CONTRIBUTIONS

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352. ACCELERATION OF THE EVOLUTIONARY RATE IN THE *ORBULINA* LINEAGE

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ABSTRACT

The stratigraphic ranges of 9 taxa of the **Orbulina** evolutionary lineage from 4 Australasian Miocene sequences have been plotted against sediment thicknesses and indicate an evolutionary acceleration from **Globigerinoides trilobus bisphericus** Todd through to **Orbulina universa** d'Orbigny. A correlation with radiometric data indicates that the first 3 taxa of the lineage appeared within about 6 m.y. and the last 6 taxa appeared within only 2 m.y. The possible biological significance of the results and taxonomic rates are discussed.

INTRODUCTION

The *Orbulina* evolutionary lineage has been recorded by many workers in Miocene sequences from many parts of the world (see Jenkins, 1965). Stratigraphically the lineage can be traced through from the Lower Miocene *Globigerina woodi* Jenkins to the end form *Orbulina universa* d'Orbigny in the Middle Miocene which ranges through to the present. This paper is an attempt to compare the measurement of the phylogenetic rate of evolution within the *O. universa* lineage.

From a comparison of the stratigraphic initial appearance of 9 named taxa within the *Orbulina* lineage in 4 stratigraphic sections from New Zealand and Australia (text fig. 1), it is suggested that there was an increase in the evolutionary tempo in the upper part of the lineage towards the Middle Miocene. There is slight evidence that there was a decrease in the tempo after the appearance of *Orbulina suturalis* Brönnimann.

ACKNOWLEDGEMENTS

The writer is indebted to many people, including Professor Alan Wood who provided the academic climate at Aberystwyth, Wales during 1956-59 when this paper was first formulated as part of a Ph.D. thesis, and Dr. W. A. Berggren for providing the quoted unpublished and radiometric data. During the ensuing period I have gained from innumerable discussions with many paleontologists. The writer is further indebted to both Mr. R. C. Brazier of the New Zealand Geological Survey who made the illustrations of the specimens and to Miss L. Fiddes of the Geology Department, University of Canterbury, who assembled the figures.

ORBULINA EVOLUTIONARY LINEAGE

The chief morphological changes within the *Orbulina* lineage are the progressive envelopment of the earlier part of the test by the final chamber and a concommittant increase in the number of apertures correlated with a decrease in the apertural size.

The first recognized taxon in the *Orbulina* lineage is *Globigerina woodi woodi* Jenkins (text fig. 2) which has 3-4 chambers in the final whorl and a single umbilical aperture, and the end form is *Orbulina universa* d'Orbigny (text fig. 2) which has a spherical test with a large number of small apertures scattered over the test surface. All the intermediate morphologies exist within the lineage, but only 7 other named taxa are here recognized. Representatives of the 9 taxa have been illustrated from the Miocene Muddy Creek section, New Zealand (text fig. 2).

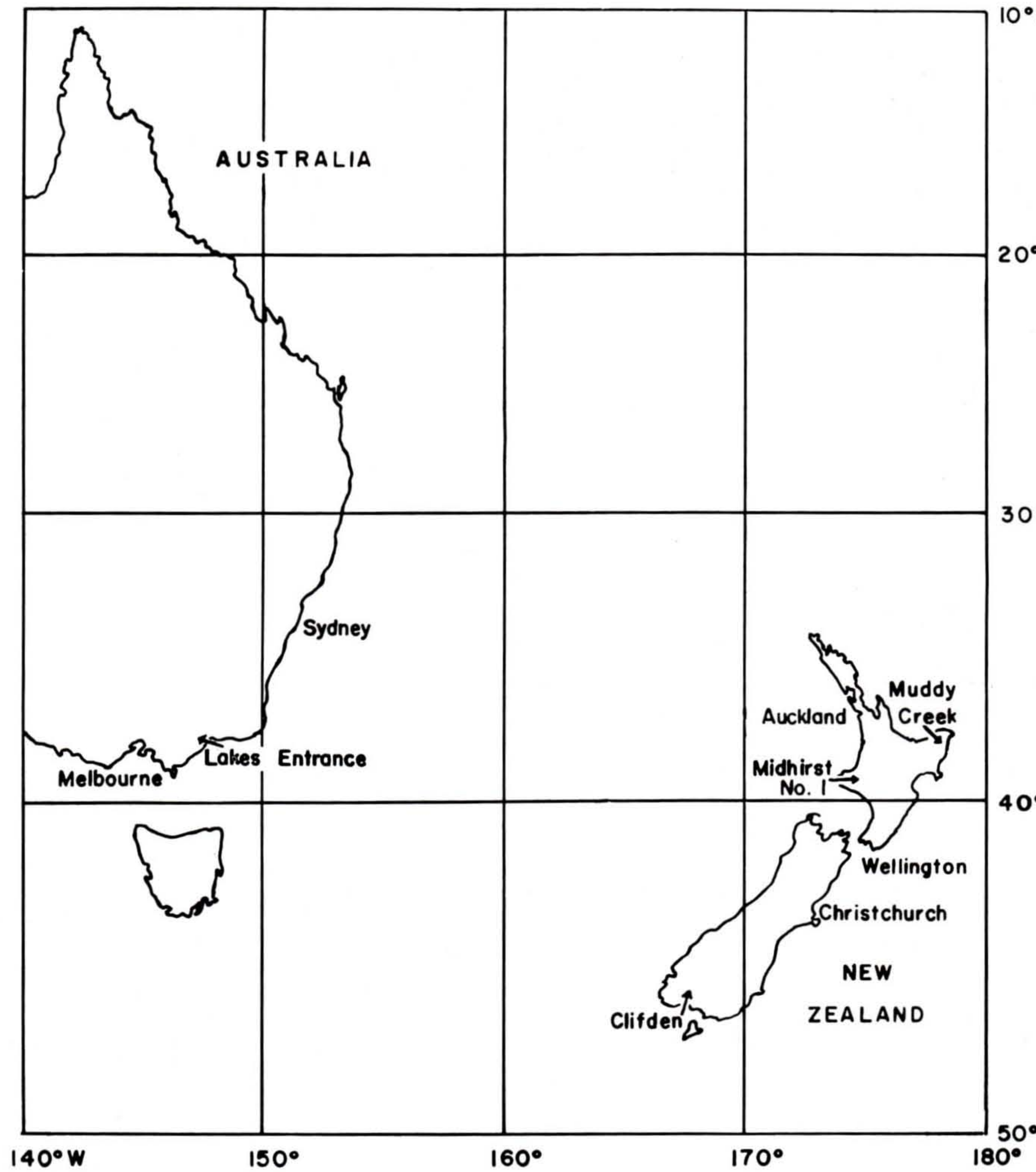
The taxa within the continually evolving *Orbulina* lineage have been arbitrarily defined, and from the writer's experience some are more easily identifiable than others. Taxonomically, the difficulties of accurate identification and delineation of the taxa lie in the region between ancestor and immediate descendant and the problems are especially true of the following taxa in table 1.

IMMEDIATE ANCESTOR	DESCENDANT
Praeorbulina glomerosa glomerosa (Blow)	*Praeorbulina glomerosa circularis* (Blow)
Praeorbulina glomerosa curva (Blow)	*Praeorbulina glomerosa glomerosa* (Blow)
Globigerinoides trilobus bisphericus (Todd)	*Praeorbulina glomerosa curva* (Blow)
Globigerinoides trilobus trilobus (Reuss)	*Globigerinoides trilobus bisphericus* Todd
Globigerina woodi woodi Jenkins	*Globigerina woodi connecta* Jenkins

TABLE 1

Pairs of ancestors and immediate descendants which are difficult to differentiate where the stratigraphic ranges and morphologies overlap.

The separating lines between the above ancestors and descendants have been fixed arbitrarily by various micropaleontologists, and one method of producing consistently accurate identifications is by relating each taxonomic identification to each holotype, which is regarded as the central morphological type. The writer has discussed the differences between *Globigerina woodi woodi* and *Globigerina woodi connecta* (Jenkins, 1964), and Blow (1956)



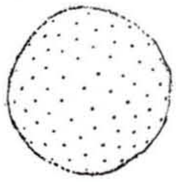
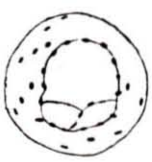
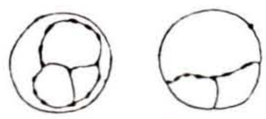
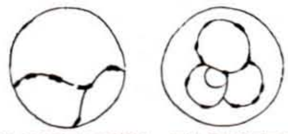
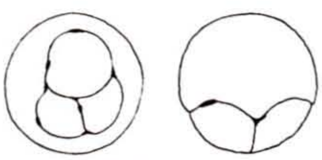
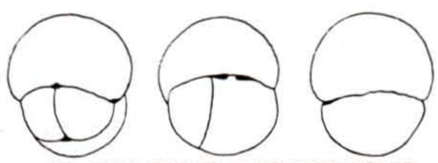
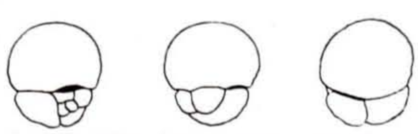
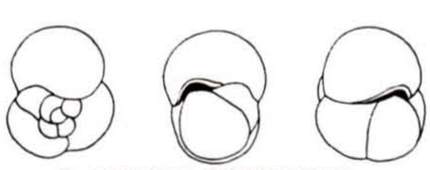
TEXT FIGURE 1
Location map

discussed the differences between the other taxa recorded in table 1.

The morphological differences between the other taxa within the lineage are more definite. Thus the ancestor *Globigerina woodi connecta* differs from its immediate descendant *Globigerinoides trilobus trilobus* by having a single umbilical aperture as opposed to the umbilical aperture plus an additional aperture or apertures on the spiral side of *G. trilobus trilobus* (text fig. 2).

A similar clear distinction occurs between *Orbulina suturalis* and *Praeorbulina glomerosa circularis* where the latter has small sutural openings limited to the outline of the *Globigerina* stage, and the former has the minute apertural openings also outside the sutures (text fig. 2).

The taxonomic distinction between the two *Orbulina* species is distinct if *O. universa* is defined as having a scatter of small apertures *all over* the surface of the test (text fig. 2).

ORBULINA LINEAGE	LAKES ENTRANCE OIL SHAFT AUSTRALIA	NEW ZEALAND		
		CLIFDEN SECTION	MIDHIRST No1 WELL TARANAKI	MUDDY CREEK SECTION
	feet	feet	feet	feet
 ORBULINA UNIVERSA	20	180	320	500
 ORBULINA SUTURALIS	0	0	90	100
 P. GLOMEROSA CIRCULARIS	4	50	0	100
 P. GLOMEROSA GLOMEROSA	8	60	235	0
 P. GLOMEROSA CURVA	32	60	825	150
 G. TRILOBUS BISPHERICUS	172	no data	1774	950
 G. TRILOBUS TRILOBUS	80	no data	no data	no data
 G. WOODI CONNECTA	152	no data	no data	no data
 G. WOODI WOODI	4ft SAMPLING	IRREGULAR SAMPLING	IRREGULAR SAMPLING	100ft SAMPLING

TEXT FIGURE 2

Nine taxa of the *Orbulina* lineage illustrated from specimens of the Muddy Creek section. All specimens approximately ×32 and deposited in the collections of the New Zealand Geological Survey, Lower Hutt, under the numbers FP 1322-1335 inclusive. Stratigraphic separation of individual taxa recorded in feet in 4 named Miocene sequences.

RESULTS

1. Evolutionary rate plotted against sediment thicknesses.

The stratigraphic ranges of the 9 taxa of the *Orbulina universa* lineage have been plotted against thicknesses of sediment of Lakes Entrance oil shaft, Victoria, Australia, and in three New Zealand sections: Midhirst No. 1 Well, Taranaki, Muddy Creek section and Clifden section, (text figs. 1-3). By comparison of sediment thicknesses in the first 3 sections, it can be demonstrated that the evolution of *Globigerina woodi woodi* to *Globigerinoides trilobus bisphericus* took place over relatively thicker sequences of rock as compared with the evolution of *G. trilobus bisphericus* to *O. universa* (table 2).

	G. woodi woodi to G. trilobus bisphericus	G. trilobus bisphericus to O. universa
Lakes Entrance oil shaft	364 ft.	64 ft.
Midhirst No. 1	2673+ ft.	1470 ft.
Muddy Creek	2950+ ft.	850 ft.

TABLE 2

Stratigraphic separation of taxa. It should be noted that in both Midhirst No. 1 and Muddy Creek, the sequences do not extend stratigraphically low enough to record the initial appearance of *Globigerina woodi woodi*; this is indicated by the + sign.

The morphological change in the evolutionary lineage from *Globigerina woodi woodi* through to *Globigerinoides trilobus bisphericus* involved radical changes in test morphology. The main changes were a reduction in the height of the aperture and the test becoming more compact, these resulting in *Globigerina woodi connecta*; the next stage was the appearance of an aperture on the spiral side of the test at the base of the final chamber, resulting in *Globigerinoides trilobus trilobus*. The final chamber showed a gradual envelopment of the rest of the test; envelopment proceeded to about 15-30% of the chambers of the earlier part of the test, and was accompanied by an increase in apertures to about 2-4, resulting in *G. trilobus bisphericus* (text fig. 2).

The morphological test changes from *Globigerinoides trilobus bisphericus* to *Orbulina universa* involved a complete envelopment of the earlier test by the final chamber; the lineage has been divided into 5 further taxa (text fig. 2).

A possible interpretation of the evolution involves the postulate that once the final chamber enveloped the earlier part of the test, beyond about 30%, then the tempo of evolution increased (see text fig 2.).

2. Evolutionary rate plotted against radiometric data.

Berggren (1968 in press: Table 38) has published a chronology of the Cenozoic. A correlation with the Australasian phylogeny of the *Orbulina universa* lineage indicates that *Globigerina woodi woodi* appeared at about 28 m.y. B.P., *Globigerinoides trilobus bisphericus* at about 22 m.y. B.P. and *O. universa* at about 20 m.y. B.P. Consequently the first 3 taxa of the *O. universa* lineage appeared within approximately 6 m.y. and the last 6 taxa appeared within only approximately 2 m.y. This possibly crude chronology tends to support the postulated acceleration in the tempo of evolution within the *O. universa* lineage.

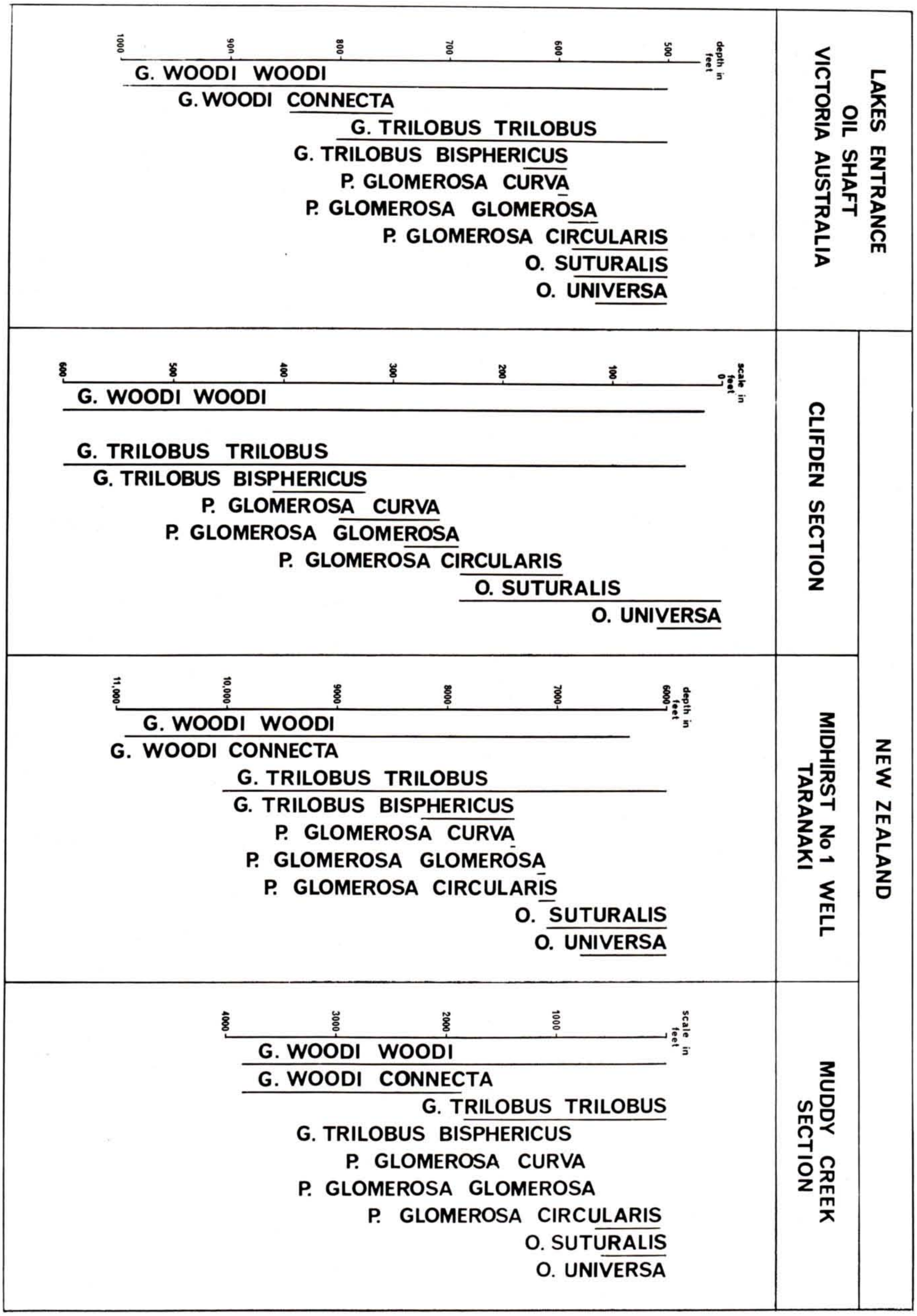
DISCUSSION OF RESULTS

Rensch (1959) quoted both Darwin (1859) and Gaudry (1896) as concluding that in the lower animals the tempo of evolution is generally slow, but Rensch considered these generalisations to be unsafe. He cited the evidence of the fossil record of the rapid splitting of the Foraminiferida *Nummulites* and *Orbitoides* in the Eocene and also numerous lines of ammonites. Rensch (1959) further stated "that the speed of evolution depends on the rates of selection, because in more mobile animals the evolutionary tempo is increased since such types are able to adapt more easily." It is therefore possible to interpret the *Orbulina universa* lineage as demonstrating an increase in the rate of selection from *Globigerinoides trilobus bisphericus* through to *O. universa*.

According to Simpson (1953) the ideal measurement of evolutionary rate would be the amount of genetic change in continuous populations per year or other unit of absolute time. Simpson concluded that "there is little hope that fossils can ever be used for any extensive study of genetic rate of evolution."

Nevertheless fossils can be used to study the rates of evolution and Simpson (1953) distinguished two main methods. The phylogenetic rate of evolution measures the changes involved within a lineage, and the taxonomic frequency rate records the changes in the numbers or frequencies of the phyla or larger taxonomic units existing at a given time.

Evolutionary rates are expressed against various temporal scales. A frequently used scale is based on the thickness of strata, but the validity of the method demands a constant relationship between not only succession but also thickness of strata and time. Simpson (1953) in a further discussion stated that the method demands the rate of deposition to have been approximately constant, but this is impossible to prove and deposition is normally not constant. Simpson concluded "that this method can give some information about fluctuations in rates of evolution and it is a valid way of comparing rates of different characters or of different phyla during the same span of time. . . ." The present



TEXT FIGURE 3

Stratigraphic ranges of 9 named taxa of the *O. universa* lineage from 4 Australasian Miocene sequences.

paper is presented to "give some information about fluctuations in the rates of evolution" of the *Orbulina universa* lineage.

It is assumed in the present work that the rocks containing the *Orbulina universa* lineage at Lakes Entrance, Australia, and in the New Zealand localities of Clifden, Midhirst No. 1, Taranaki and Muddy Creek were deposited over the same span of time in the Lower to Middle Miocene. As can be seen from text figs. 2 and 3, the thicknesses of strata are different, indicating the expected different rates of sedimentation in the various areas.

An argument which could be levelled against the postulated increase in the evolutionary tempo within the *Orbulina universa* lineage concerns its taxonomic subdivision. For example, it could be argued that the *Globigerinoides trilobus bisphericus* to *O. universa* part of the lineage has been split up into more taxa than the earlier part of the lineage.

A similar objection to studies of evolutionary rate was recently presented by Rhodes (1966), but fortunately there is some support for the writer's postulated acceleration in evolutionary tempo from the statistical work of Scott (1966, 67). In the Clifden section the rate of change of certain characters plotted against sediment thickness is considerably more rapid in *Praeorbulina glomerosa* than either before or after this species (see Scott 1966, figs. 13, 39; 1967, fig. 9).

If a taxonomist lumped the whole of the lineage taxa from *Globigerina woodi* to *Orbulina universa* into only one species, then it could be argued that its mono-taxonomic nature would not demonstrate the evolutionary acceleration. On the other hand, the observable (and measureable - see Scott 1966, 67) morphological changes of the lineage plotted against a temporal scale such as rock thicknesses demonstrate a more rapid change in morphology in the upper part of the lineage.

Huxley (1957) used the word *anagenesis* to describe "all types or degrees of biological improvement, from detailed adaptation to general organizational advance" and *stasigenesis* "to cover all processes leading to stabilization and persistence of types and of patterns of organization, from species up to phyla." Thus the *Orbulina universa* lineage could be interpreted as demonstrating anagenesis followed by stasigenesis, with the appearance of *O. universa* in the Middle Miocene, a form which has persisted for about 20 m.y. to the present day. This interpretation agrees with the general statement by Sylvester-Bradley (1967) that "periods of anagenesis alternate with periods of stasigenesis during which modification is slow and the species remain in the same adaptational grade."

The *Orbulina universa* lineage could be further interpreted as an advance in the efficiency of a major function (Huxley, 1957): a change from the multichambered botryoidal *Globigerina* to the spherical test of *Orbulina* was the result of selective survival. It is possible that functionally the spherical test has a buoyancy advantage in the planktonic environment.

TAXONOMIC RATES

Measurements of taxonomic rates are at present crude, but such studies have given approximate estimates of the rate of speciation in certain animal groups. Thus Rhodes (1966) recorded that the rate of speciation of Cenozoic mammals has been calculated as 500,000 years.

The duration of the Miocene *Orbulina* lineage from the initial appearance of *Globigerina woodi* through to the initial appearance of *Orbulina universa* is approximately 8 m.y. (Berggren, 1968, in press). The number of *species* recorded in the lineage is 5 and therefore the average speciation rate is 1.6 m.y.

Published records of evolutionary acceleration within well documented lineages are rare. The present paper attempts to demonstrate a possible interpretation of the *Orbulina universa* lineage as another example of changes in evolutionary tempo within a well-known lineage.

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353. A NEW GENUS OF THE HAPLOPHRAGMOIDINAE FROM MALAYSIA

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ABSTRACT

The new genus and species, described below, are believed at present to be restricted to the brackish-water environments of two estuaries in Malaysia. Their morphology is described in detail and their taxonomic position shown to be among the Haplophragmoidinae.

INTRODUCTION

In the course of study of the Recent brackish-water foraminifera of three estuaries in Malaysia undertaken for the purpose of preparing a thesis for the degree of Master of Science, species of foraminifera were found in the Recent sediments of two estuaries, the Labuk Estuary, Sabah, East Malaysia, and the Kuala Sungei Selangor, West Malaysia, which did not fall within existing generic and specific categories. It was therefore considered desirable to erect a new genus for these forms.

The collections that form the basis of the present paper were made by the author during the months of May, 1967, and November, 1967. The majority of the specimens come from Labuk Estuary, while only one specimen was from the Kuala Sungei Selangor, and all were found in soft, brown muds. The salinities of the waters correspond to the pliohaline (9-16 parts per thousand) and brachyhaline (16.5-30 parts per thousand) brackish-marine water facies of Hiltermann (1949). Temperatures correspond to those of shallow, warm tropical waters.

A study of the available literature indicated the new genus to be most closely related to the Haplophragmoidinae described by Maync (1952), but the difference between it and the other members of the Haplophragmoidinae is sufficient to establish its generic distinction.

DEPOSITORY OF TYPES

The figured specimens are deposited in the Research Collection of the Department of Geology, University of Malaya, Kuala Lumpur, West Malaysia.

ACKNOWLEDGEMENTS

This work was made possible by the research facilities granted by the University of Malaya and by a grant from the Geological Survey, Borneo Region, Kota Kinabalu, Sabah, East Malaysia. Sincere thanks are due to Helen Tappan, Ruth Todd, K. Asano, S. B. Bhatia, and D. J. Gobbett for examining and commenting on the new genus and species.

DESCRIPTION OF THE NEW GENUS AND SPECIES

Family LITUOLIDAE de Blainville, 1825
Subfamily HAPLOPHRAGMOIDINAE Maync, 1952

Genus **Gobbettia** Dhillon, n. gen.

Type Species **Gobbettia wilfordi** Dhillon, n. sp.

Test free, medium size, planispiral; wall chitinous or pseudochitinous, glossy, smooth, translucent to transparent, flexible; chambers inflated near periphery, increasing in length gradually but noticeably in width as added, chambers not reaching axis of coiling, leaving an open umbilicus which is greatly depressed relative to the peripheral margin; periphery broadly rounded, not lobulate; typically 8 chambers in final whorl; sutures slightly or irregularly curved, depressed; primary aperture a narrow, arched, interiomarginal slit, supplementary aperture a comparatively wide, arched opening surrounded by an everted lip placed low in the apertural face of the last chamber.

Remarks.—The genus *Gobbettia* is closest to *Trochamminita* Cushman and Bronnimann, which in the early stages is planispiral with a single or multiple aperture. However, *Trochamminita* later develops rather irregular chambers, and numerous apertures that are no longer in an equatorial position. According to Helen Tappan (personal communication) they could not be regarded as congeneric.

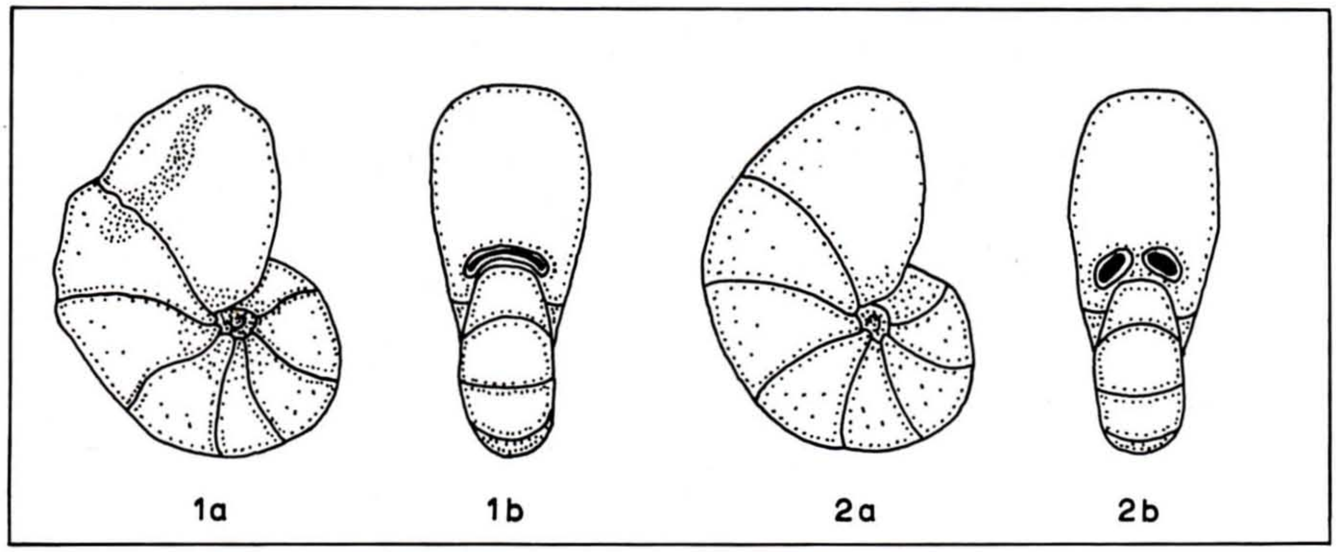
The genus is named in honour of Derek J. Gobbett, Sedgewick Museum, Cambridge, England.

Gobbettia wilfordi Dhillon, n. sp.

Text figures 1a, b

Test free, medium size, planispirally coiled; wall chitinous or pseudochitinous, glossy and smooth, translucent to transparent; chambers inflated near periphery, increasing gradually in length but rapidly in width as added; umbilicus open, depressed relative to the periphery; characteristically 8 chambers in final whorl; sutures slightly or irregularly curved, slightly depressed; periphery broadly rounded, not lobulate; primary aperture a low, arched, interiomarginal slit, supplementary aperture a wide, arched opening placed low in the apertural face of the last chamber. Specimen slightly deflated due to flexibility of the test.

Remarks.—This species is named in honour of



TEXT FIGURE 1
Gobbettia wilfordi Dhillon, n. gen., n. sp.; a. side view of Recent holotype; b. edge view. ×63.

TEXT FIGURE 2
Gobbettia klompei Dhillon, n. sp.; a. side view of Recent holotype; b. edge view. ×63.

G. E. Wilford, Geological Survey, Borneo Region, Kota Kinabalu, Sabah, East Malaysia.

Dimensions.—Maximum diameter of Recent holotype 0.34 mm., maximum thickness 0.15 mm.

Material.—One hundred specimens.

Geographic Range.—At present this species is known only from Kuala Sungei Selangor, and Labuk Estuary.

Types and Repository.—Holotype (Research Collection No. 5788) and one paratype deposited in the Department of Geology, University of Malaya, Kuala Lumpur, West Malaysia.

Gobbettia klompei Dhillon, n. sp.

Text figures 2a, b

Test medium size, free, planispiral; chambers not reaching to the axis of coiling, leaving an open umbilicus that is greatly depressed relative to the periphery; wall chitinous or pseudochitinous, translucent to transparent; surface glossy and smooth; chambers greatly inflated near periphery, increasing gradually in length but rapidly in width as added; typically 8 chambers in last whorl; sutures slightly curved, depressed; periphery broadly rounded but not lobulate; primary aperture a low, arched, interiomarginal slit, 2 supplementary apertures with everted lips around them placed low in the apertural face of the last chamber.

Remarks.—This species is similar to *Gobbettia wilfordi* in almost all respects, the only difference being in the number of the supplementary apertures.

This species is named in honour of the late Professor T. H. F. Klompe, formerly Professor and Head, Department of Geology, University of Malaya, Kuala Lumpur, West Malaysia.

Dimensions.—Maximum diameter of Recent holotype 0.33 mm., maximum thickness 0.14 mm.

Material.—Two specimens.

Geographic Range.—At present this species is known only in Labuk Estuary.

Types and Repository.—Holotype (Research Collection No. 5789) and paratype deposited in the Department of Geology, University of Malaya, Kuala Lumpur, West Malaysia.

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354. LATE EOCENE AND EARLY OLIGOCENE PLANKTONIC FORAMINIFERA FROM PORT ELIZABETH AND CAPE FOULWIND, NEW ZEALAND

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ABSTRACT

Twenty-eight species and subspecies of planktonic Foraminifera are recorded from Upper Eocene (Kaiatan and Runangan) and Lower Oligocene (Whaingaroan) strata of the west coast of South Island, New Zealand. Five biostratigraphic zones are defined and correlated with zones elsewhere in the world. Comparison with the sequence of planktonic Foraminifera in the Caribbean region and in East Africa is reasonably close.

INTRODUCTION

The Tertiary of New Zealand is remarkably well developed in a variety of facies. Much of it contains abundant fossils; it has been divided into 21 stages grouped into 7 series. This paper describes fossil planktonic Foraminifera of the Kaiatan, Runangan and Whaingaroan stages (early Upper Eocene to Lower Oligocene) at Port Elizabeth 5 miles north of Greymouth (text fig. 1) and at Cape Foulwind near Westport (text fig. 2), on the west coast of South Island, New Zealand.

The figured specimens are deposited in the Geology Department, Victoria University of Wellington. Sample numbers are the New Zealand Fossil Record numbers based on sheet districts of the New Zealand Map Series. The illustrations on plates 13-17 were drawn by the writer, with the aid of a camera lucida, at twice their present scale. The systematic order closely follows that of Loeblich and Tappan (1964).

SYSTEMATIC DESCRIPTIONS

Family HETEROHELICIDAE Cushman, 1927
Subfamily HETEROHELICINAE Cushman, 1927
Genus **Chiloguembelina** Loeblich and Tappan, 1956
Type Species **Gumbelina midwayensis** Cushman, 1940

Chiloguembelina cubensis (Palmer)
Plate 13, figure 1

1934 *Gumbelina cubensis* PALMER, Mem. Soc. Cubana Hist. Nat. 8:74, text-figs. 1-6.
1940 *Gumbelina ototara* FINLAY, Trans. Roy. Soc. N. Z. 69(4):453, pl. 63, figs. 50-52.
1961 *Chiloguembelina ototara* HORNIBROOK, N. Z. Geol. Surv. Pal. Bull. 34(1):84.

Remarks.—Hofker (1956, 1963) considered that *Chiloguembelina* has triserial initial chambers and regarded it as a junior synonym of *Stainforthia* Hofker, which has a similar aperture and toothplate, but the writer agrees with Loeblich and Tappan (1956), with Beckmann (1957), and with Reiss (1963) that *Chiloguembelina* has biserial chambers throughout and no triserial initial chambers.

A comparison of topotypes of *C. ototara* (Finlay) with topotypes of *C. cubensis* (Palmer) shows these forms to be identical.

Genus **Zeauvigerina** Finlay, 1939
Type Species **Zeauvigerina zelandica** Finlay, 1939

Zeauvigerina zelandica Finlay
Plate 13, figure 2

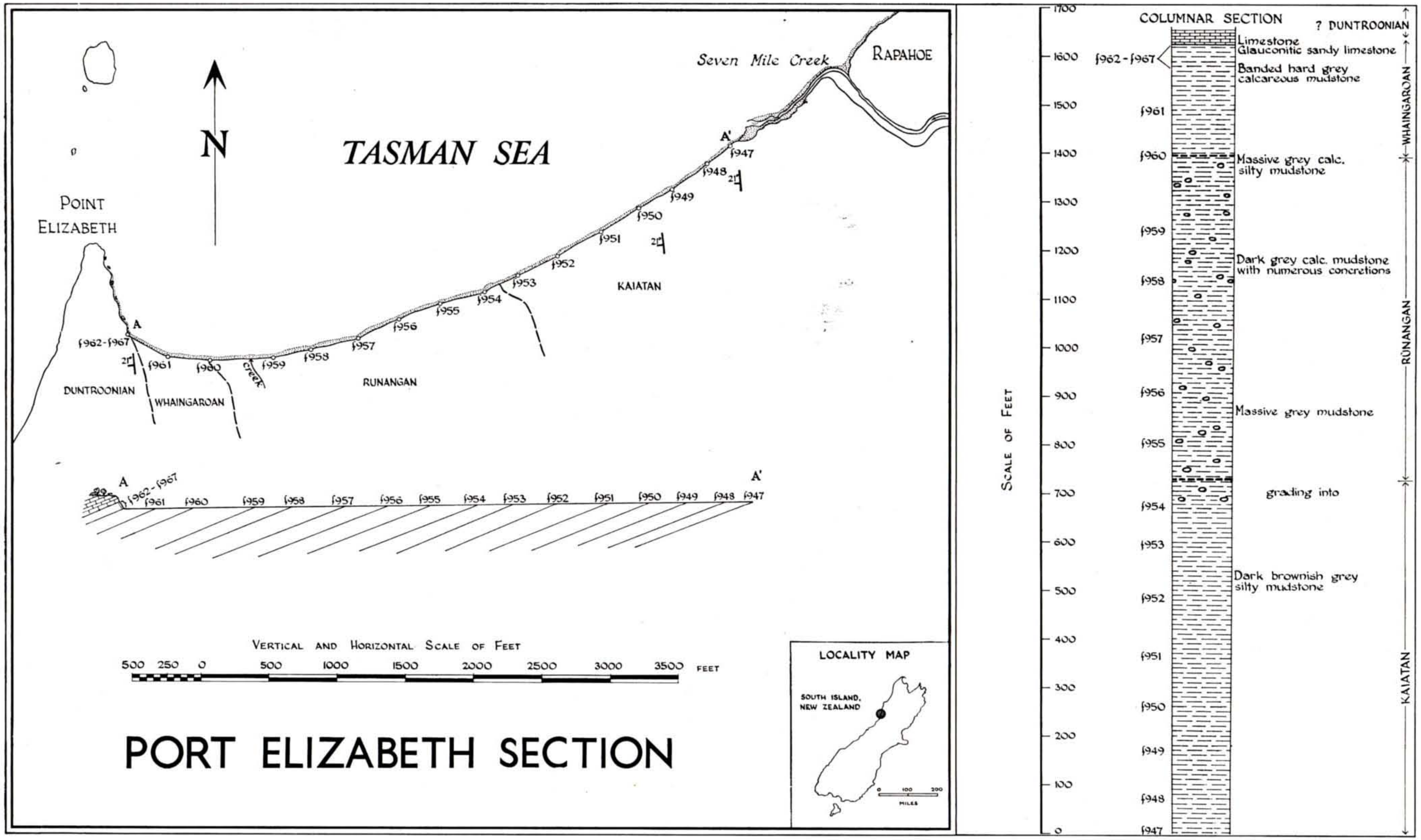
1939 *Zeauvigerina zelandica* FINLAY, Trans. Roy. Soc. N. Z. 68:541, pl. 69, fig. 4a-b.
1964 *Zeauvigerina zelandica* LOEBLICH and TAPPAN, In Moore; Treat. Inv. Paleont. (C) Protista 2(2):556, fig. 440(4).

Remarks.—Finlay (1939) separated this genus from *Eouvigerina* Cushman because the early chambers show no spiroplectine coiling and the final chambers show no tendency to become irregularly triserial. Loeblich (1951) and Loeblich and Tappan (1964) pointed out, however, that *Eouvigerina* has neither coiled early chambers nor triserial adult chambers, and therefore considered *Zeauvigerina* a junior synonym. Gallitelli (1957) also suggested that *Zeauvigerina* may be a synonym of *Eouvigerina.*

Toothplates were shown to be present in *Eouvigerina* by Hofker (1957) and by Gallitelli (1957) but are not present in *Zeauvigerina*; therefore *Zeauvigerina* is regarded as a valid genus.

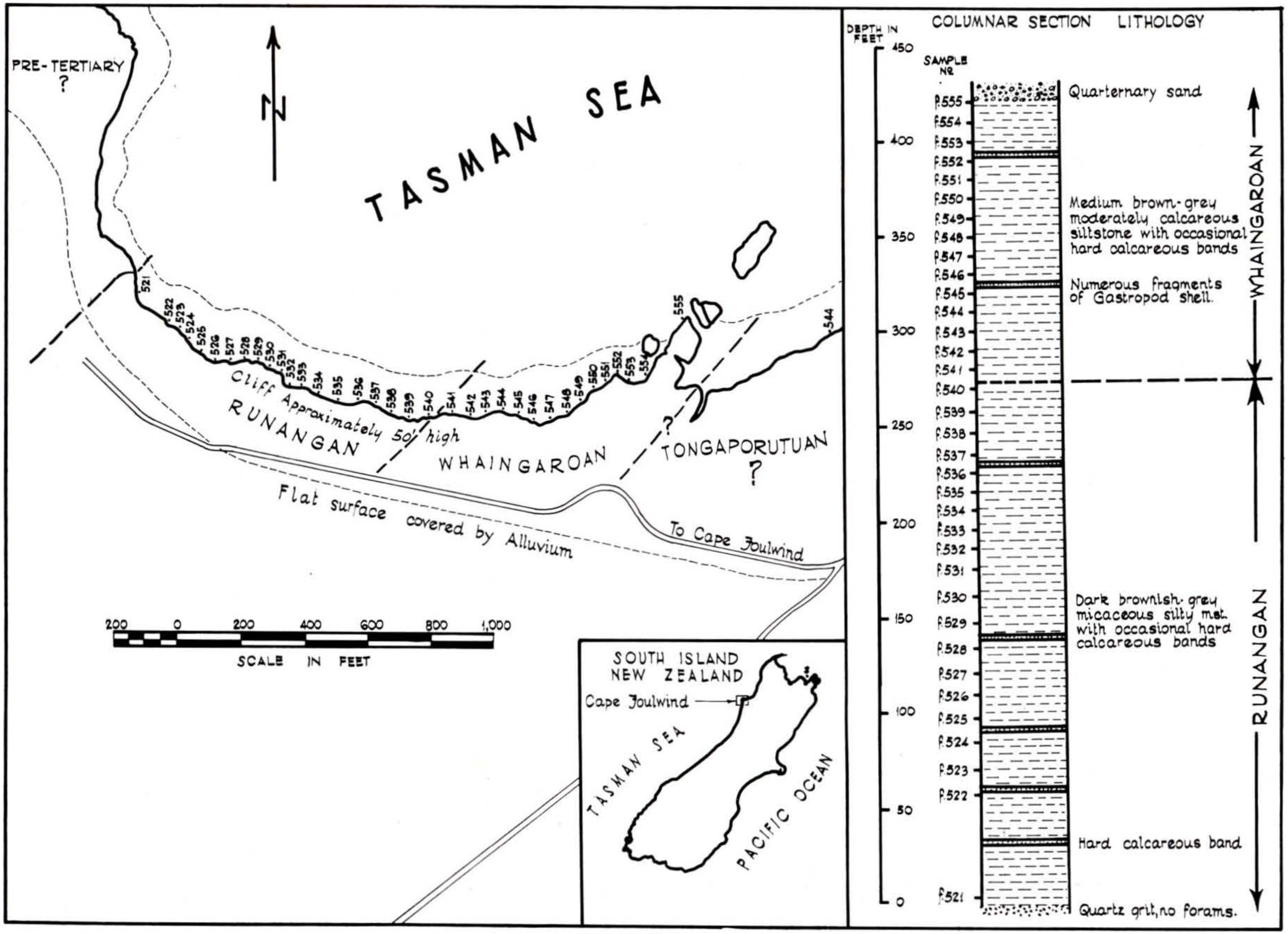
Because *Zeauvigerina* has significant similarities to *Chiloguembelina,* Reiss (1963) included both genera in a new family, Chiloguembelinidae. *Zeauvigerina* is very close to *Chiloguembelina,* differing only in having an apertural neck; therefore, both of these genera are here included in the family Heterohelicidae.

Finlay (1939) noted it from many localities in New Zealand but considered it to be a good index of Upper Bortonian (Upper Middle Eocene) age. Possibly the specimens found at Port Elizabeth are derived ones. This is the first record of *Zeauvigerina* in post-Bortonian Stage Arnold rocks.



TEXT FIGURE 1

Sketch map from pace and compass traverse and air photographs, cross-section, and columnar section, showing microsample positions (S44 F947 to S44 F967) at Port Elizabeth.



TEXT FIGURE 2

Sketch map from pace and compass traverse and air photographs, and columnar section, showing microsample positions (S23 F521 to S23 F555) at Cape Foulwind.

Family HANTKENINIDAE Cushman, 1927
Subfamily HASTIGERININAE Bolli, Loeblich and Tappan, 1957
Genus **Globanomalina** Haque, 1956
Type Species **Globanomalina ovalis** Haque, 1956
Globanomalina micra (Cole)
Plate 13, figures 3, 4

1927 *Nonion micrus* COLE, Bull. Amer. Paleont. 14(51):22, pl. 5, fig. 12.
1940 *Nonion iota* FINLAY, Trans. Roy. Soc. N. Z. 69(4):456, pl. 65, figs. 108-110.
1947 *Globigerina iota* FINLAY and MARWICK, N. Z. J. Sci. Tech. B 28(4):232.
1958 *Globigerina iota* HORNIBROOK, N. Z. J. Geol. Geophys. 1(4):664-5, fig. 20, 24.
1958 *Globigerinella iota* HORNIBROOK, Micropaleontology, 4(1):27-29, 34, pl. 1, figs. 22-24.
1961 *Pseudohastigerina iota* HORNIBROOK, N. Z. Geol. Surv. Pal. Bull. 34(1):148.
1964 *Globanomalina micra* (Cole), LOEBLICH and TAPPAN, In Moore; Treat. Inv. Paleont. (C) Protista 2(2):665, fig. 531(6-8).

Variation.—Runangan specimens show considerable variation in the inflation of chambers and the acuteness of the periphery. A few Runangan specimens from Port Elizabeth have a well-developed bulla covering the aperture. Whaingaroan specimens are smaller than the earlier ones.

Remarks.—From a comparison of topotypes of *P. iota* (Finlay) with the topotypes of *P. micra* (Cole), Berggren (1960) considered these forms to be identical.

The writer here agrees with Reiss (1963) that *Pseudohastigerina* is related to *Hantkenina* and not a descendant of *Planomalina* as thought by Banner and Blow (1959).

G. micra has been reported by Finlay (1939) and by Hornibrook (1961) from many New Zealand localities, ranging from Porangan (Lower Eocene) to Runangan (Upper Eocene) in age. At Port Elizabeth it ranges up to the Whaingaroan. The range in New Zealand is thus similar to that reported by Blow and Banner (1962) in the Lindi area of Tanganyika. *G. micra* attained world-wide distribution during the Upper Eocene and is useful for correlation.

Subfamily HANTKENININAE Cushman, 1927
Genus **Hantkenina** Cushman, 1925
Type Species **Hantkenina alabamensis** Cushman, 1925
Hantkenina alabamensis Cushman
Plate 13, figures 5, 6, 9

1925 *Hantkenina alabamensis* CUSHMAN, U. S. Nat. Mus. Proc. 66 (2567):3, pl. 1, figs. 1-6, pl. 2, fig. 5, p. 3, text-fig. 1.
1958 *Hantkenina australis* HORNIBROOK, (in part), Micropaleontology, A(1):27, 28, 29 (table).
1961 *Hantkenina alabamensis* HORNIBROOK, N. Z. Geol. Surv. Pal. Bull. 34(1):142, pl. 20, fig. 424, 429 (in part).

Remarks.—The writer agrees with Ramsay (1962), who recognised that *H. australis* is a distinct species from *H. alabamensis. H. australis* differs from *H. alabamensis* in side view, having a more or less angular outline, with triangular chambers and slightly sigmoidal sutures. Well preserved specimens of *H. alabamensis* are rare because of the fragile test.

Thalmann (1942) and Banner and Blow (1959) gave the range of the genus *Hantkenina* (S.S.) as Middle and Upper Eocene. In New Zealand *Hantkenina* has been reported by Finlay (1939) and Hornibrook (1961) from many localities.

Finlay (1939) described *H. australis* from a number of Upper Bortonian localities and considered it to be different from *H. alabamensis*. Hornibrook (1958) considered all the occurrences of *Hantkenina* from Bortonian to Runangan to represent *H. australis*. But later (1961) he reported *H. alabamensis* from Kaiatan and Runangan at Port Elizabeth and Runangan at Oamaru, considering that all New Zealand *Hantkenina* belonged to the *alabamensis* group.

All records of *australis* (at Hampden by Finlay, and at Te Uri stream, Pahi, and Kaipara Harbour by Hornibrook) are from Upper Bortonian strata. At Port Elizabeth *alabamensis* is restricted to the topmost Kaiatan and lower Runangan. At Cape Foulwind it occurs only at the base of the section which is considered to be lower Runangan in age. At Oamaru it occurs at the base of the Totara limestone [basal Runangan, Hornibrook (pers. comm.)]. Consequently, it appears that the two species distinguish two rather narrow zones. The *H. australis* zone corresponds to the Upper Bortonian (Upper Middle Eocene) and the *H. alabamensis* zone corresponds to the uppermost Kaiatan and the lower Runangan (middle Upper Eocene).

Family GLOBOROTALIIDAE Cushman, 1927
Subfamily GLOBOROTALIINAE Cushman, 1927
Genus **Turborotalia** Cushman and Bermudez, 1949
Type Species **Globorotalia centralis** Cushman and Bermudez, 1937
Turborotalia centralis (Cushman and Bermudez)
Plate 14, figures 8, 9

1937 *Globorotalia centralis* CUSHMAN and BERMUDEZ, Contr. Cushman Lab. Foram. Res. 13:26, pl. 2, figs. 62-65.
1964 *Turborotalia centralis* LOEBLICH and TAPPAN, In Moore; Treat. Inv. Paleont. (C) Protista 2(2):668, fig. 533(6).

Remarks.—The high-spired form of *T. centralis* and the forms intermediate between *T. centralis* and *G. ampliapertura* noted by Bolli (1957) in the upper part of the Navet formation and from the *G. cocoaensis* zone of Trinidad probably should be referred to *G. ampliapertura pseudoampliapertura* Blow and Banner, as should be the similar New Zealand forms frequent in the Runangan.

In Trinidad *T. centralis* makes its first appearance in the upper part of the *Globigerapsis kugleri* zone (Middle Eocene), and is replaced by *G. ampliapertura pseudoampliapertura* (high-spired intermediate forms of *T. centralis and G. ampliapertura*) in the upper part of the Navet Formation.

In the Lindi area of Tanganyika *T. centralis* ranges from the Middle Eocene within the *Cribrohantkenina danvillensis* zone (Upper Eocene), above the last appearance of the genera *Hantkenina* and *Globigerapsis.*

In New Zealand *T. centralis* makes its last appearance above that of *Hantkenina* and below that of *Globigerapsis.*

From many records of this species from various countries, it appears that *T. centralis* first enters in the Middle Eocene and makes its last appearance before the end of the Eocene. It is replaced by its direct descendant *G. ampliapertura pseudoampliapertura.* Study of the transitional stages of *T. centralis* to *G. ampliapertura pseudoampliapertura* in different parts of the world may prove of value in the stratigraphic correlation of Upper Eocene strata.

Turborotalia increbescens (Bandy)

Plate 14, figures 5-7

1949 *Globigerina increbescens* BANDY, Bull. Amer. Paleont. 32(131):120, pl. 23, figs. 3a-c.

Remarks.—The type of *T. increbescens* is from the Jackson (Upper Eocene) of Alabama. It has also been reported from the Claiborne Group (Middle Eocene), Red Bluff Formation (Lower Oligocene) and Vicksburg Group (Middle Oligocene). Blow and Banner (1962) reported the species to range from the Upper Eocene to the Oligocene in the Lindi area of East Africa. In New Zealand *T. increbescens* makes its first appearance just above the top of the basal Kaiatan and makes its last appearance just below the top of the Kaiatan Stage. Its range within the type Kaiatan section at Port Elizabeth is taken to mark a distinct planktonic zone.

Turborotalia opima nana (Bolli)

Plate 14, figures 1, 2

1957 *Globorotalia opima nana* BOLLI, U. S. Nat. Mus. Bull. 215:118, 169, pl. 28, fig. 3.

Remarks.—This form differs from *T. increbescens* (Bandy) in its tighter coiling and much lower aperture.

T. opima nana (Bolli) was first described from the *opima nana* zone (Oligocene) of Trinidad. Blow and Banner (1962) recorded it from Middle Eocene to the top of the Oligocene in the Lindi area and also from the Oligocene of Germany. The form referred to as *Globigerina* sp. by Batjes (1958) from the Oligocene of Belgium is probably this species.

Turborotalia aculeata (Jenkins)

Plate 13, figures 7, 8

1965 *Globorotalia inconspicua aculeata* JENKINS, N. Z. Jour. Geol. Geophy., vol. 8(6):1118, fig. 13, nos. 119-125.

Remarks.—In its spinose surface ornamentation this species closely resembles *Truncorotaloides collactea* (Finlay) and *T. rohri* Brönnimann. The specimens examined by the writer lack the carinate periphery on the dorsal side and the spines on the extremities of the chambers, characteristic of *G. inconspicua* Howe.

Turborotalia gemma (Jenkins)

Plate 14, figures 3, 4, 11-13

1965 *Globorotalia gemma* JENKINS, N. Z. Jour. Geol. Geophy., vol. 8(6):1115, fig. 11, nos. 97-103.

Remarks.—In New Zealand the Kaiatan forms of *T. gemma* show a more trochoidal shell than the Upper Runangan and Whaingaroan ones and have a distinctive aperture.

Subbotina (1953) recorded the form from the uppermost Eocene to the lower part of the Oligocene of the Caucasus. Blow and Banner (1962) recorded it from the Oligocene of Lindi, East Africa, and from the Rupelian of Elmsheim, Germany.

Subfamily TRUNCOROTALOIDINAE
Loeblich and Tappan, 1961
Genus **Truncorotaloides** Brönnimann and Bermudez, 1953
Type Species **Truncorotaloides rohri** Brönnimann and Bermudez, 1953

Truncorotaloides collactea (Finlay)

1939 *Globorotalia collactea* FINLAY, Trans. Roy. Soc., N. Z. 69(3):327, pl. 29, figs. 164-165.

1940 *Globorotalia collactea* FINLAY and MARWICK, Trans. Roy. Soc. N. Z. 70(1):108, 109.

1961 *Globigerina collactea* HORNIBROOK, N. Z. Geol. Surv. Pal. Bull. 34(1):149.

1965 *Truncorotaloides collactea* JENKINS, N. Z. Jour. Geol. Geophy., vol. 8(5):843, figs. 1-27.

Remarks.—The record of this species in the Kaiatan at Port Elizabeth is additional to three existing records from the Kaiatan by Hornibrook (1961).

T. collactea has been reported from the upper Middle Eocene at Hahajima, Japan (Saito, 1962). In the Caribbean region, however, this species is restricted to the Lower Eocene.

Family GLOBIGERINIDAE Carpenter, Parker and Jones, 1862
Subfamily GLOBIGERININAE Carpenter, Parker and Jones, 1862
Genus **Globigerina** d'Orbigny, 1826
Type Species **Globigerina bulloides** Parker, Jones and Brady, 1865

Globigerina ampliapertura Bolli

Plate 16, figures 5, 6

1957 *Globigerina ampliapertura* BOLLI, U. S. Nat. Mus. Bull. 215:108, pl. 22, figs. 5-7 (not fig. 4).

1962 *Globigerina ampliapertura* BLOW and BANNER, In Eames *et.al.* Fund. Mid. Tert. Strat. Correl., pt. 2:83, pl. XIa-d, XVIIC, fig. 12b.

Remarks.—The writer (Srinivasan, 1965) has stated that *Globigerina ampliapertura* appears at the base of the Whaingaroan Stage (base of Oligocene), but it since has been found near the top of the Runangan Stage (uppermost Eocene). *G. ampliapertura* is a direct descendant of *G. ampliapertura pseudoampliapertura* Blow and Banner, present in the lower part of the *G. index* zone.

Globigerina ampliapertura pseudoampliapertura Blow and Banner

Plate 17, figures 4-6

1962 *Globigerina pseudoampliapertura* BLOW and BANNER, In Eames *et.al.* Fund. Mid. Tert. Strat. Correl., pt. 2:95, pl. XII, A-C XVIIA-E, fig. 12C.

Remarks.—The subspecies *G. ampliapertura pseudoampliapertura* is here restricted to intermediate forms between *T. centralis* and *G. ampliapertura* present in the Runangan. It is distinguished from *G. ampliapertura* by its asymmetrical test, which resembles that of *T. centralis*, and from *T. centralis* by its relatively high-spired test and intraumbilical aperture.

Globigerina angiporoides Hornibrook

Plate 15, figure 9

1965 *Globigerina angiporoides* HORNIBROOK, N. Z. Jour. Geol. Geophy., vol. 8, no. 5:835, figs. 1a-i, 2.

Remarks.—*G. angiporoides*, which seems to be the direct descendant of *S. linaperta* (Hornibrook, 1961), is characterised by spherical chambers of nearly the same size in the last whorl, and with these chambers more embracing than in *S. linaperta*. The aperture in the young is a very narrow-rimmed slit, and in the adult appears to be completely sealed.

In Victoria, Australia, Carter (1958) reported *S. linaperta* having typical flattened chambers from the Brown Creek clays (Upper Eocene). He reported a variety with a tendency to develop swollen and more evenly rounded chambers, in the lower Glen Aire clays (Lower Oligocene). This variety, referred to by Carter as "*G. linaperta* (round chambered form)," is probably *G. angiporoides*.

A few specimens with smoother wall ornamentation and much smaller than the typical *G. angiporoides* were observed from the Kaiatan samples. The lowest typical *G. angiporoides* was found at the base of the Runangan Stage. This species is abundant and one of the dominant pelagic species in the Whaingaroan at Port Elizabeth, but not at Cape Foulwind.

Globigerina brevis Jenkins

Plate 13, figures 10, 11

1965 *Globigerina brevis* JENKINS, N. Z. Jour. Geol. Geophy., vol. 8(6):1100, fig. 7, nos. 58-63.

Remarks.—The deeply incised sutures of G. *brevis* suggest affinities to *Globigerapsis index*. A few specimens having a small bulla-like structure partly covering the umbilical aperture were observed in the upper part of the *G. index* zone.

Globigerina euapertura Jenkins

Plate 13, figures 12, 15

1960 *Globigerina euapertura* JENKINS, Micropaleontology, 6(4):350, pl. 1, fig. 8.

1961 *Globigerina reticulata* HORNIBROOK, N. Z. Geol. Surv. Pal. Bull. 34(1):146 (in part), text-fig. b, c (not a, d, e).

Remarks.—Young specimens of *G. euapertura*, common in the lower part of the Whaingaroan Stage, closely resemble *G. ampliapertura* Bolli; they are similar in size and have the same type of aperture. The two species were probably derived from an Upper Eocene common ancestor.

The first appearance of *G. euapertura* marks the beginning of the Landon Series. At Port Elizabeth (Whaingaroan) forms of this species having the umbilicus covered by a bulla with one opening are frequent; they resemble forms referred to as *C. unicavus* by Jenkins (1960).

Globigerina ouachitaensis Howe and Wallace

Plate 15, figures 4-8

1932 *Globigerina ouachitaensis* HOWE and WALLACE, Bull. La. Conserv. Geol., No. 2:74, pl. 10, fig. 7.

Remarks.—The species differs from *G. officinalis* in its less tightly and more trochospirally coiled shell and in its distinctly broader aperture and more open umbilicus.

Globigerina officinalis Subbotina

Plate 15, figures 1-3

1953 *Globigerina officinalis* SUBBOTINA, (Part), Trudi, UNIGRI, N. S. 76:78, pl. 11, fig. 1 (Holotype) and fig. 2 and 6.

Remarks.—The form described by Jenkins (1960) as *G. parva* Bolli, from the *Globoquadrina dehiscens* zone, southeast Australia, is probably *G. officinalis.*

Globigerina angustiumbilicata Bolli

Plate 15, figures 10, 11

1957 *Globigerina ciperoensis angustiumbilicata* BOLLI, U. S. Nat. Mus. Bull. 215:109, pl. 22, figs. 12-13.

Remarks.—This species is distinguished from *G. officinalis* Subbotina by having five chambers in the final whorl instead of four. A few Runangan samples contain intermediate forms, and *G. officinalis* is probably ancestral to *G. angustiumbilicata.* This species makes its initial appearance at the top of the *C. verrucosus* zone (Whaingaroan) at Port Elizabeth, where it is comparatively rare.

Globigerina labiacrassata Jenkins

Plate 13, figures 13, 14

1961 *Globigerina reticulata* Stache, HORNIBROOK (in part), N. Z. Geol. Surv. Pal. Bull 34(1): 146, Text-fig. 4, a, d, e.

1965 *Globigerina labiacrassata* JENKINS, N. Z. Jour. Geol. Geophy., vol. 8(6):1102, fig. 8, nos. 64-71.

Remarks.—Hornibrook (1965) found *G. reticulata* to be a *nomen dubium. G. labiacrassata* is one of the more distinctive pelagic species of the Whaingaroan Stage. It is characterized by a high-arched aperture, a thick apertural rim, and a relatively low spire with four chambers in the last whorl, giving the test an almost square shape.

Specimens from Port Elizabeth are smaller and have a less distinct apertural rim than specimens examined by the writer from southern Hawkes Bay.

Globigerina cf. **trilocularis** d'Orbigny

Plate 17, figures 1, 2

1826 *Globigerina trilocularis* D'ORBIGNY, Ann. Sci. Nat. 7:277 (Unpublished figures of d'Orbigny in Fornasini, Rend. Acad. Sci. Inst. Bologna. n.s., vol. 2, fasc. 1, pl. 1, figs. 6, 7, p. 12, text fig.).

Remarks.—The species is characterised by a low spire and rapidly enlarging chambers in the final whorl. *G. ouachitaensis* is similar but has a more trochospiral shell and chambers of more uniform size in the final whorl.

Forms similar to *G. trilocularis* were recorded from the Eocene San Fernando Formation of Trinidad (Bolli, 1957), and from the Eocene Kyoragi and Sakasegawa groups of Japan (Asano, 1962).

The present specimens do not match *G. praebulloides occlusa* Blow and Banner.

Genus **Globorotaloides** Bolli, 1957

Type Species **Globorotaloides variabilis** Bolli, 1957

Globorotaloides suteri Bolli

Plate 14, figures 10, 14

1957 *Globorotaloides suteri* BOLLI, U. S. Nat. Mus. Bull. 215:117, pl. 27, 9-13 (not fig. 14).

Remarks.—Frequent to infrequent specimens occur both at Cape Foulwind and at Port Elizabeth.

Globorotaloides turgida (Finlay)

Plate 17, figures 3, 7, 8

1939 *Globigerina linaperta* Finlay, var. *turgida* FINLAY, Trans. Roy. Soc. N. Z. 69:125.

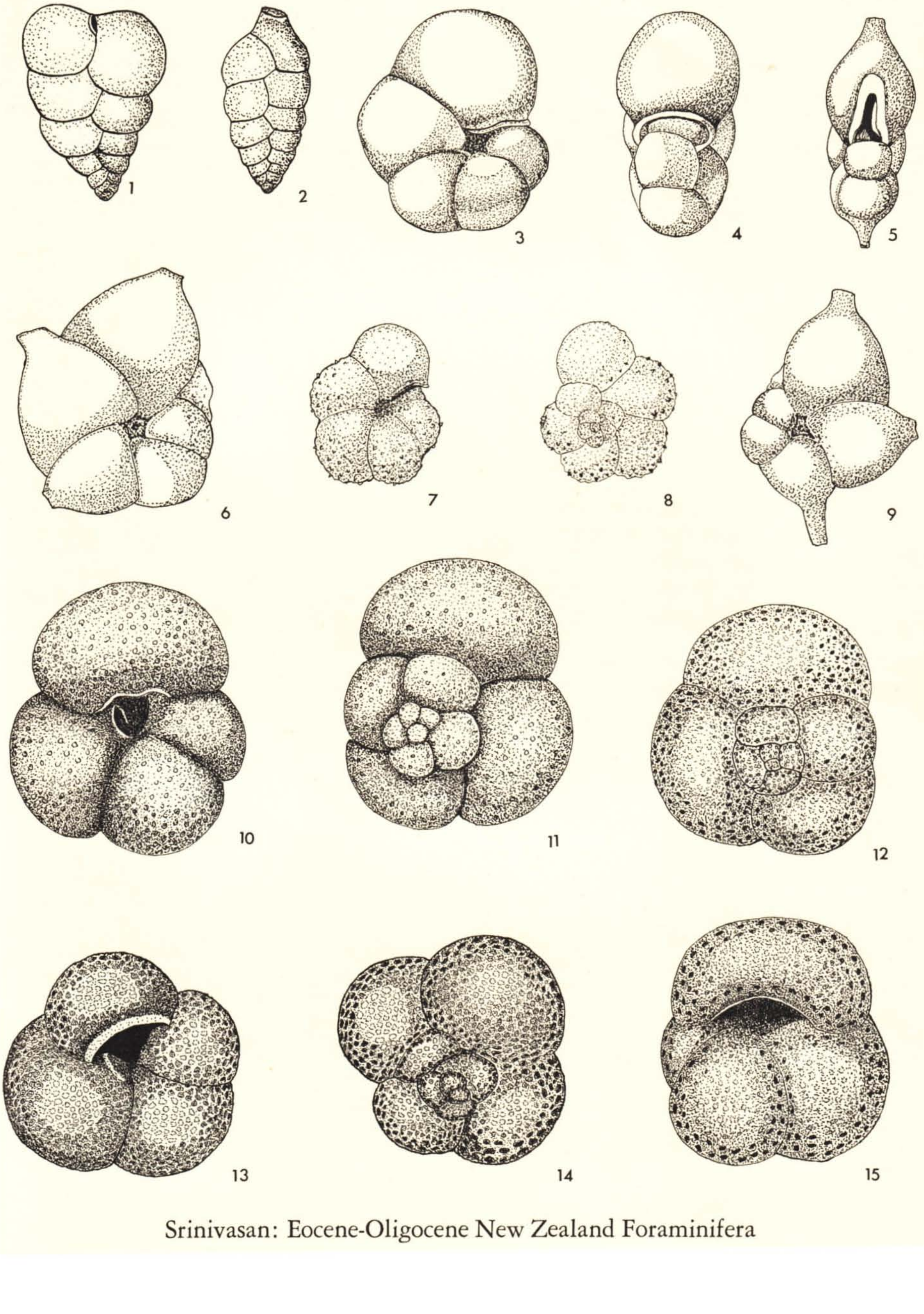
1964 *Globorotaloides turgida* JENKINS, Contr. Cushman Found. Foram. Res. 15(3):117, pl. 8, 13a-c.

Remarks.—From the figure given by Asano, *Globigerina ariakensis* (1962, pl. 20, figs. 5-7) seems to be closely related to *G. turgida* (Finlay).

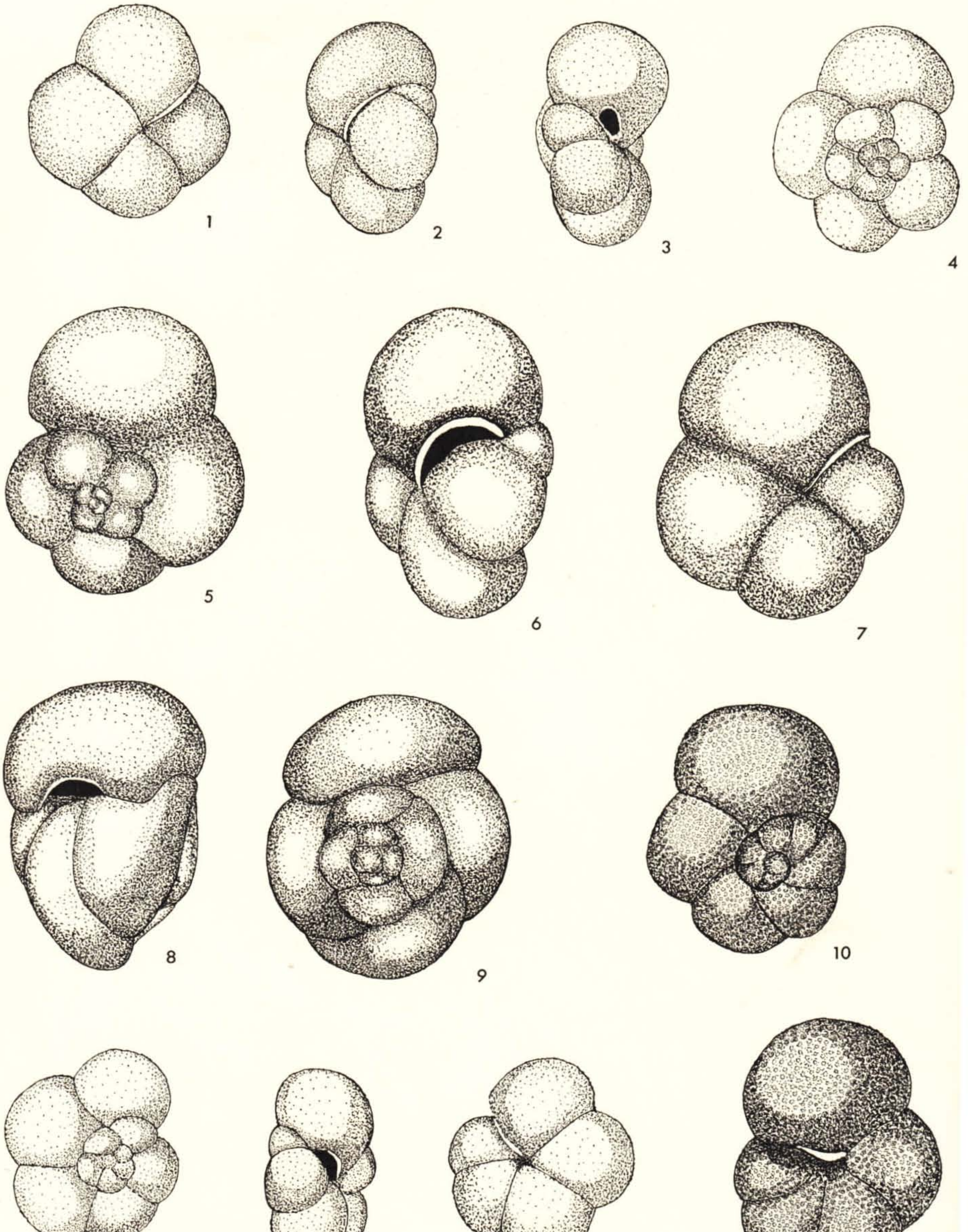
As already pointed out by Jenkins (1964), the illustration given by Bolli (1957) of *G.* cf. *suteri* (pl. 27, fig. 14) shows a flattened bulla with a distinct lip, strongly resembling the bulla of *G. turgida* (Finlay).

EXPLANATION OF PLATE 13

FIGS.		PAGE
1.	*Chiloguembelina cubensis* (Palmer). Hypotype, Ff. 699; ×70, (S23f534).	142
2.	*Zeauvigerina zelandica* Finlay. Hypotype, Ff. 702; ×70, (S44f951).	142
3, 4.	*Globanomalina micra* (Cole). Hypotype, Ff. 698; ×70, (S44f954).	145
5, 9.	*Hantkenina alabamensis* Cushman. Hypotype, Ff. 700; ×70, (S23f521).	145
6.	*Hantkenina alabamensis* Cushman. Hypotype Ff. 701; ×70, (S44f954).	145
7, 8.	*Turborotalia aculeata* (Jenkins). Hypotype, Ff. 729; ×70, (44f947).	146
10, 11.	*Globigerina brevis* Jenkins. Hypotype, Ff. 730; ×70, (S44f960).	147
12, 15.	*Globigerina euapertura* Jenkins. Hypotype, Ff. 731; ×44, (S44f966).	147
13, 14.	*Globigerina labiacrassata* Jenkins. Hypotype, Ff. 732; ×44, (S44f967).	148



Srinivasan: Eocene-Oligocene New Zealand Foraminifera



Srinivasan: Eocene-Oligocene New Zealand Foraminifera

Genus **Subbotina** Brotzen and Pozaryska, 1961
Type Species **Globigerina triloculinoides** Plummer, 1927
Subbotina linaperta (Finlay)
Plate 16, figures 7, 10, 11

1939 *Globigerina linaperta* FINLAY, Trans. Roy. Soc. N. Z. 69(1):125, pl. 13, figs. 54-57.
1948 *Globigerina linaperta* DORREEN, J. Paleont. 22(3):299.
1958 *Globigerina linaperta* HORNIBROOK, Micropaleontology, 4(1):26, 29, 33, pl. 1, figs. 19, 21.
1961 *Globigerina linaperta* HORNIBROOK, N. Z. Geol. Surv. Pal. Bull. 34(1):145.

Remarks.—Brotzen and Pozaryska (1961) proposed the genus *Subbotina* for *Globigerina*-like forms having a distinct reticulate or pitted surface ornamentation and an aperture with a distinct lip and cited *G. triloculinoides* Plummer as its type species.

The species *G. linaperta* closely resembles *G. triloculinoides*, the type species of *Subbotina*, and has been shown by several workers, including Bolli (1957), Loeblich and Tappan (1957), and Hornibrook (1961), to be a direct descendant of *G. triloculinoides*. Therefore it is here included in the genus *Subbotina*. It differs from *S. triloculinoides* (Plummer) in being larger and in having laterally compressed chambers and a less distinct apertural lip.

S. linaperta has been reported from Danian to Paleocene in Egypt (Nakkady, 1950), Lower Eocene in Trinidad (Bronnimann, 1952), Eocene on mid-Pacific sea mounts (Hamilton, 1953), Lower Eocene in the Salt Range, Pakistan (Haque, 1956), Lower to Upper Eocene in Trinidad (Bolli, 1957), Middle to Upper Eocene in Australia (Carter, 1958), Middle to Upper Eocene in Japan (Asano, Saito, 1962), and Upper Paleocene to Upper Eocene in East Africa (Blow and Banner, 1962). Judging from its world-wide distribution, as shown by these records, it is probably a valuable index fossil for intercontinental correlation.

Subbotina yeguaensis (Weinzerl and Applin)
Plate 16, figures 1-4

1929 *Globigerina yeguaensis* WEINZERL and APPLIN, J. Paleont. 3:408, pl. 43, fig. 2.
1960 *Globigerina yeguaensis* BERGGREN, Stockholm Cont. Geol. 5(3):73-83, pl. 2, figs. 1-4; pl. 3, figs. 1-3; pl. 4, figs. 1-2; pl. 8, figs. 1-5; text-fig. 11.

Remarks.—Berggren (1960) described the large degree of variation shown by individuals of *yeguaensis* and gave a complete synonymy.

The figured specimen from Port Elizabeth is very similar to one of the specimens illustrated by Berggren (1960, pl. 2, fig. 1a), but has a more prominent apertural lip.

This species closely resembles *S. triloculinoides* (Plummer), the type species of *Subbotina*, particularly in having a distinct apertural lip. The close phylogenetic relationship of *yeguaensis* to *triloculinoides* was pointed out by Berggren, and *yeguaensis* is here included in the genus *Subbotina*.

Subfamily ORBULININAE Schultze, 1854
Genus **Candeina** d'Orbigny, 1839
Type Species **Candeina nitida** d'Orbigny, 1839
Candeina zeocenica Hornibrook and Jenkins
Plate 15, figures 12, 13

1965 *Candeina zeocenica* HORNIBROOK and JENKINS, N. Z. Jour. Geol. Geophy., vol. 8(5): 839, figs. 1-5.

Remarks.—Hornibrook and Jenkins' description appears to be the first record of *Candeina* earlier than Miocene.

Its record in Cape Foulwind marks an additional stratigraphic occurrence.

Genus **Globigerapsis** Bolli, Loeblich and Tappan, 1957
Type Species **Globigerapsis kugleri** Bolli, Loeblich and Tappan, 1957
Globigerapsis index (Finlay)
Plate 16, figures 8, 9, 12

1939 *Globigerinoides index* FINLAY, Trans. Roy. Soc. N. Z. 69(1):125, pl. 14, figs. 85-88.
1948 *Globigerinoides index* DORREEN, J. Paleont. 22(3):298, pl. 41, fig. 2.
1958 *Globigerinoides index* HORNIBROOK, Micropaleontology, 4(1):27-29, 34, pl. 1, figs. 11-14.
1961 *Globigerinoides index* HORNIBROOK, N. Z. Geol. Surv. Pal. Bull. 34(1):152.

EXPLANATION OF PLATE 14

FIG.		PAGE
1, 2.	*Turborotalia opima nana* (Bolli). Hypotype, Ff. 709; ×70, (S44f952).	146
3, 4.	*Turborotalia gemma* (Jenkins). Hypotype Ff. 710; ×87, (S44f954).	146
5-7.	*Turborotalia increbescens* (Bandy). Hypotype, Ff. 712; ×70, (S44f949).	146
8, 9.	*Turborotalia centralis* (Cushman and Bermudez). Hypotype, Ff. 713; ×70, (S44f956).	145
10, 14.	*Globorotaloides suteri* Bolli. Hypotype, Ff. 714; ×87, (S44f959).	148
11-13.	*Turborotalia gemma* (Jenkins). Hypotype, Ff. 711; ×70, (S44f963).	146

Remarks.—This species has deeply cleft sutures and a subglobular shape, as stated by Finlay (1939) and Hornibrook (1958), and the typical form has never more than three apertures (one large final opening, and two others, somewhat smaller, above the sutures of previous chambers). This makes it distinct from *G. tropicalis* Blow and Banner.

Blow and Banner (1962) state that *G. index* does not extend into the Upper Eocene strata anywhere in the world. Their contention may be valid for the East African area but may not be applicable to other parts. Furthermore their suggestion that *G. tropicalis* has been incorrectly reported as *G. index* from other countries such as Cuba, Israel, Syria and South-east Australia is not warranted. The form illustrated by Carter (1958) shows the typical globular shape and cleft sutures and also the presence of the three openings, features characteristic of *G. index*.

The writer (1965) has found that in New Zealand the genus *Globigerapsis* makes its last appearance later than *H. alabamensis* and *T. centralis*. According to Blow and Banner, in East Africa it makes its last appearance earlier than *H. alabamensis* and *T. centralis*. This clearly points out the inconsistency in the range of the genus *Globigerapsis* in these two localities.

It is certain that *G. index* still existed in New Zealand and Australia during the Upper Eocene, making its last appearance at the top of the Eocene. For some reason it evidently does not range quite to the top of the Eocene in East Africa.

The top of the Runangan Stage at Port Elizabeth (Type locality) has been defined by Finlay and Marwick (1947) as coinciding with the highest occurrence of *G. index*.

Subfamily CATAPSYDRACINAE Bolli, Loeblich and Tappan, 1957

Genus **Catapsydrax** Bolli, Loeblich and Tappan, 1957

Type Species **Globigerina dissimilis** Cushman and Bermudez, 1937

The genus *Catapsydrax* was erected for the *Globigerina*-like forms having a single umbilical bulla over the aperture in the adult, with one or more accessory infralaminal apertures.

Opinions differ as to whether the umbilical bulla is of use for taxonomic differentiation or merely represents variation. Hofker (1961), for instance, interpreted the bulla to represent a closed cyst of the reproductive phase in the life history. Takayanagi and Saito (1962) considered that mere development of a transformal chamber or bulla is not sufficient for specific distinction, and suggested that these modified final chambers may develop in the reproductive phase or when individual growth is interrupted by some environmental causes.

Blow and Banner (1962) considered that in the bullate globigerinids there appears to be no fundamental difference in structure of the bullae, and, as the morphology of the primary test is in every case generically the same, they regarded *Catapsydrax* and *Tinophodella* as junior synonyms of *Globigerinita*.

The writer agrees with Loeblich and Tappan (1964) in regarding *Catapsydrax* as distinct from *Globigerinita* and *Tinophodella*. *Catapsydrax* differs from *Globigerinita* in that it has a distinct umbilical bulla, with one or more accessory infralaminal apertures, whereas *Globigerinita* has a modified final chamber with supplementary apertures. *Tinophodella* differs from *Catapsydrax* in having an umbilical bulla expanding along the earlier sutures with numerous small accessory apertures opening beneath its margin.

Catapsydrax echinatus Bolli

Plate 17, figures 10-12

1957 *Catapsydrax echinatus* Bolli, U. S. Nat. Mus. Bull. 215:165, 166, pl. 37, figs. 2-5.

Remarks.—It is characterised by distinctly spinose surface ornamentation, which distinguishes it from *C. dissimilis*. In New Zealand all the known pelagic species with spinose ornamentation (*T. aculeata, T. collactea, G. primitiva,* and *C. echinatus*) range up to the Upper Eocene. In the Caribbean region, however, the planktonic species with spinose ornamentation range from Upper Paleocene to Middle Eocene only.

Genus **Globigerinatheca** Brönnimann, 1952

Type Species **Globigerinatheca barri** Brönnimann, 1952

Globigerinatheca cf. barri Brönnimann

Plate 17, figure 9

1952 *Globigerinatheca barri* Brönnimann (part), Cushman Found. Foram. Res. Contr. 3(1): 27, 28, text-fig. 3a-c, g, h.

1964 *Globigerinatheca barri* Loeblich and Tappan, In Moore, Treat. Inv. Paleont. (C) Protista 2(2):676, fig. 543(5).

Remarks.—Rare specimens resembling *G. barri* were found only at Port Elizabeth.

BIOSTRATIGRAPHY

Planktonic Foraminiferal Zones

Check lists of actual occurrences of planktonic foraminifera at Port Elizabeth and Cape Foulwind are given in text fig. 3a and text fig. 3b respectively. On the basis of the stratigraphic ranges of planktonic foraminifera five zones are distinguished (text fig. 4). These biostratigraphic zones, which are here regarded as being informal units, are defined in terms of American and International codes on

STAGE	KAIATAN									RUNANGAN					WHAINGAROAN						
ZONE — Planktonic	*T. aculeata*			*T. increbescens*				*H. alabamensis*		*G. index*					*G. ampliapertura*						
ZONE — Benthonic	*G. reussi*			*B.* cf. *moodysensis*						*L. pontis*			*C. verrucosus*					*T. zealandica*			
Foraminifera / Fossil No.	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967
Ammodiscus archimedis (Stache)	...	1	1	...	...	...	2	1	1	2	1	...	...	...	...	1	...	...	...	...	...
Vulvulina granulosa Finlay	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	2	1	...	1	4	1
Semivulvulina capitata (Stache)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	2	1
Textularia cuspis Finlay	...	...	...	1	1	...	1	2	1	...	1	...	1	1	...	...	...	...	...	...	...
Textularia walcotti Srinivasan	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	...	...	...	...
Gaudryina proreussi x *reussi*	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gaudryina reussi Stache	...	1	...	...	...	...	1	...	...	...	...	1	...	...	...	1	...	...	1	...	...
Karrerulina obscura Srinivasan	...	...	...	...	...	...	3	1	1	...	1	...	...	1	...	...	1	...	...	...	...
Arenodosaria antipoda (Stache)	1	2	1	4	4	1	4	4	1	...	1	...	1	...	...	1	...	...	4	1	...
A. cf. *kaiataensis* Dorreen	...	...	...	...	...	...	...	1	...	...	1	1	3	2	...	...	...	...	...	...	...
Tritaxilina zealandica Finlay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	1	3	1
Miliolinella vellai Srinivasan	...	2	1	2	...	1	...	2	...	1	...	...	1	...	...	...	...	...	...	...	...
Scutuloris elizabethiae Srinivasan	1	1	1	2	...	...	1	3	...	...	1	1	...	...	...	...	...	...	...	...	...
Dentalina obliquesuturata Stache	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...
Robulus dorothiae Finlay	...	...	...	...	...	...	1	3	1	2	3	3	2	2	1	...	...	...	...	...	...
Proxifrons whaingaroica (Stache)	...	1	1	...	3	...	4	2	...	1	1	1	1	...	4	...	...	...	...	...	...
Sphaeroidina variabilis Reuss	3	2	3	3	2	4	4	2	...	...	...	...	...	...	...	...	...	...	...	...	...
S. bulloides d'Orbigny	...	...	...	...	...	...	...	...	2	3	3	3	4	4	3	4	1	4	3	2	1
Brizalina cf. *moodysensis* (Cushman & Todd)	...	...	1	1	2	2	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...
Latibolivina pontis (Finlay)	...	...	...	...	...	...	...	...	1	3	1	2	4	3	1	1	...	...	...	...	...
L. anastomosa (Finlay)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	1	1
Tappanina olsoni (Hornibrook)	...	2	3	...	2	2	...	1	...	...	2	2	1	1	1	1	2	2	...	...	...
Bulimina truncanella Finlay	...	4	4	4	2	4	1	4	4	4	4	4	4	2	...	...	...	...	...	...	...
Noviuva bortotara (Finlay)	4	...	...	4	1	4	4	4	4	4	...	1	2	4	1	...	...	...	...	...	...
Rectuvigerina postprandia Finlay	...	...	...	...	...	...	...	...	...	...	...	1	2	1	1	...	...	...	...	...	...
R. striatissima (Stache)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	1	1	2	1
Discopulvinulina apposita (Finlay)	...	...	2	...	...	...	...	1	...	1	...	...	3	2	1	1	1	1	1	...	...
D. scopos (Finlay)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	1	1	...
Siphonina australis Cushman	...	...	...	...	...	...	...	...	1	1	...	1	...	...	...	...	...	...	...	...	...
Chiloguembelina cubensis (Palmer)	1	2	2	2	2	1	1	4	4	4	4	4	4	4	4	2	3	2	3	2	2
Zeauvigerina zelandica Finlay	...	...	...	...	1	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...
Globanomalina micra (Cole)	1	1	1	1	1	1	1	4	4	4	4	4	2	2	1	1	1	1	1	...	...
Hantkenina alabamensis Cushman	...	...	...	...	...	...	...	3	2	...	...	...	...	...	...	...	...	...	...	...	...
Turborotalia centralis (Cushman & Bermudez)	1	1	...	...	1	1	...	1	1	3	...	...	...	...	...	...	...	...	...	...	...
T. increbescens (Bandy)	...	...	...	2	3	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
T. opimanana (Bolli)	1	1	1	2	2	2	1	...	...	...	1	...	...	1	...	1	...	1	...	...	...
T. aculeata (Jenkins)	2	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
T. gemma (Jenkins)	1	1	1	...	1	...	...	1	...	1	1	...	1	...	...	...	1	1	1	1	1
Globigerina ampliapertura Bolli	...	...	...	...	...	...	...	...	...	...	...	...	...	1	2	3	2	2	2	2	2
G. ampliapertura pseudoampliapertura Blow & Banner	...	...	...	...	...	...	...	...	...	2	2	1	1	1	...	...	...	...	...	...	...
G. angiporoides Hornibrook	...	...	...	...	...	...	...	...	1	2	2	1	1	2	2	4	4	4	3	4	2
G. brevis Jenkins	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	1	...	...	...	...
G. eauapertura Jenkins	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	1	1	2	1
G. angustiumbilicata Bolli	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...
G. officinalis Subbotina	...	1	...	1	...	...	1	...	...	1	1	1	...	1	...	...	...	...	...	...	...
G. ouachitaensis Howe & Wallace	1	1	1	1	1	1	...	1	1	1	1	1	1	1	1	1	...	1	...	1	1
G. labiacrassata Jenkins	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1
G. cf. *trilocularis* d'Orbigny	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Truncorotaloides collactea (Finlay)	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Globorotaloides suteri Bolli	1	1	1	...	1	1	1	...	1	1	...	1	1	1	...	1	1	1	1	1	1
G. turgida (Finlay)	...	1	...	1	1	1	...	1	...	1	1	1	1	...	...	...	...	...	...	...	...
Subbotina linaperta (Finlay)	1	2	1	1	1	1	1	2	2	2	2	3	2	4	...	...	...	...	...	...	...
S. yeguaensis Wienzierl & Applin	...	...	...	...	...	1	...	...	...	1	...	1	1	...	...	...	1	...	...	1	...
Candeina zeocenica Hornibrook & Jenkins	1	1	2	...	...	...	...	1	1	1	2	3	...	...	1	1	...	...	...	...	...
Globigerapsis index (Finlay)	1	4	4	4	4	4	4	4	4	4	4	4	4	4	...	...	...	...	...	...	...
Catapsydrax echinatus Bolli	1	1	...	1	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...
Globigerinatheca cf. *barri* Bronnimann	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cibicides pseudoconvexus Parr	...	...	1	1	1	1	...	1	...	...	...	...	...	2	...	...	...	...	...	...	...
C. parki Finlay	2	3	2	2	3	4	3	2	1	1	2	1	4	2	3	...	...	...	...	...	...
C. semiperforatus Hornibrook	2	2	2	3	2	3	3	2	...	...	...	...	...	...	...	...	...	...	...	...	...
C. perforatus (Karrer)	...	...	...	...	...	...	...	...	3	2	2	3	4	4	4	2	1	1	1	1	...
C. hampdenensis Hornibrook	1	1	2	1	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
C. verrucosus Finlay	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	2	2	1	1	1	...
C. collinsi Finlay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	...	2	1
C. karreriformis Hornibrook	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1
Ellipsoglandulina labiata (Schwager)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	2	1	...
Rotaliatina sulcigera (Stache)	...	...	...	...	...	...	4	4	...	...	...	...	4	1	3	2	3	3	2	2	1
Anomalinoides semiteres (Finlay)	...	...	...	...	...	...	...	...	3	...	1	1	2	1	...	...	...	...	...	...	...
Melonis dorreeni (Hornibrook)	4	4	3	3	4·	3	3	3	...	...	...	...	...	...	...	...	...	...	...	...	...
Vellaena zealandica Srinivasan	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...
Cerobertina kakahoica Finlay	...	1	2	1	...	2	3	2	1	2	1	3	1	...	...	...	...	...	...	...	...

Note: Only stratigraphically important benthonic species are listed.

Key: (...) = nil specimens; 1 = less than 5 specimens; 2 = 5 to 10 specimens; 3 = 10 to 20 specimens; 4 = more than 20 specimens

TEXT FIGURE 3a

Check List of the Late Eocene and Early Oligocene foraminifera from Port Elizabeth section, New Zealand

STAGE	RUNANGAN																				WHAINGAROAN														
ZONE — Planktonic	*H. alabamensis*		*G. index*																		*G. ampliapertura*														
ZONE — Benthonic	*L. pontis*																	*C. verrucosus*								*T. zealandica*									
Foraminifera / Fossil No.	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555
Triplasia marwicki Loeblich & Tappan	...	...	...	...	...	...	...	1	...	...	...	...	1	...	...	2	2	...	...	...	...	...	...	1	...	...	...	2	...	...	...	...	...	...	...
Textularia subrhombica (Stache)	1	2	1	2	1	1	1	1	...	1	1	...	...	...	1	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gaudryina reussi Stache	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	...	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...
Arenodosaria antipoda (Stache)	2	2	2	2	2	2	1	1	1	1	1	2	3	1	2	3	2	2	3	3	2	2	1	2	2	1	2	1	1	2	3	3	2	2	2
Quinqueloculina zealandica Srinivasan	1	...	...	...	...	...	...	...	...	...	...	1	...	1	1	2	2	2	2	1	...	...	2	2	1	...	...	...	...	...	...	...	...	...	...
Miliolinella vellai Srinivasan	...	...	...	...	...	...	1	...	...	...	...	...	...	3	2	2	2	1	...	...	1	...	2	2	2	...	...	...	...	...	...	...	...	...	...
Dentalina obliquesuturata Stache	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	...	1	...	...	...	...	...	...	...	...	...	...
Robulus gyroscalprus (Stache)	1	...	1	1	1	1	1	1	...	...	...	1	...	...	1	2	...	1	1	1	1	1	1	...	...	...	...	...	1	1	...	1	...	...	...
Palmula bivium Finlay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Proxifrons whaingaroica (Stache)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...
Bolivinella elegans Parr	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...
Sphaeroidina variabilis Reuss	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
S. bulloides d'Orbigny	1	1	2	2	3	2	3	2	2	2	2	1	3	2	2	3	3	3	3	2	2	2	2	1	2	2	2	3	2	2	1	2	2	2	2
Latibolivina pontis (Finlay)	1	1	1	1	2	2	2	2	2	2	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	...	...	1	...	...	...	...	1	...
Latibolivina amstomosa (Finlay)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	1	1	...	1	1	1	1	1	1	1	1
Tappanina olsoni (Hornibrook)	1	1	1	1	1	2	1	1	1	2	2	2	2	2	3	3	3	1	2	3	2	2	2	2	3	3	3	1	2	3	2	3	3	2	2
Bulimina truncanella Finlay	3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	...	1	1	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Noviuva bortotara (Finlay)	4	4	4	4	3	3	3	3	2	2	1	2	...	...	...	...	...	...	1	1	1	...	1	1	...	...	...	...	...	...	...	...	...	...	...
Rectuvigerina postprandia (Finlay)	...	...	1	...	1	...	4	4	4	1	1	1	1	4	2	3	3	3	2	4	1	1	1	...	...	...	...	...	...	...	...	...	...	...	...
R. striatissima (Stache)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	4	4	4	4	4	4	1	1	4	4	3	4	4	3
Pijpersia gracilis Srinivasan	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Discopulvinulina apposita (Finlay)	2	3	2	2	2	2	3	3	3	4	4	4	3	3	3	3	2	2	3	3	2	3	3	3	3	2	2	2	2	2	2	3	2	2	2
D. scopos (Finlay)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	1	1	...	1	1	1	1	1	1	1
Glabratella crassa Dorreen	...	...	...	1	...	1	...	1	...	1	1	1	...	1	...	1	1	...	...	...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...
G. finlayi Srinivasan	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Porosorotalia tainuia (Dorreen)	2	1	2	2	...	1	3	1	2	2	2	2	2	2	3	1	1	1	1	1	1	1	1	1	1	1	2	1	...	...	1	2	2	2	2
Porosorotalia keari (Hornibrook)	...	...	...	1	...	...	1	1	1	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	1
P. okokoensis (Hornibrook)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	2	2
Chiloguembelina cubensis (Palmer)	1	1	1	1	1	1	1	2	2	2	2	2	2	3	1	1	2	2	2	2	1	2	2	2	2	2	2	2	2	1	1	1	1	1	1
Globanomalina micra (Cole)	2	...	...	...	...	...	...	1	...	2	1	1	1	...	1	1	...	1	1	...	...	1	...	1	...	1	...	...	...	...	...	...	...	...	...
Hantkenina alabamensis Cushman	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Turborotalia centralis (Cushman & Bermudez)	...	...	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
T. opima nana (Bolli)	...	...	...	...	...	1	...	...	...	...	...	1	...	...	...	...	...	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...
T. gemma (Jenkins)	...	...	...	1	1	...	1	...	1	...	1	1	1	...	...	...	1	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...
Globigerina ampliapertura Bolli	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	1	2	2	1	...	...	1	...	...	...	...	...	1	...
G. ampliapertura pseudoampliapertura Blow & Banner	...	...	...	...	...	...	...	1	...	...	1	...	1	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
G. angiporoides Hornibrook	...	1	2	2	...	1	...	1	...	...	...	1	1	1	1	1	1	2	3	4	4	2	3	2	2	...	...	1	1	1	...	3	1	2	1
G. eaupertura Jenkins	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	1	...	...	...	1	...	...	...	...
G. ouachitaensis Howe & Wallace	2	2	1	1	1	1	...	1	1	...	1	1	1	1	...	...	1	1	1	...	1	1	1	1	1	1	...	1	1	...	...	2	...	1	...
G. officinalis Subbotina	4	3	1	1	1	1	1	1	1	1	2	2	1	1	...	1	2	1	...	...	...	...	1	...	...	...	...	1	1	1	1	1	...	1	...
Globorotaloides suteri Bolli	...	2	1	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...	...	1	...	1	...	...	...	...	1	1	...	...	1	1	1	...
G. turgida (Finlay)	...	...	1	...	2	...	...	1	...	1	...	...	...	1	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Subbotina linaperta (Finlay)	...	2	...	1	...	...	...	...	1	...	1	1	1	1	...	1	4	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Candeina zeocenica Hornibrook and Jenkins	...	...	...	...	1	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	1	4	2
Globigerapsis index (Finlay)	3	2	3	2	3	2	4	4	4	4	4	3	3	2	4	4	4	4	4	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cibicides pseudoconvexus Parr	...	...	2	1	...	1	1	1	1	...	1	1	1	1	1	1	1	...	...	...	...	...	1	1	1	1	1	1	1	1	1	1	1	1	1
C. parki Finlay	2	2	2	1	2	2	2	1	2	2	1	2	2	3	2	2	2	2	2	2	2	3	3	2	1	...	...	...	...	...	...	...	...	...	...
C. perforatus Karrer	2	3	3	3	3	3	2	2	2	2	2	2	1	1	1	3	3	3	3	3	3	2	2	2	2	1	1	1	2	1	2	3	3	2	2
C. verrucosus Finlay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	1	...	...	...	1	...	...	1	...	...	...	...	...	...	...
Halkyardia bartrumi Parr	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Ellipsoglandulina labiata Schwager	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	1	...	...
Rotaliatina suleigera (Stache)	...	2	1	...	1	2	3	1	2	...	...	2	1	2	2	1	2	1	2	3	3	3	2	...	...	1	...	...	...	...	...	...	...	...	...
Anomalinoides semiteres (Finlay)	1	1	...	...	...	...	1	...	1	...	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Melonis dorreeni (Hornibrook)	2	2	2	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	2	3	3	3	3	3	2	2	3	3	2	1	1	2	3	2	2
M. pacimaoricum Srinivasan	1	1	1	1	1	1	...	2	1	1	1	1	1	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	1	...	...	...
Ceratolamarckina clarki Srinivasan	...	...	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...
Vellaena zealandica Srinivasan	...	...	...	...	...	...	...	...	...	...	1	1	3	3	1	2	1	...	...	1	2	1	1	3	...	...	...	...	...	...	...	...	...	...	...
Cerobertina kakahoica Finlay	1	1	2	1	1	2	2	2	2	1	...	1	2	2	3	3	...	2	2	2	3	3	2	...	...	...	...	...	...	...	...	...	...	...	...

Note: Only stratigraphically important benthonic species are listed.

Key: (...) = nil specimens; 1 = less than 5 specimens; 2 = 5 to 10 specimens; 3 = 10 to 20 specimens; 4 = more than 20 specimens

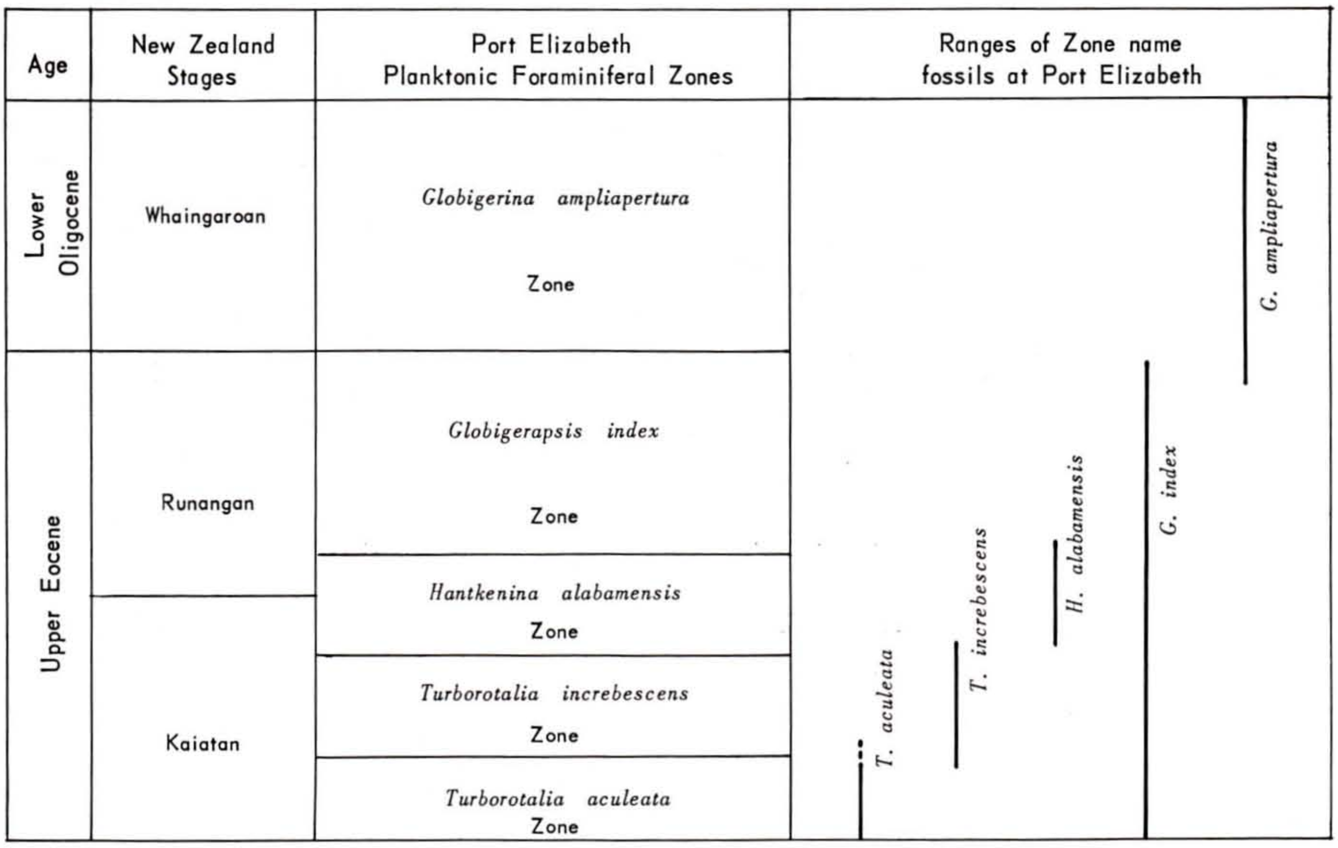
TEXT FIGURE 3b

Check List of the Late Eocene and Early Oligocene foraminifera from Cape Foulwind section, New Zealand

stratigraphic nomenclature and also in terms of the biostratigraphic zones proposed by Vella (1964). They are here treated in ascending order.

(i) *Turborotalia aculeata* Zone

The *Turborotalia aculeata* zone has its boundary defined by the initial appearance of the zone fossil, and its upper boundary is defined by the initial appearance of *Turborotalia increbescens* (Bandy). The zone is not represented at Cape Foulwind. At Port Elizabeth it is represented by the lowest exposed 120 ft. of the Kaiata mudstone. The base of the zone is not exposed; the top is immediately below the lowest occurrence of *T. increbescens*. The planktonic assemblage of *T. aculeata* zone at Port Elizabeth is the same as that in the upper part of



TEXT FIGURE 4
Stratigraphic zones distinguished by planktonic Foraminifera in the Upper Eocene and Lower Oligocene at Port Elizabeth.

the upper greensands (Basal Kaiatan) at McCullough's Bridge, south Canterbury, except that *Globoquadrina primitiva* (Finlay) does not occur at Port Elizabeth. This similarity plus the presence in both areas of a form intermediate between *Gaudryina proreussi* Finlay and *G. reussi* Stache indicates that the *T. aculeata* zone at Port Elizabeth is similar in age to the upper greensands at McCullough's Bridge. It appears that *G. primitiva* makes its last appearance within the *Gaudryina reussi* zone (Basal Kaiatan) and does not range quite to the top of that zone. Therefore, the *T. aculeata* zone at Port Elizabeth is considered to be slightly younger than the upper greensands at McCullough's Bridge and to represent the upper part of the *G. reussi* zone (Basal Kaiatan).

(ii) *Turborotalia increbescens* Zone

The *Turborotalia increbescens* zone is defined by the presence of the zone fossil and is present only at Port Elizabeth, being represented by a thickness of about 510 feet of strata in the lower part of the section and conformably overlying the *T. aculeata* zone.

The following species become extinct within the *T. increbescens* zone: *T. aculeata* (Jenkins) and *Truncorotaloides collactea* (Finlay).

The top of the *T. increbescens* zone marks the base of the upper Kaiatan Stage.

(iii) *Hantkenina alabamensis* Zone

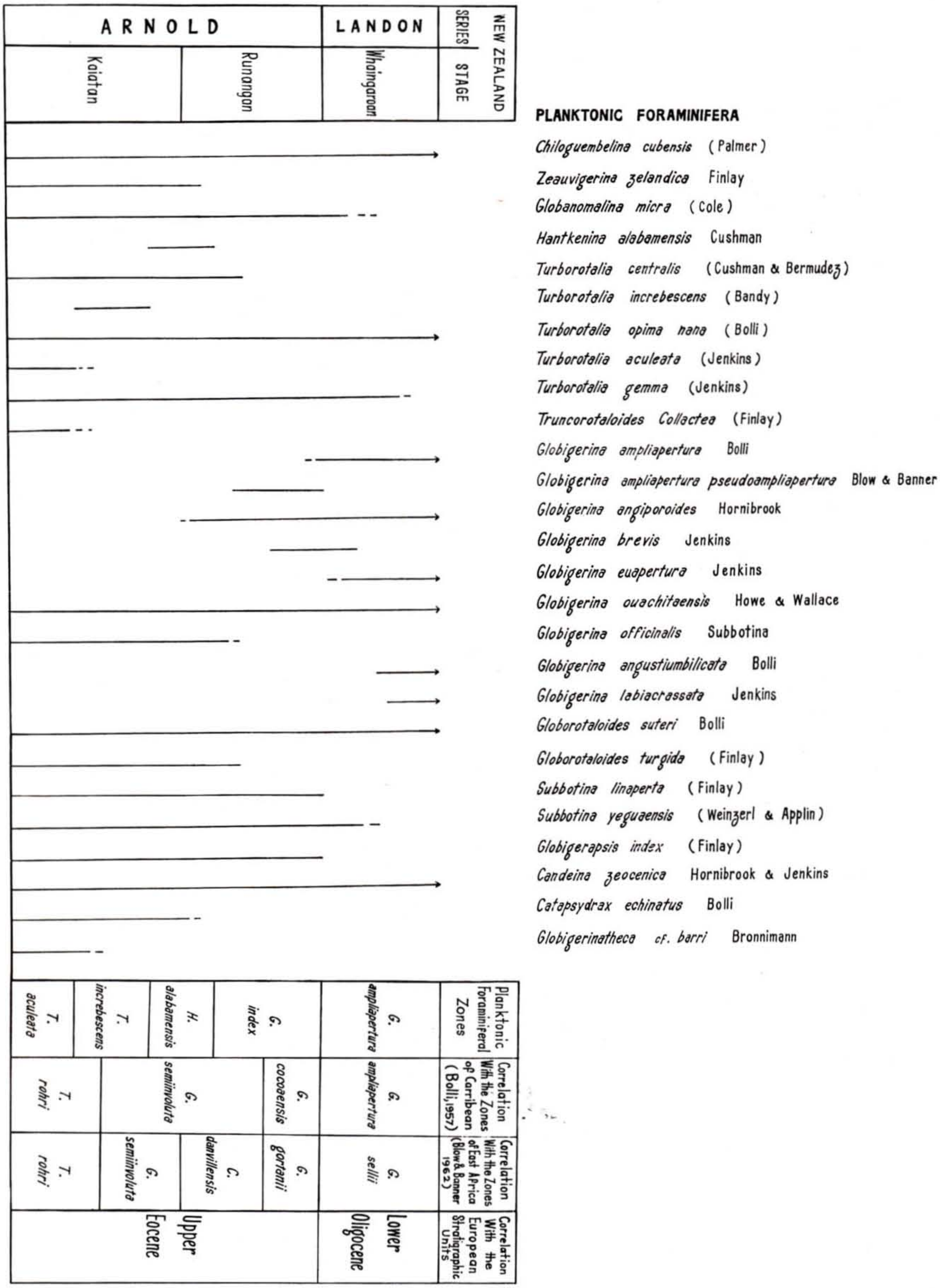
The *Hantkenina alabamensis* zone is defined by the total range of the zone fossil. The zone is represented both at Cape Foulwind and Port Elizabeth. At Cape Foulwind it is about 60 ft. thick and rests unconformably on granite; the oldest part is missing. At Port Elizabeth it is about 220 ft. thick, conformably overlies the *T. increbescens* zone, and contains an extremely rich planktonic fauna.

The following become extinct within the *H. alabamensis* zone: *Catapsydrax echinatus* Bolli, *Zeauvigerina zelandica* Finlay. *Globigerina angiporoides* Hornibrook makes its initial appearance in the middle part of the zone. *Hantkenina* itself is rare, and may be missed if not searched for carefully.

The *H. alabamensis* zone represents a short period at the close of the Kaiatan and the beginning of the Runangan during which several faunal changes took place.

(iv) *Globigerapsis index* Zone

The *Globigerapsis index* zone has its lower boundary defined by the extinction of *H. alabamensis* and its upper boundary by the extinction of *G. index*. The zone is represented at Cape Foulwind by 200 ft. of shallow-water micaceous mudstone and at Port Elizabeth by about 590 ft. of relatively deep-water calcareous mudstone. At both places it rests conformably on the *H. alabamensis* zone.



TEXT FIGURE 5

Correlation chart showing some significant planktonic Foraminifera in the Upper Eocene - Lower Oligocene of New Zealand. Arrows indicate taxa also found in younger New Zealand strata.

New Zealand Stages	New Zealand: Present paper	Carribean: Bolli, 1957	East Africa: Blow and Banner 1962	South Australia: Carter, 1958, 1959	South Australia: Wade, 1964	N. West and Western Australia: Glaessner, 1942 Chapman and Crespin, 1935	Indonesia: Van der Vlerk 1955	Burma: Nagappa, 1959	Assam India: Nagappa, 1959	West Pakistan N. W. India: Nagappa, 1959	North Baluch-istan: Eames, 1951	Middle East: Grimsdale, 1951	Age
Whaingaroan	*G. ampliapertura* Zone	*G. ampliapertura* Zone	*G. Sellii* Zone	Unit – 3	*'linaperta'* Zone	?	'C' Stage	Schwezettaw Stage	Barail 'Series'	Lower Nari ?	Lower Nari ?	Lower Oligocene	Lower Oligocene
Runangan	*G. index* Zone	*G. cocoaensis* Zone	*G. gortanii* Zone with *Pellatispira* *G. danvillensis* Zone	Unit – 2	*'index'* Zone	Giralliа-Limestone with *Pellatispira*	'b' Stage with *Pellatispira*	Yaw Stage with *Pellatispira* and *H. alabamensis*	Kopili Stage with *Pellatispira* and *C. danvillensis* and *H. alabamensis*	'Tapti Series' with *Pellatispira*	Upper Chocolate Clays *Pellatispira*	Upper Eocene	Upper Eocene
	H. alabamensis Zone	*G. semiinvoluta* Zone		Unit – 1	*'alabamensis compressa'* Zone								
Kaiatan	*T. increbescens* Zone		*G. semi-involuta* Zone	?	?								
	T. aculeata Zone	*T. rohri* Zone	*T. rohri* Zone			?	?	? Pondaung Stage	? Upper Prang Limestone	?	?		
Upper Bortonian							'a' Stage					Middle Eocene	Middle Eocene

TEXT FIGURE 6

New Zealand Upper Eocene to Lower Oligocene Foraminiferal zones and some overseas correlations.

The following become extinct in the lower part of the *G. index* zone: *Turborotalia centralis* (Cushman and Bermudez); *G. officinalis* Subbotina, and *G. turgida* (Finlay); *G. brevis* Jenkins. *G. ampliapertura* Bolli makes its initial appearance towards the upper part of the zone.

The top of the *G. index* zone is, by definition, the top of the Runangan Stage and of the Arnold Series.

(v) *Globigerina ampliapertura* Zone

The *Globigerina ampliapertura* zone is marked by the presence of *G. ampliapertura*. The lower boundary is defined by the extinction of *G. index* and *S. linaperta*, both of which range commonly throughout the underlying zone. The *G. ampliapertura* zone conformably overlies the *G. index* zone both at Cape Foulwind and at Port Elizabeth. At Cape Foulwind the zone is represented by 150 feet of shallow-water micaceous mudstone and the upper part of the zone is missing. At Port Elizabeth the *G. ampliapertura* zone is about 180 feet thick and contains a rich pelagic fauna.

Sampling was not high enough at Port Elizabeth to determine the upper boundary of the *G. ampliapertura* zone. Consequently, it was not possible to determine those species that are restricted to the zone or that make their last appearance at the top of the zone.

It may be possible to distinguish an upper subzone of the *ampliapertura* zone itself, based on the first appearance of *G. labiacrassata* Jenkins. As this species is rare at Port Elizabeth more work is required elsewhere regarding its first appearance before it can be formally proposed; however, a well defined zone based on benthonic foraminifera, the *Tritaxilina zealandica* zone, corresponds to this interval of time.

Nature of the biostratigraphic Zones

The planktonic foraminiferal zones fall into the following categories in the American Code and according to the International Subcommission on Stratigraphic Terminology (Hedberg, ed., 1961):

Range Zone: T. increbescens zone, *H. alabamensis* zone.

Concurrent range Zone: T. aculeata zone, *G. index* zone, *G. ampliapertura* zone.

In relation to the usage of the biostratigraphic zones suggested by Vella (1964), the zones fall into the following categories:

Range Zone: T. increbescens zone, *H. alabamensis* zone.

Successive appearance zone: T. aculeata zone.

Successive disappearance zone: G. index zone, *G. ampliapertura* zone.

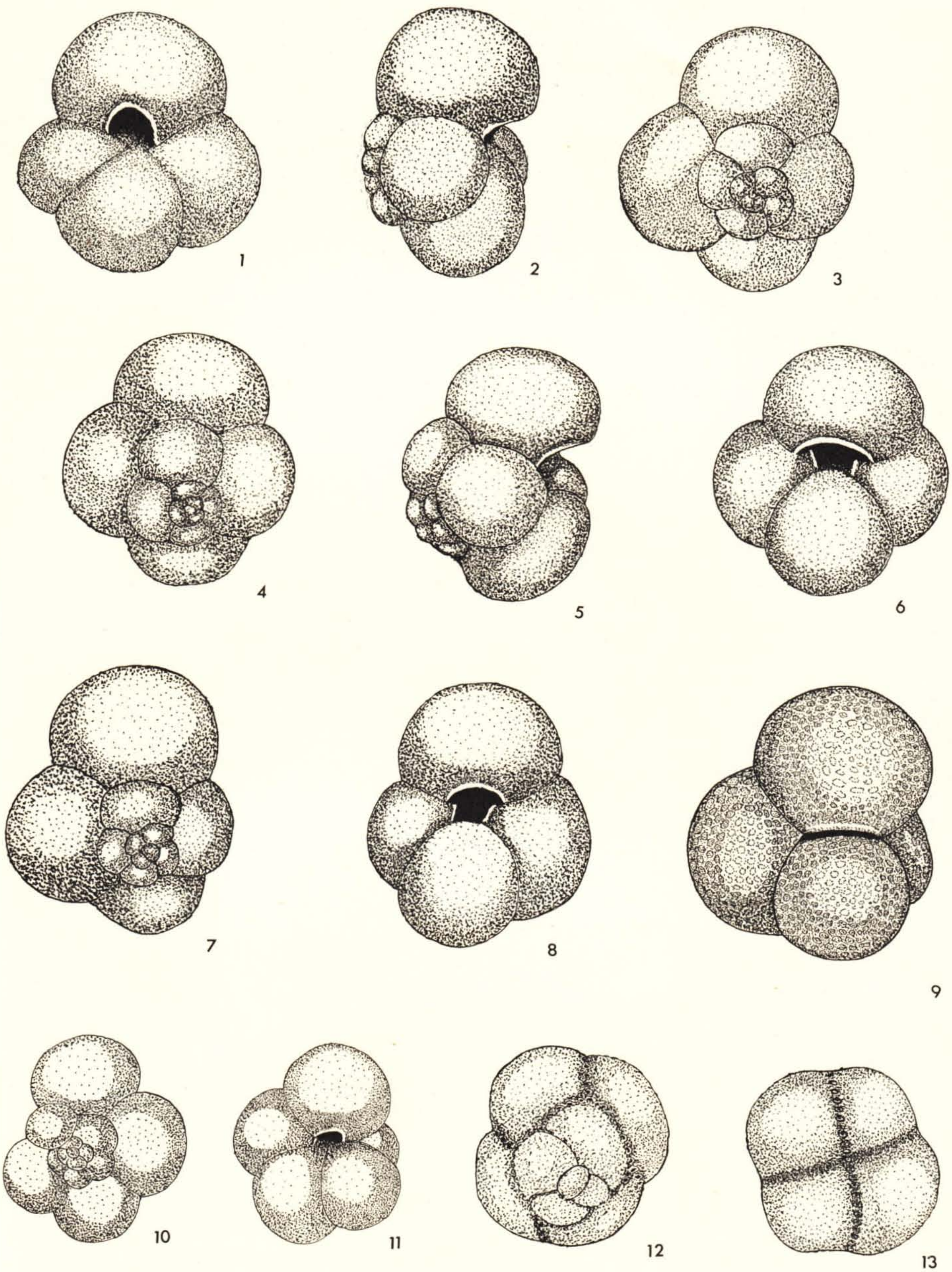
Age and Correlation

In the Tertiary strata of the Tropical-Tethyan and Indo-Pacific belts, the larger foraminifera are dominant; they are the main basis for time-stratigraphic divisions and for intercontinental correlation. During the Upper Eocene to Lower Oligocene epoch, New Zealand was situated well outside the Tropical-Tethyan and Indo-Pacific belts, and to date *Asterocyclina* is the only genus of larger foraminifera known to have invaded the New Zealand area during the Eocene epoch. The earliest attempt at extensive long-distance correlation by means of planktonic foraminifera was Grimsdale's (1951) correlation of the Tertiary rocks of western Europe with those of the middle East. The works of Glaessner (Indo-Pacific, 1942), Finlay (New Zealand, Australia, Indo-Pacific, 1947), Crespin (Australia, 1950), Hamilton (Pacific, 1953), Carter (S. Australia, 1958), Hornibrook (New Zealand, 1958), and Nagappa (Pakistan, India, Burma, 1959) have enriched the knowledge of foraminifera in dating and correlating the Tertiary strata throughout the world. Eames et al. (1962) gave extremely valuable data for correlation of zones based on planktonic foraminifera with those based on large foraminifera. Probably the most useful standard for middle Tertiary intercontinental correlation is the sequence of zones based on planktonic foraminifera established in the Caribbean region by Bolli (1957).

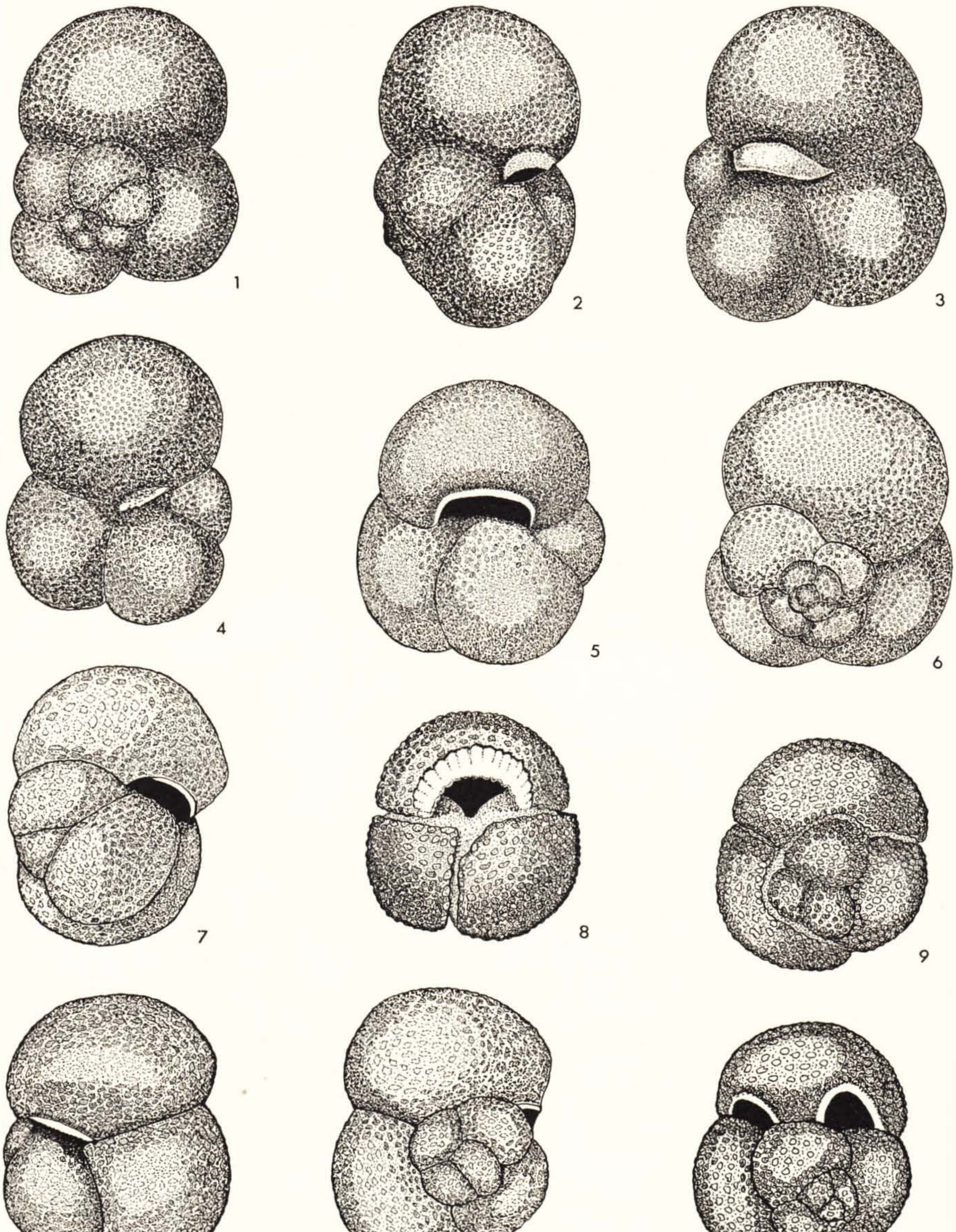
Comparison of the ranges of New Zealand Lower Tertiary planktonic species with those of the Caribbean and East Africa is not entirely straightforward. This is probably due to latitudinal difference. The Upper Eocene - Lower Oligocene foraminifera of New Zealand are different in a number of respects from those described from Trinidad by Bolli (1957) and from East Africa by Blow and Banner (1962). An instance of such differences is the complete absence of the common tropical index

EXPLANATION OF PLATE 15

FIGS.		PAGE
1-3.	*Globigerina officinalis* Subbotina. Hypotype, Ff. 715; ×87, (S44f954).	148
4-6.	*Globigerina ouachitaensis* Howe and Wallace. Hypotype, Ff. 716; ×70, (S44f950).	147
7, 8.	*Globigerina ouachitaensis* Howe and Wallace. Hypotype, Ff. 717; ×70, (S44f950).	147
9.	*Globigerina angiporoides* Hornibrook. Hypotype, Ff. 718; ×44, (S44f964).	147
10, 11.	*Globigerina angustiumbilicata* Bolli. Hypotype, Ff. 719; ×70, (S44f962).	148
12, 13.	*Candeina zeocenica* Hornibrook and Jenkins. Hypotype, Ff. 720; ×70, (S23f555).	149



Srinivasan: Eocene-Oligocene New Zealand Foraminifera



Srinivasan: Eocene-Oligocene New Zealand Foraminifera

forms *Truncorotalia, Cribrohantkenina* and several species of *Hantkenina*. On the other hand common New Zealand forms such as *G. angiporoids* Hornibrook, *G. brevis* Jenkins, and *G. labiacrassata* Jenkins are not known in the tropical regions.

Finlay and Marwick (1947) and Hornibrook (1958, 1959) considered the Kaiatan and Runangan Stages [marked by the latest occurrence of rare *Discocyclina* (now *Asterocyclina*), *Hantkenina alabamensis* and *Globigerapsis index*] to be Upper Eocene in age. They considered the Whaingaroan Stage (with no *Hantkenina* and *Globigerapsis*), conformably overlying the Runangan, to be Lower Oligocene.

The writer (Srinivasan, 1965) has previously correlated the boundary between the Arnold and Landon Series of New Zealand with the Eocene-Oligocene boundary as described by Blow and Banner in the Lindi area, East Africa.

The New Zealand upper Eocene - Lower Oligocene planktonic foraminiferal zones (text fig. 5) are correlated with a similar set of zones established in the Caribbean region by Bolli (1957) and in the Lindi area of East Africa by Blow and Banner (1962). The correlation is mainly based on the stratigraphic occurrences of the following planktonic species present in all three areas:

> *Globanomalina micra* (Cole), *Turborotalia opima nana* (Bolli), *Turborotalia increbescens* (Bandy), *Turborotalia centralis* (Cushman and Bermudez), *Hantkenina alabamensis* Cushman, *Subbotina linaperta* (Finlay), *Globigerapsis index* (Finlay), *Globigerina ampliapertura pseudoampliapertura, G. ampliapertura* and *G. euapertura.*

The accompanying chart (text fig. 6) is an attempt to correlate the Upper Eocene-Lower Oligocene strata of New Zealand with the strata elsewhere, primarily on the basis of planktonic foraminifera. Where data on planktonic foraminifera are inadequate, as in the cases of Baluchistan, Pakistan, India, Burma, Indonesia, and northwest and western Australia (Tethyan and Indo-Pacific belt), larger foraminifera have been utilized in compilation of this chart.

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EXPLANATION OF PLATE 16

FIGS.		PAGE
1-3.	*Subbotina yeguaensis* (Weinzierl and Applin). Hypotype, Ff. 703; ×70, (S44f958).	149
4.	*Subbotina yeguaensis* (Weinzierl and Applin). Hypotype, Ff. 704; ×70, (S44f953).	149
5, 6.	*Globigerina ampliapertura* Bolli. Hypotype, Ff. 705; ×70, (S44f961).	147
7, 10, 11.	*Subbotina linaperta* (Finlay). Hypotype, Ff. 706; ×70, (S44f956).	149
8, 9.	*Globigerapsis index* (Finlay). Hypotype, Ff. 707; ×44, (S44f959).	149
12.	*Globigerapsis index* (Finlay). Hypotype, Ff. 708; ×35, (S44f959).	149

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
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355. THE GENUS *SIGMOILOPSIS* FINLAY 1947 FROM CARDIGAN BAY, WALES

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ABSTRACT
Four species of **Sigmoilopsis** Finlay are described from the Recent deposits of Cardigan Bay. Two of the species, **Sigmoilopsis moyi** and **Sigmoilopsis woodi**, are new.

INTRODUCTION

In 148 surface sediment samples from Cardigan Bay, Wales, four species of *Sigmoilopsis* Finlay 1947 were found. The sediments were collected by the Department of Geology, Aberystwyth, between 1963 and 1965 during numerous cruises of the R.V. *Antur*. These samples form part of the Cardigan Bay - Irish Sea Research Project at present being carried out in the Department.

Immediately after collection, formaldehyde solution, buffered with borax, was added to the sediment to preserve the living organisms. In the laboratory the samples were washed in clean water and stained using rose Bengal (Walton, 1952). No specimens of *Sigmoilopsis* were found with the apertural plug of dark, red-stained protoplasm which is indicative of living foraminifera.

The holotypes of the new species have been presented to the British Museum (Nat. Hist.). Paratypes are deposited in the author's collection at the Museum of the Department of Geology, Aberystwyth. The type localities given in the systematics are Cardigan Bay - Irish Sea Project sample locations.

SYSTEMATIC PALAEONTOLOGY

Superfamily MILIOLACEA Ehrenberg, 1839
Family MILIOLIDAE Ehrenberg, 1839
Subfamily QUINQUELOCULININAE Cushman, 1917
Genus **Sigmoilopsis** Finlay, 1947

Sigmoilopsis schlumbergeri (Silvestri), 1904

Plate 18, figures 1a, 1b, 1c

Planispirina celata (Costa) BRADY, 1884, Chall. Repts. Zool., vol. 9, pp. 197, 198, pl. 8, figs. 1-4.

Sigmoilina schlumbergeri SILVESTRI, 1904, Mem. Accad. Pont. Rom. Nuovi. Lincei., vol. 22, pp. 267, 269. (figs.—Schlumberger, 1888, pl. 7, figs. 12-14; p. 481, text fig. 6; p. 482, text fig. 7).

Description.—Test free, elongate oval in outline, over twice as long as broad, posterior end subrounded, apertural end slightly truncate; test not greatly compressed, rounded triangular in cross section, unequally biconvex in apertural view and periphery subrounded. Sigmoidal chamber arrangement, chambers more distinct on the side with greater convexity than on the other, up to six visible externally, final chamber extending only slightly beyond the penultimate one at the posterior end. Sutures indistinct, only roughly marked, slightly depressed. Inner layer of wall calcareous; exterior arenaceous, composed of fairly large grains for the size of the test which do not protrude beyond the outline so that the finish is relatively smooth, most of the grains are colourless, markedly few are dark pyroxenes and amphiboles. Aperture terminal, oval to semi-circular on a short neck with a phialine lip and a small, broad, bar-like tooth parallel to the base of the aperture. All Cardigan Bay specimens sectioned were microspheric.

Dimensions of the figured specimen.—Length 0.67 mm.; breadth 0.30 mm.; thickness 0.23 mm.

Locality.—C.B. 555; 52°13′34″ N; 4°20′48″ W.

Depth.—7 fathoms.

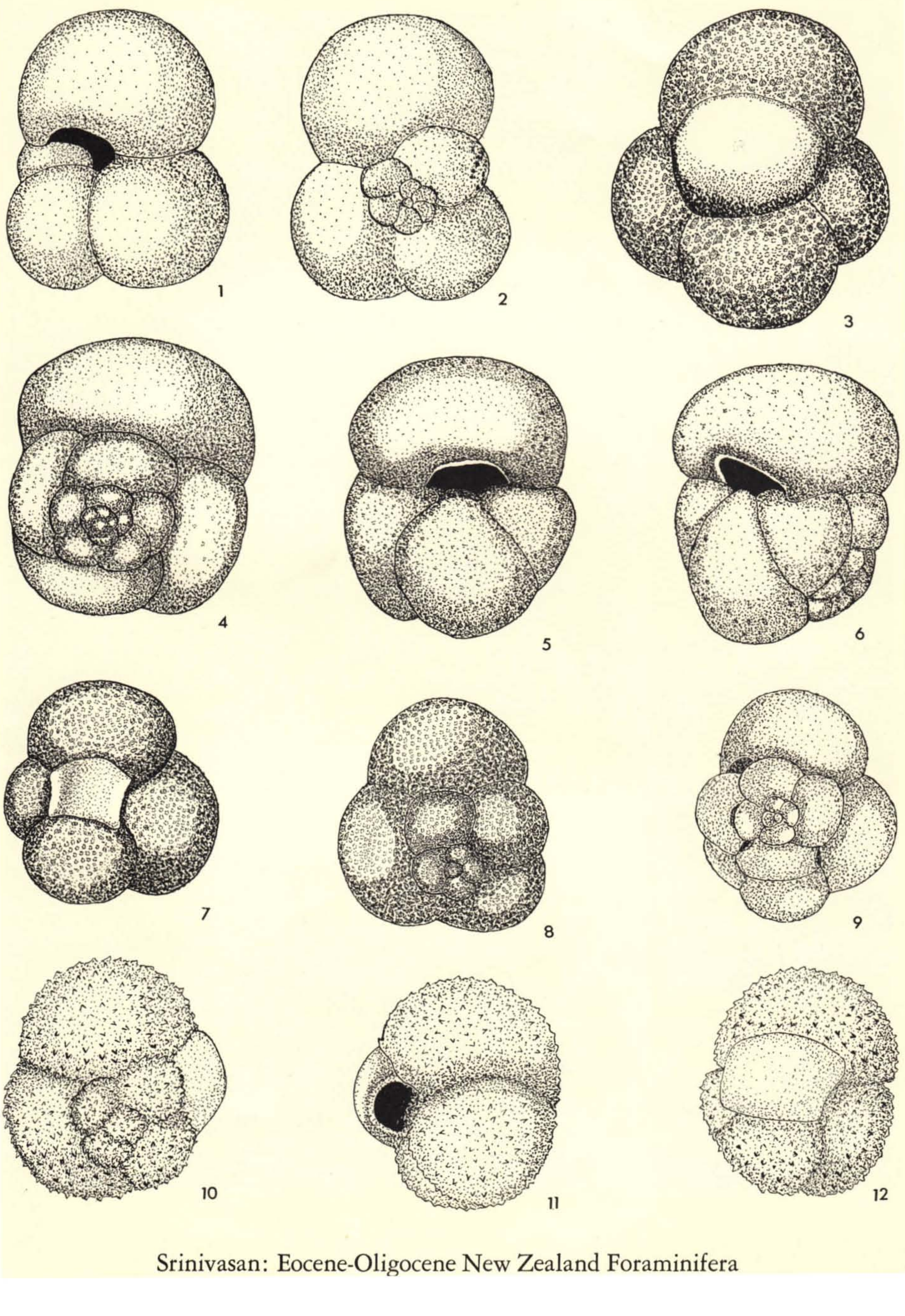
Observed range in dimensions.—Length 0.35-0.70 mm.; breadth 0.20-0.40 mm.; thickness 0.17-0.25 mm.

Occurrence.—14 stations, depth range 0 to 13 fathoms.

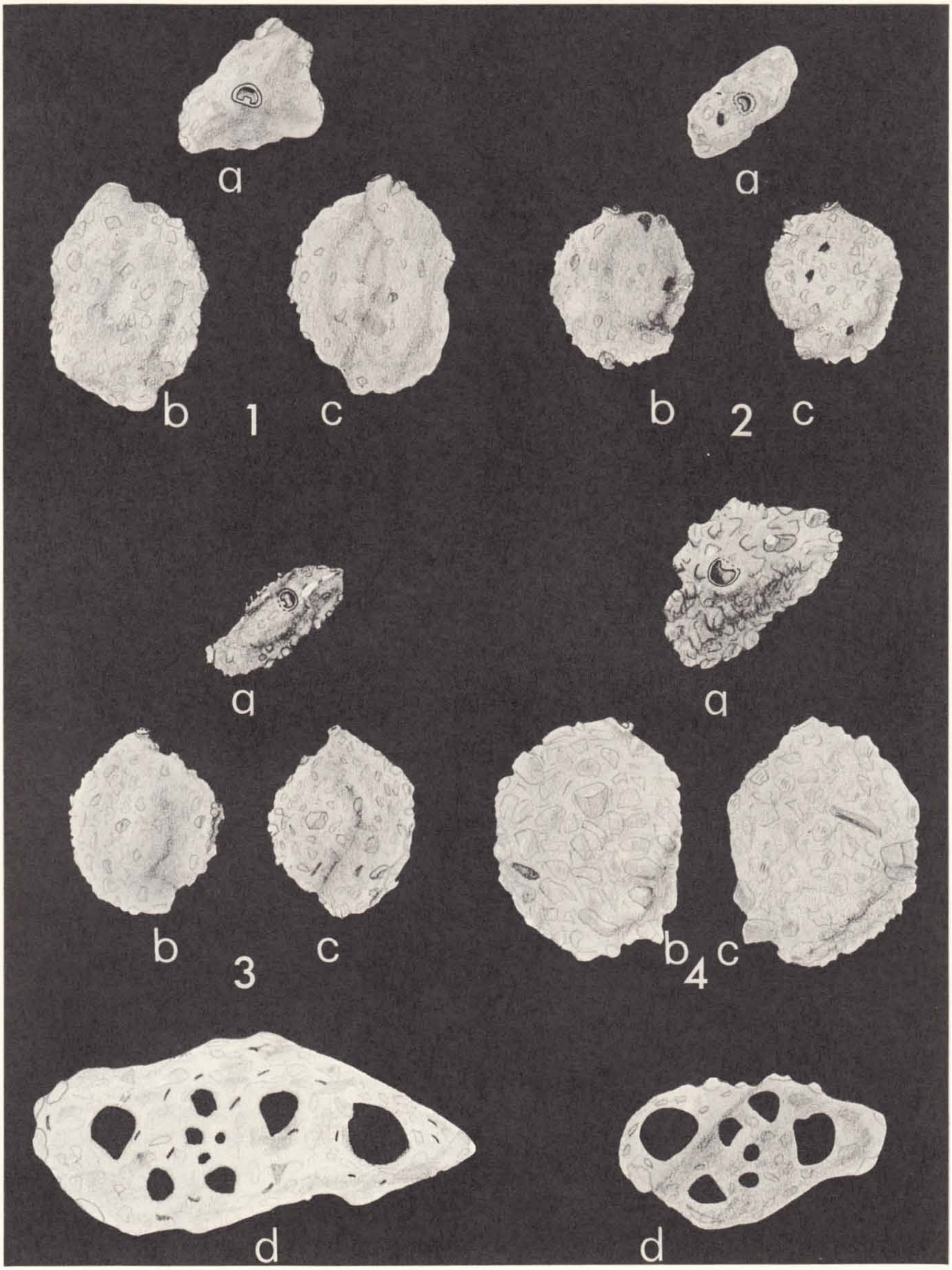
Remarks.—Before the recognition of this as a distinct species (Silvestri, 1904), there can be little doubt that many authors grouped *S. schlumbergeri*

EXPLANATION OF PLATE 17

FIGS.		PAGE
1, 2.	*Globigerina* cf. *trilocularis* d'Orbigny. Hypotype, Ff. 721; ×70, (S44f951).	148
3.	*Globorotaloides turgida* (Finlay). Hypotype, Ff. 723; ×44, (S44f965).	148
4-6.	*Globigerina ampliapertura pseudoampliapertura* Blow and Banner. Hypotype, Ff. 722; ×70, (S44f956).	147
7, 8.	*Globorotaloides turgida* (Finlay). Hypotype, Ff. 724; ×70, (S44f965).	148
9.	*Globigerinatheca* cf. *barri* Bronnimann. Hypotype, Ff. 725; ×44, (S44f949).	150
10-12.	*Catapsydrax echinatus* Bolli. Hypotype, Ff. 726; ×70, (S44f949).	150



Srinivasan: Eocene-Oligocene New Zealand Foraminifera



Atkinson: *Sigmoilopsis* From Wales

(*Planispirina celata* sensu Brady 1884) under *P. celata* Costa 1855. Costa's type has a shorter test and more conspicuous sutures.

A lectotype for this species was designated by Loeblich and Tappan (1964, p. 466) as the specimen figured by Brady 1884 from Porcupine Station 23, west of Ireland at 630 fathoms. The Cardigan Bay specimens have a generally more roughened appearance than Brady's type; this may be some direct result of the shallower depth from which they were collected. Brady recorded the world-wide depth range as 28 to 2435 fathoms.

Sigmoilopsis moyi, sp. nov.

Plate 18, figures 3a, 3b, 3c, 3d

Description.—Test free, ovate in outline, basal end broadly rounded with the last chamber extending beyond the penultimate one, apertural end gently attenuated, compressed concavo-convex in cross section; periphery sometimes keeled, more often subacute to subrounded. Chambers fairly distinct, sigmoidally arranged, four visible externally, gently inflated. Sutures only roughly visible, depressed. Wall arenaceous, fairly coarse with many angular grains scattered unevenly over the test. Aperture terminal on the attenuated final chamber, with short neck, phialine lip and short bar-like tooth.

Dimensions of the holotype.—Length 0.73 mm.; breadth 0.57 mm.; thickness 0.30 mm.

Locality of the holotype.—C.B. 561; 52°16′16″ N; 4°16′00″ W.

Depth.—9 fathoms.

Type level.—Recent.

Types.—Holotype presented to the British Museum (Nat. Hist.); paratypes deposited in the author's collection at the Department of Geology, Aberystwyth.

Observed range in dimensions.—Length 0.25-0.75 mm.; breadth 0.20-0.59 mm.; thickness 0.12-0.31 mm.

Localities of paratypes.—C.B. 502: 52°17′21″ N, 4°25′54″ W, depth 13.5 fathoms; C.B. 561: 52°16′ 16″ N, 4°16′00″ W, depth 9 fathoms.

Occurrence.—11 stations, depth range 2 to 13.5 fathoms.

Remarks.—This species varies in the amount of compression, the concavity of the side having fewer chambers visible, and in the acuteness of the periphery. It differs from *S. schlumbergeri* (Silvestri) in being more compressed, concavo-convex and having less well defined sutures. The subacute periphery distinguishes it from both Silvestri's species and *S. wanganuiensis* Vella. Compared with *S. finlayi* Vella it has a much more irregular, coarsely arenaceous wall and sub-acute periphery as well as possessing a phialine lip.

Sigmoilopsis wanganuiensis Vella, 1957

Plate 18, figures 2a, 2b, 2c

Sigmoilopsis wanganuiensis VELLA, 1957, N. Z. Geol. Surv. Pal. Bull. no. 28, p. 20, pl. 4, figs. 67-70.

Description.—Test free, sub-circular to ovate in outline, compressed, sides only gently convex in apertural view; periphery rounded. Chambers sigmoidally arranged, indistinct, final chamber extending posteriorly beyond the penultimate one, chambers not greatly inflated; sutures very indistinct. Inner layer of wall calcareous and exterior arenaceous composed of medium sized grains with an even finish, including occasional dark minerals. Aperture terminal, oval to crescentic, on a short neck with a rudimentary plate-like tooth and phialine lip.

Dimensions of the figured specimen.—Length 0.6 mm.; breadth 0.52 mm.; thickness 0.27 mm.

Locality.—C.B. 552; 52°13′27″ N; 4°22′32″ W.

Depth.—9 fathoms.

Observed range in dimensions.—Length 0.27-0.65 mm.; breadth 0.23-0.55 mm.; thickness, 0.14-0.29 mm.

Occurrence.—9 stations, depth range 0 to 12 fathoms.

Remarks.—This species is similar to *S. flintii* (Cushman) but is broader, has a more irregular grain size and a shorter neck. The Cardigan Bay specimens are smaller than the type and have a shorter neck and a less pronounced tooth structure.

Vella (1957) recorded this species as very persistent from 43 to 63 fathoms in Cook Strait.

Sigmoilopsis woodi, sp. nov.

Plate 18, figures 4a, 4b, 4c, 4d

Description.—Test free, sub-circular to ovate in outline, unequally biconvex, rounded triangular in cross section, not compressed; periphery rounded.

EXPLANATION OF PLATE 18

FIGS.		PAGE
1a, b, c.	*Sigmoilopsis schlumbergeri* (Silvestri), 1904, length 0.67 mm.	160
2a, b, c.	*Sigmoilopsis wanganuiensis* Vella, 1957, length 0.60 mm.	161
3a, b, c.	*Sigmoilopsis moyi* sp. nov., holotype, length 0.73 mm.	161
3d.	*Sigmoilopsis moyi* sp. nov., paratype, thin section, ×60.	161
4a, b, c.	*Sigmoilopsis woodi* sp. nov., holotype, length 0.48 mm.	161
4d.	*Sigmoilopsis woodi* sp. nov., paratype, thin section, ×47.	161

Chambers sigmoidally arranged, very indistinct, gently inflated, final chamber not extending posteriorly beyond the penultimate one, in transverse section the chambers are oval to circular; sutures exceedingly indistinct, slightly if at all depressed. Wall coarsely arenaceous, with many dark coloured grains, exterior rough. Aperture terminal, oval to semi-circular, a little raised above the penultimate chamber on a short neck with a phialine lip and a narrow, bar-like tooth structure.

Derivato nominis.—In honour of Professor Alan Wood.

Dimensions of the holotype.—Length 0.48 mm.; breadth 0.37 mm.; thickness 0.23 mm.

Locality of the holotype.—C.B. 561; 52°16′16″ N; 4°16′00″ W.

Depth.—9 fathoms.

Type level.—Recent.

Types.—Holotype presented to the British Museum (Nat. Hist.); paratypes deposited in the author's collection at the Department of Geology, Aberystwyth.

Observed range of dimensions.—Length 0.29-0.58 mm.; breadth 0.23-0.42 mm.; thickness 0.21-0.25 mm.

Localities of paratypes.—C.B. 646: 52°19′14″ N, 4°13′00″ W, depth 10 fathoms; C.B. 421: 52°25′ 05″ N, 4°10′44″ W, depth 8 fathoms; C.B. 736: G.R. 556 748 (SN 60 U.K. Nat. Grid), beach sample.

Occurrence.—10 stations, depth range 0 to 12 fathoms.

Remarks.—This species is very variable in cross section and some thin sections show a gradual reduction in the degree of triangularity with growth (plate 18, fig. 4d). Most large specimens are still very triangular. The amount of neck development also varies. Externally this species resembles *Flintina crassatina* (Brady), but they differ in chamber arrangement. It is similar to *S. flintii* (Cushman) but is less compressed and has a shorter neck. It differs from *S. wanganuiensis* Vella in being rounded triangular in cross section and having a coarser arenaceous wall.

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356. PRELIMINARY REPORT ON SOME LITTORAL FORAMINIFERA FROM TOMALES BAY, CALIFORNIA

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ABSTRACT

Twenty-one species are listed from Tomales Bay, California, and a proposed paleoecologic study is outlined. Results of the preliminary work showed that the fauna of Tomales Bay is very similar to that in Sunset Bay, Oregon.

INTRODUCTION

The purpose of the study is to report the preliminary results of an investigation of littoral foraminifera in Tomales Bay, California, the first phase of a proposed paleoecologic study. The macrofauna and flora of the Pleistocene Millerton formation surrounding Tomales Bay, 40 miles north of San Francisco at 38°15′N. Lat., have been described by Dickerson (1922) and Weaver (1949). Although foraminifera have been reported from these deposits, best developed as cliffs and headlands jutting into Tomales Bay (Santa Rosa, California Sheet 1963), none have been listed or described. However, Professor Don Steinker has recently examined samples of Millerton material for foraminifera (personal communications).

Johnson (1962) was concerned with developing valid criteria for distinguishing between a biocoenosis and a thanatocoenosis. By comparing fossil mollusks with modern ones from Tomales Bay he attempted to reconstruct the mode of formation of fossil assemblages in the Millerton. Since foraminifera are within the sediment size range of silt, the effects of reworking and post-mortem transportation are probably more critical on such microfossils than the macrofossils. For example, Murray (1965) described how benthic foraminifera were raised in suspension in surface waters and redistributed over relatively wide areas by storms. He indicated that small specimens were preferentially removed from source sediments and settled elsewhere. As a result the death assemblages were altered in composition: by removal and by addition. Failure to develop and apply objective discriminatory criteria would make it difficult to distinguish a biocoenosis from a thanatocoenosis in this case.

Foraminifera can be used to explore further the validity of criteria suggested by Johnson (1962) for recognition of exotic elements in a fossil assemblage. Following the present investigation of the modern foraminifers, the fossil situation would be examined with special attention to criteria like fragmentation, test abrasion, faunal composition (ecologic homogenity), density, size-frequency distribution, and sediment association. These criteria would be evaluated by checking the results of the fossil analysis with the distribution of modern foraminifera in the bay.

In addition to possible paleoecologic implications, the present research is of interest for several reasons. Considerably richer in species than originally reported by Bush (1935), the fauna contains at least twenty-one species rather than the nine she reported. On the basis of studies in other bays and estuaries (Phleger 1960), it would be expected that the marsh at the southern end of the bay would yield a characteristic assemblage of arenaceous species.

The present research extends the distribution of nearshore foraminifera north from San Francisco. Bandy (1953) reported on some collections taken near San Francisco Bay and Detling (1958) described and figured some intertidal foraminifers from Sunset Bay, Oregon. More recently Grivetti (1960) studied intertidal species of the Farallon Islands and Lankford (1962) the recent foraminifera from the nearshore turbulent zone of the entire western United States and northwest Mexico. Several of Lankford's collecting sites were in Bodega Bay, the northern extension of the fault zone that Tomales Bay occupies (personal communication).

MATERIALS AND METHODS

While working on the distribution and abundance of the tube-building polychaete *Owenia fusiformis* (Della Chiaje) during the summer of 1964, the writer noticed that its tube was composed of sand grains and tests of foraminifers. Although it is common for *O. fusiformis* to utilize material from the substratum, the abundance and variety of foraminifera thus used was so striking as to prompt further investigation. A pilot study was undertaken and twenty quantitative samples were collected with a Van Veen grab from White Gulch, a small incline about three miles south of the mouth of Tomales Bay. In addition, thirty-six samples were taken intertidally at various sites around the bay. Moreover, Mr. Ali Imam and Mr. George Seddon, graduate students attending the summer session at the University of the Pacific, kindly allowed the author to examine material which they had col-

Contribution No. 56, Univ. of Delaware Marine Laboratory

lected for class projects. Their samples included intertidal stations slightly north of the bay and subtidal sites in the southern portion.

RESULTS

From all these sources the following preliminary list of calcareous benthic foraminifera of Tomales Bay has been compiled. The asterisk following the specific name indicates that the species was listed and figured by Detling.

Oolina costata (Williamson)
Elphidium incertum (Williamson)*
Nonion grateloupii (d'Orbigny)*
Buliminella elegantissima (d'Orbigny)*
Fissurina lucida (Williamson)*
Quinqueloculina seminula (Linné)*
Quinqueloculina sp.*
Quinqueloculina rhodiensis Parker*
Cibicides lobatulus (Walker and Jacob)*
Bolivina vaughani Natland
Cornuspira involvens (Reuss)*
Discorbis columbiensis (Cushman)*
Elphidiella nitida Cushman*
Bucella inusitata Anderson*
Nonionella miocenica Cushman var. *stella* Cushman and Moyer*
Discorbis ornatissima Cushman*
Eponides columbiensis Cushman*
Cassidulina limbata (Cushman and Hughes)*
Bulimina affinis d'Orbigny
Elphidium crispum (Linné)
Trochammina inflata (Montagu)
Globigerina bulloides d'Orbigny

Rotalia beccari (Linné) has not as yet been identified, but its presence is suspected. The planktonic species *G. bulloides* was washed in. The fauna resembles to a marked degree the one described from Oregon by Detling (1958). It is suggested that *Quinqueloculina seminula*, *Quinqueloculina* sp. and *Quinqueloculina rhodiensis* are *Quinqueloculina* species A, species B and species C respectively of Detling's paper.

This paper is to be considered as a preliminary report; specimens have not as yet been deposited in a repository. Efforts to continue the study have been made, as an additional 120 quantitative samples have been collected from Tomales Bay, but the analysis of these is still to be accomplished.

The writer would like to acknowledge the aid of Professor Don Steinker, who kindly examined the species and brought the writer's attention to some references.

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CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
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357. A TAXONOMIC NOTE ON *MASSILINA CARINATA* (FORNASINI, 1905)

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ABSTRACT

Massilina nitida carinata (Fornasini, 1905) and **Massilina milletti** (Wiesner, 1912) are shown to be synonymous. The varietal name **carinata** is elevated to specific rank and the differences from **Spiroloculina nitida** d'Orbigny are discussed. The types of **M. carinata** are reillustrated together with a specimen from Cardigan Bay, Wales. The species is described and its geographical occurrence is outlined.

INTRODUCTION

The author has studied the Recent foraminifera in 148 bottom sediment samples from Cardigan Bay, Wales. Two samples contained specimens which were identical to *Spiroloculina nitida* d'Orbigny as figured by Brady (1884). This rarely recorded miliolid has been referred to *Spiroloculina milletti* Wiesner, 1912, by subsequent authors (Boltovskoy, 1954; Barker, 1960). The present work has shown that this name is invalid (Thalmann, 1960) and the prior designation, *Spiroloculina nitida* var. *carinata* Fornasini, 1905, should be used for this form.

DISCUSSION

The first mention of this species as a discrete form was by Brady in 1884. In a discussion of *S. nitida* d'Orbigny, 1826, he remarked, "Soldani's drawing . . . . named by d'Orbigny *Spiroloculina nitida* appears to be intended for one of the varieties of *Spiroloculina planulata* which differs from the typical form in its discrete and slightly inflated segments and the somewhat produced superior extremity of the final chamber. The complanate shallow water Spiroloculinae of the tropics are very variable in minor characters but a considerable section of them, well typified by the figures Pl. 9, figs. 9, 10, may be assigned to this particular form." The figures 9 and 10 of Brady are here reproduced as text figures 3 and 2 respectively.

Cushman and Todd (1944; 40) described the first apertural view of *S. nitida* d'Orbigny, given by Terquem in 1878, as having a "distinctly rounded" periphery. Fornasini's (1900) line drawing of this species, traced from d'Orbigny's 1826 unpublished plates, also showed a slightly rounded periphery. Brady's illustrations are of a species with an acute or carinate periphery on the final chamber and a double keel or excavated periphery on the penultimate chamber. It is apparent therefore that *S. nitida* sensu Brady is not *S. nitida* d'Orbigny.

Millett (1898) attributed specimens from the Malay Archipelago to *S. nitida* d'Orbigny. Although illustrations of rather wild-growing individuals, his figures 9 to 12 on Plate 5 have cylindrical chambers and fig. 12b shows well the rounded periphery. Discussing Brady's carinate form he commented "A similar form occurs at several of the Malay stations but the test is thinner and the chambers have not the inflation characteristic of *S. nitida*." No indication is given in the text as to whether this carinate type is illustrated, but his figure 13, plate 5, is very similar to Brady's figures. In the plate explanation for plate 5 of Millett's work, figure 13 is described as "*S. nitida var.*" It is here concluded that Millett's figures 9 to 12 on Plate 5 are *S. nitida* d'Orbigny and figure 13 is *S. nitida* sensu Brady.

In 1905 Fornasini erected *S. nitida* d'Orbigny var. *carinata*, designating as the type figures 9 and 10 of Brady 1884. Wiesner (1912) erected *S. milletti,* which was described as differing from *S. nitida* d'Orbigny by its slightly roughened surface as compared with the shining surface of d'Orbigny's species. He attributed the wild growth patterns of Millett's specimens to the habitat and suggested that with growth the species altered from a smooth, round-chambered form to one with clear, narrow chambers with keels or ribs. Whilst it is probably correct that environment resulted in the wild growth, there has been no further evidence available to support the idea that the smooth round-peripheried forms are juveniles of the forms illustrated by Brady.

Wiesner did not give a type figure or designate a type specimen, but his synonymy included Brady (1884, p. 149, pl. 9, figs. 9, 10) and Millett (1898, p. 265, pl. 5, figs. 9-12). Significantly he did not quote Millett's figure 13. Wiesner was apparently in ignorance of Fornasini's prior designation var. *carinata* for Brady's figures. Neglect of this fact, together with lack of a designated type, must render *Spiroloculina milletti* Wiesner, 1912 invalid.

In 1944 Cushman and Todd (p. 76) described Wiesner's species as belonging to the genus *Massilina.* Although these authors stated that it was synonymous with *S. nitida* Brady (not d'Orbigny) they retained Millett's figures 9 to 12 and ignored his figure 13.

This species has also been illustrated as *M. mil-*

letti by Boltovskoy (1954). The name was also used by Barker (1960) for Brady's original figures. Thalmann (1960) noted "*S. milletti* : invalid name : see *S. nitida carinata* Fornasini."

CONCLUSION

Although Brady (1884) was the first to illustrate this form, it was Fornasini (1905) who gave it an original and undisputed name. According to Article 17 (9) of the International Code for Zoological Nomenclature, the variety *carinata* Fornasini is available because it was proposed before 1961. Many authors [Wiesner, Boltovskoy, McKenzie (1962) and Hulme (1964)] have regarded this variety as specifically distinct from *S. nitida* by its carinate or keeled periphery and roughened surface. This foraminifer, therefore, should be called *Massilina carinata* (Fornasini, 1905).

SYSTEMATIC PALAEONTOLOGY

Superfamily MILIOLACEA Ehrenberg, 1839
Family MILIOLIDAE Ehrenberg, 1839
Subfamily QUINQUELOCULININAE Cushman, 1917
Genus **Massilina** Schlumberger, 1893
Massilina carinata (Fornasini, 1905)

Text figures 1, 2, 3

1884 *Spiroloculina nitida* BRADY, Chall. Rep. Zool., vol. 9, p. 149, pl. 9, figs. 9, 10.

pars 1898 *Spiroloculina nitida* d'Orbigny MILLETT, Jl. R. microsc. Soc., p. 265, pl. 5, fig. 13 (*S. nitida* d'Orbigny *var.* in plate explanation).

1905 *Spiroloculina nitida* d'Orbigny var. *carinata* FORNASINI, Boll. Soc. geol. ital., vol. 24, p. 389.

1954 *Massilina milletti* (Wiesner) BOLTOVSKOY, Revta Inst. nac. Invest. Cienc. nat. Mus. argent, vol. 3, p. 261, pl. 21, fig. 6.

1960 *Massilina milletti* (Wiesner) BARKER, Spec. Publs. Soc. econ. Paleont. Miner., vol. 9, p. 18, pl. 9, figs. 9, 10.

non 1826 *Spiroloculina nitida* D'ORBIGNY, Annls Sci. nat., ser. 1, vol. 7, p. 298.

non 1923 *Spiroloculina carinata* WIESNER, Die Miliolid. der ostlich., p. 28, pl. 5, figs. 42-43.

non 1947 *Spiroloculina carinata* LE CALVEZ, Mem. Serv. Carte géol. dét. Fr., p. 26, pl. 2, figs. 32, 33.

Description.—Test free, elongate, roughly oval in outline, compressed, greatest breadth at the center, almost parallel sided in edge view, sides concave. Periphery subacute, penultimate chamber with rectangular periphery and double keel, final chamber has double keel at the aboral end merging into one keel at the apertural end. Test in early stages quinqueloculine, later chambers added in one plane; chambers distinct, at least six visible from each side. Sutures distinct, depressed. Wall calcareous, imperforate, porcellaneous, surface roughened, not polished, some suggestion of faint longitudinal striae near apertural end, double keel irregularly developed. Aperture terminal at the end of a short neck, large, circular, with a conspicuous lip and small, often poorly developed bifid tooth which does not project beyond the end of the ultimate chamber.

Type specimens designated by Fornasini as Brady, 1884, pl. 9, figs. 9, 10.

Dimensions of the type specimens.—Text Fig. 9: Length 0.74 mm.; breadth 0.60 mm.; thickness 0.16 mm. Text Fig. 10: Length 1.10 mm.; breadth 0.85 mm.; thickness 0.24 mm.

Depository.—The type specimens are deposited in the British Museum (Natural History). The registered numbers are ZF 2411 (text fig. 9) and ZF 2412 (text fig. 10).

Dimensions of the figured Cardigan Bay specimen (text fig. 1).—Length 1.00 mm.; breadth 0.73 mm.; thickness 0.22 mm.

This specimen is in the author's collection at the Museum of the Department of Geology, Aberystwyth.

Observed range of dimensions of the Cardigan Bay specimens.—Length 0.50 mm.-1.00 mm.; breadth 0.22 mm.-0.73 mm.; thickness 0.10 mm.-0.22 mm.

Distribution.—This species has been recorded from 15 fathoms off Japan and at 8 fathoms in the Torres Strait (Brady, 1884). Cushman (1917) listed specimens from Honolulu, Tokyo and Hawaii. Boltovskoy (1954, 1957) described it from off the coast of central east Argentina and in the estuary of the river Platte. Occurrences in Australia and New Zealand are noted by McKenzie (1962) and Hulme (1964).

Massilina carinata has not previously been recorded from British waters. The author retrieved specimens from Cardigan Bay Stations C.B. 113 and C.B. 426. At the time of recovery the water temperature was 7°C and the salinity was 32.4‰. These stations are in 9 and 10 fathoms respectively.

ACKNOWLEDGMENTS

The author wishes to thank Dr. J. R. Haynes and Dr. R. L. Moy for critically reading the manuscript. Thanks are also due to Dr. C. G. Adams for making available the collections of the British Museum (Nat. Hist.) and to Dr. R. Hedley and Dr. R. C. Whatley for many helpful discussions and communications. The photographs of Brady's

original drawings are reproduced by kind permission of the Publications Division of Her Majesty's Stationery Office.

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358. A NEW SPECIES OF *PSEUDOGUEMBELINA* FROM THE UPPER CRETACEOUS OF TEXAS

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ABSTRACT

A new species of **Pseudoguembelina** appears to be restricted to the **Globotruncana gansseri** zone. Though rare in occurrence, it may prove to be a useful index species for this zone.

INTRODUCTION

Pseudoguembelina kempensis n. sp. has been found in surface and subsurface samples from Texas. These samples contain abundant planktonic Foraminifera belonging to the *Globotruncana gansseri* zone. *P. kempensis* is rare in these samples. It may prove to be a useful indicator of the *Globotruncana gansseri* zone, since at present it is known to occur only in this zone. The species, therefore, appears to have at least local stratigraphic significance.

ACKNOWLEDGEMENT

The writer wishes to thank Mr. D. Nugent for photographing the type specimens.

Superfamily GLOBIGERINACEA Carpenter, Parker and Jones, 1862

Pseudoguembelina kempensis n. sp.

Text figures 1-5

Test plano-biserial or biserial, consisting of 7-12 large chambers, increasing rapidly in size, and may have a small pointed early part consisting of about 7 additional chambers. The small early chambers may be coiled initially (text fig. 4). The small early chambers are not inflated and the sutures are nearly flush with the chamber surface. The surface is punctate with the alignment of the pores, particularly towards the outer margin, sometimes suggesting faint striae (text fig. 3). The microspheric forms tend to lack spines and are not as thick. The third pair of chambers is the most strongly inflated, after which later chambers tend to be less inflated and, finally, somewhat compressed. The last chamber may be very elongate and may extend completely over the preceding two chambers. On the megalospheric forms, the first few large chambers usually have short thick spines that may tend to merge to form a sort of ridge. These tend to impart a knobby appearance to the chamber (text fig. 2). Text figs. 3 and 4 show the extremes in the degree to which the test is pointed. The sutures are deeply depressed between the large chambers. A rather thick conspicuous carina is present. The primary aperture is a large lunate arch in all chambers except the last one (text fig. 5). With the completion of the final chamber, the primary aperture is reduced to a narrow slit which tends strongly to become or actually forms three separate apertures (text fig. 2). In addition to the primary aperture or apertures, there are usually at least three pairs of narrow slit-like accessory apertures with prominent flaps.

P. kempensis n. sp. can be distinguished from *P. cornuta* Seiglie, 1959; *P. costulata* (Cushman, 1938); *P. excolata* (Cushman, 1926) of which *P. costata* (Carsey, 1926) is a junior synonym; *P. palpebra* Brönnimann and Brown, 1953, and *P. striata* (Ehrenberg, 1838) in lacking well developed costae or striae. *P. kempensis* differs from *P. punctulata* (Cushman, 1938) and *P. striata* (Ehrenberg, 1838) in having more elongate arcuate later chambers and more circular early chambers. Also, *P. kempensis* appears to differ from all other species of *Pseudoguembelina* in possessing a thick prominent carina.

Dimensions.—Holotype (text figs. 1, 2): 0.407 mm. length; 0.259 mm. width; 0.148 mm. thickness, H.V.H. no. 8082., Paratype (text figs. 4, 5): 0.383 mm. length; 0.284 mm. width; 0.136 mm. thickness, H.V.H. no. 8083. Paratype (text fig. 3): 0.420 mm. length; 0.252 mm. width; 0.144 mm. thickness, H.V.H. no. 8084.

Depository.—H. V. Howe Collection, School of Geology, Louisiana State University. Holotype, H.V.H. no. 8082; paratype, H.V.H. no. 8083; paratype, H.V.H. no. 8084; and 7 paratypes, H.V.H. no. 8085.

Type locality.—Kemp Clay, 2-4′ below the contact between the Littig Conglomerate and the Kemp Clay, on Walker's Creek about 5½ miles NE of Cameron, Texas.

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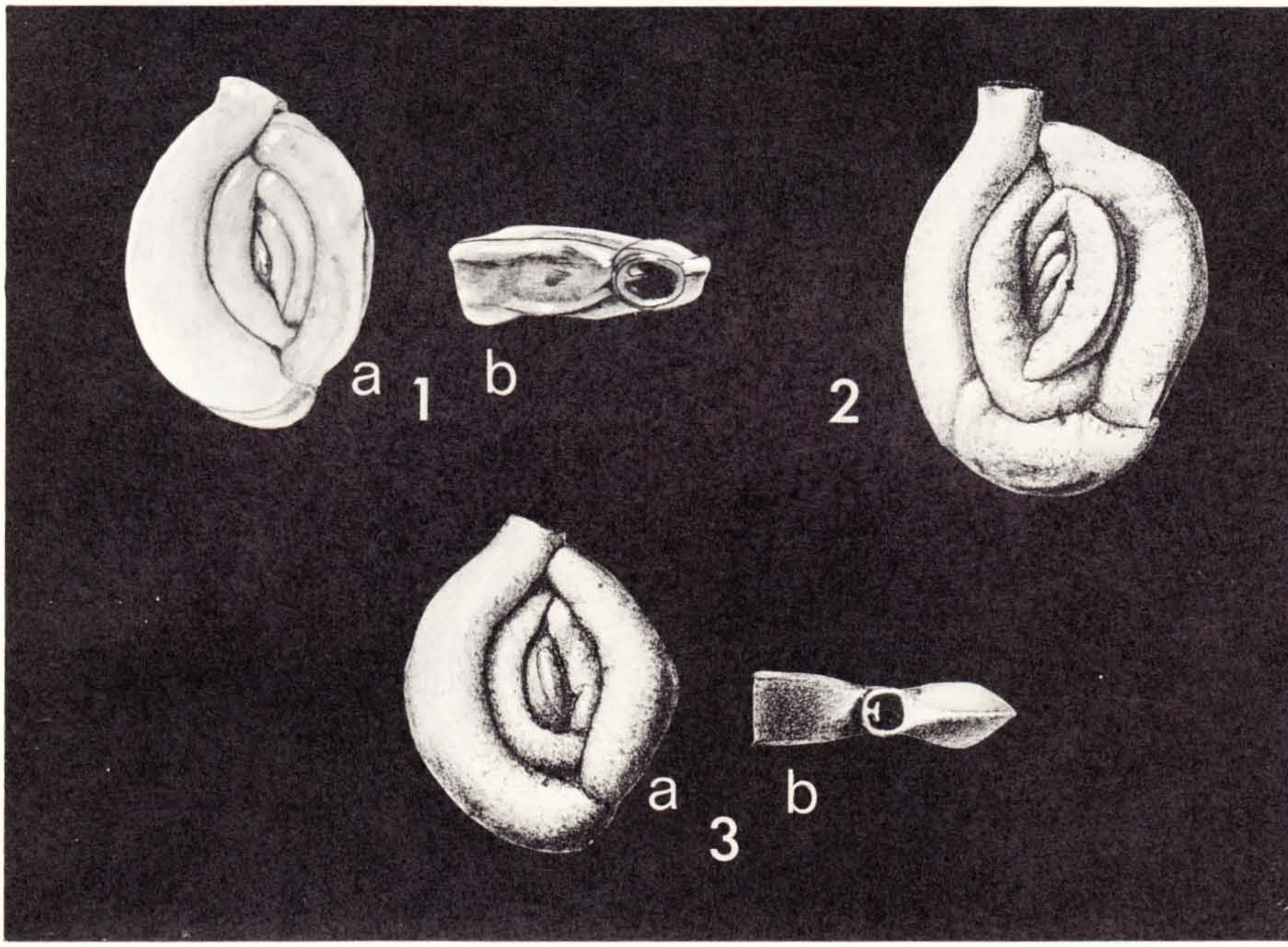
Text Figures 1-3



Atkinson: *Massilina carinata* (Fornasini, 1905)

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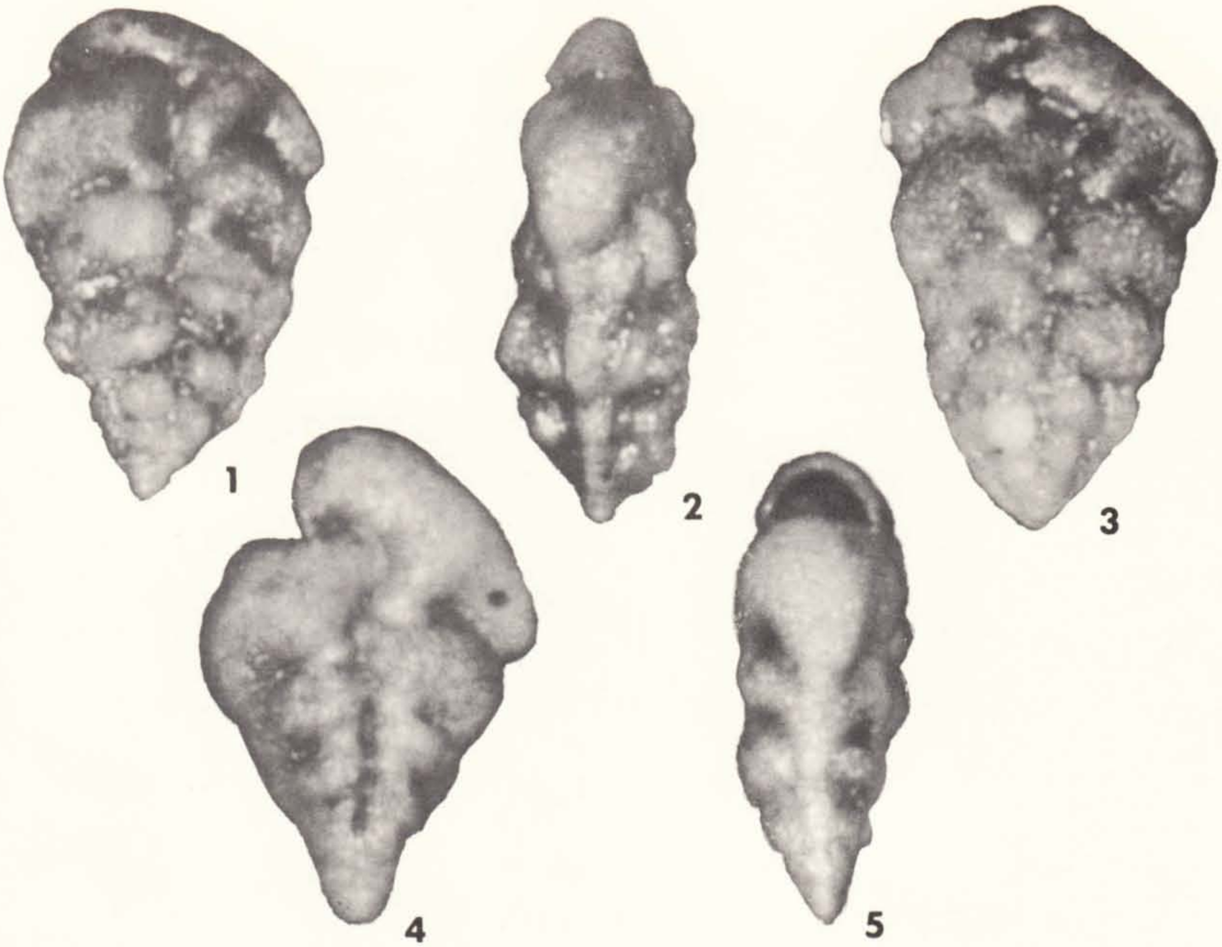
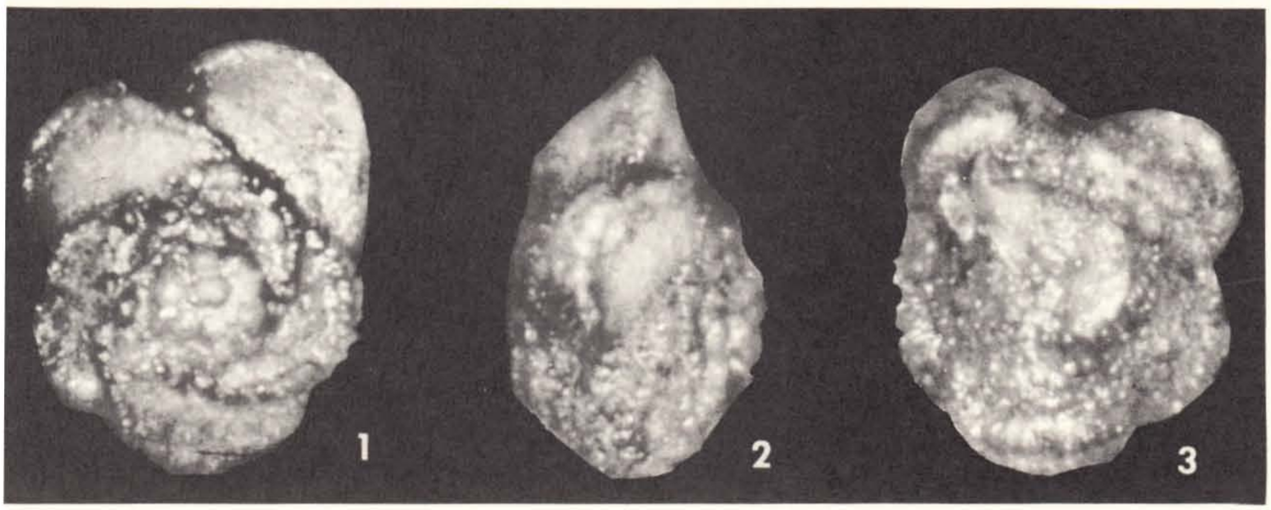
Text Figures 1-5



Esker: *Pseudoguembelina* from Texas

Text Figures 1-3



Esker: Lectotype of *Globotruncana rosetta* (Carsey)

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359. DESIGNATION OF A LECTOTYPE OF *GLOBOTRUNCANA ROSETTA* (CARSEY)

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ABSTRACT

Because of the apparent loss of the holotype of **Globotruncana rosetta** (Carsey), the author has considered it necessary to designate and describe a lectotype. After the examination of the three specimens labeled as cotypes of **Globigerina rosetta** Carsey in the Carsey collection, the specimen which most closely fitted the holotype's characteristics was selected to be the lectotype.

INTRODUCTION

Statements such as those made by Brönnimann and Brown (1955), that the holotype of *Globotruncana rosetta* (Carsey, 1926) had two closely spaced keels except for the final chamber, and by Bandy (1967), that the holotype of *Globotruncana rosetta* had only a single keel, are contradictory. The author, in an attempt to resolve such contradictory statements by studying the holotype of *Globotruncana rosetta*, was unable to locate any specimen in the Carsey collection that could be considered to be the holotype. It apparently has been lost. Therefore, in an attempt to avoid considerable controversy about the species in the future, the author decided to designate and describe a lectotype of *Globotruncana rosetta* (Carsey) from the cotypes in the Carsey collection.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. Samuel P. Ellison of the University of Texas for his help in obtaining the specimens from the Carsey collection for this study. Thanks are also due to Mr. Don Nugent for the photographs of the type specimen.

DISCUSSION

The Carsey collection includes three specimens labeled as cotypes of *Globotruncana rosetta*. Unfortunately, these do not appear to be conspecific. All three clearly have double keels. One specimen belongs to *G. aegyptiaca* Nakkady, of which *G. gagnebini* Tilev is a junior synonym. Another specimen should be assigned to *G. gansseri* Bolli *dicarinata* Pessagno. The third specimen appears to fit the concept of the species of *G. rosetta*, as held at least by some workers. This specimen has two keels on all of the chambers except the final one. The keels become more closely spaced on the younger chambers until the ventral keel disappears altogether on the final chamber.

In the original description of *G. rosetta* by Carsey (1926), she did not mention whether her species had one or two keels, nor did she include a figure by which this could be determined. Plummer (1931) reillustrated the holotype, including a side view that showed the presence of only a single keel. Later, Brönnimann and Brown (1955) stated that upon examining the holotype they found two closely spaced keels on all of the chambers except the final one. Pessagno (1960) has shown that *G. rosetta* has a rather wide double keel in the early stages at least, and that there is a tendency for the ventral keel to disappear in the adult stages. Olsson (1964) and van Hinte (1963) consider within the population of *G. rosetta* forms that have two keels throughout the test. Douglas and Sliter (1966) state that *G. rosetta* is more commonly biconvex, has a less acute axial periphery, and that its chambers have somewhat curved umbilical sides. They say that only a small percentage of typical *G. rosetta* have two keels in the early stage, yet in their article (pl. 3, fig. 6) one specimen shows a very closely spaced double keel and another (fig. 7) appears to show an imperforate keel band. Bandy (1967) has stated that the holotype of Carsey has only a single keel and that only an occasional specimen shows any trace of a second keel on the final whorl. Bandy believes that Olsson and van Hinte have erroneously considered forms of *G. ventricosa* to be *G. rosetta*. These references should serve to indicate the controversial status of *G. rosetta*.

The author has examined specimens from the upper Taylor Marl of Texas and has reached the conclusion that the double-keeled specimens therein may be assigned to two distinct species, *G. ventricosa* and *G. rosetta*, and to more obviously different species such as *G. linneiana*. The specimens assigned to *G. ventricosa* generally have a nearly flat spiral side and two moderately widely spaced keels. On immature specimens the keels are widely spaced, similar in appearance to those of *G. linneiana tricarinata*. The specimens assigned to *G. rosetta* generally have a slightly convex spiral side, usually more convex than specimens assigned to *G. ventricosa*, and two closely spaced keels. While the keels may become progressively more closely spaced in both species, those of *G. rosetta* are more closely spaced than those of *G. ventricosa*.

DESCRIPTION

Low trochospiral test, slightly convex on the spiral side, strongly convex on the umbilical side.

Moderately to strongly lobate equatorial periphery, angular rhomboidal axial periphery; with two moderately spaced keels in the first chamber of the final whorl, becoming more closely spaced on later chambers until the ventral keel disappears on the final chamber. There are adumbilical and periumbilical extensions of the ventral keel. The chamber surface is spinose on the umbilical side and on all but the last two chambers on the spiral side. There are five chambers in the final whorl. The sutures are moderately curved and raised on the spiral side, nearly radial and slightly depressed on the umbilical side. Umbilicus wide, primary aperture interiomarginal umbilical; umbilicus covered by a tegillum with infralaminal and intralaminal accessory apertures.

Dimensions.—Max. diam. 0.52 mm.; min. diam. 0.42 mm.; thickness 0.30 mm.

Depository.—University of Texas collections no. 1510.

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PLUMMER, HELEN J., 1931, Some Cretaceous Foraminifera in Texas: Univ. Texas Bull., no. 3101, pp. 109-202, pls. 8-15.

TILEV, N., 1952, Etude des Rosalines Maestrichtiennes (genre *Globotruncana*) du Sud-Est de la Turquie (Sondage de Ramandag): Maden Tetkik ve Arama Enstitüsü, ser. b, no. 16, pp. 1-101, pls. 1-3, text figs. 1-24.

CONTRIBUTIONS FROM THE CUSHMAN FOUNDATION
FOR FORAMINIFERAL RESEARCH
VOLUME XIX, PART 4, OCTOBER, 1968

RECENT LITERATURE ON THE FORAMINIFERA

Below are given some of the more recent works on the Foraminifera that have come to hand.

BERGGREN, W. A., PHILLIPS, J. D., BERTELS, A., and WALL, D. Late Pliocene-Pleistocene stratigraphy in deep sea cores from the south-central North Atlantic.—Nature, v. 216, No. 5112, Oct. 21, 1967, p. 253-254, text figs. 1, 2 (graphs, diagram).—Preliminary report of paleomagnetic studies.

BIELLE, MARIETTE, and CARALP, MICHELLE. Les Miogypsinidae de deux coupes profondes des Landes.—Bull. Soc. Géol. France, ser. 7, v. 9, No. 1, 1967 (March 1968), p. 36-42, pl. 4, tables 1-3 (range charts).

BIGNOT, GÉRARD. Nouvelle découverte de *Fabiania cassis* (Oppenheim) dans le Lutétien du Bassin de Paris.—Mém. du Bureau de Recherches Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 79-83, 1 pl., 1 text fig. (geol. section).

BIZON, GERMAINE. Contribution a la connaissance des Foraminifères planctoniques d'Épire et des Iles Ioniennes (Grèce occidentale) depuis le Paléogène supérieur jusqu'au Pliocène.—Publ. Instit. Français du Petrole, 1967 (April 1968), p. 1-142, pls. 1-29 (fossils), pls. 1-14 (maps, range charts, evolutionary series, variation series, correlation table), text figs. 1-22 (maps, range charts, geol. sections, drawings, columnar sections).—Illustrated systematic catalog includes about 75 species and subspecies, none new.

BLEAHU, M., BABUCEA, YVONNE, and PILIUTA, ANA-MARIA. Contribution to the microbiostratigraphy of the Eocretaceous rocks in the Metalliferous Mountains (English abstract of Rumanian text).—Acad. Repub. Populare Romini, Studii si Cercetari de Geol., Geofiz., Geograf., ser. Geol., tom. 13, No. 1, 1968, p. 137-155, pls. 1-4, table 1.—An exclusively arenaceous fauna of Aptian-Middle Albian age.

BLONDEAU, ALPHONSE. Révision des Nummulites et des Assilines des Alpes-Maritimes Franco-Italiennes.—Mém. du Bureau de Recherches Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 27-55, 1 pl., range chart.

BLONDEAU, ALPHONSE, BODELLE, JACQUES, COMPREDON, ROBERT, LANTEAUME, MARCAL, and NEUMANN, MADELEINE. Répartition stratigraphique des grands Foraminifères de l'Éocène dans les Alpes-Maritimes (Franco-Italiennes) et les Basses-Alpes.—Mém. du Bureau de Recherches Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 13-26, pls. 1, 2, tables 1-3, maps 1, 2.

BOLLI, H. M., BOUDREAUX, J. E., EMILIANI, CESARE, HAY, W. W., HURLEY, R. J., and JONES, J. I. Biostratigraphy and paleotemperatures of a section cored on the Nicaragua Rise, Caribbean Sea.—Bull. Geol. Soc. America, v. 79, No. 4, April 1968, p. 459-470, pl. 1, text figs. 1-3 (map, profiles, graphs).—Study of 56.4-meter core. Plio-Pleistocene boundary (700, 000 years) recognized by correlation of calcareous nannoplankton. Glacial stages present in the Pliocene.

BOULANGER, D., and DEBOURLE, A. Précisions sur *Angotia aquitanica*, Cuvillier, 1963, Foraminifère du Lutétien d'Aquitaine Occidentale.—Revue de Micropaléontologie, v. 10, No. 4, March 1968, p. 243-249, pls. 1, 2, text figs. 1, 2 (graphs).—Based on free specimens. Genus related to *Gypsina*.

BRADSHAW, JOHN S. Environmental parameters and marsh Foraminifera.—Limnology and Oceanography, v. 13, No. 1, Jan. 1968, p. 26-38, text figs. 1-10 (maps, diagram, graphs), table 1.—Continuous recording.

BRÖNNIMANN, PAUL, and CONRAD, MARC-A. Cinquième note sur les Foraminifères du Crétacé inférieur de la région genevoise. *Melathrokerion valserinensis*, n. gen., n. sp., un Foraminifère nouveau du Barrémien à faciès urgonien dans le Jura français.—Compte Rendu des Séances, Soc. Physique Hist. Nat. Genève, n. ser., v. 1, fasc. 3, Sept.-Dec. 1966 (June 1967), p. 129-151, pls. 1-3, text figs. 1-11 (map, graphs, drawings).—Similar to *Alveolophragmium*.

BRÖNNIMANN, PAUL, CURRY, DENNIS, POMEROL, CHARLES, and SZÖTS, ENDRE. Contribution a la connaissance des Foraminifères planctoniques de l'Éocène (incluant le Paléocène) du bassin Anglo-Franco-Belge.—Mém. du Bureau de Recherches Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 101-108, chart.—Planktonic species listed from Thanetian to Ludian.

CHALILOV, D. M. Mikrofauna i Stratigrafija Paleogenovykh Otlozhenij Azerbajdzhana.—Akad. Nauk Azerbajdzhan. SSR, Instit. Geol., Baku, 1967, p. 1-244, pls. 1-42, text figs. 1-9 (map, phylogenetic diagrams).—Illustrated systemat-

ic catalog of 260 species and subspecies (33 species and 10 subspecies new) from Danian to lower Oligocene. *Nonionelleta* gen. n. (type species *Nonionella tumida* Chalilov 1957) is erected.

CIFELLI, RICHARD, BLOW, WALTER H., and MELSON, WILLIAM G. Paleogene sediment from a fracture zone of the Mid-Atlantic ridge.—Jour. Marine Res., v. 26, No. 2, May 15, 1968, p. 105-109, text figs. 1, 2 (map, diagram).—Two samples, one Thanetian, the other Ypresian, with planktonic Foraminifera.

COLALONGO, MARIA LUISA. Biostratigrafia del Mesozoico nei dintorni del Passo del Diavolo (Parco Nazionale d'Abruzzo).—Giornale Geol., Ann. Mus. Geol. Bologna, ser. 2, v. 34, fasc. 1, 1966 (1967), p. 87-130, pls. 10-13, text figs. 1-3 (map, correl. chart, columnar section), tables 1, 2.—Cretaceous Foraminifera in thin section.

COLALONGO, MARIA LUISA, and SARTONI, SAMUELE. *Globorotalia hirsuta aemiliana* nuova sottospecies cronologica del Pliocene in Italia.—Giornale Geol., Ann. Mus. Geol. Bologna, ser. 2, v. 34, fasc. 1, 1966 (1967), p. 265-284, pls. 30, 31, text figs. 1, 2 (map, drawings), table 1 (phylogenetic diagram).—A fivefold zonation of Pliocene on the basis of species of *Globorotalia*.

COLE, W. STORRS. More on variation in the genus *Lepidocyclina* (Larger Foraminifera).—Bull. Am. Paleontology, v. 54, No. 243, June 21, 1968, p. 291-327, pls. 19-24.—Variation in *L. vaughani*, and several species included as synonyms.

CONATO, VITTORIO, and FOLLADOR, UMBERTO. *Globorotalia crotonensis* e *Globorotalia crassacrotonensis* nuove specie del Pliocene Italiano.—Boll. Soc. Geol. Ital., v. 86, fasc. 3, 1967, p. 555-563, text figs. 1-6 (drawings).—Related to *G. crassaformis*, but with lower ranges.

CONKIN, JAMES E., CONKIN, BARBARA M., and CANIS, WAYNE F. Mississippian Foraminifera of the United States. Part 3—The limestones of the Chouteau Group in Missouri and Illinois.—Micropaleontology, v. 14, No. 2, April 1968, p. 133-178, pls. 1-4, text figs. 1-16 (map, columnar sections, diagram, check lists, range chart), tables 1-42.—Illustrated systematic catalog includes 42 species, 5 new and 5 emended.

CORDEY, W. G. A new Eocene *Cassigerinella* from Florida.—Palaeontology, v. 11, pt. 3, June 1968, p. 368-370, text fig. 1 (drawings).

Morphology and phylogeny of *Orbulinoides beckmannii* (Saito 1962).—Palaeontology, v. 11, pt. 3, June 1968, p. 371-375, text fig. 1 (drawings).—Developed from a globorotaloid ancestor.

DE ZANCHE, VITTORIO, PAVLOVEC, RAJKO, and PROTO DECIMA, FRANCA. Microfauna and Microfacies of the Eocenic Flysch series near Ustje in the Vipava valley (Vipavska Dolina, SW Slovenia).—Acad. Sci. Art. Slovenica, Razprave, Ljubljana, v. 10, 1967, p. 205-263, pls. 1-17, text figs. 1-6 (map, columnar section, drawings, graphs, diagram), tables 1-6.—Mostly concerning *Nummulites;* 2 new species.

DREYER, EVA. Mikrofossilien des Rät und Lias von SW-Brandenburg.—Jahrbuch für Geologie, Berlin, Band 1, 1965 (1967), p. 491-531, pls. 1-9, table 1 (range chart).—Illustrations of a few Foraminifera accompanying Ostracoda.

EAMES, F. E. *Sindulites*, a new genus of the Nummulitidae (Foraminiferida).—Palaeontology, v. 11, pt. 3, June 1968, p. 435-438.—Type species is *Operculina sindensis* L. M. Davies 1927.

EISENACK, ALFRED. Foraminiferen aus dem Ordovizium und Gotlandium des baltischen Gebietes.—Neues Jahrb. Geol. Paläont. Abh., Stuttgart, Band 128, Heft 3, July 1967, p. 244-274, pls. 24-28, text figs. 1-10 (drawings).—Forty-seven species, 17 new, from Ordovician and Silurian. *Pachyammina* n. gen. (generotype *Amphitremoidea*? *pachytheca* Eisenack) erected.

FOLLADOR, UMBERTO. Il Pliocene ed il Pleistocene dell'Italia centro-meridionale, versante Adriatico. Biostratigrafia.—Boll. Soc. Geol. Ital., v. 86, fasc. 3, 1967, p. 565-584, text figs. 1, 2 (map, diagram), table 1 (range chart).—Definition and description of 5 assemblage zones and 4 subzones.

FUCHS, WERNER. Über Ursprung und Phylogenie der Trias-"Globigerinen" und die Bedeutung dieses Formenkreises für das echte Plankton. —Austria Geol. Bundes., Verhandl., Heft 1-2, 1967, p. 135-176, pls. 1-8, text figs. 1-3 (maps). —Origin of *Globigerina*-like forms traced to *Diplotremina* in the Middle Triassic and they evolved into *Gubkinella*, the first true plankton of the Jurassic. They are frequent and may have been planktonic in the Rhaetic. Five new genera and 24 species, 21 new, in upper Ladinian to Rhaetic. *Kollmannita* n. gen. (generotype *Globigerina ladinica* Oberhauser), *Schmidita* n. gen. (generotype *S. hedbergelloides* n. sp.), *Oberhauserella* n. gen. (generotype *Globigerina mesotriassica* Oberhauser), *Schlagerina* n. gen. (generotype *S. angustiumbilicata* n. sp.), and *Praegubkinella* n. gen. (generotype *P. kryptumbilicata* n. sp.).

GOFMAN, E. A. Foraminifery Jury Severnogo Kavkaza.—Akad. Nauk SSSR, Minist. Neft. Promysh. SSSR, Instit. Geol. Razrab. Gor. Iskop., 1967, p. 1-148, pls. 1-18, text figs. 1-3 (map, columnar sections, range chart), tables 1-10 (check lists).—Illustrated systematic catalog includes 92 Jurassic species (35 new and 6 indeterminate) and 4 varieties (2 new).

GOLEV, B. T. Zur Frage der Morphologie und Systematik der Unterfamilie Nummulitinae.—Austria Geol. Bundes., Verhandl., Sonderheft G, 1965, p. 265-287, pls. 1-3, text figs. 1-5.

GORBATCHIK, T. N. Javlenie Gomeomorfii u Foraminifer.—Paleont. Zhurnal, 1968, No. 1, p. 3-10, pls. 1, 2, text figs. 1-3 (diagrams).—Two new species in the Lituolidae, one in *Melathrokerian* and one in *Tonasia* gen. nov. (type species *T. evoluta* sp. nov.), both from the Berriasian.

GUDINA, V. I., NUZHDINA, N. A., and TROITSKII, S. L. New Foraminifera Forms and Recent Data on Sea Pleistocene of Taimyr Lowland (in Russian).—Acad. Sci. USSR, Siberian Branch, Geol. and Geophys., No. 1 (97), Jan. 1968, p. 40-48, 1 pl., text figs. 1-3 (map, geol. sections).—Two species (1 new) and a new subspecies.

HOFKER, J. Foraminifera of the Upper Cretaceous of South-Limburg, Netherlands. LXXXV. *Siderolites calcitrapoides* Lamarck and *Siderolites laevigata* Reuss in the Tuff Chalk of Maastricht, especially in the type-section, Section I.—Natuurhist. Maandblad, 55e Jrg., No. 9, Sept. 28, 1966, p. 140-142, text figs. 1, 2 (graphs).—Significance of variation in proloculus size.

Hat die feinere Wandstruktur der Foraminiferen suprageneriche Bedeutung?—Paläont. Zeitschr., Stuttgart, Band 41, Heft 3/4, Oct. 1967, p. 194-198, pls. 19-21.—Examples of different wall structure in phylogenetically-related genera.

Foraminifera from the Bay of Jakarta, Java.—Bijdragen tot de Dierkunde, Afl. 37, Amsterdam, 1968, p. 11-59, pls. 1-12, text figs. 1, 2 (map, check list).—Thirty-five species, 1 new.

HORNIBROOK, N. DE B. A handbook of New Zealand microfossils (Foraminifera and Ostracoda).—New Zealand Geol. Survey Handbook, Inform. Ser. 62, 1968, p. 1-136, text figs. 1-29 (plates of fossils), tables 1-11 (range charts, correl. table).—Beautifully illustrated and usable handbook of about 225 key species giving brief descriptions and local ranges.

IONESI, BICA. Stratigrafia Depozitelor Miocene de Platforma dintre Valea Siretului si Valea Moldovei.—Edit. Acad. Repub. Social Romania, Bucuresti, 1968, 391 p., 41 pls., 19 text figs., 9 tables, geol. map.—Illustrated systematic catalog (p. 257-286, pls. 10-34) includes 107 species and varieties, none new.

KAHLER, FRANZ and GUSTAVA. Zur Systematik der Fusuliniden.—Ann. Naturhist. Mus. Wien, Band 71, Nov. 1967, Kühn-Festschrift, p. 107-115.

KOEHN-ZANINETTI, LOUISETTE, and BRÖNNIMANN, PAUL. De la paroi de *Triasina hantkeni* Majzon, 1954.—Compte Rendu des Séances, Soc. Physique Hist. Nat. Genève, n. ser., v. 1, fasc. 2, May-Aug. 1966 (Nov. 1966), p. 83-88, 1 pl. —Various degrees of crystallization of the wall.

LEVEN, E. YA. Stratigraphy and Fusulinides of the Pamirs Permian deposits (in Russian).—Acad. Sci. USSR, Geol. Instit., Trans., v. 167, 1967, p. 1-224, pls. 1-39, text figs. 1-35 (maps, geol. sections, columnar sections, photos, range charts), tables 1-5.—Illustrated systematic catalog of 126 species and subspecies (40 species and 7 subspecies new).

LINDENBERG, HANS GEORG. Untersuchungen an lituoliden Foraminiferen aus dem SW-deutschen Dogger, 2: Die Arten von *Haplophragmium* und *Triplasia*. Eine Bearbeitung auf biometrischer und paläökologischer Grundlage.—Abhandl. Senckenberg. Naturforsch. Gesellschaft, No. 514, Nov. 1, 1967, p. 1-73, pls. 1-5, text figs. 1-190 (drawings, graphs), table 1.—Taxonomic revision resulting in 1 species (4 formae) of *Haplophragmium* and 2 species (1 new) of *Triplasia*.

LOURDES DIAZ DE GAMERO, MARIA. Paleontologia de la Formacion El Veral (Mioceno), Estado Falcon.—Geos, Escuela Geol., Minas y Metalurgia, Univ. Central de Venezuela, Caracas, No. 17, May 1968, p. 7-51, pls. 1-3, map, check list, correl. table.—Catalog of 85 species, a few illustrated.

MABESOONE, J. M., TINOCO, I. M., and COUTINHO, P. N. The Mesozoic-Tertiary boundary in northeastern Brazil.—Palaeogeography, Palaeoclimatology, Palaeoecology, v. 4, No. 3, April 1968, p. 161-185, text figs. 1-7 (maps, outcrop photos, sedimentary log, drawings of forams), tables 1-6.—Based on Foraminifera.

MANTOVANI UGUZZONI, M. P., and PIRINI RADRIZZANI, C. I Foraminiferi delle Marne a Fucoidi.—Riv. Ital. Paleont. Stratig., v. 73, No. 4, Dec. 1967, p. 1181-1256, pls. 85-94.—About 90 species, none new, of Aptian-Albian age recorded and illustrated.

MARGEREL, JEAN-PIERRE. Les petits Foraminifères de l'Éocène de l'ouest de la France et leur intérêt stratigraphique.—Mém. du Bureau de

Recherches de Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 93-99, text fig. 1 (map).

MARTINIS, BRUNO. Sull'età delle argille di Gallipoli (Lecce).—Rend. Atti Accad. Naz. Lincei, ser. 8, v. 42, fasc. 6, June 1967, p. 824-829, pl. 1, text figs. 1, 2 (map, columnar section).—Foraminifera of Calabrian age.

MASOLI, MARIO. Microfaune nel Domeriano di Verona.—Studi Trentini Sci. Nat., n. ser., sez. A, Biol., v. 44, fasc. 2, 1967, p. 131-151, pls. 1-4, text fig 1 (map).—Twenty-one species of Foraminifera, 11 indeterminate.

MCGOWRAN, BRIAN. Reclassification of early Tertiary *Globorotalia*.—Micropaleontology, v. 14, No. 2, April 1968, p. 179-198, pls. 1-4, text figs. 1-3 (phylogenetic diagrams).—*Truncorotaloides* is subdivided into 3 subgenera: *Acarinina, Morozovella,* and *Truncorotaloides* s.s., and retained in Truncorotaloidinae. *Planorotalites* is retained in Globorotaliinae.

MEDIZZA, F. La struttura del guscio nel genere *Aragonia* Finlay 1939 (Foraminifera).—Boll. Soc. Paleont. Ital., v. 5, No. 1, 1966, p. 92-98, pls. 33, 34, text fig. 1 (diagram).—A lamellar genus.

MÉHES, KÁLMÁN. Two species of the genus *Orbitolinopsis* from the Villány Mountains, Hungary.—Micropaleontology, v. 14, No. 2, April 1968, p. 221-224, pl. 1, text fig. 1 (map), table 1.—Two Barremian species, neither one new.

MELLO, JAMES F., and BUZAS, MARTIN A. An application of cluster analysis as a method of determining biofacies.—Jour. Paleontology, v. 42, No. 3, May 1968, p. 747-758, text figs. 1-6 (graphs, maps), tables 1-4.—Based on Phleger's (1956) paper on Recent Foraminifera off Texas. The method is useful for biofacies analysis.

MERIC, ENGIN. Sur quelques Loftusidae et Orbitoididae de la Turquie.—Revue Fac. Sci. Univ. Istanbul, ser. B: Sci. Nat., tome 32, fasc. 1-2, 1967, p. 1-58, pls. 1-36, text figs. 1-22 (map, range charts, stratigraphic profile, graphs, drawings).—Twenty species (5 new) and a variety from upper Maestrichtian.

MICHAEL, ERHARD. Variations in the number of species of benthonic Foraminifera in the Barremian of northwestern Germany.—Palaeogeography, Palaeoclimatology, Palaeoecology, v. 4, No. 4, June 1968, p. 287-303, text figs. 1-5 (map, graphs), tables 1, 2.—Number of species increases away from shorelines. Maxima and minima are observed in faunal sections, showing conformity between different sections.

MOORKENS, THIERRY. Quelques Foraminifères planctoniques de l'Yprésien de la Belgique et du nord de la France.—Mém. du Bureau de Recherches Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 109-129, pl. 1, table 1, map 1.—Eight species recorded and illustrated.

NEAGU, THEODOR. Biostratigraphy of Upper Cretaceous deposits in the southern Eastern Carpathians near Brasov.—Micropaleontology, v. 14, No. 2, April 1968, p. 225-241, pls. 1, 2, text figs. 1-3 (map, zonal charts).—Lists and outline drawings of forams from 14 horizons within a section from Cenomanian to lower Maestrichtian. Four new species and 2 new subspecies are described.

NEMKOV, G. Les Nummulites de l'U.R.S.S., leur évolution, systématique et distribution stratigraphique.—Mém. du Bureau de Recherches Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 71-78, phylogenetic diagram, range chart.

NEUMANN, MADELEINE. A propos de *Gyroidinella magna* Le Calvez en Aquitaine et en Mésogée.—Mém. du Bureau de Recherches Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 85-91, 1 pl., text fig. 1 (drawing).

NORLING, ERIK. On Liassic Nodosariid Foraminifera and their wall structures.—Sver. Geol. Unders., ser. C, No. 623, v. 61, No. 8, 1968, p. 1-75, pls. 1-9, text figs. 1-12 (map, range charts, drawings), tables 1-5.—A few species are described as to their wall texture, perforation, lamination and layering, and ornamentation. Two new genera are separated off from *Dentalina*—one not laminated, the other partially laminated, leaving *Dentalina* completely laminated. *Prodentalina* nov. gen. (type species *Dentalina terquemi* d'Orbigny 1849) and *Mesodentalina* nov. gen. (type species *Dentalina matutina* d'Orbigny 1849).

OKIMURA, YUJI. Carboniferous palaeotextulariid foraminifers from the Akiyoshi Limestone Group, Southwest Japan.—Jour. Sci. Hiroshima Univ., ser. C (Geol. and Min.), v. 5, No. 3, May 1967, p. 255-266, pl. 17, text figs. 1, 2 (map, range chart).—Nine species, 5 indeterminate.

OLBERTZ-WEHRLI, GERTA. *Epistominella alata* (Marsson), ein Beitrag zur Klärung des Begriffs *Coleites reticulosus* (Plummer) [Foram.].—Wissenschaft. Zeitschr. Ernst-Moritz-Arndt-Univ. Greifswald, Jahrg. 16, Math.-naturwiss. Reihe Nr. 3, 1967, p. 189-198, pls. 1-3.—Possible relationship between the two species.

PERCONIG, E. Microfacies of the Triassic and Jurassic sediments of Spain.—Internat. Sedimentary Petrographical Ser., v. X, 1968, p. 1-63,

pls. 1-123, text figs. 1-11 (maps).—Book includes 341 photomicrographs illustrating microfacies, some including Foraminifera.

PHILLIPS, J. D., BERGGREN, W. A., BERTELS, A., and WALL, D. Paleomagnetic stratigraphy and micropaleontology of three deep sea cores from the central North Atlantic Ocean.—Earth and Planetary Science Letters 4, North-Holland Publ. Co., Amsterdam, 1968, p. 118-130, text figs. 1-5 (graphs, phylogenetic diagram, correl. diagram), table 1.—Absolute dating of abundance changes and evolution in Foraminifera.

PICHA, FRANTISEK, HANZLIKOVA, EVA, and CICHA, IVAN. Geology of the Cejc-Zajeci zone (English summary of Czech text).—Sbornik Geol. Ved, Geologie, rada G, sv. 13, 1968, p. 37-74, pls. 1-9, text fig. 1 (diagram), tables 1-3.—Includes illustrations of key fossils between Maestrichtian and Oligocene.

PIERCE, STANLEY, KOSSOY, VICTOR, VALENTI, ROBERT, and SMETANA, DENNIS G. Cytochemical studies on the test of *Allogromia laticollare*.—Micropaleontology, v. 14, No. 2, April 1968, p. 242-246, text figs. 1, 2 (photomicrographs).

PROSNIAKOVA, L. V. *Orbitolina* from the Lower Cretaceous deposits of the Crimean lowlands (English summary of Russian text).—Paleont. Sbornik, No. 4, vyp. 1, Izdat. L'vov. Univ., 1967, p. 43-49, pls. 1-3, text fig. 1 (drawing).

REGUANT, SALVADOR. Une échelle de Nummulites pour la stratigraphie Sud-Pyrénéenne.—Mém. du Bureau de Recherches Géol. et Min., No. 58, Colloque sur l'Éocène, Paris, May 1968, p. 63-70, text figs. 1-5 (map, graphs).—Correlation by size of specimens.

REISS, Z. *Victoriella* (Foraminiferida) from Israel.—Israel Jour. Earth-Sci., v. 16, No. 3, Sept. 1967, p. 111-119, pls. 1, 2.—*V. conoidea* in the Oligocene.

ROCHA, A. TAVARES, and GOMES, J. DO NASCIMENTO. Ensaio crítico sobre a morfologia e ocorrência de *Iberina lusitanica* (Egger) (foraminífero).—Servicos Geol. de Portugal, Comunicaçoes, tomo LI, 1967, p. 169-219, pls. 1-23, text fig. 1-4 (diagrams, graph, maps), tables 1, 2.—In lower Kimmeridgian to lower Valanginian in Portugal.

RUDDIMAN, WILLIAM F. Historical stability of the Gulf Stream meander belt: foraminiferal evidence.—Deep-Sea Research, v. 15, No. 2, April 1968, p. 137-148, text figs. 1-6 (maps), tables 1, 2.—High percentages of equatorial species of planktonics in surface sediments under the present-day meander belt.

SAAKJAN-GEZALJAN, N. A., and MARTIROSJAN, JU. A. *Truncorotalia aragonensis* (Nuttall) iz Nizhnepaleogenovykh Otlozhenij Bassejna r. Vedi (Armjanskaja SSR).—Izvest. Akad. Nauk Armjans. SSR, Nauki o Zemle, v. 20, No. 1-2, 1967, p. 3-12, 1 pl., 1 table.—Three unnamed varieties in the lower Eocene of Armenia.

SAIDOVA, KH. M. The biomass and quantitative distribution of live Foraminifera in the Kurile-Kamchatka Trench area (translation).—Doklady Acad. Sci. USSR, Earth Sci. sec., v. 174, May-June 1967, p. 216-217, text fig. 1 (graphs).

SALAJ, JOZEF, and JENDREJAKOVA, OTILIA. Die Foraminiferen aus der Oberen Trias der Westkarpaten.—Geol. Sbornik, Geol. Carpathica, Bratislava, v. 18, No. 2, Nov. 1967, p. 311-313, pls. 19, 20.—Assemblages photographed.

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