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ZONATION OF UPPER CRETACEOUS BY MEANS
OF PLANKTONIC FORAMINIFERA, ATTERSEE,
(UPPER AUSTRIA)

(Pl. IX—XII, 3 Figs., 2 Tab.)

Расчленение верхнемеловых образований района Аттерзее (Горная Австрия)
по планктонным фораминиферам
(Табл. IX—XII, 3 фиг.)

Abstract: From 90 samples from the „*Helvetikum*” and „*Ultrahelvetikum*” respectively, of Attersee (Upper Austria) a series of 11 zones is established on the basis of the planktonic Foraminifera found; these correspond approximately to the stratigraphic range Albian to Maestrichtian. Pictures are made of the fossilia supplying the names to the zones.

INTRODUCTION

In the West of Attersee (Upper Austria) appear windowlike structures of „*Helvetikum*” and „*Ultrahelvetikum*” respectively, which for the most part consist of soft marls. From these marls, which possess a characteristic microfauna, altogether 90 samples were collected, washed and analysed. They form the basis of the proposed zonation.

The individual zones merely represent a succession, in which the faunal development (corresponding partly to the phylogenetic development; see f.i. Bandy 1967) reaches from *Hedbergella* in the underlying bed through *Thalmaninella*, *Rotalipora* and *Praeglobotruncana* to *Globotruncana*. The correlation of zones with stratigraphic stages was therefore made only in accordance with assertions already found in literature. New stratigraphic statements or confirmations of the present placement of the Cretaceous plankton can only be made on the basis of parallel investigations of other groups of organisms (e.g. Ammonites), as has recently been done by Malapris & Rat 1961 and Renz, Luterbacher & Schneider 1963.

The zones are named after fossils of maximum frequency and of regular occurrence in their ranges.

The determination of a zone-species proved unnecessary in the case of the *Rotalipora* zone and the *Praeglobotruncana* zone as these ranges appeared to be already sufficiently characterized by the mentioned genera.

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ZONATION

1) *Thalmaninella ticinensis* zone

The separation of this zone from the older section called *Hedbergella* zone (which could not be investigated more thoroughly, on account of the paucity of the available material) is made possible by the first appearance of representatives of the genus *Thalmaninella* S i g a l. Though at first *Thalmaninella* is only found in subordinate positions next to benthonic calcareous Foraminifera (mostly *Lenticulina* and *Gavelinella*), they appear as fauna-dominating in stratigraphically higher samples; especially *Th. ticinensis ticinensis* (G a n d.) and *Th. ticinensis subticinensis* (G a n d.) appear in much greater numbers than other *Thalmaninella* species. Partly also *Planomalina buxtorfi* (G a n d.) can form a main constituent of the faunas. *Hedbergella* div. sp. are found in the entire zone, although sparsely.

No representatives of the group *Th. appenninica* (R e n z) yet appear in the *Th. ticinensis* zone.

Planktonic Foraminifera occurring in the zone:

- Hedbergella infracretacea* (G l a e s s n e r)
- H. trocoidea* (G a n d o l f i)
- H.* div. sp.
- * *Planomalina buxtorfi* (G a n d o l f i)
- * *Thalmaninella ticinensis subticinensis* (G a n d o l f i)
- * *Th. ticinensis ticinensis* (G a n d o l f i)
- * *Th. greenhornensis* (M o r r o w)
- * *Th. multiloculata* (M o r r o w)
- * *Th. deeckeii* (F r a n k e)

Benthonic accompanying fauna:

- Ammodiscus siliceus* (T e r q u e m)
- Recurvoides gerochi* P f l a u m a n n
- Marssonella oxycona* (R e u s s)
- Dentalina gracilis* D' O r b i g n y
- Lenticulina* div. sp.
- Robulus rotulatus* (L a m a r c k)
- Cristellaria subangulata* R e u s s
- Gavelinella* div. sp.
- Epistomina chapmani* T e n D a m
- E.* div. sp.
- Cibicides refulgens* M o n t f o r t

* First appearance of a given form in the zone.

Many authors agree that *Th. ticinensis subticinensis* (Gand.) and *Th. ticinensis ticinensis* (Gand.) are the earliest primitive forms of the *Thalmanninella* group, mostly attributing to them a stratigraphic range from the Upper Albian up to the Lower Cenomanian.

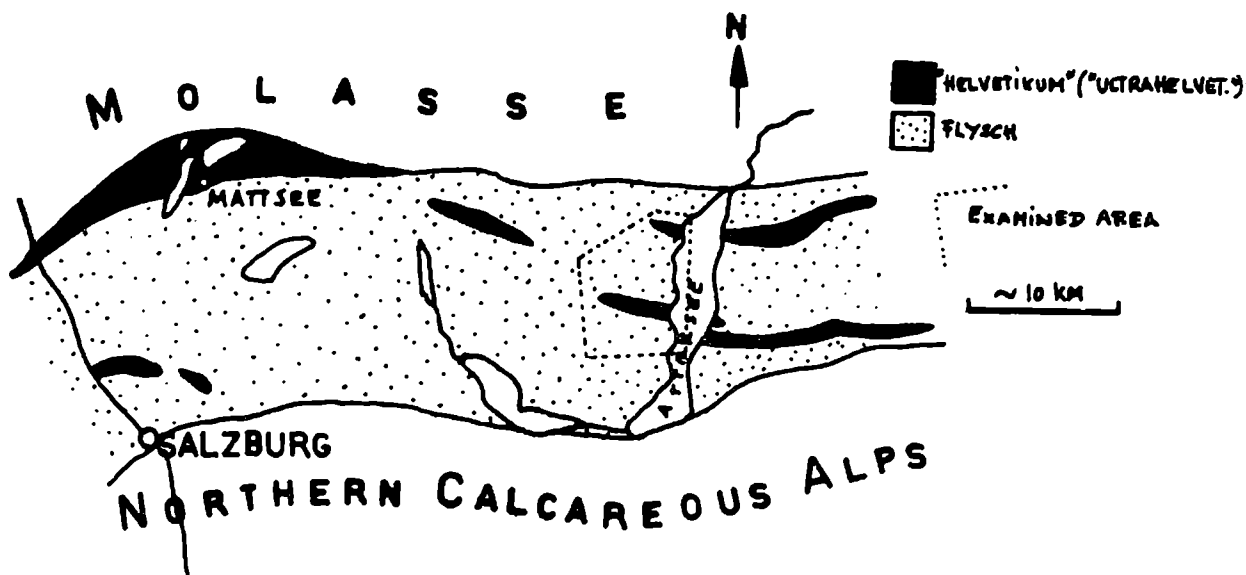


Fig. 1. Sketch-map of the „Flysch zone”, Salzburg, and Upper Austria (after Prey 1961)

Gandolfi 1942 describes these forms from the lowest part of the „Scaglia bianca” (Tessino, Cenomanian), Cita 1948 from the Lowest Cenomanian (Italy), Dubourdieu & Sigal 1949 from the Lowest Cenomanian (N. Africa), Sigal 1952 from the uppermost Albian (N. Africa), Dalbiez 1955 from the uppermost Albian to the Lowest Cenomanian (N. Africa), Klaus 1960 from Albian to the Lowest Cenomanian (Préalpes medianes: „Zone 2 et Zone 3”), Bolli 1960 from the uppermost Albian (Trinidad), Flandrin, Moulade & Porthault 1961 from Albian (France), Malapris & Rat 1961 from the Cenomanian (France), Scheibnerova 1961 from Albian to the Lower Cenomanian (Western Carpathians), Salaj & Samuel 1966 from the Middle Albian to the Lower Cenomanian (Western Carpathians) and Caron 1967 from the Upper Albian.

Of the other species of *Thalmanninella* differing ranges are given: Brönnimann & Brown 1955 *Th. greenhornensis* (Mor.) and *Th. multiloculata* (Mor.) from Cenomanian to possibly Lower Turonian, Klaus 1960 *Th. multiloculata* (Mor.) from the Upper Albian to the Lowest Cenomanian and *Th. greenhornensis* (Mor.) from the Middle Cenomanian, Salaj & Samuel 1966 the two forms form the uppermost Albian to Middle Cenomanian and *Th. greenhornensis* (Mor.) from Middle Cenomanian to Lower Turonian.

Gandolfi 1942 attributes *Planomalina buxtorfi* (Gand.) to Cenomanian, Klaus 1960 to the Lower and Middle Cenomanian, Salaj & Samuel 1966 to the Middle Albian to the Middle Cenomanian and Bandy 1967 to the Upper Albian to Lower Cenomanian.

Stratigraphic range: Upper Albian to Lower Cenomanian.

2) *Thalmaninella appenninica* zone

The *Th. appenninica* zone is that range in which *Th. ticinensis* and subspecies no longer appear, while representatives of the genus *Rotalipora* Brotz. have not yet appeared, the first appearance of *Th. appenninica* and subspecies marking the beginning of the zone; the latter comprise over 50% of the entire fauna and can therefore be well used as zone-characteristic forms.

Th. globotruncanoides (Sigal) and *Th. evoluta* Sigal decrease in numbers in favour of *Th. appenninica*. For the first time a few specimens of the genus *Praeglobotruncana* Bermudez appear in this zone.

Planktonic Foraminifera occurring in the zone:

- Thalmaninella greenhornensis* (Morrow)
- Th. deecke* (Frank)
- * *Th. appenninica appenninica* (Renz)
- * *Th. appenninica gandolfii* (Luterbacher & Premoli Silva)
- * *Th. globotruncanoides* (Sigal)
- * *Th. evoluta* Sigal
- * *Praeglobotruncana stephani stephani* (Gandolfi)

Benthonic accompanying fauna:

- Textularia turris* D'Orbigny
- Clavulinoides gaultinus* (Morozowa)
- Dorothia pupa* (Reuss)
- Eggerella trochoidea* (Reuss)
- Dentalina* div. sp.
- Lenticulina* div. sp.
- Anomalina complanata* Reuss

In the literature, the appearance of the *Th. appenninica* group is generally stated to have occurred only after the extinction of the *Th. ticinensis* group, but there are differences of opinion as to its stratigraphic placement.

Gandolfi 1942, Cita 1948, Mornod 1949, Dubourdieu & Sigal 1949 („Zone à *Acanthoceras mantelli*” = Middle Cenomanian), Gandolfi 1957, Bolli 1960, Loeblich & Tappan 1961, Malapris & Rat 1961 and Salaj & Samuel 1966 assume the appearance of the *Th. appenninica* group to have taken place in the higher Lower Cenomanian and Middle Cenomanian respectively.

Sigal 1952, Klaus 1960, Luterbacher & Premoli Silva 1962, Renz, Luterbacher & Schneider 1963 („Zone des *Mantelliceras mantelli*” = Lower Cenomanian) and Bandy 1967 describe the first appearance of *Th. appenninica* as being already in the lowest Cenomanian, though only after the extinction of the *Th. ticinensis* forms. Only Dalbiez 1955 and Scheibnerova 1961 assume the coexistence of these two groups in the entire Cenomanian.

Stratigraphic range: Upper Lower Cenomanian and Middle Cenomanian.

3) *Rotalipora* zone

The appearance of *Rotalipora* development marks the beginning of this zone. On account of its relatively short vertical distribution, the genus *Rotalipora* Brotz. can well serve as a zone designation, the

more so since as in all samples its representatives constitute 50% of the entire fauna (*Rotalipora* Brotz. is distinguished from the genus *Thalmaninella* Sigal particularly by its radial depressed umbilical sutures and its supplementary openings with small portici in sutural position).

In the floor of the zone forms belonging to the *Th. appenninica*-zone still be found, which, however, disappear from the faunal composition in upward direction. *Th. reicheli* (Mornod), which occurs only in this zone, is noteworthy. Since, however, its appearance is too irregular — it appears rarely with greater frequency and at times is missing altogether — this form was not chosen as zonal index form.

Praeglobotruncana appear already with greater frequency than in the *Th. appenninica*-zone, both as species and as individuals. Their maximal development, however, occurs only in the next younger zone.

Planctonic Foraminifera occurring in the zone:

- Thalmaninella deecke* (Frank e)
- Th. appenninica appenninica* (Renz)
- Th. appenninica gandolfii* (Luterbacher & Premoli Silva)
- Th. evoluta* Sigal
- * *Th. reicheli* (Mornod)
- * *Rotalipora montsalvensis* Mornod
- * *R. cushmani* (Morrow)
- * *R. turonica turonica* Brotzen
- * *R. turonica thomei* Hagn & Zeil
- Praeglobotruncana stephani stephani* (Gandolfi)
- * *P. stephani turbinata* (Reichel)
- * *P. delrioensis* (Plummer)
- * *P. oraviensis* Scheibnerová

Benthonic accompanying fauna:

- Ammodiscus siliceus* (Terquem)
- Clavulinoides gaultinus* (Morozova)
- Eggerella* div. sp.
- Marssonella oxycona* (Reuss)
- Dentalina* div. sp.
- Lenticulina* div. sp.

In the literature, the appearance of *Rotalipora* is generally stated to have occurred in Cenomanian, where they are found together with the *Thalmaninella* still existing; the exact stratigraphic placing however, is still uncertain.

The authors Kikoine 1947a, Sigal 1948a, Mornod 1949, Dubourdieu & Carbonnier 1952, Brönnimann & Brown 1955, Dalbiez 1955, Schijfsma 1955, Klaus 1960 („Zone à *Rotalipora*” = Upper Cenomanian to Lower Turonian), Loeblich & Tappan 1961, Malapris & Rat 1961, Scheibnerová 1961, Lehmann 1962, 1966 and Salaj & Samuel 1966 assume the first appearance of *Rotalipora* (e.g. of *R. cushmani* (Mor.)) to have occurred in the Middle to Upper Cenomanian.

Renz, Luterbacher & Schneider 1963 arrive at differing results; they assign the appearance of *R. cushmani* (Mor.) etc. already to the Lower Cenomanian.

Most of the authors cited place the upper limit of *Rotalipora* in the Lower Turonian. On the other hand, Dubourdieu & Sigal 1949, Carbonnier 1952, Schijfsma 1955 and Lehmann 1962, 1966 assume *Rotalipora* to have become extinct at the boundary between Cenomanian and Turonian, while Brönnimann & Brown 1955 describe them as being still in the Lower Coniacian.

In the samples I worked on, representatives of *Rotalipora* were never found with those of *Globotruncana* together in the same fauna.

Stratigraphic range: Upper Cenomanian to Lower Turonian.

4) *Praeglobotruncana* zone

The diagnostic characteristic of this zone is the predominance of the genus *Praeglobotruncana* Bermudez, which here reaches its maximum, both as species and as individuals (over 80% of the entire fauna in a sample). Simultaneously with this sudden rise, isolated *Globotruncana* appear for the first time, while *Thalmaninella* and *Rotalipora* have become finally extinct.

Among *Praeglobotruncana*, *P. biconvexa* + subspecies, *P. praehelvetica* (Truj.) and *P. helvetica* (Bolli) dominate. The not very frequently appearing *Globotruncana carpathica* Scheib. is limited to the *Praeglobotruncana*-zone. *G. sigali* Reichel reaches its full development only in the next younger zone.

The planktonic foraminifera constitute almost 100% of the entire fauna; only a very few benthonic Foraminifera are found.

Planktonic Foraminifera occurring in the zone:

- Praeglobotruncana stephani stephani* (Gandolfi)
- P. stephani turbinata* (Reichel)
- P. oraviensis* Scheibnerová
- * *P. biconvexa biconvexa* (Samuel & Salaj)
- * *P. biconvexa gigantea* (Samuel & Salaj)
- * *P. praehelvetica* (Trujillo)
- * *P. helvetica* (Bolli)
- * *P. imbricata* (Mornod)
- * *Globotruncana carpathica* Scheibnerová
- * *G. sigali* Reichel

Many authors describe a maximum frequency of *Praeglobotruncana* in the Turonian stage, with *P. stephani*-forms generally making their first appearance already in Cenomanian, while the other species (especially *P. helvetica* (Bolli)) appear only with the higher Lower Turonian and Middle Turonian respectively.

The following authors assume the appearance of the maximum frequency of *Praeglobotruncana* to have occurred in this stage: Trujillo 1960, Klaus 1960, 1961b („Zone à *Praeglobotruncana*”), Samuel & Salaj 1962, 1963, Lehmann 1962, Hanzlikova 1963, Klaus 1965, Salaj & Samuel 1966 and Bandy 1967. These authors also agree on the nonoccurrence of *Rotalipora* in this range.

According to Cita 1948, Mornod 1949, Sigal 1952a, b, Dalbiez 1955, Książkiewicz 1956, Scheibnerová 1958, Malapris & Rat 1961 and Scheibnerová 1961 the predominance of *Praeglobotruncana* starts already at the turn of Cenomanian/Turonian or in the Upper Cenomanian.

Finally it should be noted that the common appearance of *Praeglobotruncana* and *Globotruncana* applies only to the *Globotruncana* species *G. carpathica* Scheib. and *G. sigali* Reichel. More highly developed species as e.g. *G. lapparenti* and subspecies have not been found together with the *Praeglobotruncana* described. Samuel & Salaj 1962, 1963, Salaj & Samuel 1966 and Klaus 1960, 1961 b, 1965 also share this view (Klaus, it is true, assumes a transition period — „Zone à *Praeglobotruncana* et *Globotruncana*” — but still supposes the main development of *Praeglobotruncana* to have occurred in the lower part of this zone).

The view of Bolli 1951b, Mornod 1949, Książkiewicz 1956, Scheibnerová 1961 and Herm 1965 that the *Globotruncana lapparenti* forms appear already in the Lower Turonian along with *Rotalipora* could not be confirmed by my material.

Noteworthy is the appearance of *G. carpathica* Scheib., which according to Scheibnerová 1963 and Salaj & Samuel 1966 occurs typically only in the Middle Turonian.

Stratigraphic range: Middle Turonian.

5) *Globotruncana schneegansi* zone

The beginning of this zone is marked by the initial development of *Globotruncana* with a great number of species and subspecies, mainly the forms with a double-keel being fully developed. All *Praeglobotruncana* have become extinct, as well as *Globotruncana carpathica* Scheib. *Globotruncana sigali* Reichel, rare in the *Praeglobotruncana* zone, is now more frequently represented.

Of the many forms starting up new, only *Globotruncana schneegansi* Sigal is limited to this zone. I therefore chose it as index form for this zone, referring to Dalbiez 1955, even though this species does not exceed the other forms in quantity.

A further difficulty for the determination of the character of this zone is presented by the fact that most species or subspecies appearing are „continuous forms”, some of which can reach up to the *Globotruncana stuarti* zone; therefore the border between the *G. schneegansi*-zone and the *G. concavata* zone cannot be clearly defined.

The zonal faunal association here appears more suitable for characterization; it must, however, be taken into consideration that it is characteristic of a zone only if it is composed of those species which make up more than 50 per cent of the entire fauna of a sample. In the *Globotruncana schneegansi* zone the simultaneous appearance of *G. sigali* Reich., *G. schneegansi* Sigal, *G. renzi* and subspecies, *G. coronata* and subspecies, *G. concavata primitiva* Dalb. and, in the higher ranges, *G. lapparenti lapparenti* Brotz. is the typical zonal-faunal-association which always represents more than 70% of the entire fauna.

Again planktonic Foraminifera make up almost 100% of the entire fauna.

Planktonic Foraminifera occurring in the zone:

- Globotruncana sigali* Reichel
- * *G. schneegansi* Sigal
- * *G. renzi* Gandolfi
- * *G. renzi angusticarinata* Gandolfi

- * *G. coronata coronata* Bolli
- * *G. coronata tarfayensis* Lehmann
- * *G. marginata* (Reus)
- * *G. concavata primitiva* Dalbiez
- * *G. concavata concavata* Brotzen
- * *G. concavata carinata* Dalbiez
- * *G. lapparenti lapparenti* Brotzen
- * *G. lapparenti bulloides* Vogler
- * *G. lapparenti tricarinata* (Quereau)
- * *G. fornicata* Plummer
- * *G. arca* (Cushman)

As has been mentioned in the preceding chapter there is a variance of opinions, as regards the beginning of the *Globotruncana* development. Even though it is generally established that a variety of species started only after the extinction of *Praeglobotruncana*, this is assumed to have taken place in the Lower Turonian, Middle Turonian or Upper Turonian. I follow the division of Klaus 1960, 1961b; 1965 who places the „typogenesis” (after Schindewolf) of the genus *Globotruncana* Cushman in the Upper Turonian. A similar view is held by Dalbiez 1955, Lehmann 1962 and Salaj & Samuel 1966, who assume the *G. schneegansi* zone to have ended at the same time as Coniacian. Also Gandolfi 1955, Bolli 1957a, Samuel & Salaj 1963 and Herb 1965 place the beginning of the „typogenesis” of *Globotruncana* in the Upper Turonian.

According to Sigal 1952, Witwicka 1958, Trujillo 1960 and Alexandrowicz, Birkenmajer & Geroch 1962, this development starts already in the Middle Turonian, while according to Książkiewicz 1956, Pożaryski & Witwicka 1956, Malapris & Rat 1961, Scheibnerová 1963 and Herm 1965 even already in the Lower Turonian.

Stratigraphic range: Upper Turonian to the border of Coniacian/Santonian.

6) *Globotruncana concavata* zone

As mentioned above, the border between the *Globotruncana concavata* zone and the *G. schneegansi* zone cannot be exactly defined, since the faunas of both zones are nearly similar. The nonoccurrence of *G. schneegansi* Sig. and the regular appearance of *G. concavata* and its subspecies are characteristic of the *G. concavata* zone. The typical zonal faunal assemblage of this zone is composed of the species and subspecies *G. renzi renzi* Gand., *G. concavata concavata* Brotz., *G. concavata carinata* Dalb., *G. lapparenti lapparenti* Brotz., *G. lapparenti tricarinata* (Quer.) and *G. arca* (Cushman). Other forms appear more or less rarely.

The first appearance of *G. globigerinoides* Brotz., as well as the first occurrence of a representative of Heterohelicidae (*Heterohelix globulosa* Ehrenberg) is still noteworthy. Both forms, however, can only be found in a few specimens and are not suitable as zonal index-fossils.

Planktonic Foraminifera occurring in the zone:

- Globotruncana sigali* Reichel
- G. renzi renzi* Gandolfi

- G. renzi angusticarinata* Gandolfi
- G. coronata coronata* Bolli
- G. coronata tarfayensis* Lehmann
- G. marginata* Reuss
- G. concavata primitiva* Dalbiez
- G. concavata concavata* Brotzen
- G. concavata carinata* Dalbiez
- G. lapparenti* Brotzen
- G. lapparenti bulloides* Vogler
- G. lapparenti tricarinata* (Quereau)
- G. fornicata* Plummer
- G. arca* (Cushman)
- * *G. globigerinoides* Brotzen
- * *Heterohelix globulosa* (Ehrenberg)

Benthonic accompanying fauna:

- Psammosiphonella rzehaki* (Andreae)
- Ammodiscus siliceus* (Terquem)
- Gaudryina rugosa* D'Orbigny
- Marssonella oxycona* (Reuss)
- Nothia grilli* Pflaumann
- Dentalina gracilis* D'Orbigny
- Cristellaria* div. sp.
- Bulimina ovulum* Reuss

According to Sigal 1952, Bolli 1957, Herb 1965, Salaj & Samuel 1966 and Bandy 1967, *Globotruncana schneegansi* Sig. no longer appears in the Santonian. Brotzen 1936, Bolli 1957 and Klaus 1965 note the occurrence of *G. globigerinoides* Brotz. only from the uppermost Coniacian and Santonian. Moreover, the *G. concavata* zone and its corresponding stratigraphic range have been mostly described in the literature with a similar zonal faunal assemblage as cited above: Sigal 1955 „zone à *G. concavata*” (Santonian), Dalbiez 1955 „*G. ventricosa*-zone” (uppermost Coniacian/Santonian), Bolli 1957, 1960 „*G. concavata*-zone” + „*G. fornicata*-zone” (Santonian), Klaus 1961b, 1965 „Zone 9” (Santonian), Pessagno 1962 „*G. fornicata-lapparenti* assemblage zone” (Santonian), Lehmann 1962 „zone à *G. concavata*” (Santonian), Kollmann 1964 „Concavata-Zone” (uppermost Coniacian to Santonian), Wille-Janoschek 1966 „Zone KA” (Coniacian-Santonian) and Salaj & Samuel 1966 „*Sigalia carpathica* Zone” (Santonian).

Similar faunas from the Santonian have also been described by Cita 1948, Hamilton 1953, De Klasz (in Ganss, 1956) and Alexandrowicz, Birkenmajer & Geröch (1962). Differing from these results, Hinte 1963 and 1965 describes the occurrence of *G. elevata elevata* Brotz. already from the Santonian and introduces the „*G. elevata* Zone”. In the material I worked on, however, *G. elevata elevata* Brotz. has never been found in the range of the *G. concavata* zone, so that Hinte's „*G. elevata* zone” should rather be assigned to the Lower Campanian, that is to say to the top of my *G. concavata* zone, the more so, as the accompanying planktonic fauna he describes is also found in the Lower Campanian.

Stratigraphic range: Santonian.

7) *Globotruncana elevata* zone

The beginning of this zone is marked by the appearance of *Globotruncana elevata elevata* Brotz. This form has been chosen as zonal index form because it no longer occurs in stratigraphically higher zones (excepting a very few specimens in the lower part of the *G. ventricosa* zone), thus having a short vertical distribution. Next to *G. elevata elevata* Brotz. and *G. elevata stuartiformis* Dalb. a number of new species of *Globotruncana* are found which clearly distinguish the planktonic fauna of the *G. elevata* zone from that of the *G. concavata* zone (e.g. *G. obliqua* Herm, *G. bollii* Gand., *G. scutilla* Gand.). The following forms can be regarded as typical zonal faunal assemblage: *G. lapparenti lapparenti* Brotz., *G. fornicata* Plum., *G. arca* (Cushman), *G. elevata elevata* Brotz., *G. elevata stuartiformis* Dalb. and *G. bollii* Gand.

G. sigali Reich., *G. renzi angusticarinata* Gand. and *G. coronata tarfayensis* Lehm., as well as *G. concavata* and subspecies, no longer appear in the *G. elevata* zone. But also *G. renzi* Gand. and *G. coronata coronata* Bolli appear only sparsely, and toward the top of the zone they disappear altogether from the faunal assemblage of the zone. The two species of Heterohelicidae, *Heterohelix globulosa* (Ehrenb.) and the new species *Pseudotextularia elegans* (Rzeh.), appear only very sparsely in this zone.

Planktonic Foraminifera occurring in the zone:

- Globotruncana renzi renzi* Gandolfi
- G. coronata coronata* Bolli
- G. marginata* (Reuss)
- G. lapparenti lapparenti* Brotzen
- G. lapparenti bulloides* Vogler
- G. lapparenti tricarinata* (Quereau)
- G. fornicata* Plummer
- G. arca* (Cushman)
- G. globigerinoides* Brotzen
- * *G. elevata elevata* Brotzen
- * *G. elevata stuartiformis* Dalbiez
- * *G. obliqua* Herm
- * *G. bollii* Gandolfi
- * *G. rosetta* (Carsey)
- * *G. scutilla* Gandolfi
- Heterohelix globulosa* (Ehrenberg)
- * *Pseudotextularia elegans* (Rzehak)

Benthonic accompanying fauna:

- Psammosiphonella rzehaki* (Andreae)
- Dorothia pupoides* (D'Orbigny)
- Marsonella oxycona* (Reuss)
- Nothia grilli* Pflaumann
- Nodosaria* div. sp.
- Lenticulina* div. sp.
- Reussella* div. sp.
- Stensiöina labyrinthica* Cushman & Dorsey

One can well compare the *G. elevata* zone with the biozone, which Kollmann 1964 describes as „Campan I” (Lower Campanian), Wil-

UPPER CRETACEOUS ZONATION IN COMPARISON WITH OTHER AUTHORS.

Table 1.

Stages	SALAJ & SAMUEL 1966 Carpathians - GSSR	HINTE 1963 Carinthia - Austria		1966 (Badan)	WICHER 1956 Gams - Austria	KOLLMANN 1963, 1964 Gams - Austria	WILLE-JANOSCHEK 1966 Gosau, Abtenau - Austria	HERM 1962 Reichenhall, Salzburg	STURM 1968 Attersee - Austria	HERB 1965 Amden - Switzerl.	KLAUS 1960 Préalpes médianes - Sw.		1965 (M. CARON) Préalpes Romandes - Sw.	DALBIEZ 1956 Tunisia	LEHMANN 1962, 1966 Tarfaya - Maroc.	PESAGNO 1960, 1962 Puerto Rico	BOLLI 1957, 1960 Trinidad	BANDY 1967 (California)	Stages	
MAESTRICHTIAN	UPPER	<i>Recemiguembelina varians</i>		<i>G. gansseri</i>	Maastricht II.	Maastricht IV. Maastricht III.	Zone KF <i>G. mayaroensis</i>	Zone F Zone E	<i>G. mayaroensis</i>	<i>G. contusa</i>				<i>G. contusa</i>			<i>Abathomphalus mayaroensis</i> subz. <i>G. gansseri</i> subz.	<i>Aboth. mayaroensis</i> <i>G. gansseri</i>	1. <i>G. mayaroensis</i> - <i>G. gansseri</i> - zone 2. <i>G. ventricosa</i> - <i>Gümbelitra cretacea</i> - zone	UPPER
	LOWER	<i>G. falsostuarti</i>	<i>G. calcarata</i>	<i>G. calcarata</i>	Maastricht I.	Maastricht II. Maastricht I.	Zone KE <i>G. contusa</i>	Zone D	<i>G. stuarti</i>					<i>G. arca</i>			<i>G. tilevi</i> subz. <i>Rgl. rugosa G. rosetta</i> subz.	<i>G. lapp. tricarinata</i>	3. <i>G. calcarata</i> - <i>G. rosetta</i> - zone	LOWER
CAMPANIAN	UPPER	<i>Bolivinae dracomiliaris</i> <i>Bol. decoratus decoratus</i>	<i>G. calcarata</i>	<i>G. calcarata</i>	Oberes Ober-Campan	Campan III. Campan II.	Zone KD <i>G. calcarata</i> Zone KC <i>G. arca, G. fornicata</i>	Zone C Zone B	<i>G. calcarata</i> <i>G. ventricosa</i>	<i>G. elevata stuartiformis</i>				<i>G. elevata</i>			<i>Rgl. rugosa</i> <i>P. gautierensis</i> subz.	<i>G. stuarti</i>	4. <i>G. calcarata</i> - <i>G. rosetta</i> - zone 5. <i>G. renzi</i> - <i>Gublerina ornata</i> - <i>P. wilsoni</i> - zone	UPPER
	LOWER	<i>G. arca</i>	<i>G. stuartiformis</i>	<i>G. stuartiformis</i>	Tieferes Campan bis Coniac	Campan I.	Zone KB <i>G. elevata elevata</i>	Zone A	<i>G. elevata</i>	<i>G. elevata elevata</i>									6. <i>G. calcarata</i> - <i>G. rosetta</i> - zone 7. <i>G. calcarata</i> - <i>G. rosetta</i> - zone	LOWER
SANTONIAN		<i>A. (Gavelinella) pseudoexculata</i> <i>Gublerina decoratissima</i> <i>Neoflab. gibbera</i> <i>Sigalia deflaensis</i>	<i>G. elevata 2</i> <i>G. elevata 1</i>	<i>G. elevata</i>		<i>concovata</i> - Zone	Zone KA <i>lapparenti</i> - <i>Glabotr.</i> <i>Sigalia deflaensis</i>		<i>G. concavata</i>	<i>G. concavata carinata</i>				<i>G. ventricosa</i>	zone à <i>G. concavata</i>		upper subz. lower subz.	<i>G. fornicata</i> <i>G. concavata</i>	8. <i>G. renzi</i> - <i>Gublerina ornata</i> - <i>P. wilsoni</i> - zone	SANTONIAN
CONIACIAN		<i>G. angusticarinata</i>	<i>G. renzi, G. cf. sigali</i>	<i>G. concavata</i>					<i>G. schneegansi</i>	<i>G. schneegansi</i>	Zone 7. à <i>Praeglobotruncana</i> <i>Glabotruncana</i>	Zone 8	Zone 8	<i>G. schneegansi</i>	zone à "grandes nosalines"	<i>G. renzi</i> assembl. zone		<i>G. renzi</i>	9. <i>G. concavata</i> - <i>G. schneegansi</i> - zone	CONIACIAN
TURONIAN	UPPER	<i>G. schneegansi</i>		<i>G. schneegansi</i>																UPPER
	MIDDLE	<i>P. biconvexa biconvexa</i> <i>P. oraviensis trigona</i>		<i>G. helvetica</i>					<i>Praeglobotruncana</i>	<i>P. helvetica</i>	Zone 6 à <i>P.</i>	Zone 6	Zone 6	<i>G. helvetica</i>	zone b <i>G. helvetica</i>			<i>G. inornata</i>	10. <i>P. helvetica</i> - zone	MIDDLE
CENOMANIAN	LOWER	<i>P. imbricata</i>		"Hedberg" <i>gigantea</i>					<i>Rotalipora</i>	<i>R. cushmani</i>	Zone 5 à <i>R.</i>				zone b "grandes Globigerines"				11. <i>R. cushmani</i> - <i>R. reicheli</i> - zone	LOWER
	UPPER	<i>R. cush. turonica</i>												Upper <i>R.</i>	<i>R. cushmani</i> <i>R. greenhornensis</i> <i>R. brotzeni</i> <i>R. globotruncanoid.</i>		<i>R. appenninica</i>	12. <i>R. appenninica</i> - <i>R. cushmani</i> - <i>R. reicheli</i> - zone	UPPER	
	MIDDLE	<i>R. cush. montsalvensis</i> <i>Th. appenninica</i>		<i>R. cushmani-reicheli</i> <i>R. appenninica</i>					<i>Th. appenninica</i>	<i>R. appenninica</i>	Zone 4 Zone supérieure à <i>Th.</i>			Middle - <i>R.</i>			<i>Globigerina washitensis</i>	13. <i>Globigerina washitensis</i> - zone	MIDDLE	
LOWER	<i>Th. brotzeni</i> <i>Rotundina stephani</i>		<i>R. balernensis</i> <i>T. roberti</i> <i>R. ticinensis</i>					<i>Th. appenninica</i>	<i>R. appenninica</i>	Zone 3 Zone moyenne à <i>Th.</i>			Lower <i>R.</i>	zone à <i>R. appenninica</i>			<i>R. balernensis</i>	14. <i>R. balernensis</i> - <i>Planomalina bustorfi</i> - zone	LOWER	
ALBIAN - UP.	<i>Th. ticinensis</i>							<i>Th. ticinensis</i>	<i>R. ticinensis</i>	Zone 2 Zone inférieure à <i>Th.</i>			<i>Th.</i>	zone à <i>R. klausii</i>			<i>R. ticin. ticinensis</i>	15. <i>R. ticin. ticinensis</i> - zone	UP - ALBIAN	

T. = Ticinella, Th. = Thalmannella, R. = Rotalipora, P. = Praeglobotruncana, G. = Globotruncana, Rgl. = Rugoglobigerina

Table 2.

		Zonation of the Upper Cretaceous		by means of planktonic foraminifera	zones	<i>Hedbergella infrastrucosa</i> (LAESS) <i>H. trochiformis</i> (GAND.) <i>Pleiomolina Buxtorfi</i> (GAND.) <i>Pleiomolinella ticinensis ticinensis</i> (GAND.) <i>Th. ticinensis subticinensis</i> (GAND.) <i>Th. greenhermensis</i> (MOR.) <i>Th. multiloculata</i> (MOR.) <i>Th. deeteri</i> (FR.) <i>Th. appenninica appenninica</i> (R.) <i>Th. appenninica grandis</i> (LUT. & P.S.) <i>Th. globotruncanoides</i> (S.) <i>Th. scrofa</i> S. <i>Th. reichei</i> (MOR.) <i>Rotalipora montsalvensis</i> (MOR.) <i>Acushinai</i> (MOR.) <i>R. turonica turonica</i> BR. <i>R. turonica thomel</i> A.G.Z. <i>Praeglobotruncana stephani stephani</i> (GAND.) <i>Prglt. stephani turbinata</i> (R.) <i>Prglt. deliroensis</i> (R.) <i>Prglt. arvensis</i> SCH. <i>Prglt. biconvexa biconvexa</i> (S. & S.) <i>Prglt. biconvexa gigantea</i> S. & S. <i>Prglt. praehelvetica</i> (FR.) <i>Prglt. helvetica</i> (R.) <i>Prglt. imbricata</i> (M.) <i>Globotruncana carpathica</i> SCH. <i>G. sigali</i> R. <i>G. schneegansi</i> S. <i>G. renzi renzi</i> GAND. <i>G. renzi angusticarinata</i> GAND. <i>G. coronata coronata</i> B. <i>G. coronata tarlensis</i> L. <i>G. concavata</i> (REUSS) <i>G. concavata primitiva</i> D. <i>G. concavata concavata</i> BR. <i>G. concavata carinata</i> D. <i>G. lapparenti lapparenti</i> BR. <i>G. lapparenti buffides</i> V. <i>G. lapparenti tricarinata</i> (OU) <i>G. fornica</i> PL. <i>G. arca</i> (C.) <i>G. globotruncanoides</i> BR. <i>G. elevata elevata</i> BR. <i>G. elevata stuartiformis</i> D. <i>G. obliqua</i> H. <i>G. balli</i> GAND. <i>G. rosalia</i> (GAR.) <i>G. scutilla</i> GAND. <i>G. ventricosa</i> NH. <i>G. ventricosa</i> (OF L.) <i>G. st. sparsa</i> SAH. <i>G. st. rugosa</i> MAH. <i>G. st. st. rugosa</i> GAND. <i>G. angulifera</i> MAH. <i>G. stuarti</i> (DE L.) <i>G. calcarata</i> B. <i>G. conchus</i> (C.) <i>G. sparsa</i> R. <i>G. fibuliferi</i> S. <i>G. maffraensis</i> B. <i>Praeglobotruncana rugosa rugosa</i> (PL.) <i>Prg. rugosa retenuata</i> BRON. <i>Prg. rugosa penny</i> BRON. <i>Prg. macrocephala</i> BRON. <i>Prg. tileri</i> BRON. & BRU. <i>Globotruncana hazarensis</i> VOR. <i>Heterohelix globulosa</i> (E.) <i>H. pupa</i> (R.) <i>H. striata</i> (E.) <i>Pseudotartaria elegans</i> (R.Z.) <i>Ps. intermedia</i> DE KL. <i>Ps. varian</i> RZ. <i>Ps. gerulinoidea</i> (E.) <i>Venihelrella egeri</i> C.
		UPPER	LOWER			
MAESTRICHTIAN	UPPER	<i>Glt. mayaroensis</i>				
	LOWER	<i>Glt. stuarti</i>				
CAMPANIAN	UPPER	<i>Glt. calcarata</i>				
	LOWER	<i>Glt. ventricosa</i>				
SANTONIAN		<i>Glt. elevata</i>				
CONIACIAN		<i>Glt. concavata</i>				
TURONIAN	UPPER	<i>Glt. schneegansi</i>				
	MIDDLE	<i>Praeglobotruncana</i>				
CENOMANIAN	UPPER	<i>Rotalipora</i>				
	MIDDLE	<i>Th. appenninica</i>				
ALBIAN	LOWER	<i>Th. ticinensis</i>				

le - Janoschek 1966 as „Zone KB” (Lower Campanian), and Salaj & Samuel 1966 as „*G. arca* Zone” (Lower Campanian). Dalbiez 1955 likewise describes a similar fauna from his „*G. elevata* zone”; according to him, however, *G. elevata elevata* Brotz. occurs up to the Maestrichtian, though this cannot be confirmed in my material. The „*G. stuarti*-zone” (Lower Middle Campanian) described by Bolli 1957 and 1960 also corresponds to the *G. elevata* zone. De Klasz (in Ganss 1956) and Scheibnerová 1961 likewise assign the beginning of *G. elevata* Brotz. (= *G. andori* De Klasz) to the Lower Campanian. Gandolfi 1955 notes, simultaneously the first appearance of a great number of other forms of *Globotruncana*, only some of which could be found in my material (e.g. *G. Bolli* Gand., *G. scutilla* Gand.).

The „Zone A” (Lower Campanian) described by Herm 1962 should probably still be assigned to the *G. concavata*-zone, as it still contains *G. concavata concavata* Brotz., while the one keeled *Globotruncana* *G. elevata* and its subspecies are not yet represented. On the other hand, the „*G. stuartiformis* Zone” (Lower Campanian), established by Hinte 1963, 1965, should be assigned to my *G. ventricosa* zone. Since *G. ventricosa* White already appears, while older forms, such as *G. renzi* Gand. etc. are completely absent, it could approximately be compared with the zone mentioned above. As has already been suggested in the preceding chapter, Hinte’s deeper „*G. elevata* zone” (Santonian) very likely represents an equivalent of my *G. elevata* zone.

Stratigraphic range: Lower Campanian to the lower part of Middle Campanian.

8) *Globotruncana ventricosa* zone

Simultaneous with the beginning of this zone which is characterized by the appearance of *G. ventricosa* White, a further rich development of the forms of the genus *Globotruncana* Cushman starts (similarly as it could be observed at the beginning of the *G. schneegansi* zone), so that now altogether more than 30 different species and subspecies of planktonic Foraminifera are represented in the *G. ventricosa* zone. This richness of forms makes it difficult to state a typical zonal faunal assemblage for this zone.

The faunal composition is generally characterized by the predominance of forms with two carinas; *G. lapparenti lapparenti* Brotz., *G. lapparenti tricarinata* (Quer.), *G. fornicata* Plum., *G. arca* (Cushman) and *G. bollii* Gand. are noteworthy as regularly appearing species. Representatives of *G. elevata stuartiformis* Dalb. are also regularly found. *G. elevata elevata* Brotz. occurs only in a few specimens and toward the top of the zone disappears entirely from the faunal composition. *G. renzi renzi* Gand. and *G. coronata coronata* Bolli no longer appear in the *G. ventricosa* zone.

In the upper part of the zone the species *G. aegyptiaca* Nakk. and *G. stuarti* (De Lapp.) appear for the first time, reaching their maximal distribution, however, only in the Maestrichtian. The same applies to the *Rugoglobigerina* appearing for the first time; in some samples of the *G. ventricosa* zone they constitute up to 30% of the entire fauna. Representatives of Heterohelicidae are found, but always only in a few specimens in all samples.

Planktonic Foraminifera occurring in the zone:

- Globotruncana marginata* (Reuss)
- G. lapparenti lapparenti* Brotzen
- G. lapparenti bulloides* Vogler
- G. lapparenti tricarinata* (Quereau)
- G. fornicata* Plummer
- G. arca* (Cushman)
- G. globigerinoides* Brotzen
- G. elevata elevata* Brotzen
- G. elevata stuartiformis* Dalbiez
- G. obliqua* Herm
- G. bollii* Gandolfi
- G. rosetta* (Carsey)
- G. scutilla* Gandolfi
- * *G. ventricosa* White
- * *G. caliciformis* De Lapparent
- * *G. cf. convexa* Sandidge
- * *G. cf. riojae* Martin
- * *G. patelliformis* Gandolfi
- * *G. aegyptiaca* Nakkady
- * *G. stuarti* (De Lapparent)
- * *Globotruncanella havanensis* Vorwijk
- * *Rugoglobigerina rugosa rugosa* (Plummer)
- * *R. rugosa rotundata* Brönnimann
- Heterohelix globulosa* (Ehrenberg)
- * *H. pupa* (Reuss)
- Pseudotextularia elegans* (Rzehak)
- * *P. intermedia* De Klasz
- * *Ventilabrella eggeri* Cushman

Benthonic accompanying fauna:

- Psammosphaera fusca* Schulze
- Saccamina placenta* (Grzybowski)
- Psammosiphonella rzehaki* (Andreae)
- Rhizammina indivisa* Brady
- Reophax splendidus* (Grzybowski)
- Nodellum velascoense* (Cushman)
- Hormosina ovulum ovulum* (Grzybowski)
- H. ovulum gigantea* Geroch
- Ammodiscus siliceus* (Terquem)
- Trochamminoides contortus* (Grzybowski)
- Recurvoides deflexiformis* (Noth)
- R. gerochi* Pflaumann
- Gaudryina modica* Bermudez
- Gaudryina* div. sp.
- Clavulinoides gaultinus* Morozowa
- Dorothia* div. sp.
- Marssonella oxycona* (Reuss)
- Nothia grilli* Pflaumann
- Dentalina* div. sp.
- Lagena* div. sp.
- Glandulina obtusissima* Reuss
- Bulimina murchisonia* D'Orbigny

Reussella szajnochae szajnochae (Grzybowski)
R. szajnochae californica Cushman
Pullenia quaternaria (Reuss)
Pleurostomella subnodosa (Reuss)
Pl. wadowiciensis Grzybowski
Gyroidina nitida (Reuss)
G. umbilicata (D'Orbigny)
Stensiöina exsculpta exsculpta (Reuss)
S. pommerana Brotzen
Osangularia div. sp.
Epistomina reticulata (Reuss)
E. stelligera (Reuss)

The *Globotruncana ventricosa* zone corresponds to the upper part of the „*G. elevata* zone” of Dalbierz 1955, to the upper part of the „Zone B” of Herm 1962, to the „*G. stuartiformis* Zone” and „*G. subspinosa* Zone” of Hinte 1963, to the range „Tieferes Campan II” (lower Upper Campanian) and „Höheres Campan II” of Kollmann 1964, to the upper part of the „*G. stuartiformis* zone” and the lower part of the „*G. caliciformis* zone” of Hinte 1966, to the „Zone KC” of Wille-Janoschek 1966 and finally to the „*G. rugosa* Zone” of Salaj & Samuel 1966. The different authors note in this range planktonic faunas containing a rich variety of forms similar to the ones mentioned above.

Bolli 1951, 1957, Gandolfi 1955, Barr 1962, Hinte 1963 and Kollmann 1964 describe the appearance of *G. ventricosa* White as beginning in the Campanian range. Sigal 1962, Brönnimann & Brown 1955, Hinte 1963 and Salaj & Samuel 1966 also describe *G. rosetta* (Carsey) and *G. stuarti* (De Lapp.) in this range. Bieda 1958, Herm 1962 and Salaj & Samuel 1966 note *Globotruncana* faunas rich in species in the range of the upper Lower Campanian to the end of Campanian.

According to Brönnimann 1952, Brönnimann & Brown 1955, Gandolfi 1955, Edgell 1957, Pessagno 1960, 1962, Kollmann 1964 and Wille-Janoschek 1966, the first appearance of representatives of the genus *Rugoglobigerina* can be assumed to have occurred in the Campanian, more precisely in the Middle-Campanian.

Stratigraphic range: Uppermost Lower-Campanian to the end of the Campanian.

8a) *Globotruncana calcarata* subzone

Since on the one hand, only a few specimens of the form *G. calcarata* Cushman have been found in my material, and on the other hand there are signs that the *G. ventricosa* zone reaches to the turn of Campanian/Maestrichtian (for instances, the appearance of *G. aegyptiaca* Nakk. and *G. stuarti* (De Lapp.)), the range containing *G. calcarata* Cushman has only been designated as a subzone. This was done so as to indicate that the lack of this zonal index-fossil need not mean a stratigraphical break, but only the nonoccurrence of a species of *Globotruncana* Cushman that, though it is typical and has a short vertical distribution, is also rather rare. The planktonic and benthonic accompanying fauna appearing together with *G. calcarata* Cushman can not be distinguished from that of the *G. ventricosa*-zone.

G. calcarata C u s h m. is one of the most characteristic and best described species of *Globotruncana*. It has world-wide distribution and is limited to the highest Campanian.

S i g a l 1952 describes this species from Algeria, R e i s s 1952 from Israel, H a m i l t o n 1953 from the subsoil of the Pacific, B r ö n n i m a n n & B r o w n 1955 from Texas, B r ö n n i m a n n & R i g a s s i 1963 from Cuba and B a n d y 1967 from California. In the European range, D e K l a s z describes this form from Bavaria (in G a n s s 1956), H e r m 1962 („Zone C”) from the Gosau of Reichenhall and Salzburg, H i n t e 1963 („*G. calcarata* Zone”) from the Gosau of Krappfeld (Carinthia), K o l l m a n n 1964 („Campan III”) from the Gosau of Gams (Styria) and W i l l e - J a n o s c h e k 1966 („Zone KB”) from the Gosau of Gosau and Abtenau (Salzburg). All these authors assume for *G. calcarata* C u s h m. a stratigraphic range from the uppermost Campanian to the turn of Campanian/Maestrichtian.

Only W i c h e r 1956 (Gosau of Gams) and S a l a j & S a m u e l 1966 (Western Carpathians) note for this species a range reaching up to the Maestrichtian. In the material investigated, however, specimens of *G. calcarata* C u s h m. have never been found together with typical faunal elements of the *G. stuarti* zone (Lower Maestrichtian) so that here too this form does not transcend the border of Campanian/Maestrichtian.

Stratigraphic Range: Uppermost Upper-Campanian.

9) *Globotruncana stuarti* zone

The predominance of one-keeled *Globotruncana* forms is characteristic for this zone; its best developed species, *G. stuarti* (D e L a p p.) has therefore been chosen as zonal index-form. Though the three newly appearing species of *Globotruncana*, *G. contusa* (C u s h m.), *G. gansseri* B o l l i and *G. falsostuarti* S i g a l, are typical indicators of the Maestrichtian, they are not suitable as zonal index-form, as they reach their individual maximal development, which is always considerably below that of *G. stuarti* (D e L a p p.), only in the Upper Maestrichtian (*G. mayaroensis* zone). As typical zonal faunal assemblage I regard the common appearance of *G. elevata stuartiformis* D a l b., *G. stuarti* (D e L a p p.), *G. gansseri* B o l l i and *G. falsostuarti* S i g a l, — being prominent in quantity. Besides these, *G. patelliformis* G a n d. and *G. contusa* (C u s h m.) can also appear frequently.

The species *G. lapparenti tricarinata* (Q u e r.), *G. arca* (C u s h m.), *G. bolli* G a n d., etc. reaching up from the *G. ventricosa* zone are always found in a few specimens but in no sample assume a predominance. Worthy of note is the nonoccurrence of *G. lapparenti lapparenti* B r o t z., *G. fornicata* P l u m. and *G. obliqua* H e r m, which do not transcend the border Campanian/Maestrichtian. Few representatives of *Heterohelix* (E h r e n b e r g) and other Heterohelicidae are found in every sample, at least more frequently than in the *G. ventricosa*-zone. Something similar is true of the *Rugoglobigerina*.

Planktonic Foraminifera occurring in the zone:

- Globotruncana lapparenti tricarinata* (Q u e r e a u)
- G. arca* (C u s h m a n)
- G. elevata stuartiformis* D a l b i e z
- G. bolli* G a n d o l f i

- G. rosetta* (Carsey)
G. scutilla Gandolfi
G. ventricosa White
G. caliciformis (De Lapparent)
G. patelliformis Gandolfi
G. aegyptiaca Nakkady
G. stuarti (De Lapparent)
* *G. contusa* (Cushman)
* *G. gansseri* Bolli
Globotruncanella havanensis Vorwijk
Rugoglobigerina rugosa rugosa (Plummer)
* *R. rugosa pennyi* Brönnimann
Heterohelix globulosa (Ehrenberg)
Pseudotextularia elegans (Rzehak)
P. intermedia De Klasz
* *P. varians* Rzehak
Ventilabrella eggeri Cushman

Benthonic accompanying fauna:

- Psammosiphonella cylindrica* (Glaessner)
Rhizammina indivisa Brady
Hormosina ovulum ovulum (Grzybowski)
H. ovulum gigantea Geroch
Nodellum velascoense (Cushman)
Recurvoides deflexiformis (Noth)
Spiroplectammina sp. 3. Grün
Gaudryina rugosa D'Orbigny
Marssonella oxycona (Reuss)
Cristellaria roemeri Reuss
Gyroidina nitida (Reuss)
Stensiöina pommerana Brotzen
Vaginulinopsis intermedia (Reuss)

The biozones noted by various authors from the Maestrichtian stage can on the basis of their faunas only be partly compared to my *G. stuarti* zone: By Dalbiez 1955 the upper part of the „*G. arca* zone” and the lower part of the „*G. contusa* zone”, by Wicher 1956 the „Maestricht I.”, by Bolli 1960 the „*G. lapparenti tricarinata* zone” and the lower part of the „*G. gansseri* zone”, by Pessagno 1960, 1962 the „*G. tilevi* subzone” and the lower part of the „*G. gansseri*-zone”, by Herm 1962 the „Zone D”, by Hinte 1963 the „*G. gansseri* Zone”, by Kollmann 1964 the upper part of the „Maestricht I.” and the lower part of the „Maestricht II.” (without *G. mayaroensis* Bolli), by Wille-Janoschek 1966 the „Zone KE” and by Salaj & Samuel 1966 the „*G. falsostuarti* zone”.

Moreover, Bolli 1951, Sigal 1952 and Edgell 1957 (*G. elevata* Brotz. = *G. falsostuarti* Sig.) describe *G. falsostuarti* Sig. from the Lower Maestrichtian. Troelsen 1955 and De Klasz (in Ganss 1956) also notes *G. contusa* (Cushm.) in this range. Brönnimann & Brown 1955, Gandolfi 1955 and Brönnimann & Rigassi 1963 describe equivalent faunas, assigning them a Lower Maestrichtian age (*G. stuarti* (De Lapp.), *G. gansseri* Bolli, *G. falsostuarti* Sig. etc.). All authors agree that the first appearance species of *Globotruncana* cited, preceded the appearance of *G. mayaroensis* Bolli. The more

frequent appearance of *Rugoglobigerina* in the Lower Maestrichtian is described by Brönnimann 1952, Brönnimann & Brown 1955, Gandolfi 1955, Pessagno 1960, 1962, Olsson 1960, Brönnimann & Rigassi 1963 and Wille-Janoschek 1966.

Stratigraphic range: Lower Maestrichtian.

10) *Globotruncana mayaroensis* zone

This zone is marked by the first appearance of *G. mayaroensis* Bolli. The planktonic accompanying fauna is similar to that of the *G. stuarti* zone; forms with one carina still dominate. However, representatives of *Globotruncana* with two keels occur more frequently than in the older zone (e.g. *G. aegyptiaca* Nakk., *G. contusa* (Cushman), *G. mayaroensis* Bolli). In some samples, *G. caliciformis* (De Lapp.), *G. patelliformis* Gand. and *G. contusa* (Cushman) assume a predominance.

The frequent occurrence of *Rugoglobigerina* is characteristic; *R. macrocephala* Brönnim. and *R. tilevi* (Brönnim. & Rig.) are noteworthy as forms limited to this zone. Also the more frequent appearance of Heterohelicidae is typical for this highest range of the Cretaceous. The important position of this two groups (*Rugoglobigerina* Brönnim. and Heterohelicidae) within the entire fauna of the *G. mayaroensis* zone is made still more clear by the fact that in this range there appears but one new species of *Globotruncana* against four new species of these two groups of Foraminifera.

Planktonic Foraminifera occurring in the zone:

- Globotruncana lapparenti tricarinata* (Quereau)
- G. arca* (Cushman)
- G. elevata stuartiformis* Dalbiez
- G. bollii* Gandolfi
- G. rosetta* (Carsey)
- G. scutilla* Gandolfi
- G. ventricosa* White
- G. caliciformis* (De Lapparent)
- G. patelliformis* Gandolfi
- G. aegyptiaca* Nakkady
- G. stuarti* (De Lapparent)
- G. contusa* (Cushman)
- G. gansseri* Bolli
- G. falsostuarti* Sigal
- * *G. mayaroensis* Bolli
- Globotruncanella havanensis* Vorwijk
- Rugoglobigerina rugosa rugosa* (Plummer)
- R. rugosa rotundata* Brönnimann
- R. rugosa pennyi* Brönnimann
- * *R. macrocephala* Brönnimann
- * *R. tilevi* (Brönnimann & Rigassi)
- Heterohelix globulosa* (Ehrenberg)
- * *H. striata* (Ehrenberg)
- Pseudotextularia elegans* (Rzehak)
- P. varians* Rzehak
- * *P. acervulinoides* (Egger)
- Ventilabrella eggeri* Cushman

Benthonic accompanying fauna:

Saccamina placenta (Grzybowski)
Psammosiphonella rzehaki (Andreae)
Reophax duplex Grzybowski
Nodellum velascoense (Cushman)
Glomospira septata Grün
Recurvoides gerochi Pflaumann
Gaudryina pyramidata Cushman
Marssonella oxycona (Reuss)
Nothia grilli Pflaumann
Dentalina div. sp.
Lenticulina div. sp.
Lagena div. sp.
Neoflabellina div. sp.
Stensiöina exsculpta (Reuss)
S. pommerana Brotzen
Globorotalites div. sp.

Like *Globotruncana calcarata* Cushman, *G. mayaroensis* Bolli is well known in literature owing to its typical appearance and its relatively short vertical distribution. Since this form also appears frequently (up to 35% to the entire fauna in some of my samples), it is particularly suited as zonal index fossil.

G. mayaroensis Bolli from the non-European range is described by Bolli 1951 (Trinidad), Brönnimann 1952 („*G. mayaroensis* zone”, Trinidad), Brönnimann & Brown 1955 (Cuba), Dalbiez 1955 (Tunisia), Bolli 1966 (upper part of the „*G. gansseri* zone” + „*Abathomphalus mayaroensis* zone”, Trinidad), Pessagno 1960, 1962 (upper part of the „*G. gansseri* subzone” and „*G. mayaroensis* subzone”, Puerto Rico), Hay 1960 („*Abathomphalus mayaroensis* zone”, Mexico) and Bandy 1967 (California).

European occurrences are described by Wicher 1956 („Maestricht II.”, Gosau of Gams), De Klasz (in Ganss 1956, Bavaria), Bolli & Cita 1960 („*Abathomphalus mayaroensis* zone”, Northern Italy), Berggren 1960, 1962 („*Pseudotextularia elegans* subzone”, Scandinavia), Herm 1962 („Zone E” + „Zone F”, Gosau of Reichenhall and Salzburg), Kollmann 1964 (upper part of the „Maestricht II” + „Maestricht III” + „Maestricht IV” Gosau of Gams), Wille-Janoschek 1966 („Zone KF”, Gosau of Gosau and Abtenau) and finally Salaj & Samuel 1966 („*Recemiguembelina varians* zone”, Western Carpathians).

Most of these authors, such as Gandolfi 1955, note in this range in addition to *G. mayaroensis* Bolli, accompanying faunas, as they have also been found in the material examined: *G. contusa* (Cushman), *G. gansseri* Bolli etc. All workers assign the appearance of *G. mayaroensis* Bolli to the Upper Maestrichtian. Brönnimann 1952, Brönnimann & Brown 1955, Gandolfi 1955, De Klasz (in Ganss 1956), Berggren 1962 and Salaj & Samuel 1966, among others, also describe the *Rugoglobigerina* and Heterohelicidae that appear simultaneously with the above mentioned *Globotruncana*, from the Upper Maestrichtian. A rich development of forms of these two groups is generally assumed.

Pożaryski & Witwicka 1956 and Witwicka 1958 give differing stratigraphic positions for some of the above-mentioned *Globotruncana*-forms. Thus they describe e.g. *G. marginata* (Reuss) still far in the Maestrichtian, while they note *G. mayaroensis* (Bolli) already in the Upper Campanian. As regards the latter form, however, there is probably no actual divergence in the stratigraphic assignment of this form, but only an error in determination on the part of the authors mentioned. Thus for instance fig. 36a-c and plate XVIII purporting to represent „*G. mayaroensis* Bolli” does not really show a representative of this species, but rather a specimen of *G. globigerinoides* Brotz., which also corresponds better with the stratigraphic range entered on plate XXIV.

CONCLUSIONS

The distribution of planktonic and benthonic Foraminifera within the individual zones has been determined by the counting-out of samples and is shown in text-fig. 2. Ostracoda, Radiolaria, spines of Echinoidea, etc. which occur only very rarely in the samples, were not taken into account, as taken altogether they never constitute more than 1% of the entire fauna of a sample. It appears that the seemingly most favourable life conditions for plankton were present in the ranges of the *Praeglobotruncana*, the *Globotruncana schneegansi*, and the *G. concavata* zone; but also in the most of the remaining zones plankton is clearly dominating, only in the *G. ventricosa* zone benthos and plankton are represented with 50% each.

The counting-out of sinistral- and dextral-coiled Foraminifera tests, as represented in text-fig. 3., only concerns members of the family Globotruncanidae. It shows that only in the *Thalmanninella ticinensis*-zone sinistral- and dextral-coiled Globotruncanidae hold their balance, while in the other zones dextral-coiled shells predominate by far.

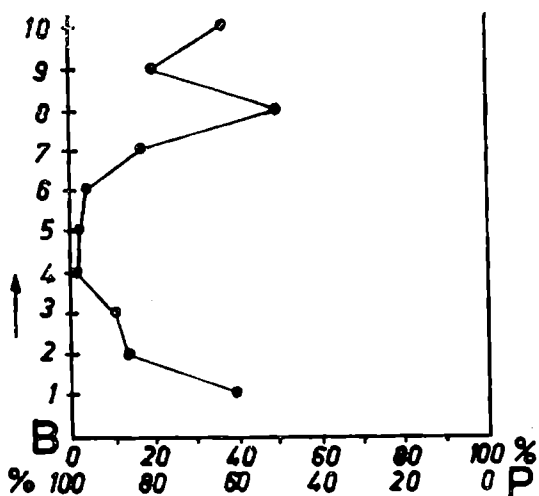


Fig. 2. Plankton-Benthos-distribution within the individual zones; B — benthonic Foraminifera; P — planktonic Foraminifera; 1, 2, 3 etc. — zone-numbers

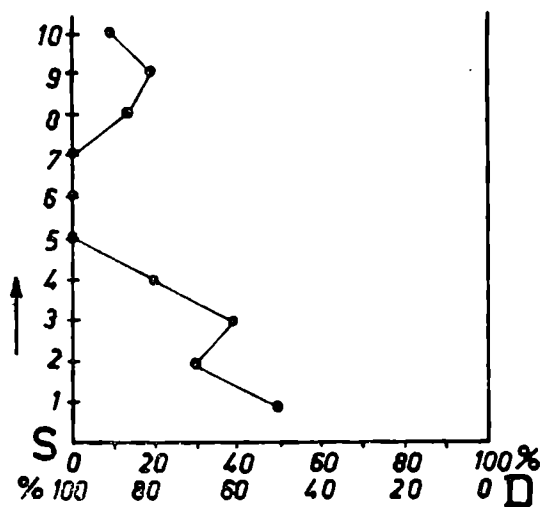


Fig. 3. Distribution of sinistral- and dextral-coiled Globotruncanidae within individual zones; S — sinistral-coiled, D — dextral-coiled, 1, 2, 3 etc. — zone numbers

The submitted results, however, are only meant to show the relations within the planktonic Foraminifera of the Upper Cretaceous as they are found in the range of „Helvetikum” („Ultrahelvetikum”) of Upper Austria. A strict assignation of the stated zones to individual stratigraphic stages (tab. 2.) was purposely avoided, so as not to make it appear that the stratigraphic significance of these zones extends beyond their regional range. Thus for instance the *Thalmaninella appenninica* zone was not defined as a section corresponding to the Middle Cenomanian, but as that range in which *Th. appenninica* and subspecies dominate and in which *Th. ticinensis* and subspecies no longer occur, while representatives of the genus *Rotalipora* Brotz. do not yet appear. In this way, it will also prove easier to correlate the faunas found with those described by other authors. As has been mentioned before (p. 103), an exact stratigraphic correlation could only be made after control tests with other groups of organisms.

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РЕЗЮМЕ

В западной части Аттерзее (Горная Австрия) появляется в тектонических окнах в пределах флишевой единицы низшая единица (Гельветикум или Ультрагельветикум). Эти образования содержат обильную фораминиферовую фауну, на основании которой выделено несколько стратиграфических горизонтов возрастом от альба/ценомана по маастрихт. Отдельные горизонты названы по находящимся в них закономерно и обильно видам, представленным в табл. 1—4. На основании литературных данных сделана лишь предварительная параллелизация выделенных зон со стратиграфическими ярусами.

1) Зона *Thalmanninella ticinensis*: Нижнюю границу этой зоны определяет появление рода *Thalmanninella* Sigal. Сначала он находится в подчиненном количестве, сопровождая бентонные известковистые фораминиферы как *Lenticulina*, *Gavalinella* и др. Выше доминируют представители *Th. ticinensis*.

2) Зона *Thalmanninella appenninica*. В этой зоне появляется *Th. appenninica* вместе с подвидами. Здесь уже отсутствует *Th. ticinensis* с подвидами и еще не встречается вида *Rotalipora Brotzen*. Среди фораминифер преобладает *Th. appenninica* вместе со своими подвидами. Впервые находится *Praeglobotruncana*.

3) Зона *Rotalipora* — начинается развитие *Rotalipora Brotzen* отличается от *Thalmanninella* Sigal по простым, радиально развитым, углубленным сутурам и сутурно расположенными добавочными отверстиями с узкими portici. В некоторых образцах обильно находится типичная *Th. reicheli* Morpd.

4) Зона *Praeglobotruncana*. Она отличается отчетливой доминацией индивидов рода *Praeglobotruncana* (выше 80% всей фауны) и отсутствием представителей *Thalmanninella* и *Rotalipora*. Второстепенно появляются первые представители рода *Globotruncana Cushman*.

5) Зона *Globotruncana schneegansi*: Нижнюю границу этой зоны обозначает внезапные и массовые появления многочисленных видов и подвидов рода *Globotruncana*. Род *Praeglobotruncana* уже вымер. Типичным для этой зоны является совместное нахождение *G. sigali* Reichel, *G. schneegansi* Sigal, *G. renzi* с подвидами, *G. coronata* с подвидами, *G. concavata primitiva* Dalbiez и в его вышней части *G. lapparenti lapparenti* Brotz. (вышеупомянутые формы составляют всегда более 70% всей фауны в образце).

6) Зона *Globotruncana concavata*. Типичный комплекс фауны сложен: *G. renzi renzi* Gand., *G. concavata concavata* Brotz., *G. concavata carinata* Dalbiez, *G. lapparenti lapparenti* Brotz., *G. lapparenti tricarinata* Quer., *G. arca* (Cushm.); *G. schneegansi* Sigal уже нет.

7) Зона *Globotruncana elevata*: Начало горизонта обозначается появлением *G. elevata elevata* Brotz. Типичный комплекс этой зоны, составляющий всегда более 60% фауны, сложен: *G. lapparenti lapparenti* Brotz., *G. fornicata* Plum., *G. arca* (Cushm.), *G. elevata elevata* Brotz., *G. elevata stuartiformis* Dalb., *G. bolli* Gand.

8) Зона *Globotruncana ventricosa*. Нижнюю границу зоны обозначает появление *G. ventricosa* White. В этой зоне наблюдается новое обильное развитие рода *Globotruncana* (свыше 30 видов и подвидов). Типичный комплекс этой зоны сложен *G. lapparenti lapparenti* Brotz., *G. lapparenti tricarinata* (Quer.), *G. fornicata* Plum., *G. arca* (Cushm.), *G. bolli* Gand., *G. elevata stuartiformis* Dalb. Это главным образом формы с двумя киями. Кроме планктона здесь находится тоже обильная сопровождающая бентонная фауна.

8а) Субзона *Globotruncana calcarata*: Так как с одной стороны типичный вид *G. calcarata* Cushm. встречен только в немногочисленных эгземплярах а с другой стороны зона *G. ventricosa* достигает границы кампан-маастрихт, эту зону можно было выделить лишь как субзону в пределах самой высокой части зоны *G. ventricosa*. Следовательно отсутствие *G. calcarata* не следует рассматривать как доказательство седиментационного перерыва.

9) Зона *Globotruncana stuarti*: Преобладают формы с одним килем. Самая характерная здесь *G. stuarti* (De Lapp.). Типичный комплекс сложен: *G. elevata stuartiformis* Dalb., *G. stuarti* (de Lapp.), *G. gansseri* Bolli, *G. falsostuarti* Sigal, *G. contusa* (Cushm.).

10) Зона *Globotruncana mayaroensis*: Нижняя граница этой зоны обозначается появлением *G. mayaroensis* Bolli. Кроме форм находящихся в предыдущей зоне здесь очень часто встречается формы с двумя киями (*G. aegyptica* Nakk., *G. patelliformis* Gand., *G. mayaroensis* Bolli). Обильны тоже представители рода *Rugoglobigerina*.

Как следует из фиг. 3 планктонные формы преобладают над бентонными с исключением зоны *Globotruncana ventricosa*. На фиг. 3 представлена частота встречаемости *Globotruncanidae* с направо- и налево-завернутыми раковинами. Лишь в зоне *Thalmaninella ticinensis* соотношение обоих форм равно 50:50. В остальных зонах, прежде всего вышних, преобладают виды с направо-завернутыми раковинами.

EXPLANATION OF PLATES

Plate IX

Fig. 1a—c. *Thalmaninella ticinensis ticinensis* (Gandolfi); P 181, Attersee *Th. ticinensis*-zone

Fig. 2a—c. *Thalmaninella ticinensis subticinensis* (Gandolfi); P 181, Attersee *Th. ticinensis*-zone

Fig. 3a—c. *Thalmaninella appenninica appenninica* (Renz); P 47, Attersee *Th. appenninica*-zone

Fig. 4a—c. *Thalmaninella appenninica gandolfii* (Luterbacher & Premoli Silva); P 46, *Rotalipora*-zone Attersee

Fig. 5a—c. *Rotalipora montsalvensis* Mornod; P 11, Attersee *Rotalipora*-zone

All Figs. 50X

Plate X

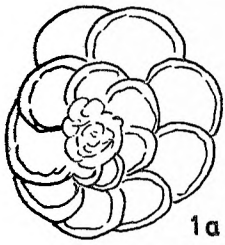
- Fig. 1a—c. *Rotalipora cushmani* (Morrow); P 46, Attersee *Rotalipora*-zone
Fig. 2a—c. *Rotalipora turonica turonica* Brotzen; P 68, Attersee *Rotalipora*-zone
Fig. 3a—c. *Rotalipora turonica thomei* Hagn & Zeil; P 68, Attersee *Rotalipora*-zone
Fig. 4a—c. *Praeglobotruncana oraviensis* Scheibnerová; P 65, Attersee *Praeglobotruncana*-zone
Fig. 5a—c. *Globotruncana carpathica* Scheibnerová; P 96, Attersee *Praeglobotruncana*-zone
All Figs. 50×

Plate XI

- Fig. 1a—c. *Praeglobotruncana helvetica* (Bolli); P 65, Attersee *Praeglobotruncana*-zone
Fig. 2a—c. *Praeglobotruncana biconvexa gigantea* (Samuel & Šalaj); P 96, Attersee *Praeglobotruncana*-zone
Fig. 3a—c. *Globotruncana schneegansi* Sigal; P 29, Attersee *G. schneegansi*-zone
Fig. 4a—c. *Globotruncana concavata carinata* Dalbiez; P 89, Attersee *G. concavata*-zone
Fig. 5a—c. *Globotruncana concavata primitiva* Dalbiez; P 73, Attersee *G. schneegansi*-zone
All Figs. 50×

Plate XII

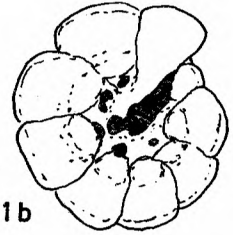
- Fig. 1a—c. *Globotruncana elevata elevata* Brotzen; P 78, Attersee *G. elevata*-zone
Fig. 2a—c. *Globotruncana ventricosa* White; P 87, Attersee *G. ventricosa*-zone
Fig. 3a—c. *Globotruncana calcarata* Cushman; P 64, Attersee *G. calcarata*-sub-zone
Fig. 4a—c. *Globotruncana stuarti* (De Lapparent); P 75, Attersee *G. mayaroensis*-zone
Fig. 5a—c. *Globotruncana mayaroensis* Bolli; P 120, Attersee *G. mayaroensis*-zone
All Figs. 50×



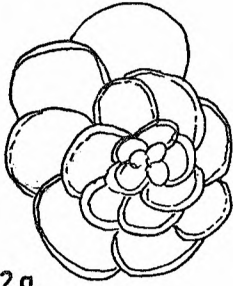
1a



1c



1b



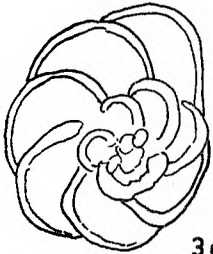
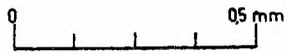
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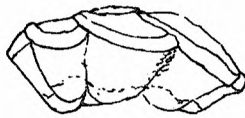
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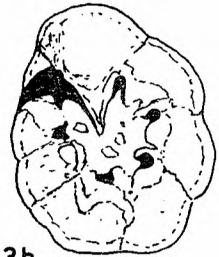
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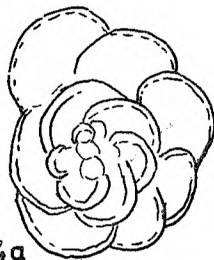
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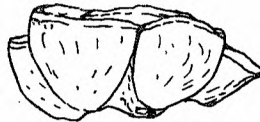
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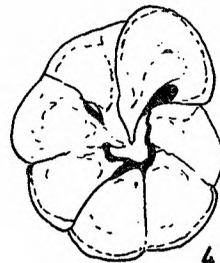
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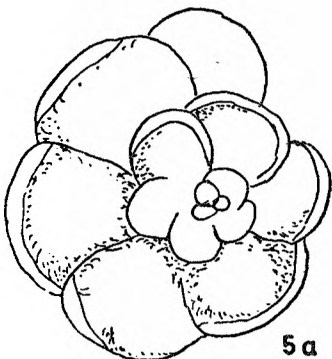
4a



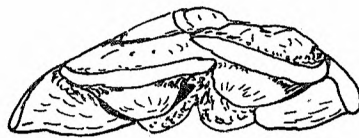
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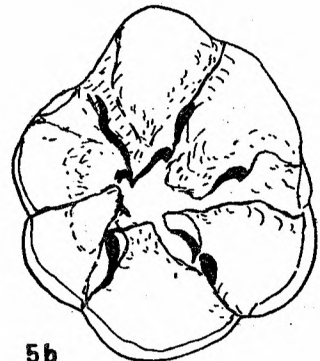
4b



5a



5c



5b

