Upper Eocene to Early Miocene Planktonic Foraminifera from the Subsurface Sediments in Cauvery Basin, South India*)

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With 13 plates, 14 figures, 1 table

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Abstract

Fifty species and subspecies of planktonic foraminifera, belonging to the genera *Globigerina, Globigerinoides, Globigerinita, Globigerapsis, Globoquadrina, Globorotalia, Globigerinopsis, Pseudohastigerina, Hantkenina, Cribrohantkenina, Cassigerinella* and *Chiloguembelina,* are systematically described, for the first time, from the Upper Eocene, Oligocene and early Miocene subsurface sediments in Cauvery basin, South India. Two new species, *Globigerina sastrii* and *Globigerinopsis guhai,* are described.

Seven planktonic foraminiferal zones are proposed for the Upper Eocene to early Miocene sequence. The zones, in order from bottom to top, are: *Globigerapsis mexicana* zone, *Globorotalia cerroazulensis* zone, *Globigerina gortanii* zone, *Globigerina sastrii* zone, *Globigerina ampliapertura* zone, *Globigerina angulisuturalis* zone and *Globorotalia kugleri/ Globigerinoides primordius* zone.

The significance of these findings in correlation of the sections in Cauvery basin with those from other tropical regions is discussed. The Eocene — Oligocene limit is placed at the top of the *Globorotalia cerroazulensis* zone. The Oligocene — Miocene limit is placed at the lower boundary of the *Globorotalia kugleri/Globigerinoides primordius* zone.

Introduction

The last two decades are marked by a stupendous increase in our knowledge on planktonic foraminifera and a rapid growth of their importance in biostratigraphic classification and intercontinental correlations. Researches of Bolli (1957) and several others in Caribbean region have led to an elaborate planktonic foraminiferal zonal classification of the Cretaceous and Cenozoic marine sediments. These works were followed by attempts to recognize the Trinidad zones in other parts of the world. Much of additional knowledge on the mid-Tertiary planktonic foramini-

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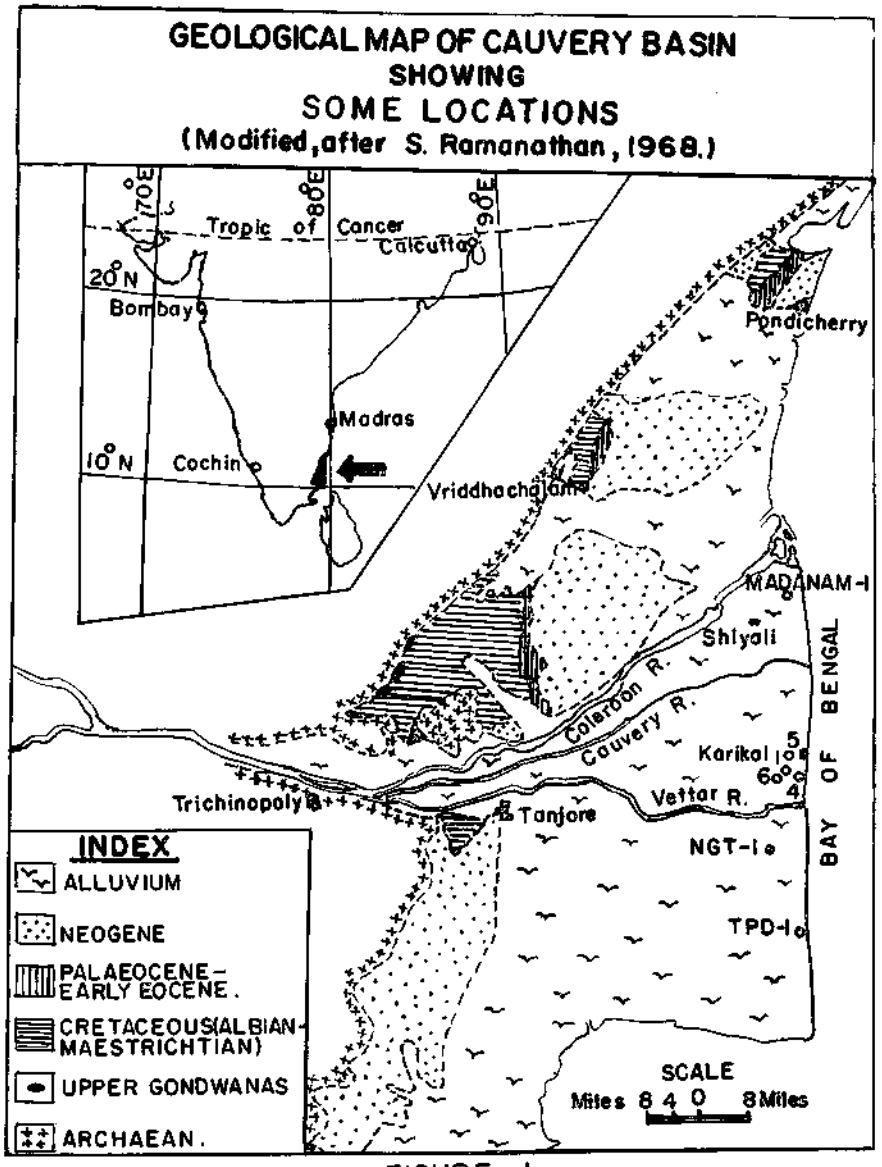
fera was brought out by BLOW & BANNER (1962) and BLOW (1969) from sections in East Africa and other tropical regions.

Some preliminary studies carried out during the last six years on Indian localities have indicated the presence of rich assemblages of planktonic foraminifera. However, most of the species were not systematically described and the knowledge on stratigraphic distribution of already known species is very limited.



FIGURE–1

The present study is an attempt to systematically describe the Upper Eocene, Oligocene and early Miocene planktonic foraminifera from the subsurface sections in Cauvery basin, South India; to define a sequence of biostratigraphic zones and to evaluate their value in correlation with sections outside this region.

Previous work

The Upper Eocene to Lower Miocene planktonic foraminifera are known in Cauvery basin only from the deep exploration wells drilled by Oil & Natural Gas Commission since 1964. The occurrence of some diagnostic species was reported by RAJU (1966). Later, RAJU (1967, 1968) recognized some planktonic foraminiferal zones in the Late Cretaceous to Oligocene subsurface sediments. However, the planktonic species were not systematically described so far. The knowledge on the mid-Tertiary planktonic foraminifera from other sedimentary basins in India is very limited.

Present work

The present study is essentially limited to the core samples. Data from the following intervals of the deep wells from Cauvery basin constitute the main theme of the present study.

Well No.	Depth interval	Number of cores studied
KKL-1	800—1600 m.	7
KKL-2	1000—1530 m.	6
KKL-4	800—1800 m.	15
KKL-5	1000—1800 m.	5
KKL-6	1000—1800 m.	4
NGT-1	1600—2000 m.	2
Madanam-1	800—1300 m.	3
TPD-1	450— 950 m.	5

The following abbreviations, KKL for Karaikal, NGT for Nagapattinam, TPD for Tirupundi, are used in this paper (see fig. 1).

One to six samples are studied from each core depending on the length recovered. Besides these almost all the cutting samples representing every three metres interval of the well are also studied. There are considerable gaps between the cores and as such the complete distribution of many of the species could not be satisfactorily determined during this study. Some data from well cutting samples are incorporated in preparing the range chart, only to indicate last occurrences (extinctions) of some diagnostic species.

Resume of the general stratigraphy of the Cauvery basin

The oldest sediments known, which overlie the Archaean metamorphics in Cauvery basin, are the so-called "Upper Gondwanas" exposed as small

patches along the western fringes of the basin. They are essentially lacustrine to brackish water deposits of ? Jurassic to Lower Cretaceous age. Overlying the "Upper Gondwanas" are the well known Cretaceous (Albian to Maestrichtian) sediments, which are widely distributed in the Cauvery basin (see Figure 1). These marine Cretaceous sediments were the source of many palaeontological works during the last 90 years.

The Cretaceous rocks are overlain by marine Paleocene-early Eocene sediments particularly in the Pondicherry and Trichinopoly areas. The Paleocene-early Eocene sediments are overlain, on the surface, by continental deposits known as "Cuddalores" of Neogene age. Large areas in the eastern part of the basin are covered by Alluvium or laterites.

Marine sediments younger than the Lower Eocene are known only in the subsurface, deep well sections. Recent Petroleum exploration activities, geophysical surveys and deep drilling by Oil & Natural gas Commission, have added considerable knowledge on the subsurface stratigraphy and structure of this basin. For some of these details reference is made to RAMANATHAN (1968).

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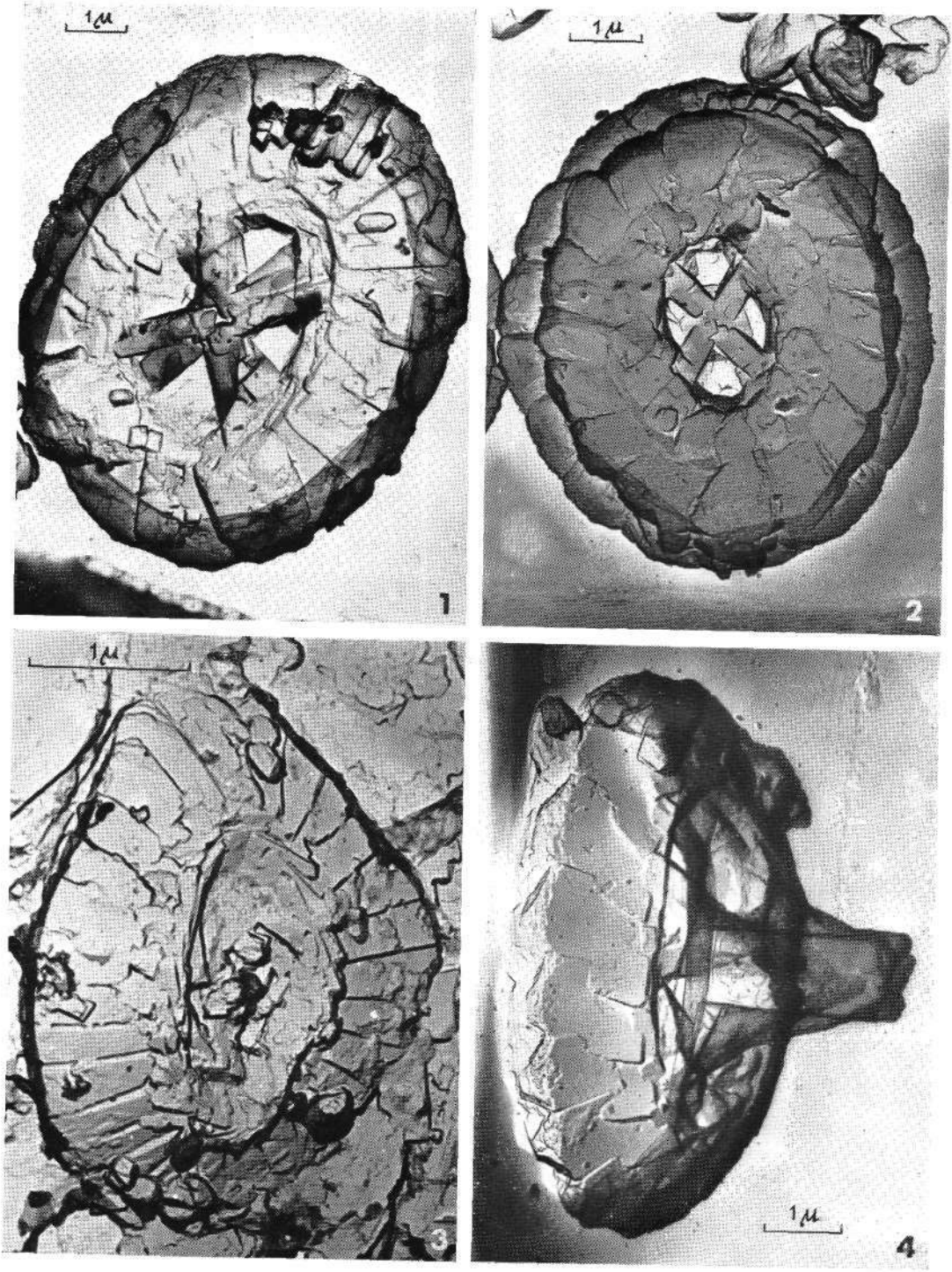
Zonation

Most of the Upper Eocene to early Miocene planktonic foraminiferal species, reported from other tropical regions, are now recorded from Cauvery basin. However, the recognition of the zonal boundaries within the subsurface sections in Cauvery basin is hamphered to a great extent due to the absence of continuous core samples. The boundary between the *Globorotalia cerroazulensis* zone and *Globigerina gortanii* zone falls within cored interval of a well. The microfaunal changes at the other zonal boundaries could not be precisely defined. Six of the zonal boundaries are defined here by horizons of extinction of markers, while two are defined by the first appearance level. The horizons of extinction, used here in definition

PLATE 18



G. semiinvoluta-G. barri zone, *G. cerroazulensis* zone and *C. cubensis-G. ampliapertura euapertura* zone. The present study has resulted in providing additional data from the *G. mexicana* zone (= *G. semiinvoluta* zone) and *G. cerroazulensis* zone, subdivision of "*C. cubensis-G. ampliapertura euapertura* zone" into three zones and in recognition of two additional zones in the Late Oligocene-early Miocene sequence.

Globigerapsis mexicana zone

Author: BOLLI, 1957 (given as *Globigerapsis semiinvoluta* zone).
Reference section: Core between 1904. 2 and 1906. 5 m. inNGT-1.
This zone is defined as the interval from the last occurrence of *Truncorotaloides rohri* BRÖNNIMANN & BERMUDEZ to the last ocurrence of *Globigerapsis mexicana* (CUSHMAN). A very rich assemblage of planktonic foraminifera is known from this interval in NGT-1. The assemblage includes *Globigerapsis mexicana*, *G.* cf. *tropicalis* BLOW & BANNER, *Globigerinatheka barri* BRÖNNIMANN, *G.* cf. *lindiensis* BLOW & BANNER, *Pseudohastigerina micra* (COLE), *Hantkenina alabamensis* CUSHMAN, *H. suprasuturalis* BRÖNNIMANN, *H. trinitatensis* BRÖNNIMANN, *H.* cf. *thalmanni* BRÖNNIMANN, *Hantkenina* sp., *Globigerina corpulenta* SUBBOTINA, *G. pseudocorpulenta* CHALILOV, *G. gortanii praeturritilina* BLOW & BANNER, *G. angiporoides* HORNIBROOK, *Chiloguembelina martini* (PIJPERS), *C. cubensis* (PALMER) and *Globigerinita* spp. A poorly preserved form with doubtful cribrate aperture, referred here to as *Cribrohantkenina* cf. *inflata* (HOWE) is also found in this zone.

A rich assemblage of larger foraminifera including *Pellatispira madaraszi*, *Nummulites* cf. *fabianii* and *Discocyclina* spp. are recorded from core samples, at a depth of 1230 m. in Madanam-1, belonging to this zone.

The extinction level of *T. rohri* was marked in almost all the wells drilled in Cauvery basin and found to be a very useful horizon in well to well correlation. The extinction level of *G. mexicana* was marked in only a few wells so far.

Globorotalia cerroazulensis zone

Author: BOLLI, 1957 (given as *Globorotalia cocoaensis* zone).
Reference section: Cores between 1689 and 1720 m. in KKL-4.
This zone is defined as the interval between the last occurrence of *Globigerapsis mexicana* and the last occurrence of *Globorotalia cerroazulensis* (COLE). *Cribrohantkenina inflata* (HOWE), *Hantkenina alabamensis*, *Globorotalia cerroazulensis*, *G. centralis* CUSHMAN & BERMUDEZ and several other species shown in table I are common in this zone. The extinction level of *G. cerroazulensis* was marked in all the wells drilled near Karaikal, Nagapattinam and Tirupundi and this horizon is one of the most useful levels in well to well correlation of the subsurface sequence and in intercontinental correlation. In Karaikal well-6, the top of *G. cerroazulensis*

zone falls within a core and the foraminiferal assemblages above and below this horizon do not indicate any major paleoenvironmental change.

Chiloguembelina cubensis assemblage

The present author (RAJU, 1968) proposed, tentatively, the *C. cubensis-G. ampliapertura euapertura* assemblage zone from the interval from the last occurrence of *G. cerroazulensis* to the last occurrence of *Chiloguembelina cubensis* (PALMER). The present study has led to the recognition of three zones within this interval.

Globigerina gortanii zone

Authors: BLOW & BANNER, 1962, emended here.
Reference section: Core between 1800 and 1803 m. in NGT-1.
This zone is defined as the interval from the last occurrence of *G. cerroazulensis* to the first appearance of *Globigerina sastrii* n. sp. The common species in this zone are *Globigerina gortanii gortanii* (BORSETTI), *G. gortanii praeturritilina* BLOW & BANNER, *G.* cf. *pseudoampliapertura* BLOW & BANNER, *G. ampliapertura* BOLLI, *G. prasaepis* BLOW, *Globorotalia increbescens* (BANDY), *Pseudohastigerina barbadoensis* BLOW and *Cassigerinella chipolensis* CUSHMANN and PONTON. *Cassigerinella chipolensis* and *P. barbadoensis* occur together even in the very basal part of this zone. No forms referable to *Globigerina sellii* BORSETTI are found in this zone.

Globigerina sastrii zone

Author: Proposed here.
Type section: Cores between 1579 and 1586 m. in KKL-4.
This zone is defined by the range of *Globigerina sastrii* n. sp. The planktonic foraminifera recorded from the type section of this zone include *Globigerina sastrii* n. sp., *G. gortanii gortanii, G. sellii* BORSETTI, *G. ampliapertura, G. tripartita tripartita* KOCH, *G. tripartita rohri* BOLLI, *G. prasaepis, Globorotalia* cf. *opima opima* BOLLI, *G. opima nana* BOLLI, *G. gemma* JENKINS, *Cassigerinella chipolensis, Chiloguembelina cubensis* and other forms. Rare forms of *Lepidocyclina (Nephrolepidina)* cf. *isolepidinoides* are also found in this zone in KKL-4 and TPD-1. *Globigerina sastrii* n. sp. is very common in Cauvery basin and has a short range. However, it may be of local value only as this species was not described from sections outside the Cauvery basin.

Globigerina ampliapertura zone

Author: BOLLI, 1957, emended.
Reference section: Drill cutting samples from section immediately overlying the *G. sastrii* zone in KKL-4.

This zone is tentatively defined as the interval from the last occurrence of *Globigerina sastrii* n. sp. to the last occurrence of *Globigerina ampliapertura*. The study of the drill cutting samples indicate that *G. ampliapertura* extincts approximately at the same level as that of *Chiloguembelina cubensis* in Karaikal wells.

Globigerina angulisuturalis zone

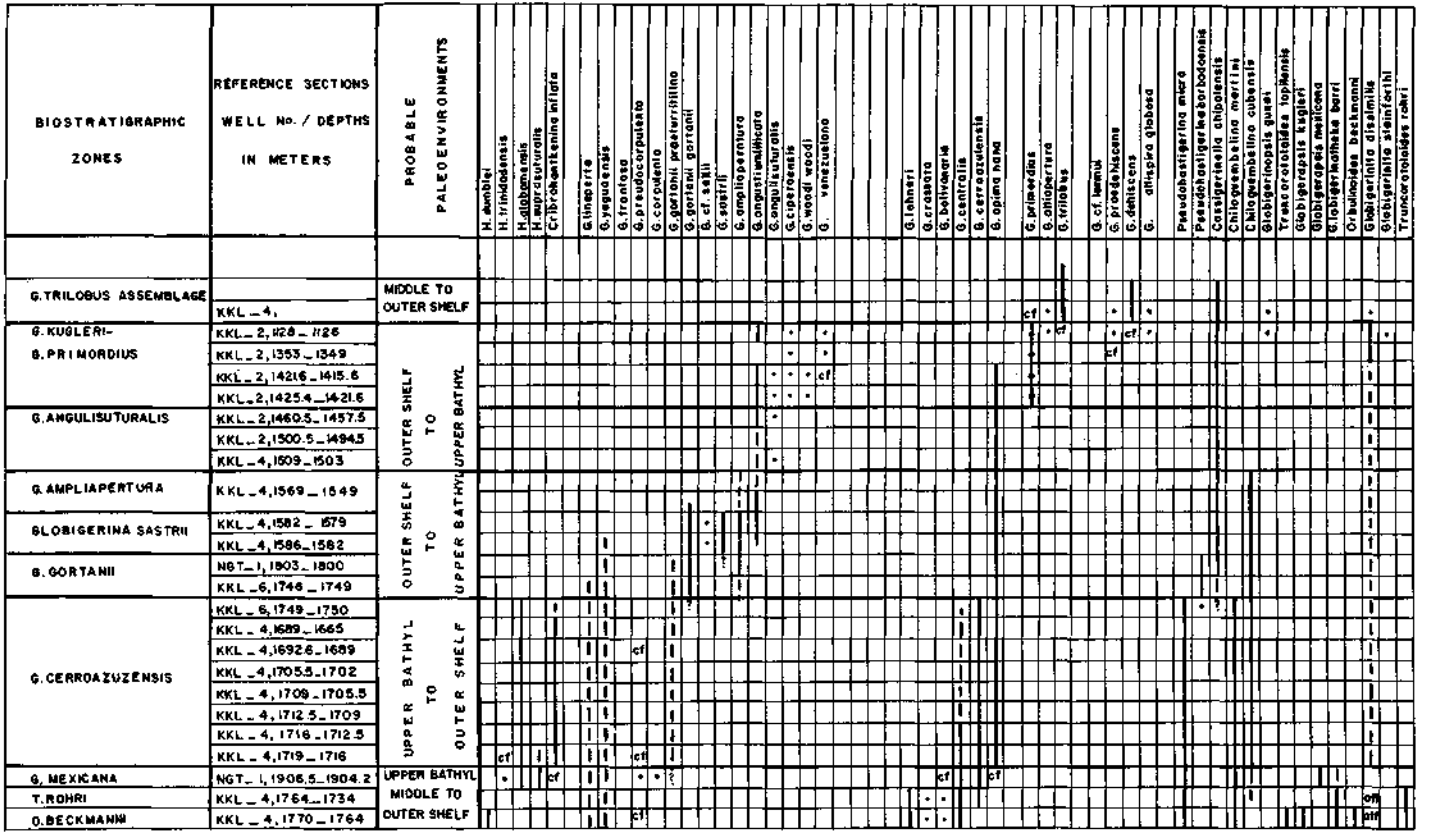
Author: BLOW, 1969, emended.
Reference section: Cores between 1450 and 1500 m. in KKL-2.
This zone is defined as the interval from the last occurrence of *Globigerina ampliapertura* to the first appearance of *Globigerinoides primordius* BLOW & BANNER. The planktonic foraminifera recorded from this zone include *Globigerina angulisuturalis* BOLLI, *G. ciperoensis* BOLLI, *G. angustiumbilicata* BOLLI, *G. woodi woodi* JENKINS, *Globorotalia siakensis* (LEROY), *G. opima nana* BOLLI, *Cassigerinella chipolensis*, *Globoquadrina* cf. *larmeui* AKERS and very rare forms referable to *Globigerina gortanii gortanii* (BORSETTI). *Globoquadrina* first appears in this zone. Larger foraminifera *Lepidocyclina (Eulepidina)* sp. and *L. (Nephrolepidina)* are also recorded within this zone in KKL-2.

Globorotalia kugleri / Globigerinoides primordius zone

Author: BLOW, 1969, Zone N 4.
Reference section: Cores between 1126 and 1425 m. in KKL-2.
This zone is defined as the interval from the first appearance of *Globigerinoides primordius* BLOW & BANNER to the last occurrence of *Globorotalia kugleri* BOLLI. The planktonic species recorded from the lower part of this zone include *Globigerina angulisuturalis*, *G. ciperoensis*, *Globigerinoides primordius*, *Globorotalia siakensis*, *G. opima nana* and *Globoquadrina* cf. *larmeui*. In the middle part of this zone, though *Globigerinoides primordius*, *Globorotalia siakensis* and a few other forms are recorded, the planktonic forms are rare. Again, the planktonic foraminifera are abundant in the upper part of this zone. The assemblage includes *Globorotalia kugleri* BOLLI, *G. siakensis*, *G. obesa* BOLLI, *Globoquadrina praedehiscens* BLOW & BANNER, *G. altispira globosa* BOLLI, *Globigerinoides* cf. *altiaperturus* BOLLI, *Globigerinopsis guhai* n. sp., *Globigerinita dissimilis* (CUSHMAN), *G. stainforthi* (BOLLI, LOEBLICH & TAPPAN), *Globigerina venezuelana* HEDBERG and rare forms of *Globigerina binaiensis* KOCH.

Globigerinoides trilobus assemblage

Planktonic foraminiferal zones are not successfully recognized so far in the interval above the *G. kugleri/G. primordius* zone in the subsurface sections in Cauvery basin. In the sequence above the *G. kugleri/G. primordius* zone, the larger foraminifera Miogypsinidae and *Lepidocyclina* are common and planktonics are not adequately represented.



TABLE–1 THE DISTRIBUTION OF SOME STRATIGRAPHICALLY IMPORTANT MIDDLE EOCENE TO LOWER MIOCENE PLANKTONIC FORAMINIFERA IN CAUVERY BASIN

The biostratigraphic unit *Globigerinoides trilobus* assemblage is proposed here, provisionally, to denote the interval in Cauvery basin from the top of *G. kugleri/G. primordius* zone to the level of the first appearance of *Globigerinoides sicanus* DE STEFANI (= *G. bisphericus* TODD). The planktonic foraminifera recorded from this interval include *Globigerinoides trilobus trilobus* (REUSS), *G. altiaperturus* BOLLI, *G. subquadratus* BRÖNNIMANN, *Globoquadrina altispira* s. l., *G. dehiscens dehiscens* (CHAPMAN, PARR & COLLINS), *Globorotalia obesa, G. siakensis* and rare forms of *Globorotalia peripheroronda* BLOW & BANNER. *Globigerina binaiensis* KOCH and *Globoquadrina praedehiscens* are found in the lower part of this unit.

In KKL-4 *Miogypsina (Miogypsinoides) dehaarti-M. (Miogypsina) tani, M. (Miogypsina) globulina* and *M. (Miogypsina) antellia* are recorded from the sequence between 940 and 246 m. In Madanam well-1 *Miogypsina (Miogypsinoides) bantamensis-M.(Miogypsina) gunteri, M.(Miogypsina)* cf. *mediterranea* and *M. (Miogypsina) antellia* are recorded from the sequence between 1050 and 250 m. Further study on the planktonics and Miogypsinidae from the interval above the *G. kugleri/G. primordius* zone is under progress.

Correlations

The distribution of the Upper Eocene to early Miocene planktonic foraminifera from the tropical regions, particularly as worked out by BOLLI (1957) from Trinidad, by BLOW & BANNER (1962) from Lindi area, East Africa and by BLOW (1969) from several tropical regions, and the data from the present investigation in Cauvery basin indicates that a detailed correlation of these sections is possible. Various successful attempts were made during the last few years to correlate the sections from different continents with the zonal scheme proposed by BOLLI (1957) and or by BLOW & BANNER (1962). The planktonic zones have found a wide spread acceptance and applicability in several regions. However, there is no agreement as to the usage of the planktonic zonal scheme. In general different zones were proposed for different parts of the world, obviously due to the reasons of geographical distribution of the planktonic foraminifera. BANNER & BLOW (1965) and BLOW (1969) have proposed a very detailed zonal scheme for the Upper Eocene to Recent tropical regions. On the other hand, a simplified planktonic foraminiferal zonal scheme applicable also to temperate Mediterranean Neogene was proposed as a result of the coordination of some 22 specialists, CATI et al. (1968).

The correlation of the zones from Cauvery basin with those proposed by BOLLI (1969) and BLOW (1969) is presented in figure 3. The correlations are based on the distribution of the planktonic foraminifera within the regions concerned with the assumption that the levels of the initial appearance and extinction of the species are synchroneus events in these regions.

In general the successive levels of appearance and extinction of species are comparable.

However, a few minor discrepancies in the ranges of the presently recorded species could be noted from the published accounts. But it may be mentioned that the present observations are very close to those of BLOW (1969).

1. *Cassigerinella chipolensis:* BOLLI (1957) has shown that *Cassigerinella chipolensis* first appears at the base of *G. ampliapertura* zone in Trinidad. BLOW & BANNER (1962) traced its range from the base of *G. oligocaenica* zone in East Africa. BLOW (1969) gave the range of *C. chipolensis* from the Zone P 18 (= *Globigerina tapuriensis* zone) to Zone

Zones proposed here for Cauvery Basin	BLOW W. H. (1969)	BOLLI H. M. (1966)
Globigerinoides trilobus assemblage	N. 6 Globigerinatella insueta / Globigerinita dissimilis	Catapsydrax stainforthi
	N. 5 Globoquadrina dehiscens praedehiscens-G. dehiscens dehiscens	Catapsydrax dissimilis
Globorotalia kugleri / Globigerinoides primordius	N. 4 Globigerinoides quadrilobatus primordius / Globorotalia kugleri	Globorotalia kugleri
Globigerina angulisuturalis	N. 3 Globigerina angulisuturalis (P. 22)	Globigerina ciperoensis ciperoensis
	N. 2 Globigerina angulisuturalis (P. 21) / Globorotalia (T) opima opima	Globorotalia opima opima
Globigerina ampliapertura	N. 1 Globigerina ampliapertura (P. 20)	Globigerina ampliapertura
Globigerina sastrii	P. 19 Globigerina sellii / Pseudohastigerina barbadoensis	Cassigerinella chipolensis / Hastigerina micra
	P. 18 Globigerina tapuriensis	
Globigerina gortanii	P. 17 Globigerina gortanii gortanii / Globorotalia (T) centralis	
Globorotalia cerroazulensisis	P. 16 Cribrohantkenina inflata	Globorotalia cerroazulensis
Globigerapsis mexicana	P. 15 Globigerapsis mexicana	Globigerapsis semiinvoluta
Truncorotaloides rohri	P. 14 Truncorotaloides rohri / Globigerinita howei	Truncorotaloides rohri
Orbulinoides beckmanni	P. 13 Orbulinoides beckmanni	Porticulasphaera mexicana

Figure 3. Relationship of the zones proposed here for Cauvery basin to those given by BOLLI (1966) and BLOW (1969).

N 13 and gave the range of *Cassigerinella eocaena* CORDEY from Zone P 16 to Zone P 19. In Cauvery basin *Cassigerinella chipolensis* is found at the very basal part of the *G. gortanii* zone.

2. *Globigerinoides primordius:* This species appears in Cauvery basin at the base of *G. kugleri/G. primordius* zone, at a level before the first appearance of *Globorotalia kugleri* and the extinction of *Globigerina angulisuturalis*. BLOW (1969) has already noted the concurrence of the ranges of *G. primordius* and *G. angulisuturalis* in the lower part of Zone N 4. However, there are some minor discrepancies in the published accounts regarding the first appearance of *Globigerinoides*.

3. *Globoquadrina* appears in Cauvery basin in the *G. angulisuturalis* zone.

4. Many planktonic species viz. *Globoquadrina altispira globosa, Globigerinita stainforthi* appear in Cauvery basin in the uppermost part of the *G. kugleri/G. primordius* zone. In Trinidad these species are known to appear at the base of *C. dissimilis* zone (BOLLI, 1957). BLOW (1969) has shown that *Globorotalia kugleri* overlaps the ranges of *G. stainforthi* and *G. altispira globosa*.

Figure 4.

BLOW, 1969	BOLLI, 1966		
N 5	C. dissimilis	M / O	BOLLI, 1957.
N 4	G. kugleri		
N 3 (= P 22)	G. ciperoensis	M / O	"Comité du Néogène", BLOW, 1969; CATI et al., 1968.
N 2 (= P 21)	G. opima opima	M / O	JENKINS, 1966.
N 1 (= P 20)	G. ampliapertura	M / O	BERGGREN, 1969.
P 19	Cassigerinella chipolensis / Hastigerina micra	M / O	EAMES et al., 1962.
P 18		O / E	EAMES et al., 1962, Eocene Colloquium, Paris, 1968.
P 17		O	BLOW, 1969.
P 16	G. cerroazulensis	O E / E	BOLLI, 1957; BANDY, 1964.
P 15	G. semiinvoluta		

M / O = Oligocene / Miocene boundary

O / E = Eocene / Oligocene boundary

Limits of Oligocene

The problem of marking the limits of Oligocene is topic of many debates and discussions during the last one and half decades. Recent attempts to relate the European Stages to the tropical planktonic zonal sequence have led to many controversial conclusions (EAMES et al, 1962; DROOGER, 1964; BLOW, 1969; BERGGREN, 1969, and others). The interpretations by various authors have led to controversies in marking the Eocene-Oligocene and Oligocene-Miocene boundaries. Some of the interpretations are summarized in figure 4.

Eocene-Oligocene boundary

The top of the *Globorotalia cerroazulensis* zone was taken to mark the Eocene-Oligocene boundary by many authors (BOLLI, 1957, 1966; BANDY, 1964, and others). The present author (RAJU, 1968) has earlier supported this view particularly taking account of the subsurface sections in Cauvery and Cambay basins, India.

The delegates to the Eocene Colloquium, Paris, 1968 (in Press, see BRABB, 1969) unanimously agreed for placing the Eocene-Oligocene limit between the *Nummulites fabianii* and *N. intermedius* zones for the *Nummulites*, between the *Globigerina gortanii* and *Hastigerina micra/ Cassigerinella chipolensis* zone (= *Globigerina sellii* zone) for the planktonic foraminifera and between the *Isthmolithus recurvus* and *Ellipsolithus subdistichus* zones for the nannoplanktons.

In Cauvery basin, in three of the wells, namely Madanam-1, TPD-1 and Tiruttaraipundi-1, where the larger foraminifera are dominant, the Eocene-Oligocene boundary is marked at the extinction level of *Pellatispira*. This level could be interpreted as marking the top of the Priabonian Stage. However, in the well sections around Karaikal and Nagapattinam the Upper Eocene larger foraminifera are not present and it is difficult to mark a horizon in the planktonic scale time equivalent to extinction level of *Pellatispira*. In these sections the extinction level of *G. cerroazulensis* and *Hantkenina* could be confidently marked on the basis of either core or cutting samples.

BLOW (1969) considered that the Eocene-Oligocene boundary will be approximately between the Zone P 17 (= *G. gortanii/G. [T.] centralis* zone) and Zone P 18 (= *G. tapuriensis* zone). BLOW (1969) and CLARKE & BLOW (1969) have shown that the characteristic Eocene foraminifera *Pellatispira, Discocyclina, Hantkenina,* and *Globorotalia cerroazulensis* all range only to the lower part of Zone P 17. It may be noted that the lower part of Zone P 17 of BLOW (1969) is equivalent to the uppermost part of *G. cerroazulensis*.

BAUMANN & ROTH (1969) observed that the *Ericsonia subdisticha (= Ellipsolithus subdistichus)* zone is restricted to the lower part of the *Globigerina gortanii gortanii* zone and further noted that the Latdorfian belongs to the *E. subdisticha* zone, and to the very base of the *Cyclococco-*

lithus margaritae zone. These evidences indicate that the Eocene-Oligocene boundary could be best placed at the top of the *G. cerroazulensis* zone.

Oligocene-Miocene boundary

This problem was discussed in detail by EAMES et al. (1962), DROOGER (1964), JENKINS (1966), RAJU (1968), BERGGREN (1969), and BLOW (1969). BERGGREN (1969) has drawn, provisionally, the Oligocene-Miocene boundary at the N 1/N 2 zonal boundary. BLOW (1969) accepted the recommendations of the "Comité du Néogène" in placing the Oligocene-Miocene boundary at the *Globigerinoides* datum, which coincides with the base of Zone N 4.

The Committee on Mediterranean Neogene stratigraphy has defined, in 1964 and 1967, the lower limit of the Miocene by the first appearance of *Globigerinoides* and *Miogypsina gunteri* (see PAPP et al., 1968). In Cauvery basin this level coincides with the lower boundary of *G. kugleri/ G. primordius* zone. In Madanam well *M. (Miogypsina) gunteri-M. (Miogypsinoides) bantamensis* assemblage is found. Thus in Cauvery basin the Oligocene-Miocene boundary could be marked on the basis of the criteria set forth by the Committee on Mediterranean Neogene Stratigraphy.

Systematics

General remarks

Planktonic foraminifera are very rich in the Upper Eocene to early Miocene sediments in parts of Cauvery basin. The preservation of the specimens is good and the morphological details could be easily observed. Some specimens from the *G. sastrii* zone are, however, poorly preserved.

The specific determination was made first with the aid of the description and illustrations of the types. Most of the specimens were sent to Prof. H. M. BOLLI (Zürich) in 1968 for checking the identifications. Prof. BOLLI has kindly gone through the specimens and opined that the identications are also in accordance with his views. The present author has compared the specimens of Cauvery basin with the types deposited by BLOW & BANNER (1962) in the British Museum (Natural History), London. However, the determination of a few species viz. *Globigerina corpulenta* SUBBOTINA, *G. pseudocorpulenta* CHALILOV, is only on the basis of literature.

No attempts are made during the present work to trace the lineages as the available samples do not represent a complete subsurface sequence.

The following five species were illustrated earlier by the present author (RAJU, 1968) and they are not repeated here. *Globorotalia centralis* CUSHMAN & BERMUDEZ, *G. cerroazulensis* (COLE), *Chiloguembelina cubensis* (PALMER), *C. martini* (PIJPERS) and *Cassigerinella chipolensis* (CUSHMAN & PONTON).

A few of the species viz. *Globigerina officinalis* SUBBOTINA, *G. praebulloides* group, *G. ouachitaensis* group, *Gobigerinita* spp. and *Globorotalia*

gemma JENKINS, though determined during the present study, are not described here.

All the illustrated types are deposited in the Palaeontology Laboratory, O. N. G. Commission, Baroda, India.

Superfamily *GLOBIGERINACEA* CARPENTER, PARKER & JONES, 1862

Family *GLOBIGERINIDAE* CARPENTER, 1862

Subfamily *Globigerininae* CARPENTER, PARKER & JONES, 1962

Genus *Globigerina* D'ORBIGNY, 1826

Globigerina ampliapertura BOLLI

(Plate I, figs. 1 a—c)

Globigerina ampliapertura BOLLI, 1957, p. 108, pl. 22, figs. 5 a—7 b (not figs. 4 a—b).
Globigerina ampliapertura BOLLI, BLOW & BANNER, 1962, pp. 83—84, pls. XI A—D, XVII c, fig. 12 b.
Globigerina ampliapertura ampliapertura BOLLI, RAJU, 1968, pl. 4, fig. 7.

Remarks: The forms from Cauvery basin are well comparable with the type description and illustrations.

Stratigraphic range: BOLLI (1957) gave the range of this species from *G. cocoaensis* zone to *G. opima opima* zone in Trinidad. BLOW (1969) gave its range from the base of Zone P 17 to the basal part of Zone P 21(= N 2). In Cauvery basin this species is known from *G. gortanii* zone to the *G. ampliapertura* zone.

Globigerina angulisuturalis BOLLI

(Plate I, figs. 2, 3 a, b)

Globigerina ciperoensis angulisuturalis BOLLI, 1957, p. 109, pl. 22, figs. 11 a—c.
Globigerina angulisuturalis BOLLI, BLOW & BANNER, 1962, p. 84, pl. IX, figs. A a—C c.

Remarks: The forms from Cauvery basin are well comparable with the type description and illustrations. These forms are compared with the hypotypes of BLOW & BANNER, 1962, from the Lower Ragusa Limestone, S. E. Sicily, deposited in British Museum (Natural History), London.

Stratigraphic range: BOLLI (1957) gave the range of this species from the base of the *G. opima opima* zone to the top of *G. ciperoensis ciperoensis* zone in Trinidad. It has also been reported from the Type Aquitanian of France (JENKINS, 1966), Israel (REISS & GVIRTZMANN, 1966), south-east Australia and Newzealand (JENKINS, 1960, 1965). BLOW (1969) gave its range from the base of Zone P 21 (= N 2) to lower part of Zone N 4.

Globigerina angustiumbilicata BOLLI

(Plate I, fig. 6)

Globigerina ciperoensis angustiumbilicata BOLLI, 1957, p. 109, pl. 22, figs. 12 a—13 c, p. 164, pl. 36, figs. 6 a—b.

Globigerina angustiumbilicata BOLLI, BLOW & BANNER, 1962, p. 85, pl. IX x—z, figs. 9 (iv), 16 (vi, vii).

Remarks: In some of the forms from Cauvery basin the last chamber is smaller in size than the penultimate chamber, otherwise well comparable with the types.

Stratigraphic range: BOLLI (1957) gave its range from the *G. ampliapertura* zone to *G. dissimilis* zone in Trinidad. BLOW (1969) gave its range from the upper part of Zone P 16 to Zone N 22. In Cauvery basin this species is common and known from the *G. cerroazulensis* zone to a level above the *G. kugleri/G. primordius* zone.

Globigerina binaiensis KOCH

(Text-figures 5, 6, 7, 8)

Globigerina binaiensis KOCH, 1935, nom. nov. for "*G. aspera* KOCH, 1926" (non EHRENBERG), type figures in KOCH, 1926, Ecologae Geol. Helv., vol. 19 (1925—1926), no. 3, p. 745, figs. 22 a—c, 23 a—c.

Globigerina binaiensis KOCH, BLOW, 1969, p. 316, pl. 13, figs. 1, 2.

Remarks: This species is characterized in having three chambers in the last whorl and a large flattened apertural face of the last chamber. The specimens from Cauvery basin are very well comparable with the illustrations given by BLOW (1969).

Stratigraphic range: BLOW (1969) gave the range of *G. binaiensis* from the Zone P 22 (= N 3) to Zone N 5, and noted that it appears to be restricted to the Indo-Pacific Province. In Cauvery basin this species is abundant in the lower most part of the *G. trilobus* assemblage. Rare forms are also recorded from core samples belonging to the upper part of *G. kugleri/G. primordius* zone and also from the cutting samples belonging to the *G. angulisuturalis* zone.

Globigerina ciperoensis BOLLI

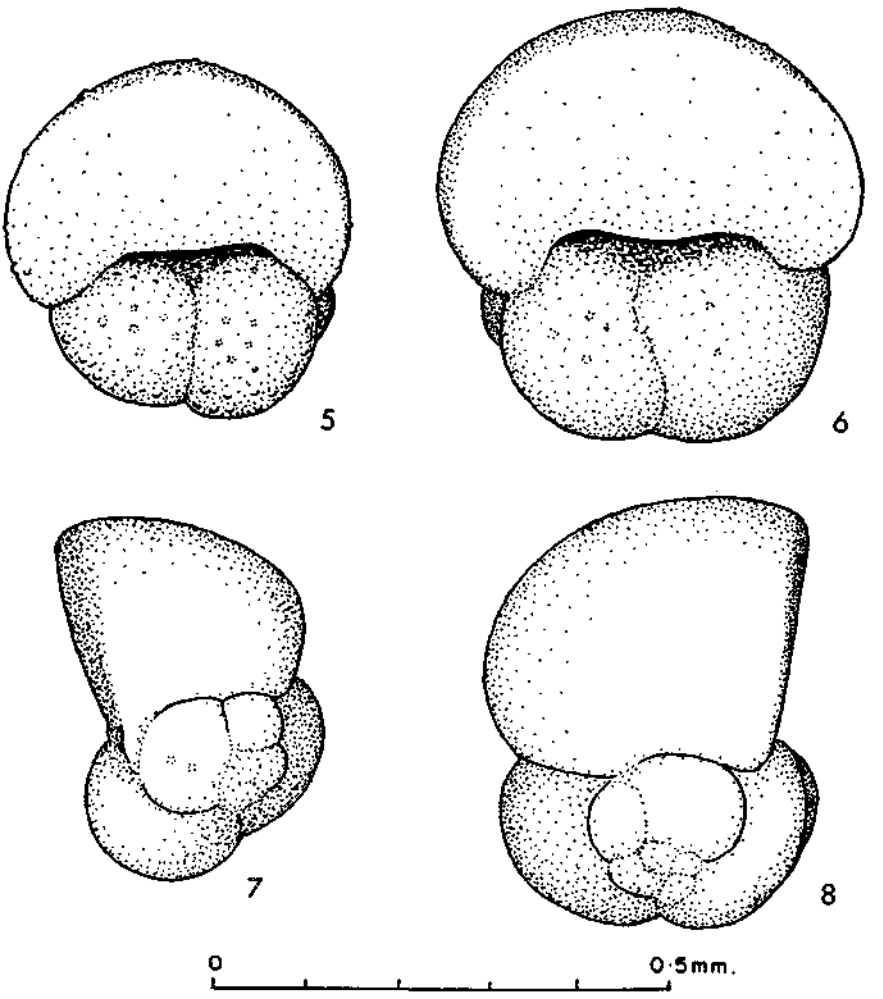
(Plate I, figs. 5 a, b)

Globigerina ciperoensis BOLLI, 1954, Contr. Cushman Found. Foram. Res., vol. 5, pt. 1, p. 1, text-figs. 3—6.

Globigerina ciperoensis ciperoensis BOLLI, BOLLI, 1957, p. 109, pl. 22, figs. 10 a—b.

Globigerina ouachitaensis ciperoensis BOLLI, BLOW & BANNER, 1962, pp. 90—91, pl. IX E—G, fig. 9 (i—iii).

Stratigraphic range: BOLLI (1957) recorded this species from the *G. opima opima* zone to the top of *G. ciperoensis* zone in Trinidad. BLOW & BANNER (1962) recorded this species from the *G. oligocaenina* zone to *G. ciperoensis* zone and also mentioned its occurrence in the Aquitanian of South-west France. BLOW (1969) gave the range of *G. ouachitaensis ciperoensis* forma *typica* from Zone P 19 to Zone N 4 and forma *atypica* is shown to range up to Zone N 5. In Cauvery basin this species is known from *G. angulisuturalis* zone to *G. kugleri/G. primordius* zone.



Text-figures 5, 6, 7, 8. *Globigerina binaiensis* KOCH, from core sample at 874 m. in Madanam-1.

Globigerina corpulenta SUBBOTINA

(Plate V, figs. 1 a—c)

Globigerina corpulenta SUBBOTINA, 1953, p. 76, pl. 9, figs. 5—7, pl. 10, figs. 1—4.

Stratigraphic range: SUBBOTINA (1953) has originally described this species from the Upper Eocene, series F 3 (middle), zone of *Globigerinoides conglobatus* and large Globigerinas, from Northern Caucasus, U. S. S. R. In Cauvery basin this species is very common in the *G. mexicana* zone and a few specimens are also recorded from the *G. cerroazulensis* zone.

Globigerina galavisi Bermudez

(Plate V, figs. 2 a—c, 3)

Globigerina galavisi Bermudez, 1961, Contribucion al Estudio de las Globigerinidea de la Region Caribe-Antillana, 3rd Congress Geol. Venezolano, Boletin de Geologia, Caracas, Venezuela, p. 1.183, pl. 4, fig. 3.

Globigerina galavisi Bermudez, Blow, 1969, p. 319, pl. 5, figs. 1—3, pl. 16, figs. 4, 5.

Remarks: The specimens from Cauvery basin are well comparable with the illustrations of holotype and metatype given by Blow (1969).

Stratigraphic range: Blow (1969) gave the range of this species from the Zone P 13 to P 21 (= N 2). This species is recorded so far from the *G. mexicana* zone to *G. sastrii* zone in Cauvery basin.

Globigerina gortanii gortanii (Borsetti)

(Plate II, figs. 1 a, b, 2)

Catapsydrax gortanii Borsetti, 1959, pp. 205—207, pl. 1, figs. 1 a—d.

Globigerina turritilina turritilina Blow & Banner, 1962, pp. 98—99, pl. XIII, figs. D—G.

Remarks: The forms from Cauvery basin, in general, are well comparable with the holotype and paratypes of *Globigerina turritilina turritilina*. In several of the specimens from Cauvery basin, the umbilicus is either filled with matrix or covered by a compressed aberrant (bulla like) final chamber. The present specimens are also well comparable with the type description and illustrations of *Catapsydrax gortanii* Borsetti.

Stratigraphic range: Borsetti (1959) has originally described this species from the Lower Oligocene of Northern Italy. Blow & Banner (1962) recorded this species from *G. turritilina turrilitina* zone to *G. oligocaenica* zone in East Africa. Blow (1969) gave its range from the base of Zone P 18 to the lower part of Zone P 22. In Cauvery basin this species is common in *G. gortanii* zone and *G. sastrii* zone.

Globigerina gortanii praeturritilina Blow & Banner

(Plate II, figs. 4 a, b, 5 a, b)

Globigerina turritilina praeturritilina Blow & Banner, 1962, p. 99, pl. XIII, figs. A—C.

Stratigraphic range: Blow & Banner (1962) gave the range of this species from *G. semiinvoluta* zone to the lower part of the *G. turritilina turritilina* zone. Blow (1969) gave its range from the Zone P 14 to the middle part of Zone P 17. In Cauvery basin this species is recorded from the *G. mexicana* zone to *G. gortanii* zone.

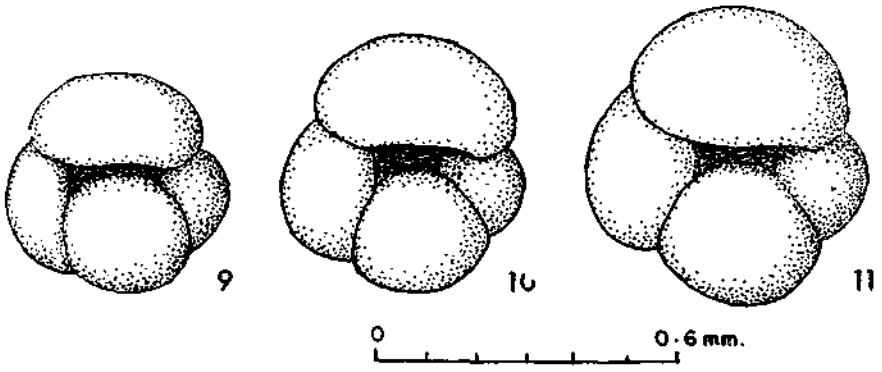
Globigerina prasaepis Blow

(Text-figures 9, 10, 11)

Globigerina ampliapertura euapertura (Jenkins), Blow & Banner, 1962, p. 84, pl. XI, figs. E—G. (= holotype of *G. prasaepis* Blow), not *Globigerina euapertura* Jenkins, 1960, p. 351, pl. 1, figs. 8 a—c.

Globigerina ampliapertura euapertura (Jenkins), Raju, 1968, pl. 4, fig. 8.

Globigerina prasaepis Blow, 1969, pp. 382—383, pl. 10, fig. 13, pl. 18, figs. 3—7.



Text-figures 9, 10, 11. *Globigerina prasaepis* BLOW, from *G. gortanii* zone, core sample at 1800 m. in NGT-1.

Remarks: The present author has compared the specimens from Cauvery basin with the hypotype of *Globigerina ampliapertura euapertura* of BLOW & BANNER, 1962 (= holotype of *G. prasaepis* BLOW, 1969) deposited in British Museum (Natural History), London. They are well comparable, except that the sutures in specimens from Cauvery basin are slightly more incised than in the type.

Stratigraphic range: BLOW (1969) gave the range of this species from upper part of the Zone P 17 to Zone P 21. In Cauvery basin this species is common in *G. gortanii* zone and *G. sastrii* zone.

Globigerina pseudocorpulenta CHALILOV

(Plate II, figs. 3 a, b)

Globigerina pseudocorpulenta CHALILOV, 1956 (on the pelagic foraminiferal fauna of the Paleogene of Azerbaidzhan; in Russian), Akad. Nauk. Azerb. S. S. R., Inst. Geol., Baku, Trudy vol. 17, p. 245, pl. 4, figs. 3 a—c (in ELLIS & MESSINA, 1940 et seq.).

Remarks: Specimens from Cauvery basin are well comparable with the illustrations and description of the type. However, the presently described forms seem to have less spinosity and the aperture often extends more towards extraumbilical.

Stratigraphic range: CHALILOV (1956) has originally described this species from lower part of the Upper Eocene, from the northeast foothills of the Maly Caucasus, Azerbaidzhan, S. S. R. In Cauvery basin this species is comon in *G. mexicana* zone. A few forms from *O. beckmanni* zone are comparable to this species.

Globigerina cf. *rubriformis* (SUBBOTINA)

(Plate II, figs. 6 a, b)

Globigerinoides rubriformis SUBBOTINA, 1953, (part), p. 92, pl. 14, figs. 6—9 (not pl. 13, figs. 19 a—b).

Remarks: SUBBOTINA (1953) has placed probably the forms of both *Globigerina* and *Globigerapsis* under this species. Only one form (pl. 13, figs. 19 a—b) has been shown in her illustrations to contain definite supplementary apertures. However, the holotype (pl. 14, figs. 6 a—c) does not seem to have any supplementary apertures and she also commented that supplementary apertures are missing in some forms.

Stratigraphic range: SUBBOTINA (1953) has originally described this species from the *Globigerinoides conglobatus* zone, Upper Eocene and from the *Bolivina* zone, in Northern Caucasus, U. S. S. R. In Cauvery basin rare forms are recorded from *G. gortanii* zone.

Globigerina sastrii n. sp.

(Plate IV, figs. 1 a—c, 2 a—c)

Description: Test low trochospiral, the equatorial profile is subcircular, equatorial periphery is broadly lobate; the axial periphery is broadly rounded with dorso-peripheral shoulder. The dorsal surface is flat to very slightly convex, the ventral surface is strongly vaulted. Wall calcareous, coarsely hispid, rugosities or short thick spines are found throughout, but more prominent around the umbilicus. Chambers, earlier ones spherical, later ones subconical, arranged in 2—3 whorls; the last 2 or 3 chambers increase very rapidly in size and strongly embrace the earlier ones; in umbilical view the last two chambers are prominently visible. Sutures on spiral side curved, less distinct in early stage, radial or oblique later, slightly depressed; umbilical side radial, depressed. Umbilicus small, narrow slit like, often covered by the last chamber, elongate, depressed; not sharply delineated. Aperture is often covered, narrow slit like.

Largest diameter of the holotype is 0.64 mm.

Depository: The types are deposited in the Palaeontology Laboratory, O. N. G. Commission, Baroda, India.

Type sample: A core sample, WLC-3, at a depth of 1580 m. in Karaikal well No. 4.

Age and distribution: Presence of *Globigerina gortanii gortanii, G. ampliapertura, G. sellii, Globorotalia increbescens* and other forms in the type sample indicates an Oligocene age. This species is recorded from TPD-1, NGT-1, Karaikal wells and Madanam well in Cauvery basin.

Remarks: This is a distinctive, short ranged species. This species is named after V. V. Sastri, O. N. G. Commission, India in recognition of his contributions to biostratigraphy in India.

Globigerina sellii (BORSETTI)

Plate III, figs. 5 a, b, 6)

Globoquadrina sellii BORSETTI, 1959, p. 209, pl. 13, figs. 3 a—d.
Globigerina oligocaenica BLOW & BANNER, 1962, p. 88, pl. X, figs. G, L—N.

Remarks: The specimens from Cauvery basin are compared with the types of *G. oligocaenica*. In the presently described forms the overlap, on the ventral side, of the last chamber is of lesser degree than in the types. In general, the apertural face of the forms is broader and slightly more flattened than in the holotype of *G. oligocaenica*. The specimens from Cauvery basin are well comparable with the illustrations and type description of *G. sellii*.

Stratigraphic range: BORSETTI (1959) has originally described this species from the Oligocene of Northern Italy. BLOW & BANNER (1962) gave its range as restricted to *G. oligocaenica* Zone, Lindi area, East Africa. BLOW (1969) gave its range from Zone P 19 to Zone P 22 (= N 3). In Cauvery basin rare forms are recorded from *G. sastrii* zone.

Globigerina tripartita tripartita KOCH

(Plate III, figs. 3 a, b)

Globigerina bulloides D'ORBIGNY var. *tripartita* KOCH, 1926, Eclogae Geol. Helv., vol. 19 (1925—1926), no. 3, p. 746, text-figs. 21 a—b.

Globigerina tripartita tripartita KOCH, BLOW & BANNER, 1962, pp. 96—97, pl. X, figs. A—F.

Stratigraphic range: KOCH (1926) described this species from the lower beds of the "Globigerinenmergel" of East Borneo. BLOW (1969) gave the range of this species from the Zone P 14 to Zone P 22. In Cauvery basin typical forms are recorded from *G. sastrii* zone. Forms comparable to this species are also recorded from *G. mexicana* and *G. cerroazulensis* zones.

Globigerina tripartita rohri BOLLI

(Plate III, figs. 2, 4 a, b)

Globigerina rohri BOLLI, 1957, p. 109, pl. 23, figs. 1 a—4 b.

Remarks: Only forms well comparable to the types are assigned to this subspecies. Some forms from upper part of the *G. kugleri/G. primordius* zone and lower part of *G. trilobus* assemblage in Cauvery basin are comparable to this subspecies except in that they developed a definite umbilical teeth, on the basis of which they are referred here to *Globoquadrina praedehiscens* BLOW & BANNER.

Stratigraphic range: BOLLI (1957) gave its range from the *G. ampliapertura* zone to *C. dissimilis* zone in Trinidad. In Cauvery basin a few forms are recorded from the *G. sastrii* zone.

Globigerina venezuelana HEDBERG

(Plate V, fig. 4, plate VI, figs. 1 a—c)

Globigerina venezuelana HEDBERG, 1937, Jour. Paleont., vol. 11, no. 8, p. 681, pl. 92, figs. 7 a—b.

Globigerina venezuelana HEDBERG, BOLLI, 1957, p. 110, pl. 23, figs. 6 a—8 b.

Globigerina venezuelana HEDBERG, BLOW & BANNER, 1962, text fig. 11.

Stratigraphic range: BOLLI (1957) recorded this species from the *G. ampliapertura* Zone to *G. menardii* Zone in Trinidad. BLOW (1969) gave its range from Zone P 22 to Zone N 9. In Cauvery basin typical forms are recorded so far from the *G. kugleri/G. primordius* zone and lower part of *G. trilobus* assemblage.

Globigerina woodi woodi JENKINS

(Plate V, figs. 5 a—c)

Globigerina woodi JENKINS, 1960, p. 352, pl. 2, figs. 2 a—c.
Globigerina woodi JENKINS, REISS & GVITZMANN, 1966, pl. 91, figs. 1 a—c.
Globigerina woodi woodi JENKINS, JENKINS, 1966, p. 6, pl. 1, figs. 18 a—c.

Stratigraphic range: JENKINS (1960) gave its range from base of the *G. woodi* zone to *G. menardii miotumida* zone in Australia. This species has also been recorded from Newzealand (JENKINS, 1965), Israel (REISS & GVIRTZMANN, 1966) and from the type Aquitanian of France (JENKINS, 1966). In Cauvery basin this species is recorded from *G. angulisuturalis* zone and *G. kugleri/G. primordius* zone.

Genus *Globigerinoides* CUSHMAN, 1927

Globigerinoides primordius BLOW & BANNER

(Plate VII, figs. 1 a, b, 2 a, b)

Globigerinoides quadrilobatus primordius BLOW & BANNER, 1962, p. 115, pl. IX, figs. D d—F f, fig. 14 (iii—viii).

Remarks: The specimens from Cauvery basin are well comparable to the holotype. The primary aperture of the Cauvery basin forms is more wider than in the holotype. However, these and other minor differences fall within the variation limits of paratypes designated by BLOW & BANNER (1962).

Stratigraphic range: BLOW & BANNER (1962) gave the range of this species as confined to the *G. kugleri* zone in Trinidad. JENKINS (1966) recorded forms comparable to this species from the type Aquitanian of France. BLOW (1969) gave its range from base of the Zone N 4 to lower part of the Zone N 5. In Cauvery basin it is common throughout the *G. kugleri/G. primordius* zone.

Globigerinoides trilobus trilobus (REUSS)

(Plate VII, figs. 4 a, b)

Globigerina triloba REUSS, 1850 Denkschr. k. k. Akad. Wiss., Wien, mathem.-naturwiss. Cl., vol. 1, p. 374, pl. 47, figs. 11 a—d (in ELLIS & MESSINA, 1940 et seq.).
Globigerinoides triloba triloba (REUSS), BOLLI, 1957, p. 112, pl. 25, figs. 2 a—c.

Stratigraphic range: BOLLI (1957) gave the range of this species from the *C. dissimilis* zone to *G. menardii* zone in Trinidad. In Cauvery basin it appears in uppermost part of the *G. kugleri/G. primordius* zone and is common throughout the Lower-Middle Miocene.

Globigerinoides trilobus altiaperturus BOLLI
(Plate VII, figs. 4 a, b)

Globigerinoides triloba altiapertura BOLLI, 1957, p. 113, pl. 25, figs. 7 a—8, text fig. 21, no. 3.

Stratigraphic range: BOLLI (1957) gave its range from base of the *C. dissimils* zone to *C. stanforthi* zone in Trinidad. This species has also been recorded from the type Burdigalian of France (JENKINS, 1966), Newzealand (JENKINS, 1965), Australia (WADE, 1964), Israel (REISS & GVITTZMANN, 1966). In Cauvery basin it is recorded from uppermost part of the *G. kugleri/G. primordius* zone and *G. trilobus* assemblage.

Genus *Globigerinita* BRÖNNIMANN, 1951 emended BLOW & BANNER, 1962

Globigerinita dissimilis (CUSHMAN & BERMUDEZ)
(Plate VI, figs. 2 a, b, 3 a, b)

Globigerina dissimilis CUSHMAN & BERMUDEZ, 1937, p. 25, pl. 3, figs. 4—6.
Catapsydrax dissimilis (CUSHMAN & BERMUDEZ), BOLLI, 1957, p. 36, pl. 7, figs. 6 a—8 c.
Globigerinita dissimilis (CUSHMAN & BERMUDEZ), BLOW & BANNER, 1962, p. 106, pl. 14, figs. A—D.

Remarks: The illustrated specimen from *G. kugleri/G. primordius* zone in Cauvery basin has a slightly more convex spiral side than in the holotype.

Stratigraphic range: BOLLI (1957) gave its range from *T. rohri* zone to *C. stainforthi* zone in Trinidad. In Cauvery basin rare forms of this species are recorded from *G. mexicana* zone to lower part of *G. trilobus* assemblage. Very rare forms comparable to *G. dissimilis* are also recorded from sequence as low as *Hantkenina aragonensis* zone in Cauvery basin.

Globigerinita stainforthi (BOLLI, LOEBLICH & TAPPAN)
(Plate VI, figs. 4 a—c)

Catapsydrax stainforthi BOLLI, LOEBLICH & TAPPAN, 1957, p. 36, pl. 7, figs. 11 a—c.

Remarks: The specimens from Cauvery basin are well comparable with the type description and illustrations.

Stratigraphic range: BOLLI (1957) gave the range of this species from the *C. dissimilis* zone to *C. stainforthi* zone in Trinidad. BLOW (1969) gave its range from the latest part of Zone N 4 to Zone N 7. In Cauvery basin this species is known from the uppermost part of *G. kugleri/G. primordius* zone and in the sequence immediately overlying this zone.

Genus *Globigerapsis* BOLLI LOEBLICH & TAPPAN, 1957

Globigerapsis mexicana (CUSHMAN)
(Plate XI, figs. 1, 2 a, b, 3 a, b, 4, 5, 6)

Globigerina mexicana CUSHMAN, 1925, Cushman Lab. Foram. Res., Contr., vol. 1, p. 6, pl. 1, fig. 8 a, b.

Globigerinoides semiinvoluta KEIJZER, 1945, Univ. Utrecht, Geogr. Geol. Med. Phys-Geol. Reeks; ser. 2, no. 6, p. 206, pl. 4, figs. 58 a—e.
Globigerapsis semiinvoluta (KEIJZER), BOLLI, 1957, p. 165, pl. 36, figs. 19—20.
Globigerapsis semiinvoluta (KEIJZER), BLOW & BANNER, 1962, p. 125, pl. XV, figs. J—L.
Globigerapsis semiinvoluta (KEIJZER), RAJU, 1968, pl. 2, figs. 4, 5.
Globigerapsis mexicana (CUSHMAN), BLOW & SAITO, 1968, Micropaleontology, vol. 14, no. 3, pp. 357—360, text-figs. 1—4.

Remarks: The specimens from Cauvery basin are in general smaller in size than the type. The sutures are not distinct and often the initial chambers are not visible. The sutures in the hypotype of *G. semiinvoluta* of BLOW & BANNER, 1962, are more prominently visible than in these forms.

Stratigraphic range: BOLLI (1957) and BLOW & BANNER (1962) have given the range of this species as restricted to the limits of its zone within the lower part of the Upper Eocene.

Globigerapsis cf. *tropicalis* BLOW & BANNER

(Plate XI, figs. 7 a, b)

Globigerapsis tropicalis BLOW & BANNER, 1962, pp. 124—125, pl. XV, figs. D—F.

Remarks: The presently illustrated forms from Cauvery basin differ slightly from the holotype of *G. tropicalis* in being larger in size, in having more depressed sutures, more elongate and lower supplementary apertures. The wall structure is comparable.

Stratigraphic range: BLOW (1969) gave the range of this species from Zone P 10 (= *H. aragonensis* Zone) to Zone P 16.

Genus *Globoquadrina* FINLAY, 1947

Globoquadrina altispira globosa BOLLI

(Plate VII, figs. 6 a, b)

Globoquadrina altispira globosa BOLLI, 1957, pp. 111—112, pl. 24, figs. 9 a—10 c.

Remarks: The specimens from Cauvery basin are often badly preserved and the umbilicus is filled with pyritized matrix. The last one or two chambers in the last whorl increase rapidly in size than in the forms described by BOLLI (1957).

Stratigraphic range: BOLLI (1957) gave the range of this species from base of the *C. dissimilis* zone to *G. insueta* zone and again from *G. fohsi robusta* zone to *G. menardii* zone in Trinidad. The presently illustrated forms are from uppermost part of the *G. kugleri/G. primordius* zone. It is common in the *G. trilobus* assemblage. BLOW (1969) gave its range from Zone P 22 (= N 3) to Zone N 20.

Globoquadrina dehiscens (CHAPMAN, PARR & COLLINS)

(Plate IX, figs. 3, 4 a, b)

Globorotalia dehiscens CHAPMAN, PARR & COLLINS, 1934, Linn. Soc. London, Jour. Zool., vol. 38, no. 262, p. 569, pl. 11, figs. 36 a—c (in ELLIS & MESSINA, 1940 et seq.).

Globoquadrina dehiscens (CHAPMAN, PARR & COLLINS), BOLLI, 1957, p. 111, pl. 24, figs. 3 a—4 c.

Remarks: The subspecies of *G. dehiscens* are not recognized in the present study.

Stratigraphic range: BOLLI (1957) gave its range from *G. stainforthi* zone to *G. menardii* zone in Trinidad. In Cauvery basin this species is common in the *G. trilobus* assemblage.

Globoquadrina cf. *larmeui* AKERS

(Plate IX, figs. 5 a, b)

Globoquadrina larmeui AKERS, 1955, p. 661, pl. 65, figs. 4 a—c.
Globoquadrina larmeui AKERS, JENKINS, 1960, p. 355, pl. 3, figs. 1 a—2 c.

Remarks: The specimens from Cauvery basin differ slightly from the type illustrations and description in being more convex dorsally and larger in size.

Stratigraphic range: JENKINS (1960) recorded this species from the Pre-*Globoquadrina dehiscens dehiscens* zone to the *O. universa* zone in Australia. In Cauvery basin this species is recorded so far from the *G. angulisuturalis* zone and *G. kugleri/G. primordius* zone.

Globoquadrina praedehiscens BLOW & BANNER

(Plate VIII, figs. 4 a—c; Plate IX, fig. 12)

Globoquadrina dehiscens praedehiscens BLOW & BANNER, 1962, pp. 116—117, pl. XV, figs. Q—S.
Globoquadrina praedehiscens BLOW & BANNER, SAITO, 1963, p. 193, pl. 55, figs. 7 a—b.
Globoquadrina dehiscens praedehiscens BLOW & BANNER, REISS & GVIRTZMANN, 1966, pl. 96, figs. 3—7.

Remarks: The specimens from Cauvery basin are compared with the holotype. In most of the present specimens the last chamber is relatively smaller, the umbilical teeth is slightly the and wider than in the holotype.

Stratigraphic range: BLOW & BANNER (1962) gave its range from middle part of the *G. ciperoensis* zone to the lower part of *G. stainforthi* zone in Trinidad. They have also reported its occurrence from Venezuela, East Africa, and Newzealand. In Cauvery basin typical forms are recorded from *G. kugleri/G. primordius* zone and lower part of the *G. trilobus* assemblage.

Genus *Globorotalia* CUSHMAN, 1927

Globorotalia centralis CUSHMAN & BERMUDEZ

Globorotalia centralis CUSHMAN & BERMUDEZ, 1937, p. 26, pl. 2, figs. 62—65.
Globorotalia centralis CUSHMAN & BERMUDEZ, BOLLI, 1957, p. 162, pl. 39, figs. 1—4.
Globorotalia (Turborotalia) centralis CUSHMAN & BERMUDEZ, BLOW & BANNER, 1962, p. 117, pl. XII, figs. K—M, Fig. 12 c, d.
Turborotalia centralis CUSHMAN & BERMUDEZ, RAJU, 1968, pl. 4, figs. 3 a—c.

Remarks: This species was earlier illustrated by the present author (RAJU, 1968) and given as *Turborotalia centralis*.

Stratigraphic range: BOLLI (1957) gave its range from the *Globigerapsis kugleri* zone to *G. cocoaensis* zone in Trinidad. BLOW (1969) noted that it ranges from Zone P 11 to Zone P 17. In Cauvery basin it has been recorded from the *H. aragonensis* zone to top of the *G. cerroazulensis* zone.

Globorotalia cerroazulensis (COLE)

Globigerina cerroazulensis COLE, 1928, Bull. Amer. Pal., vol. 14, no. 53, p. 217, pl. 32, figs. 11—13.
Globorotalia cocoaensis CUSHMAN, 1928, Contr. Cushman Lab. Foram. Res., vol. 4, pt. 3, p. 75, pl. 10, figs. 3 a—c.
Globorotalia cocoaensis CUSHMAN, BOLLI, 1957, p. 169, pl. 39, figs. 5 a—7 b.
Globorotalia (Turborotalia) cerroazulensis (COLE), BLOW & BANNER, 1962, p. 118, pl. XII, figs. D—F, Fig. 12 d, e.
Turborotalia cerroazulensis (COLE), RAJU, 1968, pl. 3, figs. 7 a—c.

Remarks: This species was earlier illustrated by the present author (RAJU, 1968) and given as *Turborotalia cerroazulensis*.

Stratigraphic range: BOLLI (1957) gave its range from the base of the *G. semiinvoluta* zone to top of the *G. cocoaensis* zone in Trinidad. BLOW (1969) gave its range from upper part of Zone P 14 (*T. rohri/G. howeii* zone) to the lower part of Zone P 17. In Cauvery basin it is known from the *G. mexicana* zone to top of the *G. cerroazulensis* zone. Some rare forms from *O. beckmanni* zone appear to be comparable to this species.

Globorotalia increbescens (BANDY)

(Plate IX, figs. 7 a—c)

Globigerina increbescens BANDY,1949, p. 120, pl. 23, figs. 3 a—c.
Globorotalia (Turborotalia) increbescens (BANDY), BLOW & BANNER, 1962, pp. 118—119, pl. XIII, figs. T—V, pl. XVII, figs. D, K, Fig. 9 (13—15).

Remarks: The specimens from Cauvery basin are compared with a metatype, from Upper Jackson, Little Stave Creek, Clarks county, Alabama, deposited in British Museum (Natural History), London. The illustrated specimen from Cauvery basin is slightly bigger in size and has slightly higher aperture, otherwise well comparable with the metatype.

Stratigraphic range: This species has been originally described by BANDY (1949) from Jacksonian Stage, Alabama, U. S. A. BLOW (1969) gave the range of this species from Zone P 15 to Zone P 19. In Cauvery basin typical forms are recorded from *G. gortanii* zone and *G. sastrii* zone.

Globorotalia kugleri BOLLI

(Plate X, figs. 1 a, b, 2 a, b)

Globorotalia kugleri BOLLI, 1957, p. 118, pl. 28, figs. 5 a—6.
Globorotalia (Turborotalia) kugleri BOLLI, BLOW, 1969, p. 350, pl. 38, figs. 1—4.

Remarks: The specimens from Cauvery basin are well comparable with the type description and illustrations given by BOLLI (1957) and the illustrations of topotypes given by BLOW (1969).

Stratigraphic range: BOLLI (1957) gave the range of this species as restricted to the *G. kugleri* zone in Trinidad. BLOW (1969) gave its range from Zone P 22 (= N 3) to the top of Zone N 4. In Cauvery basin it is recorded so far only from upper part of the *G. kugleri/G. primordius* zone.

Globorotalia obesa BOLLI

(Plate X, figs. 6 a—c)

Globorotalia obesa BOLLI, 1957, p. 119, pl. 29, figs. 2 a—c.
Globigerina obesa BOLLI, VERVLOET, 1966, p. 53, pl. II, figs. 9 a—c, pl. V, figs. 2 a—c.

Stratigraphic range: BOLLI (1957) gave its range from *C. dissimilis* zone to *G. menardii* zone in Trinidad. In Cauvery basin this species is common in the upper part of *G. kugleri/G. primordius* zone and *G. trilobus* assemblage.

Globorotalia opima nana BOLLI

(Plate X, figs. 3 a, b)

Globorotalia opima nana BOLLI, 1957, p. 118, pl. 28, figs. 3 a—c.
Globorotalia (Turborotalia) opima nana BOLLI, BLOW & BANNER, 1962, pp. 119—120, pl. XIII, figs. Q—S.

Remarks: The specimen illustrated here is slightly larger in size than the holotype. Most of the unillustrated forms are better comparable with the type.

Stratigraphic range: BLOW (1969) gave the range of this species from Zone P 15 to Zone P 22 (= N 3). In Cauvery basin it is recorded from *G. mexicana* zone to the lower part of *G. kugleri/G. primordius* zone.

Globorotalia peripheroronda BLOW & BANNER

(Plate IX, figs. 6 a—c)

Globorotalia fohsi barisanensis LEROY, BOLLI, 1957, p. 119, pl. 28, figs. 8 a—c.
Globorotalia (Turborotalia) peripheroronda BLOW & BANNER, 1966, Micropaleontology, vol. 12, no. 3, p. 294, pl. 1, figs. 1—3.

Stratigraphic range: BOLLI (1957) gave its range from the *C. dissimilis* Zone to *G. fohsi fohsi* Zone in Trinidad. This species has been also reported from several parts of the world including Japan (SAITO, 1963), Newzealand (JENKINS, 1965), Australia (JENKINS, 1960) and Israel (REISS & GVIRTZMANN, 1966). In Cauvery basin a few forms are recorded from *G. trilobus* assemblage.

Globorotalia siakensis (LEROY)

(Plate X, figs. 4, 5 a—c)

Globigerina siakensis LEROY, 1939, Natuurk. Tijdschr. Nederl.-Indie, vol. 99, no. 6, pp. 39—40, pl. 3, figs. 30—31.

Globorotalia mayeri CUSHMAN & ELLISOR, BOLLI, 1957, p. 118, pl. 28, figs. 4 a—c (not *Globorotalia mayeri* CUSHMAN & ELLISOR, 1939).
Globorotalia siakensis (LEROY), JENKINS, 1960, p. 366, pl. 5, figs. 7 a—c.
Globorotalia (Turborotalia) siakensis LEROY, BLOW (1969), p. 356, pl. 10, figs. 7—9, holotype refigured, pl. 34, figs. 4, 5.

Remarks: This species is very common throughout its range in Cauvery basin.

Stratigraphic range: BOLLI (1957) gave its range from the *G. opima opima* zone to *G. mayeri* zone in Trinidad. BLOW (1969) gave its range from Zone P 22 to N 14. In Cauvery basin this species is known from *G. angulisuturalis* zone to Middle-Upper Miocene.

Genus *Globorotaloides* BOLLI, 1957

Globorotaloides suteri BOLLI

(Plate VI, figs. 5 a, b)

Globorotaloides suteri BOLLI, 1957, p. 116, 166, pl. 27, figs. 9—13 b, pl. 37, figs. 10 a—12.
Globorotaloides suteri BOLLI, BLOW & BANNER, 1962, pp. 122—123, pl. XII, figs. N—P, Fig. 11 (V, IX).

Remarks: The specimens from Cauvery basin are well comparable with the type illustrations and description. These specimens differ slightly from the hypotypes of BLOW & BANNER (1962) in having a low lying bulla and the rate of increase in chamber size is slower.

Stratigraphic range: BLOW & BANNER (1962) recorded this species from the upper Lutetian to about the middle part of the Aquitanian in East Africa and Trinidad. BLOW (1969) gave its range from Zone P 13 to within Zone N 8. In Cauvery basin this species is recorded from *G. mexicana* zone to the *G. kugleri/G. primordius* zone.

Genus *Globigerinopsis* BOLLI, 1962

Globigerinopsis guhai n. sp.

(Plate VIII, figs. 1 a—c, 2 a—c, 3 a—c)

Description: Test low trochospiral, equatorial profile of the test subquadrate, equatorial periphery strongly lobate, axial periphery rounded. Wall calcareous, porous, finely pitted, well preserved specimens with fine small spines. Chambers inflated, spherical except the last one or two; last two in spiral view ovate, slightly elongate; the last chamber varies in size, in general equal or larger than the penultimate. Some 16 chambers arranged in 3—4 whorls; the 4—4½, rarely 5 chambers in last whorl increase rapidly in size. Sutures on spiral side radial to slightly oblique, strongly depressed; on umbilical side radial, strongly depressed. Umbilicus wide, deep, filled often with pyritized matrix. Primary aperture a high arch, interiomarginal umbilical to slightly spiroumbilical, without lip or rim. One secondary aperture, a medium arch with small rim. Largest diameter of the holotype is 0.624 mm.

Depository: The holotype and paratypes are deposited in the Palaeontology Laboratory, O. N. G. Commission, Baroda, India.

Type sample: Holotype and illustrated paratypes are from a core sample (CC I, 1126.3—1128.8 m., 15—26 cm.) from Karaikal well no. 2, Cauvery basin. Rare specimens are also recorded from cutting sample at a depth of 1000 m. in KKL-1.

Age of the type sample: Uppermost part of *Globorotalia kugleri*/ *Globigerinoides primordius* zone, Lower Miocene (Aquitanian age).

Remarks: This species has been placed under the genus *Globigerinopsis* BOLLI, 1962. However, the present species has a supplementary aperture, whereas the type of *Globigerinopsis* do not have and also the primary aperture is more spiroumbilical in the types. SCHMID (1967) described a n. sp., *Globigerinopsis grilli* SCHMID, which has a supplementary aperture, but its wall surface is coarselly pitted and cancellate.

This species is named after Mr. D. K. GUHA, O. N. G. Commission, India, in recognition of his contributions to microfauna and biostratigraphy in India.

Genus *Pseudohastigerina* BANNER & BBLOW, 1959

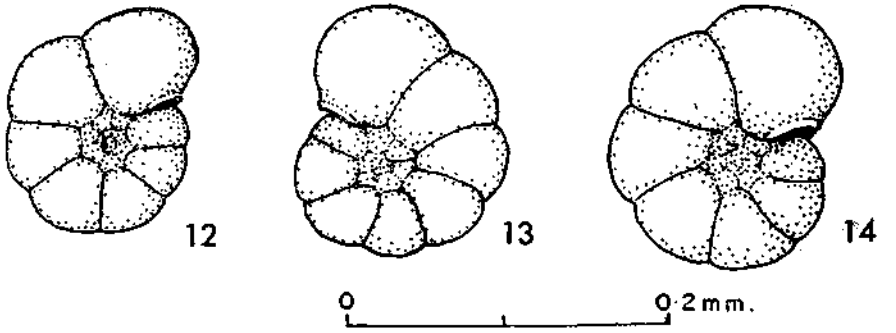
Pseudohastigerina barbadoensis BLOW, 1969

(Text-figures 12, 13, 14)

Pseudohastigerina barbadoensis BLOW, 1969, pp. 409—410, pl. 53, figs. 7—9, pl. 54, figs. 1—3.

Remarks: The specimens from Cauvery basin are very well comparable with the illustrations and description of the types.

Stratigraphic range: BLOW (1969) gave the range of this species from Zone P 16 to the top of Zone P 19. In Cauvery basin this species is very common in *G. gortanii* zone, and very rare in the *G. cerroazulensis* zone.



Text-figures 12, 13, 14. *Pseudohastigerina barbadoensis* BLOW, from *G. gortanii* zone, core sample at 1800 m. in NGT-1.

Pseudohastigerina micra (COLE)

(Plate XIII, figs. 9 a, b)

Nonion micrus COLE, 1927, Bull. Amer. Paleont., vol. 14, no. 51, p. 22, pl. 5, fig. 12.
Hastigerina micra (COLE), BOLLI, 1957, p. 161, pl. 35, figs. 1 a—2 b.
Pseudohastigerina micra (COLE), BANNER & BLOW, 1959, pp. 19—20, pl. 3, figs. 6 a—b, text-figs. 4 g—i.
Pseudohastigerina micra (COLE), BLOW, 1969, pl. 53, figs. 1, 4, 5, 6.

Stratigraphic range: BOLLI (1957) gave the range of this species from the *H. aragonensis* zone to *G. cocoaensis* zone in Trinidad. BLOW (1969) gave its range from Zone P 10 to within Zone P 19. In Cauvery basin basin typical forms are recorded from *H. aragonensis* to top of the *G. cerroazulensis* zone. Only rare forms from *G. gortanii* zone are comparable to this species.

Genus *Hantkenina* CUSHMAN, 1925

Hantkenina alabamensis CUSHMAN

(Plate XI, figs. 8, 9 a, b; Plate XII, fig. 2)

Hantkenina alabamensis CUSHMAN, 1925, Proc. U. S. Nat. Mus., vol. 66, no. 2567, art. 30, pp. 3—4, pl. 1, figs. 1—6, pl. 2, fig. 5, text-fig. 1.
Hantkenina alabamensis CUSHMAN, BANDY, 1949, p. 76, pl. 11, figs. 9 a—b.
Hantkenina (Hantkenina) alabamensis CUSHMAN, BRÖNNIMANN, 1950, p. 414, pl. 56, figs. 10, 14—16.
Hantkenina alabamensis CUSHMAN, BOLLI, LOEBLICH & TAPPAN, 1957, pp. 26—28, pl. 2, fig. 8.
Hantkenina alabamensis CUSHMAN, NAGAPPA, 1959, pl. 11, figs. 14 a—b.
Hantkenina alabamensis CUSHMAN, BLOW & BANNER, 1962, pp. 126—127, pl. XVI, figs. C—D, J, K.
Hantkenina alabamensis CUSHMAN, RAJU, 1968, pl. 1, fig. 11.

Remarks: The specimens from Cauvery basin show considerable variation in shape of the chambers and sutures. A few forms have hispid wall surface, particularly in the early chambers of the last whorl. A solitary form with twin spines (see Plate XI, figs. 9 a, b) is also found.

Stratigraphic range: BLOW (1969) gave the range of this species from within Zone P 13 (= O. *beckmanni* zone) to the top of Zone P 16. In Cauvery basin typical forms of this species are recorded so far from the *G. mexicana* zone and *G. cerroazulensis* zone.

Hantkenina suprasuturalis BRÖNNIMANN

(Plate XII, figs. 9 a, b, 10; Plate XIII, fig. 1)

Hantkenina (Hantkenina) suprasuturalis BRÖNNIMANN, 1950, p. 416, pl. 56, figs. 12, 13, text-fig. 2.

Remarks: The specimens from Cauvery basin are well comparable with the illustrations and description of the type. Several small sized specimens appear to grade morphologically to *Hantkenina alabamensis*.

Stratigraphic range: BRÖNNIMANN (1950) has originally reported this

species from the Upper Eocene of Trinidad and Barbados. In Cauvery basin typical forms of this species are common in the *G. mexicana* zone and rare in *G. cerroazulensis* zone.

Hantkenina cf. *thalmanni* BRÖNNIMANN

(Plate XII, figs. 1 a—b)

Hantkenina thalmanni BRÖNNIMANN, 1950, pp. 415—416, pl. 55, figs. 19—21, pl. 56, figs. 3, 11.

Remarks: Only three specimens which are comparable with the illustrations and description of the types are found from the *G. mexicana* zone in Cauvery basin. It is not clear from the available material whether they are juvenile forms of *H. suprasuturalis.*

Hantkenina trinitatensis BRÖNNIMANN

(Plate XII, figs. 3, 4, 5)

Hantkenina (Applinella) trinitatensis BRÖNNIMANN, 1950, pp. 410—411, pl. 56, fig. 17.

Remarks: Only a few specimens which are well comparable with the illustrations and description of the types are found from the *G. mexicana* zone in Cauvery basin.

Genus *Cribrohantkenina* THALMANN, 1942

Cribrohantkenina inflata (HOWE)

(Platte XIII, figs. 2—8)

Hantkenina inflata HOWE, 1928, Jour. Paleont., vol. 2, no. 1, p. 14, fig. 2.
Hantkenina mccordi HOWE & WALLACE, 1932, Louisiana Dept. Conserv., Geol. Bull., no. 2, p. 55—56, tab. 10, figs. 1 a, b.
Hantkenina danvillensis HOWE & WALLACE, 1934, Jour. Paleont., vol. 8, pp. 35—37, pl. 5, figs. 14—17.
Hantkenina (Cribrohantkenina) bermudezi THALMANN, 1942, Amer. Jour. Sci., vol. 240, no. 11, pp. 812, 815, pl. 1, figs. 5—6.
Cribrohantkenina mccordi HOWE & WALLACE, BANDY, 1949, p. 76, pl. 11, figs. 10 a—b.
Hantkenina (Cribrohantkenina) bermudezi THALMANN, BRÖNNIMANN, 1950, p. 417, pl. 56, figs. 6—9.
Cribrohantkenina bermudezi THALMANN, BOLLI, LOEBLICH & TAPPAN, 1957, pp. 28—29, pl. 2, figs. 9 a—11 b.
Hantkenina (Cribrohantkenina) bermudezi THALMANN, NAGAPPA, 1959, pl. 11, figs. 15 a—b.
Cribrohantkenina danvillensis HOWE & WALLACE, BLOW & BANNER, 1962, p. 128, pl. XVI, figs. G—H, Fig. 19 (i—vii).
Cribrohantkenina inflata (HOWE), SPRAUL, 1963, Jour. Pleont., vol. 37, no. 2, p. 367, pl. 14, figs. 1 a—4 b.
Cribrohantkenina inflata (HOWE), RAJU, 1968, pl. 1, fig. 7.

Remarks: BLOW & BANNER (1962) discussed in detail the apertural characters of *Cribohantkenina.* SPRAUL (1963, cited above) has reillustrated the type of *Hantkenina inflata* HOWE, 1928 and shown that it is a true *Cribrohantkenina,* thus clarified the taxonomic status of several of the species.

In Cauvery basin both juvenile and adult specimens of this species are recorded from *G. cerroazulensis* zone. A study of these forms indicate that *C. inflata* has maintained the club shaped final chambers almost throughout its ontogeny. Similar data was earlier presented by DIENE & PROTO DECIMA (1964).

Stratigraphic range: This species is known to be an important world-wide index fossil of Upper Eocene. BLOW & BANNER (1962) recorded this species from about middle part of *G. semiinvoluta* zone to the top of *C. danvillensis* zone in Lindi area, East Africa. This species is common throughout the *G. cerroazulensis* zone in Cauvery basin. Very rare and poorly preserved specimens with doubtful cribrate aperture are found in *G. mexicana* zone.

Genus *CASSIGERINELLA* POKORNY, 1955

Cassigerinella chipolensis (CUSHMAN & PONTON)

Cassidulina chipolensis CUSHMAN & PONTON, 1932, Florida Geol. Survey, Bull., no. 9, p. 98, pl. 15, figs. 2 a—c.

Cassigerinella boudecensis POKORNY, 1955, Vestnik, Ustred. Geol., 30, pp. 136—140, text-figs. 1—3.

Cassigerinella globolocula IVANOVA, 1958, in BYKOVA, Mikrofauna S. S. S. R., sb. 9, vip. 115; Trudi. Vses. Neft. Nauchno-Issled. Geol. Inst. (VNIGRI), p. 57, pl. 11, figs. 1—3.

Cassigerinella chipolensis (CUSHMAN & PONTON), BLOW & BANNER, 1962, pp. 81—82, pl. XV, figs. M, N.

Cassigerinella chipolensis (CUSHMAN & PONTON), RAJU, 1968, pl. 1, figs. 9 ,10.

Remarks: This species from Cauvery basin was illustrated earlier by the present author (RAJU, 1968). In general the size of the forms increase, slightly, from *G. gortanii* zone to *G. sastrii* zone.

Stratigraphic range: BOLLI (1957) gave the range of this species from the *G. ampliapertura* zone to *G. fohsi robusta* zone in Trinidad. BLOW (1969) gave its range from Zone P 18 to Zone N 13. In India this species is known from Kutch, Cambay basin, Assam, Cauvery basin, Quilon area and Andaman Islands. In Cauvery basin this species first appears in the basal part of the *G. gortanii* zone and is very common in the sequence from the *G. sastrii* zone to Middle Miocene. A few forms are found in the section above the extinction level of *Miogypsina antellia*.

Genus *Chiloguembelina* LOEBLICH & TAPPAN, 1956

Chiloguembelina cubensis (PALMER)

Guembelina cubensis PALMER, 1934, Mem. Soc. Cubana Hist. Nat., vol. 8, p. 74, text-figs. 1—6.

Chiloguembelina cubensis (PALMER), BECKMANN, 1957, p. 89, pl. 21, fig. 21, text-fig. 14, nos. 5—8.

Chiloguembelina cubensis (PALMER), RAJU, 1968, pl. 1, figs. 4 a—b.

Remarks: This species from Cauvery basin was illustrated earlier by the present author (RAJU, 1968). This small and distinct species is abundant in the fine fractions of the samples, within its range, in Cauvery basin. This species is also common in shallow marine facies of Oligocene age in Cambay basin, western India and found together with *Nummulites fichteli-intermedius*.

Stratigraphic range: BECKMANN (1957) gave the range of this species from *Porticulasphaera mexicana* zone to *G. opima opima* zone in Trinidad. The species has also been reported from various parts of the world in sections of Upper Eocene to Oligocene. BLOW (1969) gave the range of *Chiloguembelina* ex group *cubensis* from Zone P 13 to very close to the Zone N 4/Zone N 3 (= P 22) boundary. In Cauvery basin this species is common from the *G. mexicana* zone to *G. ampliapertura* zone.

Chiloguembelina martini (PIJPERS)

Textularia martini PIJPERS, 1933, Univ. Utrecht Geogr. Geol. Med. Phys.-Geol. Reeks, no. 8, p. 57, figs. 6—10.
Chiloguembelina martini (PIJPERS), BECKMANN, 1957, p. 89, pl. 21, fig. 14, text-fig. 14, nos. 9—11, 14—18, 20—23.
Chiloguembelina martini (PIJPERS), RAJU, 1968, pl. 1, fig. 12.

Remarks: This species from Cauvery basin was earlier illustrated by the present author (RAJU, 1968).

Stratigraphic range: BECKMANN (1957) gave the range of this species from the *Globorotalia aragonensis* zone o the top of *G. cocoaensis* zone (= *G. cerroazulensis* zone) in Trinidad. In Cauvery basin this species is recorded from the *Globorotalia spinuloinflata* subzone (Lower Eocene) to the top of *G. cerroazulensis* zone.

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(All figures: a = ventral view, b = dorsal view, c = side view)

PLATE I

Figures 1 a—c. *Globigerina ampliapertura* BOLLI, from *G. gortanii* zone, core sample at 1800 m. in NGT-1.

Figures 2, 3 a, b, 4. *Globigerina angulisuturalis* BOLLI, from *G. kugleri/G.primordius* zone, core sample at 1421.5 m. in KKL-2.

Figures 5 a, b. *Globigerina ciperoensis* BOLLI, from *G. kugleri/G. primordius* zone, core sample at 1421.5 m. in KKL-2.

Figure 6. *Globigerina angustiumbilicata* BOLLI, from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

Figures 7 a, b. *Globigerina* cf. *pseudoampliapertura* BLOW & BANNER, from *G. gortanii* zone, core sample at 1800 m. in NGT-1.

Figure 8. *Globigerina angiporoides* HORNIBROOK, from *G. gortanii* zone, core sample at 1800 m. in NGT-1.

PLATE I

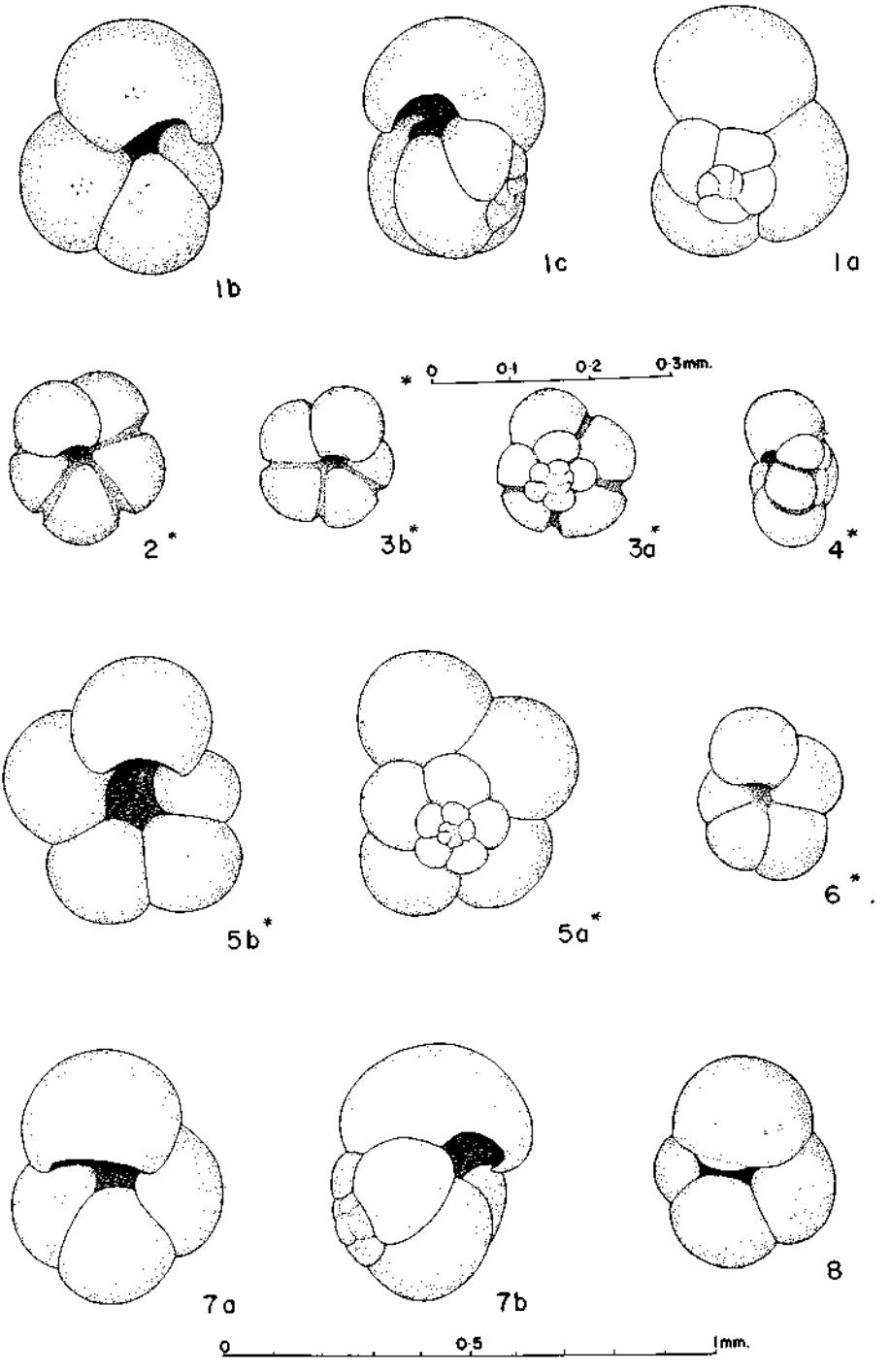


PLATE II

Figures 1 a, b, 2. *Globigerina gortanii gortanii* (BORSETTI), from *G. sastrii* zone, core sample at 1579 m. in KKL-4.

Figures 3 a, b. *Globigerina pseudocorpulenta* CHALILOV, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figures 4 a, b, 5 a, b. *Globigerina gortanii praeturritilina* BLOW & BANNER, from G. mexicana zone, core sample at 1904.2 m. in NGT-1.

Figures 6 a, b. *Globigerina cf. rubriformis* (SUBBOTINA), from *G. gortanii* zone, core sample at 1800 m. in NGT-1.

PLATE II

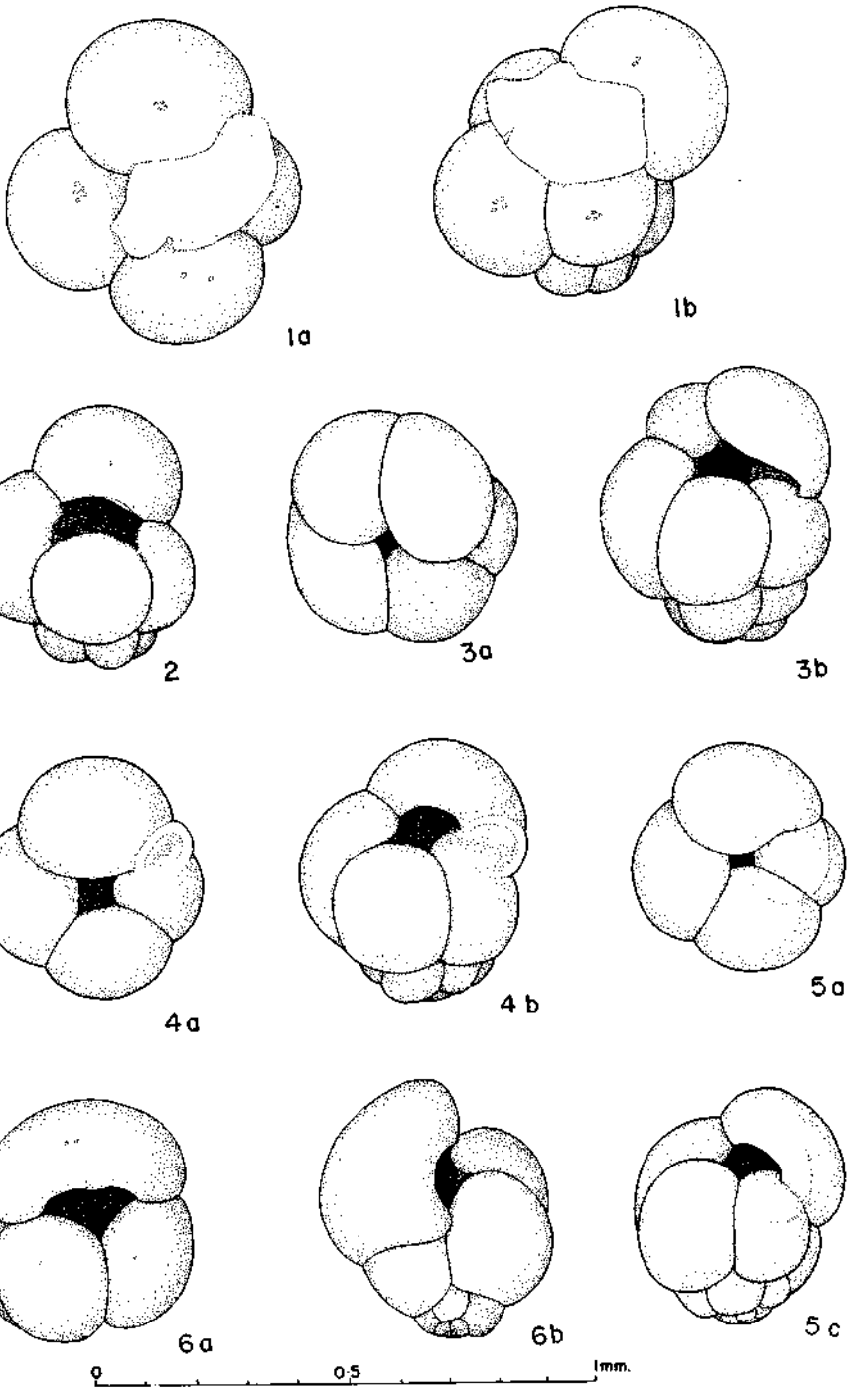


PLATE III

Figures 1 a, b. *Globigerina* sp., from G. mexicana zone, core sample at 1904.2 m. in NGT-1.
Figures 3 a, b. *Globigerina tripartita tripartita* KOCH, from *G. sastrii* zone, core sample at 1579 m. in KKL-4.
Figures 2, 4 a, b. *Globigerina tripartita rohri* BOLLI, from *G. sastrii* zone, core sample at 1582 m. in KKL-4.
Figures 5 a,b, 6. *Globigerina sellii* BORSETTI, 5 a, b from *G. sastrii* zone, core sample at 1582 m. in KKL-4; 6 from cutting sample at 1515 m. in KKL-2.

PLATE III

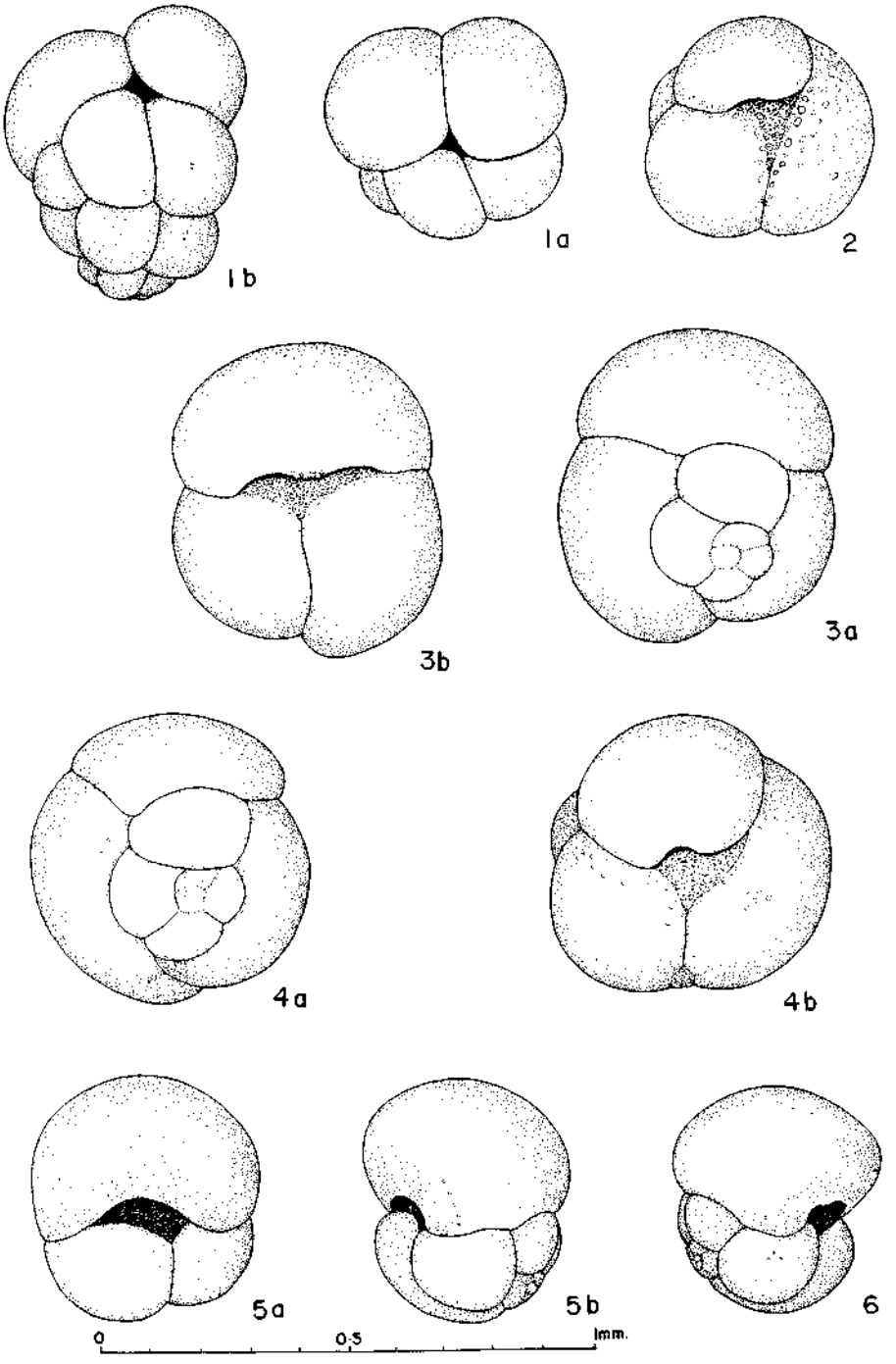
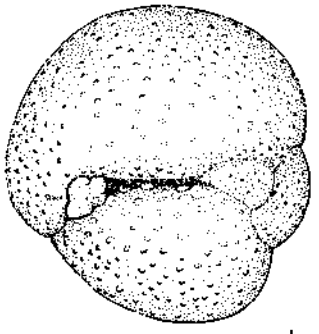


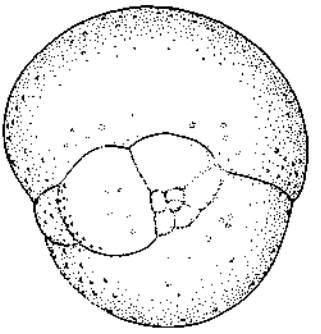
PLATE IV

Figures 1 a—c. *Globigerina sastrii* n. sp., holotype from core sample at 1579 m. in KKL-4, from *G. sastrii* zone.
Figures 2 a—c. *Globigerina sastrii* n. sp., paratype from core sample at 932 m. in TPD-1.

PLATE IV



1c



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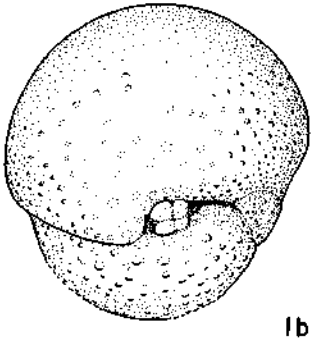

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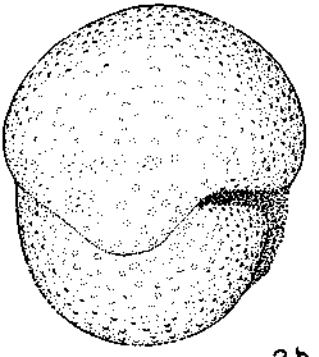
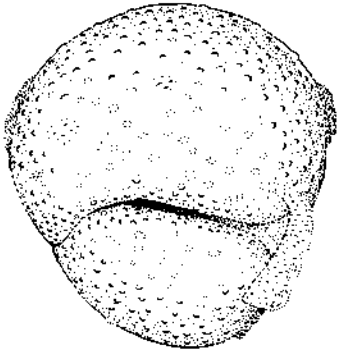


2b



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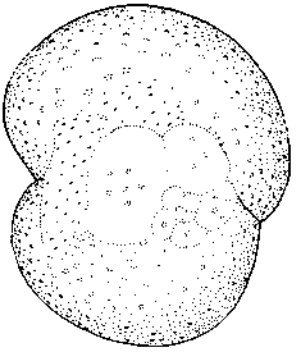

2a

0 0.5 1mm.

PLATE V

Figures 1 a—c. *Globigerina corpulenta* SUBBOTINA, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figures 2 a—c, 3. *Globigerina galavisi* BERMUDEZ, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figure 4. *Globigerina venezuelana* HEDBERG, from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

Figures 5 a—c. *Globigerina woodi woodi* JENKINS, from *G. kugleri/G. primordius* zone, core sample at 1421.5 m. in KKL-2.

PLATE V

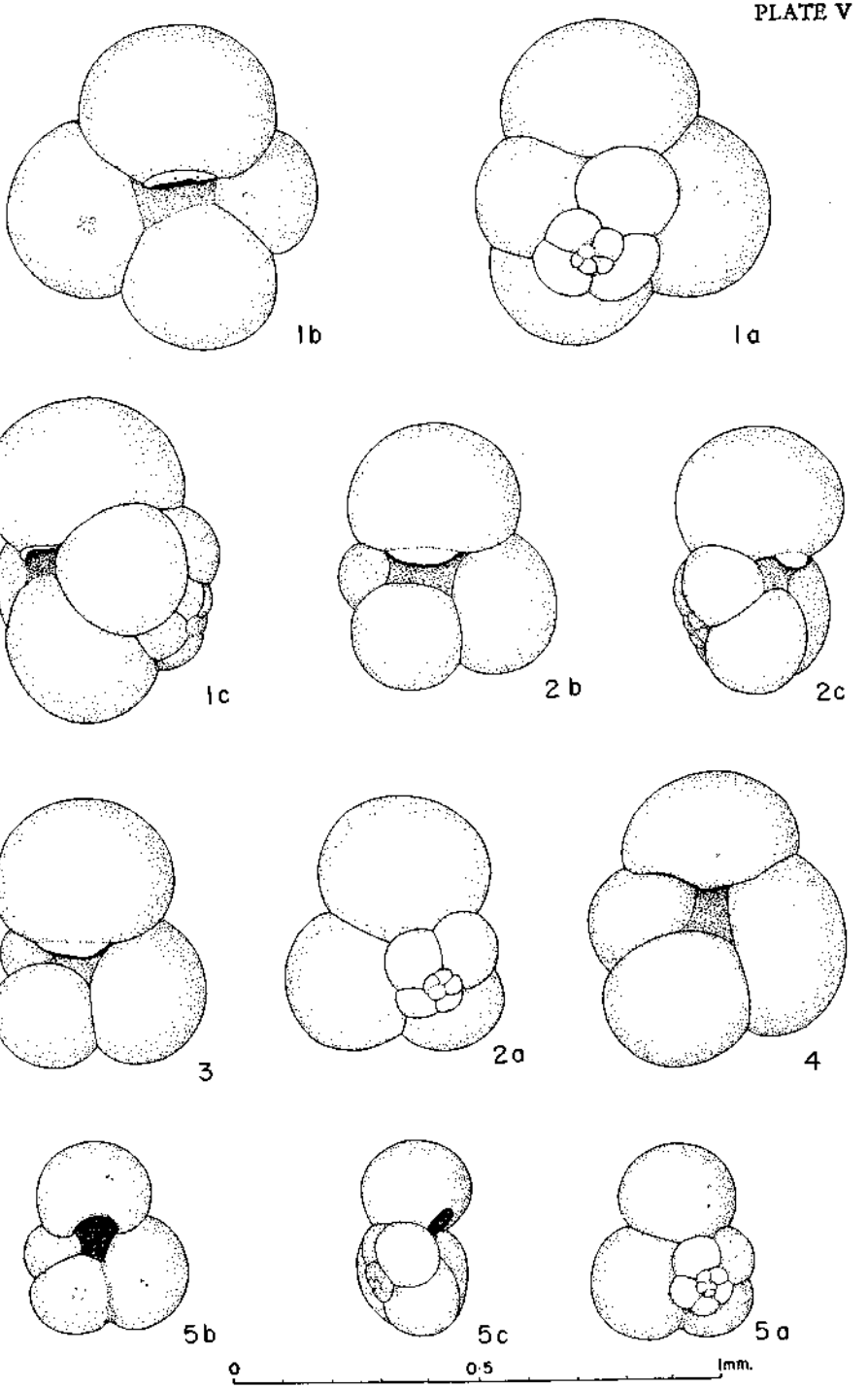

PLATE VI

Figures 1 a—c. *Globigerina venezuelana* HEDBERG, from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

Figures 2 a, b, 3 a, b. *Globigerinita dissimilis* (CUSHMAN & BERMUDEZ), from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

Figures 4 a—c. *Globigerinita stainforthi* (BOLLI, LOEBLICH & TAPPAN), from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

Figures 5 a, b. *Globorotaloides suteri* BOLLI, from a cutting sample at 1463 m. in KKL-1.

PLATE VI

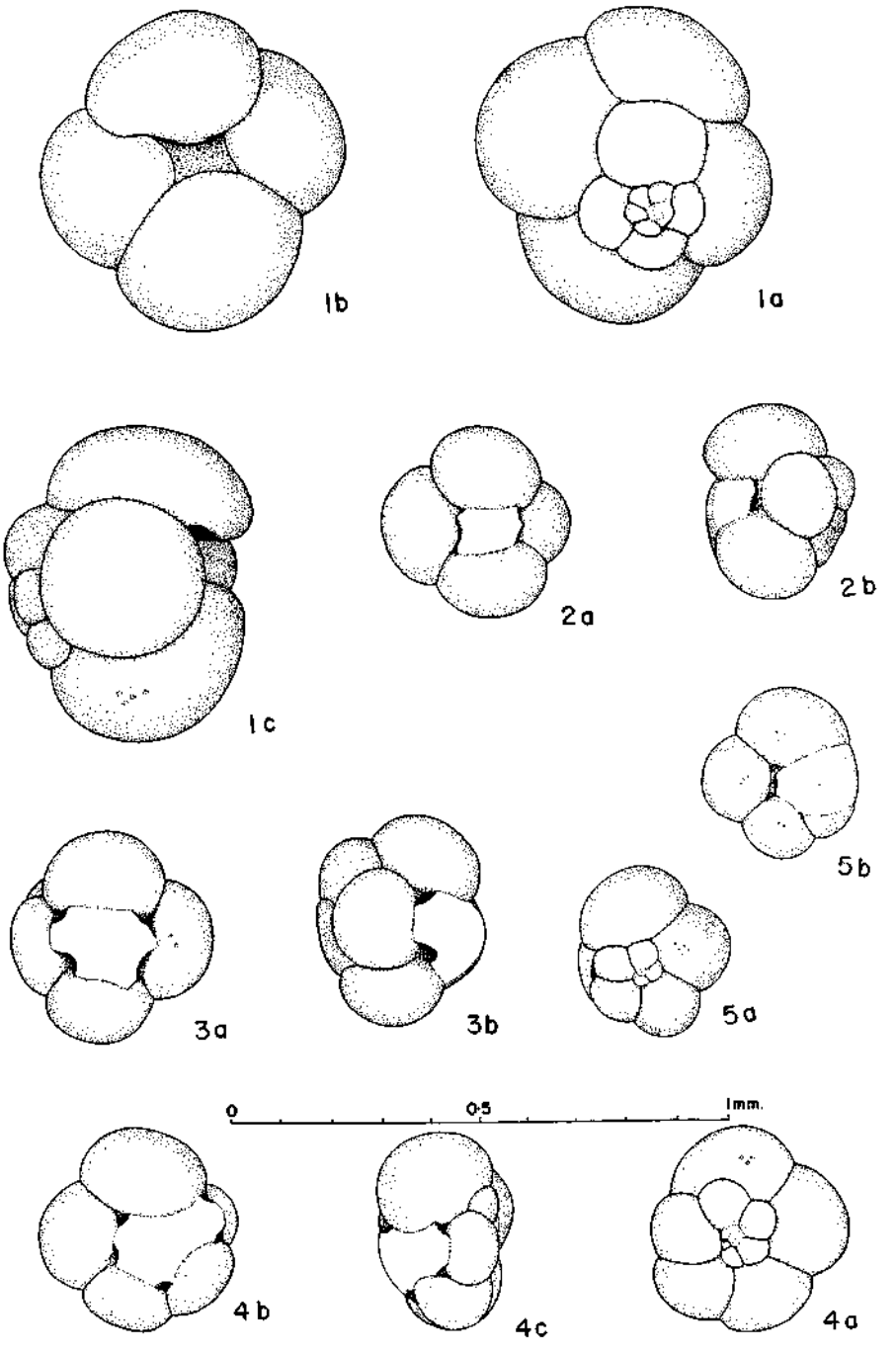

PLATE VII

Figures 1 a, b, 2 a, b. *Globigerinoides primordius* BLOW & BANNER, from *G. kugleri/G. primordius* zone, core sample at 1421.5 m. in KKL-2.

Figures 3 a, b. *Globigerinoides trilobus altiaperturus* BOLLI, from core sample at 639 m. in KKL-4.

Figures 4 a, b. *Globigerinoides trilobus trilobus* (REUSS), from core sample at 495 m. in TPD-1.

Figures 5 a, b. *Globigerinoides* cf. *subquadratus* BRÖNNIMANN, from core sample at 639 m. in KKL-4.

Figures 6 a, b. *Globoquadrina altispira globosa* BOLLI, from the upper part of *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

PLATE VII

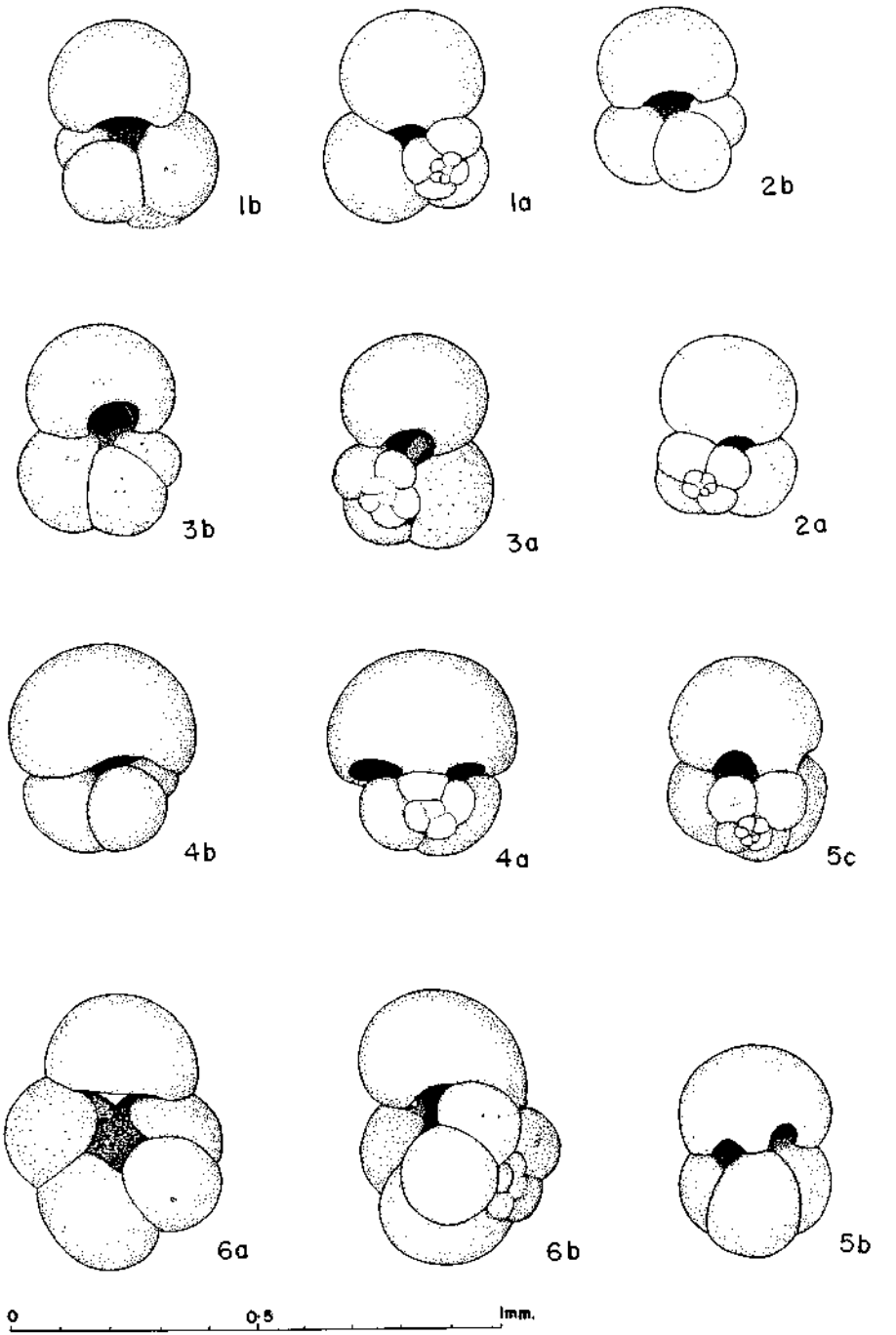

PLATE VIII

Figures 1 a—c. *Globigerinopsis guhai* n. sp., holotype from core sample at 1126.5 m. in KKL-2, upper part of the *G. kugleri/G. primordius* zone.

Figures 2 a—c, 3 a—c *Globigerinopsis guhai* n. sp., paratypes from the same level as the holotype.

Figures 4 a—c. *Globoquadrina praedehiscens* BLOW & BANNER, from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

PLATE VIII

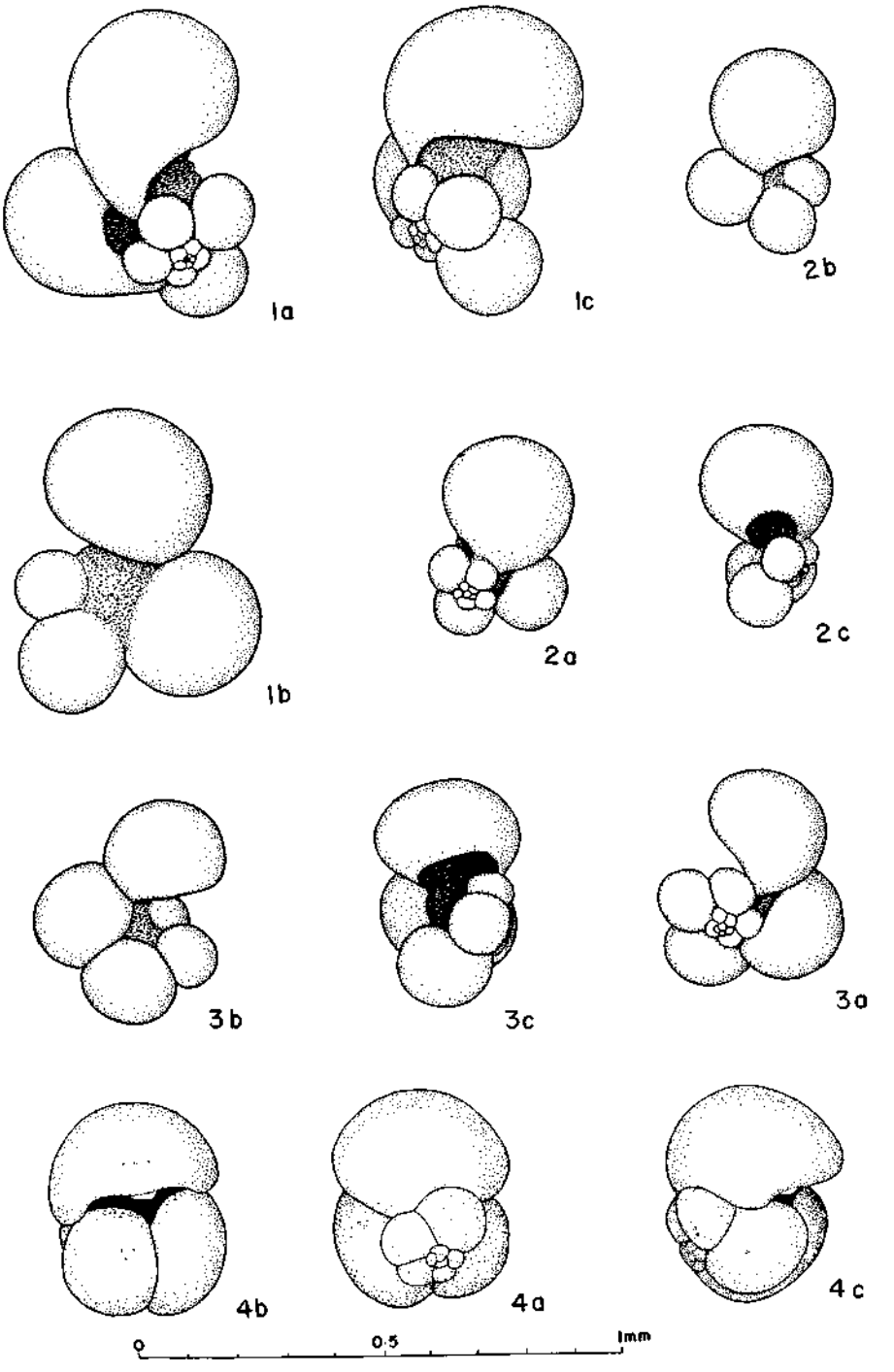

PLATE IX

Figures 1, 2. *Globoquadrina praedehiscens* BLOW & BANNER, from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

Figures 3, 4 a, b. *Globoquadrina dehiscens* (CHAPMAN, PARR & COLLINS), from core sample at 495 m. in TPD-1.

Figures 5 a, b. *Globoquadrina* cf. *larmeui* AKERS, from *G. angulisuturalis* zone, core sample at 1495.5 m. in KKL-2.

Figures 6 a—c. *Globorotalia peripheroronda* BLOW & BANNER, from core sample at 495 m. in TPD-1.

Figures 7 a—c. *Globorotalia increbescens* (BANDY), from *G. gortanii* zone, core sample at 1800 m. in NGT-1.

PLATE IX

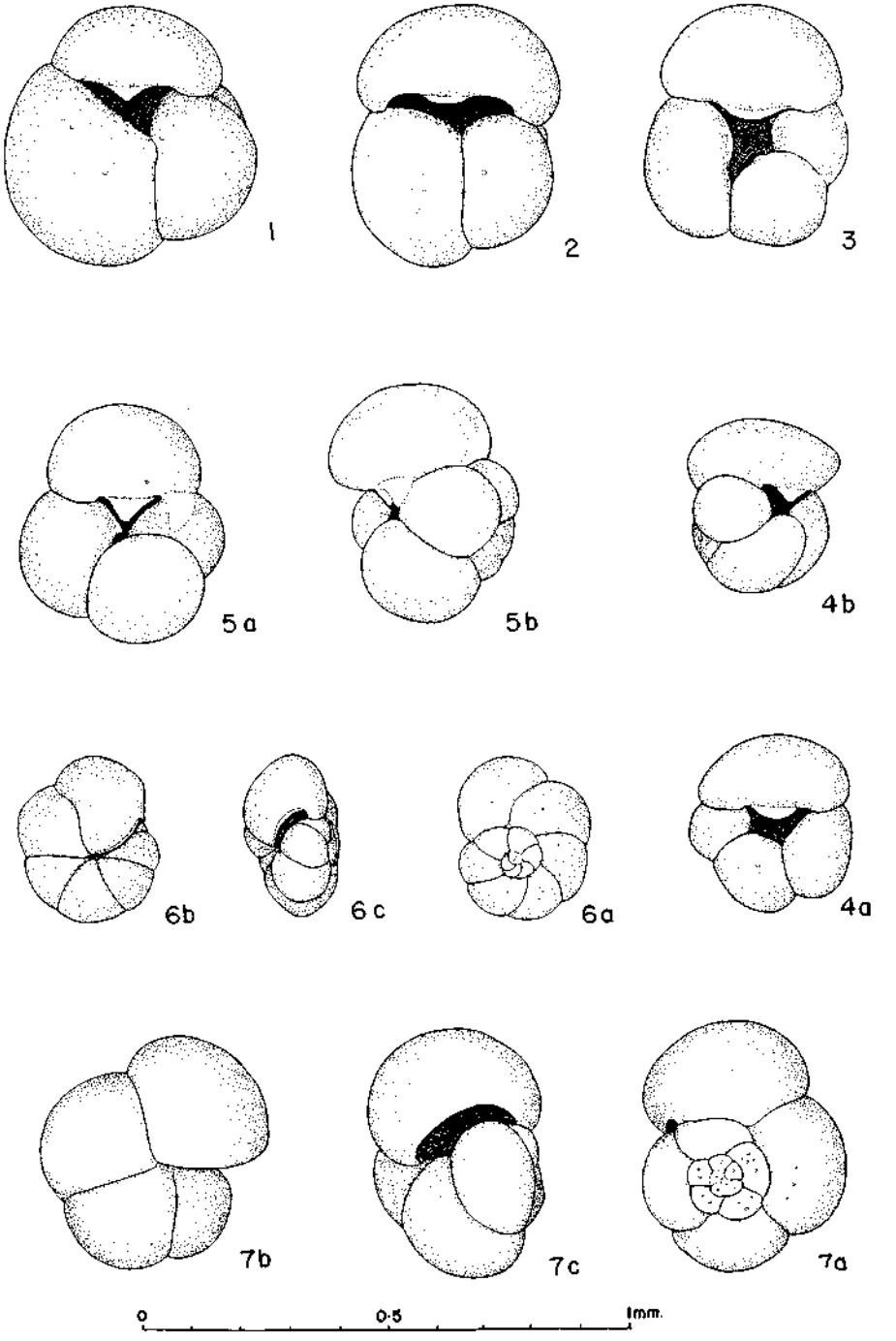

PLATE X

Figures 1 a, b, 2 a, b. *Globorotalia kugleri* BOLLI, from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

Figures 3 a, b. *Globorotalia opima nana* Bolli, from *G. sastrii* zone, core sample at 1582 m. in KKL-4.

Figures 4, 5 a—c. *Globorotalia siakensis* (LEROY), from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

Figures 6 a—c. *Globorotalia obesa* BOLLI, from *G. kugleri/G. primordius* zone, core sample at 1126.5 m. in KKL-2.

PLATE X

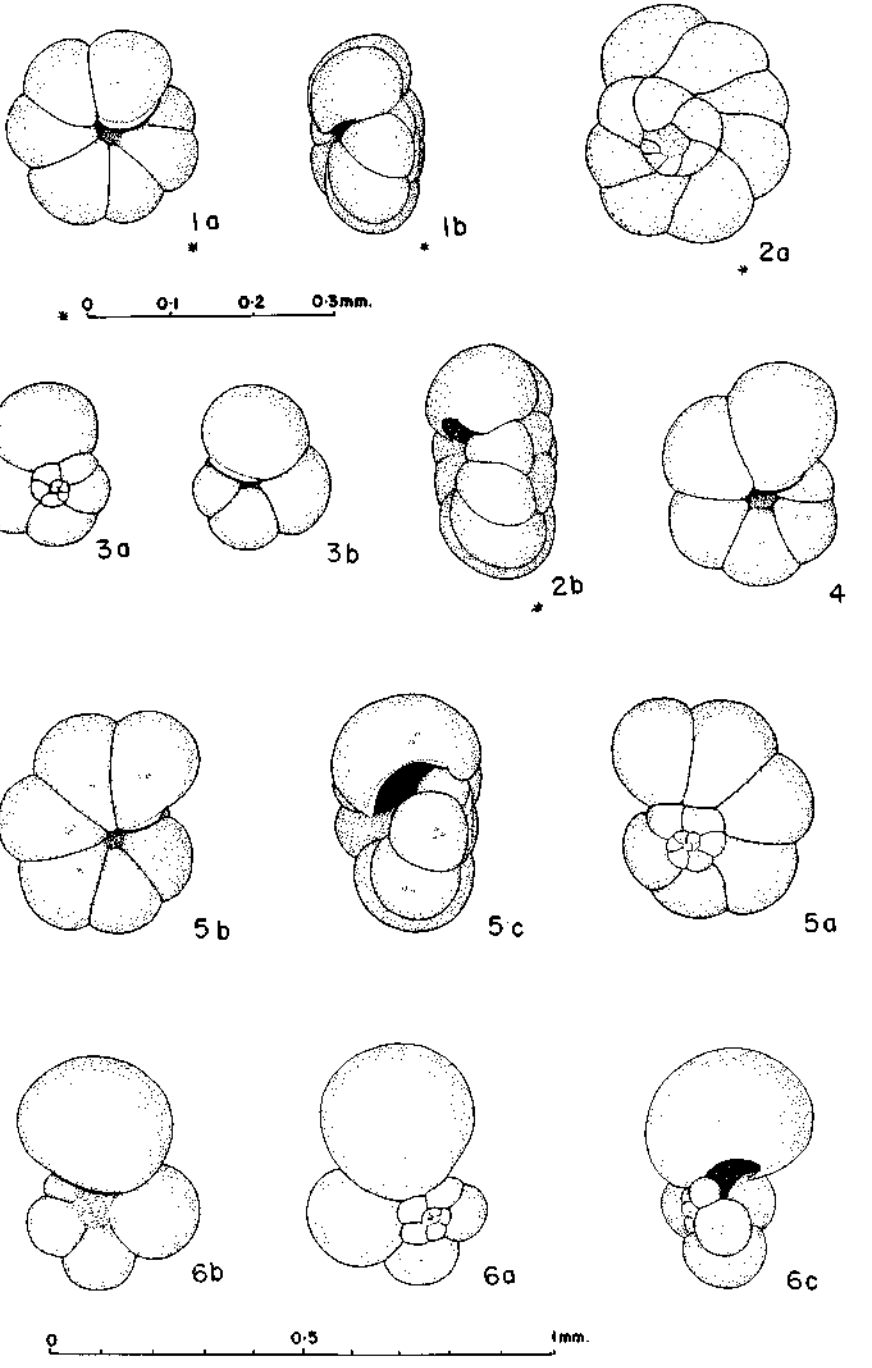

PLATE XI

Figures 1—6. *Globigerapsis mexicana* (CUSHMAN), all from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1, 1—4 juvenile forms with one to two supplementary apertures.

Figures 7 a, b. *Globigerapsis* cf. *tropicalis* BLOW & BANNER, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figure 8. *Hantkenina alabamensis* CUSHMAN, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figure 9 a, b. *Hantkenina alabamensis* CUSHMAN, from a cutting sample at 1580 m. in KKL-1. A from with twin spines.

PLATE XI

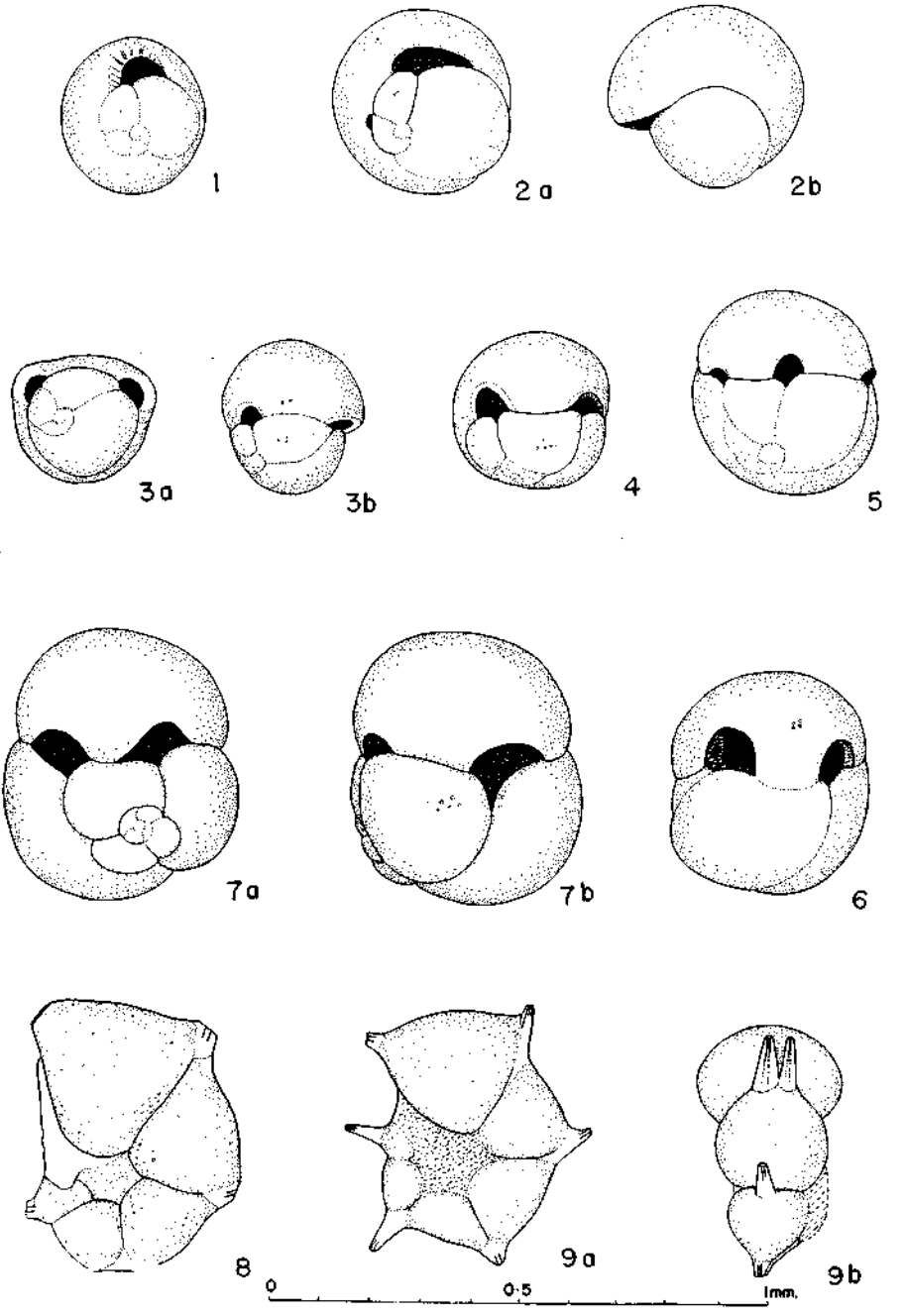

PLATE XII

Figures 1 a, b. *Hantkenina* cf. *thalmanni* BRÖNNIMANN, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figure 2. *Hantkenina alabamensis* CUSHMAN, from *G. cerroazulensis* zone in KKL-4.

Figures 3, 4, 5. *Hantkenina trinitatensis* BRÖNNIMANN, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figures 6, 7, 8. *Hantkenina* sp., from *G. cerroazulensis* zone, core sample at 1716 m. in KKL-4.

Figures 9 a, b, 10. *Hantkenina suprasuturalis* BRÖNNIMANN, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

PLATE XII

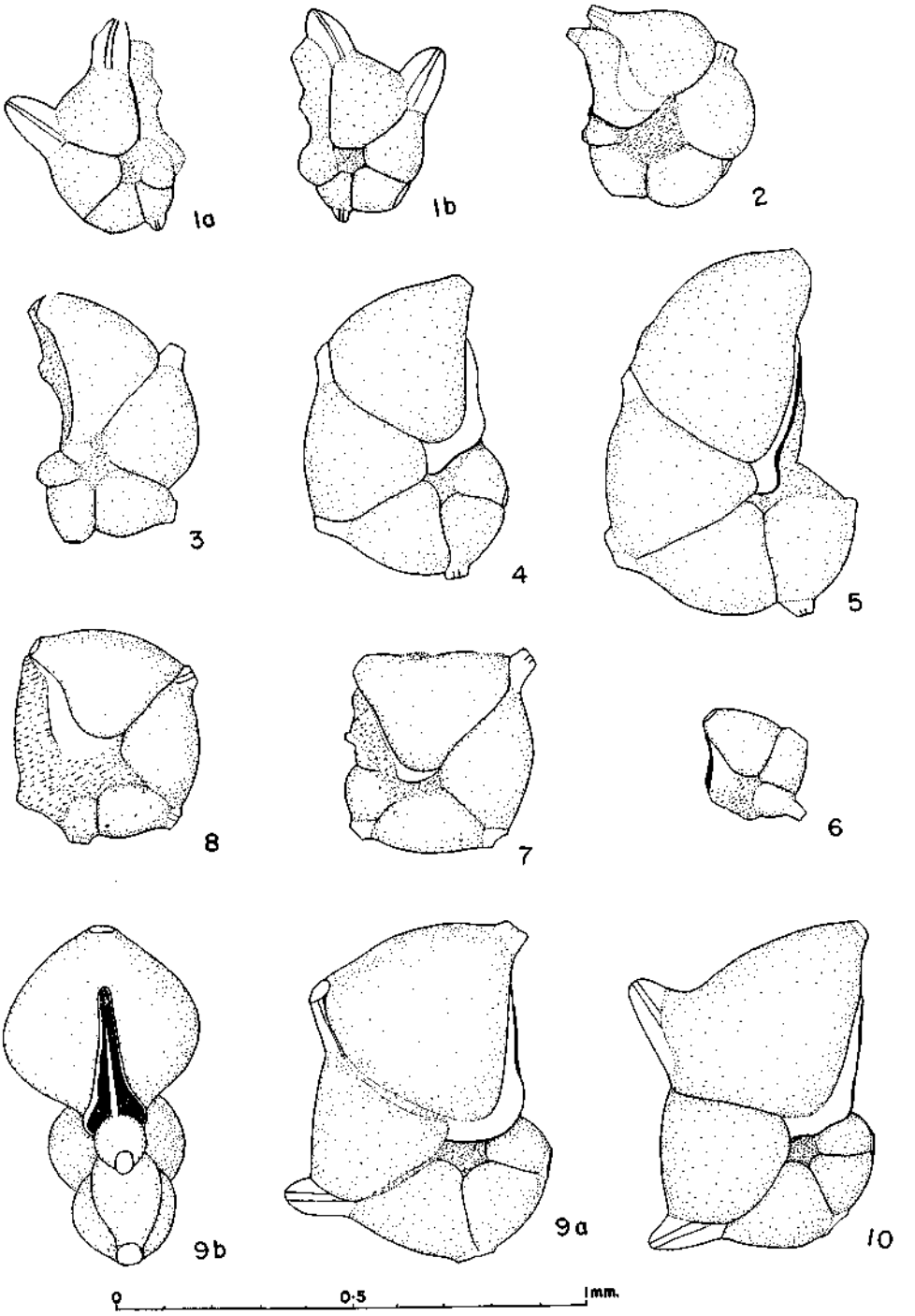

PLATE XIII

Figure 1. *Hantkenina suprasuturalis* BRÖNNIMANN, from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figures 2, 7. *Cribrohantkenina inflata* (HOWE), from *G. cerroazulensis* zone, core sample at 1690 m. in KKL-4.

Figures 3, 4, 5, 6, 8 a, b. *Cribrohantkenina inflata* (HOWE), from *G. cerroazulensis* zone, all from a core sample at 1716 m. in KKL-4.

Figures 9 a, b. *Pseudohastigerina micra* (COLE), from *G. mexicana* zone, core sample at 1904.2 m. in NGT-1.

Figures 10, 11. *Hantkenina* sp., from *G. cerroazulensis* zone, core sample at 1690 m. in KKL-4, juvenile forms with the spines bending backward.

PLATE XIII