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LATE ALBIAN FORAMINIFERA FROM THE SUBBETIC OF SOUTHERN SPAIN

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ABSTRACT

A fauna of planktonic Foraminifera from the Late Albian of southern Spain is described. The genus *Ticinella* is discussed in some detail. The species of *Hedbergella* from the Albian and Cenomanian are reviewed.

INTRODUCTION

In a previous paper (Hermes, 1966) it was pointed out that the zonation of the Lower Cretaceous on the basis of planktonic Foraminifera was far from settled. It was mentioned that one of the main obstacles seemed to be the difference of opinion regarding the range of *Ticinella roberti* (Gandolfi). According to Moullade (1965), and, to a certain extent, Sigal and Moullade (1963) this species is restricted to the lower part of the Middle Albian and the upper part of the Lower Albian. Furthermore these authors believe that *Ticinella roberti* (Gandolfi) is not the ancestor of *Rotalipora ticinensis* (Gandolfi) of the late Albian, whereas other authors believe with Gandolfi (1942) and Reichel (1949) that *Ticinella roberti* ranges up into the Upper Albian and that it does evolve into *Rotalipora ticinensis.*

Shortly after the above-mentioned paper (Hermes, 1966) was published, two publications appeared which are of the greatest importance for this problem. The first is Sigal's (1966) paper on the genus *Ticinella*, the second Moullade's (1966) thesis on the stratigraphy and paleontology of the Vocontian trough. Sigal's paper is a monographic treatment of the genus *Ticinella* and is written primarily from the standpoint of the paleontologist. Moullade's thesis on the other hand, has approached the problem of the faunal succession in the Vocontian trough mainly from the stratigrapher's point of view. He has worked out the biostratigraphy of the Valanginian to Albian sequence, which is developed in a predominantly pelagic facies, and has established the correlation between Ammonite zones and the planktonic Foraminifera zones.

In the papers cited, both Sigal and Moullade have altered their views as to the definition of *Ticinella roberti* and, consequently, as to its range. In table 1 these various views are shown graphically.

It should be mentioned that Sigal has repeatedly stated that the stratigraphic range of the several species of *Ticinella* could not be accurately established. Moullade, on the other hand, has indicated the range of the planktonic Foraminifera in a well-studied sequence in which ammonites occur relatively frequently.

Moullade has considerably detailed the biostratigraphy of the Lower Cretaceous, but he has adhered to the opinion - which he shares with Sigal - that the well-known series *trocoidea - roberti - ticinensis* is fictitious, an opinion which at the present moment I am not yet prepared to accept. Since Moullade has changed some of his previous opinions on certain species, the whole problem of the ancestry of *Rotalipora ticinensis* has become rather complicated.

In what follows I will often have occasion to differ in opinion from Moullade and I am afraid that this may be misunderstood. I gladly take this opportunity therefore to state that I have great admiration for Moullade's exhaustive treatment of the Lower Cretaceous stratigraphy of the Vocontian trough in general, and for his correlation of the

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Lithostratigraphic units	Scaglia variegata					Scaglia bianca											
Gandolfi's sample stations	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
roberti	X	X	X	–	–	X	"X"	–	–	"X"	–	–	–	–	–	–	–
ticinensis	–	–	–	–	–	–	X	X	X	X	X	X	X	–	–	–	–
breggiensis	–	–	–	–	–	–	X	X	X	X	X	–	–	–	–	–	–
appenninica	–	–	–	–	–	–	–	"X"	"X"	"X"	"X"	"X"	X	X	X	X	X
buxtorfi	–	–	–	–	–	–	–	–	X	X	X	X	X	X	X	X	–
primula	–	–	–	–	–	–	–	–	–	"X"	–	–	–	–	–	–	–
praeticinensis	–	–	–	–	–	"X"	–	–	–	–	–	–	–	–	–	–	–
Chronostratigraphic units	Albian												Albian/Cenomanian				Cenomanian

TABLE 1

Distribution of species discussed and some other important species in the Breggia gorge according to Gandolfi (1942), with additions ("X") from subsequent publications.

planktonic Foraminiferal zones and the Ammonite zones in particular. He is the first to present a well-documented zonation of the planktonic Foraminifera of the Lower Cretaceous based on a relatively continuous sequence. Compared to these achievements, the controversies mentioned are of less importance.

One of the consequences of Moullade's pioneer work is that it can now be said that the fauna characterized by the occurrence of *Globigerinelloides blowi* (Bolli), does not range down into the Barremian but is restricted to the Aptian. In view of the proximity of the Vocontian trough to the Betic Cordilleras, it is quite probable that also in southern Spain this fauna is restricted to the Aptian. In my previous paper (Hermes, 1966), its age was still indicated as early Aptian and possibly including the late Barremian. This downward extension of the range of *Globigerinelloides blowi* (Bolli) can now practically be excluded.

The same Cretaceous section which yielded the Aptian fauna mentioned above (Hermes 1966), also contains the sample (Ve.568) discussed in the present paper. This sample carries a late Albian fauna, which I hope will shed some light on the problem in discussion. The section is situated west of the town of Caravaca in the province of Murcia. It has been described in some detail by van Veen (1966), to whose paper the reader is referred for the geological setting and the exact location of the sample concerned.

The time-stratigraphic interpretation of the bio-stratigraphic zones from the interval in discussion has recently been changed considerably. Recent investigations in the Vocontian trough of the Subalpine region of southeastern France (Cotillon et al., 1965) have shown that the first occurrence of *Rotalipora appenninica* (Renz) - which has been taken by most authors to indicate the base of the Cenomanian - is in the lowermost Vraconian, in the Upper Albian therefore. The actual base of the Cenomanian is, according to Cotillon et al., marked by the appearance of *Rotalipora gr. montsalvensis* (Mornod) (= *Rotalipora cushmani* (Morrow) according to Loeblich and Tappan, 1961, p. 298), *Rotalipora greenhornensis* (Morrow) and *Schackoina cenomana* (Schacko). It should be realized that if this correction is accepted, previous time-stratigraphic interpretations of the planktonic foraminiferal zones of the interval concerned, are erroneous.

Furthermore the "Colloque sur le Crétacé inférieur" (1965, p. 832) has accepted the Vraconian as the highest subdivision of the Upper Albian, a decision which may cause a lot of semantic confusion. In order to avoid confusion Moullade (1966, fig. 18) distinguishes an "Albien s.s." and also an "Albien supérieur s.s." in his tables (see table 1). In the text however the "s.s." is often omitted and "Albien supérieur" is often used for "Albien supérieur s.s.". Under these circumstances the acceptance of the term Vraconian as a subdivision of the "Albien supérieur" is thought to be an unfortunate compromise.

PALEONTOLOGY

Ticinella roberti (Gandolfi) 1942
(Pl. 1, figs. 1-3)

1942 *Anomalina roberti Gandolfi*, Riv. Ital. Pal., 48, 4, 100, 101, pl. II, fig. 2, pl. IV, fig. 4-7, 20, pl. V, fig. 1, Pl. XIII, fig. 3-6.

In view of the many controversies which exist regarding this species, G a n d o l f i's original description (1942, p. 100) is here freely translated. "Circular test, umbilical side convex, slightly concave on the spiral side, periphery broadly rounded, trochoid spiral; on spiral side the original spire is clearly visible; two and a half whorls; chambers slightly increasing in size as added, initially spherical, subsequently a little higher, neatly separated by depressed sutures. On the umbilical side a wide umbilicus is present; the chambers are strongly convex, the sutures even more depressed, radial, straight. 8-9 chambers in the last whorl. Diameter 0.3-0.5 mm; diameter of umbilicus 0.18 mm; diameter of last whorl 0.17 mm. Occurs in notable quantities in the upper Scaglia Variegata. The best specimens occur in sample 27[2]); in sample 28[2]) a few specimens occur, which show a certain flattening of the peripheral margin of the chambers in side view ("appiatimento del bordo"), while the internal chambers clearly show a certain increased rugosity like the beginning of a keel ("come un acceno di carena") (pl. 4, fig. 6, refigured here: pl. 2, fig. 37-39); besides, some other specimens show along the suture, a series of distinct tubercles, that form the beginning of a pearly keel, restricted as yet to the internal whorls (pl. 4, fig. 7, refigured here: pl. 2, fig. 40-42). There are therefore two varieties: a) test with simple, depressed sutures, broadly rounded periphery, corresponding with the typical form: b) test with slightly flattened chambers in side view, chambers slightly coated, internal sutures with tubercles. As will be more clearly shown further on, a good series of transitionary specimens exists, leading towards *Globotruncana ticinensis* n.sp."

On table 2, which is copied from G a n d o l f i's distribution chart (1942, opposite p. 108), the range of the more important planktonic species that occur in the Upper Albian and Lower Cenomanian of the Breggia section, have been indicated. Additions to Gandolfi's original data, derived from subsequent literature, have been indicated between inverted commas.

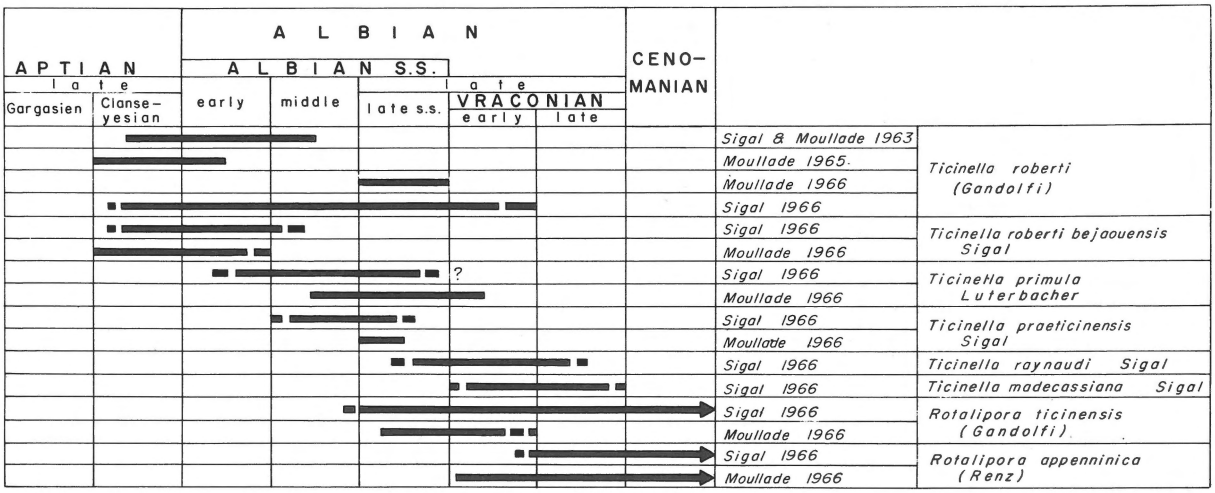


TABLE 2

Ranges of some species of Ticinella and Rotalipora in late Aptian and Albian according to Sigal and Moullade.

The boundary between Albian and Cenomanian has not been definitely established in the Breggia section. Gandolfi does not discuss the problem. In recent papers (S i g a l 1966, p. 206, C a r o n 1967, p. 66) doubtful boundaries are indicated.

The occurrence of *Ticinella roberti* in sample 28 is not indicated on Gandolfi's distribution chart

2) On the distribution chart opposite p. 108, samples 27 and 28 are indicated to belong to the Scaglia Bianca!

opposite page 108 and neither on fig. 49 on page 136, but its occurrence is specifically mentioned in the text on page 100, as shown in the translation, and again on page 135, and the specimens are figured on his pl. IV, fig. 7. Reichel (1949, p. 601) reports that after cleaning the umbilicus of the specimens of *T. roberti* from sample 22, they were found not to possess accessorial apertures and should thus be assigned to *"Pseudovalvulineria lorneiana* var. *trocoidea* (Gandolfi)", the species which was subsequently renamed *Hedbergella trocoidea* (Gandolfi). The occurrence of *T. roberti* in sample 31 is reported by Luterbacher and Premoli Silva (1962, p.274)

According to Caron, (1967, p. 74) typical *Rotalipora appenninica* Renz already appears in Gandolfi's samples 29-33. Luterbacher (in Renz, Luterbacher and Schneider 1963, p. 1086) mentions the occurrence of *Ticinella primula* Luterbacher in sample 31. *Ticinella praeticinensis* Sigal is reported from sample 27 by Moullade (1966, p.99).

The present species was described by Gandolfi as *Anomalina roberti*. Reichel (1949) subsequently discovered the accessory apertures and assigned the species to the genus *Globotruncana*, subgenus *Ticinella*. This subgenus was then raised to genus rank by Sigal (1952). Reichel refigured the species and his figures (1949, textfig. 1, pl. 16, fig. 1, pl. 17, fig. 1; textfig. 1 copied here: pl. 2, figs. 43-45) are still about the finest that have been published.

Clearly visible is the characteristic arrangement of the chambers of the last whorl, each occupying an arc segment of almost exactly 45^0. This same arrangement is shown in Reichel's figures of *Rotalipora ticinensis* var. *alpha* (= *Rotalipora ticinensis subticinensis* Gandolfi) and *Rotalipora ticinensis* (1949, pl. XVI, figs. 2, 3, pl. XVII, figs. 2, 3).

Reichel (1949, p. 601, 602) finally supports Gandolfi's view that the *ticinensis* group has evolved from *roberti* "comme l'a supposé Gandolfi (avec de bonnes raisons)".

Moullade (1966, p. 99, 100) has examined material from Gandolfi's sample stations 27 and 28 in the Breggia profile and has found that:

1. the *Ticinella's* from the Clansayesian and early Albian of the Vocontian trough are specifically different from *Ticinella roberti* from the late Albian of the Breggia,
2. that *Ticinella praeticinensis* Sigal is very rich in Gandolfi's station 27,
3. that a few specimens of *Ticinella roberti* have been found in "des niveaux vocontiens supra-albiens".

Thus Moullade (1966, p. 100) comes to the conclusion that Gandolfi has included in his description of *"Anomalina" roberti* specimens "peu différenciés de l'actuelle *Ticinella praeticinensis* (par example pl. 4, fig. 6 et 7)" (copied on pl. 2, figs. 37-39, 40-42) and that the two varieties of *"Anomalina" roberti* mentioned by Gandolfi (see translation of Gandolfi's description on p. 37 of this paper) may correspond to the species *roberti* and *praeticinensis.*

Finally Moullade writes that "... ceci expliquerait la filiation *roberti-subticinensis* relatée à tort par Gandolfi" (1966, p. 100). Thus Gandolfi describes the occurrence in sample stations 27 and 28 of one species, *Anomalina roberti*, a few specimens of which ("pochi esemplari") show increased rugosity of internal chambers, while some others ("alcuni altri") show a series of tubercles, forming a pearly keel in the internal whorls.

Although Gandolfi mentions in the text that these specimens with increased rugosities occur in sample 28, the figure supposed to show this feature (pl. 4, fig. 6, copied here, pl. 2, figs.37-39) is made from a specimen purportedly from sample 27.

But notwithstanding this inaccuracy, it is obvious that Gandolfi has meant to describe a number of intraspecific varieties, which link up the species *roberti* with *ticinensis.*

Moullade, after examining faunas from the same samples, comes to the conclusion that *Ticinella praeticinensis* is rich in sample 27, and that Gandolfi's rarely occurring variety of *T. roberti* probably represents the species *praeticinensis*. How it is possible that Gandolfi, who described not one, but two varieties in some detail, did not notice that this same variety occurred richly in sample 27, is not explained by Moullade. Neither does Moullade account for his conclusion that these observations explain why Gandolfi erroneously assumed that the species *roberti* and *ticinensis* were linked by a continuous series of transitional forms. Moullade does believe that *Ticinella praeticinensis* Sigal - thus one of the "varieties" of *Anomalina roberti* described by Gandolfi - is the ancestor of *Rotalipora ticinensis* (Gandolfi). In other words Moullade con-

firms the descent of *Rotalipora ticinensis* from *Anomalina roberti* of Gandolfi's plate 4, figs. 6, 7, (copied, pl. 2, figs. 37-39, 40-42) but he rejects the descent of the specimens represented by these figures from Gandolfi's *Anomalina roberti* from pl. 2, fig. 2 and pl. 4, figs. 4, 5 (copied, pl. 2, figs. 28-30, 31-33, 34-36).

Moullade does not give his reasons for rejecting the ancestry suggested by Gandolfi and supported by Reichel. He simply refers to a manuscript of Sigal of 1964, which was subsequently wholly or partly published (Sigal 1966) but with a different pagination. In this paper Sigal expresses the opinion that the species *praeticinensis* cannot have evolved from *roberti* - or any other known species - since the latter are already " . . . bien fixées dans leur évolution" (Sigal, 1966, p. 195).

We now have to examine Sigal's paper for evidence in favour of the above statement. On page 205 and 206 Sigal states that *T. praeticinensis* is the only *Ticinella* comparable to *T. roberti*. *T. praeticinensis* is however generally smaller and essentially the difference is situated in the ornamentation of the test. The size of *T. roberti* is on the average 0.35-0.45 mm with occasional specimens as large as 0.5 mm, and an average thickness of 0.13-0.16 mm, occasionally as much as 0.20 mm. The diameter of *T. praeticinensis* is usually between 0.35 and 0.40 mm. The ornamentation of *T. roberti* is described as: "des petits mamelons arrondis, plus gros en approchant de la périphérie, où ils se groupent même, dans quelques loges de l'avant dernier tour (mais probablement en est-il de même en remontant le spire), sous forme de protubérances plus grosses et plus irrégulières". (Sigal, 1966, p. 204).

The ornamentation of *T. praeticinensis* is "constituée uniquement par les pustules et papilles, densément réparties sur la face spirale des tours internes et des 3 à 4 premières loges du dernier tour; elles sont peu développées sur la face ombilicale; à la périphérie elles sont plus densément assemblées et souvent plus grosses, simulant une bande carénale, la paroi demeure perforée entre elles". (Sigal, 1966, p. 195). The description of the ornamentation of the two species is, to say the least, not dissimilar and there is little difference between any of these two and Gandolfi's original description as here copied on p. 37. Sigal mentions Gandolfi's figure of *Ticinella roberti* of pl. 4, fig. 7 (copied, pl. 2, figs. 40-42) as depicting a probable *Ticinella praeticinensis*. It is noted that Sigal - as opposed to Moullade - does not consider pl. 4, fig. 6 (copied, pl. 2, figs. 37-39) to represent *T. praeticinensis*. In principle it is of course possible that two species of *Ticinella* have lived just before the onset of the *Rotalipora ticinensis* group, and one of these may have evolved into the *ticinensis* group, whereas the other gave rise to a different stock or became extinct. In Gandolfi's view comparatively few specimens occur in sample stations 27 and 28 of a form, the last whorl of which is characterized by rugosities and/or tubercles, or pustules, or papillae, becoming more frequent towards the periphery, thus simulating the beginning of a peripheral keel. These specimens are classified by Gandolfi under the species *roberti* and have evolved, as shown by his figures (pl. 4, figs. 4-7, here copied as pl. 2, figs. 31-42), from the typical forms, in which the rugosities and papillae and pustules are restricted to previous whorls and therefore largely covered by the last whorl. In Moullade's views, the forms with pustules and papillae occur richly ("se révèle riche", Moullade 1966, p. 99) in sample 27; they probably correspond to the varieties described by Gandolfi and they constitute a species different from and not related to *Ticinella roberti*.

If one compares Moullade's and Sigal's figures (copied: pl. 3, figs. 51-55; pl. 4, figs. 89-91) and descriptions of the two species concerned, with those of Gandolfi, I believe that neither Moullade, nor Sigal have succeeded in either figuring or describing an essential difference between the species *roberti* and *praeticinensis* and that they have not been able to give convincing evidence against Gandolfi's contention that the *ticinensis* group evolves from the species *roberti*.

It is further noted that there is a considerable discrepancy between the ranges of *Ticinella roberti* of Moullade (1966) and of Sigal (1966), as shown on table 1. According to Moullade *Ticinella roberti* occurs only rarely in the Upper Albian of the Vocontian trough, whereas in Sigal's range chart this species is indicated to occur from the Clansayesian up into the Vraconian.

Furthermore *Ticinella roberti* var *bejaouaensis* Sigal occurs according to the author in Clansayesian, Lower Albian and part of Middle Albian strata. Moullade elevates this variety to specific range, and restricts its range to the Clansayesian and part of

the Lower Albian. Moullade (1966, p. 103), as will be subsequently discussed (p. 42), changes Sigal's definition to such an extent, that it does not agree anymore with the original description.

These remarks show clearly that the distinction of species and varieties around the central *roberti* form is apparently quite difficult, since recognized experts as Moullade and Sigal evidently cannot come to an agreement. In similar cases I believe that well-documented original descriptions like those of Gandolfi should not be changed without presenting good illustrations and arguments to support these changes. In the meantime the uncertainties mentioned do postpone a definite biostratigraphic zonation of the Lower Cretaceous. Since I do not dispose of material for comparison I cannot make any suggestions as to how to remedy this situation and would like to leave any further initiative to Moullade and to Sigal. I have the strong conviction, however, that the species *roberti* has been unreasonably suppressed.

(?) *Ticinella raynaudi digitalis' Sigal* 1966
(Pl. 1, figs. 10-12)

1966 *Ticinella raynaudi* var. *digitalis* Sigal, Eclog. Geol. Helv., 59, 202, pl. 6, fig. 6ab-8ab.

The present species corresponds in all respects with Sigal's species (copied: pl. 4, figs. 83-85) except that no trace has been found of the secondary apertures. I do not think that preservation can be held responsible for this deficiency, since the fauna is well preserved. Sigal's variety is the only taxon of this size in the late Albian which shows radially elongated chambers, and it would be a bit too much of a coincidence if in the same stratigraphic interval two species occurred which are almost exactly alike, except that one is a *Ticinella,* the other a *Hedbergella*. Differences in aperture have always been rated highly in classification.

It would seem however that during periods of rapid change, periods of "Typolyse" of "Typogenese" in the nomenclature of Schindewolf (1950, p. 212), a species may exhibit various properties which in other quieter periods serve to distinguish genera. Similar problems have led Sigal (1966) to introduce a new taxonomic conception: the "spectre".

The range, according to Sigal (1966) is "Albian supérieur" and Vraconian.

(?) *Ticinella sp. cf. T. primula* Luterbacher 1963
(Pl. 1, figs. 13-18)

1963 *Ticinella primula* Luterbacher, in Renz, Luterbacher and Schneider, Eclog. Geol. Helv., 56, p. 1085,1086, textfig. 4a-c.

The present species resembles *Ticinella primula* in having only six or seven chambers in the last whorl, by the rather strongly lobate equatorial periphery and especially by its tendency to become planispiral, a feature which is especially evident in side view (pl. 1, fig. 15, 17). Two specimens have been figured, one of which has only six complete chambers in the last whorl, has straight, radial sutures on both sides and has a practically smooth test throughout the last whorl; the other has seven chambers in the last whorl, the dorsal sutures between the first four chambers are not quite radial, and these first four chambers are distinctly rugose, especially at the periphery. Again no distinct indications have been found for the presence of accessorial, sutural apertures. The specimens have been cleaned as well as possible, but no clear apertures were found. If they are present, they must be very small. If, on the other hand, the specimens have no sutural apertures, it would again be quite a coincidence that in this particular stratigraphic interval two taxa occur which are very similar to each other and belong to different genera. There is, moreover, to my knowledge no species of *Hedbergella* which resembles the present species.

Ticinella primula occurs, according to Sigal (1966), throughout the Albian s.s. and possibly in the lower Vraconian.

Remarks on the species of Ticinella

The following species and varieties have been assigned to the genus, or subgenus *Ticinella:*

roberti (Gandolfi) 1942, Reichel 1949
multiloculata (Morrow) 1934, Loeblich & Tappan 1961
gaultina (Morozova) 1948, Subbotina 1953
aprica Loeblich & Tappan 1961
primula Luterbacher 1964
praeticinensis Sigal 1966
roberti var *bejaouaensis* Sigal 1966
raynaudi Sigal 1966

raynaudi var *digitalis* Sigal 1966
raynaudi var *aperta* Sigal 1966
madecassiana Sigal 1966

As far as they were available to me, the figures of the holotypes have been copied in the form of unretouched line drawings and magnified or reduced to the same scale, so as to enable comparison of their essential features. In addition figures of hypotypes which are discussed have been figured in the same way. It should be noted that pores and pustules have not been copied. These have not been omitted, because they are considered to be inessential, but because in most figures they are too indistinct, or only schematically indicated and cannot be used for comparison. On the other hand the pustules of the *roberti* group as figured by Gandolfi have been copied, since they play an important part in the discussion of that species.

Ticinella roberti (Gandolfi) 1942

This species has already been discussed.

Ticinella multiloculata (Morrow) 1934

1934 *Globorotalia? multiloculata* Morrow, Journ.Pal., 8. (2), 200, pl. 31, fig. 3a-b, 5-a-b.

Morrow described this species from the Hartland Shale Member of the Greenhorn Limestone Formation of Kansas, which is thought to be of Late Cenomanian age (Cobban and Reeside, 1952). The species is associated with Morrow's species *cushmani* and *greenhornensis*. Morrow's holotype has been copied here. (pl. 3, figs. 61-62) Brönnimann and Brown (1955, p. 534) have redescribed and refigured the holotype. Their figure has again been copied here (pl. 3, figs. 65-67). These authors claim that Gandolfi's species *Globotruncana ticinensis var. alpha*, subsequently renamed *ticinensis subticinensis* by Gandolfi (1957) and variously assigned to the genera *Globotruncana (Thalmanninella), Thalmanninella* or *Rotalipora,* is a synonym of *Thalmanninella multiloculata* (Morrow). There is however a serious discrepancy between the stratigraphic ranges of Morrow's and Gandolfi's species. The former is described from the late Cenomanian and reported to be associated with such species as *Praeglobotruncana stephani* (Gandolfi) and *Rotalipora cushmani* (Morrow).

Gandolfi's *Rotalipora ticinensis subticinensis* on the other hand occurs typically in the late Albian and does not range much above the base of *Rotalipora appenninica,* a level which according to the latest data (Cotillon, Moullade and Porthault 1965, Moullade 1965) is placed well below the base of the Cenomanian. I know of no range chart in which the *ticinensis* group and *Rotalipora cushmani* are indicated to occur in the same samples and, speaking from experience, would consider it most unlikely that the *ticinensis* group of species persisted in the United States till the late Cenomanian, whereas elsewhere it had become extinct just before or possibly slightly after the beginning of the Cenomanian. I submit therefore that either the Hartland Shale is considerably older than late Cenomanian, in which case Morrow's species *cushmani* cannot be the same as *Rotalipora cushmani* of subsequent authors, or the Hartland Shale is of Cenomanian age, but then Morrow's species *multiloculata* cannot be identical with *Rotalipora ticinensis subticinensis,* unless of course the Hartland Shale fauna is partly redeposited.

Subsequently Loeblich & Tappan (1961) describe and figure *Ticinella multiloculata* (Morrow) from the Hartland Shale Member and in both description and figure, the chambers are described as globular and non-keeled. Their figure has also been copied (pl. 4, figs. 68-70). Morrow, in her original description (1934, p. 200) mentioned "a suggestion of a development of the keeled periphery of *Globorotalia*". Brönnimann and Brown too (1955, p. 534) state: "Some but not all later chambers exhibit a faint to strong, single-keeled, imperforate, peripheral band", and in their figure (see our copy, pl. 3, fig. 66) this keel is clearly shown.

Klaus (1959) and Caron (1967) have described and figured a species which they call *Rotalipora (Thalmanninella) multiloculata* (Morrow), which has a very pronounced keel at least in the earlier chambers of the last whorl and "un bourrelet périombilical sur le coté ventral" (Klaus, 1959, p. 804). This latter feature is neither mentioned nor figured by previous authors. According to Klaus' range chart (Klaus 1959, p. 840) his *multiloculata* becomes extinct (c.q. disappears) just above the base of the Cenomanian, considerably below the first appearance of *Rotalipora cushmani*. The sam-

ples studied by Caron neither range higher, so there is as yet no evidence that her species ranges up into the interval where *Rotalipora cushmani* appears.

Moullade (1966, p. 106) includes Klaus' reference in the synonymy of *Rotalipora ticinensis*.

Sigal (1966, p. 207) finally suggests that some of the references to Morrow's species may be synonymous to his *Ticinella roberti* var. *bejaouaensis*. He realized that although morphologically the two forms are very similar, one is a late Cenomanian, and the other an early Albien species.

The above discussion may be summarized as follows:

1. Morrow's species *multiloculata* occurs together with her species *cushmani* and *greenhornensis* in beds reported to be of late Cenomanian age.
2. Subsequent authors have identified forms of the *Rotalipora ticinensis* group with Morrow's species. This identification is most doubtful, since according to most authors the *ticinensis* group becomes extinct just after the Cenomanian, and the species *multiloculata* does not appear until the later part of the Cenomanian.
3. Loeblich and Tappan's *Ticinella multiloculata* differs from all other references to Morrow's species in being non-keeled.
4. Brönnimann and Brown's figure of the holotype of Morrow's species is quite different from the species figured by Loeblich and Tappan.

At the present moment it can only be recommended that the species *multiloculata* be not used and that the original type material be restudied and accurately described and figured. Any further suggestions would only add to the confusion.

Ticinella gaultina (Morozova) 1948

According to Subbotina (1953, p. 167-170) this species from the Albian of the Kaukasus (copied, pl. 4, figs. 71-73) belongs to the genus *Ticinella*. Maslakova (1963) places it in the synonymy of *Hedbergella planispira* (Tappan). Sigal (1966, p. 209) also considers this species to belong to the genus *Hedbergella* and gives his reasons for this conclusion. The present author quite agrees with Sigal's arguments. However, there may be some doubt as to the validity of the genus *Ticinella* (see p. 40).

Ticinella aprica Loeblich and Tappan 1961

Sigal (1966, p. 208) claims that this species, the original figure of which is copied on pl. 4, figs. 74-76, is not a *Ticinella* but a *Hedbergella,* since it has no true accessory apertures. Extensive lamellar expansions leave some residual openings which are however no true accessory apertures. These latter should be openings in the proximal, posterior end of the umbilical chamber wall, covered by an extensive, tunnel-shaped, imperforate lip, as beautifully illustrated by Caron (1967, p. 73, fig. 21). I agree with Sigal that the original figures of this species suggest a *Hedbergella* rather than *Ticinella*. Loeblich and Tappan's species has been described from the Eagleford Group, which is usually considered to be of late Cenomanian to Turonian age.

Ticinella roberti var. bejaouaensis Sigal 1966

Sigal (1966, p. 207) states that the variety (original copied: pl. 3, figs 56-58) differs from the species in the following respects: the number of chambers in the last whorl is about nine, thus higher than in the species; the wall of the chambers is more rugose; the last half whorl (delimited by a line from the base of the last chamber through the proloculum) has more than 4.5 chambers; the variety is more loosely coiled dorsally.

Moullade (1966, p. 103, p. 100) has raised the variety to species rank, but at the same time has given quite a different interpretation of Sigal's variety, which he considers to be simply a senile form of the species, and only characterized by a slightly larger number of chambers. According to Moullade these late Aptian (Clansayesian) and early Albian Ticinella's belong to one species - *bejaouaensis* - which has evolved from *Hedbergella trocoidea* (Gandolfi) and is specifically different from *Ticinella roberti* (Gandolfi). Thus all Aptain/early Albian Ticinella's belong to the species *bejaouaensis*, whereas a different species, *roberti*, is restricted to the late Albian. Moullade's *Ticinella bejaouensis* thus comprises Sigal's *Ticinella roberti* - so far as it occurs in the Aptain and early Albian - as well as Sigal's variety *bejaouaensis*. Even if Moullade is right, I think that it is incorrect to maintain the name *bejaouaensis* and use it in a sense completely different from that of the original author.

The differences between *Ticinella bejaouaensis* Moullade, non Sigal and *Ticinella roberti* (Gandolfi)

as interpreted by Moullade are (M o u l l a d e 1966), p. 100)

1. *Ticinella roberti* has a thicker test.
2. *Ticinella roberti* has more globular chambers, slightly broader in lateral view.
3. The texture of the test as well as the pores of *Ticinella roberti* are coarser, reminding one of "*Globigerinelloides*" *breggiensis*.
4. The umbilicus of *Ticinella roberti* is deeper, more abrupt and smaller.
5. The lamellar expansions of *Ticinella roberti* are not so strongly developed.
6. The supplementary apertures of *Ticinella roberti* are more nearly "rotaliporaform", like those of *Rotalipora ticinensis* or of *Rotalipora appenninica*.
7. In *Ticinella roberti* there is far less difference between the degree of ornamentation of the last and the first chambers of the last whorl than this is in *Ticinella bejaouaensis*.

Moullade's illustrations of *Ticinella bejaouaensis* and *Ticinella roberti* have been copied here (pl. 3, figs. 59, 60 and pl. 2, figs. 46, 47). If one compares these figures with the copy of the holotype and tries to locate the presumably diagnostic differences listed above, it will be clear that either the figures are inadequate, or the differences are very difficult to detect. In any case they are chiefly differences of degree, which will make the distinction of the species very difficult indeed and lead to confusion instead of enlightenment. A similar situation may lead to distinction of species on the base of stratigraphic position, which is the exact opposite of the intention of William Smith.

Ticinella primula Luterbacher 1964

The restricted number of chambers, the relatively thin test in side view, the lack of ornament, but especially the pseudoplanispiral mode of coiling serve to distinguish this species - of which the figure of the holotype has been copied (pl. 4, figs. 77-79) - from other Ticinella's.

Ticinella praeticinensis Sigal 1966

In his description Sigal states that the present species (figure of holotype copied: pl. 3, figs. 51-53) differs from *Rotalipora ticinensis subticinensis* in having a strong development of "pustules et papilles" in place of a keel. As mentioned before, Sigal places one of Gandolfi's figures of *Ticinella roberti* (pl. 4, fig. 7; copied here: pl. 2, figs. 40-42) in the synonymy of this species. Sigal does not discuss the differences between the present species and *Ticinella roberti*, although he mentions that certain smaller forms of *Ticinella roberti* var *bejaouaensis* approach *Ticinella praeticinensis*. The variety *bejaouaensis* however lacks the pseudo-keel. I do not think that Sigal has proved his statement that the present species has not evolved from *Ticinella roberti* or *Ticinella primula*, which were "déja bien fixées dans leur évolution".

M o u l l a d e (1966) states that Sigal has described forms which are already considerably evolved and in accordance with this statement he includes one more figure of Gandolfi's morphogenetic series (1943, pl. IV, fig. 6; copied here: pl. 2, fig. 37-39) in the synonymy of this species. For a further discussion of the validity of the present species, the reader is referred to p. 38-39.

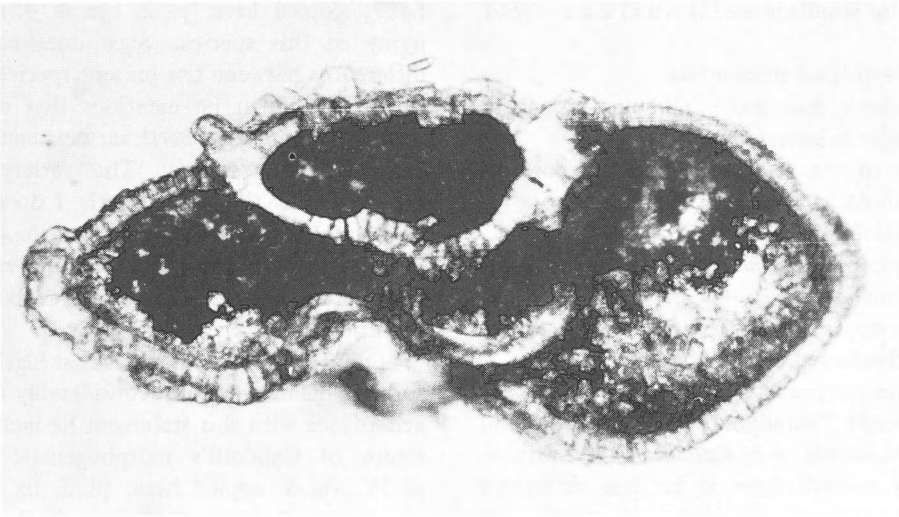
Moullade further states that the species *praeticinensis*, *ticinensis subticinensis* and *ticinensis ticinensis* are man-made, artificial subdivisions of a continuous series of forms. Moullade suggests to drop the variety *ticinensis subticinensis*, which is "particulièrement instable, fugace". According to the various descriptions the differences between the three forms would be as follows:

Ticinella praeticinensis has pustules and papillae on the periphery suggesting a keel, but presumably this is no true keel consisting of imperforate shell material, although this has not been investigated, as far as I know.

Rotalipora ticinensis subticinensis has a true keel - that is an imperforate keel in cross section (textfig. 1) – which is restricted to the first chambers of the last whorl. *Rotalipora ticinensis ticinensis* finally has an imperforate keel extending over all chambers of the last whorl.

These differences are clear; either there is an imperforate keel or not, and if there is one, it either persists till the last chamber of the last whorl or it does not. Thus the keel evidently first appears in the youthful stages and in time gradually expands over the adult organism. Further investigation of this phenomenon may yield new data as to the much debated ancestry of the *ticinensis* group.

Moullade's other argument that the two subspecies of *Rotalipora ticinensis* both occupy nearly the same stratigraphic interval, hardly seems to hold water, considering the fact that in two sections the base of



Textfig. 1
Rotalipora ticinensis subticinensis Gandolfi. Section showing imperforate "keel" in early part of last whorl. x 280

praeticinensis is also only ±16 m (Moullade 1966, fig. 19) and ± 9 m (Moullade 1966, fig. 18) below the base of *ticinensis*, in a sequence in which the interval from the base of the Albian to the base of the Cenomanian is at least 270 m thick. In principle however, I agree with Moullade, that the main yardstick for the recognition of species and subspecies should be their stratigraphie usefulness.

Ticinella raynaudi Sigal 1966

The author mentions that four varieties occur, two of which have been named: *raynaudi* var *aperta* and *raynaudi* var *digitalis*. The species *raynaudi* (copied: pl. 4, figs. 80-82) and its varieties are distinguished from other species of *Ticinella* by being more compressed axially than most other species, with the exception of *Ticinella primula* and possibly *Ticinella praeticinensis*. However, *Ticinella primula* is more planispiral and *Ticinella praeticinensis* has a pseudokeel.

The variety *digitalis* (copied: pl. 4, figs. 83-85) is easily distinguished from all other species of *Ticinella* by its radially elongated chambers. The variety *aperta* (copied: pl. 4, figs. 86-88) has fewer chambers than the species, which grow more rapidly in size as added. Of the two unnamed varieties one stands between the species and the variety *aperta* and the other is distinguished by having at least 9 chambers in the final whorl.

Ticinella madecassiana Sigal 1966

This species (copied: pl. 3, figs. 48-50) has only 6 to 7 chambers in the last whorl, but is much stouter than *Ticinella raynaudi aperta* or *Ticinella primula*, which are the only other Ticinella's having a similar number of chambers in the last whorl.

Rotalipora ticinensis subticinensis (Gandolfi) 1957
(Pl. 1, figs. 7-9)

1942 *Globotruncana ticinensis* var *alpha*, Gandolfi, Riv. Ital. Pal., 48, p. 113, pl. 2, figs. 4a-c; pl. 4, fig. 8, 9, 21, 22; pl. 5, fig. 3, pl. 11, fig. 5; pl. 13, fig. 9, 19.
1957 *Globotruncana (Thalmanninella) ticinensis subticinensis* Gandolfi, Gandolfi, Contrib. Cushman Found. Foram. Res., 8, (2), p. 59, pl. 8, fig. 1. For further synonymies see Brönnimann and Brown, 1955.

(Holotype copied: pl. 5, figs. 92-94)

Trochospiral, 8 chambers in the last whorl. In side view, the periphery is broadly rounded, but chambers are distinctly flattened on the umbilical side. The equatorial periphery is subcircular, somewhat lobulate. Ventrally the eight chambers each typically occupy a 45° arc segment, with the exception of the first chamber of the last whorl, which takes up less, and the last chamber, which takes up more than 45°, the two together still occupying approximately 90°. The wall surface is coarsely porous, quite similar, in

fact to the pore pattern in *Ticinella roberti*. Ventral sutures are radial, straight, depressed. The dorsal side is slightly convex, the spiral suture is flush with the surface, but becomes slightly depressed in the latest third of the last whorl. The intercameral dorsal sutures are approximately radial and straight. At the proximal end they are practically flush with the surface but they become depressed distally, as clearly shown by the lobulate appearance of the equatorial profile. The "umbilicus" is deep and steep-walled. The main aperture is a high arch and extends from the umbilicus nearly to the periphery. It is provided with a thin lip, which may be a remnant of a larger structure. Secondary openings into the posterior side of the chambers are visible on the last few chambers. They are furnished with narrow lips, which may also be remnants of erstwhile larger structures. The keel consists of a concentration of pustules superimposed upon an imperforate wall, as shown on textfig. 1. In the discussion of *Ticinella praeticinensis* it has been mentioned that the present subspecies has been maintained in spite of Moullade's objections.

It differs from *Rotalipora ticinensis ticinensis* in having the keel restricted to the first few chambers of the last whorl, while it differs from *Ticinella praeticinensis* or *Ticinella roberti* in having a true, imperforate keel and in having the chambers flattened at the ventral side, lending a lenticular habit to the subspecies, where *Ticinella praeticinensis* is planoconvex.

Biticinella breggiensis (Gandolfi) 1942
(Pl. 1, figs. 4-6)

1942 *Anomalina breggiensis* Gandolfi, Riv.Ital.Pal., 48, p. 102, 103, pl. 3, fig. 6; pl. 5, fig. 3; pl. 9, fig. 1; pl. 13, fig. 7, 8; textfig. 34 (1-4).

(Holotype copied: pl. 5, figs. 95-97)

Only two specimens were encountered. The main aperture is obscured. Sutural apertures are visible on both sides. Both specimens are clearly planispiral. I agree with Sigal that the secondary apertures so typical for *Ticinella* and the often observed asymmetry speak for a separate genus, different from *Globigerinelloides*.

Hedbergella sp. cf. *H. planispira* (Tappan) 1940
(pl. 1, fig. 25-27)

Six chambers in the last whorl. Chambers nearly globular, increasing rapidly in size as added. Equatorial periphery strongly lobate. Ventral side slightly concave; ventral sutures straight, radial, depressed. Umbilicus relatively narrow as usual in the genus. Aperture a rather high arch extending from the umbilicus to just below the periphery.

Remnants of a lip are attached to the aperture and are also visible on the umbilical margin of previous chambers. Spiral side almost flat, sutures straight, varying between almost radial to nearly rangential. Axial periphery broadly rounded. Wall finely perforate, smooth. Largest diameter 0.240 mm.

It has lately become very difficult to determine the species of the genus *Hedbergella*. The smaller specimens are habitually assigned to the species *infracretacea* Glaessner or *planispira* Tappan, often preceded by cf., aff. or a query. The former species (holotype copied: pl. 5, figs. 101, 102) is usually shown with 5 or 6 chambers which increase fairly rapidly in size as added, the latter (holotype copied: pl. 5, figs. 98-100) has usually more chambers which increase very little in size in the last whorl. On these criteria, our specimens could be assigned to *Hedbergella infracretacea* (Glaessner). However, Glaessner (1966) has recently figured topotypes of his species (copied pl. 5, figs. 103-105). They appear to be small (up to 0.230 mm), stout, five-chambered specimens from an Albian clay in the North Caucasus. The chambers are largest in the axial direction. Glaessner explicitly states that the species *infracretacea* is "distinguishable by small size" from *Hedbergella delrioensis* (Carsey), which it resembles in general shape. Glaessner's figures differ considerably from our specimens, which have six, spherical chambers and which are moreover much more slender in axial view.

There seems to be agreement that *Hedbergella planispira* (Tappan) is distinguishable from *Hedbergella infracretacea* (Glaessner) by the slower increase in size of successive chambers (Loeblich and Tappan, 1961, p. 276, Moullade, 1966, p. 93, Glaessner, 1966, p. 181). However, in her description of the holotype, Tappan states that chambers are "increasing rapidly in size", which just goes to show the relativity of qualitative statements. *Hedbergella planispira* (Tappan) is also a very small

species, the holotype having a largest diameter of 0.240 mm (Loeblich and Tappan, 1961, p. 276), while the largest specimens range up to 0.260 mm in diameter. Finally Tappan's species has six or seven chambers in the last whorl, chambers which are nearly spherical. Our specimens differ from *Hedbergella planispira* by the relatively fast increase of the size of the chambers as they are added. I am not sure how variable Tappan's species is and possibly our specimens are intraspecific variants, which have no stratigraphic significance. Loeblich and Tappan's figures (1961, pl. 5, fig. 4-11) of Tappan's species show considerable differences. The specimen figured from the Blake Plateau core (fig. 11, copied pl. 5, figs. 109-111), although smaller, is very similar to the specimens of *Hedbergella trocoidea* (Gandolfi) from the same submarine core figured by the same authors (Loeblich and Tappan, 1961, pl. 5, fig. 1, 2, fig. 2 copied: pl. 5, figs. 115-117). A much more slender form is that pictured by Loeblich and Tappan from the Eagle Ford (Loeblich and Tappan, 1961, pl. 5, fig. 4-6, 9-10). The specimens from figures 9 and 10 have 7 chambers in the last whorl and the chambers are nearly spherical, with the exception of the last chamber of the specimen of figure 9, which on the dorsal side seems to be tangentially elongated. Figure 5 also shows a specimen with nearly spherical chambers, but figures 4 and 6 show specimens in which at least the chambers of the last whorl are clearly tangentially elongated, and which consequently have only 5 or 5.5 chambers in the last whorl. Of the topotypes from the Grayson Formation, figure 8 (copied here: pl. 5, figs. 112-114) again shows a rather stout specimen similar to that from the submarine core. It is possible that these different forms are variants which have no stratigraphic value. I have not enough material to investigate this. It may be useful though, to verify the range of some of these variations and see whether they are stratigraphically restricted.

Hedbergella sp. aff. *H. infracretacea* (Glaessner)
(pl. 1 fig. 19-24)

Four and a half to nearly five chambers in the last whorl. The tangential diameter of most chambers is larger than the radial diameter. The last three or four chambers increase little in size. The dorsal side is very slightly convex. Dorsal sutures are usually straight, although curved sutures also occur (pl. 1, fig. 19, suture between second and third chambers of the last whorl). The sutures of the smaller specimen (pl. 1, fig. 19-21) are tangential or nearly so, although here too, exceptions are found. In the larger specimen the dorsal sutures remain practically radial. Ventral side is flat to slightly concave; the ventral sutures are straight, radial. The aperture is an interiomarginal, umbilical-extraumbilical slit. Wall smooth, finely perforate.

The present species differs from *Hedbergella sp.* cf. *H. planispira* (Tappan) in having consistently less chambers in the last whorl, while moreover the chambers in the last whorl grow more slowly in size as added. The differences are however slight.

Hedbergella delrioensis (Carsey) as figured by Loeblich and Tappan (1961, pl. 2, fig. 13; copied: pl. 6, figs. 136-138), Moullade (1966, pl. 8, fig. 17; copied: pl. 6, fig. 142) and by Jones (1960, pl. 15, fig. 1-9, under the name of *Praeglobotruncana gautierensis;* fig. 1, copied: pl. 5, figs. 130-132) differs in being somewhat more lobulate and in lacking the tendency to form tangentially elongated chambers, bordered by nearly tangential sutures. Loeblich and Tappan's figures of the topotypes (1961, pl. 2, fig. 11, 12; fig. 11 copied: pl. 6, figs. 133-135) are more similar to our species in side view, but the axial view shows the species from Texas to be much stouter.

The topotypes of *Hedbergella infracretacea* (Glaessner) as figured by Glaessner (1966, pl. 1, fig. 1-3; partly copied, pl. 5, figs. 103-105) also show a much stouter species than ours. In fact, although they are twice as big, the topotypes of *Hedbergella delrioensis* as figured by Loeblich and Tappan (1961, pl. 2, fig. 11, 12; fig. 11 copied: pl. 6, figs. 133-135) are very similar to Glaessner's species except for the difference in size. Glaessner (1966, p. 181) mentions two other differences between his species and *Hedbergella delrioensis*, but expresses as his opinion that after further investigation *infracretacea* from 1937 may be found to be a chronosubspecies of *delrioensis* from 1926.

There are many other references to Glaessner's species, but the accompanying figures usually little resemble the topotype. In our case the affinity to the species from Russia is based mainly on the small size and the small number of chambers in the last whorl; comparison with the topotype figure, however, seems

to preclude specific identity.

Remarks on the Cenomanian and older species of Hedbergella

The following species from Cenomanian and older beds may belong to the genus *Hedbergella*, or have been assigned to it.

delrioensis Carsey 1926
washitensis Carsey 1926
seminolensis Harlton 1927
infracretacea Glaessner 1937
planispira Tappan 1940
trocoida Gandolfi 1942
almadenensis Cushman and Todd 1948
portsdownensis Williams-Mitchell 1948
globigerinelloides Subbotina 1949
gautierensis Brönnimann 1952
paradubia Sigal 1952
kelleri Subbotina 1953
simplicissimus Magné and Sigal 1954
youngi Fox 1954
crassa Bolli 1959
modesta Bolli 1959
rohri Bolli 1959
amabilis Loeblich and Tappan 1961
brittonensis Loeblich and Tappan 1961
hiltermanni Loeblich and Tappan 1961
infracretacea gargasiana Moullade 1961
aptiana Bartenstein 1965
sigali Moullade 1966
aptica Agalarova ?
caspia (Vassilenko)?

Hedbergella delrioensis (Carsey) 1926

This species from the Del Rio Clay of Cenomanian age (Loeblich and Tappan 1961, p. 278) has had a rather complicated history. It was originally described by Carsey as a variety of *Globigerina cretacea* d'Orbigny, but she did not figure it. The name *delrioensis* does not reappear until 1954 when Carsey's variety is given species rank and figured for the first time by Frizzell (1954, p. 127, pl. 20, fig. 1; copied: pl. 5, figs. 118-120). Frizzell actually copied Tappan's figure of *Globigerina cretacea* (1943, pl. 82, fig. 16) from the Albian Duck Creek Formation. This taxon was placed in the synonymy of *Globigerina delrioensis* together with Tappan's *Globigerina cretacea* from the Cenomanian Grayson Formation (Tappan, 1940) and a species described by Brönnimann as *Globigerina gautierensis* (Brönnimann 1952, p. 11). Brönnimann figures a trochoidal species, but the aperture is peripheral, symmetrical in axial view, "almost that of *Globigerinella*". Six figures show the same axial view. Brönnimann has twice figured the holotype (1952, textfig. 2a-c, copied: pl. 5, figs. 121-123 and pl. 1, figs. 1-3; copied: pl. 5, figs. 124-126), but the two figures are quite dissimilar. Neither of these two figures show the aperture. Textfigures 2e, 2f and 2i, however, clearly show the aperture to be almost symmetrical and astride the periphery. It is rather surprising that subsequently Bolli (1959), and Jones (1960) record *Praeglobotruncana gautierensis* (Brönnimann) and figure specimens with clearly asymmetrical umbilical-extraumbilical aperture, completely different from those in Brönnimann's figures. It should be noted that Tappan's figure and Frizzell's copy also seem to show a peripheral aperture. In the text however Tappan (1943, p. 512) clearly indicates that the aperture extends into the "umbilical area".

Loeblich and Tappan (1961) also include *Globigerina gautierensis* Brönnimann in the synonymy of *Hedbergella delrioensis*. Their figure of *Hedbergella delrioensis* of the Del Rio Formation (copied: pl. 6, figs. 133-135) is very similar to Glaessner's figures of the topotype of *infracretacea*, although the latter species is twice as small. The specimens from the Grayson Formation (copied pl. 6, figs. 136-138) seem to have much more globular chambers. This latter form is very similar to Moullade's figure of *Hedbergella delrioensis* (Carsey) (1966, p. 94, pl. 8, fig. 17, copied, pl. 6, fig. 142). The species figured by Bolli as *Praeglobotruncana* cf. *gautierensis* (1959, p. 266, pl. 21, fig. 7, 8, copied pl. 6, figs. 143-146) is a five-chambered form, somewhat similar to Carsey's species. A subsequent record of Carsey's species by Takayanagi and Iwamoto (1962, p. 160, pl. 28, fig. 10-12, partly copied, pl. 6, figs. 139-141) shows one specimen (fig. 10) rather similar to Brönnimann's holotypes of his species *gautierensis*.

It is evident that *Hedbergella delrioensis* is not unlike *Hedbergella infracretacea*, as already suggested by Glaessner. It is equally evident that reexamination of the species of Hedbergella is required.

Hedbergella washitensis (Carsey) 1926

(Holotype copied, pl. 7, figs. 175-176)

This is a usually four-chambered species, originally described from the Del Rio Clay, a Formation which according to Loeblich and Tappan (1961, p. 278) is of Cenomanian age. It is characterized by a reticulate wall pattern. The chamber walls of *Hedbergella hiltermanni* also show a reticulate pattern, but this is considerably coarser than that of the present species.

Hedbergella (?) *seminolensis* (Harlton)

(Holotype copied, pl. 8, figs. 198, 199)

This species was described as *Globigerina seminolensis* from the Pennsylvanian. The correctness of this designation was repeatedly questioned. Brönnimann and Brown (1955, p. 529-530) mention that the Cretaceous Comanchean Formation crops out in the general area of the reported locality of Harlton's species, which they designate the type of their new Cretaceous genus *Hedbergina*. Bolli, Loeblich and Tappan (1957, p. 39, 40) reexamined Harlton's material and found it to consist of a single, poorly preserved specimen, the holotype, which they refigure (1957, pl. 9, fig. 4) and which they consider to be specifically different from the species described and figured by Brönnimann and Brown as *Hedbergina seminolensis* (Harlton) from Cuba. Subsequently Brönnimann and Brown (1958) report that the species which they had figured from Cuba does not agree with Harlton's species *seminolensis* and that consequently their genus *Hedbergina* becomes invalid. They instate a new genus, *Hedbergella*, with Gandolfi's species *trocoidea* as the genotype. Banner and Blow (1959, p. 15) voice their intention to apply for *Globigerina seminolensis* Harlton to be considered nomen dubium. Loeblich and Tappan (1961, p. 277) place Harlton's species in the synonymy of *Hedbergella trocoidea* (Gandolfi).

Hedbergella infracretacea (Glaessner) 1937

(Holotype copied, pl. 5, figs. 101, 102)

This species has already been discussed. It should be noted that the original figures are hardly adequate and that references to Glaessner's species prior to 1966 should be viewed with doubt. The figures of the topotypes are excellent, however. Glaessner himself has expressed the opinion that further investigation may show that his species is a chronosubspecies of *Hedbergella delrioensis*.

Hedbergella planispira (Tappan)

This species has already been discussed.

Hedbergella trocoidea (Gandolfi) 1942

Gandolfi first described *Anomalina lorneiana* d'Orbigny var. *trocoidea*, but did not specify a holotype. Brönnimann and Brown (1958, p. 16) subsequently raised the variety to species rank, made it the type species of their genus *Hedbergella* and designated a specimen figured by Gandolfi (1942, pl. 2, figs. 1a-c; copied here, pl. 8, figs. 200-202) as lectotype.

This is a rather stout species with 7 to 9 chambers in the last whorl. As already mentioned, Gandolfi believes it to be the ancestral form of *Ticinella roberti*, a relation which is strongly suggested by the strong similarity in the arrangement of the chambers, which in the average form occupy each an arc segment of practically 45°. Both the axial and the radial diameter of the chambers seems to be larger than the tangential diameter. Gandolfi does not specify its range.

Loeblich and Tappan's figures of this species (1961, pl. 5, fig. 1, 2, partly copied: pl. 5, figs. 115-117) are rather similar in general shape, but the specimens show only 7 chambers in the last whorl; in their description, Loeblich and Tappan (1961, p. 277) state that the last whorl consists of 6 or 7 chambers. These specimens come from a submarine core from the Blake Plateau and the fauna of this core is mentioned to be of Cenomanian age. Since *Rotalipora greenhornensis* (Morrow) is also reported by Loeblich and Tappan from the same core, it may be assumed that it is of post-Albian age. Unless therefore the core contains redeposited specimens, Loeblich and Tappan's *Hedbergella trocoidea* occurs in the Cenomanian. It may be mentioned in this connection that both Sigal (1966, p. 210) and Moullade (1966, fig. 19, p. 248) did not find *Hedbergella trocoidea* above the top of the Albian. This is the opinion of most authors, an exception being Klaus (1959), but his figures of *Hedbergella trocoidea* do not resemble those of Gandolfi's species, an opinion already brought forth by Moullade (1966, p. 90, 92, 93).

Hedbergella almadenensis (Cushman and Todd) 1948

(Holotype copied, pl. 8, figs. 190, 191)

This species was originally described from the Cenomanian of California as *Globigerina almadenensis* and has been placed among others by Loeblich and Tappan (1961, p. 277) in the synonymy of *Hedbergella trocoidea* (Gandolfi).

Hedbergella portsdownensis (Williams-Mitchell) 1948

As figured and described by Williams-Mitchell (1948, p. 96, pl. 8, fig. 4, copied here: pl. 7, fig. 166-168) this rather nondescript species consists of spherical chambers, of which there are 4.5 in the last whorl. The last chamber "appearing to be almost detached in the adult stage . . ." The wall is perforate and cancellate and the aperture is "small and indistinct, opening into the umbilicus". Williams-Mitchell states that this species is confined to the Cenomanian. On his range chart it can be clearly seen that the species does not occur above the top of the Cenomanian. The Albian was however not included in the investigation, and it is not definitely established therefore, that the species does not occur in the Albian. Loeblich and Tappan (1961, p. 277, pl. 5, fig. 3) record and figure a very similar form from the Cenomanian of Germany. Apertural characters of this form indicate the genus *Hedbergella*. The species is characterized by having relatively few chambers per whorl (less than 6), spherical chambers, and, apparently, an "abnormal" last chamber, which does not conform to the arrangement as shown by previous chambers; the latter, a rather doubtful characteristic.

Hedbergella globigerinelloides (Subbotina) 1949

(Holotype copied, pl. 7, figs. 182-184)

This species was placed in the synonymy of *Hedbergella planispira* (Tappan) by Loeblich and Tappan (1961, p. 276), and subsequently by Maslakova (1963, p. 114). It certainly falls within the range of variation displayed by the various specimens figured as *Hedbergella planispira* by Loeblich and Tappan. According to Subbotina (1953, p. 61) it has been found in beds of Aptian to early Cenomanian age.

Hedbergella gautierensis (Brönnimann) 1952

This species was originally described as *Globigerina* from the *Globotruncana appenninica* Zone in Trinidad. It has already been mentioned that in axial view the original species is practically symmetrical, whereas forms subsequently referred to this species are usually asymmetrical (Bolli, 1959, p. 264, pl. 21, fig. 3-6, fig. 3 copied: pl. 5, figs. . 127-129; Jones 1960, p. 102, pl. 15, fig. 1-7, partly copied: pl. 5, figs. 130-132). Bolli (1959, p. 265) states that "better preserved material shows that the forms described by Brönnimann as *Globigerina gautierensis* and *Globigerina cretacea* possess distinctly interiomarginal, umbilical-extraumbilical apertures . . .". He further claims that "Typical *P. gautierensis* has six-seven chambers in the last whorl". Of the five specimens figured by Brönnimann, however, none has more than 5,5 chambers in the last whorl. Bolli's figures of *"Praeglobotruncana" gautierensis* have subsequently been assigned to *Hedbergella delrioensis* (Carsey) by Loeblich and Tappan (1961, p. 275). Moullade, (1966, p. 90) on the other hand assigns Bolli's figures 3 and 5 to *Hedbergella trocoidea* (Gandolfi). *"Praeglobotruncana" gautierensis* (Brönnimann) of Jones (1960, p. 102) is figured with 5 chambers in the last whorl. Jones' form is very similar to some of the figures of *Hedbergella delrioensis* (Carsey). *Hedbergella gautierensis* (Brönnimann) does not seem to be a clearly defined species. There is doubt whether Bolli's emendation is valid. On the other hand Brönnimann's illustrations with the different figures of the holotype (see p. 47), show indeed rather badly preserved specimens. The species has, as far as I know, only been rarely referred to. Except for the doubtful references already mentioned above (p. 47), the references of Pessagno (1960, p. 98, 1962, p. 358) from the Campanian/Maestrichtien of Puerto Rico may be mentioned. The post-Cenomanian species of *Hedbergella* have not been considered here. Finally Hofker (1961, p. 97, 1963, p. 281, pl. 1, figs. 1, 2) described *"Praeglobotruncana" gautierensis* and cf. *gautierensis* stages within his "gens *Globigerina cretacea*". It is quite possible that Hofker is correct. However, there are objections against the use of the name *Globigerina cretacea* d'Orbigny as Banner and Blow (1960) have shown that this taxon has two keels. Furthermore Hofker gives no clear indications for the distinction of the various species within the "gens *Globigerina cretacea*" and neither discusses the differences with other species of the same genus. *Hedbergella gautierensis* remains therefore one of the

many species of planktonic Foraminifera of which apart from the author's only doubtful references are known. In most cases they are insufficiently figured or described, or the difference with other species is not adequately indicated. This would not matter so much, were it not for the fact that these "species" are sometimes dug out of their natural graves and redescribed and refigured. Other, sometimes well–known and well defined species are then placed in the synonymy of this obscure, resurrected species, thus creating the completely unnecessary complications which make the study of planktonic Foraminifera so forbidding to newcomers.

Hedbergella paradubia (Sigal) 1952

Sigal described this species from the Cenomanian of Algeria as *Globigerina paradubia*. The figure of the holotype has been copied (pl. 8, figs. 187-189). Sigal did not give any details regarding the aperture. However, at present all trochospiral forms from the Cenomanian, which lack a keel and which have no accessory apertures, are assigned to *Hedbergella*. The author compares the species to *Globigerina portsdownensis* Williams-Mitchell. *Hedbergella brittonensis* Loeblich and Tappan is also a related form. These three species are all characterized by the possession of spherical or nearly spherical chambers which increase little in size as they are added, and by a rather strongly trochoid mode of coiling. This latter characteristic is least pronounced in *Hedbergella portsdownensis* where it is mainly due to the anomalous position of the last chamber. If the last chamber of this, as yet rather unsatisfactory species is removed, there remains a form not unlike some of the figures of *Hedbergella delrioensis*, although in most figures of that latter species the chambers increase more rapidly in size as they are added. *Hedbergella paradubia* differs from *Hedbergella brittonensis* in having more chambers in the last whorl; seven, as against the "five to six or rarely seven chambers" recorded by L o e b l i c h and T a p p a n (1961, p. 274).

Hedbergella kelleri (Subbotina) 1953

This species of which the figure of the holotype has been copied (pl. 7, fig. 185, 186), was originally described as *Globigerina elevata* by Keller, from the Campanian of the Kaukasus and further reported from Lower Senonian, Upper Cretaceous, Maestrichtian and Danian and Lower Pliocene in the Russian area, according to S u b b o t i n a (1953, p. 63, 64). It is strongly similar to the figures of *Hedbergella paradubia* (Sigal) from the Cenomanian of Algeria. For this reason this "young" Hedbergella is mentioned here.

Hedbergella simplicissima (Magné and Sigal) 1954

The species from the basal Cenomanian of Tunisia was described as *Hastigerinella*. According to L o e b l i c h and T a p p a n (1961, p. 240) it is a synonym of *Clavihedbergella simplex* (Morrow). This latter species has however much more elongated chambers, as already remarked by M a g n é and S i g a l (1954, p. 487). In my opinion the present species is much more like *Hedbergella amabilis* Loeblich and Tappan, as will be apparent from a comparison of the copies of the figures of the two holotypes (pl. 7, fig. 172-174 and pl. 8, fig. 203-205).

Hedbergella youngi (Fox) 1954

This species from the Cenomanian/Turonian Greenhorn Limestone was placed by L o e b l i c h and T a p p a n (1961, p. 276) in the synonymy of *Hedbergella planispira*. The figure of the holotype and paratypes have been copied (pl. 8, fig. 194-197). As far as I know the name has not been used for a seperate taxon except by the author.

Hedbergella crassa (Bolli) 1959

According to M o u l l a d e this species (the figure of the holotype of this species has been copied, pl. 6, figs. 153-155) is similar to his *Hedbergella (Hedbergella) sp.*, aff.*infracretacea* (Glaessner) (1966, p. 90, pl. 8, fig. 6-16). Although Moullade does not show his specimens in axial view, his figures suggest a much more slender form than Bolli's species, which is very stout. Furthermore Moullade's species finds its main development below, and occurs only doubtfully above, the base of *Rotalipora appenninica* (Renz), whereas Bolli's species from Trinidad makes its appearance well above this level, in what Bolli indicates to be Turonian.

Hedbergella modesta (Bolli) 1959

The figure of the holotype has been copied (pl. 6, figs. 150-152).

According to L o e b l i c h and T a p p a n (1961,

p. 276) this species is a synonym of *Hedbergella planispira* (Tappan). In the same publication in which he introduced his species *modesta*, Bolli described and figures *Hedbergella planispira* (Tappan) (B o l l i, 1959, pl. 22, fig. 3, 4). In this latter form the chambers of the last whorl increase slightly more rapidly in size as they are added and therefore it has half a chamber to one chamber less in the last whorl than Hedbergella modesta. However, as mentioned before, the figures of L o e b l i c h and T a p p a n of *Hedbergella planispira* (1961, pl. 5, fig. 4-11) show considerable variation and may include both Bolli's species *modesta* and the same author's figures of *Hedbergella planispira*. On B o l l i's rangechart (1959, opposite p. 258) *Hedbergella modesta* occurs from the Aptian to the Cenomanian and *Hedbergella planispira* begins immediately after the disappearance of *modesta* in the Turonian.

Hedbergella rohri (Bolli) 1959

The figure of the holotype has been copied here (pl. 6, figs. 147-149).

The species from the Middle Albian Maridale Formation of Trinidad has been placed in the synonymy of *Hedbergella trocoidea* (Gandolfi) by M o u l l a d e (1966, p. 90), and H e r m e s (1966, p. 158). B o l l i's description (1959, p. 267, 268) agrees closely with that of Gandolfi. He remarks that his species "resembles *Rotalipora roberti* (Gandolfi) in general shape and number and arrangement of chambers. It differs, however, from this species in having a narrower umbilicus and in the absence of supplementary sutural apertures". Finally Bolli's and Gandolfi's species occur in the same stratigraphic interval (H e r m e s 1966, p. 158, 159).

Hedbergella amabilis Loeblich and Tappan 1961

The figure of the holotype has been copied here (pl. 7, figs. 172-174).

This species from the Britton Clay of the Eagleford Group in Texas and the Atkinson Formation of the subsurface of Georgia, is characterized by having radially elongated chambers. The elongation is less pronounced however than in the genus *Clavihedbergella*. As already remarked, it is possible that this species is the same as *Hedbergella simplicissima* (Magné and Sigal). If comparison of type material would confirm this opinion, Loeblich and Tappan's species would become a synonym of the species of Magné and Sigal.

Hedbergella brittonensis Loeblich and Tappan 1961

The figure of the holotype has been copied here (pl. 7, figs. 169-171).

The similarity of this species from the Britton Clay of the Eagleford Group of Texas, the Hartland Shale Member of the Greenhorn Limestone of Kansas and the Atkinson Formation of Georgia, to *Hedbergella portsdownensis* and *Hedbergella paradubia* has already been discussed. The present species has five to six spherical chambers in the last whorl and is dorsally strongly convex.

Hedbergella hiltermanni Loeblich and Tappan 1961

The present species and *Hedbergella washitensis* are the only reticulate Hedbergella's so far described. In *Hedbergella hiltermanni* the cancellation is much coarser, however, while moreover elongate ridges develop (L o e b l i c h and T a p p a n, 1961, p. 275). The holotype stems from the Lower Cenomanian of Germany (Ziegelei Zeltberg at Luneberg). Its figure has been copied here (pl. 7, figs. 177-179).

Hedbergella infracretacea gargasiana Moullade 1961

In 1966 the author has withdrawn this subspecies and placed it in the synonymy of *Hedbergella infracretacea* (M o u l l a d e 1966, p. 88, 89).

Hedbergella aptiana Bartenstein 1965.

The figure of the holotype and a paratype have been copied here (pl. 8, figs. 192, 193).

A four to six chambered species from the Middle Barremian to Lower Aptian of Germany which is rather similar to some of the species described as *Hedbergella infracretacea* or aff. *infracretacea*. Further investigation of this as yet little known interval will be necessary to establish the relation between these rather similar forms.

Hedbergella sigali Moullade 1966

Moullade's species of which the figure of the holotype has been copied (pl. 7, figs. 180, 181), has only four chambers in the last whorl. The ventral side of this very characteristic species looks very much like *Globigerinelloides blowi* Bolli. It is recorded from the uppermost Hauterivian, the Barremian and

the Lower Aptian (Bedoulian) of the Vocontian trough in SE France

Hedbergella aptica Agalarova

This species is mentioned by G l a e s s n e r (1966, p. 182) and by M a sl a k o v a (1963, p. 114, 115). I have not seen a figure of it. According to Maslakova it occurs in the Late Aptian and Albian.

Hedbergella caspia (Vassilenko)

M a s l a k o v a (1963, p. 114, 115) reports this species from the Lower Cenomanian, but she does not figure it.

THE AGE OF THE FAUNA

The present fauna agrees with that of the lower part of the *praeticinensis* Subzone of the *breggiensis* Zone of Moullade (1966, figs. 18, 19). In the following table the two faunas are compared.

The last two species recorded by Moullade occur only in the upper part of his *praeticinensis* Subzone. *Ticinella roberti*, which is lacking in Moullade's distribution charts, does occur in our sample. In his text, however, Moullade (1966, p. 100) mentions the occurrence of very rare *Ticinella roberti* from several levels of the Late Albian of the Vocontian trough.

In the discussion of the species *Rotalipora ticinensis subticinensis* I have mentioned Moullade's objections against the distinction of two subspecies of *Rotalipora ticinensis*. The material from the present sample does not lend support to these objections, but on principle I agree with Moullade that stratigraphically there is little sense in distinguishing the two subspecies. For the same reasons, however, I doubt whether it is wise to distinguish the species *praeticinensis* which, in my opinion, may be just another stage between *Ticinella roberti* and *Rotalipora ticinensis*.

The *praeticinensis* Subzone of Moullade occupies the lower portion of his "albien supérieur". This age designation is based on the ammonite fauna which accompanies the Foraminifera in the Vocontian trough. Since at the present moment we do not dispose of other data, which might have a bearing on the age of the sample concerned, we cannot but accept Moullade's age determination.

CONCLUSIONS

It will be noticed that in the foregoing I have refrained as much as possible from suggesting changes in the existing nomenclature. This has been done chiefly because I did not have the opportunity to compare the original types with each other, and in the second place because I believe that the time is near that the nomenclatorial jungle will have extinguished the ambitions of paleontologists and that the planktonic Foraminifera will have become another one of the divisions of the animal kingdom which have not fulfilled the expectations of earlier investigators.

One of the main stumbling blocks is our incapacity to give steadfast rules for the distinction of species or subspecies and since no two shells are ever exactly alike there is practically no limit to the number of species that may be distinguished except perhaps a sense of propriety and the self-restraint of paleontologists. In neontology the possibility to verify if two individuals are able to produce fertile offspring imposes a limit on the number of species but in paleontology this criterion can obviously not be used.

Species which constitute a morphogenetic series,

Present fauna	Fauna of praeticinensis subzone of Moullade (1966, figs. 18, 19
H. sp. cf. *H. planispira* (Tappan)	*H. planispira* (Tappan)
H. sp. aff. *H. infracretacea* (Glaessner)	*H. sp.*, aff. *infracretacea* (Glaessner)
(?) *Ticinella sp.*, cf. *T. primula* Luterbacher	*Ticinella primula* Luterbacher
Biticinella breggiensis (Gandolfi)	*"Globigerinelloides" breggiensis* (Gandolfi)
Ticinella roberti (Gandolfi)	*Ticinella praeticinensis* Sigal
Rotalipora ticinensis subticinensis (Gandolfi)	*Rotalipora ticinensis* (Gandolfi)
(?) *T. raynaudi digitalis* Sigal	*Hedbergella delrioensis* (Carsey)

and thus succeed each other in the course of time, can not be separated on account of phenetic discontinuities. Boundaries between such species are therefore entirely arbitrary. The only criterion that could be used to place limits on the number of taxa that are erected is stratigraphic utility. In order to satisfy this condition, however, a new taxon should not be created unless its development can be studied in a vertical sequence. Usually however, this condition is not fulfilled, and I believe that its fulfilment will remain an illusion for some time to come. As matters stand at this moment one can only hope that paleontologists dealing with planktonic Foraminifera will use the utmost restraint in suggesting new taxa. Only in monographic studies, when all literature and all available material of certain faunal units are examined, the erection of new taxa might be excusable.

Finally a few words have to be said about the introduction of statistical methods in order to satisfy the need for more quantitative criteria for the recognition of species. Most recently statistical methods have been applied in the study of planktonic Foraminifera by Klaus (1960), Berggren and Kurten (1961), Reyment (1961), Caron (1967), Scott (1966, 1967) and Berggren, Olsson and Reyment (1967).

I do not want to enter into a lengthy discussion of the merits of these individual papers, but I would like to point out that they clearly show that the road towards a statistical treatment of planktonic Foraminifera will be a long and difficult one.

The problem of the distinction of taxa is often discussed as if it only concerns the distinction of taxa in one sample. In single samples morphological differences between species are often obvious to the observer. There are cases however where these "species" exhibit considerable variety and here it used to be a matter of the temperament of the investigator whether he "lumped" or "splitted". In these cases statistical treatment does not eliminate the temperament of the investigator since also in statistics one subjectively chooses one's subdivisions or levels of significance. However the stratigraphic usefulness of these subunits can be objectively verified.

This is however only part of the story. Each "species" is not only limited in one sample, but its limits should also be established upwards and downwards. Whereas in each sample, thus practically in a single time-plane, there may be phenetic discontinuities, there is usually no phenetic discontinuity in time, downwards nor upwards. Consequently, in statistical paleontology most vertical boundaries will necessarily be arbitrary. Here, I believe, lies an as yet hardly explored field for statistics. In order to carry out such investigations it will be necessary that samples from rock sequences are investigated in such detail that from each sample to the next higher one the "flow of genes" can be traced. It follows that in order to gain the insight which enables one to establish arbitrary divisions, one has to study closely sampled uninterrupted successions. It will be obvious that all this requires an immense amount of statistical work.

I would like to add, however, that I am convinced that statistical treatment is the only road towards a more exact paleontology and in this connection I feel that students of planktonic Foraminifera owe a debt of gratitude to the above mentioned authors, whose reconnaissance work will help to clear this road.

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PLATE 1

Figs. 1- 3 *Ticinella roberti* (Gandolfi), Ve 568, Represa Formation, SE Spain; 100 x

4- 6 *Biticinella breggiensis* (Gandolfi), Ve 568, Represa Formation, SE Spain; 100 x

7- 9 *Rotalipora ticinensis subticinensis* (Gandolfi), Ve 568, Represa Formation, SE Spain; 100 x

10-12 (?) *Ticinella raynaudi digitalis* Sigal, Ve 568, Represa Formation, SE Spain; 100 x

13-15 (?) *Ticinella sp.* cf. *T. primula* Luterbacher, Ve 568, Represa Formation, SE Spain; 100 x

16-18 (?) *Ticinella sp.* cf. *T. primula* Luterbacher, Ve 568, Represa Formation, SE Spain; 100 x

19-21 *Hedbergella sp.* aff. *H. infracretacea* (Glaessner), Ve 568, Represa Formation, SE Spain; 100 x

22-24 *Hedbergella sp.* aff. *H. infracretacea* (Glaessner), Ve 568, Represa Formation; SE Spain; 100 x

25-27 *Hedbergella sp.* cf. *H. planispira* (Tappan), VE 568, Represa Formation, SE Spain, 100 x

PLATE 2

Figs. 28-30 *Ticinella roberti* (Gandolfi). Copy of figures of holotype of Gandolfi, 1942, pl. II, fig. 2; 75 x

31-33 "*Ticinella roberti* (Gandolfi)". Copy of figures of paratype of Gandolfi, 1942, pl. IV, fig. 4; 75 x
According to Reichel (1949, p. 601), the specimen figured has no accessorial apertures and should thus be assigned to *Hedbergella trocoidea* (Gandolfi)

34-36 *Ticinella roberti* (Gandolfi). Copy of figures of paratype of Gandolfi, 1942, pl. IV, fig. 5; 75 x

37-39 *Ticinella roberti* (Gandolfi). Copy of figures of paratype of Gandolfi, 1942, pl. IV, fig. 6; 75 x

40-42 *Ticinella roberti* (Gandolfi). Copy of figures of paratype of Gandolfi, 1942, pl. IV, fig. 7; 75 x

43-45 *Ticinella roberti* (Gandolfi). Copy of figures of Reichel, 1949, p. 601, textfig. 1; 75 x

46-47 *Ticinella roberti (Gandolfi). Copy of figures* of Moullade, 1966, pl. 9, figs. 9, 10; 75 x

PLATE 3

Figs. 48-50 *Ticinella madecassiana* Sigal. Copy of holotype of Sigal, 1966, pl. 3, figs. 9a, 8a, 7a. 75 x

51-53 *Ticinella praeticinensis* Sigal. Copy of figure of holotype of Sigal 1966, pl. II, figs. 3a, 5a, 4a; 75 x

54-55 *Ticinella praeticinensis* Sigal. Copy of figure of Moullade, 1966, pl. 8, figs. 23, 22; 75 x

56-58 *Ticinella roberti* var. *bejaouaensis* Sigal. Copy of figure of holotype of Sigal 1966, pl. V, figs. 7a, 5a, 6a; 75 x

59-60 *Ticinella bejaouaensis* Sigal. Copy of figure of Moullade 1966, pl. 9, figs. 5, 4; 75 x

61-62 *Ticinella multiloculata* (Morrow). Copy of figure of holotype of Morrow 1934, pl. 31, figs. 3a, 3b.

65-67 *Ticinella multiloculata* (Morrow). Copy of figure of Brönnimann & Brown (1955, pl. 20, figs. 1-3); 75 x

Brönnimann & Brown have refigured Morrow's holotype.

PLATE 4

Figs. 68-70 *Ticinella multiloculata* (Morrow). Copy of figure of Loeblich & Tappan 1961, pl. 6, figs. 13b, c, a,; 75 x

71-73 *Ticinella gaultina (*Morozova). Copy of figure of Subbotina 1953, pl. 1, figs. 1 b, c, a; 75 x

74-76 *Ticinella aprica* Loeblich & Tappan. Copy of figure of holotype of Loeblich & Tappan 1961, pl. 4, figs. 16 b, c, a; 75 x

77-79 *Ticinella primula* Luterbacher. Copy of figure of holotype of Luterbacher 1963, textfig. 4; 75 x

80-82 *Ticinella raynaudi raynaudi* Sigal. Copy of figure of holotype of Sigal 1966, pl. 6, figs. 2a, 3a, 1a; 75 x

83-85 *Ticinella raynaudi* var. *digitalis* Sigal. Copy of figure of holotype of Sigal 1966, pl. 6, figs. 7a, 8a, 6a; 75 x

86-88 *Ticinella raynaudi* var. *aperta* Sigal. Copy of figure of holotype of Sigal 1966, pl. 6, figs. 13a, 12a, 11a; 75 x

89-91 *Ticinella roberti* (Gandolfi). Copy of figure of Sigal, 1966, pl. IV, figs. 12a, 10a, 11a; 75 x

PLATE 5

Figs. 92- 94 *Globotruncana ticinensis* var. *alpha* Gandolfi. Copy of figure of holotype of Gandolfi 1942, pl. 2, figs. 4 c, b, a; 75 x

95- 97 *Anomalina breggiensis* Gandolfi. Copy of figure of holotype of Gandolfi 1942, pl. 3, figs. 6 c, b, a; 75 x

98-100 *Globigerina planispira* Tappan, Copy of figure of holotype of Tappan 1940, pl. 19, figs. 12 b, c, a; 75 x

101-102 *Globigerina infracretacea* Glaessner. Copy of figure of Ellis & Messina 1940, microfilm. Approx. 75 x

103-105 *Hedbergella infracretacea* (Glaessner). Copy of figure of topotype of Glaessner 1966, pl. 1, figs. 1 c, b, a; 75 x

106-108 *Hedbergella planispira* Loeblich & Tappan. Copy of figure of Loeblich & Tappan 1961, pl. 5, figs. 6 b, c, a; 75 x

109-111 *Hedbergella planispira* Loeblich & Tappan. Copy of figure of Loeblich & Tappan 1961, pl. 5, figs. 11 b, c, a; 75 x

112-114 *Hedbergella planispira* Loeblich & Tappan. Copy of figure of Loeblich & Tappan 1961, pl. 5, figs. 8 b, c, a; 75 x

115-117 *Hedbergella trocoidea* Loeblich & Tappan. Copy of figure of Loeblich & Tappan 1961, pl. 5, figs. 2 b, c, a; 75 x

118-120 *Globigerina delrioensis* Carsey (Copy of figure of Frizzel 1954, pl. 20, figs. 1, a, b, c). 75 x

121-123 *Globigerina gautierensis* Brönnimann. Copy of figure of holotype of Brönnimann 1952, textfig. 2 b, c, a; 75 x

124-126 *Globigerina gautierensis* Brönnimann. Copy of figure of holotype of Brönnimann 1952, pl. 1, figs. 2, 3, 1; 75 x

127-129 *Praeglobotruncana gautierensis* (Brönnimann). Copy of figure of Bolli 1959, Bolli 1959, pl. 21, figs. 3 b, c, a. 75 x

130-132 *Praeglobotruncana gautierensis* (Brönnimann). Copy of figure of Jones 1960, "typical specimen", pl. 15, figs. 1 c, b, a; 75 x

PLATE 6

Figs. 133-135 *Hedbergella delrioensis* (Carsey). Copy of figure of Loeblich & Tappan 1961, pl. 2, figs. 11 b, c, a; 75 x

136-138 *Hedbergella delrioensis* (Carsey). Copy of figure of Loeblich & Tappan 1961, pl. 2, figs. 13 b, c, a; 75 x

139-141 *Hedbergella delrioensis* (Carsey). Copy of figure of Takayanagi & Iwamoto 1962, pl. 28, figs. 10 b, c, a; 75 x

142 *Hedbergella delrioensis* (Carsey). Copy of figure of Moullade 1966, pl. 8, fig. 17; 75 x

143-145 *Praeglobotruncana* cf. *gautierensis* Bolli. Copy of figure of Bolli 1959, pl. 21, figs. 7 b, c, a; 75 x

146 *Praeglobotruncana* cf. *gautierensis* Bolli. Copy of figure of Bolli 1959, pl. 21, fig. 8; 75 x

147-149 *Praeglobotruncana rohri* Bolli. Copy of figure of holotype of Bolli 1959, pl. 22, figs. 6 b, c, a; 75 x

150-152 *Praeglobotruncana modesta* Bolli. Copy of figure of holotype of Bolli 1959, pl. 22, figs. 2 b, c, a; 75 x

153-155 *Praeglobotruncana crassa* Bolli. Copy of figure of holotype of Bolli 1959, pl. 21, figs. 1 b, c, a; 75 x

156-159 *Hedbergella sp.* aff. *infracretacea* (Glaessner). Copy of figure of Moullade 1966, pl. 8, figs. 6, 7, 8, 9; 75 x

160-165 *Hedbergella sp.* aff. *infracretacea* (Glaessner). Copy of figure of Moullade 1966, pl. 8, figs. 10, 11, 12, 14, 15, 16; 75 x

PLATE 7

Figs. 166-168 *Globigerina portsdownensis* Williams-

Mitchell. Copy of figure of holotype of Williams-Mitchell 1948, pl. 8, figs. 4 b, c, a; 75 x

169-171 *Hedbergella brittonensis* Loeblich & Tappan. Copy of figure of holotype of Loeblich & Tappan 1961, pl. 4, figs. 1 b, c, a; 75 x

172-174 *Hedbergella amabilis* Loeblich & Tappan. Copy of figure of holotype of Loeblich & Tappan 1961, pl. 3, figs. 1 b, c, a; 75 x

175-176 *Globigerina washitensis* Carsey. Copy of figure of neoholotype of Plummer 1931, pl. 13, figs. 12 a, b; 75 x

177-179 *Hedbergella hiltermanni* Loeblich & Tappan 1961, pl. 4, figs. 13 b, c, a; 75 x

180-181 *Hedbergella sigali* Moullade. Copy of figure of holotype of Moullade 1966, pl. 7, figs. 24, 25. 75 x

182-184 *Globigerina globigerinelloides* Subbotina. Copy of figure of holotype of Subbotina 1953, pl. 1, figs. 11 b, c, a; 75 x

185-186 *Globigerina kelleri* Subbotina. Copy of figure of holotype of *Subbotina* 1953, pl. 1, figs. 16 a, b; 75 x

PLATE 8

Figs. 187-189 *Globigerina paradubia* Sigal. Copy of figure of holotype of Sigal 1952, textfig. 28. 75 x

190 *Globigerina almadenensis* Cushman & Todd. Copy of figure of holotype of Cushman & Todd 1948, pl. 16, fig. 18. 75 x

191 *Globigerina almadenensis* Cushman & Todd. Copy of figure of paratype of Cushman & Todd 1948, pl. 16, fig. 19; 75 x

192-193 *Hedbergella aptiana* Bartenstein. Copy of figure of holotype of Bartenstein 1965, textfig. 3 and paratype textfig. 4; 75 x

194-197 *Globorotalia youngi* Fox. Copy of figure of holotype of Fox 1954, pl. 26, fig. 15 and paratypes pl. 26, figs. 16, 17, 18; 75 x

198-199 *Globigerina seminolensis* Harlton. Copy of figure of holotype of Harlton 1927, pl. 5, figs. 7 b, a; 75 x

200-202 *Anomalina lorneiana* d'Orbigny var. *trocoidea* Gandolfi. Copy of figure of Gandolfi 1942, holotype, pl. 2, figs. 1 c, b, a; 75 x

203-205 *Hastigerinella simplicissima* Magné & Sigal. Copy of figure of holotype of Magné & Sigal 1954, pl. 15, figs. 11 c, b, a; 75 x

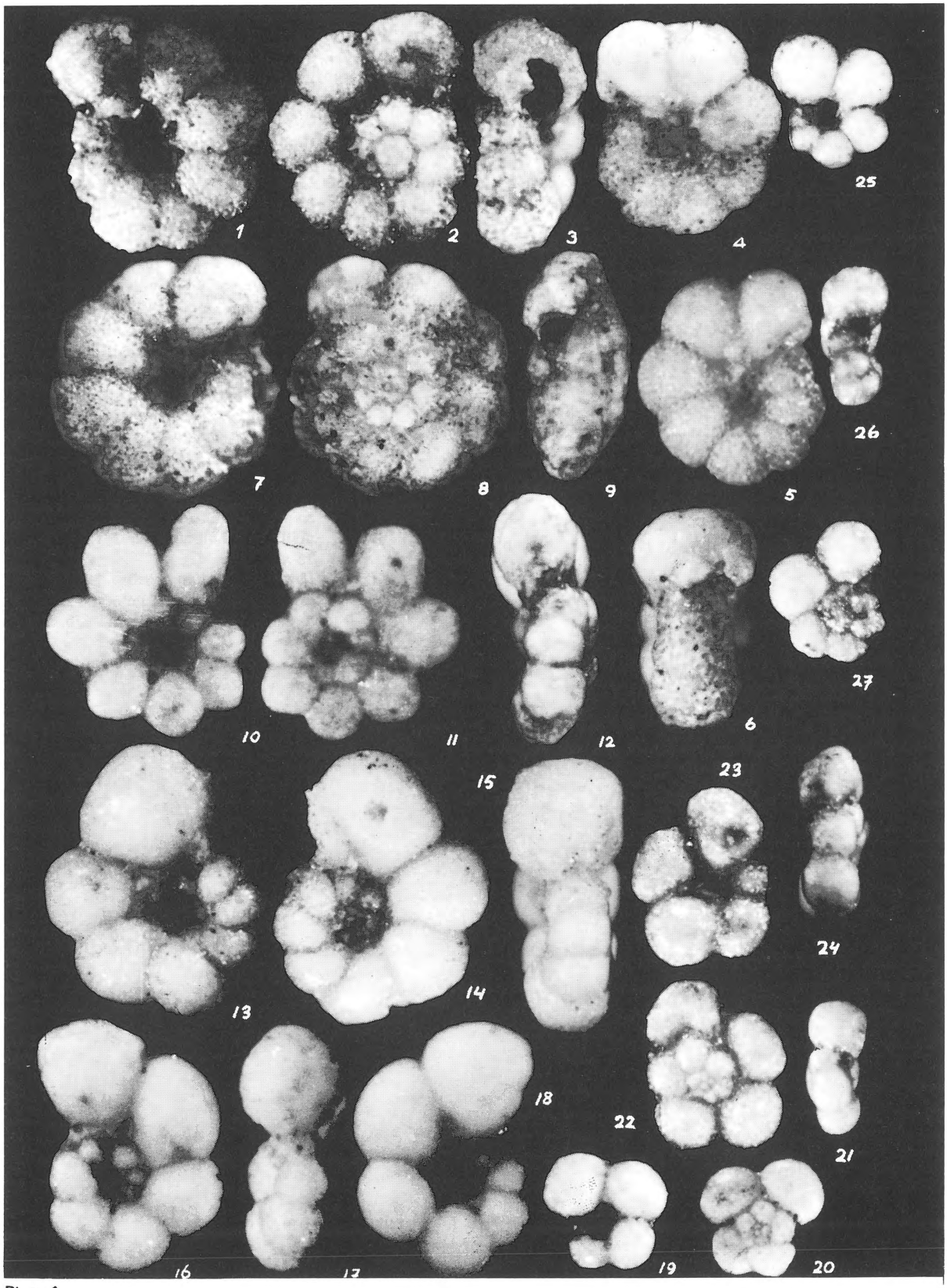


Plate 1

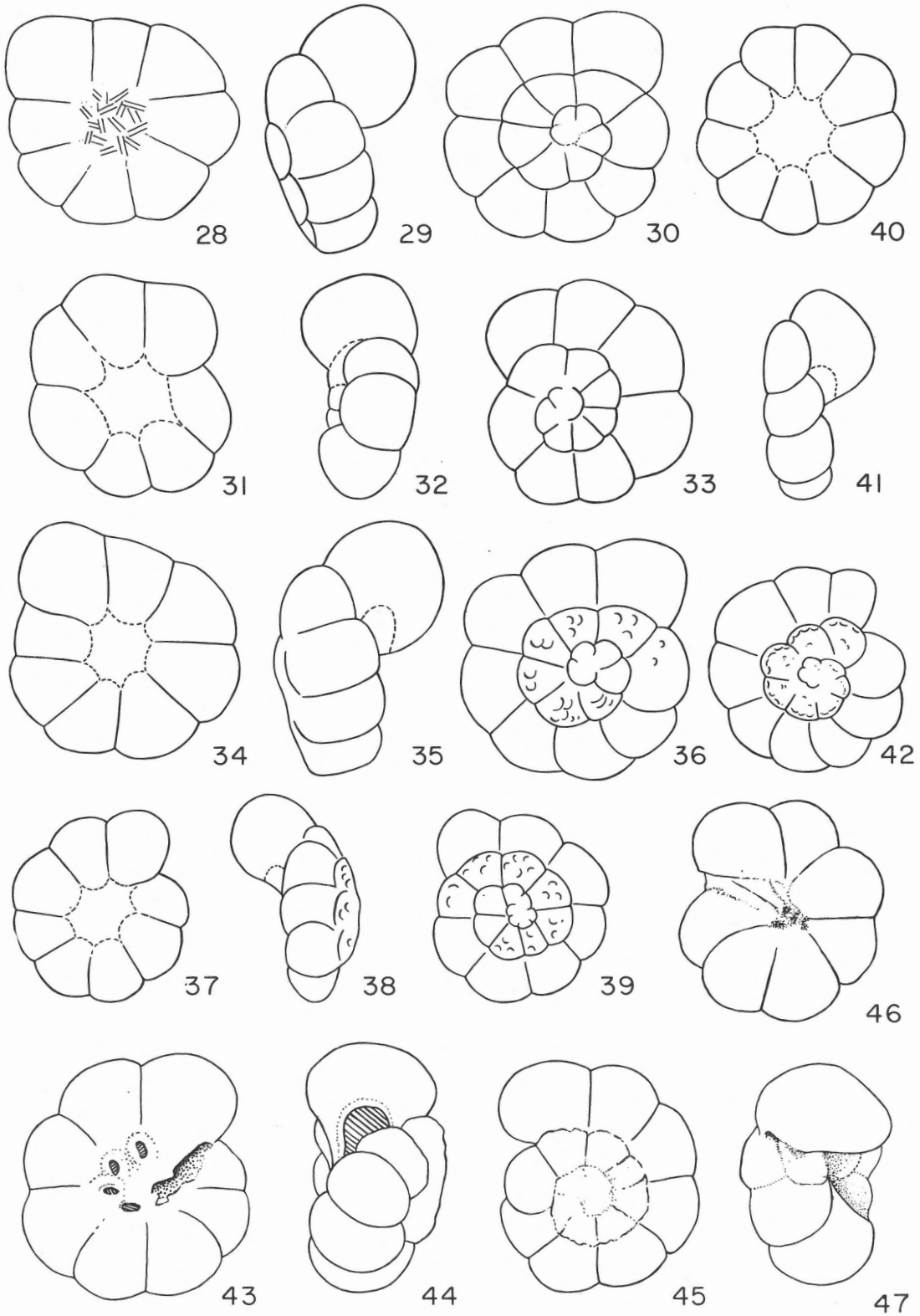


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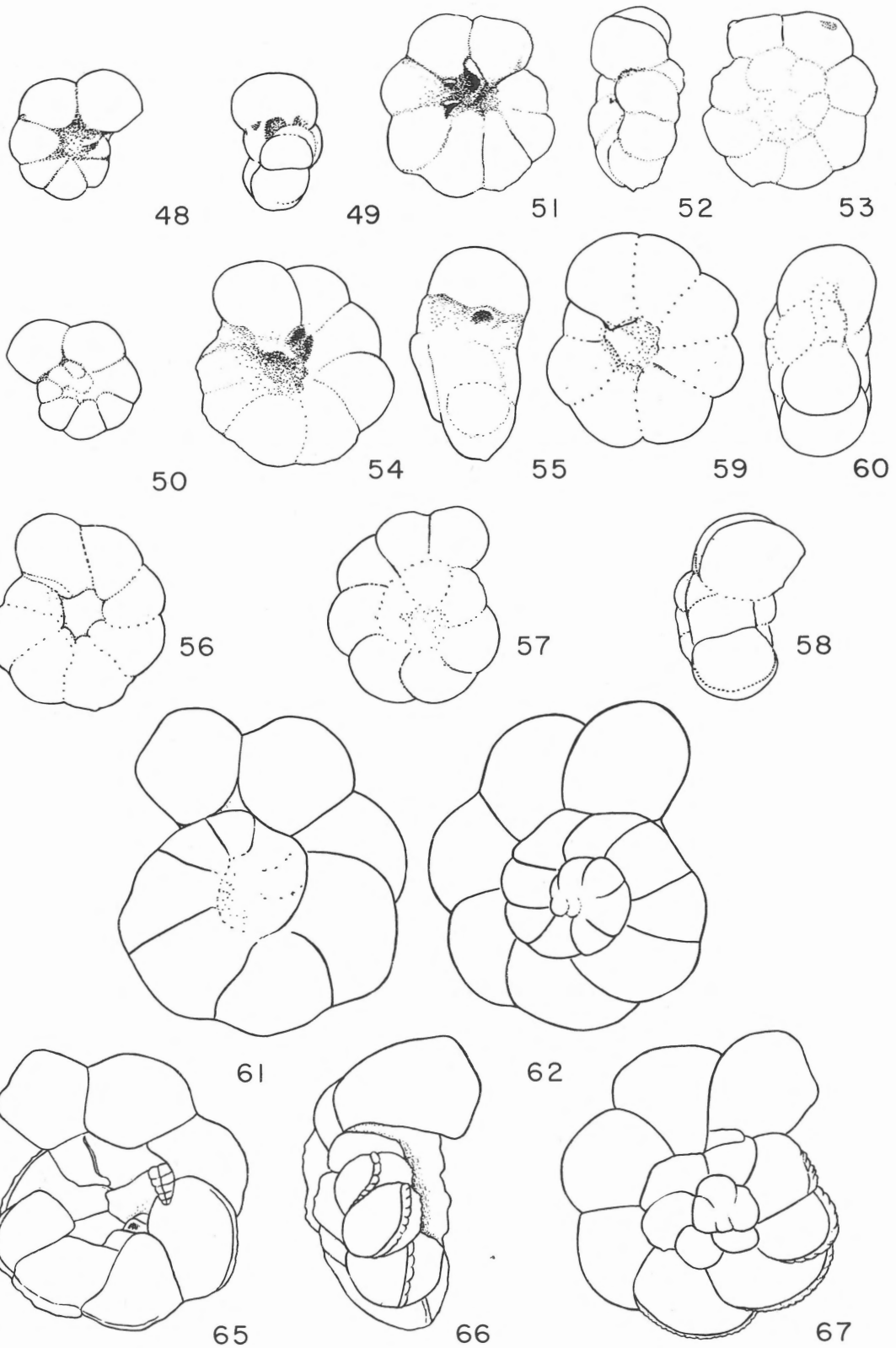


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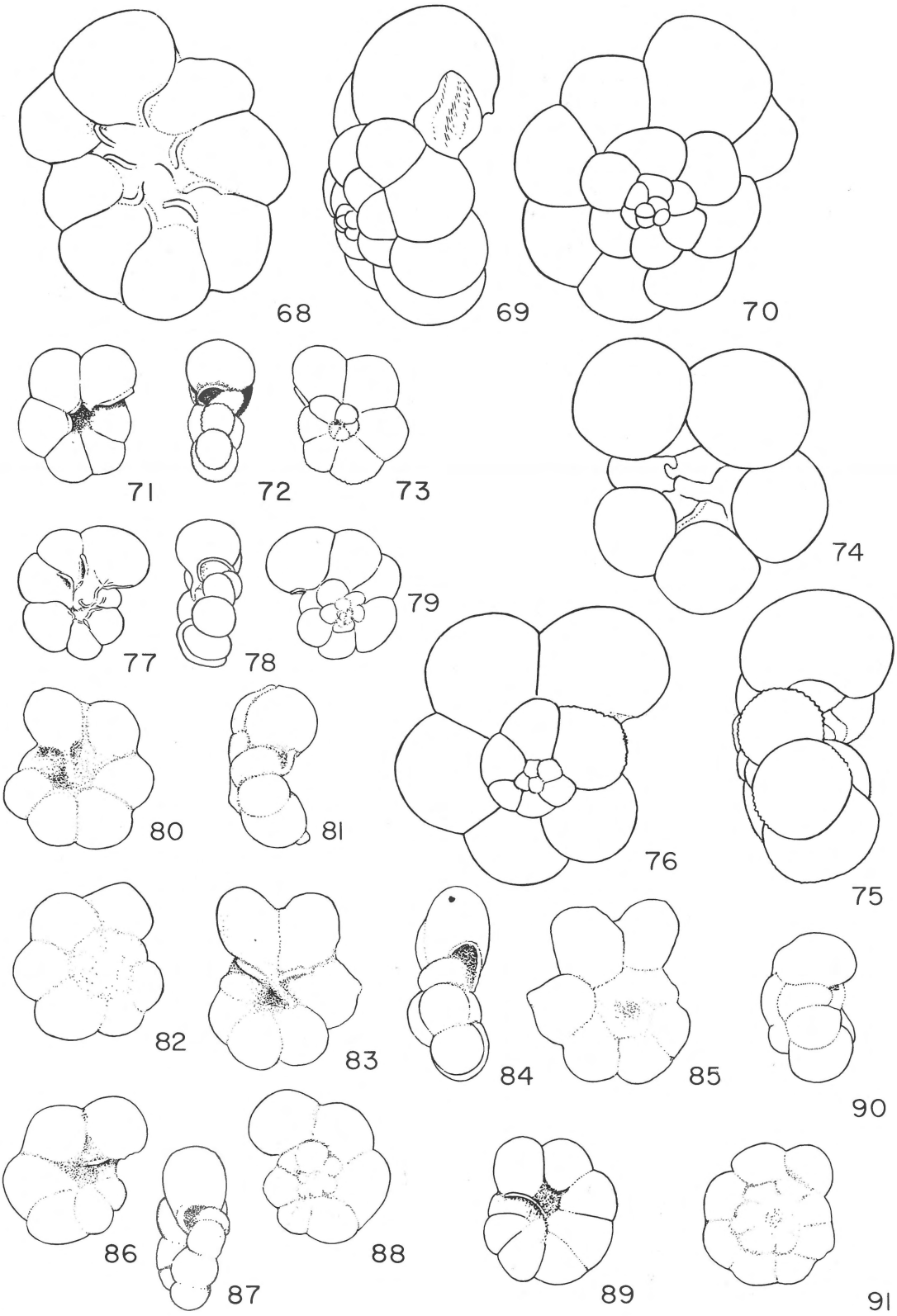


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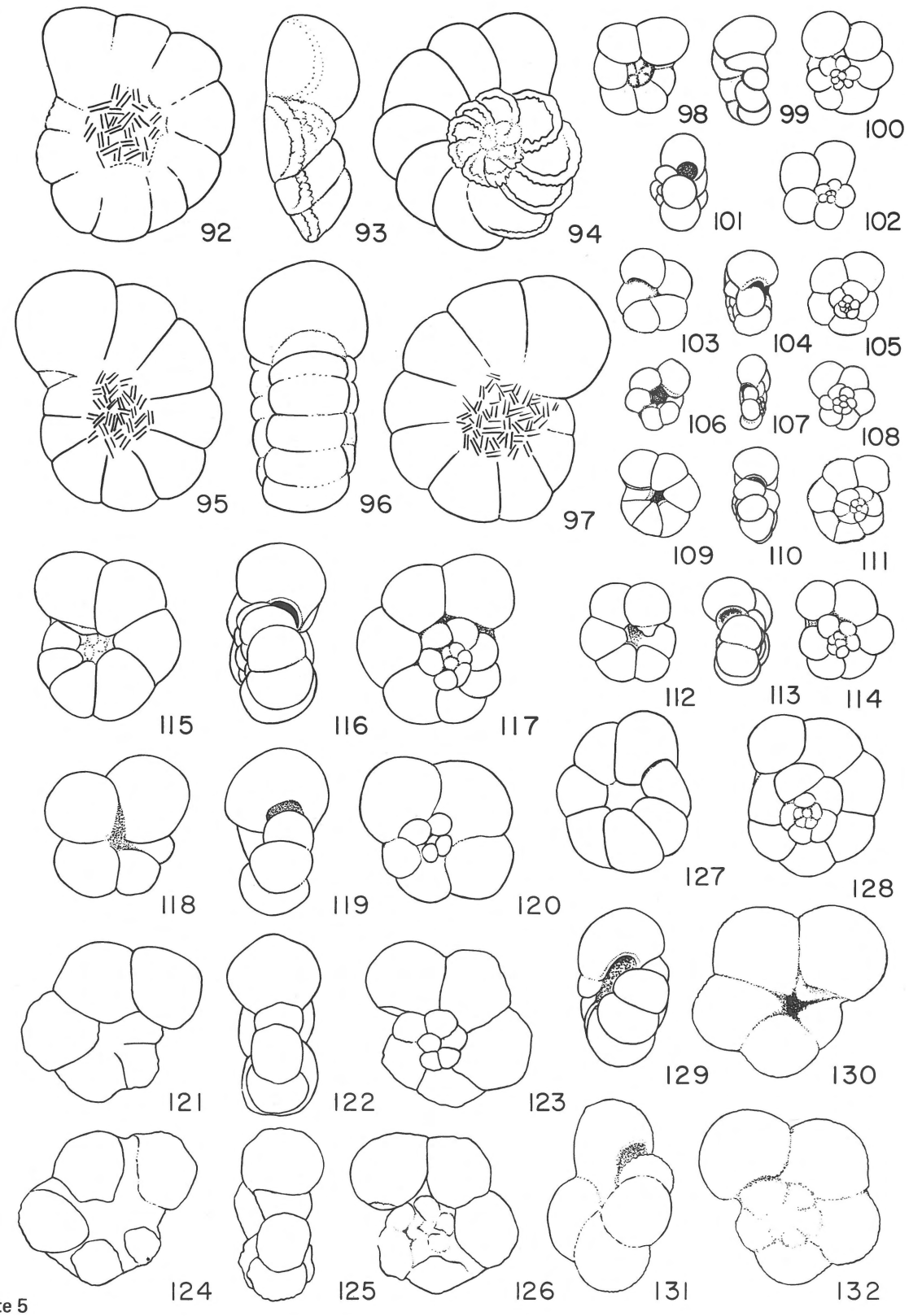

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Plate 5

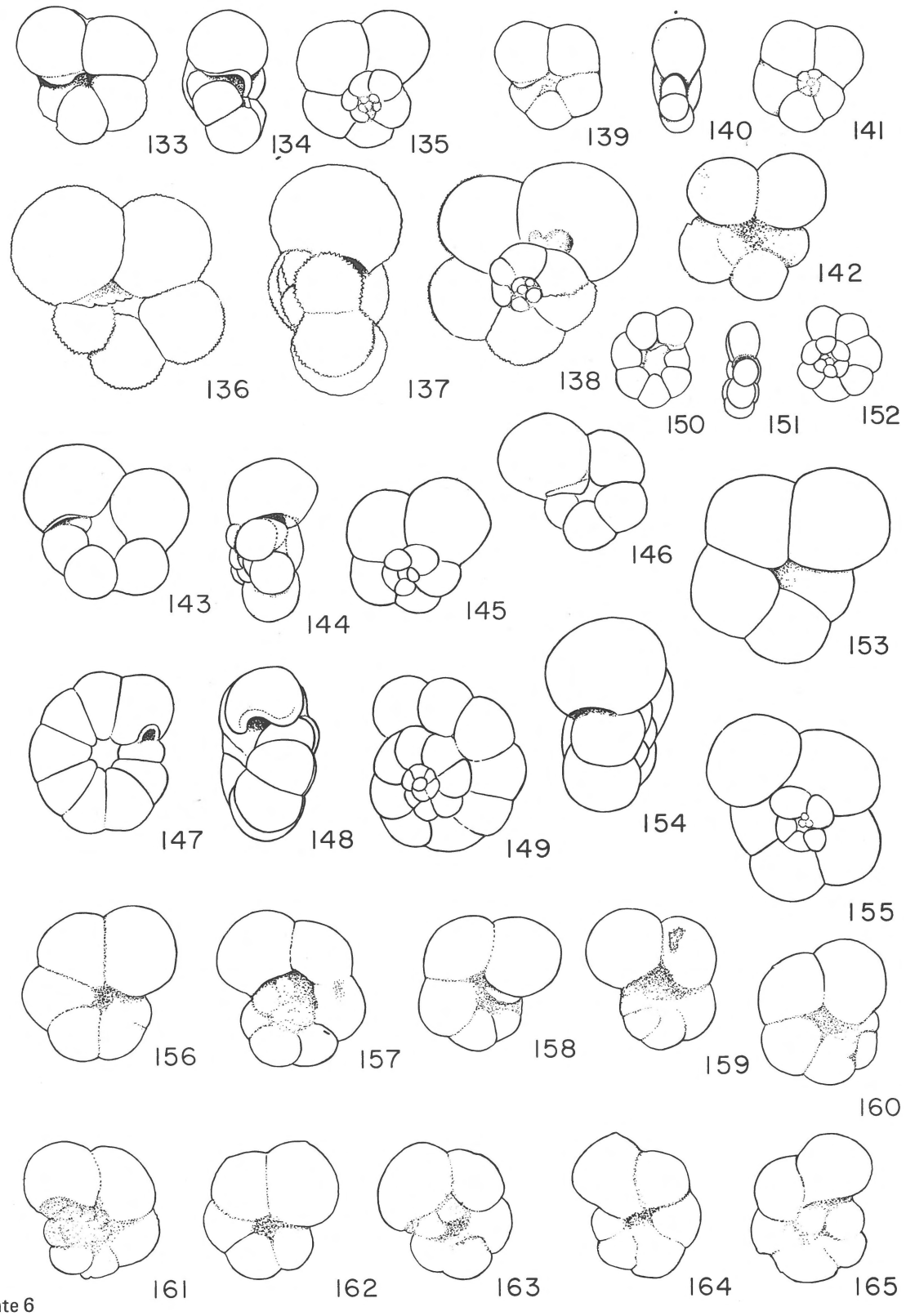

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Plate 6

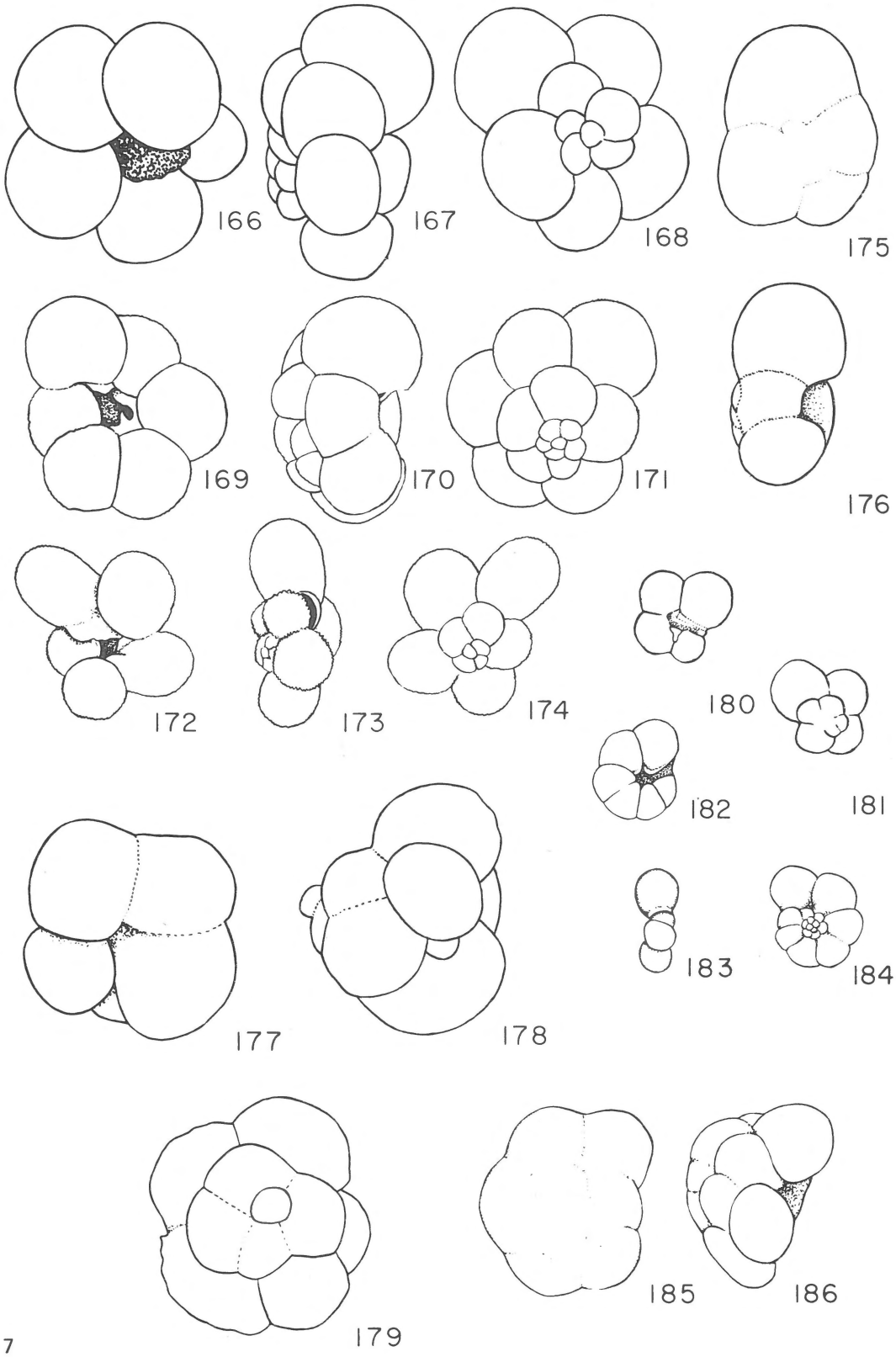

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Plate 7

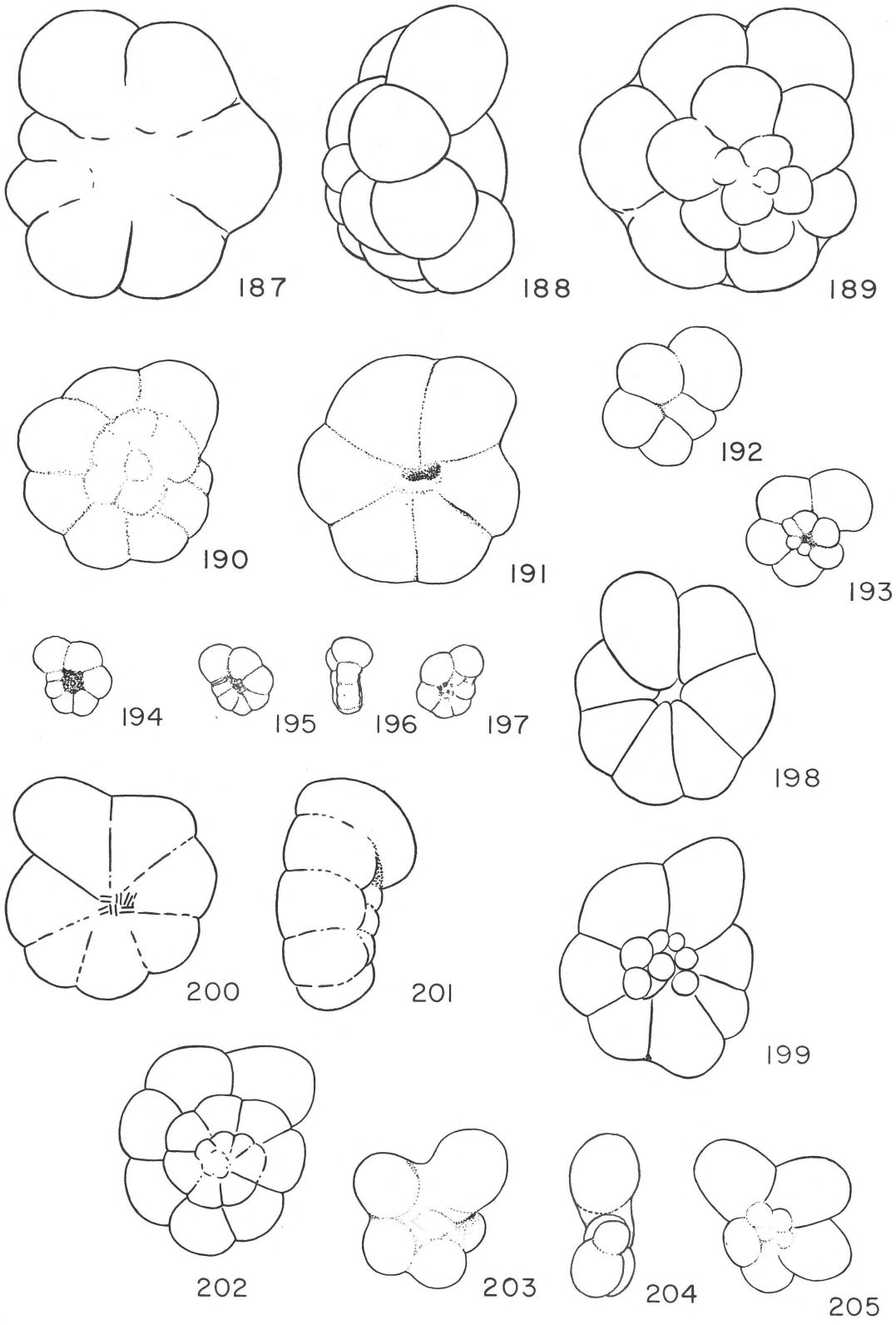

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Plate 8