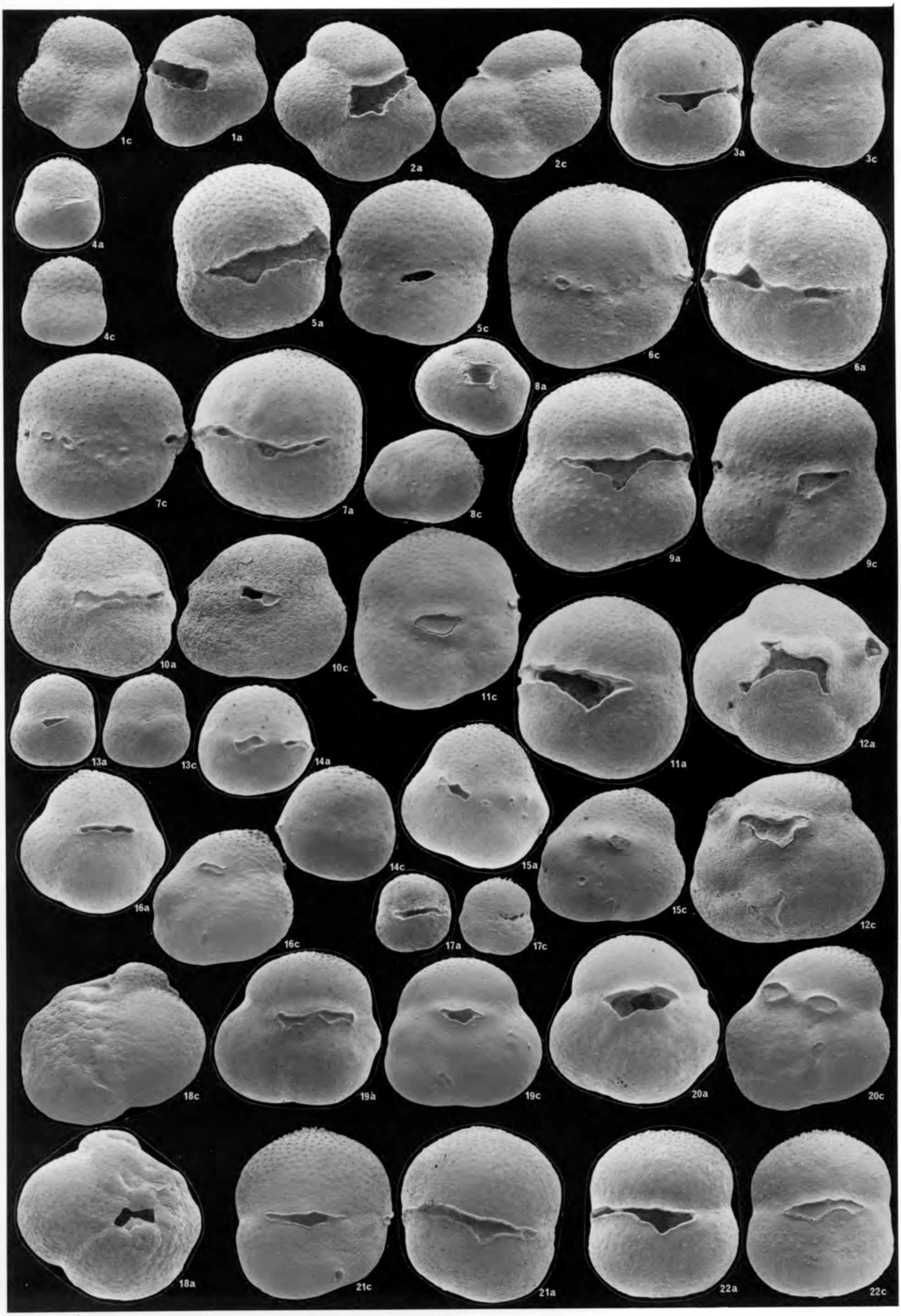
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Plate 17

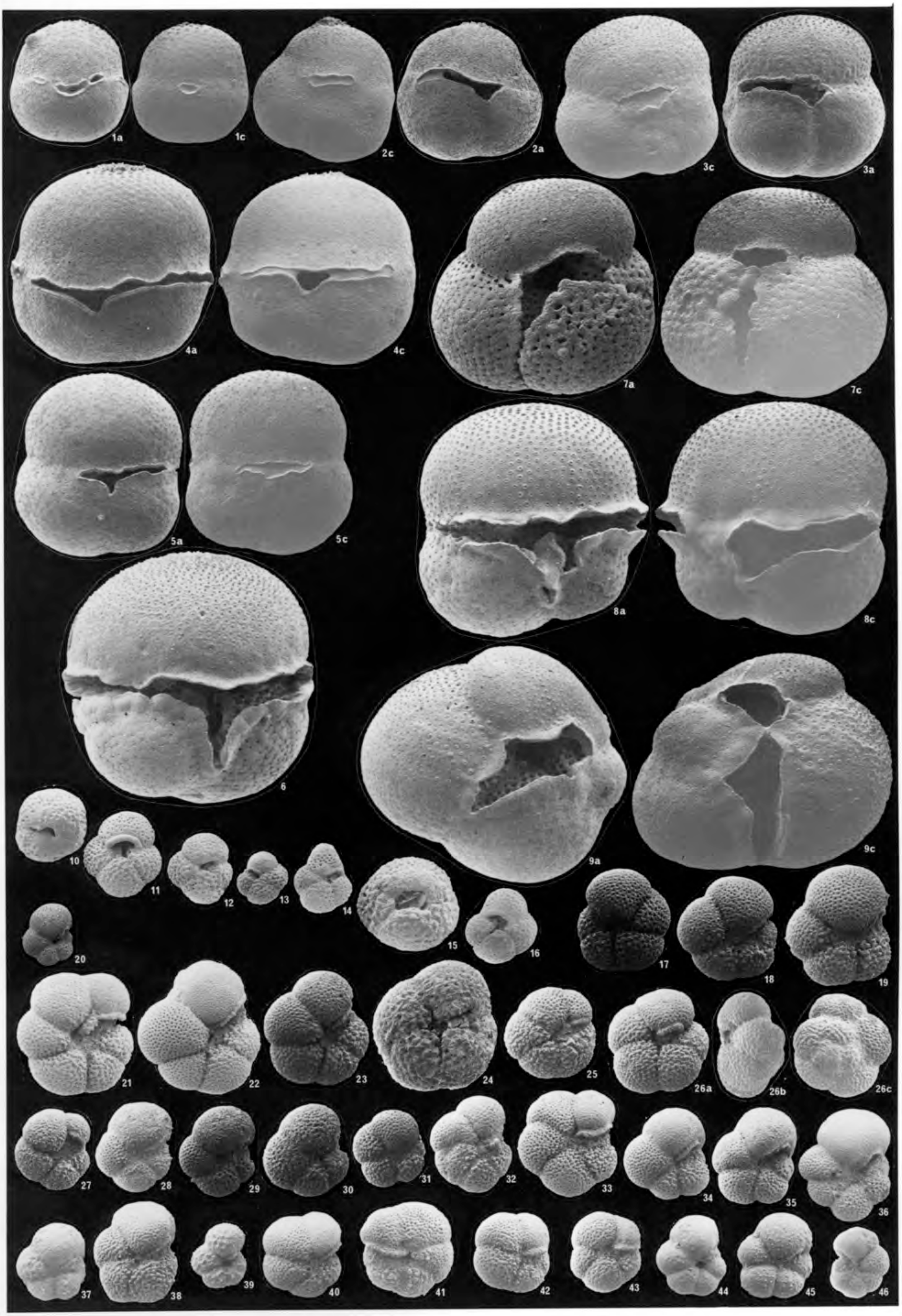
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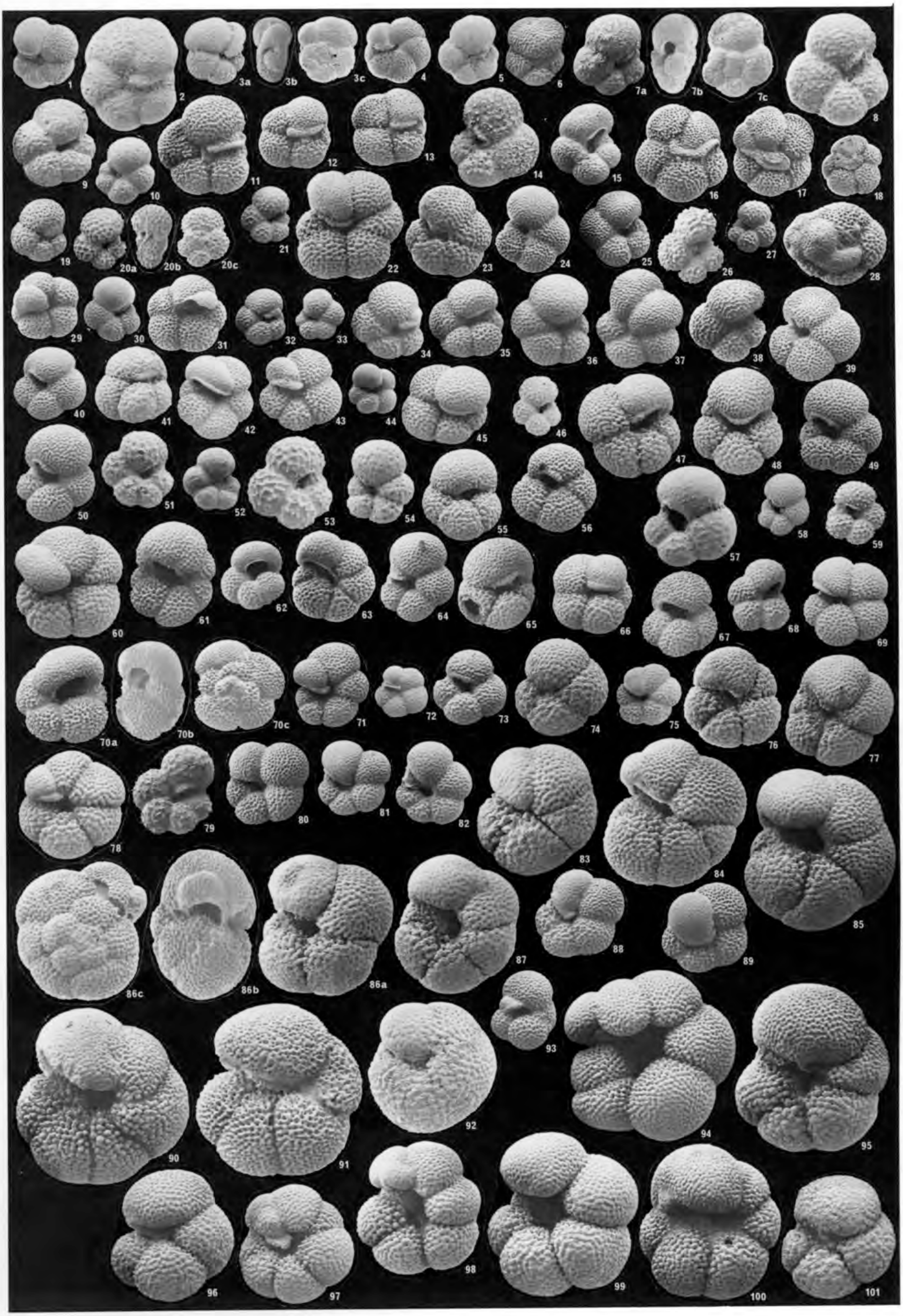
Plate 18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70a
70b
70c
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86c
86b
86a
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101

Plate 19

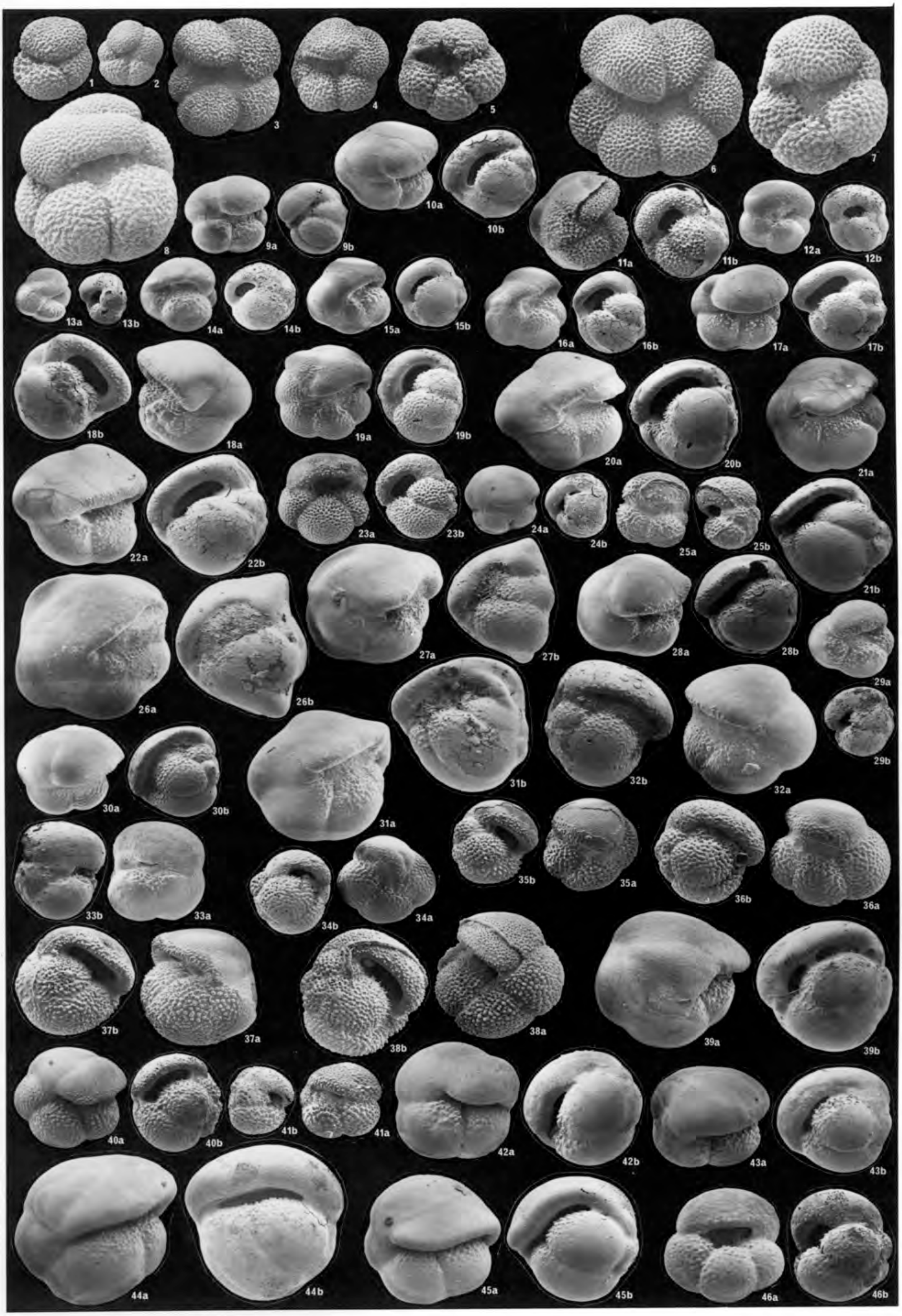
1
2
3
4
5
6
7
8
9a
9b
10a
10b
11a
11b
12a
12b
13a
13b
14a
14b
15a
15b
16a
16b
17a
17b
18b
18a
19a
19b
20a
20b
21a
22a
22b
23a
23b
24a
24b
25a
25b
21b
26a
26b
27a
27b
28a
28b
29a
29b
30a
30b
31a
31b
32b
32a
33b
33a
34b
34a
35b
35a
36b
36a
37b
37a
38b
38a
39a
39b
40a
40b
41b
41a
42a
42b
43a
43b
44a
44b
45a
45b
46a
46b

Plate 20

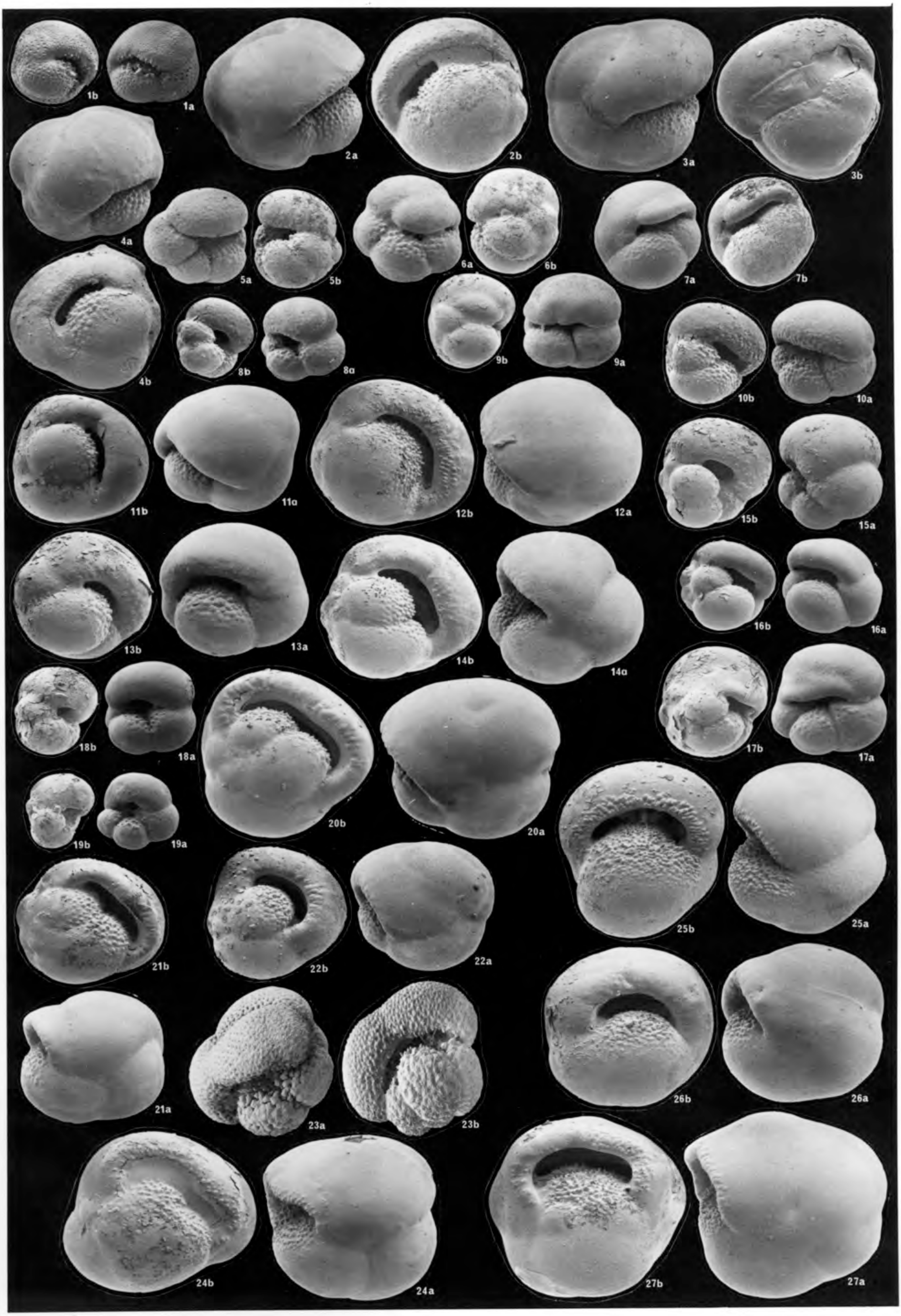
1b
1a
2a
2b
3a
3b
4a
5a
5b
6a
6b
7a
7b
4b
8b
8a
9b
9a
10b
10a
11b
11a
12b
12a
15b
15a
13b
13a
14b
14a
16b
16a
18b
18a
20b
20a
17b
17a
19b
19a
25b
25a
21b
22b
22a
21a
23a
23b
26b
26a
24b
24a
27b
27a

Plate 21

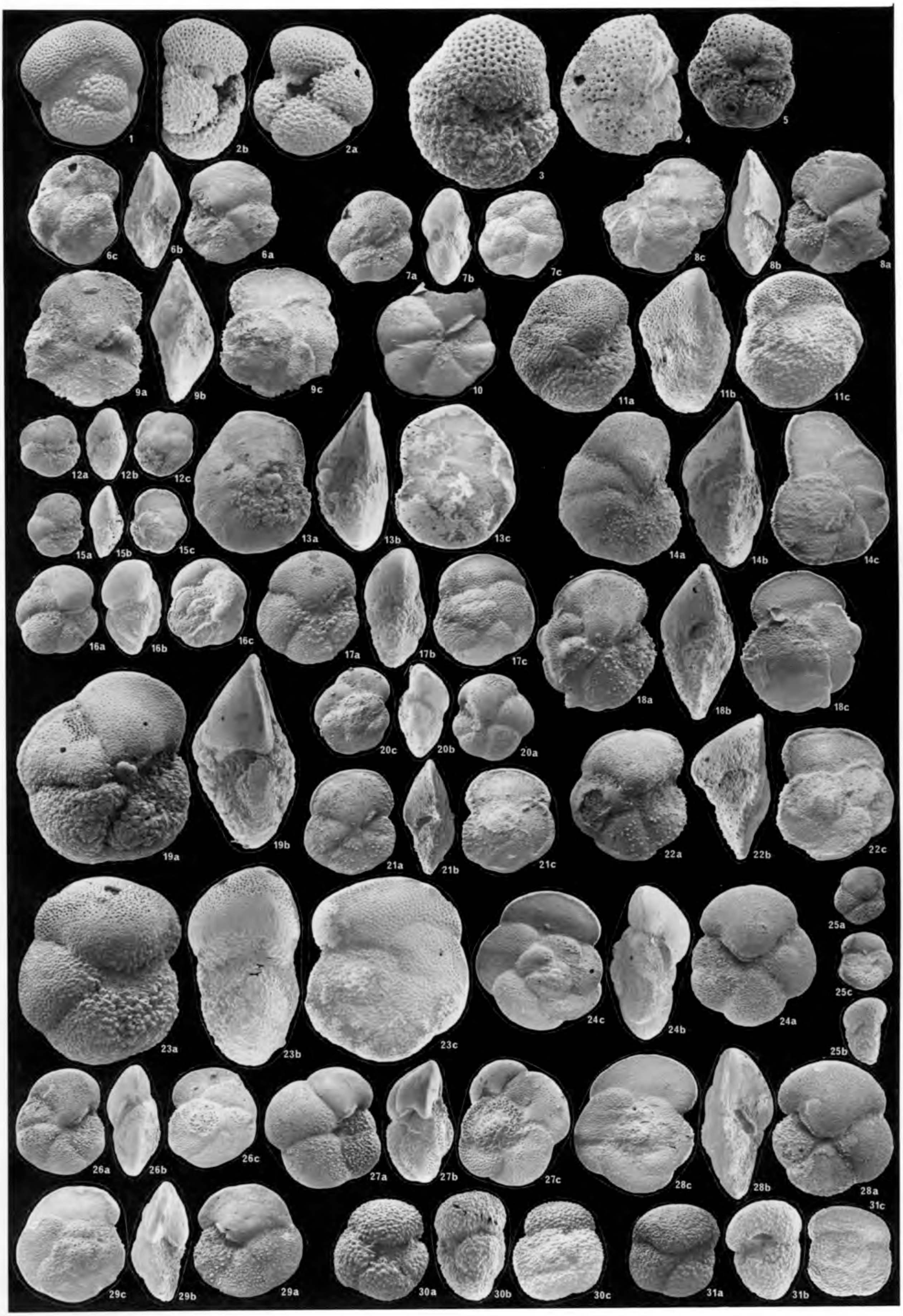
1
2b
2a
3
4
5
6c
6b
6a
7a
7b
7c
8c
8b
8a
9a
9b
9c
10
11a
11b
11c
12a
12b
12c
13a
13b
13c
14a
14b
14c
15a
15b
15c
16a
16b
16c
17a
17b
17c
18a
18b
18c
20c
20b
20a
19a
19b
21a
21b
21c
22a
22b
22c
25a
25c
23a
23b
23c
24c
24b
24a
25b
26a
26b
26c
27a
27b
27c
28c
28b
28a
31c
29c
29b
29a
30a
30b
30c
31a
31b

Plate 23

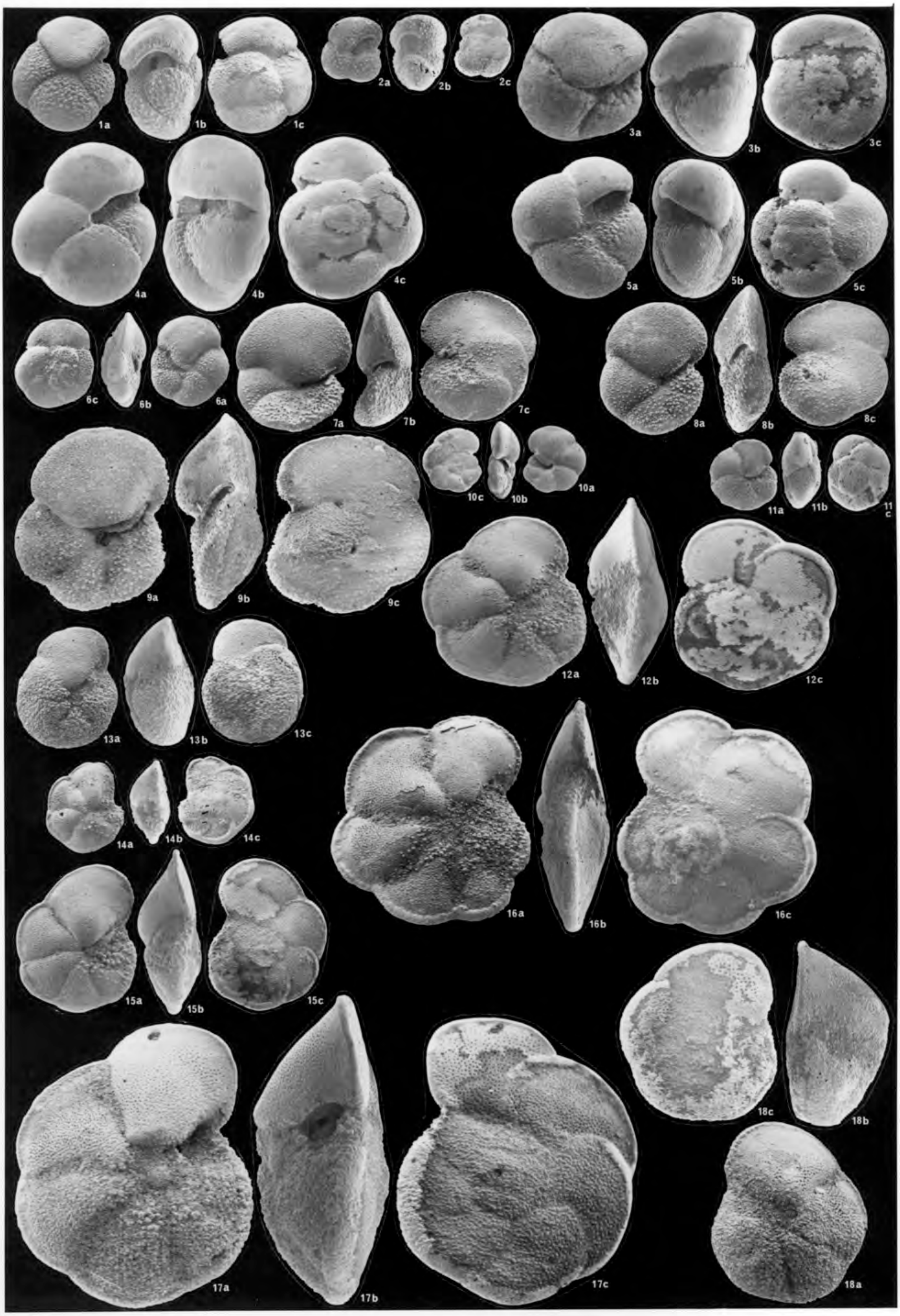
1a
1b
1c
2a
2b
2c
3a
3b
3c
4a
4b
4c
5a
5b
5c
6c
6b
6a
7a
7b
7c
8a
8b
8c
9a
9b
9c
10c
10b
10a
11a
11b
11 c
12a
12b
12c
13a
13b
13c
14a
14b
14c
15a
15b
15c
16a
16b
16c
17a
17b
17c
18c
18b
18a

Plate 22


1a
1b
1c
2c
2b
2a
3a
3c
4a
4b
4c
5a
5b
5c
3b
6a
6c
6b
7c
7b
7a
11c
11b
11a
8a
8b
8c
12a
12b
12c
9a
9b
9c
13c
13b
13a
10c
10b
10a
14a
14b
14c
15a
15b
15c

Plate 24

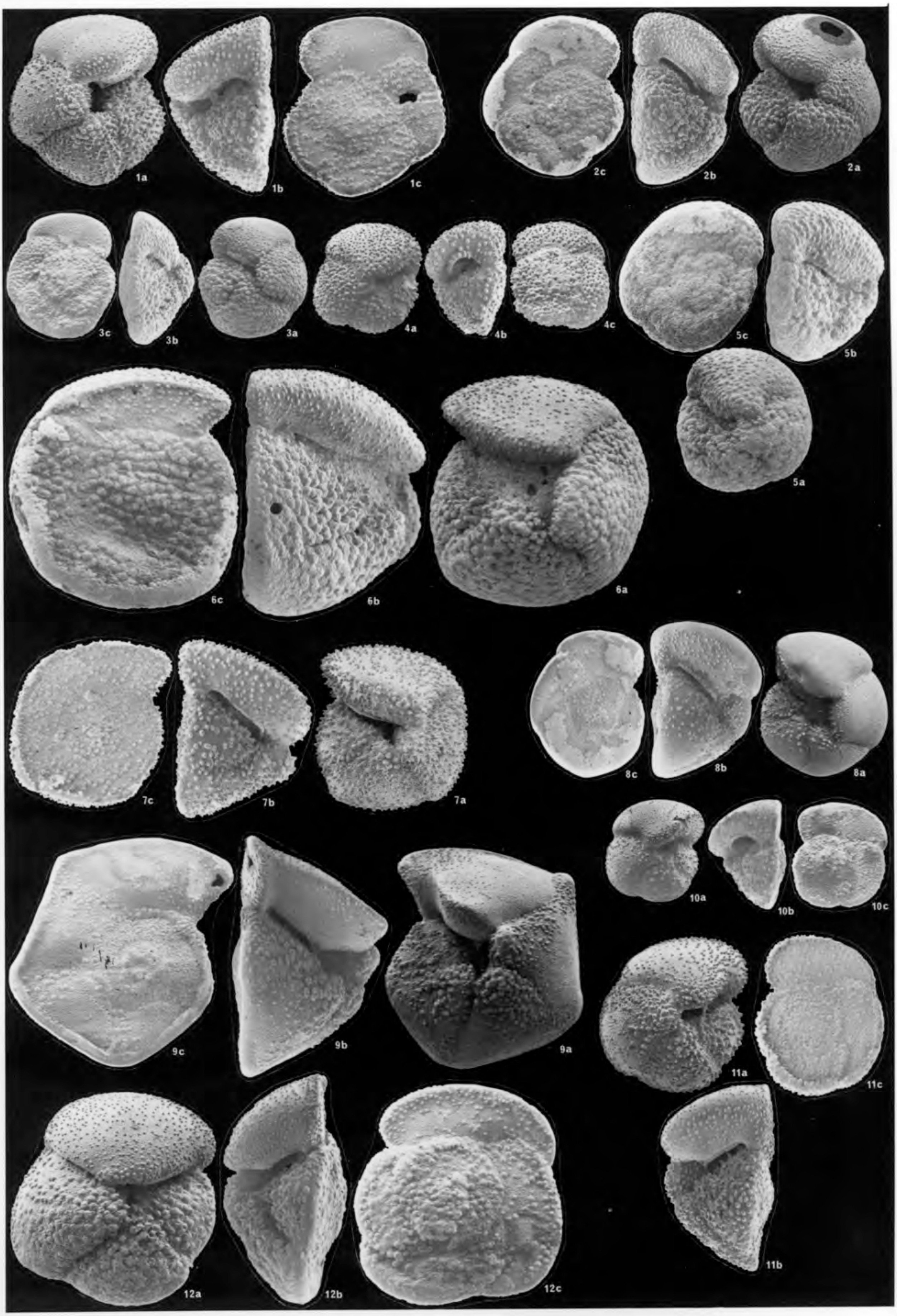
1a
1b
1c
2c
2b
2a
3c
3b
3a
4a
4b
4c
5c
5b
5a
6c
6b
6a
7c
7b
7a
8c
8b
8a
10a
10b
10c
9c
9b
9a
11a
11c
11b
12a
12b
12c

Plate 25