APPENDIX

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APPENDIX I

I: THE TAXONOMY OF THE PLANKTONIC FORAMINIFERA

INTRODUCTION

Three families of the superfamily *GLOBIGERINACEA* are represented, the *HANTKENINIDAE*, *GLOBOROTALIIDAE* and *GLOBIGERINIDAE*. Fifty seven species and subspecies within thirteen genera have been identified.

Genera are primarily classified and arranged according to the scheme of LOEBLICH and TAPPAN (1964). The genera *GLOBOQUADRINA* and *GLOBIGERINITA* have been placed in the family *GLOBOROTALIIDAE* following the recommendations and classificatory scheme presented by BE' (1977) for Recent planktonic foraminifera.

The systematic review is organised in the following manner:

Synonymy : This includes the first description of the species, important name changes, references containing clear illustrations used for identification purposes, references used for biostratigraphic information and any further references which expand or qualify the concept of a particular taxon as used herein.

Diagnosis : A complete description of every species/ subspecies was considered beyond the scope of the present study. Instead a diagnosis is presented which highlights the features used for the identification of a species.

Stratigraphical Distribution : This has been given in terms of the European stratigraphical units and the zonal scheme of BLOW (1969). Ranges of most species have been according to BLOW (1969) with supplementary information where possible, offered by BRÖNNIMANN and RESIG (1971) from tropical west Pacific sequences (DSDP Leg 7).

Material : The stratigraphical distribution and relative abundance of each species within the studied sequences is considered. The stratigraphical intervals are:

1) DSDP Site 289 : Approximate base of the Middle Miocene (within Zone N. 9) to within the Late Miocene (within Zone N. 17). One hundred and nine samples from core 50 to core 24.

2) DSDP Site 71 : Within the Middle Miocene (within Zone N. 11-12). Seventeen samples from core 15 to core 13.

The following terms, with percentage equivalents, are used to indicate the range of relative abundance for each species within each sequence.

Very rare	:	Less than 0.1%
Rare	:	0.1 to 1%
Few	:	>1% to 5%
Common	:	>5% to 10%
Very common	:	>10% to 25%
Abundant	:	>25% to 40%
Very abundant	:	>40%

The terms continuous and discontinuous distribution are qualitative rather then quantitative parameters, i.e. they refer to the presence or absence of a species.

Geographical Distribution and Palaeoecology : The following works from the Pacific Ocean and surrounding margins were used whenever possible to indicate the geographical and palaeogeographical extent of species encountered in the present study. This information, when persuasive, was tentatively used to infer palaeoecological preferences for species which are today extinct. In addition, the works of BRADSHAW (1959) and BE' (1977) were used to indicate ecological information for the few species which range from the Miocene and are today extant.

Tropical and Subtropical Pacific Ocean

i	BRÖNNIMANN and RESIG (DSDP Leg 7, 1971)	low latitudes
ii	JENKINS and ORR (DSDP Leg 9, 1972)	

Subtropical and Temperate Pacific Ocean

iii KRASHENINNIKOV and HOSKINS (DSDP Leg 20, 1973)

iv KENNETT (DSDP Leg 21, 1973)

Temperate, Subarctic and Subantarctic Pacific Ocean

v	JENKINS, (New Zealand, 1971)	high latitudes
vi	INGLE (DSDP Leg 18, 1973)	
vii	JENKINS (DSDP Leg 29, 1975)	

Fig. AI illustrates the geographical localities of these investigations. Tropical and subtropical sites may be regarded as low latitude and temperate, subartic and subantarctic sites may be regarded as high latitude.

In addition, the worldwide distribution of species has been considered with reference to BLOW (1969), BOLTOVSKOY (1974a), STAINFORTH et al. (1975), SALVATORINI and CITA (1979) and others.

Discussion : Comparisons and affinities of species are considered here together with points of interest directly relevant to the material encountered in the present study.

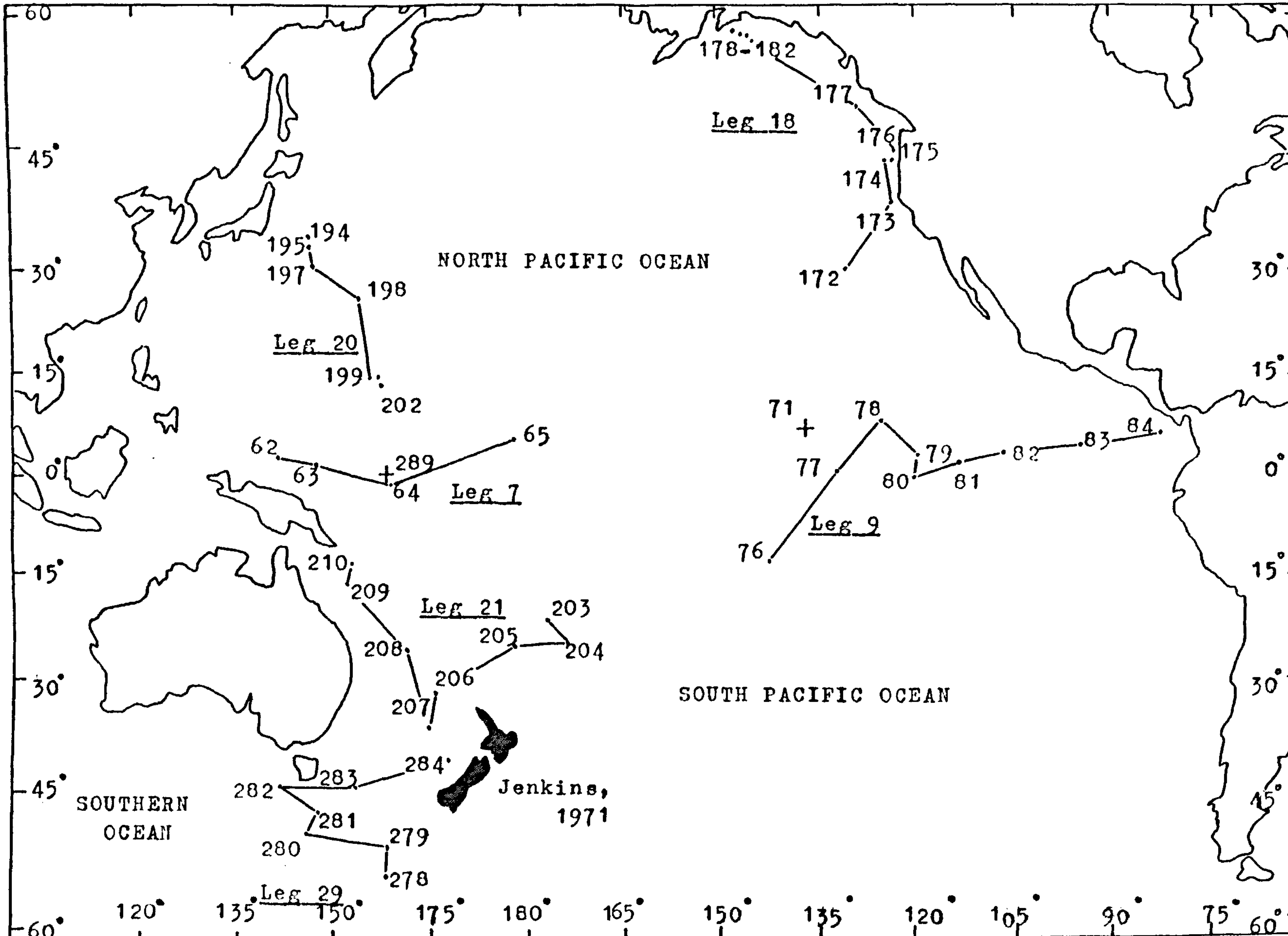

Fig. AI Location of Previous Investigations

Remarks : Comments, if any, on the synonymy.

The degree of **detail in** which each species is reviewed reflects its biostratigraphical, palaeoecological and numerical importance within the sequences.

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Class : *RHIZOPODEA* van SIEBOLD, 1845

Subclass : *GRANULORETICULOSIA* de SAEDELEER, 1934

Order : *FORAMINIFERIDA* EICHWALD, 1830

Superfamily : *GLOBIGERINACEA* CARPENTER, 1862

Family : *HANTKENINIDAE* CUSHMAN, 1927

Subfamily : *HASTIGERININAE* BOLLI, LOEBLICH and TAPPAN, 1957

Genus : *HASTIGERINA* THOMSON, 1876

Hastigerina (H.) pelagica (d'ORBIGNY), 1839

1839 *Nonionina pelagica* d'ORBIGNY, p.27, pl.3, figs.13-14.
1876 *Hastigerina murrayi* THOMSON, p.534, pl.22, fig.3 (lectotype : lower specimen on pl.22 designated by BANNER and BLOW, 1960).
1884 *Hastigerina pelagica* (d'ORBIGNY). BRADY, p.613, pl.83, figs. 1-8 (neotype : pl.83, fig.4 designated by BANNER and BLOW, 1960).
1960a *Hastigerina (H) pelagica* (d'ORBIGNY). BANNER and BLOW, p.20, text fig.1.
1979 *Hastigerina pelagica* (d'ORBIGNY). POORE, p.472, pl.1, fig.6.

Diagnosis : Test with an exceedingly short trochospire followed by an involute planispiral stage. The chambers are inflated and globose and the aperture extends across the lateral margin of the test to connect both umbilici. Sparsely distributed trigonal-prismatic spines arise from short stumpy bases. Surface pustulate, finely perforate.

Stratigraphical Distribution : Late Miocene (N.16) to Recent (N.23) (BLOW, 1969).

Material : At Site 289, *H. (H.) pelagica* occurs in one sample, in very rare abundance.

Geographical Distribution and Palaeoecology : BRADSHAW (1959) reports the species as widely distributed in the plankton of tropical and warm temperate regions of the Pacific Ocean. PARKER (1962) attributed the scarcity of the species in sediments to the fragile nature of the test.

Family : *GLOBOROTALIIDAE* CUSHMAN, 1927

Genus : *GLOBOROTALIA* CUSHMAN, 1927

Discussion : The generic and subgeneric classification of Cenozoic planktonic foraminifera by LOEBLICH and TAPPAN (1964) and BLOW (BANNER and BLOW, 1959; BLOW, 1969), which has been largely followed in this work, is based mainly on morphological features of the foraminiferal tests. Such a classification does not reflect natural evolutionary relationships; it is to a large extent artificial and it is thus unsatisfactory in that it separates closely related species and juxtaposes unrelated forms. The weakness of the system is especially evident in the systematic treatment of globorotaliid species. BLOW (1969) divides the genus *GLOBOROTALIA* into two main subgenera, *GLOBOROTALIA* and *TURBOROTALIA* on the basis of the presence or absence of an imperforate keel respectively. During the evolution of Cenozoic planktonic foraminifera, close morphological similarity has arisen between unrelated groups, perhaps as they take on similar life habits (CIFELLI, 1969). An example of this adaptive convergence is no better illustrated than by reference to the development of the keel. Within the Neogene, there are at least five well documented lineages which independantly culminate in a keeled 'globorotaliid' from a non-keeled 'turborotaliid' ancestor (BLOW, 1969; BANDY, 1972; FLEISHER, 1974). Application of BLOW's classification (1969) divides species within each lineage on a subgeneric level and thus disguises phylogenetic relationships. It appears that the aquisition of a keel should have no taxonomic significance above specific level in any classification scheme propounding to infer phylogenetic relationships between the constituent species (FLEISHER, 1974). Present knowledge of the complex relationship between the majority of planktonic foraminiferal taxa remains insufficient to erect a comprehensive natural classification which highlights phylogenetic lineages (STEINECK and FLEISHER, 1978). Nevertheless, in some instances, it is possible to discriminate globorotaliid lineages on a subgeneric level by ammending the classification scheme of BLOW (1969). In such an attempt, BANDY (1972) proposed five subgenera of the genus *GLOBOROTALIA*, three of which, *FOHSELLA*, *MENARDELLA* and *HIRSUTELLA* were new. Application of these new subgenera by subsequent authors has been limited, perhaps because a) of their reluctance to involve such an unwieldly number of taxonomic catagories, and b) because the phylogenetic lineages may prove to be more complicated than previously believed. To use an example relevant to the present study, BLOW (1969), JENKINS (1971) and STAINFORTH et al.(1975) have shown that phylogenetic speciation from *Globorotalia peripheroronda* may differ substantially between low and high latitudes in the Pacific Ocean (see Discussion under *G. (F) peripheroronda* herein). Nevertheless, FLEISHER (1974), a protagonist of a 'natural' classification, referred all members of the *Globorotalia fohsi* lineage to a modification of the subgenus *FOHSELLA* of BANDY (1972). This scheme is utilised herein because a) in recognition of the need to promote the development of 'natural' classificatory schemes which take into consideration important features of phylogeny and wall structure (STEINECK and FLEISHER, 1978).

b) it combines a group of closely related species which had been previously separated on a subgeneric level (BLOW, 1969).
c) it separates that group from contemporaneous or near contemporaneous homeomorphs.

Apart from this deviation, and until new schemes are prepared, the generic and subgeneric format of BLOW (1969) will be followed. The reader is referred to the works of FLEISHER (1974) and STEINECK and FLEISHER (1978) for a more complete review of classificatory schemes and taxonomic philosophy as applied to Cenozoic planktonic foraminifera.

Subgenus : *FOHSELLA* BANDY, 1972

Discussion : Members of the subgenus *FOHSELLA* constitute a well documented phylogenetic lineage which has been utilised extensively for biostratigraphical zonations of the **early** Middle Miocene, particularly in tropical regions (BOLLI, 1957b, 1967; BLOW and BANNER, 1966; BLOW, 1969; STAINFORTH et al., 1975). The taxonomic status and nomenclature of the various morphotypes has however, varied according to author and the reader is referred to STAINFORTH et al. (1975), for a review of the problem. Members of the phylogenetic lineage are well represented in the present study, especially at Site 289. Table A1 compares the subgeneric, specific and subspecific designations of BOLLI (1967), BLOW (1969) and those used herein. Taxa are arranged in phylogenetic order, headed by the oldest, most primitive member.

BOLLI, 1967	BLOW, 1969	Herein
G. fohsi peripheroronda	*G. (T.) peripheroronda*	*G. (F.) peripheroronda*
G. fohsi peripheroacuta	*G. (T.) peripheroacuta*	*G. (F.) peripheroacuta*
G. fohsi fohsi	{ *G. (G.) praefohsi* *G. (G.) fohsi* }	*G. (F.) fohsi fohsi*
G. fohsi lobata	*G. (G.) fohsi forma lobata*	*G. (F.) fohsi lobata*
G. fohsi robusta	*G. (G.) fohsi forma robusta*	*G. (F.) fohsi robusta*

TABLE A1

Reasons for the taxonomic format used herein are given briefly below where necessry. Further discussion is included under individual taxa in the following systematic treatments.

The designation of the subgenus *FOHSELLA* follows FLEISHER (1974) (see Discussion under genus: *GLOBOROTALIA*). BANDY (1972) restricted this subgenus to sharp to keeled edged members of this lineage although FLEISHER (1974) includes *G. (F.) peripheroronda* within the subgenus because of the close phylogenetic relationship between it and the younger decendants.

On the specific level, the scheme used herein combines the taxonomic philosophies of BLOW and BANNER (1966), BOLLI (1967) and BLOW (1969). For the sake of continuity through the studied sequences, the zonation of BLOW (1969) was applied where possible during the biostratigraphical synthesis from the resultant species.

1) The 'morphotype' *G. (T.) peripheroacuta* of BLOW and BANNER (1966), easily recognised in the present study, is given full specific status becasue of its' biostratigraphical usefulness.

2) *G. (F.) fohsi fohsi* herein includes *G. fohsi fohsi* of BOLLI (1967) (excluded non-keeled forms : herein designated *G. (F.) peripheroacuta*) and *G. (G.) praefohsi* and *G. (G.) fohsi s.s.* of BLOW and BANNER, (1966), BLOW (1969). *G. (G.) praefohsi* was identified by the latter authors by the presence of a keel on the final chambers only. The distinction between a partly keeled individual and a fully keeled individual was extremely difficult to observe in the present study and all keeled forms (except phylogenetically advanced forms : see below) were referred to *G. (F.) fohsi fohsi*.

3) The end members of the lineage, *G. (F.) fohsi lobata* and *G. (F.) fohsi robusta* are retained on subspecific status following BOLLI (1967) (see Remarks under *G. (F.) fohsi lobata* herein).

Globorotalia (F.) peripheroronda BLOW and BANNER, 1966

1939	*Globorotalia barisanensis* LEROY, p.265, pl.1, figs. 8-10.
1966	*Globorotalia (T.) peripheroronda* BLOW and BANNER, p.294, pl.1, fig. 1; pl.2, figs. 1-3.
1967	*Globorotalia fohsi peripheroronda* BLOW and BANNER. BOLLI, p.505-508, fig.2.
1969	*Globorotalia (T.) peripheroronda* BLOW and BANNER. BLOW, p.230-233, 354.
1974	*Globorotalia (F.) peripheroronda* BLOW and BANNER. FLEISHER, p.1026, pl.10, figs. 7-8.
1975	*Globorotalia fohsi peripheroronda* BLOW and BANNER. STAINFORTH et al. p.277, fig. 119.

Diagnosis : Test a discoidal trochospire with five to six chambers in the final whorl. The umbilical side is more convex than the spiral and possesses curved sutures and a slit-like aperture from the umbilicus to the periphery, bordered by a thin lip. The spiral sutures are recurved to produce crescentric chambers. The equatorial outline is subcircular and the side profile shows a definite, blunt, shoulder. Surface smooth, perforate.

Stratigraphical Distribution : Early to Middle Miocene (N.6 to N.11, ?N.12) BLOW (1969). BRÖNNIMANN and RESIG (1971) record a similar range.

Material : The species is present in one sample, in very rare abundance, at Site 289.

Geographical Distribution and Palaeoecology : *G. (F.) peripheroacuta* is a cosmopolitan species. It has been recognised in sediments from the north east Pacific (INGLE, 1973), New Zealand (as *G. (T.) mayeri barisanensis*, JENKINS, 1971), the Indian Ocean (FLEISHER, 1974) and the English Channel (JENKINS, 1977).

Discussion : According to BLOW (1969) and JENKINS (1971), the species gave rise to the keeled *G. (F.) fohsi* and related species in tropical and subtropical areas and to the unkeeled *G. (T.) mayeri* in cooler waters.

Globorotalia (F.) peripheroacuta BLOW and BANNER, 1966

Pl. I, fig. 1a-c

part. 1957b *Globorotalia fohsi fohsi* CUSHMAN and ELLISOR. BOLLI, p.119.

1966 *Globorotalia (T.) peripheroacuta* BLOW and BANNER, p.294-295, pl.1, fig. 2; pl.2, fig.4-5,13.

1967 *Globorotalia fohsi peripheroacuta* BLOW and BANNER. BOLLI, p.508, fig.2.

1969 *Globorotalia (T.) peripheroacuta* BLOW and BANNER. BLOW, p.232-238, 353.

1972 *Globorotalia peripheroacuta* BLOW and BANNER. JENKINS and ORR, p.1102, pl.29, figs. 6-8.

1974 *Globorotalia (F.) peripheroacuta* BLOW and BANNER. FLEISHER, p.1026, pl.10, figs. 5,6.

Diagnosis : Test a discoidal to lenticular trochospire with five to seven chambers in the final whorl. The umbilical side is more convex than the spiral side and possesses almost radial sutures and a slit-like aperture from a closed umbilicus to the periphery. Equatorial profile ovate; side profile with an acute periphery but showing no evidence of a keel. Surface smooth, perforate.

Stratigraphical Distribution : The initial appearance of *G. (F.) peripheroacuta* defines the base of Zone N.10; the species ranges into Zone N.12-?N.13 of the Middle Miocene (BLOW, 1969). BRÖNNIMANN and RESIG (1971) record the species in Zones N.12 to N.13. At DSDP Site 71, BECKMANN (1971) tabulates the taxon within Zone N.11.

Material : At Site 289, *G. (F.) peripheroacuta* ranges from the base of Zone N.10 to within Zones N.11-12 of the Middle Miocene. Abundance varies from very rare to few. The species was not recorded within the studied sequence at Site 71 (cf. BECKMANN, 1971).

Geographical Distribution and Palaeoecology : Unlike their precursor, *G. (F.) peripheroronda*, the more advanced elements of this lineage appear to be restricted to low and mid-latitudes (STAINFORTH et al., 1975). *G. (F.) peripheroacuta* has been recorded in sediments from the South west Pacific (KENNETT, 1973) but is apparently absent in the north east Pacific (INGLE, 1973). The species is tabulated from sediments of the Indian and Atlantic Oceans (FLEISHER, 1974; SALVATORINI and CITA, 1979, respectively).

Discussion :. *G. (F.)peripheroacuta* evolved from *G. (F.) peripheroronda* by aquisition of an acute periphery and modification of a subcircular to an ovate outline (BLOW and BANNER, 1966; BLOW, 1969).

Globorotalia (F.) fohsi fohsi CUSHMAN and ELLISOR, 1939

Pl. I, fig. 2a-e

	1939	*Globorotalia fohsi* CUSHMAN and ELLISOR, p.12, pl.2, fig. 6.
part.	1957b	*Globorotalia fohsi fohsi* CUSHMAN and ELLISOR. BOLLI, p.119, pl.28, figs. 9-10.
	1966	*Globorotalia (G.) fohsi* CUSHMAN and ELLISOR. BLOW and BANNER, pl.1, figs. 5-7 (holotype redrawn); pl.2, figs. 8-9, 12.
	1966	*Globorotalia (G.) praefohsi* BLOW and BANNER, p. 295-296, pl.1, figs. 3-4; pl.2, figs. 6-7.
	1969	*Globorotalia (G.) fohsi* CUSHMAN and ELLISOR. BLOW, p.362.
	1969	*Globorotalia (G.) praefohsi* CUSHMAN and ELLISOR. BLOW, p.358.
part.	1975	*Globorotalia fohsi fohsi* CUSHMAN and ELLISOR. STAINFORTH et al., p.274, fig. 117, 5-8; non 1-4.

Diagnosis : Test a discoidal to lenticular trochospire with five to seven chambers in last whorl. Umbilical side slightly more convex than spiral with almost radial sutures and a silt-like aperture from a closed umbilicus to the periphery. Spiral surface sutures are recurved. Equatorial outline ovate or ear-shaped; side profile terminating in an acute periphery which possesses an imperforate keel on at least the final chamber. Surface smooth, finely perforate.

Stratigraphical Distribution : The initial appearance of *G. (F.) fohsi fohsi* (as *G. (G.) praefohsi)* defines the base of Zone N.11; the species ranges into Zone N.12 - ?N.13 of the Middle Miocene (BLOW, 1969).

Material : At Site 289, *G. (F.) fohsi fohsi* ranges from the base of Zone N.11 into Zone N.13 of the Middle Miocene. Abundance varies from very rare to common. At Site 71, the subspecies ranges throughout the studied sequence and abundance varies from very rare to few.

Geographical Distribution and Palaeoecology : *G. (F.) fohsi fohsi* appears to have a more restricted geographical range than its precursor, *G. (F.) peripheroacuta.* Occurrences at tropical and subtropical localities are common (STAINFORTH et al., 1975), although the species is reported absent from sediments of the north east Pacific (INGLE, 1973), the south west Pacific (KENNETT, 1973) and mid-latitudes of the Indian Ocean (BOLTOVSKOY, 1974a). A comprehensive study of New Zealand Cenozoic planktonic foraminifera by JENKINS (1971) has revealed the occurrence of just two individuals, significantly perhaps on the North Island.

Discussion : The range of variation encountered in individuals at Site 289 reflects the evolutionary trends of the species outlined by STAINFORTH et al. (1975). Primitive individuals, direct descendants of *G. (F.) peripheroacuta*, possess an imperforate keel on the ultimate chamber only and are ovate in outline. In more advanced forms, 1) the keel extends around the periphery to all chambers in the final whorl and 2) successive chambers of the final whorl extend their radial length to produce an ear-shaped outline for the test. Occasional forms have a lobate outline; they are distinguished from more advanced species of the lineage by their smaller size.

Globorotalia (F.) fohsi lobata BERMÚDEZ, 1949

Pl. I, fig. 3a-b

1949	*Globorotalia lobata* BERMÚDEZ, p.286, pl.22, figs. 15-17.
1957b	*Globorotalia fohsi lobata* BERMÚDEZ. BOLLI, p.119, pl.28, figs. 13-14.
1966	*Globorotalia (G.) fohsi forma lobata* BERMÚDEZ. BLOW and BANNER, p.293, fig. 4.
1969	*Globorotalia (G.) fohsi forma lobata* BERMÚDEZ. BLOW, p.239-241, 362.
1975	*Globorotalia fohsi lobata* BERMÚDEZ. STAINFORTH et al., p.276, fig. 118.

Diagnosis : Test a lenticular trochospire with six to eight chambers in the final whorl which have irregular radial prolongations that impart a distinct lobate outline. The sutures on the spiral side are recurved, limbate and merge into a well developed keel. Umbilicus slightly open. Surface mostly smooth, finely perforate.

Stratigraphical Distribution : BLOW (1969) cites the range as Zone N.12 to within Zone N.13 of the Middle Miocene.

Material : At Site 289, *G. (F.) fohsi lobata* ranges from within Zone N.11-12 to within Zone N.13. Abundance varies from very rare to common. At Site 71, the subspecies ranges throughout the studied sequence and abundance varies from rare to few.

Geographical Distribution and Palaeoecology : *G. (F.) fohsi lobata* appears to be restricted to tropical and subtropical localities. The subspecies is reported absent from sediments of the north east Pacific (INGLE, 1973), the south west Pacific and New Zealand (KENNETT 1973; JENKINS, 1971 resp.) and from mid-latitude localities from the Indian Ocean (BOLTOVSKOY, 1974a). This distributional feature is well documented by STAINFORTH et al. (1975), who further suggest that local distribution within a tropical realm such as Trinidad may be subject to ecological control. OLSSON (1972) had related maximum size of both *G. (F.) fohsi lobata* and *G. (F.) fohsi robusta* to the peak of a Middle Miocene warming cycle.

Discussion : *G. (F.) fohsi lobata* evolved from its precursor, *G. (F.) fohsi fohsi*, by the aquisition of a well-developed keel, limbate sutures on the spiral side and a lobate outline (STAINFORTH et al., 1975). There is also an abrupt increase in average size between the two subspecies (BOLLI, 1967; OLSSON, 1972), although intermediate forms exist.

Remarks : BLOW and BANNER (1966) and BLOW (1969) contend that *G. (F.) fohsi lobata* and the younger end member, *G. (F.) fohsi robusta*, are ecological variants of *G. (F.) fohsi fohsi*. STAINFORTH et al. (1975) offer evidence in partial support of this theory. BOLLI (1957b, 1967), however, has consistently postulated that the taxa *lobata* and *robusta* are normal elements within the main lineage that deserve subspecific status as the basis of their distinct outlines and size. The biostratigraphical evidence at Site 289 supports the view of BOLLI (1967) concerning the phylogeny of the group and the end members are thus afforded subspecific status herein.

Globorotalia (F.) fohsi robusta BOLLI, 1950

Pl. I, fig. 4a-b

1950 *Globorotalia fohsi robusta* BOLLI, p.89, pl.15, fig. 3.
1957b *Globorotalia fohsi robusta* BOLLI. BOLLI, p.119, pl.23, fig. 16.
1966 *Globorotalia (G.) fohsi* forma *robusta* BOLLI. BLOW and BANNER, p.293, pl.2, fig. 9.
1969 *Globorotalia (G.) fohsi* forma *robusta* BOLLI. BLOW, p. 239-242, 363.
1975 *Globorotalia fohsi robusta* BOLLI. STAINFORTH et al. p.279, fig. 120.
1975 *Globorotalia fohsi robusta* BOLLI. SRINIVASAN, p.140, pl.3, figs. 11-12.

Diagnosis : Test a discoidal trochospire with six to eight chambers in the final whorl. Equatorial profile is circular and smooth and is bounded by a thick, blunt keel. Sutures on the spiral side are limbate and merge into the keel; on umbilical side are radial, straight to wavy. Umbilicus slightly open. Surface smooth, finely perforate with pustulate secondary shell.

Stratigraphical Distribution : BLOW (1969) cites the range as Zone N.12 to Zone N.13 of the Middle Miocene.

Material : At Site 289, *G. (F.) fohsi robusta* ranges from N.11-12 to N.13. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : The distribution of this subspecies appears to parallel that of *G. (F.) fohsi lobata* (see herein), although STAINFORTH et al. (1975) regard the form as strictly tropical in distribution.

G. (F.) fohsi robusta is absent from sediments of the north east Pacific (INGLE, 1973), the southwest Pacific (KENNETT, 1973), mid-latitude localities from the Indian Ocean (BOLTOVSKOY, 1974a) and Europe (STAINFORTH et al., 1975).

Discussion : *G. (F.) fohsi robusta* is the end member of the *Fohsella* lineage (BOLLI, 1967; STAINFORTH et al. 1975). The subspecies is the largest form and differs from its precursor, *G. (F.) fohsi lobata*, in its more circular outline.

Remarks : See Remarks under *G. (F.) fohsi lobata* for a discussion of the taxonomic status of this form.

Subgenus : *GLOBOROTALIA* CUSHMAN, 1972

Globorotalia (G.) cultrata Group (d'ORBIGNY), 1839

Pl. II, fig. 1a-e

1826 *Rotalia (Rotalie) menardii* d'ORBIGNY, p.273 (nomen nudum).

1826 *Rotalia limbata* d'ORBIGNY, p.274, list no. 30 (nomen nudum).

1839 *Rotalina (Rotalina) cultrata* d'ORBIGNY, p.76. v.8, pl.5, figs. 7-9.

1865 *Rotalia menardii* PARKER, JONES and BRADY, p.20, pl.3, fig. 81.

1902 *Rotalia limbata* d'ORBIGNY. FORNASINI, p.56, text fig. 55.

1957b *Globorotalia menardii* (d'ORBIGNY). BOLLI, p.120, pl.29, figs. 6a-10b.

1960b *Rotalia cultrata* d'ORBIGNY. BANNER and BLOW, p.34. pl.6, fig. 1a-c.

1960b *Rotalia menardii* PARKER, JONES and BRADY. BANNER and BLOW, p.31, pl.6, figs. 2a-c (lectotype).

1969 *Globorotalia (G.) cultrata cultrata* (d'ORBIGNY). BLOW, p.358, pl.6, figs. 4-8.

1969 *Globorotalia (G) cultrata menardii* (PARKER, JONES and BRADY). BLOW, p.359, pl.6, figs. 9-11.

1969 *Globorotalia (G.) cultrata limbata* (FORNASINI) (ex. d'ORBIGNY). BLOW, p.359, pl.7, figs. 4-6; pl.42, figs. 2-3.

1971 *Globorotalia (G.) cultrata cultrata* (d'ORBIGNY). BRÖNNIMANN and RESIG, pl.29, figs. 1-2.

1971 *Globorotalia (G.) cultrata* (d'ORBIGNY) *menardii* (PARKER, JONES and BRADY). BRÖNNIMANN and RESIG, pl.29, fig. 7.

1975 : *Globorotalia cultrata* (d'ORBIGNY). STAINFORTH et al., fig. 177.

1975 *Globorotalia menardii* (PARKER, JONES and BRADY) (ex. d'ORBIGNY). STAINFORTH et al., p. 371-376, figs. 178-179.

Diagnosis : Test a lenticular trochospire with five to six chambers in the final whorl. Equatorial profile subcircular, rounded-polygonal or lobate; axial profile equally or unequally biconvex or acute with chambers tumid or dorso-ventrically compressed. Chambers increase regularly in size, maintain a constant shape and bear a well developed blunt keel. Sutures on spiral side, including those of the penultimate whorl, are recurved, limbate and continuous with the keel. Umbilical sutures are incised and radial. Umbilicus a narrow pit. Aperture a low-arched slit from umbilicus to near periphery. Surface smooth and finely perforate or pustulose near umbilicus.

Stratigraphical Distribution : Middle Miocene (N.11) to Recent (N.23) for *G. (G.) cultrata s.l.* (BLOW, 1969). BRÖNNIMANN and RESIG (1971) tabulate *G. (G) cultrata s.l.* from Zone N.13 to Recent.

Material : At Site 289, *G. (G.) cultrata* group ranges from the Middle Miocene (N.11- 12) to beyond the upper limit of the studied sequence. Abundance and distribution is cyclic and varies from very rare to very abundant.

Geographical Distribution and Palaeoecology : BE´ has conducted a synthesis of numerous plankton and surface sediment studies involving planktonic foraminiferal distribution throughout the worlds' oceans (1977; see extensive bibliography within). Extant populations of the *G. (G.) cultrata* group (as *G. menardii s.l.*) predominate in tropical oceanic provinces where surface water temperatures are above 20°C. Adult stages concentrate below 100 meters in the water column (BÉ, 1977). This preference for tropical water masses is reflected in surface sediments. In the south west Pacific, PARKER (1962) notes the taxon restricted to sediments north of latitude 30°S. In tropical sediments, *G. (G.) cultrata* is one of a few species which dominate foraminiferal assemblages, constituting over 20% of the taxa in some Indian Ocean samples (BÉ, 1977).

Fossil representatives appear to have been restricted by similar constraints (STAINFORTH et al, 1975). JENKINS (1971) records only infrequent incursions into the New Zealand area during the Miocene, an observation reflected in the results of KENNET (1973) from a regional study in the south west Pacific Ocean. In the north east Pacific, INGLE (1973) tabulates the species from one sample in a sequence spanning the Middle Miocene to Recent.

Discussion : Observations in the present study substantiate previous reports noting the considerable variation exhibited by members of the *G. (G.) cultrata* group (BOLLI, 1957b; BÉ, 1977; see synonymy herein). At Site 289 there appears to be a gradation between the various subspecies of BLOW (1969) which makes consistent discrimination impossible. Aberrant forms are occasionally encountered similar the the plano-convex Pliocene species, *G. (G.) miocenica* (see Pl. II, fig. 1e).

A detailed account of the mode and significance of coiling direction trends in the *G. (G.) cultrata* group in the present study is presented in Chapter VI.

Members of the group differ from homeomorphic taxa of the subgenus *Fohsella* by the more flaring spire in the latter.

Remarks : The reader is referred to STAINFORTH et al. (1975), who presents a critique of previous nomenclatural useage within the group.

Globorotalia (G.) miozea FINLAY, 1939

Pl. II, fig. 2

1939 *Globorotalia miozea* FINLAY, p.326, pl.29, figs. 159-161.
1969 *Globorotalia (G.) miozea miozea* FINLAY. BLOW, p.366, pl.45, fig. 7.
1971 *Globorotalia (G.) miozea miozea* FINLAY. JENKINS, p. 94, pl.6, figs. 144-148 (holotype refigured : figs. 144-146).
1979 *Globorotalia (G.) miozea* FINLAY. POORE, p.471, pl. 6, figs. 6-12.

Diagnosis : Test similar in many respects to *G. (T.) scitula* (see Diagnosis herein) except in this case the umbilicus is open and distinct and the equatorial periphery has developed a distinct imperforate keel, at least as the final chamber.

Stratigraphical Distribution : Early to Late Miocene (N.6 to N.16: ?early N.17) (BLOW, 1969). JENKINS (1971) records the species from the Early to Middle Miocene of New Zealand (*G. trilobus trilobus* Zone to the *G. (T.) mayeri mayeri* Zone).

Material : At Site 289, *G. (G.) miozea* is present in only two samples, is very rare abundance, from the Middle Miocene (N.13 to N.15). At Site 71, the species is present in seven samples from the Middle Miocene (N.11-12), where abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : The species has been reported in sediments from the north east Pacific Ocean (INGLE, 1973), the Southern Ocean (JENKINS, 1975) and the Atlantic Ocean (Poore, 1979). According to BLOW (1969), the species does not form a very significant component of equatorial-tropical assemblages but prefers cooler water environments such as the Australasia region where it is particularly common.

Discussion : In the present study, individuals similar to *G. (T.) scitula* are referred to *G. (G.) miozea* only when a distinct keel is present. Transitionary forms with thickened peripheries are included in the former taxon.

Globorotalia (G.) praemenardii CUSHMAN and STAINFORTH, 1945

Pl. II, fig. 3a-b

1945 *Globorotalia praemenardii* CUSHMAN and STAINFORTH, p. 70, pl.13, fig. 14.

1957b *Globorotalia praemenardii* CUSHMAN and STAINFORTH. BOLLI, p.120, pl.29, fig.4.

1969 *Globorotalia (G.) praemenardii praemenardii* CUSHMAN and STAINFORTH. BLOW, p.368-370, pl. 6, figs. 1-3 (holotype redrawn).

1975 *Globorotalia praemenardii* CUSHMAN and STAINFORTH. STAINFORTH et al. p.302, fig. 134.

Diagnosis : Test a discoidal trochospire with four and a half to six chambers in the final whorl. Equatorial profile lobate; side profile acute. The chambers increase regularly in size, maintain a constant shape, and bear a delicate keel in the final whorl. Sutures on spiral side strongly recurved; on umbilical side almost straight and radial. Surface smooth, finely perforate.

Stratigraphical Distribution : Middle Miocene (?N.9-N.10 to N.12-?N.13) (BLOW, 1969). BRÖNNIMANN and RESIG (1971) tabulate the species from Zone N.13.

Material : At Site 289, *G. (G.) praemenardii* ranges from Zone N.9 to Zone N.13. Abundance varies from very rare to rare and distribution is discontinuous.

At Site 71, the species is continuously present throughout the studied sequence (N.11-12); abundance varies from very rare to few.

Geographical Distribution and Palaeoecology : A tropical species scarce in temperate regions (STAINFORTH et al., 1975). *G. (G.) praemenardii* has been recorded from sediments of the south west Pacific and New Zealand by KENNETT (1973) and JENKINS (1971) respectively. The species was not tabulated however, from sediments of the south east Pacific (INGLE, 1973) or mid-latitudes of the Indian Ocean (BOLTOVSKOY, 1974a).

Discussion : *G. (G.) praemenardii* differs from its decendants *G. (G.) cultrata s.l.* by lacking a limbate keel and limbate sutures on the spiral side (BLOW, 1969).

Globorotalia sp. cf. *G. (G.) merotumida* BLOW and BANNER, 1965

Pl. II, fig. 4a-c

cf. 1965b *Globorotalia (G.) merotumida* BLOW and BANNER. In BANNER and BLOW, p.1352, fig. 1,a-c.
cf. 1969 *Globorotalia (G.) merotumida* BLOW and BANNER. BLOW, p.364, pl.9, figs. 4-6, pl.45, figs.4,9.
cf. 1979 *Globorotalia merotumida* BLOW and BANNER. POORE, p.471, pl.8, figs.1-3.

Diagnosis : Test a small tumid trochospire with six chambers in the final whorl. Equatorial profile 'ear-shaped'; axial profile inflated, with the ventral surface more convex than the dorsal surface. The sutures on the dorsal surface are strongly limbate and merge with a well developed peripheral keel. On the ventral surface, the chambers are slightly concave near the keel but inflate rapidly towards the narrow umbilicus. An equatorial face is separated from the ventral surface by an abrupt change of slope. Surface smooth and finely perforate with pustules around the umbilicus and aperture.

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (within N.16) to Pliocene (within N.18). An extended range of Middle Miocene (N.13) to Pliocene (N.20) has been proposed by BRÖNNIMANN and RESIG (1971) following oral confirmation by BLOW.

Material : At Site 289, *G.* sp. cf. *G. merotumida* ranges from within the Late Miocene (N.16) to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : STAINFORTH et al. (1975) regard to species as a warm water index form. In the Pacific Ocean, records of the taxon appear to be confined to low latitude, tropical localities

(PARKER, 1967 ; JENKINS and ORR, 1972). INGLE (1973) tabulates a brief occurrence within the Middle Miocene (N.15) at Site 173 in the north east Pacific Ocean while KENNETT (1973) does not record the species in south west Pacific sediments. FLEISHER (1974) and SALVATORINI and CITA (1979) encountered the form in Indian and Atlantic Ocean sediments respectively.

Remarks : PARKER (1967) and BRÖNNIMANN and RESIG (1971) have each commented on the difficulty in separating the species from closely related forms. In the present study, given the large populations and wide range of variation within the *G. (G.) cultrata* group, similar problems were encountered. Consequently, forms referrable to *G. (G.) merotumida* are here included under *G.* sp. cf. *G. merotumida* because of the apparent gradation with normal *G. (G.) cultrata* group morphotypes. *G. plesiotumida* of authors (see STAINFORTH et al., 1975), a direct decendant of *G. merotumida* (BLOW, 1969), are possibly included within this group.

Globorotalia sp. cf. *G. (G.) multicamerata* CUSHMAN and JARVIS, 1930

Pl. II, fig. 5a-b

cf. 1930 *Globorotalia menardii* var. *multicamerata* CUSHMAN and JARVIS, p.367, pl.34, fig.8.

cf. 1967 *Globorotalia multicamerata* CUSHMAN and JARVIS. PARKER, p.180, pl.31, figs. 5-6.

cf. 1969 *Globorotalia (G.) multicamerata* CUSHMAN and JARVIS. BLOW p.367-368, pl.7, figs.7-9; pl.42, fig.7.

Diagnosis : Test a large lenticular trochospire with at least seven chambers in the final whorl. Equatorial profile subcircular and lobate; axial profile compressed. Sutures on the spiral side are strongly limbate and merge into a thick, well developed keel. On the ventral surface, incised, wavy sutures radiate from a wide, deep umbilicus. Surface smooth except for some pustulate development around the umbilicus.

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (within N.17) to Pliocene (N.21). BRÖNNIMANN and RESIG (1971) tabulate the species from the Middle Miocene (N.15) to Pliocene (N.21).

Material : At Site 289, *G.* sp. cf. *G. (G.) multicamerata* ranges from the Middle Miocene (N.15) to beyond the upper limit of the studied sequence. Distribution is discontinuous and abundance varies from very rare to few.

Geographical Distribution and Palaeoecology : STAINFORTH et al. (1975) cite the species restricted to warm, tropical areas. In the Pacific Ocean, the taxon has been recorded in sediments from mid-latitudes by KENNETT (1973) as well as from low latitudes by PARKER (1967) and BRÖNNIMANN and RESIG (1971). FLEISHER (1974) identified the species from tropical sites in the Indian Ocean while SALVATORINI and CITA (1979) tabulate the form from Atlantic Ocean sediments.

Discussion : BLOW (1969) documents the evolutionary transition of *G. (G.) multicamerata* from *G. (G.) cultrata limbata* during Zone N.17. In the present study, specimens from the uppermost part of the sequence (N.17) can undoubtably be referred to *G. (G.) multicamerata* sensu BLOW (1969). However, the appearance of slightly more transitional forms with seven chambers in the final whorl within Zone N.15 casts doubt on the biostratigraphical utility of the species. All such forms, together with the more advanced individuals, are herein referred to as *G.* sp. cf. *G. (G.) multicamerata*.

Subgenus : *TURBOROTALIA* CUSHMAN and BERMÚDEZ, 1949

Globorotalia (T.) acostaensis acostaensis BLOW, 1959

Pl. III, fig. 1a-b

1959	*Globorotalia acostaensis* BLOW, p.208, pl.17, fig. 106.
1969	*Globorotalia (T.) acostaensis acostaensis* BLOW. BLOW, p.344-345, pl.9, figs. 13-15.
1975	*Globorotalia acostaensis* BLOW. STAINFORTH et al. p.333, figs. 152-153.

Diagnosis : Test a discoidal trochospire with four and a half to six chambers in last whorl. The equatorial outline is subcircular and strongly lobate; sutures are radial and a low arched aperture with associated rim or flap extends from the periphery to an inconspicuous umbilicus. Surface pustulate.

Stratigraphical Distribution : The appearance of *G. (T.) acostaensis s.s.* defines the base of Zone N.16 at the base of the Late Miocene. The subspecies extends to within the Pliocene (N.21) (BLOW 1969).

Material : At Site 289, *G. (T.) acostaensis s.s.* extends from the base of the Late Miocene (N.16) to beyond the upper limit of the studied sequence. Abundance varies from very rare to few.

Geographical Distribution and Palaeoecology : BLOW (1969) cites a wide geographical extent for the taxon throughout tropical, subtropical and temperate regions. KRASHENINNIKOV and HOSKINS (1973) reveal a cosmopolitan distribution in north Pacific sediments.

Discussion : *G. (T.) acostaensis* is a close homeomorph of the Early to Middle Miocene species, *G. (T.) siakensis* (see BLOW, 1969 for morphological differences). Coiling direction changes in the subspecies have been used for biostratigraphical correlation within the Late Miocene (see STAINFORTH et al., 1975 and Chapter IV herein for a further discussion of the phenomenon as applied in the present study).

Globorotalia (T.) acostaensis humerosa TAKAYANAGI and SAITO, 1962

Pl. III, fig. 2a-b

1962 *Globorotalia humerosa* TAKAYANAGI and SAITO, p.78, pl.28, figs. 1-2.
1967 *Globoquadrina humerosa* (TAKAYANAGI and SAITO). PARKER, p.169, pl.24, figs. 10-11; pl.25, figs.1-6.
1969 *Globorotalia (T.) acostaensis humerosa* TAKAYANAGI and SAITO. BLOW, p.345-346, pl.33, figs. 4-9; pl.34, figs. 1-3.
1975 *Globorotalia humerosa* TAKAYANAGI and SAITO. STAINFORTH et al., p.357, fig. 170.

Diagnosis : Test a discoidal trochospire with five to seven chambers in last whorl. The equatorial outline is subpolygonal and slightly lobate. Sutures are depressed; the umbilicus is clearly defined and the aperture is an umbilical-extraumbilical arch bearing a rim or more rarely a tooth. Surface pustulate, finely perforate.

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (within N.16) to Recent (N.23). BRÖNNIMANN and RESIG (1971) tabulate the range as Zone N.17 to Recent in western equatorial Pacific sediments.

Material : At Site 289, *G. (T.) acostaensis humerosa* ranges from the Late Miocene (N.16) to beyond the upper limit of the studied sequence. Distribution is discontinuous and abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : The subspecies appears to have been wide ranging and is documented in Late Neogene sediments from the south west Pacific (KENNETT, 1973) the eastern equatorial Pacific (JENKINS and ORR, 1972), the north east Pacific (INGLE, 1973) the Indian Ocean (BOLTOVSKOY, 1974a) and the Atlantic Ocean (SALVATORINI and CITA, 1979).

Discussion : *G. (T.) acostaensis humerosa* is believed to have evolved from *G. (T.) acostaensis s.s.* by an increase in size and development of a distinct umbilicus through a looser mode of coiling (STAINFORTH et al., 1975). This evolutionary transition is gradual and intermediate forms are difficult to catagorise. Consequently the stratigraphic level of the first appearance is subjective and has varied according to authors (see PARKER, 1967, p.164).

Globorotalia (T.) continuosa BLOW, 1959

Pl. III, fig. 3a-b

1959 *Globorotalia opima continuosa* BLOW, p.218, pl.19, figs. 125a-c.
1967 *Globoquadrina continuosa* (BLOW). PARKER, p.166, pl.24, figs. 1-2.
1969 *Globorotalia (T.) continuosa* BLOW. BLOW, p.347, pl.3, figs. 4-6 (holotype refigured).
1971 *Globorotalia (T.) mayeri continuosa* BLOW. JENKINS, p.120, pl.11, figs. 294-6.

Diagnosis : Test a low trochospire with four chambers in the last whorl. The equatorial outline is lobate, sutures are radial and depressed and the umbilicus is deep. The aperture extends from the umbilicus to the periphery, is comma-shaped, and possesses a distinct lip. Surface smooth, pustulate and perforate.

Stratigraphical Distribution : BLOW (1969) gives the range as Early to Middle Miocene (N.6 to N.16:?N.17). BRÖNNIMANN and RESIG (1971) tabulate a similar distribution although JENKINS and ORR (1972) extend it from the Late Oligocene (N.3) to Late Miocene (N.17).

Material : At Site 289, *G. (T.) continuosa* ranges from the Middle to Late Miocene (N.11-12 to N.17). At Site 71, the species is present in samples from the Middle Miocene (N.11-12). Abundance varies from very rare to few and distribution is discontinuous, especially towards the upper range of the species at Site 289.

Geographical Distribution and Palaeoecology : The species appears to display a cosmopolitan distribution, at least in Pacific Ocean sediments. It is recorded in the Southern Ocean by JENKINS (1975), the south west Pacific by KENNETT (1973) and in the north east Pacific by INGLE (1973). SALVATORINI and CITA (1979) tabulate the species from Atlantic Ocean sediments.

Discussion : *G. (T.) continousa* is believed to have evolved into *G. (T.) acostaensis* (BLOW, 1969).

Globorotalia (T.) obesa BOLLI, 1957

Pl. III, fig. 4a-b

1957b	*Globorotalia obesa* BOLLI, p.119, pl.29, figs.2-3.
1969	*Globorotalia (T.) obesa* BOLLI. BLOW, p.352, 409.
1971	*Globorotalia (T.) obesa* BOLLI. JENKINS, p.127, pl.13, figs.348-350.
1975	*Globorotalia obesa* BOLLI. STAINFORTH et al., p.297, fig. 130.

Diagnosis : Test a low, quadrate trochospire, with chambers increasing in size rapidly and maintaining a globose shape. Sutures depressed on outer whorl. The aperture is a simple arch extending from a small umbilical pit to the periphery and the test surface is typically finely hispid.

Stratigraphical Distribution : BLOW (1969) gives the range as Late Oligocene (N.2 (=P.21)) to Recent (N.23). BRÖNNIMANN and RESIG (1971) tabulate the species from the Early Miocene (N.4) to Recent (N.23).

Material : At Site 289, *G. (T.) obesa* ranges from the Middle Miocene (N.11-12) to beyond the upper limit of the studied sequence. At Site 71, the species is present in eight samples from the Middle Miocene (N.11-12). Abundance varies from very rare to few.

Geographical Distribution and Palaeoecology : *G. (T.) obesa* has been recorded in north east Pacific sediments by INGLE (1973) and in New Zealand by JENKINS (1971), while SALVATORINI and CITA (1979) tabulate the species in Atlantic Ocean sediments. STAINFORTH et al. (1975), testify to a worldwide distribution.

Discussion : JENKINS and ORR (1972) attribute the general absence of the species in the eastern equatorial Pacific sediments of DSDP Leg 9 to dissolution activity. *G. (T.) obesa* is absent from **early** Middle Miocene assemblages at Site 289 (N.9 to within N.11-12), where a similar process may be responsible. The role of dissolution in altering foraminiferal assemblages of the present study is discussed in Chapter **V**. The species is considered ancestral to the planispiral *Globigerinella aequilateralis* (see BLOW, 1969; JENKINS, 1971).

Globorotalia (T.) scitula (BRADY), 1882

Pl. III, fig. 7

1882 *Pulvinulina scitula* BRADY, p.716.
1931 *Globorotalia scitula* (BRADY). CUSHMAN, p.100, pl.17, fig.5.
1959 *Globorotalia scitula scitula* (BRADY). BLOW, p.219, pl.16, fig. 126.
1959 *Globorotalia scitula gigantea* BLOW, p.220, pl.16, fig.127.
1969 *Globorotalia (T.) scitula scitula* (BRADY). BLOW, p.356, pl.39, fig.7.
1969 *Globorotalia (T.) scitula gigantea* BLOW. BLOW, p.354.
part. 1975 *Globorotalia scitula* (BRADY). STAINFORTH et al. p.313, fig.140 (non *G. praescitula;* fig.140, 4a-c).

Diagnosis : Test a discoidal trochospire with four to five chambers of constant shape in the final whorl. Sutures on the spiral side are very strongly recurved and produce elongate crescentic chambers; sutures on umbilical side almost straight. Umbilicus closed or narrow. The periphery is bluntly rounded with no true imperforate keel present. Test surface smooth and is usually pustulate near aperture.

Stratigraphical Distribution : BLOW (1969) gives the combined range of both subspecies as Early Miocene (N.6) to Recent (N.23). BRÖNNIMANN and RESIG (1971) tabulate a similar range for the "*G. scitula* group" in western equatorial Pacific sediments.

Material : At Site 289, *G. (T.) scitula* ranges from the Middle Miocene (N.11-12) to beyond the upper limit of the studied sequence. Distribution is discontinuous and abundance varies from very rare to rare. The species is present in the samples from Zone N.11-12 at Site 71 within a similar range of abundance.

Geographical Distribution and Palaeoecology : BRADSHAW (1959) reports extant populations widely distributed throughout the north Pacific and scattered occurrences in the equatorial Pacific Ocean. Fossil forms have been reported from the Southern Ocean by JENKINS (1975), the Indian Ocean by BOLTOVSKOY (1974a) and from the Atlantic Ocean by SALVATORINI and CITA (1979). A cosmopolitan species (STAINFORTH et al., 1975).

Discussion : According to BLOW (1969), *G. (T.) scitula* (as subsp. *gigantea*) gave rise to the keeled form *G. (T.) miozea miozea* during the Early Miocene (N.7). Transitional forms posess a peripheral thickening of the test and were found difficult to catagorise in the present study (see Discussion under *G. (T.) miozea*).

Remarks : Separation of the two subspecies of BLOW (1959) on size differences proved impossible in the present study and following the work of STAINFORTH et al., (1975) they are here synonymised.

Globorotalia (T.) siakensis LEROY, 1939

Pl. III, fig. 5a-d

1939 *Globorotalia siakensis* LEROY, p.39-40, pl.3, figs. 30-31.

1939 *Globorotalia mayeri* CUSHMAN and ELLISOR, p.11, pl.2, fig.4.

1969 *Globorotalia (T.) siakensis* LEROY. BLOW, p.356, pl.10, figs.7-9 (holotype refigured); pl.34, figs. 4-5.

1969 *Globorotalia (T.) mayeri* CUSHMAN and ELLISOR. BLOW, p.351. pl.3, figs. 7-9 (holotype refigured).

1971 *Globorotalia mayeri* CUSHMAN and ELLISOR. BECKMANN, p.720.

1975 *Globorotalia siakensis* LEROY. STAINFORTH et al., p.317, fig.143.

1977 *Globorotalia siakensis* LEROY. BERGGREN, p.595, pl.6, figs. 14-17.

1977 *Globorotalia mayeri* CUSHMAN and ELLISOR. BERGGREN, p.595, pl.6, figs. 18-23.

Diagnosis : Test a low trochospire with five to seven chambers in the last whorl. The equatorial outline is lobate; sutures are depressed and may be straight or backwardly curved, wide and deep. The aperture is cresentic to comma shaped, extends from the umbilicus to the periphery and is bordered by an inconspicuous lip on the final chamber. Surface smooth, pustulose and perforate.

Stratigraphical Distribution : *G. (T.) siakensis* appears in the Late Oligocene (N.2 (=P.21)) and becomes extinct in the Middle Miocene where the datum defines the top of Zone N.14 (BLOW, 1969). BRÖNNIMANN and

RESIG (1971) tabulate a similar range in western equatorial Pacific sediments. *G. (T.) mayeri* of authors (see synonymy), has a more restricted range within the Middle Miocene (N.9 to N.13) BLOW (1969).

Material : At Site 289, *G. (T.) siakensis* ranges from beyond the lower limit of the studied sequence into the Middle Miocene. The extinction event is abrupt and the datum (top of N.14) easily recognisable. Distribution within this range however is markedly discontinuous and abundance varies from very rare to very abundant. At Site 71, the species is present in samples from the Middle Miocene (N.11-12). Distribution is more stable within this shorter stratigraphic interval and abundance varies from common to abundant.

Geographical Distribution and Palaeoecology : *G. (T.) siakensis* (sensu BLOW 1969) appears to be ubiquitous in equatorial, tropical and subtropical assemblages (BLOW, 1969). The species has been recorded in Early and Middle Miocene sediments from the Southern Ocean (as *G. (T.) mayeri mayeri*; JENKINS, 1975), in the south west Pacific (KENNETT, 1973) and in the northeast Pacific (INGLE, 1973). SALVATORINI and CITA (1979) have tabulated the species from Atlantic Ocean sediments. This extensive distribution prompted STAINFORTH et al. (1975), to suggest wide environmental tolerances for the species.

Remarks : Many modern authors claim that *G. (T.) siakensis* and *G. (T.) mayeri* are close homeomorphs, distinguishable by subtle morphological differences and having separate phylogenies (see BLOW, 1969; BERGGREN 1977). In the large populations at Sites 289 and 71, it was found extremely difficult to consistently separate the two species, given that the full range of variation for each in their respective type areas is unknown. Following BECKMANN (1971) and STAINFORTH et al. (1975) both species have been here grouped.

Discussion : 'Intraspecific' variation within the taxon is wide-ranging amongst large populations from single samples. One of the most variable characters involves the degree of uncoiling; tightly coiled individuals with narrow umbilici were found alongside loosely coiled forms with wide umbilici (see **Pl. III, fig. 5b-c**)

Globorotalia sp. aff. *G. (T.) continuosa* BLOW, 1959

Pl. III, fig. 6

aff. 1959 *Globorotalia opima continuosa* BLOW, p.218, pl.19, figs. 125a-c.

Diagnosis : Similar in most respects to *G. (T.) continuosa* except in this case the aperture is a high arch rather than comma-shaped.

Material : At Site 289, *G. (T.)* sp. aff. *G. (T.) continuosa* ranges from Zone N.11-12 to Zone N.13 of the Middle Miocene. Abundance varies from very rare to few. At Site 71, the form is present in three samples from Zone N.11-12 in very rare abundance.

Discussion : Apart from the morphological similarities, this taxon displays a similar stratigraphical distribution to *G. (T.) continuosa*.

Genus : *GLOBOQUADRINA* FINLAY, 1947

Several authors have experienced the need for major taxonomic revision of the forms currently grouped within the genus *GLOBOQUADRINA* (PARKER, 1967; BLOW, 1969; BRONNIMANN and RESIG, 1971; STAINFORTH et al. 1975). FLEISHER (1974) has summarised the phylogenetic relationships of the various taxa although several inconsistencies remain unresolved (see STAINFORTH et al., 1975).

Globoquadrina altispira altispira (CUSHMAN and JARVIS), 1936

Pl. IV, fig. 1a-b

1936	*Globigerina altispira* CUSHMAN and JARVIS, p.5, pl.1, figs. 13-14.
1957b	*Globoquadrina altispira altispira* (CUSHMAN and JARVIS). BOLLI, P.111, pl.24, figs. 7-8.
1975	*Globoquadrina altispira altispira* (CUSHMAN and JARVIS). STAINFORTH et al., p.245, fig.100.

Diagnosis : Test a large, high trochospire with four to six chambers in the final whorl. Chambers initially globose but become later appressed and prolonged towards the umbilicus. Spiral profile subcircular; side profile ovate. Sutures distinct and depressed. The umbilicus is wide and deep and encloses an aperture partly concealed by a triangular tooth. Previous apertures and teeth are visible. Test finely cancellate.

Stratigraphical Distribution : BLOW (1969) gives the range as Early Miocene (N.6) to Pliocene (N.20). BRÖNNIMANN and RESIG (1971) tabulate a slightly longer range (N.5/6 to N.20).

Material : *G. a. altispira* constitutes an important element of the planktonic foraminiferal assemblages in the present study. At both Sites 289 and 71 the taxon ranges continuously throughout the studied sequences. Abundance varies from very rare to very abundant at Site 289 and from few to very common at Site 71.

Geographical Distribution and Palaeoecology : STAINFORTH et al. (1975) regard *G. a. altispira* as a warm water species whose extinction in the Late Miocene in low latitudes coincides with the onset of climatic deterioration. KANEPS (1973) suggest the taxon was probably widely distributed and cosmopoliton with a fairly wide environmental tolerance. High latitude occurrences in Pacific and Indian Ocean sediments are however, rare or absent (JENKINS, 1971, 1975; INGLE, 1973; BOLTOVSKOY, 1974a).

Discussion : A wide range of intraspecific varients were encountered in the present study. The number of chambers in the final whorl was usually four although some individuals possessed six. Trochospiral elevation varied from low to high.

Globoquadrina altispira globosa BOLLI, 1957

Pl. IV, fig. 2a-c

1957b	*Globoquadrina altispira globosa* BOLLI, p.111, pl.24, figs. 4-10.
1969	*Globoquadrina altispira globosa* BOLLI. BLOW, p. 339.
1975	*Globoquadrina altispira globosa* BOLLI. STAINFORTH et al., p.245, fig. 101.

Diagnosis : Test a large elevated trochospire with five to six chambers in the final whorl. Chambers are globular throughout. Spiral profile lobate; side profile plano-convex. Sutures distinct and depressed. The umbilicus is wide and deep and encloses an aperture partly concealed by a triangular tooth. Previous apertures and teeth are visible. Surface finely cancellate.

Stratigraphical Distrubution : Early Miocene (N.3) to Pliocene (N.19/N.20) BLOW (1969). BRÖNNIMANN and RESIG (1971) tabulate a slightly shorter range (N.5/6 to N.20).

Material : *G. a. globosa* ranges continuously throughout the studied sequences at both Site 289 and 71. Abundance varied from rare to very common at Site 289 and from few to very common at Site 71.

Geographical Distribution and Palaeoecology : STAINFORTH et al. (1975) suggest a wide geographical range for the subspecies. Comments regarding the distribution of *G. a. altispira* are probably pertinent to this closely related subspecies.

Discussion : STAINFORTH et al. (1975) regard *G. a. globosa* as the precursor of *G. a. altispira*. In the former taxon the later chambers remain globular, usually with five in the final whorl and the spire remains relatively low. Nevertheless, intersubspecific gradation is occasionally apparent at Site 289.

Globoquadrina dehiscens s.s. (CHAPMAN, PARR and COLLINS), 1934

Pl. IV, fig. 3a-c

1934 *Globorotalia dehiscens* CHAPMAN, PARR and COLLINS, p.569, pl.11, fig.6.
1957b *Globoquadrina dehiscens* (CHAPMAN, PARR and COLLINS). BOLLI, p.111, pl.24, fig.3a-c. (non) fig.4.
1969 *Globoquadrina dehiscens* (CHAPMAN, PARR, and COLLINS). BLOW, p.341, pl.28, fig. 1.
1973 *Globoquadrina dehiscens* (CHAPMAN, PARR and COLLINS). KRASHENINNIKOV and HOSKINS, p.125, pl.16, figs.4-6.
part. 1975 *Globoquadrina dehiscens* Group. STAINFORTH et al. p.266, fig.113, 4a-c. (non) 1-3, 5,6.
1976 *Globoquadrina dehiscens s.s.* (CHAPMAN, PARR and COLLINS). QUILTY, p.644, pl.10, figs. 16-17.

Diagnosis : Test a tight quadrate coil with four strongly angular, wedge-shaped chambers in the final whorl. Spiral outline square; side profile with flat spire and conical dorsal surface. A large, conspicuous imperforate apertural face on the dorsal side of each chamber terminates in a tooth covering the slit-like aperture. Surface cancellate with pustules around the umbilicus.

Stratigraphical Distribution : BLOW (1969) gives the range as Early Miocene (N.4) to Pliocene (N.19).

Material : *G. dehiscens s.s.* is discontinuously distributed throughout the studied sequences at Sites 289 and 71. Abundance varies from very rare to very common at Site 289 and from very rare to common at Site 71.

Geographical Distribution and Palaeoecology : *G. dehiscens s.s.* has been identified from many localites worldwide and appears to be a cosmopolitan species (JENKINS, 1971; POAG, 1972; KRASHENNINNIKOV and HOSKINS, 1973).

Remarks : Various authors have included a series of intergrading morphotypes within "*G. dehiscens*" (see STAINFORTH et al. 1975). In the present study, forms consistent with the above diagnosis and similar to the holotype appear to be consistently distinct from closely related morphotypes (herein referred to to *G. langhiana* group and others; see Discussion below).

Discussion : *G. dehiscens s.s.* differs from other taxa of the genus by its tight mode of coiling and sharply angular chambers.

Globoquadrina langhiana Group

Pl. IV, fig. 4a-h

	1939	*Globigerina baroemoensis* LEROY, p.263, pl.6, figs. 1-2.
	1960	*Globoquadrina langhiana* CITA and GELATI, p.241-246, pl.29, fig.1
	1969	*Globoquadrina baroemoensis* (LEROY). BLOW, p.340-341, pl.28, figs. 4,8.
	1969	*Globoquadrina langhiana* CITA and GELATI. BLOW, p.341.
part.	1972	*Globoquadrina dehiscens* (CHAPMAN, PARR and COLLINS). JENKINS and ORR, p.1094, pl.17, figs. 8-10.
	1972	*Globoquadrina langhiana* CITA and GELATI. JENKINS and ORR, p.1095, pl.17, figs. 11-13.
part.	1975	*Globoquadrina dehiscens* Group. STAINFORTH et al., p.266, fig. 133, 1-3,5,6. (non) 4a-c.

Diagnosis : Test a regular quadrate coil with four sub-globular to angular chambers in the final whorl. Spiral outline square to subcircular; side profile with slightly convex spire and conical dorsal surface. Coiling rather loose with a rectangular umbilicus. The final chamber may possess a rounded apertural face or less often, a narrow imperforate plate, although in both cases, it terminates in a small tooth partly concealing a slit-like aperture. Surface cancellate with pustules around the umbilicus.

Stratigraphical Distribution : BLOW (1969) gives the range (of *G. baroemoensis*) as Early Miocene (N.4) to Late Miocene (N.16 "at least").

Material : *G. langhiana* group ranges continuously through the studied sequences at both Sites 289 and 71. Abundance varies from rare to abundant at Site 289 and from few to very common at Site 71.

Geographical Distribution and Palaeoecology : *G. langhiana* group has been encountered in many localities through much of the Pacific Ocean. The occurrence of the taxon in sediments from New Zealand (JENKINS, 1971), the equatorial regions (JENKINS and ORR, 1972) and the north Pacific (KRASHENINNIKOV and HOSKINS, 1973) testify to a wide distribution in low and mid-latitudes. *G. langhiana s.s.* was first described from Italy (CITA and GELATI, 1960).

Discussion : Members of the *G. langhiana* group exhibit a wide range of variation and previous authors have referred such forms to several different taxa. In the present study, loosely coiled forms with rounded inflated chambers (resembling the holotype of *G. langhiana*) appear to intergrade with more tightly coiled forms with angular chambers and well defined apertural teeth (*G. dehiscens* of authors : see synonymy and pl. IV figs. 4a-h herein).

Globoquadrina larmeui AKERS, 1955

Pl. IV, fig. 5a-b

1955 *Globoquadrina larmeui* AKERS, p.661, pl. 55, fig. 4,
1969 *Globoquadrina larmeui* AKERS. BLOW, p.341, pl.28, figs. 5-6.
1971 *Globoquadrina larmeui* AKERS. JENKINS, p.167, pl.17, figs. 522-4.
1979 *Globoquadrina larmeui* AKERS. POORE, p.470, pl.18, figs. 1-3.

Diagnosis : Test a regular quadrate coil with four sub-globular chambers in the final whorl. Spiral outline rectangular; side profile reveals dorso-ventral compression. The umbilical face of the final chamber is flat, long and extends into the centre of the dorsal surface to restrict the umbilicus to a narrow rectangle. A small tooth covers a slit-like aperture. Surface cancellate.

Stratigraphical Distribution : Early Miocene (N.6) to Pliocene (N.18) (BLOW, 1969).

Material : *G. larmeui* ranges throughout the studied sequences at Sites 289 and 71. Abundance varies from very rare to very common at Site 289 and from very rare to few at Site 71.

Geographical Distribution and Palaeoecology : Data relating to distribution is limited because of taxonomic inconsistencies (see Discussion herein). JENKINS (1971) and KENNETT (1973) have encountered the taxon in New Zealand and south west Pacific sediments respectively. The species was first described from the Gulf Coast (AKERS, 1955).

Discussion : FLEISHER (1974) following BLOW (1969) suggests *G. larmeui* developed from *G. baroemoensis* by dorso-ventral compression of the test and an increase in the size of the apertural face in the final chamber. PARKER (1967) and BRÖNNIMANN and RESIG (1971) prefer to synonymise the form with *G. dehiscens*.

Globoquadrina venezuelana Group (HEDBERG), 1937

Pl. V, fig. a-l

	1937	*Globigerina venezuelana* HEDBERG, p.681, pl.92, fig. 7.
	1957b	*Globigerina venezuelana* HEDBERG. BOLLI, p.110, pl.23, figs. 6-8.
part.	1957b	*Globoquadrina dehiscens* (CHAPMAN, PARR and COLLINS). BOLLI, p.111, pl.24, figs. 4a-c. (non fig. 3a-c).
	1967	*Globoquadrina venezuelana* (HEDBERG). PARKER, p.171, pl.26, figs. 4-10.
part.	1967	*Globoquadrina dehiscens* (CHAPMAN, PARR and COLLINS). PARKER, p.166.
	1969	*Globigerina venezuelana* HEDBERG. BLOW, p.322-323.
	1969	*Globoquadrina dehiscens advena* BERMÚDEZ. BLOW, p.514, pl.4, figs. 7-8.
	1972	*Globoquadrina advena* BERMÚDEZ. POAG, p.513, pl.8, figs.3-4.
part.	1975	*Globigerina venezuelana* HEDBERG. STAINFORTH et al., p.331, fig.151.
	1979	*Globoquadrina venezuelana* (HEDBERG). POORE. p.470, pl.14, figs.4-6.

Diagnosis : Test large, with four globular or appressed chambers in the final whorl. Spiral profile lobate to subsquare; side profile ovate. Sutures depressed. Umbilicus rectangular; aperture intraumbilical, marked by a triangular lip. Surface cancellate, though coarsely pustulose around umbilicus. Morphology highly variable (see Discussion)

Stratigraphical Distribution : BLOW (1969) gives the range of *G. venezuelana* an Early Miocene (N.3) to Pliocene (N.19.), BRÖNNIMANN and RESIG (1971) tabulate a slightly modified distribution (N.4 to N.20). *G. dehiscens advena* ranges from the Early to Middle Miocene (N.6 to N.15) (BLOW, 1969).

Material : *G. venezuelana* group is an important constituent in the planktonic foraminiferal assemblages of the present study. The taxon ranges continuously throughout the studied seuqnces and abundance varies from rare to very abundant at Site 289 and from very common to very abundant at Site 71.

Geographical Distribution and Palaeoecology : The distribution of *G. venezuelana* group is wide ranging (PARKER, 1967; POAG, 1972; BOLTOVSKOY, 1974a). In the Pacific Ocean, KRASHENINNIKOV and HOSKINS (1973) suggest a cosmopolitan distribution for *G. venezuelana s.s.* in the Miocene of tropical, subtropical and temperate areas. However, JENKINS (1971) reveals the species rare, sporadic and apparently confined to the North Island in New Zealand. Further evidence of low and mid-latitude restriction is afforded by the distribution charts of INGLE (1973) for the north east Pacific Ocean.

Discussion : BOLLI (1957b) has commented on the considerable variation of chamber size and shape in *G. venezuelana s.s.* In the present study, this range of variation appears to transgress established taxonomic boundaries. Individuals referrable to *G. venezuelana s.s.* possesses a lobate spiral outline, a convex spiral surface,

with inflated globular chambers of which the ultimate is somewhat appressed. The apertural face of the chambers of the dorsal surface is partly curved and the umbilicus is wide (Pl. V, fig. a-e). Central forms in the plexus possess a similar lobate spiral outline although the test is slightly dorso-ventrally compressed so that the spiral surface is flat. In dorsal view, the apertural face of the chambers is wide and flat and the umbilicus is narrow (Pl. V, fig. f-i). Forms referrable to *G. dehiscens advena* show the tightest mode of coiling. The spiral outline is subsquare and the spiral surface is flat. The chambers are appressed, dorso-ventrally elongate with the dorsal apertural face flat, well defined and forming an acute angle with the chamber top in side view. The umbilicus is narrow and elongate (Pl. V, fig. j-l). The three morphotypes described above appear to intergrade within single samples although each type may dominate the populations at particular horizons. The continuous range or variation inhibits consistent taxonomic differentiation and the morphotypes are herein grouped together. High magnification studies of wall textures reveal no major differences between the forms.
PARKER has commented on similar morphological, similarities between *G. venezuelana* and *G. dehiscens s.l.* (1967, p.167, 168, 171). JENKINS and ORR (1972) suggest that *G. venezuelana* is highly solution resistant.

Genus : *GLOBIGERINITA* BRÖNNIMANN, 1951

Globigerinita sp. cf. *G. glutinata flparkerae* BERMÚDEZ, 1960

Pl. VI, fig. 1a-c

cf. 1960 *Globigerinoides parkerae* BERMÚDEZ, p.1232, pl.10, figs. 10-11.

part. 1971 *Globigerinita glutinata* (EGGER) *flparkerae* (BERMUDEZ) nom. nov. BRÖNNIMANN and RESIG, p.1303, text fig. 15,c-d. (non) text. fig.15,a-b; pl.23, figs. 1-4;

Stratigraphical Distribution : Middle Miocene (N.13) to Recent (N.23) (BRÖNNIMANN and RESIG, 1971).

Material : At Site 289 the taxon ranges from the Middle Miocene (N.13) to beyond the upper limit of the studied sequence. Distribution is sparce and discontinuous and abundance varies from very rare to rare.

Discussion : Specimens encountered at Site 289 possess a cancellate surface texture and a small dorsal supplementary aperture similar to the specimen illustrated by BRÖNNIMANN and RESIG (1971, text fig. 15,c-d.) but unlike the remaining forms possessing a smooth to finely hispid surface texture characteristic of *G. glutinata s.l.* (BRÖNNIMANN and RESIG, 1971, text fig.15,a-b, pl.23, figs. 1-4; pl.50, fig.6).

Globigerinita naparimaensis Group BRÖNNIMANN, 1951

Pl. VI, fig. 2a-c

1911 *Globigerina glutinata* RHUMBLER, pl.29, figs. 14-26; pl.33, fig.20; pl.34, fig.1.

1951 *Globigerinita naparimaensis* BRÖNNIMANN, p.16-18, figs. 1-14.

part. 1955 *Globigerinita incrusta* AKERS, p.286, p.655, pl.65, fig.2.

1957b *Globigerina juvenilis* BOLLI, p.110, pl.24, figs. 5a-b.

1962 *Globigerinita glutinata* (EGGER). PARKER, p.246-249, pl.9, fig.1-16.

1969 *Globigerinita ambitacrena* (LOEBLICH and TAPPAN). BLOW, p.327.

1969 *Globigerinita incrusta* AKERS. BLOW, p.328, pl.24, fig. 3.

1969 *Globigerina juvenilis* BOLLI. BLOW, p.320, pl.17, figs. 5-6.

1969 *Globigerinita naparimaensis* BRÖNNIMANN. BLOW, p.328-329.

1975 *Globigerinita incrusta* AKERS. STAINFORTH et al. p.289, fig.124.

1975 *Globigerinita naparimaensis* BRÖNNIMANN. STAINFORTH et al. p.295, fig.129.

Diagnosis : Test a small, ovate trochospire with three to four inflated chambers in the final whorl, increasing regularly in size. Sutures faint. Profile lobulate. Umbilicus small, usually covered by a bulla. Non-bullate specimens reveal a long elongate slit-like aperture bordered by a thin lip and interiomarginal in position. Bulla variable, ranging from an inflated chamberlet with one to four apertures to appressed sheet spreading along sutures on umbilicus side and bordered by small raised openings. Surface smooth or finely hispid with fine perforations.

Discussion : The above diagnosis encompasses a plexus of closely related forms which exhibit continuous variation in the present study and which have been subject to a considerable amount of taxonomic splitting (see above synonymy). STAINFORTH et al. (1975) have attempted to stabilise the group by including most forms under *G. naparimaensis*. In the present study, and following POORE (1979), *G. incrusta* and *G. juvenilis* are also included within the taxon. The plexus consists of a group of forms all showing similar chamber arrangement and wall texture. Variation involves the absence *(G. juvenilis)* or presence (all other 'taxa') of a umbilical bulla and the nature of this enigmatic structure (see Pl. VI, fig. 2a-c). The stratigraphic ranges of the various morphotypes as given by BLOW (1969) and BRÖNNIMANN and RESIG (1971) are identical in almost all cases (Early Miocene : N.4 to Recent : N.23).

Stratigraphical Distribution : STAINFORTH et al. (1975) give a combined range of *G. incrusta* and *G. naparimaensis s.l.* as Early Miocene to Holocene.

Material : At Site 289, *G. naparimaensis* group ranges from the Middle Miocene (N.11-12) to beyond the upper limit of the studied sequence. Distribution is discontinuous. At Site 71, the species is present in three samples from the Middle Miocene (N.11-12).

Geographical Distribution and Palaeoecology : BRADSHAW (1959) records the species (as *G. glutinata*) throughout the surface waters of the Pacific Ocean, from the tropics to subarctic water, although abundance is greatest in the former region. A wide distribution in the past is evident from the recorded occurrences of fossil representatives in Pacific sediments (JENKINS, 1971; JENKINS and ORR, 1972; INGLE, 1973).

Remarks : The reader is referred to the works of BLOW (1969), FLEISHER (1974) and STAINFORTH et al. (1975) for an appraisal of the biological and geological significance and relationship of the various 'taxa' within the plexus. STAINFORTH et al (1975) have reviewed the taxonomic history of the group.

Family : *GLOBIGERINIDAE* CARPENTER, PARKER and JONES, 1862

Genus : *GLOBIGERINA* d'ORBIGNY, 1826

Globigerina apertura CUSHMAN, 1918

Pl. VI, fig. 3

1918 *Globigerina apertura* CUSHMAN, p.138, pl.15, figs. 426-427.
1972 *Globigerina apertura* JENKINS and ORR, p.1086, pl.5, figs.1-3.

Stratigraphical Distribution : Late Miocene (N.16) to Pliocene (N.19) (BLOW (1969) as *G. bulloides apertura)*.

Material : Present in one sample, in very rare abundance, from the Middle Miocene (N.15) at Site 289.

Discussion : The characteristic large aperture with coarsely cancellate and pustulose surface serve to differentiate this species.

Globigerina bulbosa LEROY, 1944

Pl. VI, fig. 4

1944 *Globigerina bulbosa* LEROY, p.39, pl.3, fig. 26-27.
1969 *Globigerina bulbosa* LEROY. BLOW, p.316, pl.13, figs. 3-6.
1973 *Globigerina bulbosa* LEROY. KRASHENINNIKOV and HOSKINS, p.128, pl.6, figs.9-11.

Diagnosis : Test a flattened trochospire with four bulbous chambers in the final whorl, increasing in size rapidly so that the final chamber is elongate. Spiral view subquadrate. Aperture umbilical in position, slit-like and bordered by a narrow imperforate lip. Surface finely porous and hispid.

Stratigraphical Distribution : BLOW (1969) gives the range as Middle to Late Miocene (N.11 to N.16-?N17).

Material : At Site 289 *G. bulbosa* occurs in four closely spaced samples within the Middle Miocene (N.11-12). Abundance is always very rare.

At Site 71, the species is present in two samples within Zone N.11-12. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : KRASHENINNIKOV and HOSKINS (1973) suggest a wide geographical range for the species in the Pacific region.

Globigerina bulloides d'ORBIGNY, 1826

Pl. VI, fig. 5

part.	1791	*"Polymorphidium tuberosumetglobiferum"* SOLDANI, p.117, pl.123, fig.O. (non) figs. H,I,P.
	1826	*Globigerina bulloides* d'ORBIGNY. list no.1.
	1960b	*Globigerina bulloides* d'ORBIGNY. BANNER and BLOW, p.3, pl.1, figs. 1,4, (lectotype).
	1969	*Globigerina bulloides* d'ORBIGNY. BLOW, p.316, pl.14, figs.1,2.
	1971	*Globigerina bulloides* d'ORBIGNY. BRÖNNIMANN and RESIG, p.1292, fig.5, pl.6, fig.3.

Diagnosis : Test a low trochospire with four inflated, subglobular chambers in final whorl. Spiral profile lobate; side profile ovate. Sutures depressed, radial. Umbilicus open and deep. Aperture interiomarginal, a large symmetrical arch. Surface smooth and finely porous between short spine bases, i.e. hispid.

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (N.16) to Recent (N.23). BRÖNNIMANN and RESIG (1971) extend the lower range into the Middle Miocene (N.15).

Material : At Site 289, *G. bulloides* occurs in a short, discrete stratigraphical interval within Zone N.17 of the Late Miocene. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : BE´ (1977) regards extant *G. bulloides* as one of the most successful and ubiquitous species of planktonic foraminifera. It occurs predominantly in subpolar regions with highest densities in the southern hemisphere between 35°S and 50°S. The taxon is also commonly encountered in upwelling areas of low latitudes (BE´, 1977). Fossil distributions appear to reflect this modern trend. In the equatorial Pacific, JENKINS and ORR (1972) report only rare and sporadic occurrences in Neogene sediments. KENNETT (1973) regards the species as characteristic of temperate faunas in the Late Miocene of the south west Pacific while JENKINS (1971, 1975) indicates a high incidence of the species in New Zealand and Southern Ocean planktonic foraminiferal assemblages of Neogene age.

Globigerina calida praecalida BLOW, 1969

Pl. VI, fig. 6

1969 *Globigerina calida praecalida* BLOW, p.317, 380-381, pl.13, figs.6,7; pl.14,fig.3.

Diagnosis : Test a low trochospire with four to four and a half inflated, well separated chambers in the final whorl. Sutures depressed, incised and radial.

Spiral outline subquadrate. Umbilicus wide, open and deep. Aperture a low arch with a narrow imperforate lip, umbilical/extraumbilical in position. Surface hispid.

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (N.17) to Recent (N.23). BRÖNNIMANN and RESIG (1971) tabulate the lower range into Zone N.16.

Material : *G. calida praecalida* ranges from the Middle Miocene (N.14) to beyond the upper limit of the studied sequence at Site 289. Distribution is discontinuous and abundance is always very rare.

Globigerina decoraperta TAKAYANGI and SAITO, 1962

Pl. VII, fig. 1a-b

1962 *Globigerina druryi decoraperta* TAKAYANAGI and SAITO, p.85, pl.28, fig.10.

1969 *Globigerina decoraperta* TAKAYANAGI and SAITO. BLOW, p.318.

1972 *Globigerina decoraperta* TAKAYANAGI and SAITO. JENKINS and ORR, p.1087, pl.6, figs. 4-6.

Diagnosis : Test a compact, low trochospire with four chambers in the final whorl. Spiral outline lobate; side profile subquadrate and rounded. Sutures incised, radial. Umbilicus narrow. Aperture a moderately large hemisphere bordered by a lip and umbilical in position. Surface cancellate and pustulose.

Stratigraphical Distribution : Middle Miocene (?N.13/N.14) to Pliocene (N.21) (BLOW, 1969). BRÖNNIMANN and RESIG (1971) tabulate a slightly modified range (N.14 to N.22).

Material : *G. decoraperta* is present in five samples from the Late Miocene (N.16 to N.17) at Site 289. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : *G. decoraperta* seems to have a widespread distribution in Pacific Ocean sediments, having been recorded in both low and high latitudes (BRÖNNIMANN and RESIG, 1971; INGLE, 1973 respectively). KENNETT (1973) includes *G. decoraperta*, together with *G. nepenthes*, *G. bulloides*, *G. falconensis* and *G. woodi* as characteristic of temperate faunas of the Late Miocene in the south west Pacific Ocean. The taxon has been recorded (as *G. woodi decoraperta*) in sediments of the Southern Ocean (JENKINS, 1975).

Discussion : *G. decoraperta* appears to intergrade with *G. nepenthes* at Site 289. STAINFORTH et al. (1975) refer to the wide range of variation associated with the latter taxon.

Globigerina falconensis BLOW, 1959

Pl. VI, fig. 7a-b

1959	*Globigerina falconensis* BLOW, p.177, pl.19, figs. 40-41.
1969	*Globigerina falconensis* BLOW. BLOW, p.319, pl.16. fig.1.
1971	*Globigerina falconensis* BLOW. BRÖNNIMANN and RESIG, p.1295, pl.3, figs.1-2, 4-8.

Diagnosis : Test a low trochospire with four subspherical chambers in the final whorl.. Spiral profile lobate; side profile rounded. Sutures depressed. Umbilicus small but deep. Aperture a low arch bordered by a well developed lip. Wall heavily built; coarsely perforate and pustulate.

Stratigraphical Distribution : BLOW (1969) gives the range as Early Miocene (N.7) to Recent (N.23). BRÖNNIMANN and RESIG (1971) extend the lower range into Zone N.6.

Material : At Site 289, *G. falconensis* appears to range throughout the studied sequence although distribution is sparce and discontinuous, with almost all occurrences within Zone N.17 of the Late Miocene. Abundance varies from very rare to rare.

At Site 71, the species is present in two samples, in very rare abundance, from Zone 11-12 of the Middle Miocene.

Geographical Distribution and Palaeoecology : PARKER (1962) records *G. falconensis* mainly between 20°S and 50°S in Recent sediments of the south Pacific Ocean. KENNETT (1973) regards the species as characteristic of temperate planktonic faunas in the south west Pacific during the Late Miocene while JENKINS and ORR (1972) record the taxon as very rare in equatorial regions.

Globigerina foliata BOLLI, 1957

Pl. VI, fig. 8a-b

1957b *Globigerina foliata* BOLLI, p.111, pl.24, fig.1a-c.
1969 *Globigerina foliata* BOLLI, BLOW, p.319, pl.16, figs.2-3.

Diagnosis : Test a low trochospire with four discrete chambers in the final whorl all rapidly increasing in size. Spiral profile lobate; side profile rounded. Sutures depressed. Aperture a low arch with a thin lip, interiomarginal/umbilical in position. Umbilicus small. Surface cancellate to finely pitted.

Stratigraphical Distribution : BLOW (1969) gives the range as Early Miocene (N.6) to Pliocene (N.18).

Material : At Site 289, *G. foliata* ranges from the Middle Miocene (N.11-12) to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare and distribution is discontinuous.

At Site 71, the species is present in six samples from the Middle Miocene (N.11-12) within a similar range of abundance.

Geographical Distribution and Palaeoecology : *G. foliata* appears to be widely distributed in Pacific Ocean sediments although abundance is usually reported as rare (JENKINS, 1971 for New Zealand; JENKINS and ORR, 1972 for equatorial regions).

Globigerina nepenthes TODD, 1957

Pl. VI, fig. 9

1957 *Globigerina nepenthes* TODD, p.301, pl.78, fig.7.
1969 *Globigerina nepenthes* TODD. BLOW, p.320, pl.14, fig.5.
1975 *Globigerina nepenthes* TODD. STAINFORTH et al. p.378,, fig.183-184.

Diagnosis : Test a small, compact high or low trochospire with four to five chambers in the final whorl. An elongate final chamber protrudes obliquely, producing a variable profile. Sutures indistinct. Umbilicus narrow; aperture a broad arch bordered by a thick rim, in umbilical position. Surface coarsely perforate and pitted.

Stratigraphical Distribution : According to BLOW (1969), *G. nepenthes* ranges from the base of Zone N.14 of the Middle Miocene to within Zone N.19 of the Pliocene.

Material : At Site 289, the initial appearance of *G. nepenthes* is used to define the base of Zone N.14. The species appears to range beyond the upper limit of the studied sequence although occurrence becomes very sparce and discontinuous in the Late Miocene interval. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : *G. nepenthes* has a nearly worldwide distribution (STAINFORTH et al., 1975). In Pacific Ocean sediments the species has been reported in low and high latitudes (BRÖNNIMANN and RESIG, 1971; INGLE, 1973 respectively). KENNETT (1973) suggests the taxon is characteristic of temperate planktonic faunas in the south west Pacific during the Late Miocene.

Globigerina praebulloides Group BLOW, 1959

1959	*Globigerina parabulloides* BLOW, p.179, pl.10, figs. 46a-c.
1959	*Globigerina praebulloides* BLOW, p.180, pl.8, figs. 47a-c; pl.9, fig.48.
1975	*Globigerina parabulloides* BLOW. SRINIVASAN, p.137, pl. 1, fig.8.
1975	*Globigerina praebulloides* BLOW. SRINIVASAN, p.137, pl.1, fig.7.
1976	*Globigerina praebulloides* group. QUILTY, p.638, pl.3, figs. 15-16.

Diagnosis : Test a low trochospire with usually four inflated chambers in the final whorl, increasing rapidly in size as added. Spiral profile lobate; side profile rounded. Sutures depressed to incised. Umbilicus small and shallow. Aperture a low to moderate arch, with or without a distinct lip and interiomarginal/umbilical in position. Surface weak to strongly cancellate.

Stratigraphical Distribution : BLOW (1969) gives a combined range (for *G. praebulloides s.s.* and *G. parabulloides*) as Late Eocene (P.16) to Pliocene (N.22).

Material : At Site 289, *G. praebulloides* group ranges from beyond the lower limit of the studied sequence to the Late Miocene (N.17). Distribution is discontinuous and abundance varies from very rare to rare.

At Site 71, the taxon is present in one sample, in rare abundance, from the Middle Miocene (N.11-12).

Geographical Distribution and Palaeoecology : KRASHENINNIKOV and HOSKINS (1973) report *G. parabulloides* as common in Pacific tropical, subtropical and temperate regions. *G. bulloides s.l.* (including *G. parabulloides* and *G. praebulloides*) is an important constituent in New Zealand Miocene planktonic assemblages (JENKINS, 1971).

Discussion : *G. praebulloides* group herein consists of a number of simple globigerine forms with cancellate well textures. Variation involves the size of the aperture, the presence or absence of an apertural lip and the degree of chamber inflation. Morphological intergradation deemed consistant discrimination of the various forms extremely difficult.

Genus : *GLOBIGERINELLA* CUSHMAN, 1927

Globigerinella aequilateralis (BRADY), 1879

Pl. VIII, fig. 13a-b

1879	*Globigerina aequilateralis* BRADY, p.285.
1927	*Globigerinella aequilateralis* (BRADY). CUSHMAN, p.87.
1960a	*Hastigerina (H.) siphonifera* (d'ORBIGNY). BANNER and BLOW, p.22, text-fig. 2a-c (lectotype).

1960a	*Globigerina aequilateralis* BRADY. BANNER and BLOW, p.23, text-fig. 31-c (lectotype).
1969	*Hastigerina (H.) siphonifera siphonifera* (d'ORBIGNY). BLOW, p.375.
1969	*Hastigerina (H.) siphonifera praesiphonifera* BLOW, p.408, pl.54, figs. 7-9.
1971	*Globigerinella aequilateralis* (BRADY). JENKINS, p.77, pl.2, figs. 47-49.

Diagnosis : Test with an initial trochospiral coil which becomes planispiral before or in the final whorl. The chambers are inflated and globose. The aperture is umbilical - extraumbilical and arched or lies across the lateral margin of the test to connect both umbilici and is slit-like. Surface finely perforate and pustulate.

Stratigraphical Distribution : BLOW (1969) records the species (as *H. siphonifera s.l.*) from the Early Miocene (N.7) to Recent (N.23). A similar range was tabulated by BRÖNNIMANN and RESIG (1971).

Material : At 289, *G. aequilateralis* ranges from the Middle Miocene (N.13) to beyond the upper limit of the studied sequence. Abundance varies from very rare to few.

At Site 71, the species is present in very rare abundance in one sample from the Middle Miocene.

Geographical Distribution and Palaeoecology : BRADSHAW (1959) records highest frequencies of extant individuals in equatorial waters of the Pacific Ocean. However, BOLTOVSKOY (1974a) implies a preference of fossil forms to warm temperate regions in the Indian Ocean. In addition, JENKINS (1975) records the species in Southern Ocean sediments in the absence of known warm water forms such as *Globigerinoides* spp. *G. aequilateralis* has been recorded in Atlantic Ocean sediments by SALVATORINI and CITA (1979).

Discussion : BLOW (1969) described and erected a subspecies (*H. siphonifera praesiphonera*) to amplify the evolutionary relationship between *G. (T.) obesa* and *G. aequilateralis*, although such forms have been herein included within the latter species. The discrepant stratigraphical range between that offered by BLOW (1969) and that apparent at Site 289 may be due to subjective discrimination of morphotypes within the *G. obesa/G. aequilateralis* transition in the present study.

Remarks : The reader is referred to the works of PARKER (1962) and JENKINS (1971) with regard the steps by BANNER and BLOW (1960a) over lectotype designation and taxonomic nomenclature in this species.

Genus : *GLOBIGERINOIDES* CUSHMAN, 1927

Globigerinoides bollii BLOW, 1959

Pl. VII, fig. 2a-b

1959 *Globigerinoides bollii* BLOW, p.189, pl.10. fig. 65a-c.
1972 *Globigerinoides bollii* BLOW. JENKINS and ORR, p.1091, pl.4, figs.1-3.

Diagnosis : Test small with four tightly coiled chambers in the final whorl. Spiral and side profile ovate. Sutures depressed, straight or slightly curved. Umbilicus small and contains a hemispherical primary aperture. One or two supplemementary apertures are small and sutural in position. Test surface coarsely granular.

Material : Three single occurrences (very rare) within the Middle Miocene (N.11-12 to N.15) at Site 289.

Geographical Distribution and Palaeoecology : Distributional data for this rare taxon is scarce. In Pacific Ocean sediments, the species has been tabulated from mid-latitude south west and north east localities (KENNETT, 1973 and INGLE, 1973 respectively).

Globigerinoides mitra TODD, 1957

Pl. VII, fig.7

1957	*Globigerinoides mitra* TODD, p.302, pl.78, figs. 3,6.
1957b	*Globigerinoides mitra* TODD. BOLLI, p.114, pl.26, figs 1a-4.
1973	*Globigerinoides mitra* TODD. KRASHENINNIKOV and HOSKINS, p.125, pl.14, figs. 1-2.
1974a	*Globigerinoides mitra* TODD. BOLTOVSKOY, p.704, pl.5, figs. 1-2.

Diagnosis : Test a high trochospire with four globular chambers in the final whorl. Spiral outline lobate; side profile highly conical and lobate. Primary aperture a low to high arch; secondary aperture(s) single or double of variable size and shape. Final chambers may be hemispherical or elongate thumb-shaped. Sutures incised. Surface cancellate.

Stratigraphical Distribution : Early to Middle Miocene (BOLTOVSKOY, 1974a).

Material : At Site 289, *G. mitra* ranges within the Middle Miocene (Zone N.11-12 to Zone N.14). Abundance varies from very rare to rare and distribution is discontinuous.

At Site 71, the species is present in one sample, in rare abundance, from the Middle Miocene (N.11-12).

Geographical Distribution and Palaeoecology : KRASHENINNIKOV and HOSKINS (1973) refer to both Atlantic and Pacific Ocean occurrences. The species appears to display a preference for warm water localities in Indian Ocean sediments (BOLTOVSKOY, 1974a).

Discussion : *G. mitra* is closely related to the *G. obliquus/G. subquadratus* stock but possesses a much higher trochospire and aberrant final chamber (BOLLI, 1957b; STAINFORTH et al. 1975). At Site 289, the extinction levels of *G. mitra* and *G. subquadratus* almost coinside. Reference to *G. mitra* in Late Miocene to Pliocene sediments are probably homeomorphs derived from *G. ruber s.s.* (e.g. POAG, 1972).

Globigerinoides obliquus obliquus BOLLI, 1957

Pl. VII, fig. 3a-b

1957b	*Globigerinoides obliqua* BOLLI, p.113, pl.25, figs. 9.10.
1969	*Globigerinoides obliquus obliquus* BOLLI. BLOW, p.324.
1975	*Globigerinoides obliquus* BOLLI. STAINFORTH et al. p.385, fig. 188.

Diagnosis : Test with three or four inflated chambers in the final whorl, the last two of which are obliquely appressed. Spiral (equatorial) outline lobate; side profile conical with high or low spire. Sutures depressed. The primary aperture is a high asymmetrical arch which reflects the chamber appression. Supplementary apertures may be double or single but are much smaller. Surface finely pitted.

Stratigraphical Distribution : BLOW (1969) gives the range as Miocene (N.5) to Pleistocene (N.22). BRÖNNIMANN and RESIG (1971) tabulate the taxon to within the Holocene (N.23).

Material : At Site 289, *G. obliquus s.s.* ranges almost continuously from the Middle Miocene (N.10) to beyond the upper limit of the studied sequence. Abundance varies from very rare to abundant.

At Site 71, the subspecies occurs sporadically within the Middle Miocene sequence (N.11-12). Abundance varies from very rare to few.

Geographical Distribution and Palaeoecology : STAINFORTH et al. (1975) suggest an almost worldwide distribution for *G. obliquus s.l.* In Pacific Ocean sediments, KRASHENINNIKOV and HOSKINS (1973) record a wide geographical range for *G. obliquus s.s.* although KENNETT (1973) relates incursions of the species into south west Pacific sediments as indicative of warm conditions, suggesting a low latitude preference.

Globigerinoides obliquus extremus BOLLI and BERMÚDEZ, 1965

Pl. VII, fig. 4a-b

1965	*Globigerinoides obliquus extremus* BOLLI and BERMÚDEZ, p.139, pl.1, figs. 10-12.
1969	*Globigerinoides obliquus extremus* BOLLI and BERMÚDEZ. BLOW, p.324, pl.21, figs.2-3.
1975	*Globigerinoides extremus* BOLLI and BERMÚDEZ. STAINFORTH et al., p.351, fig.165.

Diagnosis : Test a high trochospire with three or four chambers in the final whorl, all of which show increasingly oblique appression so that the final chamber is mitriform. Spiral profile lobate; side profile conical with an elevated spiral surface. Sutures incised. The primary aperture is a high asymmetrical arch reflecting the chamber appression. Smaller supplementary apertures may be double or single and sutural in position. Surface pitted to pustulose.

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (N.16) to Pliocene (N.21) although BRÖNNIMANN and RESIG (1971) extend the lower range into the Middle Miocene (N.14).

Material : At Site 289, *G. obliquus extremus* ranges from the Late Miocene (N.16) to beyond the upper limit of the studied sequence. Abundance varies from very rare to few and distribution is continuous.

Geographical Distribution and Palaeoecology : Comments regarding *G. obliquus s.s.* are almost certainly pertinent to this closely related subspecies.

Discussion : *G. obliquus extremus* evolved from *G. obliquus s.s.* by an earlier ontogenetic appearance of obliquely appressed chambers and the development of a mitriform final chamber. (STAINFORTH et al., 1975).

Globigerinoides quadrilobatus triloba (REUSS), 1850

Pl. VII, fig. 8

1850 *Globigerina triloba* REUSS, p.347, pl.47, fig.11.
1940 *Globigerinoides triloba* (REUSS). CORYELL and RIVERO, p.340.

1969	*Globigerinoides quadrilobatus trilobus* (REUSS). BLOW, p.326.
1969	*Globigerinoides quadrilobatus immaturus* LEROY. BLOW, p.325.
1969	*Globigerinoides quadrilobatus quadrilobatus* (d'ORBIGNY). BLOW, p.325.
1975	*Globigerinoides quadrilobatus triloba* (REUSS). STAINFORTH et al., p.310, fig.138.

Diagnosis : Test a low trochospire with three or four subspherical chambers in the final whorl. Spiral outline ovate, with an incised suture forming a medium line between the final and preceding chambers. Primary aperture a simple arch; supplementary apertures slit-like along spiral suture. Surface coarsely cancellate.

Stratigraphical Distribution : *G. quadrilobatus s.s.* and *G. q. trilobus* range from the Early Miocene (N.4 and N.6 respectively) to Recent (N.23) (BLOW, 1969).

Material : *G. q. triloba* ranges continuously throught the studied sequences at both Sites 289 and 71. Abundance varies from rare to very abundant at Site 289 and from rare to common at Site 71.

Geographical Distribution and Palaeoecology : Most workers of Recent planktonic foraminiferal ecology treat extant populations of *G. q. triloba* within *G. q. sacculifer* (BRADSHAW, 1959; BÉ 1977). Comments on the Recent ecology of this latter taxon made herein are therefore also pertinent to the former. Fossil *G. q. triloba* populations developed a worldwide distribution and were apparently more tolerant than most planktonic foraminifera of environmental variation (STAINFORTH et al., 1975). A widespread distribution in Pacific Ocean sediments is suggested from JENKINS and ORR (1972) KENNETT (1973) and

JENKINS (1971) who record the taxon in low and middle latitudes. JENKINS (1975) however, reports the subspecies generally rare in the Neogene sediments of the Southern Ocean. In temperate areas of the Indian Ocean, BOLTOVSKOY (1974a) has suggested the distribution of the taxon in high latitude localities was restricted by cool palaeotemperatures.

Discussion : The wide range of variation apparent in the present study for *G. q. triloba* encompasses the taxa *G. quadrilobatus s.s.* and *G. q. immaturus;* it was found impossible to consistantly separate three from four chambered forms, and those with reduced final chambers, which are herein regarded as kummerform varients.

It was noticeable that as the relative abundance of *G. q. triloba* increased gradually through the Middle to Late Miocene at Site 289, so to did the mean size of individuals, although this observation has not been quantified.

Globigerinoides quadrilobatus sacculifer (BRADY), 1877

Pl. VII, fig. 9

1877	*Globigerina sacculifera* BRADY, p.535, based on figure of *Globigerina helicina* CARPENTER (non d'ORBIGNY) 1862, pl.12, fig.11.
1930	*Globigerinoides sacculifera* (BRADY). CUSHMAN and JARVIS, p.366, pl.34, fig.4.
1969	*Globigerinoides quadrilobatus sacculifer* (BRADY), *forma typica*. BLOW, p.326.
1975	*Globigerinoides quadrilobatus sacculifer* (BRADY). STAINFORTH et al., p.307, fig.137 (incl. extensive synonymy).

Diagnosis : Test morphologically the same as *G. q. triloba* except the final chamber is prolonged into a thumb or almond shaped form with high arched apertures.

Stratigraphical Distribution : BLOW (1969) gives the range of *G. q. sacculifer forma typica* as Early Miocene (N.6) to Recent (N.23) (see Remarks herein).

Material : *G. q. sacculifer* ranges throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to very common at Site 289 where the distribution is almost continuous and from rare to few at Site 71.

Geographical Range and Palaeoecology : BÉ (1977) records extant *G. q. sacculifer* (including *G. q. triloba*) as the most prolific tropical species, whose peak abundance occurs in a circumglobal belt between 20°N and 20°S. Its distributional limits coincide approximately with the 50°N and 40°S latitudes in the Pacific Ocean. STAINFORTH et.al. (1975) regard *G. q. sacculifer* as widespread in post-Oligocene assemblages. In sediments of the Pacific Ocean, the subspecies has been perpetually recorded (PARKER, 1962, 1967; BRÖNNIMANN and RESIG, 1971; JENKINS and ORR, 1972; KENNETT, 1973). However, JENKINS (1971) explains the rarity of the taxa in the New Zealand Miocene by assuming that climatic conditions were too cool, allowing only infrequent incursions of the subspecies from the north. No record of *G. q. sacculifer* exists in Southern Ocean sediments (JENKINS, 1975).

Remarks : BLOW (1969) distinquished a Neogene morphotype *G. q. sacculifer forma typica*, from a form restricted to the Quaternary, *G. q. sacculifer forma* α.

Globigerinoides ruber (d'ORBIGNY), 1839

Pl. VII, fig. 6

	1839	*Globigerina rubra* d'ORBIGNY, p.82, pl.4, figs. 12-14.
	1967	*Globigerinoides ruber* (d'ORBIGNY). CORDEY, p.647-659, fig.1-3, pl.103, figs.7-15.
	1969	*Globigerinoides ruber* (d'ORBIGNY). BLOW, p.326, pl.21, fig.4,7.
part.	1975	*Globigerinoides ruber* (d'ORBIGNY) s.l. STAINFORTH et al., p.310, fig.139, 3-5. (non) fig. 139, 1-2, 6-7.

Diagnosis : Similar in outward appearance to *G. subquadratus* except that there are three instead of four chambers in the penultimate whorl (CORDEY, 1967).

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (N.16) to Recent (N.23). BRÖNNIMANN and RESIG (1971) record a similar distribution in the western equatorial Pacific Ocean.

Material : At Site 289, *G. ruber* ranges from the Late Miocene (within N.16) to beyond the upper limit of the studied sequence. Distribution is discontinuous and abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology : BÉ (1977) records extant *G. ruber* as the most successful warm water species both in terms of distribution and abundance in ocean waters as well as surface sediments, with peak abundance occurring in subtropical regions. The distribution of fossil forms in Pacific Ocean sediments is widespread. JENKINS and ORR (1972) in equatorial regions and JENKINS (1971), KENNETT (1973), INGLE (1973) and JENKINS (1975) in mid-and high latitudes all record the species.

Discussion : *G. ruber* is believed to have evolved from *G. obliquus* during the Late Miocene (CORDEY, 1967; STAINFORTH et al., 1975).

Globigerinoides seigliei BERMÚDEZ and BOLLI, 1969

Pl. VII, fig. 10a-c

1969 *Globigerinoides ruber siegliei* BERMÚDEZ and BOLLI, p.164, pl.8, figs.10-12.
1977 *Globigerinoides seigliei* BERMÚDEZ and BOLLI. BERGGREN, p.594, pl.1, figs.13-18.
1979 *Globigerinoides seigliei* BERMÚDEZ and BOLLI. POORE, p.470, pl.3, figs. 10-12.

Diagnosis : Test large, thin walled with three to four globular chambers in the final whorl. The primary aperture is a large arch; smaller secondary aperture(s) may be single or double and of variable size. Sutures incised. Spiral outline subquadrate; side outline ovate. Surface coarsely perforate, strongly pustulose though rather fragile.

Stratigraphical Distribution : *G. siegliei* was originally described from sediments later interpreted by BERGGREN (1977) to be of early Pliocene age. BERGGREN himself (1977) tabulates the species from the Middle Miocene (N.11) to Early Pliocene.

Material : At Site 289, *G. seigliei* ranges from the Late Miocene (N.16) to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare and distribution is discontinuous.

At Site 71, the species is present in one sample, in very rare abundance, from the Middle Miocene (N.11-12).

Discussion : All known previous accounts of *G. seigliei* have been from the Atlantic Ocean or margins.

Globigerinoides subquadratus BRÖNNIMANN, 1954

Pl. VII, fig. 5a-b

	1954	*Globigerinoides subquadratus* BRÖNNIMANN, in TODD et al., p.680, pl.1, fig.5,8.
	1957b	*Globigerinoides rubra* d'ORBIGNY. BOLLI, p.113, pl.25, figs.12a-13b, text-fig. 21, no.6.
	1967	*Globigerinoides subquadratus* BRÖNNIMANN. CORDEY, p.650, figs.1-2, pl.103, figs.1-4.
	1969	*Globigerinoides subquadratus* BRÖNNIMANN. BLOW, p.326-327, pl.21, figs.5-6.
part.	1975	*Globigerinoides ruber* (d'ORBIGNY) s.l. STAINFORTH et al., p.310, fig.139, 1-2,6-7. (non) fig.139, 3-5.

Diagnosis : Test a high or low trochospire with three and a half subglobular chambers in a loosely coiled final whorl. Spiral outline subquadrate; side view subquadrate to conical. Sutures depressed to incised. Primary aperture is a large high symmetrical arch; smaller secondary apertures, usually numbering two in latter chambers, are situated along the spiral suture. Surface coarsely cancellate.

Stratigraphical Distribution : BLOW (1969) gives the range as Early to Middle Miocene (N.5 to N.13). BRÖNNIMANN and RESIG (1971) extend the lower range into Zone N.4.

Material : At Site 289, *G. subquadratus* ranges from beyond the lower limit of the studied sequence into the late Middle Miocene (N.15) where distribution is discontinuous.

At Site 71 the species is present in all samples from the Middle Miocene (N.11-12). Abundance varies from very rare to few at both Sites.

Geographical Distribution and Palaeoecology : *G. subquadratus* is relatively widespread in Pacific Ocean sediments and has been recorded by BRÖNNIMANN and RESIG (1971) and KRASHENNIKOV and HOSKINS (1973) in low and mid-latitudes. JENKINS (1960, 1975) encounters the species (as *G. ruber*) within Early and Middle Miocene sediments of Australia and the Southern Ocean respectively, although abundance is always rare.

Discussion : *Globigerinoides ruber* (d'ORBIGNY), ranging from the Late Miocene to Recent, and a close homeomorph of *G. subquadratus*, has served to confuse previous authors (see BOLLI, 1957b and synonymy herein). CORDEY (1967) however has demonstrated ontogenetic, phylogenetic and stratigraphical differences between the two species (see *G. ruber* herein). *G. subquadratus* is believed to have developed from *G. q. altiapertura* in the Early Miocene whilst *G. ruber* evolved from *G. obliquus* during the Late Miocene (CORDEY, 1967). The stratigraphic gap between the extinction of *G. subquadr atus* and the appearance of *G. ruber* is well demonstrated at Site 289. In spite of the work of CORDEY (1967), several subsequent workers have continued to include *G. subquadratus* under *G. ruber s.l.* (JENKINS and ORR, 1972; STAINFORTH et al., 1975).

Genus : *GLOBIGERINOPSIS* BOLLI, 1962

Globigerinopsis aquasayensis BOLLI, 1962

Pl. VIII, fig. 10

1962 *Globigerinopsis aquasayensis* BOLLI, p.282-283, pl.1, figs.1-7.
1969 *Globigerinopsis aquasayensis* BOLLI. BLOW, p.375.
1974a *Globigerinopsis aquasayensis* BOLLI. BOLTOVSKOY, p.705, pl.6, figs.5-14.

Diagnosis : Test an initial "globigerine" coil with later chambers becoming detached along the spiral suture. These large evolute adult chambers tend towards a streptospiral mode. A large, high arched aperture occupies an umbilical, extraumbilical position. Surface coarsely porous and pustulose.

Stratigraphical Distribution : Early to Late Miocene (N.8 to N.17) (BOLTOVSKOY, 1974a).

Material : At Site 289, *G. aquasayensis* is present in four samples from the Midddle to Late Miocene (N.13 to N.16).

At Site 71, the species is present in three samples from the Middle Miocene (N.11-12).

Abundance at both Sites varies from very rare to rare.

Genus : *GLOBOROTALOIDES* BOLLI, 1957

Globorotaloides variablis BOLLI, 1957

Pl. VIII, fig. 1a-c

1957b *Globorotaloides variablis* BOLLI, p117, pl.27, figs. 15-20.
1969 *Globorotaloides hexagona variablis* BOLLI. BLOW, p.374.
1976 *Globorotaloides hexagona variablis* BOLLI. QUILTY, p.649, pl.16, figs. 19-20.

Diagnosis : Test a low compressed trochospire with five to seven chambers in the final whorl increasing rapidly in size. Spiral outline lobate, ovate; side profile biconvex, rounded. Sutures depressed; curved on spiral side, radial on umbilical side. Umbilicus wide. Aperture a slit or low arch, bordered by a small lip or tooth and umbilical in position. Surface very finely cancellate.

Stratigraphical Distribution : According to BLOW (1969), *G. variablis* ranges from the Early Miocene (N.8) to the Pliocene (N.18/?N.19).

Material : At Site 289, *G. variablis* ranges from the Middle Miocene (N.13) to beyond the upper limit of the studied sequence. Abundance varies from very rare to few and distribution is almost continuous.

The species is present in one sample from the Middle Miocene (N.11-12) at Site 71 in very rare abundance.

Geographical Distribution and Palaeoecology : KRASKENINNIKOV and HOSKINS (1973) tabulate the species from north east Pacific sediments.

Discussion : Specimens illustrated by QUILTY (1976) have a coarser cancellate surface than those encountered in the present study and those first described by BOLLI (1957b).

Genus : *ORBULINA* d'ORBIGNY, 1839

Orbulina bilobata (d'ORBIGNY), 1839

Pl. VIII, fig. 3a-b

1846	*Globigerina bilobata* d'ORBIGNY, p.164, pl.9, figs. 11-14.
1956	*Biorbulina bilobata* (d'ORBIGNY). BLOW, p.69, text fig. 2, No.16.
1969	*Biorbulina bilobata* (d'ORBIGNY). BLOW, p.334, pl.23, figs.5,6.
1971	*Orbulina universa* (d'ORBIGNY) *parkerae* BRÖNNIMANN and RESIG, p.1284, pl.45, figs.1-4.
part. 1975	*Orbulina universa* d'ORBIGNY. STAINFORTH et al., p.328, fig. 150, 3,5. (non) 1,2,4.

Diagnosis : Test bilobate with the ultimate and penultimate chambers similar or unequal in size and early chambers nearly or completely embraced by the penultimate chamber. Apertures multiple, around the final suture or on the surface of the final two chambers. Surface cancellate.

Stratigraphical Distribution : Middle Miocene (within N.9) to Recent (N.23) (BLOW, 1969). BRÖNNIMANN and RESIG (1971) tabulate the species from the Middle Miocene (N.13) to Pliocene (N.20).

Material : At Site 289, *O. bilobata* ranges from the Middle Miocene to beyond the upper limit of the studied sequence.

At Site 71 the species is present in four samples from the Middle Miocene (N.11-12).

At both Sites, distribution is discontinuous and abundance varies from very rare to rare.

Discussion : Many workers regard *O. bilobata* as a varient of *O. universa* (STAINFORTH et al., 1975). In this instance the taxonomic philosophy of BLOW (1969, p.334) has been followed. BRÖNNIMANN and RESIG (1971) erected

O. universa parkerae for unequally bilobate forms which would normally be included under *O. bilobata* but which exhibit a more restricted stratigraphical range (N.16 to N.20). At Site 289 however, the range of similar forms is identical to that of *O. bilobata* and they are here grouped together.

Orbulina suturalis BRÖNNIMANN, 1951

Pl. VIII, fig. 4

1934	*Candorbulina universa* JEDLITSCHKA, pl.21, figs. 1-7, 19, 21-23.
1951	*Orbulina suturalis* BRÖNNIMANN, p.135, figs.2-4.
1956	*Orbulina suturalis* BRÖNNIMANN. BLOW, p.66, fig. 2, No.5-7.
1975	*Orbulina suturalis* BRÖNNIMANN. STAINFORTH et al., p.325, fig.147.

Diagnosis : Final chamber is an incomplete sphere enveloping most of the initial globigerine coil, the exposed part of which lies flush with, or slightly protrudes from, the spherical outline of the final chamber. Small spherical apertures are present both along the final suture and on the surface of the final chamber. Surface cancellate, often finely hispid.

Stratigraphical Distribution : BLOW (1969) uses the initial appearance of *O. suturalis* to define the base of Zone N.9 at the Early/Middle Miocene boundary. Estimates of an upper stratigraphical limit vary from Pleistocene (Zone N.22) (BRÖNNIMANN and RESIG, 1971) to Recent (Zone N.23) (BLOW, 1969).

Material : At Site 289, *O. suturalis* ranges from the Middle Miocene (N.11-12) to beyond the upper limit of the studied sequence. Distribution is continuous.

At Site 71, the species ranges throughout the studied sequence though distribution is discontinuous. Abundance varies from very rare to few at both sites.

Geographical Distribution and Palaeoecology : *O. suturalis*, like it's decendant, *O. universa*, appears to have been widely distributed. In Pacific Ocean sediments, KRASHENINNIKOV and HOSKINS (1973) suggest tropical, subtropical and temperate occurrences, a view substantiated by the work of BRÖNNIMANN and RESIG (1971), KENNETT (1973), INGLE (1973) and JENKINS (1975) who report the species in the above mentioned regions.

Discussion : *O. suturalis* is believed to have evolved from *Praeorbulina glomerosa s.l.* by the development of apertural pores on the final chamber (BLOW, 1956; STAINFORTH et al., 1975). The effect of dissolution on the distribution of this species at Site 289 is briefly mentioned under *O. universa* and further discussed in Chapter V.

Orbulina universa d'ORBIGNY, 1839

Pl. VIII, fig. 5

1839	*Orbulina universa* d'ORBIGNY, p.2, pl.1, fig.1.
1956	*Orbulina universa* d'ORBIGNY. BLOW, p.66, text. fig.2, Nos. 8-9.
1969	*Orbulina universa* d'ORBIGNY. BLOW, p.234.
part, 1975	*Orbulina universa* d'ORBIGNY. STAINFORTH et al., p.328, fig.150, 1,2,4. (non) 3,5. (Ref. includes location of extensive synonymies).

Diagnosis : Final chamber is a complete sphere enclosing the initial 'globigerine' coil which is thus not visible on the test surface. Small spherical multiple apertures are scattered over the final chamber. Surface cancellate, often finely hispid.

Stratigraphical Distribution : BLOW (1969) gives the range as Middle Miocene (within zone N.9) to Recent (N.23).

Material : At Site 289, *O. universa* ranges from the Middle Miocene (N.11-12) to beyond the upper limit of the studied sequence. Distribution is continuous.

At Site 71, the species ranges throughout the studied sequence of the Middle Miocene (N.11-12).

Abundance varies from very rare to few at both sites.

Geographical Distribution and Palaeoecology : BÉ (1977) regards extant *O. universa* as a subtropical species which is sparse but widely encountered in surface sediments of the Pacific Ocean between 55°N and 50°S. The distribution of fossil individuals seems also widespread and the initial appearance of species of *Orbulina* defines a worldwide datum (STAINFORTH et al., 1975). KRASKENINNIKOV and HOSKINS (1973) cite a cosmopolitan distribution for the species in Pacific Ocean sediments. KENNETT (1973) and INGLE (1973) report the taxon form mid- and high latitude localities.

Discussion : *O. universa* is believed to have evolved from *O. suturalis* (BLOW, 1956) by complete envelopment of the initial coil by the final chamber. STAINFORTH et al. (1975) review the phylogeny of the genus. The delayed stratigraphic appearance of *Orbulina* spp., at Site 289 deserves comment. BERGER (1970) believes *O. universa* has a low resistance to solution in deep sea environments, prompting JENKINS and ORR (1972) to suggest the rarity of *O. suturalis* together with its precursor, *Praeorbulina* spp. in the Middle Miocene of eastern equatorial Pacific DSDP Sites be due to dissolution processes. A similar mechanism is thought to have destroyed all specimens of *Praeorbulina* spp., and *Orbulina* spp. at Site 289 at the base of the Middle Miocene (core 50 and part of core 49). The effect of dissolution processes in the present study is further discussed in Chapter V.

A biometric study of *O. universa* for the purpose of palaeoenvironment reconstruction has been carried out on Site 289 material and is discussed in Chapter VI.

Genus : *PRAEORBULINA* OLSSON, 1964

Praeorbulina glomerosa circularis (BLOW), 1956

Pl. VIII, fig. 2

part. 1956 *Globigerinoides glomerosa* BLOW, p.64-65, text. fig. 2, Nos.3-4.

1969 *Praeorbulina glomerosa circularis* (BLOW). BLOW, p.333.

part. 1975 *Praeorbulina glomerosa* (BLOW). STAINFORTH et al., p.281, fig.12. 1,2,5. (non) 1,3,4,6.

Diagnosis : Test spherical, consisting of an initial "globigerine" coil partly enveloped by the final chamber. Apertures multiple; a series of slits or pores situated along the suture of the final chamber. Surface cancellate.

Stratigraphical Distribution : BLOW (1969) gives the range of *P. glomerosa circularis* as spanning the Early/Middle Miocene boundary (N.8 to N.9).

Material : Present in only two samples, in very rare abundance, from the Middle Miocene (base of N.11-12) at Site 289.

Genus : *SPHAEROIDINELLOPSIS* BANNER and BLOW, 1959

Sphaeroidinellopsis paenedehiscens BLOW, 1969

Pl. VIII, fig. 9

1969 *Sphaeroidinellopsis subdehiscens paenedehiscens* BLOW, p.336, 338, 386-387, pl.30, figs. 4-5,9.

1969 *Sphaeroidinellopsis sphaeroides* LAMB, p.571, pl.1, figs.1-5; pl.2, figs. 1-3.

1975 *Sphaeroidinellopsis paenedehiscens* BLOW. STAINFORTH et al., p.389, figs. 189-190.

Diagnosis : Test an ovoid or spherical trochospire with three to four chambers in the final whorl. A thick smooth cortical layer envelopes the test to give a rounded outline and obscure the early whorls and sutures. Umbilicus coincides with aperture which is a prominant slit bordered by slightly projecting crenulate cortical lips. Primary surface texture stongly cancellate or "honeycomb".

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (within N.17) to Pliocene (N.20).

Material : *S. paenedehiscens* ranges from the Late Miocene (N.17) to beyond the upper limit of the studied sequence at Site 289. Abundance is always very rare.

Geographical Distribution and Palaeoecology : According to STAINFORTH et al. (1975), *S. paenedehiscens* has been found nearly worldwide, prefering, like its modern decendant *Sphaeroidinella dehiscens*, a warm water habitat.

Discussion : *S. paenedehiscens* is believed to have evolved from *S. subdehiscens* by developing more inflated chambers, a thicker cortex and projecting apertural lips. The transition is well displayed at Site 289.

Remarks : This morphotype had been included within other species of the genus prior to the work of BLOW (1969) (STAINFORTH et al., 1975).

Sphaeroidinellopsis seminulina seminulina (SCHWAGER), 1866

Pl. VIII, fig. 6a-d

	1866	*Globigerina seminulina* SCHWAGER, p.256, pl.7, fig. 112.
	1960b	*Globigerina seminulina* SCHWAGER. BANNER and BLOW, p.241, pl.7, fig.2 (neotype).
	1960	*Sphaeroidinellopsis seminulina* (SCHWAGER). BANNER and BLOW, p.40.
	1969	*Sphaeroidinellopsis seminulina* (SCHWAGER). BLOW, p.337, pl.30, fig.7.
	1972	*Sphaeroidinella seminulina* (SCHWAGER). JENKINS and ORR, p.1109, pl.40, figs.9-11.
part.	1975	*Sphaeroidinellopsis seminulina* (SCHWAGER). STAINFORTH et al., p.317, figs. 142,4,6-7. (non) 1-3,5.

Diagnosis : Test a compressed trochospire with three or four ovate chambers in the final whorl. Spiral profile variable; side profile rounded. Umbilicus well developed, encompassing a low arched aperture bordered by a smooth or crenulated lip. Inner layer of test well a porous "honeycomb" lattice; outer layer a smooth vitreous cortex.

Stratigraphical Distribution : According to BLOW (1969) *S. seminulina s.s.* ranges from the Early Miocene (N.6) to the Pliocene (N.21). BRÖNNIMANN and RESIG (1971) tabulate the form from the Middle Miocene (N.9) to Pleistocene (N.22).

Material : *S. seminulina* ranges continuously through the studied sequences at both Sites 289 and 71. Abundance varies from very rare to very common at Site 289 and from few to very common at Site 71.

Geographical Distribution and Palaeoecology : In Pacific Ocean sediments, KRASHENINNIKOV and HOSKINS (1973) report a wide geographical distribution for the subspecies with most common occurrence in tropical and subtropical areas. *S. seminulina s.s.* is rare or sparsely distributed in higher latitudes (JENKINS, 1971; INGLE, 1973).

Discussion : The considerable variation within this taxon has led to taxonomic inconsistencies and, partly following PARKER (1967) and STAINFORTH et al., (1975), the specific names *disjuncta*, *grimsdalei* and *rutschi* of authors are regarded herein as synonymous with *seminulina s.s.* In the present study, variation involved the number of chambers in the final whorl, test outline, the nature of the aperture and surface texture. Problems associated with this latter feature are accentuated by the susceptibility of the outer cortex to dissolve, revealing the coarsely honeycomb or cancellate inner layer. So called "naked" forms were often encountered in the present study (Pl. VIII, fig. 6c-d)

Sphaeroidinellopsis seminulina kochi (CAUDRI), 1934

Pl. VIII, fig.7

1934 *Globigerina kochi* CAUDRI, p. 144.

1969 *Sphaeroidinellopsis seminulina kochi* (CAUDRI). BLOW, p.337, pl.30, fig.8.

part. 1975 *Sphaeroidinellopsis seminulina* (SCHWAGER). STAINFORTH <u>et al</u>., p.317, fig. 142, 1-3,5. (non) 4,6-7.

<u>Diagnosis</u> : Test a compressed trochospire with five or six well separated ovate chambers in the final whorl. Spiral profile subcircular to ovate, highly lobate; side profile rounded. Umbilicus very open and wide, enclosing a strongly arched aperture. Wall texture as in *S. seminulina s.s.*

<u>Stratigraphical Distribution</u> : BLOW (1969) gives the range as Middle Miocene (N.10) to Pliocene (N.19). BRÖNNIMANN and RESIG (1971) tabulate a slightly extended range (N.10 to N.20).

<u>Material</u> : At Site 289, *S.s. kochi* ranges from the Middle Miocene (N.11-12) to beyond the upper limit of the studied sequence. Distribution is almost continuous. The subspecies is present in ten samples from the Middle Miocene (N.11-12) at Site 71.

Abundance at both sites varies from very rare to rare.

<u>Discussion</u> : Individuals of *S. s. kochi* encountered in the present study are both morphologically and stratigraphically distinct from *S. seminulina* and thus substantiates BLOW's concept (1959, 1969) of separate taxonomic status.

Sphaeroidinellopsis subdehiscens (BLOW), 1959

Pl. VIII, fig. 8

part. 1941 *Sphaeroidinella rutschi* CUSHMAN and RENZ, p.25, pl.4, fig. 5c. (non) fig. 5a-b = holotype.

1959	*Sphaeroidinella dehiscens subdehiscens* BLOW, p.195, pl.12, figs. 71-72.
1969	*Sphaeroidinellopsis subdehiscens subdehiscens* (BLOW). BLOW, p.338, pl.10, figs. 1-3, 6.
1975	*Sphaeroidinellopsis subdehiscens* (BLOW). STAINFORTH et al., p.410, fig. 205.

Diagnosis : Test a compressed trochospire with three compact subglobular chambers in the final whorl. Spiral and side profiles ovate. Umbilicus slightly open. Aperture an elongate umbilical slit bordered by thickened margins of the final three chambers. The cortical layer becomes well developed in this species.

Stratigraphical Distribution : BLOW (1969) uses the initial appearance of *S. subdehiscens* to define the base of Zone N.13 within the Middle Miocene. The species ranges into the Pliocene (BLOW, 1969; BRÖNNIMANN and RESIG, 1971).

Material : *S. subdehiscens* ranges from the Middle Miocene (N.13) to beyond the upper limit of the studied sequence. Abundance varies from very rare to few and distribution is almost continuous.

Geographical Distribution and Palaeoecology : KRASHENINNIKOV and HOSKINS (1973) record the species as common in the sediments of tropical and subtropical areas of the Pacific Ocean. KENNETT (1973) tabulates the taxon from south west Pacific core material.

Discussion : *S. subdehiscens* is believed to have evolved from *S. seminulina s.s.* by the restriction of three chambers on the final whorl and the development of a straight "letter-box" slit-like aperture (BLOW, 1969; STAINFORTH et al., 1975). The evolutionary transition is well represented at Site 289.

Genus : *CANDEINA* d'ORBIGNY, 1839 emended BLOW, 1969

Candeina nitida nitida d'ORBIGNY, 1839

Pl. VIII, fig. 12

1839 *Candeina nitida* d'ORBIGNY, p.108, pl.2, figs.27-28.
1969 *Candeina nitida nitida* d'ORBIGNY. BLOW, p.335, 384-386, pl.23, figs.1-4.
1975 *Candeina nitida* d'ORBIGNY. STAINFORTH et al., p.381, fig.185.

Diagnosis : Test a high, tightly coiled trochospire with three inflated, subglobular chambers in each whorl. Spiral profile trilobate; side profile ovate. Sutures depressed. Umbilicus closed with no primary aperture in the adult. Large apertural pores are arranged evenly along the spiral and intercameral sutures into the early ontogenetic stage. Surface smooth, very finely perforate, with very small pustules, especially in the early chambers.

Stratigraphical Distribution : BLOW (1969) gives the range as Late Miocene (N.17) to Recent (N.23). BRÖNNIMANN and RESIG (1971) tabulate a similar distribution.

Material : Present in two samples, in very rare abundance, from the uppermost part of the studied sequence (Late Miocene : N.17) at Site 289.

Geographical Distribution and Palaeoecology : BÉ (1977) indicates extant *C. nitida* as mainly restricted to the tropical oceanic region. PARKER (1962) records the species north of 30°S in Recent sediments of the south Pacific. Fossil forms have been regarded as warm water indicators by KENNETT (1973) and BOLTOVSKOY (1974a).

Discussion : According to BLOW (1969), *C. nitida* evolved from *C. praenitida* by the development of small supplementary apertures in the intercameral sutures prior to the suture between the penultimate and antipenultimate chambers. Other biocharacter differences exist (cf. respective diagnoses; see BLOW, 1969). The figured hypotype possesses a narrow bulla over the spiral suture and associated apertures.

Candeina nitida praenitida BLOW, 1969

Pl. VIII, fig. 11

1969 *Candeina nitida praenitida* BLOW, p.384-386, pl.22, figs.5-8.

Diagnosis : As *C. nitida s.s.* but with four chambers in the penultimate whorl and with spiral sutural apertures and intercameral sutural apertures confined to those sutures circumscribing and lying between the last three chambers respectively.

Stratigraphical Distribution : Middle Miocene (N.15) to Pleistocene (N.22) (BLOW, 1969).

Material : At Site 289 *C. nitida praenitida* ranges from the Late Miocene (within N.17) to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare.

Geographical Range and Palaeoecology : Observations made for *C. nitida s.s.* are perhaps pertinent to this closely related subspecies. The taxon has been recorded in Pacific tropical and subtropical sediments by KRASHENINNIKOV and HOSKINS (1973).

Discussion : BLOW (1969) has demonstrated the evolution of *C. nitida praenitida* from *Globigerinoides parkerae* by the development of intercameral sutural apertures.

II: THE TAXONOMY OF THE RADIOLARIA

INTRODUCTION

Seven families of Spumellaria and seven families of Nassellaria are represented: the Collosphaeridae, Actinommidae, Phacodiscidae, Porodiscidae, Spongodiscidae, Tholoniidae, Litheliidae, Acanthodesmiidae, Plagoniidae, Theoperiidae, Carpocaniidae, Pterocorythidae, Artostrobiidae and Cannobotrythidae.

One hundred and sixty three taxa have been differentiated. Of these, one hundred and twenty are at the specific level, twenty five are left at the generic level, seventeen are above the generic level (forms) and one is left with open nomenclature. Four new species are described.

Families and genera are primarily classified and arranged according to the schemes of PETRUSHEVSKAYA and KOSLOVA (1972), RIEDEL (1967, 1971) and RIEDEL and SANFILIPPO (1977).

The systematic review is organised in the following manner:

Synonymy: as for the planktonic foraminifera.

Distinguishing Features: A complete description or diagnosis of every species was considered beyond the scope of the present study. Instead a brief description of those features which are used to differentiate the taxon from closely related forms is presented.

Stratigraphical Distribution: This has been given in terms of the European stratigraphical units and the zonal schemes of RIEDEL and SANFILIPPO (1970, 1971, 1978).

When present, the ranges given by HOLDSWORTH (1975) and WESTBERG and RIEDEL (1978) for Site 289 and by MOORE (1971) for Site 71 have been given when they differ from the ranges offered by the present study.

Material: The stratigraphical distribution and relative abundance of each taxon within the studied sequences is considered. The ranges, where appropriate, are given in terms of both the radiolarian and planktonic foraminiferal biostratigraphical zonal schemes. The stratigraphical intervals are listed in the introduction to the taxonomy of the planktonic foraminifera although total sample numbers are different. Sample numbers for radiolaria are:-

1) from within the *Dorcadospyris alata* Zone to within the *Ommatartus penultimus* Zone, DSDP Site 289 - fifty six samples.

2) from within the *Dorcadospyris alata* Zone, DSDP Site 71 - nine samples.

The significance of terms used to denote relative abundance and distribution are similar to those used for the planktonic foraminifera.

Geographical Distribution and Palaeoecology: Various works,to numerous to mention here, were used to indicate palaeogeographical distribution for well known species. For those species still extant, the work of CASEY (1966, 1971a,b, 1977) were used for ecological information within the Pacific Ocean.

Discussion and Remarks: As for the planktonic foraminifera.

The amount of detail in which each taxon is reviewed is a function of its biostratigraphical, palaeoecological and numerical importance within the sequences. Many new species were encountered; only those which were considered important have been described and named.

Index

Family :COLLOSPHAERIDAE MULLER, 1858

Genus :ACROSPHAERA HAECKEL, 1881

Acrosphaera murrayana (Haeckel), 1887

Pl.IX, fig. 2

1887 Choenicosphaera murrayana HAECKEL, p.102, pl.8, fig.6

1917 Acrosphaera murrayana (Haeckel). POPOFSKY, p.259, text figs.22-23.

1971 Polysolenia spp. RIEDEL and SANFILIPPO, p.1586, pl.1B, figs.4,7,13,14;2A, figs.12,14.

Distinguishing Features: The test is smooth walled and spherical or ellipsoidal with numerous large subcircular pores each bearing a ring of short pointed spines.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the species from the Early Miocene (Calocycletta virginis Zone) to the Pliocene (Pterocanium prismatium Zone). The range extends into the Recent (NIGRINI, 1968).

Material: A.murrayana ranges throughout the studied sequences at both Sites 289 and 71. Distribution at Site 289 is virtually continuous and abundance varies from very rare to few. At Site 71, the species is found in all nine samples and abundance varies from very rare to rare.

Remarks: The genus Polysolenia has been synonymised with Acrosphaera following the recommendations of BJØRKLUND and GOLL (1979).

Acrosphaera spinosa s.l. (Haeckel), 1862

Pl.IX, fig. 1a-f

1862 Collosphaera spinosa HAECKEL, p.536, pl.34, figs.12,13

1887 Acrosphaera echinoides HAECKEL, p.100, pl.8, fig.1.

1971 Polysolenia spp. RIEDEL and SANFILIPPO, p.1586, pl.1B, fig.1-3,5,6,8,9,12,15; pl.2A, fig.11,13, pl.2B, fig.1-4.

1979 *Acrosphaera spinosa spinosa* (Haeckel). BJØRKLUND and GOLL, p.1308, pl.1, figs.8,9.

1979 *Acrosphaera spinosa echinoides* HAECKEL. BJØRKLUND and GOLL, p.1311, pl.1, figs.7,10-13; pl.4, figs.1-4,7,8.

Distinguishing Features: The lattice test is thick walled, spherical and possesses numerous perforate protuberences of variable size, each of which usually projects a single spine of variable length. The intervening areas are perforated by small, round or large, subangular pores.

Stratigraphical Distribution: BJØRKLUND and GOLL (1979) give the lower range as Early Miocene (*Cyrtocapsella tetrapera* Zone), while RIEDEL and SANFILIPPO (1971), figure the form continuously into the Quaternary.

Material: *A. spinosa* ranges throughout the studied sequences at both Sites 289 and 71. At Site 289, the species distribution is virtually continuous and abundance varies from very rare to very common. At Site 71, *A. spinosa* is present in all nine samples and abundance varies from very rare to rare.

Discussion: Variation in size and morphology amongst individuals of *A. spinosa* encountered in the present study is quite extensive. Not all the specimens included in the taxon may be represented in the synonymy, especially for forms with extended protuberences (pl.IX, fig.1e,1f).

Genus :*COLLOSPHAERA* MULLER, 1885 *emend.* BJØRKLUND and GOLL, 1979

Collosphaera brattstroemi BJØRKLUND and GOLL, 1979

Pl.IX, fig.3

?1971 *Tribonosphaera sp.* RIEDEL and SANFILIPPO, p.1526, pl.2B, figs.6-8.

1979 *Collosphaerabrattstroemi* BJØRKLUND and GOLL, p.1315, pl.3, figs.10-26; pl.4, figs.13-16.

Distinguishing Features: An irregularly spherical test with subangular pores. An internal system of tubes and spines radiate inwards from the test surface in descrete clusters that are marked by external depressions.

Stratigraphical Distribution: Early Miocene (Stichocorys wolffii Zone) to Middle Miocene (Cannartius? petterssonii Zone) (BJØRKLUND and GOLL, 1979).

Material: At Site 289, C. brattstroemi ranges from beyond the lower limit of the studied sequence into the Cannartus? petterssorii Zone:N.13. Distribution is virtually continuous and abundance varies from very rare to few. At Site 71 the species is present in all nine samples from the Dorcadospyris Zone. Abundance varies very rare to rare.

Discussion: C. brattstroemi differs from other Miocene species of the genus by possessing internal lattice structures.

Remarks: Despite having a similar stratigraphical range and apparent identical morphology, BJØRKLUND and GOll (1979) neglect to include Tribonosphaera sp. of RIEDEL and SANFILIPPO (1971) in their synonymy.

Collosphaera sp. 1

Pl. IX, fig. 4

1971 Collosphaera spp. RIEDEL and SANFILIPPO, p.1586, pl.1A, fig.9; pl.2A, fig.2.

Distinguishing Features: The large, subspherical pores and relatively narrow inter-pore bars in this form enabled a consistent recognition in the present study.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the form from the Middle Miocene (Dorcadospyris alata Zone).

Material: At Site 289, Collosphaera sp. 1 ranges from the Middle Miocene (Cannartus? petterssoni Zone: N.13) to beyond the upper limit of the studied sequence. Abundance varies from very rare to few. At Site

71, the species is present in six samples from the Dorcadospyris alata Zone. Abundance varies from very rare to rare.
The presence of the taxon at Site 71 may be due to downhole contamination (see Chapter V).

Collosphaera spp.

Pl.IX, fig.5a-b

1971 Collosphaera spp. RIEDEL and SANFILIPPO, p.1586, pl.1A, figs.2-7,10; pl.2A, figs.1,3.

1979 Collosphaera glebulenta BJØRKLUND and GOLL, p.1316, pl.2, figs.9-25.

Distinguishing Features: This taxon includes a wide variety of simple lattice tests with shape ranging from spherical or ellipsoidal to convolute with alternating swellings and depressions. Pore size may vary from large to small; pore shape from circular or elliptical to subangular, and pore distribution from unimodal to multimodal.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the taxon from the Early Miocene (Calocycletta costata Zone) to Quaternary.

Material: Collosphaera spp. ranges throughout the studied sequences at both Sites 289 and 71. Distribution at Site 289 is discontinuous and abundance varies from very rare to very common. At Site 71, the taxon is present in all nine samples and abundance varies from very rare to rare.

Discussion: Consistent differentiation of species was found impossible.

Genus :SIPHONOSPHAERA MULLER, 1858

Siphonosphaera sp.

Pl.IX, fig. 6

1971 Siphonosphaera sp. RIEDEL and SANFILIPPO, pl.2B, fig.5.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure this form from the Early Miocene (*Calocycletta virginis* Zone).

Material: At Site 289, this species has a markedly discontinuous range. It is present in five closely adjacent samples from the Middle Miocene (*Dorcadospyris alata* Zone: N.10 to N.11-12) and appears again in three samples from the Late Miocene (*Ommatartus antepenultimus*/*Ommatartus penultimus* Zones:N.17). Abundance varies from very rare to rare.

Genus :TRISOLENIA EHRENBERG, 1860

Trisolenia omnitubus (Riedel and Sanfilippo), 1971

Pl.IX, fig.8a-b

1971 *Solenosphaera omnitubus* RIEDEL and SANFILIPPO, p.1586, pl.1A, figs.23,24; pl.4, figs.1,2.

Distinguishing Features: The perforate tubes, which may be long or short, are closely spaced and cover virtually all of the spherical test.

Stratigraphical Distribution: Late Miocene (*Ommatartus penultimus*Zone) to Pliocene (*Spongaster pentas* Zone) (RIEDEL and SANFILIPPO, 1971).

Material: At Site 289, *T. omnitubus* extends from the *Ommatartus antepenultimus* Zone:N.17 to beyond the upper limit of the studied sequence. Abundance varies from rare to common.

Geographical Distribution and Palaeoecology: HOLDSWORTH (1975) remarked on the apparent restriction of this species to low latitudes in Pacific Ocean sediments.

Remarks: The generic name *Solenosphaera* has been synonymised with *Trisolenia* following the recommendations of BJØRKLUND and GOLL (1979).

Trisolenia spp.

Pl.IX, fig.7a-c

1872 *Trisolenia megalactus* EHRENBERG, pl. 8, fig. 19.

1971 *Solenosphaera spp.* RIEDEL and SANFILIPPO, p.1586, pl.1A, figs.12-17,19,21,22; pl.2A, figs.4-9.

1979 *Trisolenia megalactus* EHRENBERG *emend.* BJØRKLUND and GOLL s.l., p.1318, pl.4, figs.9-12; pl.5, figs.1-21; pl.6, figs.1-11.

Distinguishing Features: The lattice test possesses external tubes that vary in size from short 'cones' to long subcylindrical protuberences. Test outline varies from triangular to subspherical.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the taxon from the Early Miocene (*Calocycletta virginis* Zone) to Quaternary.

Material: *Trisolenia spp.* is ubiquitous at both Sites 289 and 71. Abundance varies from very rare to abundant at Site 289 and from few to common at Site 71.

Discussion: The range of variation exhibited by *Trisolena* spp. in the present study is quite extensive. In the Late Miocene at Site 289, individuals are encountered possessing numerous wide and flaring tubes and are possible precursors of *T. omnitubus* (pl.IX, fig.7c).

Family :*ACTINOMMIDAE* HAECKEL, 1862 *sensu* RIEDEL, 1967

Discussion: Apart from representatives of the subfamilies *Saturnalinae* and *Artiscinae*, little modern work has been carried out on Neogene actinommid taxa at the specific level. This lack of taxonomic information is reflected in the present study where only five specific identifications outside the above mentioned subfamilies have been made. Other taxa have been arranged into morphotypic groups that probably do not reflect 'natural' phylogenetic relationships. Attempts at consistent discrimination of the various species comprising these groups were unsuccessful in the present study.

Genus :ACTINOMMA HAECKEL, 1860 emend. NIGRINI, 1967

Actinomma medianum NIGRINI, 1967

Pl.IX, fig.9

1967 Actinomma medianum NIGRINI, p.27, pl.2, figs.2a,b.

Stratigraphical Distribution: NIGRINI (1967) records the species from the Quaternary.

Material: At Site 289, A. medianum appears to range throughout the studied sequence although the species is only present in five samples. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: NIGRINI (1967) regards A. medianum as "a reliable and potentially useful member of the middle latitude (radiolaria) assemblage" in the Indian Ocean.

Actinomma sp. aff. A. tanycantha CHEN, 1974

Pl.IX, fig.10a-b

aff. 1974 Actinomma tanycantha CHEN, p.481, pl.1, fig.1-2.

Stratigraphical Distribution: Middle to Late Miocene (CHEN, 1974).

Material: At Site 289, the form ranges from the Middle Miocene (Cannartus? petterssoni Zone:N.13) to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare and distribution is discontinuous.

Remarks: Unlike the holotype of CHEN (1974, pl.1, fig.1) individuals encountered in the present study rarely possess even traces of external spines. Nevertheless, the similarity of the inner medullary and outer cortical shells between forms from Site 289 and those figured by CHEN warrants inferred affinity.

Genus : CLADOCOCCUS MULLER, 1857

Cladococcus spp.

Pl.IX, fig.11

1887 Cladococcus dendrites HAECKEL, p.227, pl.27, fig.5.

1887 Cladococcus scorparius HAECKEL, p.225, pl.27, fig.2.

1976 Cladococcus scorparius HAECKEL. RENZ, p.101, pl.2, fig.5.

Stratigraphical Distribution: RENZ (1976) reports the taxon from the Quaternary.

Material: At Site 289 the species range from the Late Miocene (Ommatartus antepenultimus Zone:N.17) to beyond the upper limit of the studied sequence. At Site 71, Cladococcus spp. is present in all nine samples from the Middle Miocene (Doradospyris alata Zone). Abundance at both sites varies from very rare to rare.

Discussion: The occurrence of the taxon at Site 71 is possibly due to downhole contamination (see Chapter V).

Genus : HALIOMMA EHRENBERG, 1838

Haliomma horridum STOHR, 1860

Pl.IX, fig.12a-c

1880 Haliomma horridum STOHR, p.87, taf.1, fig.10.

1887 Haliomma horridium STOHR. HAECKEL, p.232.

Distinguishing Features: The test has an obscure shape; circular in plan view and strongly bioconvex in side view. An inner medullary shell is linked to the cortical shell via multiple bars which extend exteriorly with short spines which, in some individuals, have divided ends. The cortical pores are subcircular and multimodal.

Stratigraphical Distribution: HAECKEL (1887) reports the species "fossil in the Tertiary rocks of Barbados and Sicily, and living in the Atlantic".

Material: H. horridium ranges throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to few and distribution is virtually continuous.

Genus : STYLACONTARIUM POPOFSKY, 1912

Stylacontarium sp. aff. S. bispiculum POPOFSKY, 1912

Pl.IX, fig.13a-c

1973 Stylacontarium sp. aff. S. bispiculum POPOFSKY. KLING, p.634, pl.6, figs.19-23; pl.14, figs.5-8; pl.15, figs.11-14.

Stratigraphical Distribution: KLING (1973) gives a minimum lower range of Early Miocene (Calocycletta costata Zone) to Late Miocene (Stichocorys peregrina Zone).

Material: This taxon ranges continuously throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to rare at Site 289 and is always rare at Site 71.

Discussion: Included under this name, and outside the concept of KLING (1973) are forms that deviate from the normal bipolar aspect by a reduction in size of the two main spines and a concomitant increase in other radial spines. S. sp. aff. S.bispiculum is differentiated from closely related forms included in "Actinommid spp. group 3" by the spherical or slightly ellipsoidal cortical shell.

"Actinommid spp. group 1"

Pl.IX, fig.14a-b

Discussion: This group comprises forms with one or two inner medullary shells and a spherical outer cortex. A system of spines pass out from the central medulla to beyond the cortical shell and imparts a radial symettry. Representatives of the following genera are included:

1887 HALIOMMA EHRENBERG. HAECKEL, p.230.

1887 HEXASTYLUS HAECKEL. HAECKEL, p.171, pl.21, figs.3,4,6.

1887 HEXACONTIUM HAECKEL. HAECKEL, p.192, pl.24, figs.2,3,6.

1887 HEXALONCHE HAECKEL. HAECKEL, p.179, pl.22, figs.1-4.

Material: This taxon ranges throughout the studied sequences at Sites 289 and 71. Distribution is continuous and abundance varies from very rare to few at Site 289 and from rare to few at Site 71.

"Actinommid spp. group 2"

Pl.IX, fig.15a-b

Discussion: This group comprises forms with one or two inner medullary shells and a weakly ellipsoidal outer cortex. A system of spines radiate from the central medulla although only two, elongate and thickened spines fully penetrate the cortex in the region of each pole of the ellipsoid. Representatives of the following genera are included:

1973 AXOPRUNUM HAECKEL. KLING, p.634, pl.1, figs.13-16; pl.6, figs.14-18.

1976 DRUPPATRACTUS HAECKEL. WEAVER, p.573, pl.5, figs.1-2.

Material: This taxon ranges throughout the studied sequences at both Sites 289 and 71. Distribution is continuous and abundance varies from very rare to few at Site 289 and from rare to few at Site 71.

"Actinommid spp. group 3"

Pl.IX, fig.16a-d

Discussion: This group comprises forms with two inner medullary shells and a strongly ellipsoidal outer cortex. A system of spines radiate from the central medulla although only two, in polar positions, normally extend beyond the cortex. Representatives of the following genera are included:

1972 STYLATRACHUS HAECKEL sensu PETRUSHEVSKAYA and KOZLOVA, p.519, pl.11, figs.10-12.

1973 STYLACONTARIUM POPOFSKY. KLING, p.634, pl.1, figs.17-20; pl.14, figs.1-4.

Material: This taxon ranges continuously throughout the studied sequences at Sites 289 and 71. Abundance varies from very rare to few at Site 289 and from very rare to rare at Site 71.

"Actinommid spp. group 4"

Pl.IX, fig.17a-c

Discussion: The group comprises forms with a cortical shell only. Several species are included and can be arbitarily divided on pore size, shape and arrangement. Most of the forms fall within the following genus:

1887 CENOSPHAERA EHRENBERG. HAECKEL, p.61, pl.12, figs.7-11.

Material: This taxon ranges throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to rare and distribution is continuous.

"Actinommid spp. group 5"

Pl.IX, fig.18a-b

Discussion: This group consists of quite large forms possessing a single inner medulla and outer cortical shell. The cortex possesses closely spaced subangular to subcircular pores of various size and is penetrated by four to six bladed spines of equal length which radiate from the centre. Representatives of the following two genera are included:

1973 LITHOMESPILUS HAECKEL. SANFILIPPO and RIEDEL, p.517.

1978a HEXALONCHE HAECKEL. RIEDEL and SANFILIPPO in ZACHARIASSE *et al.*, p.104.

Material: This taxon ranges continuously throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to few at Site 289 and is always rare to Site 71.

"Actinommid spp. group 6"

Pl.IX, fig.19a-d

Discussion: This group includes forms with multiple spherical and/or ellipsoidal shells. The outer shell bears a pylome in a pole position and possesses a porous or spongy wall texture. A system of spines radiate from the central shell and normally extend slightly beyond the outer shell. Representatives of the following genera are included:

1973 SPHAEROPYLE DREYER. KLING, p.634, pl.1, figs.5-10.

1979 PRUNOPYLE DREYER. KEANY, p.53, pl.5, fig.3.

Material: The taxon ranges continuously throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to few at the former and from rare to few at the latter Site.

Subfamily : SATURNALINAE DEFLANDRE, 1953

Genus : SATURNALIS HAECKEL, 1881 emend. NIGRINI, 1967

Saturnalis circularis HAECKEL, 1887

Pl.X, fig.1

1887 Saturnalis circularis HAECKEL, p.131.

1887 Saturnalis annularis HAECKEL, p.132, pl.13, fig.16.

1967 Saturnalis circularis HAECKEL. NIGRINI, p.25, pl.1, fig. 9.

Stratigraphical Distribution: KLING (1973) gives a minimum range of Early Miocene (Calocycletta costata Zone) to Pleistocene. The species is extant (NIGRINI, 1967).

Material: S. circularis ranges throughout the studied sequences at Sites 289 and 71 with an abundance range of very rare to rare. The species exhibits discontinuous distribution at Site 289 but is present in all nine samples in the shorter stratigraphical interval at Site 71.

Remarks: Individuals are rarely found complete.

Subfamily : ARTISCINAE HAECKEL, 1881 *sensu* RIEDEL, 1967

Genus : CANNARTUS HAECKEL, 1881 *sensu* RIEDEL, 1971

Discussion: Members of this species constitute part of a well documented phylogenetic lineage which spans most of the Cenozoic, commencing with *Lithocyclia spp.* during the Eocene and culminating in the extant species *Ommatartus tetrathalamus*. KLING (1978) gives the most concise and recent account of the series, first suggested and later confirmed by RIEDEL (1959) and RIEDEL and SANFILIPPO (1971) respectively. The following taxa are arranged in phylogenetic order.

Cannartus tubarius (Haeckel), 1887

Pl.X, fig.2

1887 *Pipettaria tubaria* HAECKEL, p.339, pl.39, fig.15.

1978 *Cannartus tubarius* (Haeckel). RIEDEL and SANFILIPPO, p.67, pl.4, fig.3.

Distinguishing Features: Coarse longitudinal plicae are present in the region of an indistinct equatorial constriction. The spongy polar columns are narrow.

Stratigraphical Distribution: Early Miocene (*Calocycletta virginis* Zone:N.5 to *Calocycletta costata* Zone:N.8) (RIEDEL and SANFILIPPO, 1971).

Material: At Site 289, *C. tubarius* ranges from the base of the studied sequence into the *Dorcadospyris alata* Zone:N.10 of the Middle Miocene. Abundance varies from very rare to rare.

Cannartus violina HAECKEL, 1887

Pl.X, fig.3

1887 *Cannartus violina* HAECKEL, p.358, pl.39, fig.10.

1978 *Cannartus violina* HAECKEL. RIEDEL and SANFILIPPO, p.67, pl.4, fig.4.

Distinguishing Features: Short coarse plicae surround a distinct equatorial constriction. The spongy polar columns are narrow.

Stratigraphical Distribution: Early Miocene (*Calocycletta virginis*: N.5) to Middle Miocene (*Dorcadospyris alata* Zone:N.9) (RIEDEL and SANFILIPPO, 1971).

Material: The species is present in one sample, in very rare abundance from the *Dorcadospyris alata* Zone:N.9 at Site 289.

Discussion: *C. violina* differs from its precursor, *C. tubarius*, in that the cortical plicae do not occur in the equatorial region, thus producing a noticeable constriction. The evolutionary transition occurred during the Early Miocene (*Calocycletta virginis* Zone:N.6) (RIEDEL and SANFILIPPO, 1971).

Cannartus bassanii (Carnevale), 1908 *emend*. SACHS and HASSON, 1979

Pl.X, fig.4

1908 *Cannartidium bassanii* CARNEVALE, p.21, pl.3, fig.12.

1979 *Cannartus bassanii* (Carnevale). SACHS and HASSON, p.1118, text fig.3c.

Distinguishing Features: The cortical shell is an elongate ellipsoid with each half noticeably lengthened poleward. An equatorial constriction is marked by the termination of plicae.

Stratigraphical Distribution: Early Miocene (*Calocycletta costata* Zone) to Middle Miocene (*Dorcadospyris alata* Zone) (SACHS and HASSON, 1979).

Material: At the Site 289, *C. bassanii* ranges from the base of the studied sequence into the *Dorcadospyris alata* Zone:N.11-12. Abundance varies from very rare to rare and distribution is discontinuous.

Discussion: *C.bassanii* appears to have been an off shoot from the main artiscinid lineage. The phylogenetic relationships with contemporaneous taxa remains uncertain however.

Cannartus mammiferus (Haeckel), 1887

1887 *Cannartidium mammiferum* HAECKEL, p.375, pl.39, fig.16.

1971 *Cannartus mammiferus* (Haeckel), RIEDEL and SANFILIPPO, p.1587, pl.2C, figs.1-3.

Distinguishing Features: The equatorial constriction is accentuated by the development of pronounced mound-like protuberaces from the cortical plicae.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) give the range as Early Miocene (*Calocycletta costata* Zone) to Middle Miocene (*Dorcadospyris alata* Zone). At Site 289, HOLDSWORTH (1975) extended the upper range into the Late Miocene (*Ommatartus antepenultimus* Zone).

Material: At Site 289, *C. mammiferus* ranges from beyond the lower limit of the studied sequence into the Middle Miocene (*Cannartus? petterssoni* Zone:N.13). Abundance varies from very rare to rare and distribution is discontinuous. At Site 71, the species is present at four samples in very rare abundance.

Discussion: *C. mammiferus* evolved from *C. violina* during the late Early Miocene by the aquisition of 'mammilate' cortical protuberances (KLING, 1978). The recorded extinction level of this species, as given by various workers, appears to vary quite considerably. At the Site 289, there is a discrepancy between the upper limit given by HOLDSWORTH (1975) and that presented here. Such anomalies are probably a function of subjective specific concepts by the workers concerned. Miocene cannartids consist of a wide plexus of morphotypes with many characters apparently transgressing species boundaries (SACHS and HASSON, 1979). Given such limitations, high resolution stratigraphical taxonomy is complex and open to individual interpretation.

Cannartus laticonus RIEDEL, 1959

Pl.X, fig. 5a-c

1959 Cannartus laticonus RIEDEL, p.291, pl.1, fig.5.

1975 Cannartus laticonus RIEDEL. HOLDSWORTH, p.519.

1975 Cannartus cf. laticonus RIEDEL. HOLDSWORTH, p.519.

1978 Cannartus laticonus RIEDEL. RIEDEL and SANFILIPPO, p.66, pl.4, fig.1.

Distinguishing Features: Pronounced mound-like protuberances surround the equatorial constriction. The spongy polar columns are wide at the base, taper distally and exhibit single, narrow, parellel sided clear zones at the junction with the cortex. The width of this clear zone relative to the cortical shell length increases in time (WESTBERG and RIEDEL, 1978).

Stratigraphical Distribution: WESTBERG and RIEDEL (1978) give the range as Middle Miocene (Dorcadospyris alata Zone) to Late Miocene (Ommatartus antepenultimus Zone:N.16) at Site 289 (Zonation taken from present study).

Material: At Site 289, C. laticonus ranges from beyond the lower limit of the studied sequence to the Ommatartus antepenultimus Zone:N.17. Abundance varies from very rare to few and distribution is almost continuous. At Site 71, the species is present in all nine samples from the Dorcadospyris alata Zone. Abundance varies from very rare to rare.

Discussion: C. laticonus evolved from C. mammiferus during the Middle Miocene (Dorcadospyris alata Zone) by the aquisition of clear zones at the base of broadened polar columns (RIEDEL and SANFILIPPO, 1971; 1978). As in the case of C. mammiferus, the stratigraphical range of this species differs in several accounts. HOLDSWORTH (1975) extends the upper range into the Ommatartus penultimus Zone (zonation as given here) at Site 289 (cf. WESTBERG and RIEDEL, 1978; and range given here). Discrepencies also occur with the lowermost range of the species (cf. WESTBERG and RIEDEL, 1978 with range given here). The explanation for such anomalies in the case of C. mammiferus are perhaps pertinant for C. laticonus.

"Cannartus pseudoprismaticus"

Pl.X, fig.6a-b

1974 Cannartus sp. cf. C. prismaticus SANFILIPPO and RIEDEL, p.1021, pl.1, fig.7.

1974 Cannartus sp. SANFILIPPO and RIEDEL, pl.1, fig.9.

1975 "Cannartus pseudoprismaticus" HOLDSWORTH, p.521.

1975 "Cannartus pseudoprismaticus FORM A" HOLDSWORTH, p.521.

Distinguishing Features: The cortical shell is almost spherical with no marked equatorial constriction, although very weak plicae may be present. Polar columns, when present, taper distally and possess narrow clear zones at each base.

Stratigraphical Distribution: Middle Miocene (Dorcadospyris alata Zone) to Late Miocene (Ommatartus penultimus Zone) at Site 289 (HOLDSWORTH, 1975).

Material: The range at Site 289 corresponds with that given by HOLDSWORTH (1975) and extends from Zone N.9 to N.17 of BLOW (1969). Abundance varies from very rare to rare and distribution is discontinuous. At Site 71 "C. pseudoprismaticus" is present at only one sample, in very rare abundance.

Remarks: Both SANFILIPPO and RIEDEL (1974) and HOLDSWORTH (1975) distinguished smooth from slightly mammilate forms and columned from columnless forms. They are all grouped here because of the limited biostratigraphical application of, and ambiguous relationship between, the various morphotypes. The informal name refers to the superficial resemblance with the stratigraphically older Cannartus prismaticus HAECKEL, 1887.

Cannartus? petterssoni RIEDEL and SANFILIPPO, 1970

Pl.X, fig.7

1970 Cannartus? petterssoni RIEDEL and SANFILIPPO, p.520, pl.14, fig.3.

1971 Cannartus? petterssoni RIEDEL and SANFILIPPO. RIEDEL and SANFILIPPO, p.1587, pl.1C, fig.19.

Distinguishing Features: The cortical shell is cylindrical with the protuberances situated distally. Broad spongy columns are seperated from the cortex by a narrow clear zone.

Stratigraphical Distribution: The range of this species is more or less consistent with the limits of the Cannartus? petterssoni Zone of the Middle Miocene (RIEDEL and SANFILIPPO, 1978).

Material: At the Site 289, the first appearance of the species defines the base of the Cannartus? petterssoni Zone within N.13 (RIEDEL and SANFILIPPO, 1978). The species ranges into the lower limit of the Ommatartus antepenultimus Zone:N.16 of the Late Miocene. Abundance varies from very rare to few and distribution is continuous. At Site 71, the species is present in five samples from the Dorcadospyris alata Zone. Abundance varies from very rare to rare. The presence of undoubted individuals within this Zone (cores 15-13) is enigmatic. Previous reports by MOORE (1971) and WESTBERG and RIEDEL (1978) place the lowest occurrence of the species within core 10. The possibility of downhole contamination should therefore be considered.

Discussion: The evolutionary transition of *C.? petterssoni* from *C. laticonus* was achieved by distal widening of the polar caps and concomitant poleward movement of the cortical protuberances. This trend, culminating in the evolutionary sterile species, *O. hughesi*, appears to be a divergence from the main artiscan lineage (KLING, 1978).

Cannartus? sp. aff. C.? petterssoni RIEDEL and SANFILIPPO, 1971

Pl.X, fig.8

1971 *Cannartus? sp. aff. C.? petterssoni* RIEDEL and SANFILIPPO, pl. 1C, figs.15,16.

Distinguishing Features: Similar in outline to *C.? petterssoni* but with an ellipsoidal cortical shell showing a tendancy for reduced protuberances with multiple, though indiscrete, clear zones in the polar columns.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the form from the *Ommatartus antepenultimus* Zone.

Material: At Site 289 the morphotype has a restricted range at the Middle/Late Miocene boundary (*Cannartus? petterssoni/Ommatartus antepenultimus* Zones:N.16). It is present in three samples in very rare abundance. The occurrence of the taxon in one sample from the *Dorcadospyris alata* Zone at Site 71 poses a similar problem to that discussed for *C.? petterssoni*.

Genus : *OMMATARTUS* HAECKEL, 1881 *sensu* RIEDEL, 1971

Ommatartus hughesi (Campbell and Clark), 1944

Pl.X, fig.9a-c

1944 *Ommatocampe hughesi* CAMPBELL and CLARK, p.23, pl.3, fig.12.

1971 *Ommatartus hughesi* (Campbell and Clark). RIEDEL and SANFILIPPO, p.1588, pl.1C, figs. 17,18.

1975 *Ommatartus hughesi* (Campbell and Clark). HOLDSWORTH, p.521.

1975 *Ommatartus hughesi* FORM A. HOLDSWORTH, p.521, pl.1, figs.3-6.

Distinguishing Features A cylindrical cortical shell bears multiple polar caps (at least three or more) which may grade into broad spongy columns.

Stratigraphical Distribution: Middle Miocene (*Cannartus? petterssoni* Zone) to Late Miocene (*Ommatartus antepenultimus* Zone) (RIEDEL and SANIFILIPPO, 1971). The evolutionary transition of *O. hughesi* from *C.? petterssoni* defines the base of the *Ommatartus antepenultimus* Zone near the Middle/Late Miocene boundary. The latter extinction datum defines the base of the succeeding *Ommatartus penultimus* Zone (RIEDEL and SANFILIPPO, 1978).

Material: At Site 289, *O. hughesi* ranges from the Middle Miocene (*Cannartus? petterssoni* Zone:N.15) into the Late Miocene (top of *O. antepenultimus* Zone : N.17). Abundance varies from very rare to few and distribution is continuous.

Discussion: *O. hughesi* is believed to have evolved from *C.? petterssoni* by the development of multiple polar caps (KLING, 1978), although HOLDSWORTH (1975), because of the wide range of variation exhibited by the species at the Site 289, suggests a polyphyletic origin also involving *O. antepenultimus*.

Ommatartus antepenultimus RIEDEL and SANFILIPPO, 1970

Pl.X, fig.10

1970 *Ommatartus antepenultimus* RIEDEL and SANFILIPPO, p.521, pl.14, fig.4.

1971 *Ommatartus antepenultimus* RIEDEL and SANFILIPPO. RIEDEL and SANFILIPPO, p.1588, pl.1C, figs.11,12.

Distinguishing Features: The cortical shell has a pronounced equatorial constriction and bears a distinct polar cap at the base of each spongy column.

Stratigraphical Distribution: Middle Miocene (Cannartus? petterssoni Zone) to Late Miocene (RIEDEL and SANFILIPPO, 1971).

Material: At Site 289 O. antepenultimus ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to beyond the upper limit of the studied sequence. Abundance varies from very rare to few and distribution is continuous.

Discussion: The evolutionary transition of O. antepenultimus from C. laticonus is believed to have occurred during the Cannartus? petterssoni Zone (RIEDEL and SANFILIPPO, 1978). In the present study, individuals are identified as O. antepenultimus when the length of each polar cap is greater than the height of the adjacent cortical protuberance.

Ommatartus antepenultimus FORM A

Pl.X, fig.11a-b

1975 Ommatartus antepenultimus FORM A. HOLDSWORTH, p.521.

Distinguishing Features: This form is similar to O. antepenultimus except the columns bear an extra polar cap.

Material: At Site 289, O. antepenultimus FORM A ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to the Late Miocene (Ommatartus antepenultimus Zone:N.17). Abundance varies from very rare to rare and distribution is discontinuous.

Ommatartus penultimus (Riedel), 1957

Pl.X, fig.12

1957 Pararium penultimum RIEDEL, p.76, pl.1, fig.1.

1971 Ommatartus penultimus (Riedel). RIEDEL and SANFILIPPO, p.1588, pl.1C, figs.8-10.

Distinguishing Features: The cortical shell has a tuberculate surface and bears inflated polar caps that are approximately as large as half the cortex.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) give the 'evolutionary range' as Late Miocene to Pliocene.

Material: At Site 289, *O. penultimus* ranges from the *Ommatartus antepenultimus* Zone:N.16 to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare and distribution is continuous.

Discussion: The evolutionary transition of *O. antepenultimus* to *O. penultimus* is a long ranging and subjective event which is difficult to apply as a biostratigraphical datum.

"columnless artiscans"

Pl.X, fig.13

part. 1975 Columnless mammiferous cannartids. HOLDSWORTH. p. 519.

This morphological group comprises species of *Cannartus* and *Ommatartus* in which the cortex only is preserved. The individuals may be juveniles or stunted adults. The lack of caps and spongy columns renders specific identification difficult and such forms have been grouped together in the present study. Columnless artiscans range continuously throughout the studied sequences and form an important element in radiolarian assemblages at certain levels, especially at Site 289. Abundance varies from very rare to very common at Site 289 and is always few at Site 71.

Family : PHACODISCIDAE HAECKEL, 1881

Genus : HELIODISCUS HAECKEL, 1862

Heliodiscus asteriscus HAECKEL, 1887

Pl.XI, fig.5a-b

1887 *Heliodiscus asteriscus* HAECKEL, p.445, pl.33, fig.8.

1967 *Heliodiscus asteriscus* HAECKEL. NIGRINI, p.32, pl.3, figs.1a,b.

1974 *Heliodiscus asteriscus* HAECKEL. RIEDEL, SANFILIPPO and CITA, p.707, pl.56, fig.4.

Distinguishing Features: A biconvex discoidal test with seven to eight circular pores on the radius of the cortex. Marginal spines may or may not be present.

Stratigraphical Distribution: RIEDEL, SANFILIPPO and CITA (1974) figure the species from the Lower Pliocene. The taxon is extant (RENZ, 1976).

Material: At Site 289, *H. asteriscus* ranges from the Middle Miocene (*Cannartus? petterssoni* Zone:N.13) to beyond the upper limit of the studied sequence. Distribution is continuous and abundance ranges from very rare to few.

Geographical Distribution and Palaeoecology: RENZ (1976) discovered peak abundances of *H. asteriscus* in equatorial regions of the central Pacific Ocean in both plankton and surface sediment samples.

Heliodiscus echiniscus HAECKEL, 1887

Pl.XI, fig.4

1887 *Heliodiscus echiniscus* HAECKEL, p.448, pl.34, fig.5.

1967 *Heliodiscus echiniscus* HAECKEL. NIGRINI, p.34, pl.3, figs.2a,b (partim).

1974 *Heliodiscus echiniscus* HAECKEL. RENZ, p.793, pl.13, fig.1.

Distinguishing Features: A biconvex discoidal test which is often distorted. The cortical pores are subcircular, show much size variation and comprise up to six to a radius. In addition to the marginal spines there are also many shorter spines on the discoidal surface of the cortex.

Stratigraphical Distribution: RENZ (1974) records the species from the Quaternary.

Material: At Site 289 *H. echiniscus* is present from the Late Miocene (*Ommatartus antepenultimus* Zone:N.17) to beyond the upper limit of the studied sequence. The distribution in this short stratigraphical interval is continuous and abundance varies from very rare to rare. At Site 71 the species is present in two samples, in very rare abundance.

Discussion: The presence of the species in the Middle Miocene at Site 71 is possibly due to downhole contamination.

Heliodiscus? circumcincta DYER, sp. nov.

Pl.XI, figs.1a-g

?1975 *Astrophacus* sp. LING, p.725, pl.2, figs.18-20.

Description (based on holotype and paratypes): A single medulla is surrounded by a leticular, discoid cortex. The medulla is spherical, bears large pores (approximately four to the diameter) and is connected to the cortical shell by numerous radiating bars. The surface of the cortex bears small pores with approximately eight to a radius. Between these pores, short spines radiate to produce a thorny surface. The circular margin of the cortex bears a hyaline girdle of various width which is penetrated by spinose extensions of the intershell bars. Longer spines radiating from the margins may originate from the girdle itself which, when fully developed, produces an undulating, stellate outline.

Dimensions: Holotype (from 30, 289, 50ccR. Middle Miocene: *Dorcadospyris alata*; N.9 Zones. England Finder Coordinates: U42/2):

Diameter of cortical shell : 140μ

Diameter of medullary shell: 50μ

Stratigraphical Distribution: LING (1975) tabulates a similar form from the Late Eocene (*Thyrsocyrtis bromia* Zone) to at least the Early

Miocene (*Calocycletta virginis* Zone).

Material: *H. circumcincta* ranges throughout the studied sequences at both Sites 289 and 71 where distribution is continuous. The species varies from rare to abundant at Site 289 and is always few at Site 71.

Discussion: Intraspecific variation mainly involves the nature of the marginal girdle. The degree of development varies from forms with a simple narrow hyaline rim bounding the margin, to forms with up to seventeen short, broad or long, thin spines radiating from the girdle (Pl.XI, figs.1d,1e).

The species differs primarily from *H. asteriscus* by possessing a greater number of cortical pores.

The holotype and other type material are stored in the Micropalaeontology Laboratory, Department of Geology, University of Keele. Paratypes include all other occurrences within the stuided sequence at Site 289.

The specific name makes reference to the marginal girdle.

Remarks: Placement of the species in the genus *Heliodiscus* is tentative. HAECKEL (1887) divided phacodiscids with multiple simple marginal spines into two genera: *Heliodiscus*, with a single medulla and *Astrophacus* with a double medulla. Individuals encountered in the present study possess only a single medullary shell although LING (1975) places apparently identical forms within *Astrophacus*.

"Phacodiscid sp."

Pl.XI, fig.2a-b

Distinguishing Features: A narrow lenticular disc. The medullary shell appears small compared to the diameter of the cortical shell, which appears to be concentric. Up to fifteen small, closely spaced cortical pores radiate from the centre to the first 'circumference'. No specimens were preserved complete so that the overall nature of the second cortical margin is unknown.

Material: Although distribution is discontinuous, the species appears to range throughout the studied sequences at Sites 289 and 71. Abundance varies from very rare to rare.

Family : PORODISCIDAE HAECKEL, 1887 sensu KOZLOVA in PETRUSHEVSKAYA and KOZLOVA, 1972

Genus : AMPHYMENIUM HAECKEL, 1881

Amphymenium sp. cf. A. splendiamartum CLARK and CAMPBELL, 1942

Pl.XI, fig.6a-b

1977 Amphymenium sp. cf. A. splendiamartum CLARK and CAMPBELL. RIEDEL and SANFILIPPO, pl.18, fig.14.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) figure the form from the Middle Miocene (Cannartus? petterssoni Zone).

Material: The taxon ranges throughout the studied sequences at both Sites 289 and 71. At Site 289 distribution is discontinuous while at Site 71 the form is present in all nine samples. Abundance varies from very rare to rare.

Genus : CIRCODISCUS KOZLOVA, 1972 in PETRUSHEVSKAYA and KOZLOVA, 1972

Circodiscus microporus (Stohr), 1880

Pl.XI, fig.3

1880 Trematodiscus microporus STOHR, p.108, pl.4, fig.17.

1972 Circodiscus microporus (Stohr). PETRUSHEVSKAYA and KOZLOVA, p.526, pl.19, figs.1-7.

1976 Porodiscus microporus (Stohr). RENZ, p.109, pl.3, fig.15.

Stratigraphical Distribution: Miocene to Quaternary (PETRUSHEVSKAYA and KOZLOVA, 1972).

Material: C. microporus ranges throughout the studied sequences at both Sites 289 and 71. In the short stratigraphical interval at Site 71 the species is present in all nine samples whereas at Site 289, distribution over a longer time interval is discontinuous. Abundance varies from very rare to rare.

Genus : SPIREMA HAECKEL, 1881

Spirema sp. KLING, 1973

Pl.XI, fig.7

1973 Spirema sp. KLING, p.635, pl.7, figs.23-25.

1975 Spirema (?) sp. KLING. PETRUSHEVSKAYA, p.576, pl.16, fig.6.

Stratigraphical Distribution: Miocene (KLING, 1973; PETRUSHEVSKAYA, 1975).

Material: Spirema sp. ranges throughout the studied sequences at both Sites 289 and 71. Distribution is almost continuous and abundance varies from very rare to rare.

Genus : STYLOCHLAMYDIUM HAECKEL, 1881

Stylochlamydium asteriscus HAECKEL, 1887

Pl.XI, fig.8a-b

1887 Stylochlamydium asteriscus HAECKEL, p.514, pl.41, fig.10.

1976 Stylochlamydium asteriscus HAECKEL. RENZ, p.109, pl.3, fig.12.

Distinguishing Features: Subquadrate test comprising concentric chambers arranged around four main spines normal to each other in the equatorial plane. Between spines, the chamber walls are less curved than similarly quadrate members of Stylodictya spp.

Stratigraphical Distribution: The previous known range is Quaternary

(RENZ, 1976).

Material: At Site 289, S. asteriscus ranges from the Middle Miocene (Cannartus? petterssoni Zone:N:13) to beyond the upper limit of the studied sequence. Distribution is markedly discontinuous and abundance varies from very rare to rare.

Genus : STYLODICTYA EHRENBERG, 1847 emend. KOZLOVA in PETRUSHEVSKAYA and KOZLOVA, 1972

Stylodictya spp.

Pl.XI, fig.9a-c

1972 Stylodictya aculeata (Jorgensen). PETRUSHEVSKAYA and KOZLOVA, p.526, pl.18, fig.6.10

1973 Xiphospira sp. cf. X. circularis (Clark and Campbell). KLING, p. 635, pl.2, figs.1-3; pl.7, figs.11-14; (non) figs.15-17.

1975 Stylodictya stellata BAILEY group. PETRUSHEVSKAYA, p.577, pl.6, fig.9.

Stratigraphical Distribution: Miocene to Recent (KLING, 1973; PETRUSHEVSKAYA, 1975)

Material: At Site 289, Stylodictya spp. ranges throughout the studied sequence. Distribution is almost continuous and abundance varies from very rare to rare. At Site 71, the taxon is present in all nine samples, with abundance ranging from rare to few.

Discussion: Because of inter-specific gradation, attempts to differentiate the species comprising this group were unsuccessful in the present study.

Forms range from totally circular morphotypes to quadrate individuals possessing four main peripheral spines. These latter types are not represented in the synonymy.

Genus : STYLOTROCHUS HAECKEL, 1862

Stylotrochus ?sp.

Pl.XI, fig.10

1977 Stylotrochus ?sp. RIEDEL and SANFILIPPO, pl.21, fig.15.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) figure the taxon from the Late Miocene (Stichocorys peregrina Zone).

Material: At Site 289 the species ranges from the Late Miocene (Ommatartus antepenultimus Zone:N.17) to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare.

Genus : XIPHOSPIRA HAECKEL, 1887

Xiphospira sp. cf. X. circularis (Campbell and Clark), 1942

Pl.XI, fig.11

1972 Phacodiscidae ?gen indet. PETRUSHEVSKAYA and KOZLOVA, pl.19, fig.15.

1973 Xiphospira sp. cf. X. circularis (Campbell and Clark). KLING, p.635, pl.7, fig.16; (non) pl.2, figs.1-3; pl.7, figs.11-15,17.

Stratigraphical Distribution: Both PETRUSHEVSKAYA and KOZLOVA (1972) and KLING (1973) figure this form from the Early Miocene.

Material: The taxon ranges throughout the studied sequences at both Sites 289 and 71. Distribution is continuous and abundance varies from very rare to few at Site 289 and from very rare to rare at Site 71.

Discussion: Inclusion of this form in the genus Xiphospira is for temporary convenience. The generic classification of the porodiscids in the present study is essentially similar to that followed by KOZLOVA in PETRUSHEVSKAYA and KOZLOVA (1972) who restrict Xiphospira to the Palaeogene and who in fact tentatively include this form in the family Phacodisdiae.

"Porodiscid spp. group"

Pl.XI, fig.12a-d

1887 PORODISCUS HAECKEL. HAECKEL, p.491.

1887 STYLODICTYA EHRENBERG. HAEKEL, p.509.

1887 STYLOTROCHUS HAECKEL. HAECKEL, p.583.

Distinguishing Features: This group includes all porodiscids encountered in the present study that have not been discriminated at a generic or specific level. Individuals of this group have been synonymised with the above genera.

Material: The porodiscids form an important element of the radiolarian assemblages at both Sites 289 and 71 where they range continuously through the studied sequences. "Porodiscid spp. group" varies from rare to abundant at Site 289 and is very common at Site 71.

Discussion: An attempt to differentiate the various taxa of this group in the present study was unsuccessful.

Family : SPONGODISCIDAE HAECKEL, 1862 sensu KOZLOVA in PETRUSHEVSKAYA and KOZLOVA, 1972

Genus : RHOPALASTRUM EHRENBERG, 1847 sensu KOZLOVA in PETRUSHEVSKAYA and KOZLOVA, 1972

Rhopalastrum angulatum Group (Ehrenberg), 1872

Pl.XI, fig.13a-b

1872 Dictyastrum angulatum EHRENBERG, pl.8, fig.18.

1972 Rhopalastrum angulatum (Ehrenberg). PETRUSHEVSKAYA and KOZLOVA, p.529, pl.17, fig.8. (non) fig.7.

Distinguishing Features: The spongy central disc consists usually of four concentric rings. A patagium of variable size may be present on three arms.

Stratigraphical Distribution: Early Miocene to Recent (PETRUSHEVSKAYA and KOZLOVA, 1972).

Material: R. angulatum exhibits continuous distribution throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to common at Site 289 and from rare to few at Site 71.

Discussion: R. angulatum is distinguished from R. profunda in the present study on the basis of the concentric chambers and the nature of the arm ends. In R. angulatum the chambers are wider spaced and consequently less numerous, while arm edges are usually flat and angular.

Rhopalastrum müller (Haeckel), 1862

Pl.XI, fig.14

1862 Euchitonia mülleri HAECKEL, p.508, pl.30, figs. 5-10.

1872 Euchitonia furcata EHRENBERG, p.289, pl.IV(iii), fig.6.

1967 Euchitonia mülleri HAECKEL. NIGRINI, p.37, pl.4, figs.1a,1b.

Distinguishing Features: Test with three arms of approximately equal length. The proximal portions of the arms are narrow and the angles between them vary to produce a bilateral symmettry for the test. A patagium may or may not be present.

Stratigraphical Distribution: STOHR (1880) records the species from the Late Miocene of Sicily. The taxon is extant (RENZ, 1976).

Material: At Site 289, R. mulleri appears in the Late Miocene (Ommatartus antepenultimus Zone:N.17) and is present consistently to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: NIGRINI (1970) cites the species (as E. furcata) as characteristic of tropical radiolarian assemblages in Holocene sediments from the north Pacific Ocean. In plankton tows from the central Pacific Ocean, RENZ (1976) found peak abundance of the species at the equator.

Remarks: The species has been transferred to the genus *Rhopalastrum* following the work of PETRUSHEVSKAYA and KOZLOVA (1972).

Rhopalastrum profunda Group (Ehrenberg), 1861

Pl.XI, fig.13a,15a-b

1861 *Dictyocoryne profunda* EHRENBERG, p.767.

1971 *Dictyocoryne ontongensis* RIEDEL and SANFILIPPO, p.1588, pl.1E, figs.1-2; pl.4, figs.9-11.

1972 *Rhopalastrum profunda* (Ehrenberg). PETRUSHEVSKAYA and KOZLOVA, p.529, pl.17, fig.4,5. (non) fig.6.

Distinguishing Features: The spongy central disc consists usually of five concentric rings. A patagium of variable size may be present on arms that either terminate in a rounded bulbous end or bifurcate.

Stratigraphical Distribution: Early Miocene to Recent (PETRUSHEVSKAYA and KOZLOVA, 1972). RIEDEL and SANFILIPPO (1978) gave the range of *D. ontongensis* as Middle to Late Miocene (*Cannartus? petterssoni* to *Ommatartus antepenultimus* Zone).

Material: *R. profunda* appears consistently throughout the studied sequences at Sites 289 and 71. At Site 289 abundance varies from very rare to common. At Site 71 abundance is few.

Remarks: The nature of the central disc in *R. profunda* of PETRUSHEVSKAYA and KOZLOVA (1972) and *D. ontongensis* of RIEDEL and SANFILIPPO (1971) appears identical. In most individuals encountered the distal portions of the arms are missing and so differentiation of the two "species" is impossible. Consequently they have been synonymised.

Genus : *SPONGASTER* EHRENBERG, 1860 *emend*. RIEDEL and SANFILIPPO, 1971

Spongaster berminghami (Campbell and Clark), 1944

Pl.XI, fig.16

1944 Spongasteriscus berminghami CAMPBELL and CLARK, p.30, pl.5, figs.1,2.

1971 Spongaster klingi RIEDEL and SANFILIPPO, p.1589, pl.1D, figs.8-10, pl.4, figs.7,8.

1978 Spongaster berminghami (Campbell and Clark). RIEDEL and SANFILIPPO, p.73, pl.2, figs.14-16.

Distinguishing Features: Elliptical spongy test with a bipolar symmetry accentuated by distal thickenings.

Stratigraphical Distribution: Late Miocene (Ommatartus antepenultimus Zone) to Pliocene (RIEDEL and SANFILIPPO, 1978).

Material: At Site 289, S. berminghami ranges from the Late Miocene (Ommatartus antepenultimus Zone:N.16) to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare.

Discussion: RIEDEL and SANFILIPPO (1978) have discussed the position of S. berminghami within a phylogenetic lineage leading to the evolution of S. tetras during the Neogene. The lineage, in chronological order, involves Spongodiscus corpusculus, Spongaster spp. 1,2,3,4, S. berminghami, S. pentasand S. tetras. Detailed work by RIEDEL and SANFILIPPO (1978) show, however, that the lineage is quite complex and not simply rectilinear.

Spongaster sp. aff. S. tetras EHRENBERG, 1860

Pl.XI, fig.17a-b

1975 Spongaster aff. tetras. HOLDSWORTH, p.528.

1978 Spongaster (quadrangular). RIEDEL and SANFILIPPO, p.73, pl.2, fig.10.

Distinguishing Features: A quadrate form with a central thickened area surrounded by four dense regions more or less corresponding to the peripheral angles.

Material: This form is present in just one sample from the *Ommatartus antepenultimus* Zone:N.17 of the Late Miocene at Site 289.

Discussion: The taxon probably represents a quadrate variant of the normally bipolar *S. berminghami*. It occurs much earlier than *S. tetras* (a Pliocene species : RIEDEL and SANFILIPPO, 1978).

Spongaster sp. 1

Pl.XI, fig.18

1971 *Spongodiscid, gen. et. sp. indet.* RIEDEL and SANFILIPPO, p.1589, pl.1D, fig.14.

1978 *Spongaster* (circular). RIEDEL and SANFILIPPO, p.73, pl.2, fig.17.

Distinguishing Features: A discoidal spongodiscid with a thickened centre and periphery. A narrow cone or pylome tube extends in from the margin.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1973) encountered this form throughout the Late Miocene and Pliocene (see WESTBERG and RIEDEL, 1978 for the zonation).

Material: This species only occurs at Site 71. It is found in all nine samples from the *Dorcadospyris alata* Zone of the Middle Miocene and abundance varies from very rare to rare.

Spongaster sp. 2

Pl.XI, fig.19

1971 *Spongodiscid gen. et sp. indet.*, RIEDEL and SANFILIPPO, p.1589, pl.5, fig.1.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the form from the Middle Miocene (Dorcadospyris alata Zone).

Material: At Site 289 the taxon is present in four samples from the lower part of the Dorcadospyris alata Zone. Abundance is always very rare.

Discussion: This form superficially resembles S. tetras but occurs much earlier in the stratigraphical sequence. It possibly represents a quadrate variant of Spongaster sp.3.

Spongaster sp. 3

Pl.XI, fig.20

1978 Spongaster (triangular). RIEDEL and SANFILIPPO, p.73.

Distinguishing Features: Triangular spongodiscid consisting of a central disc of concentric chambers surrounded by a spongy network differentiated by three circular dense areas at the apices of the test.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1978) encountered this form from the Late Miocene (Ommatartus antepenultimus Zone) at DSDP Site 77B (see WESTBERG and RIEDEL (1978) for the zonation).

Material: At Site 289, Spongaster sp. 3 ranges from the base of the studied sequence into the Middle Miocene (Cannartus? petterssoni Zone:N.13). At Site 71, the species is found in five samples from the Dorcadospyris alata Zone of the Middle Miocene. Abundance at both Sites varies from very rare to rare.

Spongaster sp. 4

1971 Spongaster sp. (?) RIEDEL and SANFILIPPO, p.1589, pl.1D, figs.11,12.

Distinguishing Features: A semicylindrical form with a central area and two long radial thickenings.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the species from the Late Miocene (*Ommatartus antepenultimus* and *Stichocorys peregrina* Zones).

Material: *Spongaster* sp. 4 occurs in two samples from Site 71. Abundance varies from very rare to rare.

Genus : SPONGOCORE HAECKEL, 1887

Spongocore puella HAECKEL, 1887

Pl.XII, fig.1

1887 *Spongocore puella* HAECKEL, p. 347, pl.48, fig.6.

1973 *Spongocore puella* HAECKEL. KLING, p.635, pl.7, figs.18-22.

Stratigraphical Distribution: KLING (1973) figures the species from the Early to Late Miocene. It is extant (CASEY, 1966).

Material: *S. puella* ranges throughout the studied sequences at both Sites 289 and 71. Distribution is discontinuous at Site 289 but continuous at the stratigraphically shorter sequence at Site 71. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: CASEY (1966, 1971a,b.) indicates *S. puella* as characteristic of equatorial central shallow radiolarian assemblages in the Pacific Ocean plankton and surface sediment samples.

Genus SPONGODISCUS EHRENBERG, 1854 *sensu* SANFILIPPO and RIEDEL, 1971

Spongodiscus corpusculus DYER, sp. nov.

Pl.XII, fig.2a-b

1971 "*Circular spongodiscid*." KLING, p.1086, pl.1, fig.8.

1974 *Spongodiscid*. JOHNSON, pl.9, fig.18

1976 *Spongodiscidae gen. et sp. indet.* RIEDEL and SANFILIPPO in

BERGGREN *et al*. p.236, pl.XII, fig.10.

Description (based on holotype and paratypes): A circular form with a wide, thickened margin separated from a dense centre by a delicate latticed intermediate region. The central disc consists of up to six discrete concentic chambers with thickened spongy walls. Further chamber boundaries are discontinuous and blend rapidly into an intermediate region of similar thickness but comprising a double layer of open network with anastomosing radial and concentric beams forming circular to irregularly shaped multimodal pores in an irregular arrangement. The marginal region is thickened by a dense spongy network of closely packed circular pores. This construction is elliptical in cross section. Short, irregular thorny or simple spines radiate from the circumference at uneven intervals.

Dimensions: Holotype (from 30, 289, 32cc R. Late Miocene: *Ommatartus antepenultimus*: N.16 Zones. England Finder Co-ordinates G45/3):

Maximum diameter: 295μ ; minimum diameter; 290μ ; diameter of dense centre: 55μ ; width of thickened margin: 70μ .

Stratigraphical Distribution: KLING (1971) records the species from the Middle to Late Miocene (*Cannartus? petterssoni* to *Ommatartus antepenultimus* Zones). RIEDEL and SANFILIPPO (in BERGGREN *et al*., 1976) figure the form from contemporaneous sediments while JOHNSON (1974) extends the upper range into the *Stichocorys peregrina* Zone.

Material: At Site 289, *S. corpusculus* ranges throughout the studied sequence. Abundance varies from very rare to rare and distribution is continuous. At Site 71, the species is found in only two samples, in very rare abundance, from the *Dorcadospyris alata* Zone.

Discussion: Individuals are rarely preserved in pristine condition and usually only the thickened spongy rim persists. KLING (1971) and RIEDEL and SANFILIPPO (1971) suggest *S. corpusculus* (as 'circular spongodiscid') as the precursor of the genus *Spongaster* during the Middle and Late Miocene. This species differs from other Spongaster spp. by it's circular outline, associated radial symmetry and/or its lack a pylome tube.

The holotype and other type material are stored in the Micropalaeontology Laboratory, Department of Geology, University of Keele. Paratypes include all other occurrences within the studied sequence at Site 289.

The specific name reflects the resemblance of the species to a red blood corpuscle.

Spongodiscus sp.

Pl.XII, fig.3

1973 Spongodiscus sp. LING, p.778, pl.1, figs.9,10.

1975 Spongodiscus sp. LING, p.725, pl.4, fig.5.

Distinguishing Features: A large distinctive biconvex form with a smooth surface consisting of an irregular meshwork of circular pores. A dense region, with faint concentric rings, marks the centre of the disc.

Stratigraphical Distribution: LING (1973) records a similar form restricted to the Pleistocene.

Material: Spongodiscus sp. ranges throughout the studied sequences at both Sites 289 and 71. Distribution is discontinuous at Site 289 and continuous at the stratigraphically shorter sequence at Site 71. Abundance varies from very rare to rare.

"Spongodiscid spp. group"

Pl.XII, fig.4a-b

1854 SPONGODISCUS EHRENBERG, p.237.

1860 SPONGOTROCHUS HAECKEL, p.844.

Distinguishing Features: This group includes most spongodiscids with flat or lenticular discoidal tests with or without radial spines around the periphery.

Material: The group forms an important constituent of radiolarian assemblages at Sites 289 and 71 where members range continuously throughout the studied sequences.

Abundance varies from very rare to very common at Site 289 and from few to common at Site 71.

Discussion: Apart from that by PETRUSHEVSKAYA and KOZLOVA (1972), little taxonomic work has been carried out on Neogene members of these genera since the early studies of EHRENBERG (1854) and HAECKEL (1862). The systematics of the genera as followed in the present study are outlined by HAECKEL (1887), who discriminated the species on the basis of the presence or absence of internal structures and peripheral spines. In the present study, such features were considered ambiguous given the preservational state of the individuals. Consequently, specific discrimination and identifications were not undertaken.

Family : THOLONIIDAE HAECKEL, 1887

Genus : CUBOTHOLUS HAECKEL, 1887

Cubotholus regularis HAECKEL, 1887

Pl.XII, fig.5

1887 Cubotholus regularis HAECKEL, p.680, pl.10, fig.14.

1976 Cubotholus regularis HAECKEL. RENZ, p.113, pl.1, fig.18.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) figure representatives of the genus from the Middle Miocene (Cannartus? petterssoni Zone) to the present.

Material: At Site 289 C. regularis ranges continuously from the Middle Miocene (Dorcadospyris alata Zone: N.11-12) to beyond the upper limit of the studied sequence. At Site 71, the species is present in eight samples from the Dorcadospyris alata Zone.

Abundance at both Sites varies from very rare to rare.

Family : LITHELIIDAE HAECKEL, 1887 emend. PETRUSHEVSKAYA, 1975

"Litheliid spp."

Pl.XII, fig.6a-j

Remarks: PETRUSHEVSKAYA (1975) combined the LITHELIIDAE and PYLONIIDAE of HAECKEL (1862 and 1881 respectively). This was the first, major taxonomic revision of the groups since their erection and has been followed in the present study. However, the LITHELIIDAE remain largly an unknown group, possibly as a result of complex morphologies and consequental neglect in stratigraphical studies. An attempt to differentiate members on the generic and specific level in the present study was unsuccessful and the group has been 'lumped'. Nevertheless, the following genera have been identified, though not quantitatively discriminated. This synonymy however, does not probably represent the full range of taxa encountered.

1975 LITHELIUS HAECKEL. PETRUSHEVSKAYA, p.572.

1975 LITHOCARPIUM STOHR emend. PETRUSHEVSKAYA, p.572.

1975 PYLOSPIRA HAECKEL. PETRUSHEVSKAYA, p.573.

1977 LARCOSPIRA HAECKEL. RIEDEL and SANFILIPPO, pl.18, fig.18; pl.20, fig.19.

Material: "Litheliid spp." form an important element in radiolarian assemblages at Sites 289 and 71, where the group ranges throughout the studied sequences. Abundance varies from rare to abundant at Site 289 and is always very common at Site 71.

Discussion: The range of morphologies within this group is quite diverse, being built around complex models of heavily latticed tests arranged in either a spiral manner or in a succession of concentric girdles arranged in three mutually perpendicular planes.

Order : NASSELLARIA EHRENBERG, 1875

Suborder : SPYRIDA EHRENBERG, 1847 emend. PETRUSHEVSKAYA, 1971

Family : ACANTHODESMIIDAE HAECKEL, 1862

Form : "Spyrid spp."

Discussion: Spyrids constitute an important element in Neogene radiolarian assemblages. However, because of taxonomic difficulties the majority of species have been grouped together in the present study. Two species of the same genus, one of which has biostratigraphical importance, have been identified. Spyrids at Site 289 vary in abundance from rare to abundant. At Site 71, the group ranged from common to very common. Distribution at both sites is continuous.

Genus : DORCADOSPYRIS HAECKEL, 1881

Dorcadospyris alata (Riedel), 1959

1959 Brachiospyris alata RIEDEL, p.293, pl.1, figs.11,12.

1971 Dorcadospyris alata (Riedel). RIEDEL and SANFILIPPO, p.1590, pl.2D, fig.1.

Distinguishing Features: Test small and thick walled with two very widely divergent feet bearing short thorns.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1978) use the 'evolutionary' transition of D. dentata to D. alata to define the base of the Dorcadospyris alata Zone, concurrent with the Early/Middle Miocene boundary. The species becomes extinct during the Cannartus? petterssoni Zone (WESTBERG and RIEDEL, 1978).

Material: At Site 289, D. alata ranges from the base of the studied sequence (HOLDSWORTH, 1975) to the top of the Dorcadospyris alata

Zone:N.13. Abundance varies from very rare to rare. At Site 71, the species is found in four samples in similar abundance.

Towards the top of its range at Site 289, D. alata exhibits a markedly discontinuous distribution. This may explain the discrepant upper range given here compared to that given by HOLDSWORTH (1975) and WESTBERG and RIEDEL (1978).

Dorcadospyris forcipata Group (Haeckel), 1887

1887 Dipospyris forcipata HAECKEL, p.1037, pl.85, fig.1.

1971 Dorcadospyris forcipata (Haeckel). RIEDEL and SANFILIPPO, p.1590, pl.2C, figs.20-23; pl.3A, fig.8.

1975 Dorcadospyris forcipata (Haeckel) Group. HOLDSWORTH, p. 529.

Distinguishing Features: Forms encountered in the studied sequence at Site 289 possessed only the pendant feet and no cephalic horn (see HOLDSWORTH, 1975).

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) cite the range as Oligocene to Early Miocene. By including morphotypes similar to those encountered in the present study, HOLDSWORTH (1975) extended the range at Site 289 into the Dorcadospyris alata Zone of the Middle Miocene.

Material: D. forcipata ranges from beyond the base of the studied sequence into the Dorcadospyris alata Zone:N.10 at Site 289. The species is present in only three samples and abundance is always very rare.

Suborder : CYRTIDA EHRENBERG, 1862 emend. PETRUSHEVSKAYA, 1971

Family : PLAGONIIDAE HAECKEL, 1881 emend. RIEDEL, 1967

Genus : CALLIMITRA HAECKEL, 1881

Callimitra spp.

Pl.XII, fig.7a-b

1979 Callimitra spp. GOLL, p.386.

1979 Clathrocorys spp. GOLL, p.386.

Stratigraphical Distribution: Late Eocene to Pleistocene (GOLL, 1979).

Material: Clathrocorys spp. ranges throughout the studied sequences at both Sites 289 and 71. At the former, distribution is almost continuous and abundance varies from very rare to few. At Site 71, the taxon is present in all samples with abundance varying from very rare to rare.

Remarks: This species group includes all plagoniids that possess three large lattice pannels extending laterally from the tip of the apical apophysis to the tips of each of the frontal and primary lateral apophyses.

Genus : CLATHROCANIUM EHRENBERG, 1860.

Clathrocanium reginae HAECKEL, 1887

Pl.XII, fig.8

1887 Clathrocanium reginae HAECKEL, p.1212, pl.64, fig.4.

Distinguishing Features: A large spherical cephalis bears an elongate club-shaped horn with a spongy termination. Three ribs, with similar spongy ends, enclose a finely porous inflated thorax. Three thoracic 'gates' are outlined by small pores although in most cases these remain closed by finely porous shell.

Stratigraphical Distribution: HAECKEL (1887) collected the species from surface sediment samples in the Pacific Ocean.

Material: At Site 289, C. reginae ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to beyond the upper limit of the studied sequence. Distribution is very discontinuous. The species is present at all nine samples from Site 71. Abundance at both Sites varies from very rare to rare.

Clathrocanium sphaerocephalum HAECKEL, 1887

Pl.XII, fig.9a-d

1887 Clathrocanium (Clathrocanidium) sphaerocephalum HAECKEL, p.1211, pl.64, fig.1.

1973 Clathrocanium sphaerocephalum HAECKEL. SANFILIPPO et al., p.220, pl.4, fig.9.

Distinguishing Features: A large spherical cephalis bears a simple or latticed prismatic horn. Three simple thoracic ribs intercalate with three open 'gates'. The thorax is coarsely perforate and is separated from a subcylindrical abdomen by a narrow peristome.

Stratigraphical Distribution: HAECKEL (1887) collected the species from surface sediment samples in the western equatorial Pacific Ocean. SANFILIPPO et al. (1973) figure the species from the Middle Miocene (Dorcadospyris alata Zone) at DSDP Site 66 in the central Pacific.

Material: C. sphaerocephalum ranges throughout the studied sequences at both Sites 289 and 71. Distribution at Site 289 is almost continuous while at Site 71 the species is present in all nine samples. Abundance varies from very rare to rare.

Discussion: SANFILIPPO et al. (1973) have commented on the close relationship between C. sphaerocephalum and Clathrocorona atreta (see below). At Site 289, a possible transitionary morphotype was encountered in two samples from the Dorcadospyris alata Zone. These forms possess similar thoracic wall textures to C.sphaerocephalum and have similar outlines except in the region of the thoracic gates which are here closed, serve to inflate the thorax, and thus show a close resemblance to heavy individuals of C. atreta (Pl.XII, fig.9d).

Genus : CLATHROCORONA HAECKEL, 1881

Clathrocorona atreta SANFILIPPO and RIEDEL, 1973

Pl.XII, fig.10a-e

1973 Clathrocorona atreta SANFILIPPO and RIEDEL. in SANFILIPPO et al., p.219, pl.4, figs.5-8.

Stratigraphical Distribution: SANFILIPPO et al. (1973) give a minimum range of Early to Late Pliocene.

Material: The species ranges throughout the studied sequences at both Sites 289 and 71 and exhibits almost continuous distribution, though abundance varies from very rare to rare.

Discussion: Individuals encountered in the present study resemble quite closely those figured by SANFILIPPO et al. (1973). However, intraspecific variation is quite considerable at certain horizons and involves pore size and test wall thickness. Extreme forms include heavy thick walled individuals with large thoracic pores (Pl.XII, fig.10e) and 'light' thin walled varieties with small thoracic pores (Pl.XII, fig.10a). Intermediate forms (Pl.XII, fig.10d) substantiate this intraspecific gradation.

Genus : TEPKA SANFILIPPO and RIEDEL, 1973

Tepka perforata SANFILIPPO and RIEDEL, 1973

Pl.XII, fig.11

1973 Tepka perforata SANFILIPPO and RIEDEL. in SANFILIPPO et al., p.228, pl.6, figs.18-20.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) give the range as Early Miocene (Lychnocanoma elongata Zone) to Middle Miocene (Dorcadospyris alata Zone).

Material: At Site 289, T. perforata is found in only four samples from the Middle Miocene (Dorcadospyris alata Zone:N.9 to Cannartus?

pettersssoni Zone:N.14). Abundance varies from very rare to rare.

Genus : VERTICILLATA POPOFSKY, 1913

Verticillata hexacantha POPOFKSY, 1913

Pl.XII, fig.12

1913 Verticillata hexacantha POPOFSKY, p.282, text fig.11.

1974 Verticillata hexacantha POPOFSKY. RENZ, p.799, pl.18, fig.1.

Stratigraphical Distribution: Quaternary (RENZ, 1974).

Material: The species is present in two samples from the Late Miocene (Ommatartus antepenultimus Zone:N.16/17) at Site 289 and one sample from the Middle Miocene (Dorcadospyris alata Zone) at Site 71. Abundance is always very rare.

Discussion: The presence of the species in the Middle Miocene at Site 71 may be due to downhole contamination (see Chapter V).

"Plagoniid spp. group"

Pl.XII, fig.13a-c

1974 Lophophaena sp. RIEDEL, SANFILIPPO and CITA, p.709, pl.59, figs.6,7.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) figure Lophophaena spp. from the Late Oligocene to Quaternary.

Material: This group ranges throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to common at the former and from rare to few at the latter site.

Discussion: This group includes all plagoniid species that superficially resemble the synonymised form. There are probably several species involved in the present study though attempts to separate them have been unsuccessful.

Family : <u>THEOPERIDAE</u> HAECKEL, 1881 <u>emend</u> RIEDEL, 1976

Genus : <u>ARTOPHORMIS</u> HAECKEL, 1881 <u>sensu</u> RIEDEL and SANFILIPPO, 1970

<u>Artophormis sp. cf. A. gracilis</u> RIEDEL, 1959

Pl.XIII, fig. 1

1974 <u>Artophormis sp. cf. A. gracilis</u> RIEDEL. SANFILIPPO and RIEDEL, p.1000, pl.2, fig.2.

<u>Stratigraphical Distribution</u>: SANFILIPPO and RIEDEL (1974) record the taxon from the Pliocene.

<u>Material</u>: Present in three samples from Site 71. Abundance always very rare.

Genus : <u>ARTOPILIUM</u> HAECKEL, 1881

<u>Artopilium undulatum</u> POPOFSKY, 1913

Pl.XIII, fig.2

1913 <u>Artopilium undulatum</u> POPOFSKY, p.405, pl.36, figs.4,5.

1976 <u>Artopilium undulatum</u> POPOFSKY. RENZ, p.116, pl.4, fig.12.

<u>Stratigraphical Distribution</u>: RENZ (1976) records this species from both plankton and surface sediment samples from the central Pacific Ocean.

<u>Material</u>: At Site 289, <u>A. undulatum</u> is found in only four samples from the <u>Cannartus? petterssoni</u> (N.14) and <u>Ommatartus antepenultimus</u> (N.16/17) Zones of the Middle and Late Miocene respectively. Abundance is always very rare. At Site 71 however, the species is found in all nine samples within the older <u>Dorcadospyris alata</u> Zone (N.11-12) of the Middle Miocene.

<u>Discussion</u>: The presence of the species at Site 71 may be due to downhole contamination (see Chapter V).

Genus : <u>BATHROPYRAMIS</u> HAECKEL, 1881

<u>Bathropyramis woodringi</u> CAMPBELL and CLARK, 1944

Pl.XIII, fig.3a-b

1944 Bathropyramis woodringi CAMPBELL and CLARK, p.39, pl.5, figs.21,22.

1973 Bathropyramis woodringi CAMPBELL and CLARK. KLING, p.635, pl.2, figs.20-23; pl.9, figs.5-7.

Stratigraphical Distribution: KLING (1973) identified the species in Early Miocene (Calocycletta costata Zone) to Pleistocene sediments from the north east Pacific Ocean.

Material: At Site 289, B. woodringi ranges from the Middle Miocene (Dorcadosypris alata Zone:N.11-12) to beyond the upper limit of the studied sequence. Distribution within this range is almost continuous, though abundance varies from very rare to rare. At Site 71, the species is found in five of the nine samples from the Dorcadospyris alata Zone (N.11-12). Abundance is always very rare.

Genus : BEKOMIFORMA SANFILIPPO and RIEDEL, 1974

Bekomiforma mynx SANFILIPPO and RIEDEL, 1974

Pl.XIII, fig.4a-b

1974 Bekomiforma mynx SANFILIPPO and RIEDEL, p.1020, pl.2, figs.3-5.

Distinguishing Features: Cephalis with two horns followed by a campanulate thorax bearing three strong feet. The thoracic pores are small, closely spaced and vary from circular, unimodal and neatly arranged to subcircular, multimodal and irregularly arranged.

Stratigraphical Distribution: SANFILIPPO and RIEDEL (1974) tabulate the species from the Late Miocene (Stichocorys peregrina Zone) to Quaternary.

Material: At Site 289, B. mynx is discontinually distributed within the Middle to Late Miocene (Dorcadospyris alata :N.11-12 to Ommatartus antepenultimus: N.16 Zones). At Site 71, the species is present in three samples from the Dorcadospyris alata Zone. Abundance varies from very rare to rare.

Discussion: SANFILIPPO and RIEDEL (1974) do not mention forms with irregularly shaped, sized and arranged thoracic pores although such forms encountered in the present study are identical in all other respects to their original description of the species.

Bekomiforma hyalina DYER sp.nov.

Pl.XIII, fig.5a-e

1977 Lychnocanoma ?sp. RIEDEL and SANFILIPPO, pl.20, fig.10.

Description (based on holotype): Cephalis with two horns, followed by a campanulate thorax, three strong feet and rudimentary abdomen. The cephalis is spherical, almost poreless and bears two large strong spines. The internal spicule consists of a median bar, positioned within the cephalis above the collar stricture, from which emerge an apical bar leading to a strong spine, a vertical bar leading to an indistinct thorn, and two lateral and a dorsal bar leading to the three post-thoracic feet. The second apical spine is unrelated to the internal spicule. The thorax can be seperated into two regions: a narrow hyaline proximal portion and an inflated distal portion which bears up to seven vertical rows of circular pores per side, possesses a rugose wall and is seperated from the former by a distinct break in contour. The three feet are strong and wide at the base where they bear a highly latticed and delicate abdomen.

Dimensions: Holotype (from 40cc R(a)). Middle Miocene: Cannartus? petterssoni :N.13 Zones. England finder Co-ordinates: X57/2.

Length of apical spine:20μ

Length of cephalis:25μ

Length of thorax:55μ

Maximum width of thorax:16μ

Length of feet:130μ

Total length of test:230μ

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) figure the form from the Late Miocene (*Ommatartus antepenultimus* Zone).

Material: At Site 289, *B. hyalina* ranges from beyond the lower limit of the studied sequence into the Late Miocene (*Ommatartus antepenultimus* Zone :N.16). Distribution is almost continuous. At Site 71, the species is present in all nine samples from the *Dorcadospyris alata* Zone. Abundance varies from very rare to rare.

Discussion: Intraspecific variation is quite pronounced and mainly concerns the shape of the thorax and nature of the associated pores. The distribution of these characters are possibly related. Individuals may possess a relatively wide thorax with well developed rows of pores in the distal region (Pl.XIII, fig.5e); other forms possess a relatively narrow thorax which is very sparsely porous or even completely hyaline (Pl.XIII, fig.5d). The holotype lies between these two extremes.

B. hyalina appears to be closely related to *B. mynx* but differs in the partly hyaline nature of the thorax and by possessing larger thoracic pores. The stratigraphical evidence suggests that *B. hyalina* is the precursor of the latter.

The holotype and other type material are sorted in the Micropalaeontology Laboratory, Department of Geology, University of Keele. Paratypes include all other occurrences within the studied sequences at Site 289.

The specific name makes reference to the hyaline nature of the thorax.

Genus : *CALOCYCLAS* EHRENBERG, 1847

Calocyclas monumentum HAECKEL, 1887

Pl.XIII, fig.6

1887 Calocyclas monumentum HAECKEL, p.1385, pl.73, fig.9.

1976 Calocyclas monumentum HAECKEL. RENZ, p.128, pl.5, fig.1.

1977 Calocyclas ?sp. RIEDEL and SANFILIPPO, pl.19, fig.13.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) record this taxon from the Middle Miocene (Cannartus? petterssoni Zone). RENZ (1976) collected the species from plankton and surface sediment samples in the central Pacific Ocean.

Material: At Site 289, C. monumentum ranges throughout the studied sequence. Distribution is discontinuous however, and abundance varies from very rare to rare. At Site 71 the species is found in all nine samples but similarly varies from very rare to rare in abundance.

Genus : CORNUTELLA EHRENBERG, 1838

Cornutella profunda EHRENBERG, 1856

Pl.XIII, fig.7

1856 Cornutella clathra, β profunda EHRENBERG, pl.35B, fig.21.

1973 Cornutella profunda EHRENBERG. KLING, p.635, pl.3, fig.1-4, pl.9, fig.8-17.

1976 Cornutella profunda EHRENBERG. RENZ, p.149, pl.7, fig.11.

Stratigraphical Distribution: CHEN (1975) gives the range of this species as Oligocene to Recent.

Material: At Site 289, C. profunda ranges throughout the studied sequence with distribution almost continuous. At Site 71, the species is found in all nine samples from the Dorcadospyris alata Zone of the Middle Miocene. Abundance at both Sites varies from very rare to rare.

Geographical Distribution and Palaeoecology: CASEY (1966, 1971a,b), working on plankton and surface sediment samples from the Pacific Ocean, suggests C. profunda characterises the 'subarctic (Antarctic) Intermediate Fauna'. He discovered high abundances in high latitude sediments and low abundances in low latitude sediments. In the water column, he suggests the species tends to live below 200 metres in subarctic and antarctic waters and, by the process of 'tropical submergence', below 900 metres in equatorial waters.

Discussion: C. profunda consists of many intergrading morphotypes, used by REYNOLDS (1978) for biostratigraphical purposes. NIGRINI (1967) lists an extensive synonymy.

Genus : COROCALYPTRA HAECKEL, 1887

Corocalyptra cervus (Ehrenberg), 1872

Pl.XIII, fig.8a-c

?1872 Eucyrtidium cervus EHRENBERG, p.291, Tef.IX, fig.21.

1976 Corocalyptra cervus (Ehrenberg). RENZ, p.129, pl.5, fig.2.

Stratigraphical Distribution: RENZ (1976) collected this species from both plankton and surface sediment samples from the central Pacific Ocean.

Material: At Site 289, C. cervus ranges from the Middle Miocene (Dorcadospyris alata Zone: N.11-12) to beyond the upper limits of the studied sequence. Distribution is discontinuous however, and abundance varies from very rare to rare. At Site 71, the species is present in all nine samples from the Dorcadospyris alata Zone. Abundance is similar to that at Site 289.

Corocalyptra killmari RENZ, 1976

Pl.XIII, fig.9a-b

1976 Corocalyptra killmari RENZ, p.118, pl.4, fig.11.

Stratigraphical Distribution: RENZ (1976) collected the species from both plankton and surface sediment samples from the central Pacific Ocean.

Material: At Site 289 C. killmari ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to beyond the upper limit of the studied sequence. The species is only found in six samples and thus distribution is very discontinuous. Abundance varies from very rare to rare. Distribution at Site 71 is far more continuous where it is found in eight of the nine samples from the Dorcadospyris alata Zone of the Middle Miocene. Abundance is however, similar.

Genus : CYCLAMPTERIUM HAECKEL, 1887 sensu SANFILIPPO and RIEDEL, 1970

Remarks: Species of this genus form a well documented phylogenetic lineage which spans the Early Oligocene to Recent (SANFILIPPO and RIEDEL, 1970; RIEDEL and SANFILIPPO, 1977). Four of these species are represented at Site 289.

Cyclampterium (?) brachythorax SANFILIPPO and RIEDEL, 1970

Pl.XIII, fig.11

1970 Cyclampterium (?) brachythorax SANFILIPPO and RIEDEL, p.457, pl.2, figs.15,16.

Distinguishing Features: The thorax is broad and compressed and the abdomen reduced in size so that the outline is oblate - ellipsoidal.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) give the range as Middle Miocene (Cannartus? petterssoni Zone) to Late Miocene (Ommatartus antepenultimus Zone). At Site 289 HOLDSWORTH (1975) records the oldest occurrence in the Dorcadospyris alata Zone (N.11-12).

Material: The species is only found at Site 289, where it ranges from the Middle Miocene (Cannartus? petterssoni Zone:N.14) to the Late Miocene (Ommatartus antepenultimus Zone:N.17). Abundance ranges from very rare to rare and the distribution is discontinuous.

Discussion: C. (?) brachythorax is the decendant of C. (?) tanythorax and the precursor of C. (?) neatum. In the present study, the lower levels of occurrence have been included with C. (?) tanythorax because of the transitional nature of the morphotypes (cf. range of HOLDSWORTH, 1975).

Cyclampterium (?) leptetrum SANFILIPPO and RIEDEL, 1970

Pl.XIII, fig.12

1970 Cyclampterium (?) leptetrum SANFILIPPO and RIEDEL, p.456, pl.2, figs.11,12.

1975 Cyclampterium leptetrum SANFILIPPO and RIEDEL. HOLDSWORTH, p.529.

Distinguishing Features: Thorax hemispherical or inflated with a nodose surface. Abdomen (when present) is inverted cap shaped or open subcylindrical.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) give the range as Early Miocene (Calocycletta virginis Zone) to Middle Miocene (Dorcadospyris alata Zone).

Material: At Site 289, C. (?) leptetrum ranges from beyond the base of the studied sequence into the Middle Miocene (Dorcadospyris alata Zone:N.11-12). At Site 71, the species is found in four samples from the Dorcadospyris alata Zone. Distribution at both Sites is discontinuous and abundance varies from very rare to rare.

Discussion: C. (?) leptetrum is the precusor of C. (?) tanythorax.

Cyclampterium (?) neatum SANFILIPPO and RIEDEL, 1970

1970 Cyclampterium (?) neatum SANFILIPPO and RIEDEL, p.457, pl.2, figs.17,18.

1975 Cyclampterium neatum SANFILIPPO and RIEDEL. HOLDSWORTH, p.529.

Distinguishing Features: Test approximately spherical due to gross inflation of the thorax. The abdomen in short, cap shaped and continuous in outline with the thorax.

Stratigraphical Distribution: SANFILIPPO and RIEDEL (1970) give the range as Late Miocene (?*Ommatartus antepenultimus* Zone) to Recent. RENZ (1976) has recorded very rare occurrences in the plankton of the central Pacific Ocean. At Site 289 however, HOLDSWORTH (1975) suggests a local extinction during the Pliocene (*Spongaster pentas* Zone).

Material: At Site 289, *C. (?) neatum* ranges from the Late Miocene (*Ommatartus antepenultimus* Zone:N.17) to beyond the upper limit of the studied sequence. Distribution is continuous and abundance varies from very rare to rare.

Cyclampterium (?) tanythorax SANFILIPPO and RIEDEL, 1970

Pl.XIII, fig.13

1970 *Cyclampterium (?) tanythorax* SANFILIPPO and RIEDEL, p.457, pl.2, fig.13,14.

1975 *Cyclampterium tanythorax* SANFILIPPO and RIEDEL. HOLDSWORTH, p.530.

Distinguishing Features: Test subspherical or subellipsoidal in outline. Thorax inflated with a thorny, rather than nodose, surface. Abdomen ranging in size and shape from a small convex cap to a large inflated hemisphere.

Stratigraphical Distribution: SANFILIPPO and RIEDEL (1970) give the range as restricted to the Middle Miocene (*Dorcadospyris alata* Zone). HOLDSWORTH (1975) extends the range at Site 289 from the base of the Middle Miocene (*Dorcadospyris alata* Zone) to the Late Miocene (*Ommatartus antepenultimus* Zone:N.17).

Material: At Site 289, *C. (?) tanythorax* ranges from beyond the base of the studied sequence into the Late Miocene (Ommatartus antepenultimus Zone:N.17). Distribution is continuous for most of this range and abundance varies from very rare to rare. At Site 71, the species is found in all nine samples from the Dorcadospyris alata Zone in similar abundance.

Genus : CYRTOCAPSELLA HAECKEL, 1887

Cyrtocapsella cornuta (Haeckel) emend. HOLDSWORTH, 1975

Pl.XIV, fig.1

1887 Cyrtocapsa (Cyrtocapsella) cornuta HAECKEL, p.1513, pl.78, fig.9.

1970 Cyrtocapsella cornuta HAECKEL. SANFILIPPO and RIEDEL, p.453, pl.1, fig.19-20.

1975 Cyrtocapsella cornuta (Haeckel). HOLDSWORTH, p. 530, pl.2, fig.1-3,5-7,8,10,16.

Distinguishing Features: Four segmented, large, pyriform test. Thorax separated by a much wider abdomen by a pronounced change in contour. Terminal aperture varies in size and may be much larger than two pore diameters. A delicate fifth segment is sometimes present.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1978) give the range as Early Miocene (Cyrtocapsella tetrapera Zone) to Middle Miocene (Cannartus? petterssoni Zone). The emended species of HOLDSWORTH (1975) extends from the Late Oligocene (?Lychnocanoma elongata Zone of RIEDEL and SANFILIPPO (1978)) to the Cannartus? petterssoni Zone of the Middle Miocene.

Material: At Site 289, C. cornuta ranges from beyond the lower limit of the studied sequence into the Cannartus? petterssoni Zone:N.13. Distribution is continuous and abundance varies from very rare to few. At Site 71, the species is found in all samples and varies in abundance from very rare to rare.

Remarks: HOLDSWORTH (1975) emended this species to provide a more easily recognisable base to the Calocycletta virginis Zone at Site 289 in the Late Oligocene. RIEDEL and SANFILIPPO (1978) have since dispensed with this zone however, in favour of three smaller zones, the oldest of which, the Cyrtocapsella tetrapera Zone, has its base defined by the initial appearance of Cyrtocapsella spp. sensu SANFILIPPO and RIEDEL (1970) within the Early Miocene.

Cyrtocapsella japonica (Nakeseko), 1963

Pl.XIV, fig.2

1963 Eusyringium japonium NAKASEKO, p.193, text-figs.20-21; pl.4, fig.1-3.

1963 Theocapsa himiensis NAKASEKO, p.184, text-fig.15; pl.3, fig.1-3.

1970 Cyrtocapsella japonica (Nakaseko). SANFILIPPO and RIEDEL, p. 452, pl.1, figs.13-15.

Distinguishing Features: Test consisting of only three segments. Terminal aperture not much larger than a pore.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) cite the range in western equatorial Pacific sediments as Middle Miocene (Dorcadospyris alata to Cannartus? petterssoni Zones).

Material: At Site 289 C. japonica ranges from beyond the base of the studied sequence to the Cannartus? petterssoni Zone:N.13. The distribution, which is markedly discontinuous, is interrupted during the upper half of the Dorcadospyris alata Zone:N.11-12. Abundance varies from very rare to rare. At Site 71, the species is very rare in four of the nine samples from the Dorcadospyris alata Zone.

Cyrtocapsella tetrapera (Haeckel) emend. HOLDSWORTH, 1975

Pl.XIV, fig.3a-b

1887 Cyrtocapsa tetrapera HAECKEL, p.1512, pl.78, fig.5.

1970 Cyrtocapsella tetrapera HAECKEL. SANFILIPPO and RIEDEL, p.453, pl.1, fig.16-18.

1975 Cyrtocapsella tetrapera (Haeckel). HOLDSWORTH, p.530, pl.2, fig.9,13-15.

Distinguishing Features: A four segmented cyrtocapsellid with no pronounced change in contour between the thorax and abdomen. The terminal aperture varies in size, and may be much larger than two pore diameters. Test smaller than C. cornuta.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977; 1978) give the range as Early Miocene (Cyrtocapsella tetrapera Zone) to Middle Miocene (Cannartus? petterssoni Zone). The emended species of HOLDSWORTH (1975) ranges from the Late Oligocene (?Lychnocanoma elongata Zone of RIEDEL and SANFILIPPO (1978)) to Middle Miocene (Cannartus? petterssoni Zone).

Material: At Site 289, C. tetrapera ranges from beyond the lower limit of the studied sequence to the very top of the Dorcadospyris alata Zone:N.13. Distribution is discontinuous and abundance varies from very rare to few. At Site 71, the species is consistently encountered and varies from rare to common.

Discussion: At certain levels at Site 289, individuals are encountered that possess a 'tetraporoid' outline but which are larger than normal C. tetrapera individuals. They may represent a variety of C. cornuta with thoracic wall thickening but here are seperately tabulated as C. aff. C. tetrapera (see Pl.XIV, fig.3c)

Geographical Distribution and Palaeoecology: C. tetrapera appears to have had a cosmopolitan distribution during the Early and Middle Miocene.

It has been encountered in the north east Pacific Ocean (KLING, 1973), the Southern Ocean (CHEN, 1975; WEAVER, 1976) and the Mediterranean (SANFILIPPO *et al.* 1973). WEAVER (1976) records the species in a well preserved Middle Miocene assemblage constituting 30% - 40% of the entire fauna. SANCETTA (1978) cite *C. tetrapera* and *C. cornuta* as important species in tropical, subtropical and subarctic faunal provinces.

Remarks: The *Remarks* given for *C. cornuta* also hold for *C. tetrapera*. SANFILIPPO and RIEDEL (1970) give an extensive synonymy.

Genus : *DICTYOPHIMUS* EHRENBERG, 1847

Dictyophimus crisiae EHRENBERG, 1854

Pl.XIII, fig.10a-c

1854 *Dictyophimus crisiae* EHRENBERG, p.241.

1887 *Pterocorys hirundo* HAECKEL, p.1318, pl.71, fig.4.

1971b *Pterococrys hirundo* HAECKEL. CASEY, pl.23.1, fig.6,7.

1973 *Dictyophimus crisiae* EHRENBERG. KLING, p.636, pl.4, figs.11-15, pl.10, figs.18-20.

Distinguishing Features: A three segmented theoperid. The cephalis possesses an apical horn of variable length. The thorax has large pores and three longitudinal ribs which each develop into feet. Abdomen variable in size.

Stratigraphical Distribution: KLING (1973) cites the possible stratigraphical origin of *D. crisiae* from the *Dorcadospyris alata* Zone of the Middle Miocene. The species is extant (CASEY, 1966).

Material: At Site 289, *D. crisiae* ranges throughout the studied sequence. Distribution is almost continuous and abundance varies from very rare to rare. At Site 71, the species is found in all nine samples in similar abundance.

Geographical Distribution and Palaeoecology: RIEDEL (1958) suggests the species cosmopolitan in surface sediments of the worlds oceans. CASEY (1966, 1971a,b) cites D. crisiae (as P. hirundo) as characteristic of, and showing maximum abundance in, the shallow 'Transitional fauna' of northern high latitudes, living within the top 100 metres of the water column.

Discussion: Very rare forms at Site 289 possess four, instead of the diagnostic three feet radiating from the thorax.

Remarks: The smaller forms with compact thorax (pl.XIII, fig.10c) figured by HAECKEL (1887) may represent a distinct species.

Genus : EUCYRTIDIUM EHRENBERG, 1847

Eucyrtidium acuminatum s.l. (Ehrenberg), 1844

Pl.XIV, fig.4a-b

1844 Lithocampe acuminatum EHRENBERG, p.84.

1973 Eucyrtidium acuminatum (Ehrenberg). KLING, p.636, pl.4, figs.20-23.

Distinguishing Features: The first three segments form a cone and the following post abdominal segments are subcylindrical. Segments may be closely spaced with a gradual length increase distally or be widely spaced and irregular in length.

Stratigraphical Distribution: KLING (1973) gives the range as Late Miocene (Stichocorys peregrina Zone) to Recent.

Material: E. acuminatum s.l. ranges throughout the studied sequences at Sites 289 and 71. The species varies in abundance from very rare to rare and distribution is almost continuous.

Discussion: Included in this taxon are forms not represented in the synonymy. Unlike E. acuminatum s.s., these individuals possess irregularly spaced segments with the thorax noticeably larger than the abdomen and range throughout the Middle and Late Miocene. They are probable precursors of true E. acuminatum, which is restricted to the late

Middle and Late Miocene at Site 289.

Eucyrtidium anomalum HAECKEL, 1862

Pl.XIV, fig.5a-c

1862 Eucyrtidium anomalum HAECKEL, p.323, pl.7, figs.11-13.

1976 Eucyrtidium anomalum HAECKEL. RENZ, p.131, pl.5, fig.8.

Distinguishing Features: Multisegmented form with pyramidal thorax. The abdomen is usually the broadest segment but is shorter than the thorax. Post abdominal segments are shorter and taper distally.

Stratigraphical Distribution: E. anomalum is extant (RENZ, 1976). The oldest stratigraphical occurrence is not known.

Material: The species ranges throughout the studied sequences at both Sites 71 and 289. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: RENZ (1976) records the species as most common above 75 metres depth in the central Pacific Ocean water column.

Eucyrtidium calvertense MARTIN, 1904

Pl.XIV, fig.6

1904 Eucyrtidium calvertense MARTIN, p.450.

1971 Eucyrtidium calvertense MARTIN. KLING, p.636, pl.4, figs.16,18,19; pl.11, figs.1-5.

Distinguishing Features: Test multisegmented, conical from the cephalis to the fourth segment and tapering distally from the fifth segment. Longitudinal rows of pores are separated by furrows.

Stratigraphical Distribution: KLING (1971) gives the minimum range as Early Miocene (Calocycletta costata Zone) to Pleistocene. HAYS (1970) reports the species live in the North Pacific Ocean.

Material: At Site 289, E. calvestense ranges from the base of the

Late Miocene (Ommatartus antepenultimus Zone:N.16) to beyond the upper limits of the studied sequence. Distribution is discontinuous and abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: HAYS (1970) suggests E. calvertense is restricted to the central water masses of the North Pacific at the present day. Most fossil occurrences seem similarly restricted to middle and high latitudes (HAYS, 1965; KLING, 1971), a feature which prompted JOHNSON (1974) to imply the species is indicative of relatively cold climatic conditions.

Eucyrtidium cienkowskii Group HAECKEL, 1887

Pl.XIV, fig.7a-b

cf. 1887 Eucyrtidium cienkowskii HAECKEL, p.1493, pl.80, fig.9.

1973 Eucyrtidium cienkowskii HAECKEL Group. SANFILIPPO et al., p.221, pl.5, figs.7-11.

1975 Eucyrtidium cienkowskii HAECKEL Group. CHEN, p.460, pl.15, fig.7.

Distinguishing Features: The cephalis and narrow thorax are separated from the remaining test by a pronounced change in contour. The abdomen is subconical and the following segments are subcylindrical. The thoracic and upper abdominal surface may possess up to three wings.

Stratigraphical Distribution: JOHNSON (1974) and CHEN (1975) give the lower and upper range in DSDP Sites as Oligocene and latest Miocene respectively, although HAECKEL (1887) collected the species from surface sediments of the south Pacific Ocean.

Material: E. cienkowskii ranges throughout the studied sequences at both Sites 71 and 289 and exhibits almost continuous distribution. Abundance varies from very rare to few at Site 289, and from rare to few at Site 71.

Discussion: SANFILIPPO et al. (1973) suggest the group comprises several species although attempts to seperate them were unsuccessful. Morphological variation at Site 289 does not seem to warrent subdivision of the taxon.

Eucyrtidium punctatum Group (Ehrenberg), 1844

Pl.XIV, fig.8a-b

cf. 1844 Lithocampe punctata EHRENBERG, p.84.

1973 Eucyrtidium punctatum (Ehrenberg) Group. SANFILIPPO et al., p.221, pl.5, fig.15,16.

Distinguishing Features: A four or more? segmented form with a long conical thorax followed by a shorter subcylindrical abdomen and long tapering fourth segment. The abdomen is the widest segment.

Stratigraphical Distribution: SANFILIPPO et al. (1973) give a minimum range as Early Miocene (Lychnocanoma elongata Zone) to Early Pliocene (Stichocorys peregrina Zone).

Material: At Site 289, E. punctatum ranges from beyond the lower limit of the studied sequence into the Late Miocene (Ommatartus antepenultimus Zone:N.17). Distribution is discontinuous and markedly interrupted during the Dorcadospyris alata:N.11-12 and Cannartus? petterssoni: N.15 Zones. Abundance varies from very rare to rare. At Site 71 the species is only found in three samples from the Dorcadospyris alata Zone, where abundance is always very rare.

Eucyrtidium sp. 1

1970 Eucyrtidium sp. SANFILIPPO and RIEDEL, p.446, pl.1, fig.8.

Distinguishing Features: A thick walled conical/cylindrical form with up to seven segments terminating in a closed aperture.

Stratigraphical Distribution: SANFILIPPO and RIEDEL (1970) figure the species from the Middle Miocene (Dorcadospyris alata Zone).

Material: The species is present in eight of the nine samples from the Dorcadospyris alata Zone at Site 71. Abundance varies from very rare to rare.

Eucyrtidium sp. 2

Pl.XIV, fig.9a-c

1974 Eucyrtidium sp. JOHNSON, pl.10, fig.17,18.

Distinguishing Features: A conical/subcylindrical form showing a high degree of variability with respect to individual segment size, and pore size and arrangement. Although more than one species may be involved, the morphotypes are here grouped because they all show a similar disjointed outline.

Stratigraphical Distribution: JOHNSON (1974) figures similar forms from the Pliocene.

Material: At Site 289, Eucyrtidium sp. 2 ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to beyond the upper limit of the studied sequence. Distribution is discontinuous. At Site 71, the species is present in all nine samples from the Dorcadospyris alata Zone. Abundance varies from very rare to rare.

Eucyrtidium sp. 3

Pl.XIV, fig.10

1975 Eucyrtidium sp. CHEN, p.461, pl.7, figs.6-8.

Stratigraphical Distribution: CHEN (1975) records the species from the Oligocene.

Material: This species ranges throughout the studied sequences at Sites 289 and 71, although distribution is very discontinuous. At Site 289, Eucyrtidium sp. is present in five widely spaced samples whilst at

Site 71, the species is present in six samples from the Dorcadospyris alata Zone. Abundance varies from very rare to rare.

Genus : LIPMANELLA LOEBLICH and TAPPAN, 1961

Lipmanella dictyoceras (Haeckel), 1860

Pl.XV, fig.10

1860 Lithornithium dictyoceras HAECKEL, p.840.

1973 Lipmanella dictyoceras (Haeckel). KLING, p.636, pl.4, figs.24-26.

1978 Lipmanella dictyoceras (Haeckel). PISIAS and MOORE, p.847, pl.3, fig.4.

Distinguishing Features: A three segmented form with large thorax and abdomen. The thorax is pyramidal and possesses three protruding spines or latticed wings, depending on development. The abdomen is subcylindrical and open distally.

Stratigraphical Distribution: KLING (1973) gives the range as Pliocene to Pleistocene.

Material: At Site 289, L. dictyoceras ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to beyond the upper limit of the studied sequence. Distribution is very discontinuous (present in only nine samples) and abundance always very rare. By contrast, the species is present in all nine samples from the Dorcadospyris alata Zone of Site 71, where abundance varies from very rare to rare.

Lipmanella sp. cf. Dictyoceras xiphephorum JORGENSEN, 1900

Pl.XV, fig.14

cf. 1900 Dictyoceras xiphephorum JORGENSEN, p.84, pl.5, fig.25.

1973 Lipmanella (?)sp. KLING, pl.10, figs.25,26. (non) fig.24.

1974 Lipmanella sp. cf. Dictyoceras xiphephorum JORGENSEN. RIEDEL et al., p.709, pl.59, fig.9.

Distinguishing Features: A small lipmanellid with a subspherical thorax which occasionally possesses spines. Abdomen rarely developed.

Stratigraphical Distribution: Middle Miocene (Dorcadospyris alata Zone) to Recent (KLING, 1973; PETRUSHEVSKAYA, 1975).

Material: At Site 289, the species is found in only three samples from the Dorcadospyris alata Zone of the Middle Miocene. Abundance is always very rare. At Site 71, the species is present in all nine samples and abundance varies from very rare to rare.

Genus : LITHARACHNIUM HAECKEL, 1860 emend. PETRUSHEVSKAYA, 1971

Litharachnium tenthorium HAECKEL, 1862

1862 Litharachnium tenthorium HAECKEL, p.281, pl.IV, figs.7-10.

1974 Litharachnium sp. RIEDEL, SANFILIPPO and CITA, p.710, pl.59, fig.14; pl.62, fig.8-10.

1976 Litharachnium tenthorium HAECKEL. RENZ p.150, pl.7, fig.6.

Stratigraphical Distribution: RIEDEL et al., (1974) record the species from the Middle Miocene (Cannartus antepenultimus Zone) to Quaternary.

Material: At Site 289, L. tenthorium ranges from the Middle Miocene (Dorcadospyris alata Zone:N.13) to beyond the upper limit of the studied sequence. Distribution is very discontinuous (present in only seven samples) and abundance always very rare. At Site 71, the species is found in three samples in similar abundance to that at Site 289.

Geographical Distribution and Palaeoecology: RENZ (1976) and CASEY (1966, 1971a,b) indicate a preference by this species for equatorial shallow water masses (above 200 metres) in the Pacific Ocean.

Genus : LITHOPERA EHRENBERG, 1847

Remarks: The genus comprises the phylogenetic lineage leading to the divergent development of *Lithopera bacca* and *Lithopera thornburgi* respectively (see SANFILIPPO and RIEDEL, 1970).

Subgenus : LITHOPERA EHRENBERG, 1847

Lithopera (Lithopera) bacca EHRENBERG, 1872

Pl.XIV, fig.11

1872 *Lithopera bacca* EHRENBERG, p.314.

1967 *Lithopera bacca* EHRENBERG. NIGRINI, p.54, pl.6, fig.2.

1970 *Lithopera (L.)bacca* EHRENBERG. SANFILIPPO and RIEDEL, p.455, pl.1, fig.29.

Distinguishing Features: Test consists of cephalis and thorax only, forming smooth outline, with thoracic pores numerous, circular, and arranged in regular rows.

Stratigraphical Distribution: *L. bacca* ranges from the Middle Miocene (*Cannartus? petterssoni* Zone) to Recent (RIEDEL and SANFILIPPO, 1977).

Material: At Site 289, the species originates in the *Cannartus? petterssoni* Zone:N.15 and ranges to beyond the upper limit of the studied sequence. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: SANCETTA (1978) cites *L. bacca* as a characteristic element in the 'Transitional Faunal Provinces' of mid-latitudes in the Pacific Ocean during the Late Miocene to Holocene. This is substantiated in plankton studies (RENZ, 1976).

Discussion: *L. bacca* evolved from *L. neotera* by complete loss of the abdomen and by regular arangement of the thoracic pores. Towards the top of its range, *L. neotera* itself tends to loose its abdomen and the criterion used to distinguish these forms from *L.bacca* involves the subjective character of pore arrangement. This probably explains the anomalous stratigraphical range documented between HOLDSWORTH (1975) and that tabulated here.

Lithopera (L.) neotera SANFILIPPO and RIEDEL, 1970

Pl.XIV, fig.12

1970 Lithopera (Lithopera) neotera SANFILIPPO and RIEDEL, p.454, pl.1, figs.24-26,28.

Distinguishing Features: Test an irregular ellipsoid with a 'vestigial' abdomen, continuous in outline with the thorax, and seperated by a faint septum.

Stratigraphical Distribution: SANFILIPPO and RIEDEL (1970) and WESTBERG and RIEDEL (1978) give the 'morphotypic' range as Middle Miocene (Dorcadospyris alata Zone) to Late Miocene (Ommatartus antepenultimus Zone).

Material: At Site 289, L. neotera ranges from the Dorcadospyris alata: N.11-12 to the Ommatartus antepenultimus: N.16 Zones. Abundance varies from very rare to few. At Site 71, the species occurs in eight of the nine samples with abundance variation of very rare to rare.

Discussion: L. neotera evolves from L. renzae by a reduction of the abdominal segment and the development of a well organised pore arrangement. The upper limit of this species as tabulated by HOLDSWORTH (1975) at Site 289 is somewhat higher than that given here (see 'Discussion' under L. bacca).

Lithopera (L.) renzae SANFILIPPO and RIEDEL, 1970

Pl.XIV, fig.13

1970 Lithopera (L.)renzae SANFILIPPO and RIEDEL, p.454, pl.1, figs.21-23,27.

Distinguishing Features: Subellipsoidal test in which the thorax usually forms the major part. Pores irregular. There is a distinct contour change between the thorax and abdomen. This third segment may vary in size to approximate that of the thorax.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) give the range as Early Miocene (Calocycletta virginis Zone) to Middle Miocene (Dorcadospyris alata Zone).

Material: At Site 289, the species ranges from beyond the lower limit of the studied sequence into the Dorcadospyris alata Zone:N.11-12. Distribution is discontinuous and abundance varies from very rare to rare. At Site 71, L. renzae is found in all nine sample with abundance varying from rare to few.

Subgenus : GLOMARIA SANFILIPPO and RIEDEL, 1970

Lithopera (Glomaria) baueri SANFILIPPO and RIEDEL, 1970

Pl.XIV, fig.14

1970 Lithopera (G.)baueri SANFILIPPO and RIEDEL, p.455, pl.2, figs.1-2.

Distinguishing Features: Test an elongate ellipsoid of two segments. The cephalis is partly enclosed in a thorax consisting of either a system of irregular pores or a loose spongy meshwork.

Stratigraphical Distribution: Middle Miocene (Dorcadospyris alata to Cannartus? petterssoni Zone) (SANFILIPPO and RIEDEL, 1970)

Material: At Site 289, the species ranges from the Dorcadospyris alata Zone:N.9 to the Cannartus? petterssoni Zone:N.15. Distribution is very discontinuous. At Site 71, L. baueri is present in six samples. Abundance at both sites varies from very rare to rare.

Discussion: L. baueri is thought to have evolved from L. neotera by an increase in size with the development of a more spongy wall (SANFILIPPO and RIEDEL, 1970).

Lithopera (Glomaria) thornburgi SANFILIPPO and RIEDEL, 1970

Pl.XIV, fig.16

1970 Lithopera (G.)thornburgi SANFILIPPO and RIEDEL, p.455, pl.2, figs.4-6.

Distinguishing Features: Test elongate and spindle shaped, pointed at both ends, with the cephalis embedded in the spongy thoracic wall.

Stratigraphical Distribution: Middle Miocene (Dorcadospyris alata to Cannartus? petterssoni Zones) (RIEDEL and SANFILIPPO, 1977)

Material: At Site 289, the range of this species conforms with that given by RIEDEL and SANFILIPPO (1977) (N.11-12 to N.15). At Site 71 L. thornburgi is found in six of the nine samples from the Dorcadospyris alata Zone. Distribution at both sites is discontinuous and abundance varies from very rare to rare.

Discussion: L. thornburgi is thought to have evolved from L. baueri by aquisition of pointed ends, incorporation of the cephalis into the thorax and the full development of a spongy wall in the latter segment (SANFILIPPO and RIEDEL, 1970).

Remarks: A rare form possessing an abdomen and occurring at both Sites 71 and 289 has been separately tabulated as L. sp. cf. L. thornburgi (see pl.XIV, fig.15).

Genus : LITHOSTROBUS BUTSCHLI, 1882

Lithostrobus sp. cf. L. hexagonalis HAECKEL, 1887

Pl.XV, fig.11

cf. 1887 Lithostrobus hexagonalis HAECKEL, p.1475, pl.79, fig.20.

Material: At Site 289, the species ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to the Late Miocene (Ommatartus antepenultimus Zone:N.16). At Site 71, it is present in six samples from the Dorcadospyris alata Zone. Abundance varies from very rare to rare and distribution is discontinuous.

Discussion: L. sp. cf. L. hexagonalis differs from the extant species (RENZ, 1976) in that the segmental walls are convex rather than concave. The two forms are similar in almost all other respects.

Genus : LYCHNOCANOMA HAECKEL, 1887

Lychnocanoma grande s.s. (Campbell and Clark), 1944

Pl.XV, fig.1a-b

1944 Lychnocanium grande CAMPBELL and CLARK, p.42, pl.6, figs.3-6.

1973 Lychnocanium grande (Campbell and Clark). KLING, p.637, pl.10, figs.10-12; (non) pl.10, figs.13,14.

Distinguishing Features: A two segmented species with a round cephalis and a campanulate thorax possessing three feet on the distal margin. Thoracic pores number nine to ten in a vertical row and approximately 30 to 40 around widest circumference.

Stratigraphical Distribution: KLING (1973) figures the species from the Middle and Late Miocene.

Material: At Site 289, L. grande s.s. ranges from within the Dorcadospyris alata Zone of the Middle Miocene:N.11-12, to beyond the upper limit of the studied sequence. At Site 71, the species is found in all nine samples. Abundance at both sites varies from very rare to rare.

Lychnocanoma grande rugosum (Riedel), 1952

Pl.XV, fig.2

1952 Lychnocanium grande (Campbell and Clark) rugosum RIEDEL, p.6, pl.1, fig.1.

1971 Lychnocanoma grande (Campbell and Clark). KLING, p.637, pl.10, figs.13-14. (non) pl.10, figs.10-12.

1976 Lychnocanoma grande rugosum (Riedel). WEAVER, p.581, pl.9, fig.5.

Distinguishing Features: This subspecies resembles *L. grande* s.s. except the thorax is more inflated, with a subspherical outline and possesses a rugose surface.

Stratigraphical Distribution: KLING (1973) figures the taxon from the Early Miocene (*Calocycletta costata* Zone) to Middle Miocene (*Dorcadospyris alata* Zone). HAYS (1965) and WEAVER (1976) report the subspecies in Pliocene high latitude sediments.

Material: At Site 289, *L. g. rugosum* ranges from beyond the lower limit of the studied sequence into the *Cannartus? peterssoni* Zone of the Middle Miocene :N.13. At Site 71 the species is found in all samples from within the *Dorcadospyris alata* Zone. The taxon exhibits a remarkably continuous distribution within its stratigraphical range at both sites with abundance ranging from very rare to rare.

Genus : *PERIPYRAMIS* HAECKEL, 1881

Peripyramis circumtexta HAECKEL, 1887

1887 *Peripyramis circumtexta* HAECKEL, p.1662, pl.54, fig.5.

1973 *Peripyramis circumtexta* HAECKEL. KLING, p.637, pl.2, figs.15-19; pl.9, figs.1-3.

Stratigraphical Distribution: KLING (1973) gives the range as Middle Miocene (*Dorcadospyris alata* Zone) to Recent.

Material: At Site 289 the species ranges almost continuously from within the *Dorcadospyris alata* Zone:N.11-12 to beyond the upper limit of the studied sequence. It is found in all nine samples from the *Dorcadospyris alata* Zone at Site 71. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: CASEY (1966, 1971a,1971b) considered *P. circumtexta* as indicative of the North (and perhaps South) Pacific Central Water, living at depths of between 200 and

500 metres and exhibiting tropical submergence in low latitudes.

Genus : PTEROCANIUM EHRENBERG, 1847

Pterocanium trilobum (Haeckel), 1860

Pl.XV, fig.3a-b

1860 Dictyopodium trilobum HAECKEL, p.839.

1967 Pterocanium trilobum (Haeckel). NIGRINI, p.71, pl.7, figs.3a,3b.

1973 Pterocanium trilobum (Haeckel). KLING, p.638, pl.4, figs.5-8.

Stratigraphical Distribution: KLING (1973) figures the species from the Early Pliocene to Pleistocene.

Material: P. trilobum ranges throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: NIGRINI (1967,1970), CASEY (1966, 1971a,b) and RENZ (1976) relate this species to tropical shallow water masses and associated sedimentary faunal assemblages.

Discussion: A large variation in test and thoracic pore size seen at Site 289 is consistent with the remarks of RENZ (1976).

Genus : STICHOCORYS HAECKEL, 1881

Stichocorys delmontensis (Campbell and Clark), 1944

Pl.XV, fig.4a-b

1944 Eucyrtidium delmontensis CAMPBELL and CLARK, p.56, pl.7, figs.19,20.

1970 Stichocorys delmontensis (Campbell and Clark). SANFILIPPO and RIEDEL, p.451, pl.1, fig.9.

1971 Stichocorys delmontensis (Campbell and Clark). RIEDEL and SANFILIPPO, p.1595, pl.1f, figs.5-7; pl.2E, figs.10,11.

1975 Stichocorys delmontensis (Campbell and Clark). HOLDSWORTH, p.531.

Distinguishing Features: A multisegmented form, seperated into two 'stages'. The first three segments tend to be conical, robust and continuous in outline, and are followed by a series of post-abdominal segments which are narrower, subcylindrical and thinner walled. The thorax and abdomen usually have strong convex outlines.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) give the range as Early Miocene (Calocycletta virginis Zone) to Late Miocene (Ommatartus antepenultimus Zone). However, MOORE (1971) and HOLDSWORTH (1975) both extend the upper range into the Stichocorys peregrina Zone of the Late Miocene at Sites 71 and 289 respectively. In the Late Miocene, at levels where S. delmontensis gives rise to S. peregrina, separation of the two species becomes intuitive and this may explain the apparent anomaly.

Material: S. delmontesis ranges throughout the sequences under study at both Sites 71 and 289. At Site 289 relative abundance varies considerably, from very rare to very abundant. In the shorter sequence of Site 71, the species varies in abundance from common to very common.

Geographical Distribution and Palaeoecology: S. delmontensis appears to have exhibited a cosmopolitan distribution. It has been recorded throughout its known range in sediments of the north east Pacific Ocean (KLING, 1973), the Indian Ocean (JOHNSON, 1974) and the Mediterranean (SANFILIPPO et al., 1973). CHEN (1975) lists the species from Late Miocene sediments of the Southern Ocean. SANCETTA (1978), in a synthesis of DSDP data from multi-latitude sites in the Pacific Ocean, regards S. delmontensis as an important element of Middle Miocene assemblages in tropical, transitional and subarctic faunal provinces.

Discussion: S. delmontensis evolved from multisegmented "Eucyrtidium spp." in the Early Miocene by differentiation of the first three segments

(SANFILIPPO and RIEDEL, 1970). The taxon appears to be included within a plexus of forms, all well represented at Site 289, which display a wide range of variation and which can be seen to intergrade at certain stratigraphic levels. Representatives of this plexus include S. delmontensis, S. delmontensis FORM A, S. wolffii, S. wolffii FORM A, S. armata and S. armata FORM A.

At almost all levels of occurrence, thoracic pore numbers in S. delmontensis vary so that individuals appear to grade into normal S. wolffii populations. Less common (289, 48.3), individuals are encountered where the fourth segment may form part of the continuous conical arrangement normally restricted to the first three segments (cf. S. peregrina). The most extensive morphological deviation from normal S. delmontensis populations concerns integradation with a form here referred to as S. delmontensis FORM A. The two forms are distinguished by the character of overall size, outline, shell wall thickness and number of segments. Individuals of S. delmontensis FORM A differ from S. delmontensis in the following points:

i. The tests are smaller.

ii. The thoracic and abdominal segments possess straight, rather than convex walls in outline view; consequently the contour break between the abdominal and post abdominal segments is less pronounced.

iii. The walls of the thoracic and abdominal segments are thinner.

iv. Post thoracic and/or abdominal segmentation is commonly absent.

Consequently, S. delmontensis FORM A has the appearance of a 'stunted' representative of S. delmontensis. Biometric studies show that at levels where both forms occur, they may either show a continuous size gradation, or remain as distinct and seperate elements. The phenomenon has been identified at both Sites 71 and 289. Ecophenotypic variation rather than distinct speciation is inferred although the two forms are taxonomically distinguished in the present study. A more extensive description and discussion of the phenomeon within the Stichocorys spp. plexus, incorporating the biometric study, is given in Chapter VII.

Stichocorys delmontensis (Campbell and Clark), 1944 FORM A

Pl.XV, figs.5a-c

Distinguishing Features: A small, thin walled 'stunted' variant. The cephalis and thorax possess convex walls and form a conical outline; the post thoracic segments possess straight walls and form a subcylindrical outline. Post thoracic segmentation is commonly absent but when the absence is obvious there may be a slight change in contour outline between the post abdominal segment and the abdominal segment.

Material: At Site 289, the form ranges from the base of the studied sequence into the Late Miocene (Ommatartus antepenultimus Zone:N.16). Occurrence is discontinuous and abundance varies from very rare to few. At Site 71, S. delmontensis FORM A is found throughout the studied sequence and varies from very rare to rare.

Discussion: In the present study S. delmontensis FORM A is not seperated from S. delmontensis at the specific level. Biometric studies at both Sites 71 and 289 show that whilst at some levels there is a continuous size distribution and intergradation between individuals of the two forms, at other horizons, the forms plot as discrete and seperate entities. Where the two forms can be seen to intergrade with respect to size, there are concomitant changes in the character of test outline and wall thickness so that intermediates are difficult to catagorise. Nevertheless, because of the discontinuous variation between the two forms at certain levels at Site 289 and because S. delmontensis FORM A has a shorter stratigraphical range, they are here treated separately.

S. delmontensis FORM A may also vary with respect to thoracic pore numbers so that at certain levels (e.g. 289, 45cc) the form appears to grade with S. wolffii FORM A.

A more detailed account of variation within the Stichocorys spp. plexus, incorporating the biometric study, is given in Chapter VII.

Remarks: No mention of such a stunted form has been encountered in previous literature.

Stichocorys wolffii HAECKEL, 1887

Pl.XV, fig.6a-c

1887 Stichocorys wolffii HAECKEL, p.1479, pl.80, fig.10.

1971 Stichocorys wolffii HAECKEL. RIEDEL and SANFILIPPO, p.1595, pl.2E, figs.8-9.

1975 Stichocorys wolffii HAECKEL. HOLDSWORTH, p.531.

Distinguishing Features: S. wolffii is practically identical to S. delmontensis except in the character of the thorax. In the present study individuals were identified as S. wolffii when they possessed less than six thoracic pores on the facing surface, imparting a hyaline character to that segment.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) give the range as Early Miocene (Calocycletta virginis Zone) to Middle Miocene (Cannartus? petterssoni Zone).

Material: At Site 289, S. wolffii displays a distinctly discontinuous range from the base of the studied sequence into the Ommatartus antepenultimus Zone:N.16. Abundance varies considerably from very rare to very common.

At Site 71, distribution within the studied sequence is restricted to the upper three samples where the species is rare.

Discussion: S. wolffii displays a wide range of variation at Sites 71 and 289. Gradation between S. wolffii and S. delmontensis individuals has been discussed under the latter taxon. Additionally, in the upper part of its range, S. wolffii individuals appear to be smaller and less robust than S. delmontensis counterparts, although this has not been established quantitatively. Intraspecific variation includes an analagous phenomenon to that seen between S. delmontensis and S. delmontensis FORM A. At both Sites 71 and 289, individuals of S. wolffii intergrade with a variant known here as S. wolffii FORM A. As in S. delmontensis, the two forms are distinguished by the same character of overall size, outline, shell wall thickness and segment number. S. wolffii FORM A is thus similar to S. delmontensis FORM A in all respects except that of thoracic pore number which are reduced in the former. Although no biometric study has been carried out on S. wolffii populations, intermediate forms between S. wolffii and S. wolffii FORM A are apparent at certain levels of Site 289. Other aspects of intraspecific variation concerns pore reduction in post thoracic segments. Individuals are encountered with reduced post thoracic pores so that in extreme cases the whole of the test may be hyaline (pl. XV, fig. 6c).

At 289, populations of S. wolffii may be numerically dominant over those of S. delmontensis during part of the Early Miocene (HOLDSWORTH, 1975). In the Middle and Late Miocene at both Sites 289 and 71, the converse holds.

Stichocorys wolffii HAECKEL, 1887 FORM A

Pl.XV, fig.7

? 1978 Stichocorys wolffii HAECKEL. RIEDEL and SANFILIPPO, p.74, pl.1, fig.3.

Distinguishing Features: A small, thin walled 'stunted' variant. The cephalis, thorax and abdomen possess slightly convex walls and form a conical outline while the post abdominal segments possess straight walls and form a subcylindrical outline. Post thoracic segmentation is commonly absent but when the abdomen is discrete there may by a slight change in outline between it and the post abdominal segment. The thorax possesses less than six pores on any facing side.

Material: At Site 289, the form ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) into the Late Miocene (Ommatartus antepenultimus Zone:N.16). Occurrence in discontinuous and abundance ranges from very rare to rare. At Site 71, S. wolffii FORM A is found in only one sample and is rare.

Discussion: In the present study, although S. wolfii FORM A is treated seperately from S. wolffii, it is not regarded as a separate species. While the two forms probably intergrade, S. wolffii FORM A has a shorter stratigraphical range. It is here regarded as an ecophenotypic variant. The relationship between S. wolffii and S. wolffii FORM A is similar to that between S. delmontensis and S. delmontensis FORM A. (see 'Discussion' under S. wolffii). Indeed, S. wolffii FORM A and S. delmontensis FORM A) tend to occur at similar stratigraphical levels, especially at Site 289, where they become 'extinct' at about the same horizon in the O. antepenultimus Zone. On the basis of the interspecific gradation and changes in numerical dominance between S. delmontensis and S. wolffii at Site 289, HOLDSWORTH (1975) suggested the latter is merely a dimorph of the former. The parallel changes in ecophenotypic variation with respect to both morphology and stratigraphical occurrence seem to substantiate this idea. However, S. wolffii will probably continue to be treated as a separate species by workers so long as it remains useful in biostratigraphical studies (HOLDSWORTH, 1975).

Remarks: RIEDEL and SANFILIPPO (1978) commented on and figured a variant of S. wolffii which is quite similar to S. wolffii FORM A. Both the variant and S. wolffii FORM A occur within the latter part of the stratigraphical range of S. wolffii and for this reason it is here tentatively synonymised.

Stichocorys armata (Haeckel), 1887

Pl.XV, fig.8

1887 Cyrtophormis armata HAECKEL, p.1460, pl.78, fig.17.

1971 Stichocorys armata (Haeckel). RIEDEL and SANFILIPPO, p.1595, pl.2E, figs.13-15.

Distinguishing Features: Test consists of four or more segments that can be divided into two 'stages'. The first three segments are conical, robust and continuous in outline. The base of the abdominal segment marks a distinct break in outline and the following post abdominal segments are usually narrower, fragile, have a choatic pore arrangement and taper distally. This second stage may be long and unsegmented. Small spines bristle from all segments although they tend to concentrate on the first three and are strongest around the cephalis where they are associated with wall thickening.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) give the range as Early Miocene (Calocycletta virginis Zone) to Middle Miocene (Cannartus? petterssoni Zone).

Material: At Site 289, S. armata ranges from beyond the base of the studied sequence into the Dorcadospyris alata Zone (N.11-12) of the Middle Miocene. Abundance varies from very rare to few. The taxon was not encountered at Site 71.

Discussion: S. armata is probably closely related to S. delmontensis. Differences include the presence of spines and the nature of the post abdominal segments. No interspecific gradation is apparent. However, the phenomenon of ecophenotypic variation as described in S. delmontensis and S. wolffii is also seen in S. armata. The variant is here known as S. armata FORM A, and the changes that occur between the two morphotypes is discussed under that form. It has been treated as a seperate taxonomic entity in the present study although speciation is not inferred.

Stichocorys armata (Haeckel), 1887 FORM A

Pl.XV, fig.9

Distinguishing Features: A small 'stunted' form of S. armata. The first three segments are thin walled and conical although the walls are straight rather than convex in outline view. Post abdominal segments were never preserved in Site 289 populations. The characteristic spines on the segments persist.

Material: S. armata FORM A ranges from beyond the base of the studied sequence at Site 289 into the Dorcadospyris alata Zone (N.11-12) of the Middle Miocene. Abundance varies from very few to rare. The upper stratigraphical range is slightly higher than for S. armata.

Discussion: S. armata FORM A differs from S. armata in the following characters.

i. The tests are smaller.

ii. The thoracic and abdominal segments have straight rather than strongly convex walls in outline view.

iii. The thoracic and abdominal walls are thinner. Although no biometric study has been presently undertaken on S. armata or S. armata FORM A, intermediate forms are apparent at certain levels.

S. armata FORM A appears to be an ecophenotypic variant analogous to those seen in S. delmontensis and S. wolffii. However, whereas in the latter two distribution at Site 289 appear to show parallel trends, for S. armata FORM A, distribution seems to be independant.

Genus : STICHOPERA HAECKEL, 1881

Stichopera pectinata Group HAECKEL, 1887

Pl.XV, fig.12

1887 Stichopera pectinata HAECKEL, p.1449, pl.75, fig.11.

1887 Cyrtopera laguncula HAECKEL, p.1451, pl.75, fig.10.

1973 Stichopera pectinata HAECKEL group. KLING, p.638, pl.3, figs. 25-27; pl.10, figs.1-5.

Stratigraphical Distribution: KLING (1973) gives a minimum range of Early Miocene (Calocycletta costata Zone) to Recent.

Material: S. pectinata ranges throughout the studied sequence at both sites. Abundance is always very rare and at Site 289 the species exhibits a particularly discontinuous distribution.

Genus : STICHOPILIUM HAECKEL, 1881

Stichopilium sp. cf S. bicorne

Pl.XV, fig.13

1887 Stichopilium bicorne HAECKEL, p.1437, pl.77, fig.9.

1974 Stichopilium bicorne HAECKEL. RENZ, p.798, pl.16, fig.24.

Stratigraphical Distribution: RENZ (1974) records the taxon from the Quaternary.

Material: Present in one sample from the Dorcadospyris alata Zone of the Middle Miocene at Site 289.

Stichopilium rhinoceros (Haeckel), 1887

Pl.XV, fig.17a-b

1887 Pterocorys rhinoceros HAECKEL, p.1320, pl.71, fig.1.

1977 Stichopilium ?sp. RIEDEL and SANFILIPPO, pl.23, fig.5.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1977) figure this species from the Quaternary.

Material: S. rhinoceros is present in two samples at Site 289 from the Late Miocene (Ommatartus antepenultimus Zone:N.16/17). Abundance is very rare to rare. By contrast, the species is present in all nine samples in very rare abundance from the Middle Miocene Dorcadospyris alata Zone at Site 71, although the presence here may be due to downhole contamination (see Chapter V).

Stichopilium sp. cf. S. rhinoceros (Haeckel), 1887

Pl.XV, fig.16

cf. 1887 Pterocorys rhinoceros HAECKEL, p.1320, pl.71, fig.1.

Material: At Site 289 S. sp. cf. S. rhinoceros ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to beyond the upper limit of the studied sequence. At Site 71, the species is present in six samples. Abundance varies from very rare to rare and distribution is discontinuous.

Discussion: Complete specimens are seldom observed. The form differs from S. rhinoceros by possessing wider post-thoracic segments.

Genus : THEOCORYS HAECKEL, 1881

Theocorys? subcylindrica DYER, sp. nov.

Pl.XVI, fig.1a-e

1974 Theoperid, gen. et sp. indet. JOHNSON, pl.8, fig.18.

1975 Theocorys sp. FOREMAN, p.621, pl.9, fig.8.

1975 Calocyclas (?) sp. K. PETRUSHEVSKAYA, p.580, pl.21, fig.10.

1978 Theoperid, gen. et sp. indet. WEAVER and DINKELMAN, pl.2, fig.5.

Description (based on holotype and paratypes): Normally a three segmented species with a spherical cephalis, inflated thorax and subcylindrical abdomen. The cephalis bears an apical spine of variable size which may attain a similar length to the thorax. Several small pores punctuate the cephalis. The nature of the internal spicule is difficult to ascertain; a medium bar at the base of the cephalis gives rise to a curved apical bar running the length of the segment along its wide wall and terminates in the apical spine. Lateral and dorsal spines extend into the thorax where they attach to the inside wall in a proximal position. The thorax bears up to eight usually well aligned rows of circular pores (on the facing side), with up to six pores per row arranged in a hexagonal pattern. The hexagonal apices are raised into small nodes or occasional spines, especially in the proximal region. A subcylindrical abdomen connects to the thorax via a series of vertical bars and bears similar rows of pores which become irregular distally. Abdominal constrictions are in anterior, median and posterior positions. The mouth is open and wide.

Dimensions: Holotype (from 30, 289, 39cc R(a). Middle Miocene: Cannartus? petterssoni: N.13 Zones. England finder co-ordinates:N42/0)

Spine length (incomplete): 5μ

Cephalis length: 20μ

Thoracic length: 35μ; Thoracic width (max) :60μ

Abdominal length (incomplete): 85μ ; Abdominal width (max.) :80μ

Stratigraphical Distribution: JOHNSON (1974), FOREMAN (1975) and PETRUSHEVSKAYA (1975) figure or tabulate the form from the Middle and Late Miocene.

Material: T.? subcylindrica ranges throughout the studied sequences at Sites 289 and 71. Abundance varies from very rare to common at Site 289 and from rare to few at Site 71. Distribution is everywhere continuous. The stratigraphical range of T.? subcylindrica appears to extend beyond the Middle and Late Miocene although a preliminary reconnassance beyond the studied sequence at Site 289 indicates a possible extinction around the Miocene/Pliocene boundary within the Stichocorys peregrina Zone.

Discussion: Individuals are rarely preserved complete and are usually represented by the cephalis and the thorax only. Intraspecific variation is pronounced and mainly involves the nature of the thoracic and abdominal pores. These can be reduced in size and/or number to give the respective segment a semi-hyaline appearance. In addition, the pores may loose their regular arrangement,(pl.XVI, fig.1d). Within the abdomen, the median contriction may develop into a stricture and divide the segment.

The holotype and other type material are stored in the Micropalaeontology Laboratory, Department of Geology, University of Keele. Paratypes include all other occurrences within the studied sequence at Site 289.

Remarks: The phylogeny of *T.? subcylindrica* is unknown and inclusion of the species in the genus *Theocorys* is tentative. The specific name refers to the shape of the abdomen.

Gen. et sp. Indet.

"Theoperid sp. 1"

Pl.XV, fig.18

Material: Present in one sample from the Late Miocene (*Ommatartus antepenultimus* Zone:N.16) at Site 289. Abundance is very rare.

"Theoperid sp. 2"

Pl.XV, fig.15

1975 *Gen. and sp. indet.* CHEN, pl.19, fig.5

Stratigraphical Distribution: CHEN (1975) figures the form from the Quaternary.

Material: The species is present in two samples, in very rare abundance, at Site 71.

Family : *CARPOCANIIDAE* HAECKEL, 1881 *emend.* RIEDEL, 1967

Genus : *CARPOCANISTRUM* HAECKEL, 1887 *sensu* RIEDEL and SANFILIPPO, 1971

Carpocanistrum spp.

Pl.XVI, fig.2a-c

1971 Carpocanistrum spp. RIEDEL and SANFILIPPO, p.1596, pl.1G, figs.11-13; pl.2F, figs.5-7.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure this species group from the Late Eocene to Quaternary.

Material: Carpocanistrum spp. ranges continuously through the studied sequences at both Sites 289 and 71. Abundance varies from very rare to very common at Site 289 and from rare to few at Site 71.

Discussion: RIEDEL and SANFILIPPO (1971) made an unsuccessful attempt to subdivide this group. The representatives at Sites 289 and 71 may well constitute one species consisting of approximately three morphotypes, primarily seperated by wall thicknes but exhibiting gradation at certain levels.

Carpocanistrum sp. 1

Pl.XVI, fig.3

Distinguishing Features: A distinctive form with up to fourteen well aligned rows of small, closely spaced thoracic pores.

Material: Present in three widely spaced samples within the studied sequence at Site 289. Abundance varies from very rare to rare.

Genus : CARPOCANOPSIS RIEDEL and SANFILIPPO, 1971

Carpocanopsis bramlettei REIDEL and SANFILIPPO, 1971

Pl.XVI, fig.4a-c

1971 Carpocanopsis bramlettei RIEDEL and SANFILIPPO, p.1597, pl.2G, figs.8-14; pl.8, fig.7.

Distinguishing Features: Cephalis distinct from thorax, which possesses up to ten rows of usually well aligned pores on facing side. Abdomen subcylindrical, hyaline, usually with one row of pores proximally and a row of teeth distally.

Stratigraphical Distribution: Early Miocene (Stichocorys delmontensis Zone) to Middle Miocene (Cannartus? petterssoni Zone) (RIEDEL and SANFILIPPO, 1978; WESTBERG and RIEDEL, 1978).

Material: At Site 289, C. bramlettei ranges from beyond the lower limit of the studied sequence into the Middle Miocene (Cannartus? petterssoni Zone:N.14). At Site 71, the species is present in all nine samples from the Dorcadospyris alata Zone. At both sites distribution is continuous and abundance varies from very rare to rare.

Carpocanopsis cingulatum RIEDEL and SANFILIPPO, 1971

Pl.XVI, fig.5

1971 Carpocanopsis cingulatum RIEDEL and SANFILIPPO, p.1597, pl.2G, figs.17-21; pl.8, fig.8.

Distinguishing Features: Test large and thick walled. Cephalis, thorax and abdomen form a continuous outline, with the abdomen tapering. Thoracic pores aligned in well defined vertical rows. The abdomen is porous.

Stratigraphical Distribution: Late Oligocene (Lychnocanoma bipes Zone) to Early Miocene (Calocycletta costata Zone) (RIEDEL and SANFILIPPO, 1971).

Material: At Site 289, C. cingulatum extends into the early part of the Middle Miocene (Dorcadospyris alata Zone:N.11-12). Abundance varies from very rare to rare.

Carpocanopsis sp. cf. C. cingulatum RIEDEL and SANFILIPPO, 1971

Pl.XVI, fig.6a-b

1974 Carpocanopsis sp. JOHNSON, pl.8, fig.6.

Distinguishing Features: This species is similar to C. cingulatum except that the rows of thoracic pores are reduced in number and are not organised into well defined rows. In some individuals the cephalis and abdomen are distinct from the thorax in outline view. Such specimens resemble C. bramlettei, but still possess a porous and distally tapering abdomen.

Stratigraphical Distribution: JOHNSON (1974) figured a similar form from the Middle Miocene (Cannartus? petterssoni Zone).

Material: At Site 289, the species ranges within the Middle Miocene (Dorcadospyris alata Zone:N.11-12 to the Cannartus? petterssoni Zone:N.14). At Site 71, C. sp. cf. C. cingulatum is present in seven samples from the Dorcadospyris alata Zone. Abundance at both Sites varies from very rare to rare.

Discussion: C. sp. cf. C. cingulatum is stratigraphically seperated from the older C. cingulatum by most of the Dorcadospyris alata Zone at Site 289. Though the two taxa are morphologically similar it is not thought reworking is involved because the former species is found within the younger stratigraphical interval at both Sites 289 and 71.

Carpocanopsis cristatum? (Carnevale), 1908

Pl.XVI, fig.7

? 1908 Sethocorys cristata CARNEVALE, p.31, pl.4, fig.18.

1971 Carpocanopsis cristatum (Carnevale)? RIEDEL and SANFILIPPO, p.1597, pl.1G, fig.16; pl.2G, fig.1-7.

Distinguishing Features: Heavy test with thick walled thorax. Up to eight poorly defined rows of pores are present on the facing side of the thorax.

Stratigraphical Distribution: Early Miocene (Calocycletta costata

Zone) to Late Miocene (Ommatartus antepenultimus Zone) (JOHNSON, 1974).

Material: At Site 289 C. cristatum? ranges continuously from beyond the lower limit of the studied sequence into the Middle Miocene (Cannartus? petterssoni Zone:N.14). Abundance varies from very rare to few.

The species was found in only three samples at Site 71, in very rare to rare abundance.

Carpocanopsis sp. cf. C. favosum (Haeckel), 1887

Pl.XVI, fig.8

cf. 1887 Cycladophora favosa HAECKEL, p.1380, pl.62, figs.5,6.

cf. 1971 Carpocanopsis favosum (Haeckel). RIEDEL and SANFILIPPO, p.1597, pl.2G, figs.15,16; pl.8, figs.9-11.

Distinguishing Features: Cephalothorax ellipsiodal in outline with up to seven vertical rows of pores on facing side of thorax. Abdomen narrow proximally; widening distally, so that there is a sharp change in contour between thorax and abdomen. The non-porous abdomen is usually divided into six elongate feet.

Material: At Site 289 the species ranges within the Middle Miocene (Dorcadospyris alata Zone:N.11-12 to the Cannartus? petterssoni Zone:N.14). It is present in six samples and varies in abundance from very rare to rare. At Site 71, C. sp. cf. C. favosum is found in two samples, in very rare abundance, within the Dorcadospyris alata Zone.

Discussion: Although similar in many respects, C. sp. cf. C. favosum differs from C. favosum in possessing well aligned rows of thoracic pores and elongate abdominal feet.

There is a stratigraphical break between the occurrence of C. sp. cf. C. favosum and C. favosum (Early Miocene; RIEDEL and SANFILIPPO, 1971). However, because the former taxon is found at both Sites 289 and 71, at similar stratigraphical levels, it seems doubtful they represent reworked individuals of the latter.

Family : PTEROCORYTHIDAE HAECKEL, 1881 emend RIEDEL, 1967

Genus : ANDROCYCLAS JØRGENSEN, 1906

Androcyclas sp. cf. A. gamphonycha (Jørgensen), 1905

Pl.XVI, fig.9

cf. 1976 Androcyclas gamphonycha (Jørgensen). BJØRKLUND, p.1124, pl.10, fig.2-6.

Material: Present in three samples from the Middle Miocene (Dorcadospyris alata Zone) at Site 71, in very rare to rare abundance.

Discussion: The taxon differs from A. gamphonycha in the size, shape and arrangement of the pores, which in this case are multimodal per segment, subangular and irregularly arranged rather than showing a more unimodal, regular arrangement of subcircular pores.

Genus : ANTHOCYRTIDIUM HAECKEL, 1881 sensu PETRUSHEVSKAYA in PETRUSHEVSKAYA and KOZLOVA, 1972

Anthocyrtidium ehrenbergi (Stohr), 1880

Pl.XVI, fig.10a-c

1880 Anthocyrtis ehrenbergi STOHR, p.100, pl.3, figs.21a,b.

1957 Anthocyrtium ehrenbergi ehrenbergi (Stohr). RIEDEL, p.83, pl.2, figs.1-3.

1978 Anthocyrtidium ehrenbergi (Stohr). WEAVER and DINKELMAN, p.867, pl.1, fig.1.

Stratigraphical Distribution: WEAVER and DINKELMAN (1978) tabulate the species from the Early to Middle Miocene.

Material: A. ehrenbergi ranges throughout the studied sequences at both Sites 289 and 71. At Site 289 the species exhibits a discontinuous distribution with abundance varying from very rare to rare. By contrast, the species is found in all nine samples from the Dorcadospyris alata Zone at Site 71, where abundance is always rare.

Discussion: Forms with a narrower, less inflated thorax and well developed peristome (Pl.XVI, fig.10c) may well represent a distinct species.

Genus : CALOCYCLETTA HAECKEL, 1887 sensu MOORE, 1972

Calocycletta caepa MOORE, 1972

Pl.XVII, fig.1a-e

1971 Calocycletta sp. RIEDEL and SANFILIPPO, p.1598, pl.1G, fig.18; pl.2H, figs.1,2.

1972 Calocycletta caepa MOORE, p.150, pl.2, figs.4-7.

Distinguishing Features: Apical horn may be conical or bladed. The thorax is subspherical to campanulate in outline, with up to fourteen rows of closely spaced, longitudinally aligned, circular pores in a hexagonal arrangement on the facing side. Abdomen is cylindrical, and terminates in a series of small triangular feet.

Stratigraphical Distribution: Middle Miocene (Dorcadospyris alata Zone) to Late Miocene (Ommatartus antepenultimus Zone) (MOORE, 1972).

Material: C. caepa ranges continuously throughout the studied sequences at both Sites 289 and 71. At Site 289, the species varies in abundance from very rare to common. At Site 71, abundance ranges from very rare to few.

Discussion: In samples which fall within the range of C. virginis (a closely related form), individuals of Calocycletta spp. may be difficult to catagorise when the abdomen is lost. In the present study, such specimens are differentiated as the basis of thorax outline and pore arrangement. In general, C. caepa has a more inflated, campanulate or onion shaped outline, possessing a greater number of thoracic pore rows. Nevertheless, intermediate forms exist, although those have here been counted under C. caepa for taxonomic convenience.

Calocycletta costata (Riedel), 1959

Pl.XVII, fig.2

1959 Calocyclas costata RIEDEL, p.296, pl.2, fig.9.

1971 Calocycletta costata (Riedel). RIEDEL and SANFILIPPO, p.1598, pl.2H, figs.12-14.

1972 Calocycletta costata (Riedel). MOORE, p.147, pl.1, fig.8.

Distinguishing Features: A distinctive species. The horn is long and robust and the thorax possesses well aligned rows of pores seperated by ridges. Abdomen consists almost entirely of numerous parallel lamellar feet.

Stratigraphical Distribution: Early Miocene (base of Calocycletta costata Zone) to Middle Miocene (Dorcadospyris alata Zone) (RIEDEL and SANFILIPPO, 1978).

Material: At Site 289, C. costata ranges from beyond the base of the studied sequence into the Dorcadospyris alata Zone:N.11-12. Abundance varies from very rare to few.

Calocycletta virginis (Haeckel), 1887

Pl.XVII, fig.3a-b

1887 Calocyclas virginis HAECKEL, p.1381-1382, pl.74, fig.4.

1972 Calocycletta virginis (Haeckel). MOORE, p.147, pl.1, fig.7.

Distinguishing Features: Thorax campanulate to hemispherical, without longitudinal ribs. Abdomen consists of latticed portion followed by numerous, well developed lamellar feet.

Stratigraphical Distribution: Early to Middle Miocene (MOORE, 1972).

Material: At Site 289, C. virginis ranges from the base of the studied sequence into the Dorcadospyris alata Zone:N.11-12. Abundance varies from rare to common. The species is present in all nine samples from Site 71 and varies from very rare to few.

Geographical Distribution and Palaeoecology: SANCETTA (1978) identified C. virginis as a dominant element in tropical radiolarian assemblages from the Pacific Ocean during the Early Miocene.

Discussion: Individuals of C. virginis possessing a complete abdomen, including the diagnostic feet, are extremely scarce at both Sites. Identification is therefore made in most cases, on the character of the thorax (see 'Discussion', C. caepa).

Genus : LAMPROCYCLAS HAECKEL, 1881

Lamprocyclas maritalis s.l. HAECKEL, 1887

Pl.XVI, fig.12a-c

1887 Lamprocyclas maritalis HAECKEL, p.1390.

1974 Lamprocyclas maritalis maritalis HAECKEL. JOHNSON, p.551, pl.10, fig.11.

1975 Lamprocyclas maritalis martialis HAECKEL. LING, p.731, pl.13, fig.1.

1975 Lamprocyclas sp. LING, p.731, pl.13, fig.2.

Distinguishing Features: A three segmented form with a subcylindrical cephalis bearing a stout apical horn; thorax campanulate and followed by a wider and larger abdomen. The thoracic/abdominal stricture is usually marked in outline view by a constriction of varying intensity. Peristome may be in various stages of development, from narrow undulating band to a long, advanced structure bearing both terminal and subterminal teeth. Both thoracic and abdominal pores are usually arranged in well aligned vertical rows.

Stratigraphical Distribution: Late Oligocene (*Lychnocanoma elongata* Zone) to Pleistocene (LING, 1975). The species is extant (RENZ, 1976).

Material: *L. maritalis* ranges throughout the studied sequences at both Sites 289 and 71. Distribution is almost continuous through the Middle and Late Miocene at Site 289. At Site 71, the species is present in all nine samples. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: In surface sediment samples from the Pacific Ocean, CASEY (1971a,b) and RENZ (1976) found peak abundances in equatorial regions. The evidence for life habitat is, however, conflicting. CASEY (1966, 1971a,b) cites *L. maritalis* as an equatorial shallow water species (in the top 200 metres), while RENZ (1976) suggests a deep dwelling habitat in the water column.

Discussion: The Miocene specimens encountered in the present study possibly constitute a seperate species from the modern counterparts, although a direct phylogenetic relationship is inferred. Recent forms possess larger thoracic and abdominal pores so that the number of rows are reduced (see NIGRINI, 1967, pl.7, fig.5). At Site 289, it is possible to identify 'primitive' forms, with no thoracic/abdominal constriction, poorly aligned pores and a weak peristome, from advanced forms, with a marked constriction, well aligned pores and a strongly developed peristome with up to two sets of teeth.

Genus : *LAMPROCYRTIS* KLING, 1973

Lamprocyrtis? hannai (Campbell and Clark), 1944

Pl.XVI, fig.11a-c

1944 *Calocyclas hannai* CAMPBELL and CLARK, p.48, pl.6, figs.21,22.

?1944 *Calocyclas margatensis* CAMPBELL and CLARK, p.47, pl.6, figs.17,18.

1973 *Lamprocyrtis(?) hannai* (Campbell and Clark). KLING, p.638, pl.5, figs.12-14; pl.12, figs.10-14.

Stratigraphical Distribution: KLING (1973) figures the species from the Early Miocene (Calocycletta costata Zone) to the Pleistocene.

Material: L. hannai ranges throughout the studied sequences at both Sites 289 and 71. The species is found in most samples at the former and all samples at the latter Site. Abundance varies from very rare to rare.

Discussion: Individuals of L.? hannai display a wide range of variation with regard abdominal pore size and arrangement. They may possess pores of multimodal size which are widely spaced and haphazardly arranged on the one extreme, and unimodal, closely spaced pores in well arranged vertical rows on the other.

Genus : PTEROCORYS HAECKEL, 1881

Pterocorys campanula HAECKEL, 1887

Pl.XVII, fig.4

1887 Pterocorys campanula HAECKEL, p.1316, pl.71, fig.3.

Stratigraphical Distribution: HAECKEL (1887) collected the species from surface sediments of the central Pacific Ocean.

Material: At Site 289, the species is present in four samples from the Middle Miocene (Cannartus? petterssoni Zone:N.13) to the Late Miocene (Ommatartus antepenultimus Zone:N.17). At Site 71 the species is found in two samples. Abundance is always very rare. The presence of the species at Site 71 may be due to downhole contamination (see Chapter V).

Genus : SETHOCORYS HAECKEL, 1881

Sethocorys achillis? HAECKEL, 1887

Pl.XVII, fig.5a-c

? 1887 Sethocorys achillis HAECKEL, p.1301, pl.62, fig.8.

1973 Sethocorys spp. KLING, p.639, pl.12, figs.15-18.

Stratigraphical Distribution: KLING (1973) figures the taxon from the Middle Miocene (Dorcadospyris alata Zone) to the Late Miocene.

Material: At Site 289, S. achillis? ranges virtually throughout the studied sequence, from beyond the lower limit into the Late Miocene (Ommatartus antepenultimus Zone:N.17). Distribution is discontinuous and abundance varies from very rare to rare. The species is found in six samples at Site 71 in a similar range of abundance.

Remarks: Forms encountered in the present study probably all belong to the same species and seem suitably similar to that described by HAECKEL (1887) to warrant tentative inclusion.

Genus : THEOCONUS HAECKEL, 1887

Theoconus jovis HAECKEL, 1887

Pl.XVII, fig.8a-b

1887 Theoconus jovis HAECKEL, p.1401, pl.69, fig.4.

Distinguishing Features: An elongate cephalis bears a long simple spine. The thorax and abdomen are inflated, join at a distinct constriction and possess large pores.

Stratigraphical Distribution: HAECKEL (1887) collected the species from surface sediments of the Pacific Ocean.

Material: At Site 289, T. jovis ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to beyond the upper limit of the studied sequence. Distribution is discontinuous. At Site 71 the species is present in four samples from the Dorcadospyris alata Zone. Abundance varies from very rare to rare.

Theoconus zancleus? (Muller), 1858

Pl.XVII, fig.6a-b

1858 Eucyrtidium zancleum MULLER, p.672.

? 1887 *Theoconus zancleus* (Muller). HAECKEL, p.1399.

? 1973 *Theoconus zancleus* (Muller). KLING, p.639, pl.5, fig.9-11; pl.12, fig.7-9.

Distinguishing Features: The cephalis bears a bladed spine so that the two elements normally form a perfect cone in outline view. There is a slight or no constriction between the thorax and abdomen which each bear small pores.

Stratigraphical Distribution: KLING (1973) tabulates the species from the Middle Miocene (*Cannartus? petterssoni* Zone) to the Pleistocene. The species is extant (CASEY, 1966).

Material: *T. zancleus?* ranges throughout the studied sequence at both Sites 289 and 71. Distribution is continuous and abundance varies from very rare to few at Site 289 and from rare to few at Site 71.

Geographical Distribution and Palaeoecology: CASEY (1966, 1971a,b) suggests *T. zancleus* characterises the 'Equatorial central shallow' radiolaria fauna in the Pacific Ocean, living in the top 200 metres of the water column.

Discussion: KLING (1973) suggests the Miocene specimens of *T. zancleus* may constitute a seperate species from the Recent counterparts. He cites a cylindrical abdomen possessing longitudinal ridges and terminating in a weak peristome as features diagnostic of the former. In the present study there is no Recent material with which a comparative study can be made and so the individuals are tentatively synonymised with Muller's form.

Genus : *THEOCORYTHIUM* HAECKEL, 1887

Theocorythium sp. cf. *T. trachelium* (Ehrenberg), 1872

Pl.XVII, fig.7

cf. 1974 *Theocorythium trachelium* (Ehrenberg). JOHNSON, p.551, pl.10, fig.6.

Material: One specimen from the Late Miocene (Ommatartus antepenultimus Zone:N.16) at Site 289.

Remarks: This form is similar in many respects to the Pliocene species except that the thorax is not distally inflated.

Family : ARTOSTROBIIDAE RIEDEL, 1967 sensu FOREMAN, 1973

Remarks: NIGRINI (1977) has conducted the most recent taxonomic and biostratigraphical study of this family. Her taxonomic recommendations have been followed here.

Genus : BOTRYOSTROBUS HAECKEL, 1887 emend. NIGRINI, 1977

Botryostrobus auritus - austalis Group (Ehrenberg), 1838

Pl.XVIII, fig.2

part.1838 Lithocampe lineata EHRENBERG, p.130.

1854 Lithocampe lineata EHRENBERG, pl.19, fig.54.

1971 Artostrobium auritum (Ehrenberg) group. RIEDEL and SANFILIPPO, p. 1599, pl.1H, figs.5-7. (non) pl.1H, fig.8.

1977 Botryostrobus auritus-australis (Ehrenberg) group. NIGRINI, p.246, pl.1, figs.2-5.

Distinguishing Features: Chambers are seperated by distinct strictures possessing poreless bands.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Middle Miocene (Cannartus? petterssoni Zone) to Recent.

Material: At Site 289 the taxon first appears in the Ommatartus antepenultimus Zone:N.17. It is present in only three samples in very rare abundance.

Discussion: NIGRINI (1977) was uncertain as to the affinities of this group.

Botryostrobus bramlettei (Campbell and Clark), 1944

Pl.XVIII, fig.1

1944 *Lithomitra bramlettei* CAMPBELL and CLARK, p. 53, pl.7, figs.10-14.

1971 *Artostrobium auritum* (Ehrenberg) group, RIEDEL and SANFILIPPO, p.1599, pl.1H, fig.8; (non) pl.1H, figs.5-7.

1977 *Botryostrobus bramlettei* (Campbell and Clark). NIGRINI, p.248, pl.1, figs.7-8.

Distinguishing Features: The intersegmented constrictions are apparent in outline view. Poreless intersegmental bands are not developed.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Middle Miocene (*Cannartus? petterssoni* Zone) to Late Miocene (*Stichocorys peregrina* Zone).

Material: *B. bramlettei* appears in the *Cannartus? petterssoni* Zone:N.15 at the Site 289 and ranges beyond the upper limits of the studied sequence. It is found in most samples within this range and varies in abundance from very rare to rare. There is an anomalous stratigraphical appearance within the *Dorcadospyris* Zone:N.11-12 at Site 71 where the species is present in most samples though is consistently very rare to rare in abundance. Presence here may be due to downhole contamination (see Chapter V).

Discussion: NIGRINI (1977) suggests *B. bramlettei* as a transitional form between the older *B. miralestensis* and the younger *Botryostrobus aquilonaris* (Bailey).

Botryostrobus miralestensis (Campbell and Clark), 1944

Pl.XVIII, fig.3

1944 *Dictyocephalus miralestensis* CAMPBELL and CLARK, p.45, pl.6, figs.12-14.

1971 Artostrobium miralestensis (Campbell and Clark). RIEDEL and SANFILIPPO, p.1599, pl.1H, figs.14-17; pl.2I, figs.9,10. (non) pl.1H, fig.9-13; pl.3E, fig.12.

1977 Botryostrobus miralestensis (Campbell and Clark). NIGRINI, p.249, pl.1, fig.9.

Distinguishing Features: The intersegmented constrictions are externally obscure because of test wall thickening.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Early Miocene (Cyrtocapsella tetrapera Zone) to Middle Miocene (Cannartus? petterssoni Zone).

Material: At Site 289, the species ranges from beyond the lower limits of the studied sequence into the Late Miocene (Ommatartus antepenultimus Zone:N.17). It appears in almost all samples and varies in abundance from very rare to rare. At Site 71, the species is found in all samples within the Dorcadospyris alata Zone:N.11-12. Abundance varies from very rare to rare.

Discussion: NIGRINI (1977) infers B. miralestensis as the indirect precursor of B. aquilonaris.

Botryostrobus sp. aff. B. bramlettei (Campbell and Clark), 1944

Pl.XVIII, fig.4

Distinguishing Features: Possessing at least seven segments with small pores arranged in closely spaced transverse rows.

Material: This taxon is restricted to the Dorcadospyris alata Zone:N.11-12 at Site 289. It is present in only three samples in very rare abundance.

Remarks: Suggested affinity to B. bramlettei is based on the large number of segments, all of which are also seperated by constrictions visible in outline.

Genus : CARPOCANARIUM HAECKEL, 1887

Carpocanarium spp.

Pl.XVIII, fig.5a-c

1971 Carpocanarium spp. RIEDEL and SANFILIPPO, p.1599, pl.1I, figs.18,20,22,24,25. (non) figs.17,19,21,23; pl.2J, figs.8,9.

Distinguishing Features: This group contains all forms with a hemispherical cephalis, an ovate thorax with large pores and a poreless subcylindrical peristome.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the species group from the Middle Miocene (Dorcadospyris alata Zone) to Quaternary.

Material: At Site 289 the taxon ranges throughout the studied sequence. Abundance varies from very rare to rare and distribution is discontinuous. The species are absent at Site 71.

Discussion: RIEDEL and SANFILIPPO (1971) classified the genus within the Artostrobiidae because of the presence on some specimens from the lower part of the range of an inconspicuous lateral cephalic tubule.

Carpocanarium sp. 1

Pl.XVIII, fig.6

Distinguishing Features: A distinct hemispherical cephalis with an apical spine is separated from the thorax by a well defined stricture. The thorax bears up to nine vertical rows of small pores, usually in a regular arrangement, and terminates distally in a short, constricted poreless peristome.

Material: The species range throughout the studied sequences at Sites 289 and 71. Distribution is markedly discontinuous at Site 289 where the species is present above and below but absent within the *Cannartus? petterssoni* Zone:N.13-15 of the Middle Miocene. At Site 71, the taxon is present in all nine samples from the *Dorcadospyris alata* Zone. Abundance varies from very rare to rare.

Discussion: The species is placed in the genus *Carpocanarium* because of the superficial similarly to forms included under *Carpocanarium spp.* herein. It is however, sufficiently distinctive to allow consistent discrimination.

Genus : *PHORMOSTICHOARTUS* CAMPBELL *emend*. NIGRINI, 1977

Phormostichoartus corbula (Harting), 1863

Pl.XVIII, fig.7a-b

1863 *Lithocampe corbula* HARTING, p.12, pl.1, fig.21.

1967 *Siphocampe corbula* (Harting). NIGRINI, p.85, pl.8, fig.5; pl.9, fig.3.

1971 *Siphocampe corbula* (Harting). RIEDEL and SANFILIPPO, p.1601, pl.1H, figs.18-25.

1977 *Phormostichoartus corbula* (Harting). NIGRINI, p.252, pl.1, fig.10.

Distinguishing Features: A four segmented form with small pores, regularly arranged in closely spaced transverse rows.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Middle Miocene (*Dorcadospyris alata* Zone) to Recent.

Material: *P. corbula* ranges throughout the studied sequences at both Sites 289 and 71. Distribution is discontinuous and abundance varies from very rare to rare.

Discussion: NIGRINI (1977) suggests *P. corbula* as a decendent of *P. fistula*.

Phormostichoartus doliolum (Riedel and Sanfilippo), 1971

Pl.XVIII, fig.8

1971 Artostrobum doliolum RIEDEL and SANFILIPPO, p.1599, pl.1H, figs.1-3; pl.8, figs.14-15.

1977 Phormostichoartus doliolum (Riedel and Sanfilippo). NIGRINI, p.252, pl.1, fig.14.

Distinguishing Features: A four segmented form with post cephalic segmental pores arranged in closely spaced transverse rows.

Stratigraphical Distribution: NIGRINI (1977) gives a range from the Late Miocene (Ommatartus antepenultimus Zone) to the Pliocene (Spongaster pentas Zone). WESTBERG and RIEDEL (1978) however extend its range at Site 289 down into the Middle Miocene (Dorcadospyris alata Zone), possibly reflecting differences in the specific concept between these workers.

Material: At Site 289, P. doliolum ranges virtually from the base of the Late Miocene (Ommatartus antepenultimus Zone:N.16) to beyond the upper limits of the studied sequence. Abundance varies from very rare to rare.

Discussion: NIGRINI (1977) regards P. doliolum as a decendant of P. marylandicus. In the present study, individuals of P. doliolum are seperated from P. marylandicus by possessing a well developed thorax with four complete rows of closely spaced pores.

Phormostichoartus fistula NIGRINI, 1977

Pl.XVIII, fig.9a-c

1971 Siphocampe sp. aff. S. corbula (Harting). RIEDEL and SANFILIPPO, p.1601, pl.1H, figs.26-28; pl.2I, figs.11-13.

1977 Phormostichoartus fistula NIGRINI. NIGRINI, p.253, pl.1, fig.11-13.

Distinguishing Features: Test consisting of three or four segments. Pore size varies with maximum development in four segmented forms.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Late Eocene (*Thyrsocyrtis bromia* Zone) to Pliocene (*Spongaster pentas* Zone).

Material: The species is almost continuously distributed throughout the studied sequences at Sites 289 and 71. Abundance varies from very rare to rare.

Discussion: NIGRINI (1977) tentatively suggests *P. fistula* as the ancestor of *P. corbula*.

Remarks: In contrast to NIGRINI (1977), the present author tentatively includes three segmented forms within the specific concept.

Phormostichoartus marylandicus (Martin), 1904

Pl.XVIII, fig.10a-b

1904 *Lithocampe marylandica* MARTIN, p.450, pl.130, fig.4.

1971 *Artostrobium sp. aff. A. doliolum* RIEDEL and SANFILIPPO, pl.1H, fig.4; pl.2I, figs.1-8; pl.3E, fig.7-9.

1977 *Phormostichoartus marylandicus* (Martin). NIGRINI, p.253, pl.2, figs.1-3.

Distinguishing Features: Test with four segments; all except cephalis containing rows of subcircular pores arranged in transverse fashion and usually widely spaced.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Early Oligocene (*Theocyrtis tuberosa* Zone) to Middle Miocene (*Cannartus? petterssoni* Zone).

Material: At Site 289, *P. marylandicus* ranges from beyond the lower limit of the studied sequence into the Late Miocene (*Ommatartus antepenultimus* Zone:N.17). Distribution is almost continuous and abundance varies from very rare to few. At Site 71 the species is found in most samples where abundance ranges from very rare to rare.

Discussion: NIGRINI (1977) regards *P. marylandicus* as the precursor of P. doliolum. At Site 289, the species are seperated on the basis of pore arrangement (see 'Discussion' for P. doliolum).

Genus : SIPHOCAMPE HAECKEL, 1881 emend. NIGRINI, 1977

Siphocampe spp. Group (Ehrenberg)

Pl.XVIII, fig.11a-b

1838 Lithocampe lineata EHRENBERG, p.130 (partim).

1854 Lithocampe lineatum EHRENBERG, pl.22, fig.26; pl.36, fig.16.

1887 Lithomitrea nodosaria HAECKEL, p.1484, pl.79, fig.1.

1971 Lithomitra lineata (Ehrenberg) group. RIEDEL and SANFILIPPO p.1600, pl.1I, figs.1-11; pl.2I, fig.14-16.

1977 Siphocampe arachnea (Ehrenberg) group. NIGRINI, p.255, pl.3, figs.7,8.

1977 Siphocampe lineata (Ehrenberg) group. NIGRINI, p.256, pl.3, figs.9,10.

1977 Siphocampe nodosaria (Haeckel). NIGRINI p.256, pl.3, fig.11.

Distinguishing Features: A group of three segmented artostrobiids with a cylindrical or subcylindrical abdomen, possessing transverse rows of subcircular pores which may or may not be seperated by indentations displaying various modes of development.

Stratigraphical Distribution: NIGRINI (1977) gives the combined range of her three taxonomic catagories as Middle Eocene (Thyrsocyrtis triacantha Zone) to Recent.

Material: Siphocampe spp. ranges throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to rare.

Remarks: The three taxonomic groups of NIGRINI (1977) have been lumped in the present study because of interspecific gradation.

Genus : SIPHOSTICHOARTUS NIGRINI, 1977

Siphostichoartus corona (Haeckel), 1887

Pl.XVIII, fig.12a-b

1887 Cyrtophormis (Acanthocyrtis) corona HAECKEL, p.1462, pl.77, fig.15.

1971 Phormostichoartus corona (Haeckel). RIEDEL and SANFILIPPO, p.1600, pl.1I, figs.13-15; pl.2J, figs.1-5.

1977 Siphostichoartus corona (Haeckel). NIGRINI, p.257, pl.2, figs.5,6.

Distinguishing Features: A four segmented form. The abdomen is inflated and possesses four to seven transverse rows of pores. The post abdominal segment is inflated proximally and tapers distally.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Early Miocene (Stichocorys wolffii Zone) to Late Miocene (Stichocorys pergerina Zone).

Material: S. corona ranges throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to rare.

Discussion: See 'Discussion' under S. praecorona for comparison and affinities.

Siphostichoartus praecorona NIGRINI, 1977

Pl.XVIII, fig.13

1971 Phormostichoartus sp. aff. P. corona HAECKEL. RIEDEL and SANFILIPPO, p.1600, pl.2J, figs.6,7; pl.3f, figs.1-3.

1977 Siphostichoartus praecorna NIGRINI, p.258, pl.2, figs.8-9.

Distinguishing Features: Four segmented form with a relatively short abdomen possessing two to three transverse rows of pores.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Late Oligocene (Dorcadospyris ateuchus Zone) to Early Miocene (Stichocorys wolffii Zone).

Material: In the present study, S. praecorona has been identified at higher stratigraphical levels compared to the range given by NIGRINI (1977). At Site 289 the species ranges from beyond the lower limit of the studied sequence into the Middle Miocene (Cannartus? petterssoni Zone:N.13). At Site 71, the species is present through most of the sequence within the Dorcadospyris alata Zone:N.11-12. Abundance at both sites ranges from very rare to rare.

Discussion: NIGRINI (1977) regards S. praecorona as the precursor of S. corona and a close relative of P. marylandicus, which tends to have a less inflated fourth segment. In S. corona the abdomen possesses up to seven transverse rows of pores and the fourth segment is more inflated. Transitional forms are difficult to catagorise in the present study.

Genus : SPIROCYRTIS HAECKEL, 1881 emend. NIGRINI, 1977

Spirocyrtis gyroscalaris NIGRINI, 1977

Pl.XVIII, fig.14a-b

1971 Spirocyrtis sp. aff. S. scalaris HAECKEL. RIEDEL and SANFILIPPO, p.1601, pl.1b, figs.21,23. (non)figs.19,20,22,24.

1977 Spirocyrtis gyroscalaris NIGRINI, p.258, pl.2, figs.10-11.

Distinguishing Features: Test with seven to nine segments, all of which possess a rounded outline. The post-thoracic segments contain multiple rows of subcircular pores.

Stratigraphical Distribution: NIGRINI (1977) gives the range as Late Miocene (Ommatartus antepenultimus Zone) to Quaternary.

Material: At Site 289, S. gyroscalaris ranges from the Middle Miocene (Dorcadospyris alata Zone:N.11-12) to the Late Miocene (Ommatartus antepenultimus Zone:N.17). At Site 71, the species is present in four samples from the Middle Miocene (Dorcadospyris alata Zone). Distribution at both sites is discontinuous and abundance varies from very rare to rare.

Remarks: NIGRINI (1977) regards *S. gyroscalaris* as a decendant of *Spyrocyrtis subtilis*, which has a narrower test.

Spirocyrtis spp.

Pl.XVIII, fig.15a-c

1971 *Spirocyrtis sp. aff. S. scalaris* HAECKEL. RIEDEL and SANFILIPPO, p.1601, pl.1G, figs.19,20,22,24; pl.2H, figs.15-18.

1977 *Spirocyrtis subscalaris* NIGRINI, p.259, pl.3, figs.1,2.

1977 *Spirocyrtis subtilis* PETRUSHEVSKAYA. NIGRINI, p.260, pl.3, fig.3.

Distinguishing Features: Test consisting of up to eight narrow segments of rounded outline with two to five rows of subcircular pores in each. Short spines may develop on the thorax.

Stratigraphical Distribution: NIGRINI (1977) gives the range (of the two species combined) as Early Miocene (*Stichocorys wolffii* Zone) to Recent.

Material: At both Sites 289 and 71, *Spirocyrtis spp.* ranges throughout the studied sequences. Abundance varies from very rare to rare.

Discussion: Elements of this species group (*S. subtilis* of NIGRINI (1977)) give rise to *S. gyroscalaris* by means of increase width. A semi-hyaline form (pl.XVIII, fig.15c) was occasionally encountered at Site 289.

Remarks: Separation of the two species of NIGRINI (1977) was found difficult in the present study and they were thus combined.

Family : CANNOBOTRYTHIDAE HAECKEL, 1881 sensu RIEDEL, 1967

Genus : ACROBOTRYS HAECKEL, 1881 sensu RIEDEL and SANFILIPPO, 1971

Acrobotrys spp.

Pl.XVII, fig.12

1957 Acrobotrys tritubus RIEDEL, p.80, pl.1, fig.5.

1971 Acrobotrys tritubus RIEDEL. RIEDEL and SANFILIPPO, p.1602, pl.1J, figs.19,20.

1971 Acrobotrys spp. RIEDEL and SANFILIPPO, p.1601, pl.1J, figs.12-16; pl.2J, figs.13-15; pl.3F, fig.8.

Stratigraphical Distribution: The genus ranges from Early Miocene (Calocycletta virginis Zone) to Recent (Riedel and Sanfilippo, 1977).

Material: Members of this genus range throughout the studied sequences at both Sites 289 and 71 although distribution is very discontinuous. Abundance is always very rare at Site 71 and varies from very rare to rare at Site 289.

Genus : BOTRYOCYRTIS EHRENBERG, 1860 sensu RIEDEL and SANFILIPPO, 1971

Botryocyrtis spp.

Pl.XVII, fig.9

1971 Botryocyrtis spp. RIEDEL and SANFILIPPO, p.1602, pl.1J, figs.1-11; pl.2J, figs.10-12; (non)pl.3F, fig.7.

Stratigraphical Distribution: The genus ranges from the Early Miocene (Calocycletta virginis Zone) to Recent (RIEDEL and SANFILIPPO, 1977).

Material: Botryocyrtis spp. ranges throughout the studied sequences at both Sites 289 and 71. At Site 289, distribution is discontinuous and abundance varies from very rare to rare. At Site 71, the taxon is present in all nine samples with abundance varying from very rare to few.

Geographical Distribution and Palaeoecology: CASEY (1966; 1971a,b) and RENZ (1976) both identify living Botryocyrtis sp. in shallow equatorial planktonic faunas in the Pacific Ocean, living mainly in the top 100 metres of the water column. Consequently, peak abundance in surface sediments is found in these equatorial regions.

Genus : BOTRYOPYLE HAECKEL, 1881

Botryopyle dictyocephalus Group HAECKEL, 1887

Pl.XVII, fig.10

1887 Botryopyle dictyocephalus HAECKEL, p.1113, pl.96, fig.6.

1971 Botryopyle dictyocephalus HAECKEL group. RIEDEL and SANFILIPPO, pl.1J, figs.21-26; pl.2J, figs.16-17; pl.3F, figs.9-12.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure this group from the Late Eocene (Thyrsocyrtis bromia Zone) to Quaternary.

Material: This taxon is very scarce at both Sites 289 and 71. At Site 289 it appears to range throughout the studied sequence but is only present in eight samples. Abundance varies from very rare to rare. At Site 71, B. dictyocephalus group is found in one sample and is very rare.

Geographical Distribution and Palaeoecology: RENZ (1976) discovered peak abundances of this taxon both in plankton and surface sediment samples around the equator in the central Pacific Ocean. In the water column, highest numbers were found in the top 75 metres.

Genus : CENTROBOTRYS PETRUSHEVSKAYA, 1965

Centrobotrys thermophila PETRUSHEVSKAYA, 1965

Pl.XVII, fig.11

1965 Centrobotrys thermophila PETRUSHEVSKAYA, p.115, text-fig.20.

1971 Centrobotrys thermophila PETRUSHEVSKAYA. RIEDEL and SANFILIPPO, p.1602, pl.1J, figs.27-31; pl.2J, fig.19; pl.3F, fig.14.

Stratigraphical Distribution: RIEDEL and SANFILIPPO (1971) figure the species from the Late Oligocene (*Dorcadospyris ateuchus* Zone) to Quaternary.

Material: *C. thermophila* ranges throughout the studied sequence at both sites. At Site 289, distribution is discontinuous, whereas at Site 71, the species is found in all nine samples. Abundance varies from very rare to rare.

Geographical Distribution and Palaeoecology: RENZ (1976) found *C. thermophila* at peak abundance in both plankton and surface sediment samples in equatorial regions of the central Pacific Ocean. In the water column, the species tends to peak in the top 75 metres.

Radiolaria incertae sedis

"Cyrtid spp. group 1"

Pl.XII, fig.14a-d

Discussion: This is an artificial "morpho-group" comprised of flatly expanding forms belonging to both the plagoniid and theoperid families. Attempts to subdivide the group in the present study have been unsuccessful.

Material: The group ranges throughout the studied sequence at both Sites 289 and 71. At Site 289 distribution is discontinuous and abundance varies from very rare to few. Representatives of the group are found in all nine samples at Site 71 where abundance is always rare.

"Cyrtid spp. group 2"

Pl.XII, fig.15a-e

1973 *Clathrocyclas spp.* KLING, p.635, pl.3, figs.17-22; pl.9, figs.26-31.

1973 Theocalyptra sp. KLING, pl.9, figs.18-22.

Stratigraphical Distribution: KLING (1973) figures representatives of this group from the Middle Miocene (Dorcadospyris alata Zone) to Pleistocene.

Material: At Site 289 this group ranges throughout the studied sequence. Distribution is almost continuous and abundance varies from very rare to few. At Site 71 the taxon is present in all nine samples. Abundance ranges from few to common.

Discussion: This polyspecific group includes species of the synonymised genera although other genera may also be included. Attempts to subdivide the group in the present study have beem unsucessful.

Lithocyclia ? sp. cf. L. ocellus Group EHRENBERG

Pl.XII, fig.16

?1887 Coccocyclia heliantha HAECKEL, p.468, pl.36, figs.5,6.

part.1970 Lithocyclia ocellum EHRENBERG group. RIEDEL and SANFILIPPO, p.522.

part.1973 Lithocyclia ocellus EHRENBERG group. SANFILIPPO and RIEDEL, p.523, pl.10, fig.2.

Material: Present in two samples from the Middle Miocene (Dorcadospyris alata Zone:N.9) at Site 289. Abundance is very rare.

Discussion: This taxon shows no affinity to, and is quite unlike, any figured Neogene spumellarian. Also the central form of the Eocene coccodiscid species Lithocyclia ocellus differs quite considerably by possessing clear medullary shells and discrete concentric rings in the cortical shell. However, SANFILIPPO and RIEDEL (1973), refer to an early form with a spongy meshwork covering the cortical shell, with no concentric zonation in the spongy flange but having only 3-6 bladed spines originating on the periphery. Apart from the difference in the number of marginal spines (cf. eleven in the present form), this morphotype most closely resembles those encountered at Site 289. Identification must remain tentative however, for while these robust forms may represent reworked Eocene individuals, one cannot discount the possibility that the species is an Early or Middle Miocene cryptogene.

Radiolaria? incertae sedis

<u>Gen. et sp. indet</u>

Pl.XII, fig.17

<u>Distinguishing Features</u>: An ellipsoidal form with irregularly spaced multimodal subcircular pores penetrating the test wall. A 'pylome' may be present in a polar position.

<u>Material</u>: The form ranges throughout the studied sequences at both Sites 289 and 71. Abundance varies from very rare to rare.

All references cited in Appendix I are listed
in full in the bibliography section of the main text

APPENDIX II

RADIOLARIA DIVERSITY : BASIC DATA, SITE 289

Sample	Inds.*	Taxa*	Total Taxa*	∝	Sample	Inds.*	Taxa*	Total Taxa*	∝
50cc	720	50	89	12	50.3	904	33	62	7
49cc	771	40	74	9	49.5	840	27	48	6
48cc	687	33	69	7	49.3	923	34	74	7
47cc	633	46	77	12	48.5	711	24	45	5
46cc	574	54	82	15	48.3	736	27	46	6
45cc	765	48	89	12	47.5	675	32	61	7
44cc	816	49	92	12	47.3	553	39	65	10
43cc	805	45	75	11	45.3	719	35	65	8
42cc	693	62	98	16	44.5	796	36	68	8
41cc	723	50	89	12	44.3	703	34	67	8
40cc	707	39	83	9	42.4	903	38	70	8
39cc	869	49	88	12	41.1	657	30	54	7
38cc	790	46	85	11	40.5	748	33	67	7
37cc	489	40	81	11	40.3	715	44	74	11
36cc	598	48	86	12	39.3	715	32	71	7
35cc	780	41	73	9	38.5	800	33	59	7
34cc	698	41	74	10	38.3	773	32	59	7
33cc	601	41	77	10	37.4	641	29	65	7
32cc	652	40	74	10	36.4	611	24	56	5
31cc	686	37	81	9	35.3	755	26	64	6
30cc	664	47	87	12	34.4	671	34	73	8
29cc	584	42	76	11	33.4	667	37	70	9
28cc	667	46	87	12	32.3	924	38	82	8
27cc	615	53	92	14	31.4	627	41	76	10
26cc	632	43	79	11	30.2	662	28	67	6
25cc	686	48	88	12	28.4	669	36	71	8
24cc	614	46	72	12	26.4	788	39	66	9
					25.3	855	41	74	9
					24.4	587	32	64	7

RADIOLARIA DIVERSITY : BASIC DATA, SITE 71

Sample	Inds.*	Taxa*	Total Taxa*	∝
15.6	482	52	100	15
15.4	536	59	102	17
15.2	772	59	105	15
14.6	718	57	110	14
14.4	558	60	99	17
14.2	510	55	99	16
13.6	600	62	109	17
13.4	476	60	106	17
13.2	597	70	105	18

Inds.* = Individuals found in three fields of view at x60 mag.
Taxa* = No. of taxa found in three fields of view at x60 mag.
Total Taxa* = Total no. of taxa on slide.

PLATES I-XVIII

Specimens are from DSDP Site 289 unless otherwise indicated. For full details of sample location, see figs. 4 and 7. For radiolarian samples, R refers to normal slide (>63µ), C = coarse fraction (>150µ) and Ph = fine fraction (>63µ - <150µ). R(a) indicates one of several slides prepared from a sample residue. England finder codes are indicated.

A few radiolarian individuals are illustrated from above the main studied sequence at Site 289; they have been selected because of their favoured state of preservation.

All magnifications given approximately reflect the actual test dimensions.

PLATE I

Fig.1a	Globorotalia (F.) peripheroacuta	49-6, spiral view x87
Fig.1b	" "	49-4, umbilical view x82
Fig.1c	" "	49-6, side view x82
Fig.2a	Globorotalia (F.) fohsi fohsi	47-6, spiral view x104
Fig.2b	" "	47-6, umbilical view x76
Fig.2c	" "	47-6, side view x86
Fig.2d	" "	43-6, umbilical view x87
Fig.2e	" "	43-6, side view x70
Fig.3a	Globorotalia (F.) fohsi lobata	45-5, spiral view x67
Fig.3b	" "	45-5, umbilical view x54
Fig.4a	Globorotalia (F.) fohsi robusta	45-2, spiral view x75
Fig.4b	" "	45-2, umbilical view x53

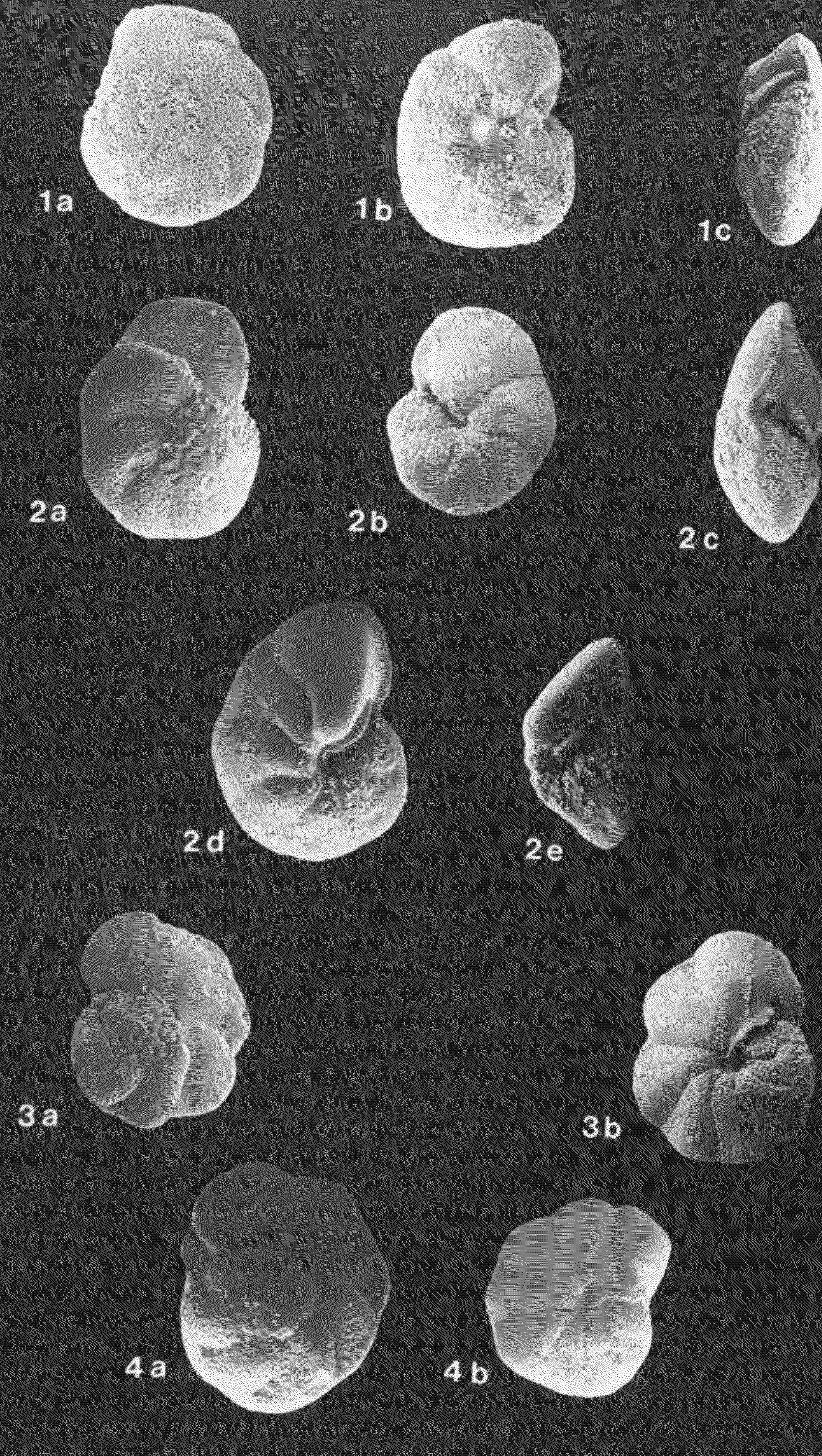

PLATE I

PLATE II

Fig.1a Globorotalia (G.) cultrata Group 40-4, spiral view x63

Fig.1b " " 40-4, spiral view x72

Fig.1c " " 40-4, umbilical view x66

Fig.1d " " 31-6, umbilical view x67

Fig.1e " " 28-5, side view x73

Fig.2 Globorotalia (G.) miozea Site 71, 13-2, umbilical view x96

Fig.3a Globorotalia (G.) praemenardii 48-2, spiral view x72

Fig.3b " " 48-2, umbilical view x73

Fig.4a Globorotalia sp. cf. G. (G.) merotumida 28-5, spiral view x76

Fig.4b " " 28-5, umbilical view x72

Fig.4c " " 28-5, side view x78

Fig.5a Globorotalia sp. cf. G. (G) multicamerata 25-4, spiral view x45

Fig.5b " " 25-4, umbilical view x36

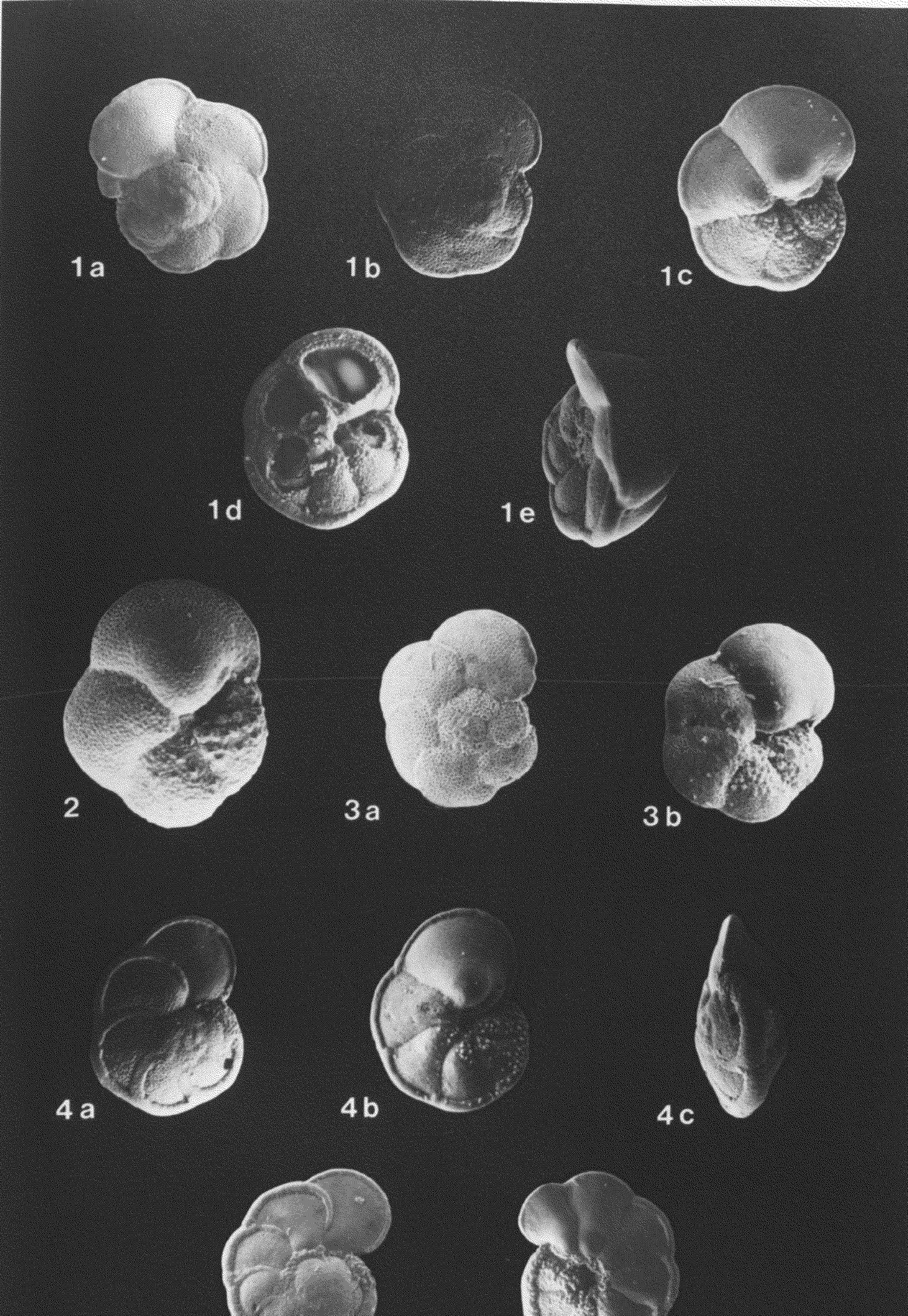

PLATE II

PLATE III

Fig.1a	Globorotalia (T.) acostaensis acostaensis 24-3, spiral view x87
Fig.1b	" " " 24-3, umbilical view x95
Fig.2a	Globorotalia (T.) acostaensis humerosa 29-1, spiral view x97
Fig.2b	" " " 29-1, umbilical view x87
Fig.3a	Globorotalia (T.) continuosa 38-6, spiral view x89
Fig.3b	" " 38-6, umbilical view x95
Fig.4a	Globorotalia (T.) obesa 43-4, spiral view x93
Fig.4b	" " 43-4, side view x83
Fig.5a	Globorotalia (T.) siakensis 38-6, spiral view x83
Fig.5b	" " 38-6, umbilical view x80
Fig.5c	" " 38-6, umbilical view x76
Fig.5d	" " 38-6, umbilical view x118
Fig.6	Globorotalia sp. aff. G. (T.) continuosa 45-6, umbilical view x79
Fig.7	Globorotalia (T.) scitula 44-6, umbilical view x78

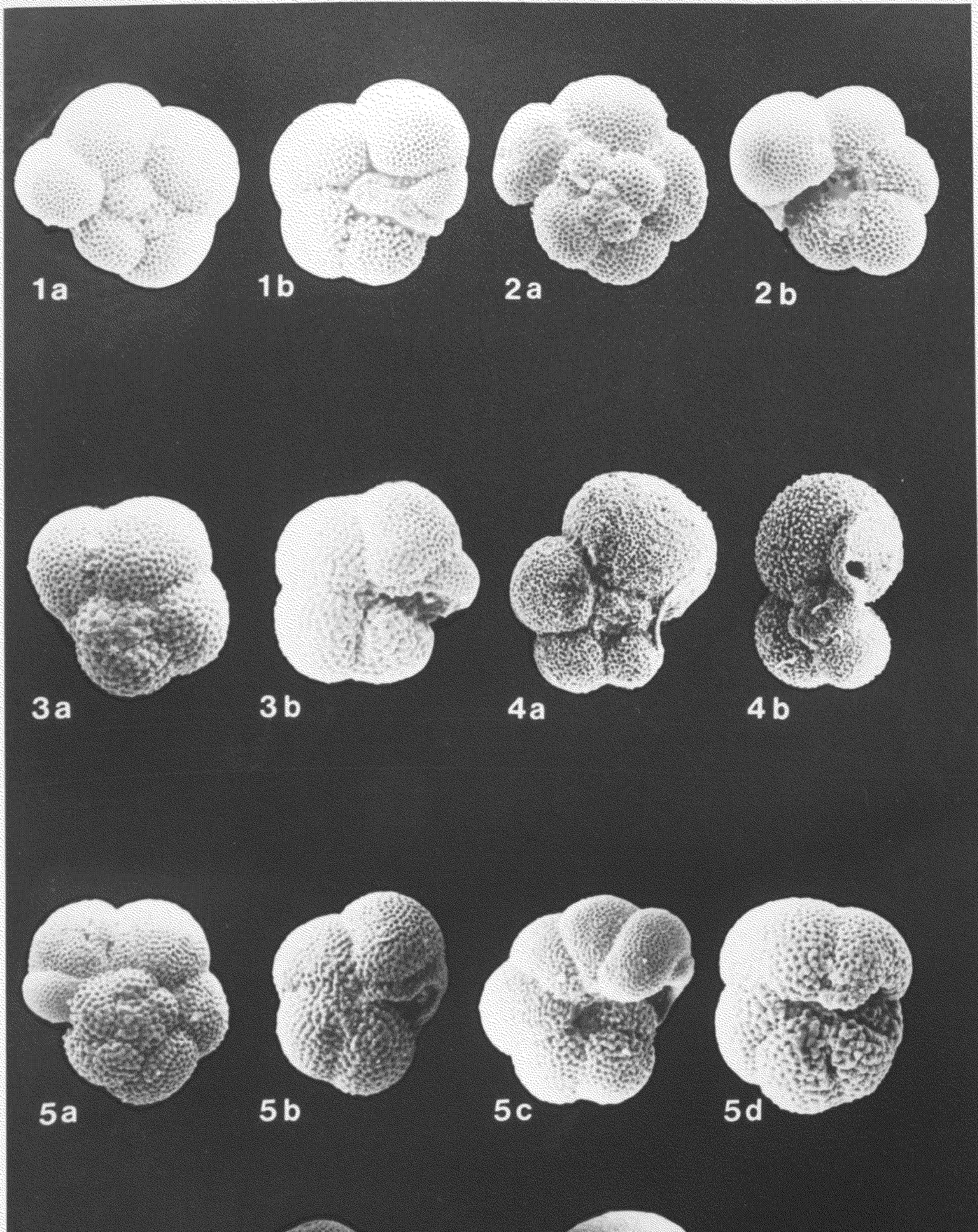

PLATE III

PLATE IV

Fig.1a Globoquadrina altispira altispira 50-4, umbilical view x63

Fig.1b " " " 50-4, side view x68

Fig.2a Globoquadrina altispira globosa 45-6, side view x65

Fig.2b " " " 45-6, umbilical view x89

Fig.2c " " " 45-6, umbilical view x65

Fig.3a Globoquadrina dehiscens s.s. 40-4, umbilical view x105

Fig.3b " " 40-4, side view x98

Fig.3c " " 40-4, spiral view x77

Fig.4a Globoquadrina langhiana Group 48-6, umbilical view x67

Fig.4b " " " 48-6, umbilical view x68

Fig.4c " " " 50-4, umbilical view x100

Fig.4d " " " 48-6, umbilical view x84

Fig.4e " " " 48-6, side view x80

Fig.4f " " " 49-2, side view x80

Fig.4g " " " 48-6, side view x80

Fig.4h " " " 49-2, spiral view x82

Fig.5a Globoquadrina larmeui 44-1, umbilical view x77

Fig.5b " " 44-4, spiral view x80

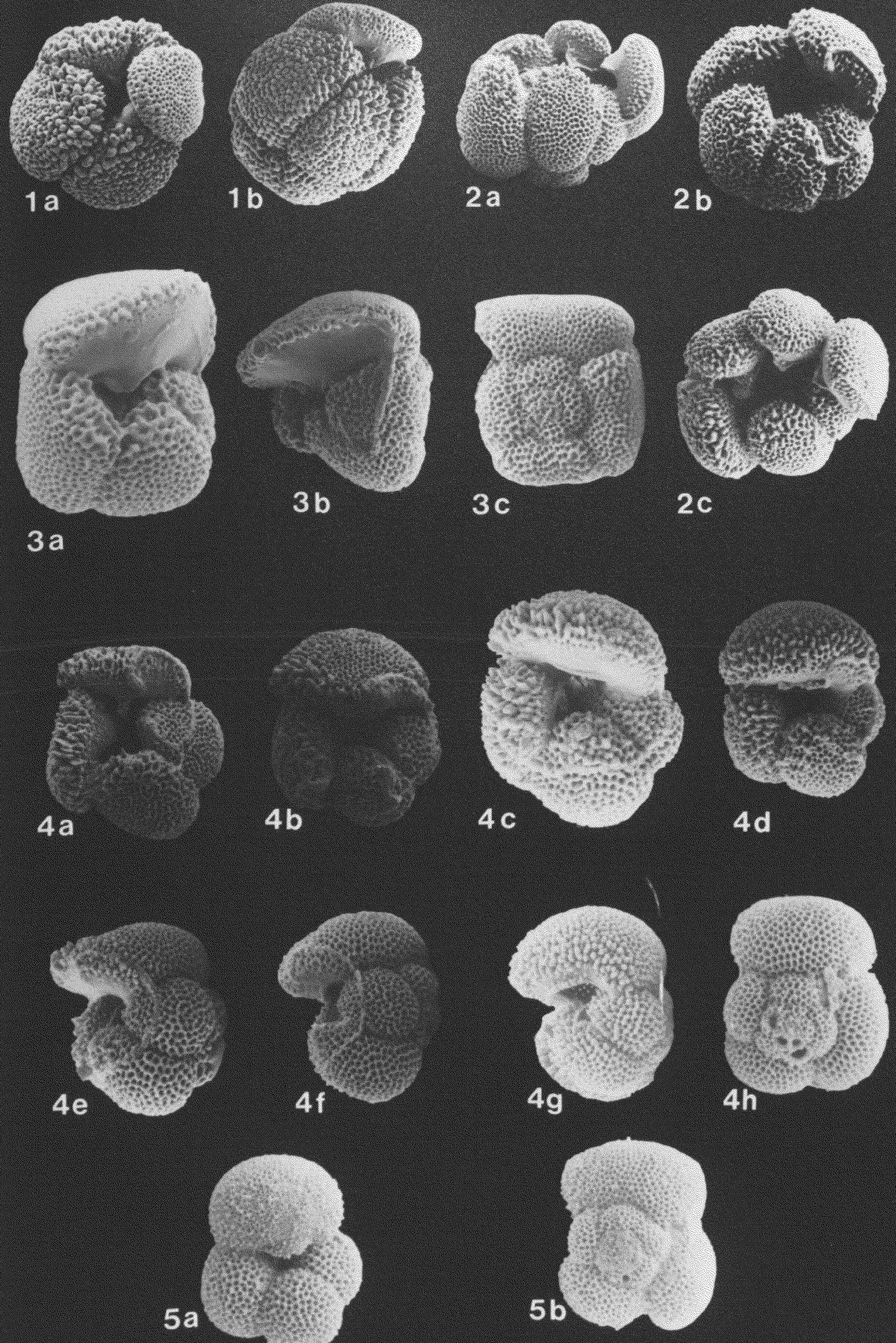

PLATE IV

PLATE V

Fig.a	Globoquadrina venezuelana	Group		50-6, umbilical view x57
Fig.b	"	"	"	37-3, umbilical view x46
Fig.c	"	"	"	50-6, spiral view x61
Fig.d	"	"	"	37-3, umbilical view x43
Fig.e	"	"	"	37-3, side view x49
Fig.f	"	"	"	49-6, umbilical view x60
Fig.g	"	"	"	50-2, umbilical view x72
Fig.h	"	"	"	42-6, umbilical view x65
Fig.i	"	"	"	42-6, umbilical view x63
Fig.j	"	"	"	40-6, umbilical view x63
Fig.k	"	"	"	49-4, umbilical view x57
Fig.l	"	"	"	49-4, side view x52

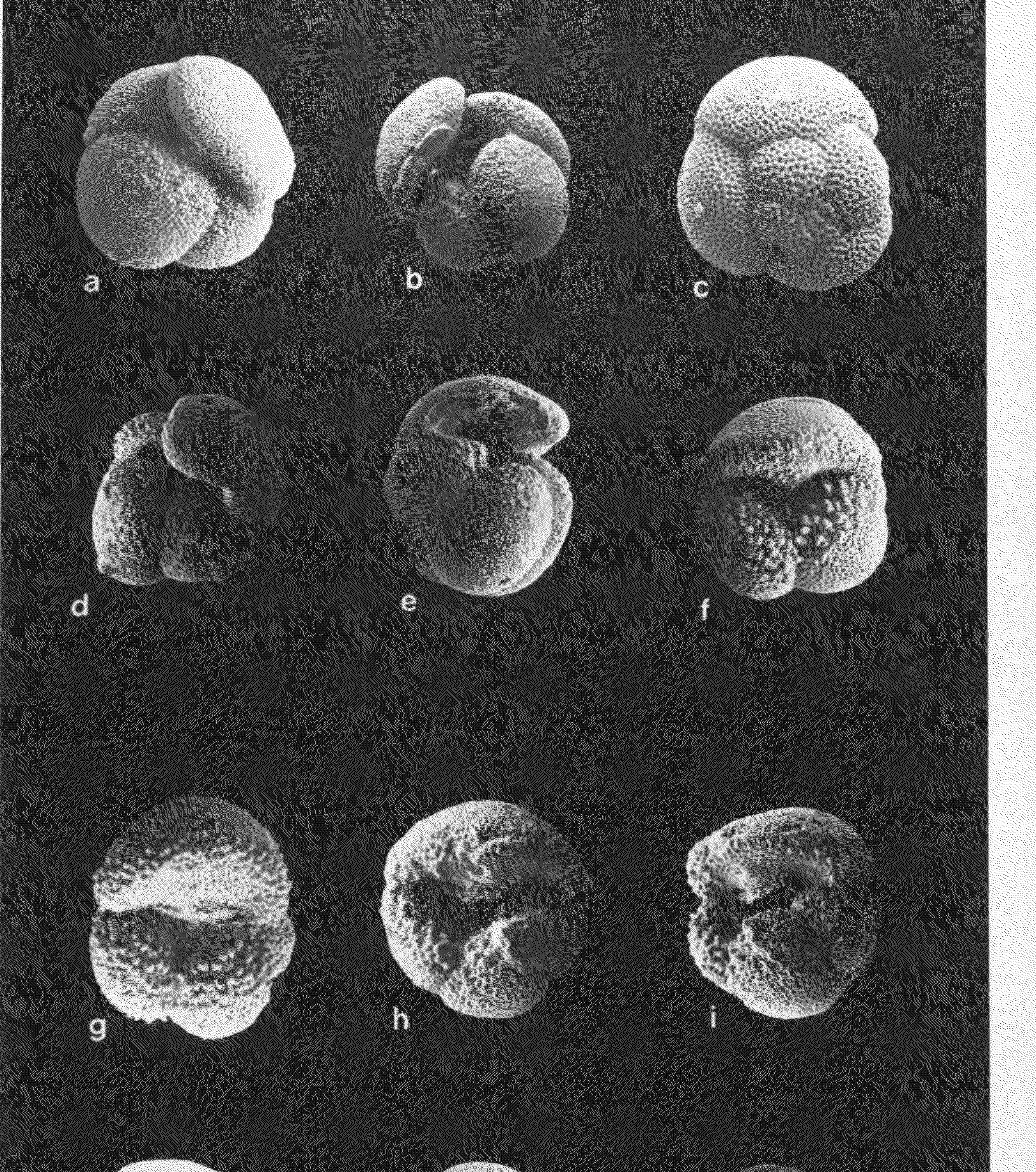

PLATE V

PLATE VI

Fig.1a Globigerinita sp. cf. G. glutinata flparkerae 27-3, umbilical view x93

Fig.1b " " " 27-3, umbilical view x104

Fig.1c " " " 27-3, spiral view x85

Fig.2a Globigerinita naparimaensis Group 43-1, umbilical view x88

Fig.2b " " " 43-1, umbilical view x90

Fig.2c " " " 43-1, umbilical view x90

Fig.3 Globigerina apertura 35-4, umbilical view x97

Fig.4 Globigerina bulbosa 43-3, umbilical view x85

Fig.5 Globigerina bulloides 27-3, umbilical view x84

Fig.6 Globigerina calida praecalida 37-6, umbilical view x98

Fig.7a Globigerina falconensis 49-2, umbilical view x86

Fig.7b " " 49-2, umbilical view x91

Fig.8a Globigerina foliata 45-4, umbilical view x83

Fig.8b " " 45-4, umbilical view x98

Fig.9 Globigerina nepenthes 36-3, umbilical view x82

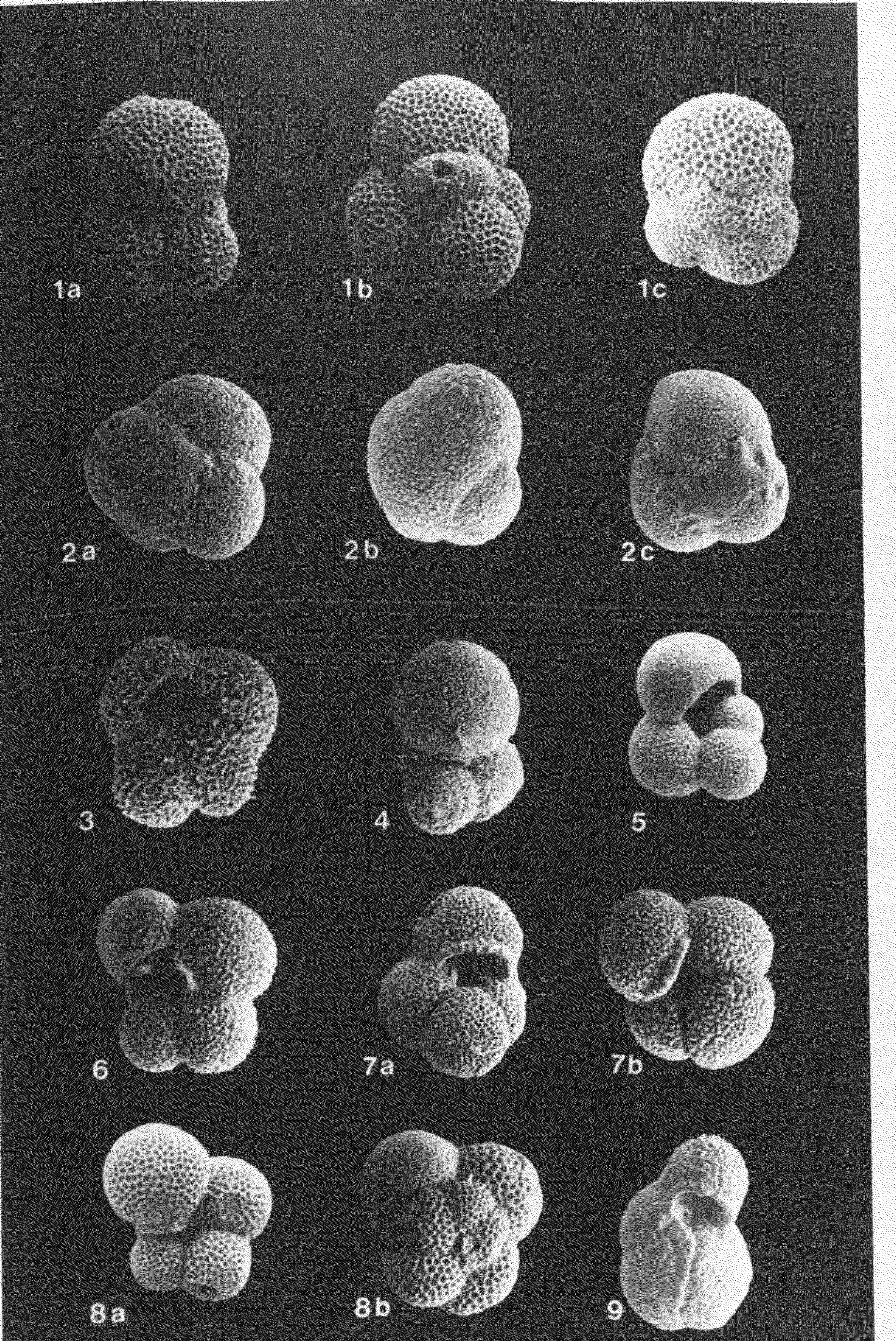

PLATE VI

PLATE VII

Fig.1a Globigerina decoraperta 28-6, spiral view x91

Fig.1b " " 28-6, umbilical view x90

Fig.2a Globigerinoides bollii 36-5, umbilical view x88

Fig.2b " " 36-5, side view x90

Fig.3a Globigerinoides obliquus obliquus 37-2, umbilical view x88

Fig.3b " " " 37-2, spiral view x81

Fig.4a Globigerinoides obliquus extremus 28-6, umbilical view x77

Fig.4b " " " 28-6, spiral view x87

Fig.5a Globigerinoides subquadratus 45-4, spiral view x83

Fig.5b " " 45-4, umbilical view x88

Fig.6 Globigerinoides ruber 31-6, spiral view x81

Fig.7 Globigerinoides mitra 45-6, umbilical view x75

Fig.8 Globigerinoides triloba 43-3, umbilical view x66

Fig.9 Globigerinoides sacculifer 45-1, umbilical view x81

Fig.10a Globigerinoides seigliei 31-5, spiral view x73

Fig.10b " " 31-5, umbilical view x100

Fig.10c " " 31-5, side view x59

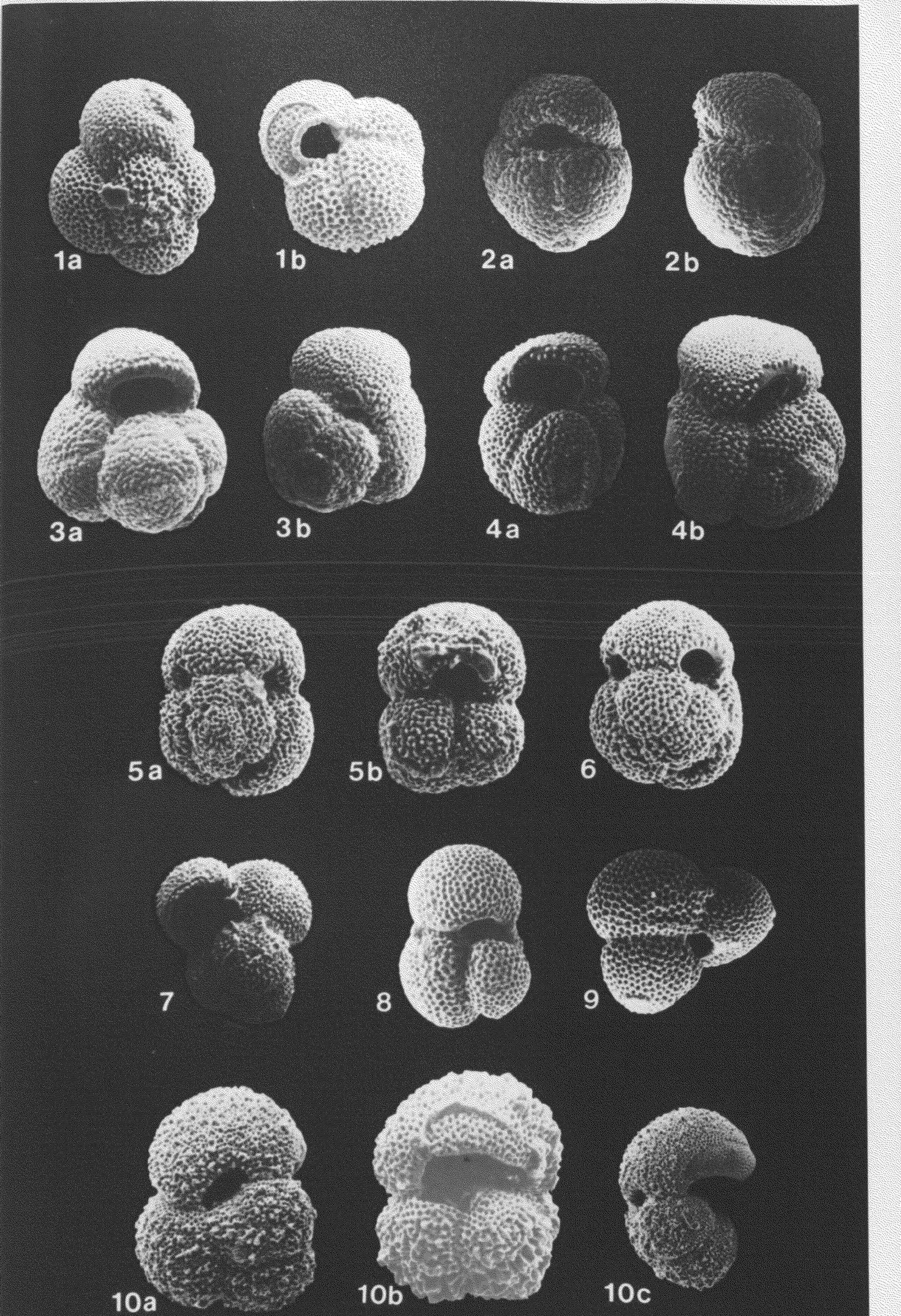

PLATE VII

PLATE VIII

Fig.1a Globorotaloides variablis 36-6, umbilical view x81

Fig.1b " " 36-6, spiral view x87

Fig.1c " " 36-6, side view x72

Fig.2 Praeorbulina glomerosa circularis 49-2, umbilical view x97

Fig.3a Orbulina bilobata 44-4, x76

Fig.3b " " 29-2, x55

Fig.4 Orbulina suturalis 32-4, x93

Fig.5 Orbulina universa 28-6, x58

Fig.6a Sphaeroidinellopsis seminulina seminulina 45-6, umbilical view x81

Fig.6b " " " 45-6, spiral view x95

Fig.6c " " " (naked) 45-6, spiral view x78

Fig.6d " " " (naked) 49-2, umbilical view x81

Fig.7 Sphaeroidinellopsis seminulina kochi 43-4, umbilical view x61

Fig.8 Sphaeroidinellopsis subdehiscens 38-6, umbilical view x81

Fig.9 Sphaeroidinellopsis paenedehiscens 24-2, umbilical view x71

Fig.10 Globigerinopsis aguasayensis Site 71, 15-4, side view x90

Fig.11 Candeina nitida praenitida 27-1, spiral view x95

Fig.12 Candeina nitida nitida 24-3, side view x98

Fig.13a Globigerinella aequilateralis 32-4, side view x57

Fig.13b " " 32-4, side view x85

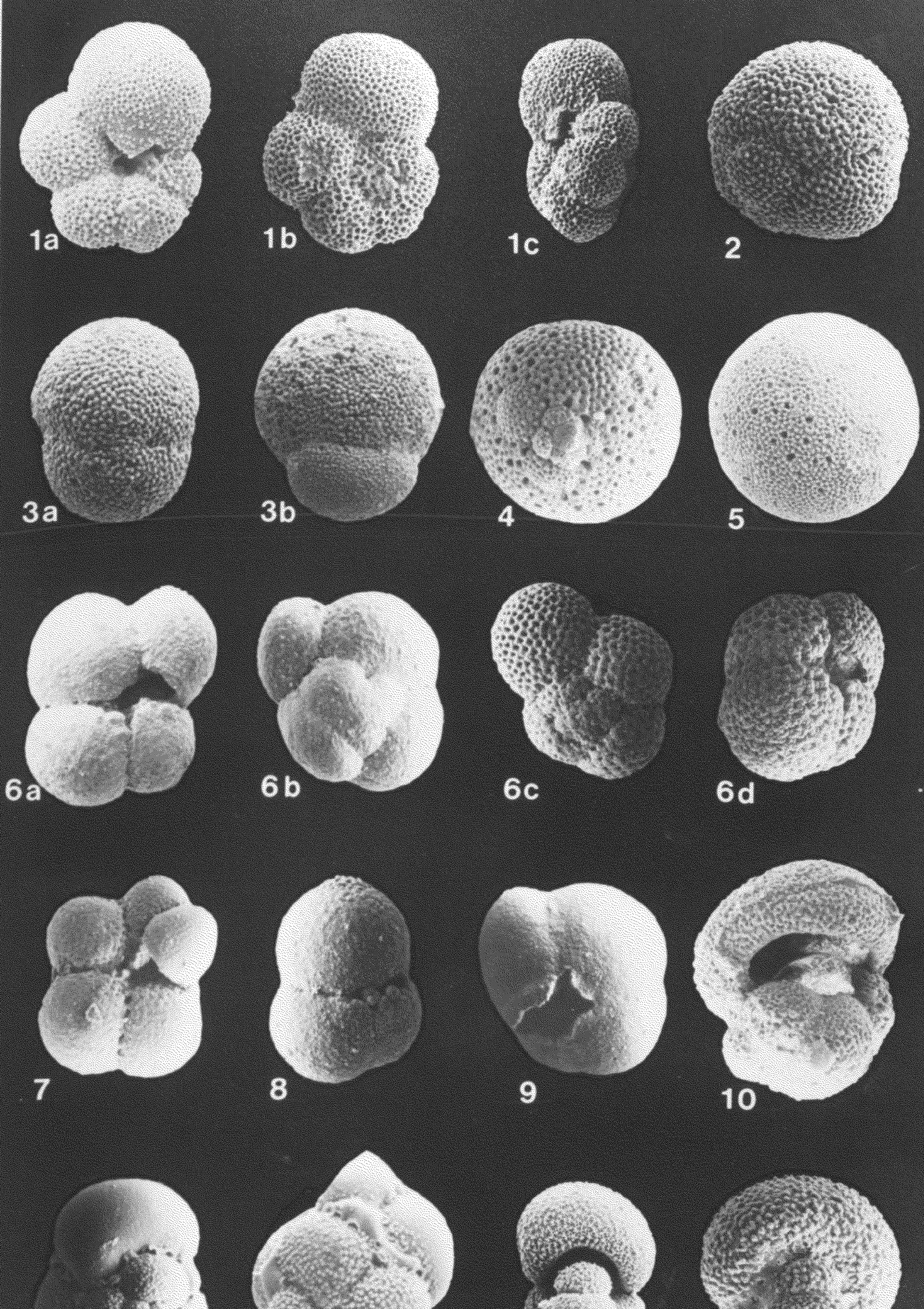

PLATE VIII

PLATE IX

Fig.1a <u>Acrosphaera spinosa</u> s.l. 49-3 R(a), R29/0 x132

Fig.1b " " 47cc R, X44/1 x133

Fig.1c " " 17-4 R(a), W58/0 x160

Fig.1d " " 47cc R,Z68/4 x133

Fig.1e " " 22cc R(a), V41/4 x138

Fig.1f " " 21-2 R(a),N60/2 x166

Fig.2 <u>Acrosphaera murrayana</u> 47cc R, X44/3 x125

Fig.3 <u>Collosphaera brattstroemi</u> 46cc R(a), M48/1 x146

Fig.4 <u>Collosphaera sp.1</u> 37cc R, M48/4 x126

Fig.5a <u>Collosphaera spp.</u> 41cc R, W58/0 x146

Fig.5b " " 42cc R(a), X52/2 x150

Fig.6 <u>Siphonosphaera sp.</u> 48-5 R, G42/2 x111

Fig.7a <u>Trisolenia spp.</u> 48cc R, F38/0 x192

Fig.7b " " 32-3 R(a), X52/0 x242

Fig.7c " " 27cc R(a), X45/0 x150

Fig.8a <u>Trisolenia omnitubus</u> 20cc R(a), T55/0 x158

Fig.8b " " 23cc R(a), L37/2 x133

Fig.9 <u>Actinomma medianum</u> 50cc R(a), S45/3 x150

Fig.10a <u>Actinomma sp. aff. A. tanycantha</u> 40cc R(a), Y42/0 x200

Fig.10b " " " 40cc R(a), Y42/0 x200

Fig.11 <u>Cladococcus spp.</u> 29cc R(a), P48/4 x135

Fig.12a <u>Haliomma horridum</u> 39-3 R, Y30/0 x180

Fig.12b " " 47cc R, Y41/2 x138

Fig.12c " " 32cc R(a), Q38/0 x154

Fig.13a <u>Stylacontarium sp.aff. S. bispiculum</u> 47-5 R, Y63/0 x127

PLATE IX (Continued)

Fig.13b Stylacontarium sp. aff. S. bispiculum 47cc R, F54/3 x136

Fig.13c " " " 42cc R(a), T41/1 x145

Fig.14a "Actinommid spp. group 1" 47cc R, x200

Fig.14b " " " 38cc R, Q65/1 x200

Fig.15a "Actinommid spp. group 2" 47-5 R, X28/1 x140

Fig.15b " " " 38-5 R, Q44/3 x126

Fig.16a "Actinommid spp. group 3" 48-5 R, J42/3 x119

Fig.16b " " " 45-3 R, Q58/3 x156

Fig.16c " " " 49-5 R(a), S45/0 x155

Fig.16d " " " 43cc R(a), D41/2 x125

Fig.17a "Actinommid spp. group 4" 38-3 R(a), 046/0 x115

Fig.17b " " " 45cc R(a), 047/1 x153

Fig.17c " " " 49-5 R(a), T28/2 x147

Fig.18a "Actinommid spp. group 5" 48-5 R, F59/0 x87

Fig.18b " " " 50cc R(a), Y49/4 x76

Fig.19a "Actinommid spp. group 6" 67cc R, X58/2 x138

Fig.19b " " " 35cc R', R51/4 x131

Fig.19c " " " 17cc R(a), G50/3 x146

Fig.19d " " " 50-3 C, M48/3 x129

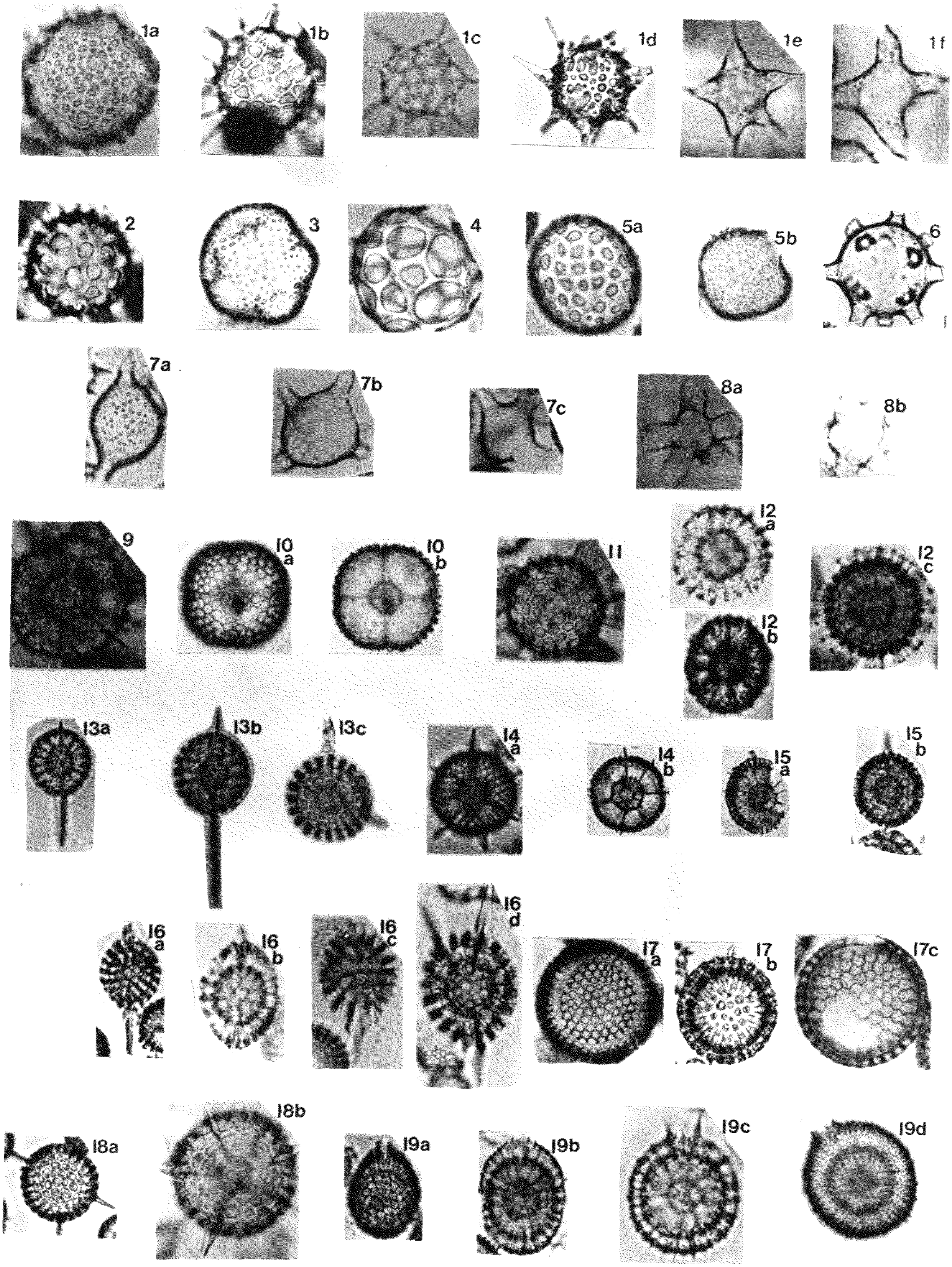
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PLATE IX

PLATE X

Fig.1 Saturnalis circularis 30cc R, P51/3 x128

Fig.2 Cannartus tubarius 49-5 R(a), U52/3 x220

Fig.3 Cannartus violina 50-3 R(a), H32/2 x216

Fig.4 Cannartus bassanii 47cc R, U66/0 x195

Fig.5a Cannartus laticonus 44-3 R, 044/1 x196

Fig.5b " " 50cc R(a), J55/0 x196

Fig.5c " " 47cc R, V36/0 x205

Fig.6a "Cannartus pseudoprismaticus" 39-3 R, X54/1 x200

Fig.6b " " 25-3 R(a), J27/4 x186

Fig.7 Cannartus? petterssoni 38-5 R, X58/3 x182

Fig.8 Cannartus? sp. aff. C.? petterssoni 32cc R(a), G49/3 x166

Fig.9a Ommatartus hughesi 32-3 R(a), U51/0 x142

Fig.9b " " 33-4 R, R42/4 x190

Fig.9c " " 35cc R', T59/3 x188

Fig.10 Ommatartus antepenultimus 42cc R(a), S57/4 x203

Fig.11aOmmatartus antepenultimus Form A 32cc R(a), D45/0 x190

Fig.11b " " Form A 30-2 R,W39/0 x147

Fig.12 Ommatartus penultimus 30-2 R, R60/0 x144

Fig.13 "Columnless artiscans" 47cc R, V63/1 x230

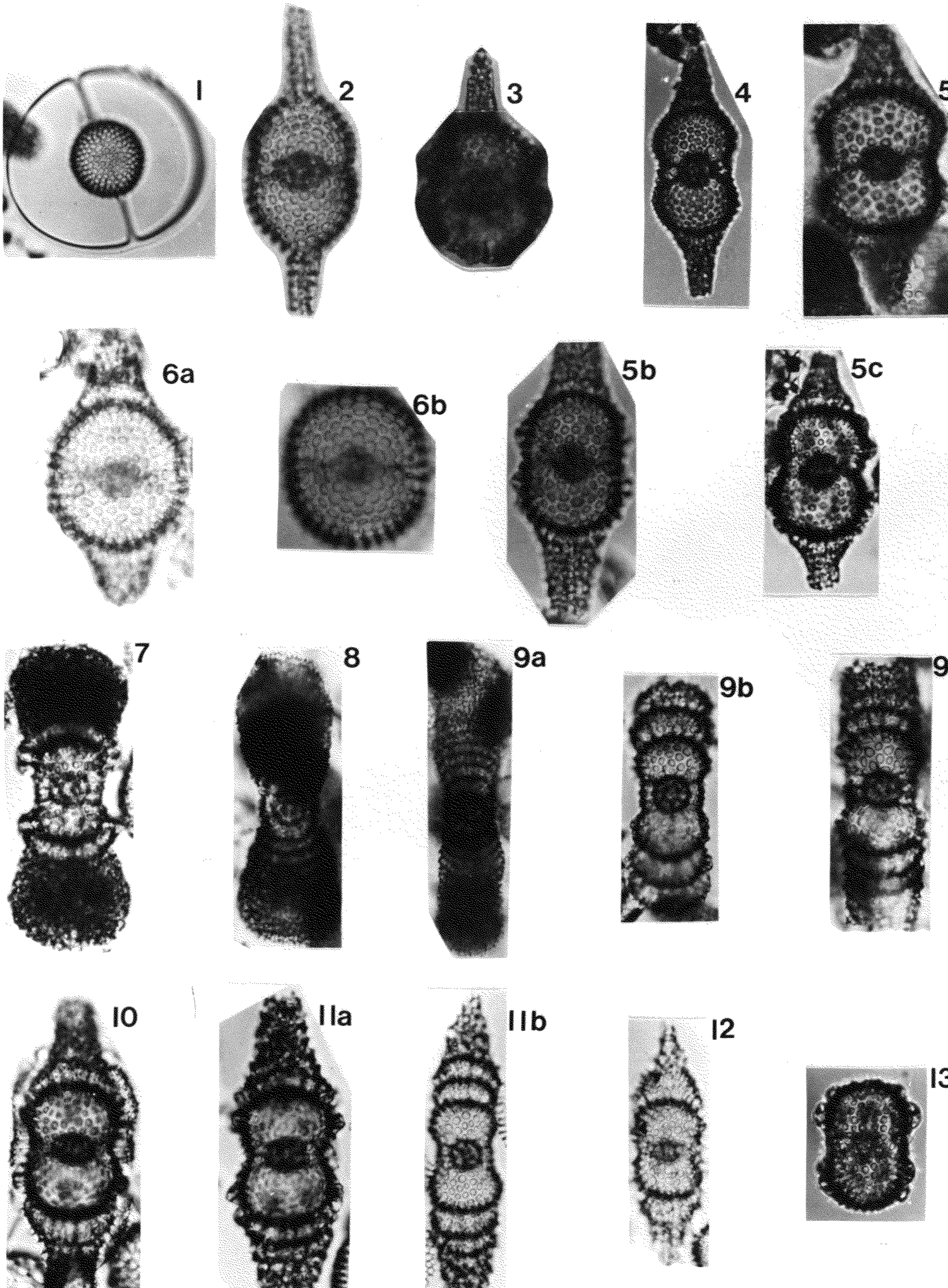


PLATE X

PLATE XI

Fig.1a Heliodiscus circumcincta 47cc R, x160

Fig. b " " holotype, 50cc R, U42/2 x164

Fig.1c " " 39cc R(a), R35/3 x129

Fig.1d " " 48-3 R, L27/4 x72

Fig.1e " " 38-5 C, P37/0 x70

Fig.1f " " 39cc R(a), R36/4 x80

Fig.1g " " 39cc R(a), R35/4 x82

Fig.2a "Phacodiscid sp." 47cc R, P46/0 x125

Fig.2b " " 32cc R(a), E43/3 x125

Fig.3 Circodiscus micróporus 44-3 R, D40/0 x157

Fig.4 Heliodiscus echiniscus 28cc R(a), S51/4 x153

Fig.5a Heliodiscus asteriscus 40cc R(a), U34/0 x138

Fig.5b " " 34cc R, T34/0 x94

Fig.6a Amphymenium sp. cf. A. splendiarmatum 45-3 R, T53/2 x105

Fig.6b " " " 45cc R(a), 043/0 x154

Fig.7 Spirema sp. 48-3 R, Z32/4 x144

Fig.8a Stylochlamydium asteriscus 21cc R(a), Z62/1 x117

Fig.8b " " 19cc R(a), F52/2 x181

Fig.9a Stylodictya spp. 39cc R(a), D38/2 x128

Fig.9b " " 42-4 R, K52/2 x144

Fig.9c " " 45cc R(a), H44/2 x156

Fig.10 Stylotrochus? sp. 21-2 R(a), P47/0 x133

Fig.11 Xiphospira sp. cf. X. circularis 40cc R(a),R33/4 x100

Fig.12a "Porodiscid spp. group" 47cc R, M46/3 x120

Fig.12b " " " 29cc R(a), E34/0 x113

Fig.12c " " " 47cc R, T61/0 x163

PLATE XI (Continued)

Fig.12d "Porodiscid spp. group" 35cc R, W40/0 x135

Fig.13a Rhopalastrum angulatum Group (left); R. profunda Group (right) 27cc R(a), X47/4 x58

Fig.13b Rhopalastrum angulatum Group 44-3 R(a), V50/3 x75

Fig.14 Rhopalastrum mülleri 27cc R(a), T50/1 x97

Fig.15a Rhopalastrum profunda group 47-5 R, Q50/3 x71

Fig.15b " " " 29cc R(a), Y47/0 x76

Fig.16 Spongaster birminghami 32-3 R(a), F27/2 x85

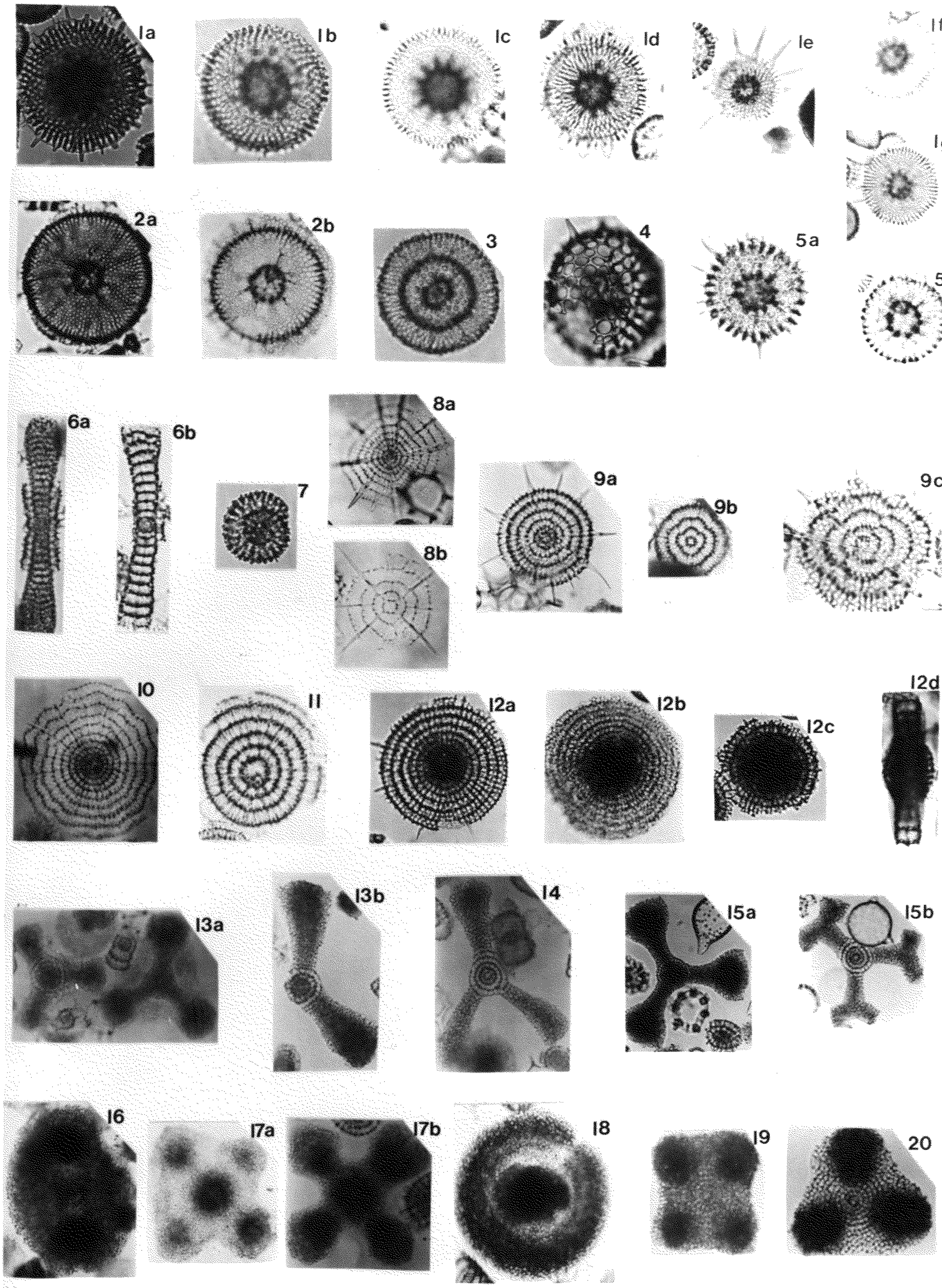
Fig.17a Spongaster sp. aff. S. tetras 28-4 R, Y27/4 x93

Fig.17b " " " 28-4 R, T31/0 x100

Fig.18 Spongaster sp. 1 Site 71, 15-2 R(a), X32/4 x100

Fig.19 Spongaster sp. 2 49-3 R(a), M28/4 x156

Fig.20 Spongaster sp. 3 50-3 C, K52/2 x136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17b
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PLATE XI

PLATE XII

Fig.1 Spongocore puella 47-3 R, Q57/4 x134

Fig.2a Spongodiscus corpusculus holotype, 32cc R, G45/3 x110

Fig.2b Spongodiscus corpusculus holotype, 32cc R, G45/3 x162

Fig.3 Spongodiscus sp. 39-3 C, F48/2 x78

Fig.4a "Spongodiscid spp. group" Site 71, 13-6 R(a),U53/4 x105

Fig.4b " " " 47cc R, F58/0 x114

Fig.5 Cubolithus regularis 47cc R, F55/4 x175

Fig.6a "Litheliid spp." 27cc R(a), Y63/3 x115

Fig.6b " " 16-4 R(a), V42/0 x138

Fig.6c " " 47cc R, F58/3 x187

Fig.6d " " 25cc R(a), F64/1 x200

Fig.6e " " 39-3 R, N61/3 x133

Fig.6f " " 17cc R(a), X38/3 x142

Fig.6g " " 47cc R, E57/0 x180

Fig.6h " " 18cc R(a), K33/3 x133

Fig.6i " " 38-3 R(a), U31/2 x126

Fig.6j " " 42-4 R, D33/0 x135

Fig.7a Callimitra spp. 46cc R(a), S61/0 x120

Fig.7b " " 27cc R(a), D37/1 x121

Fig.8 Clathrocanium reginae 46cc R(a), K43/2 x120

Fig.9a Clathrocanium sphaerocephalum 40-3 R, H59/0 x150

Fig.9b " " 44-3 R, R30/3 x129

Fig.9c " " 47cc R,Z67/3 x123

Fig.9d " " 49-3 R(a), V63/1 x158

Fig.10a Clathrocorona altreta 25cc R(a), M56/4 x170

PLATE XII (Continued)

Fig.10b Clathrocorona atreta 44cc R(a), V34/1 x160

Fig.10c " " 41-1 R, J36/0 x160

Fig.10d " " 44cc R(a), Q41/0 x190

Fig.10e " " 50cc R(a), 053/2 x161

Fig.11 Tepka perforata 41cc R, N34/4 x266

Fig.12 Verticillata hexacantha 30cc R, U54/4 x126

Fig.13a "Plagoniid spp. group" 46cc R(a), S60/3 x171

Fig.13b " " " 39cc R(a), Y56/4 x228

Fig.13c " " " 47cc R, H57/2 x187

Fig.14a "Cyrtid spp. group 1" 25cc R(a), W51/4 x150

Fig.14b " " " 25cc R(a), S43/0 x100

Fig.14c " " " 42cc R(a), Y60/0 x144

Fig.14d " " " 44cc R(a), Y53/0 x113

Fig.15a "Cyrtid spp. group 2" 45cc R(a), D47/3 x130

Fig.15b " " " 42cc R(a), Y61/0 x144

Fig.15c " " " 44cc R(a), V49/2 x127

Fig.15d " " " 49cc R, P44/4 x121

Fig.15e " " " 25cc R(a), W57/4 x260

Fig.16 Lithocyclia? sp. cf. L. ocellus 50-3 C, N54/2 x80

Fig.17 gen. et. sp. indet. 47cc R, W62/4 x150

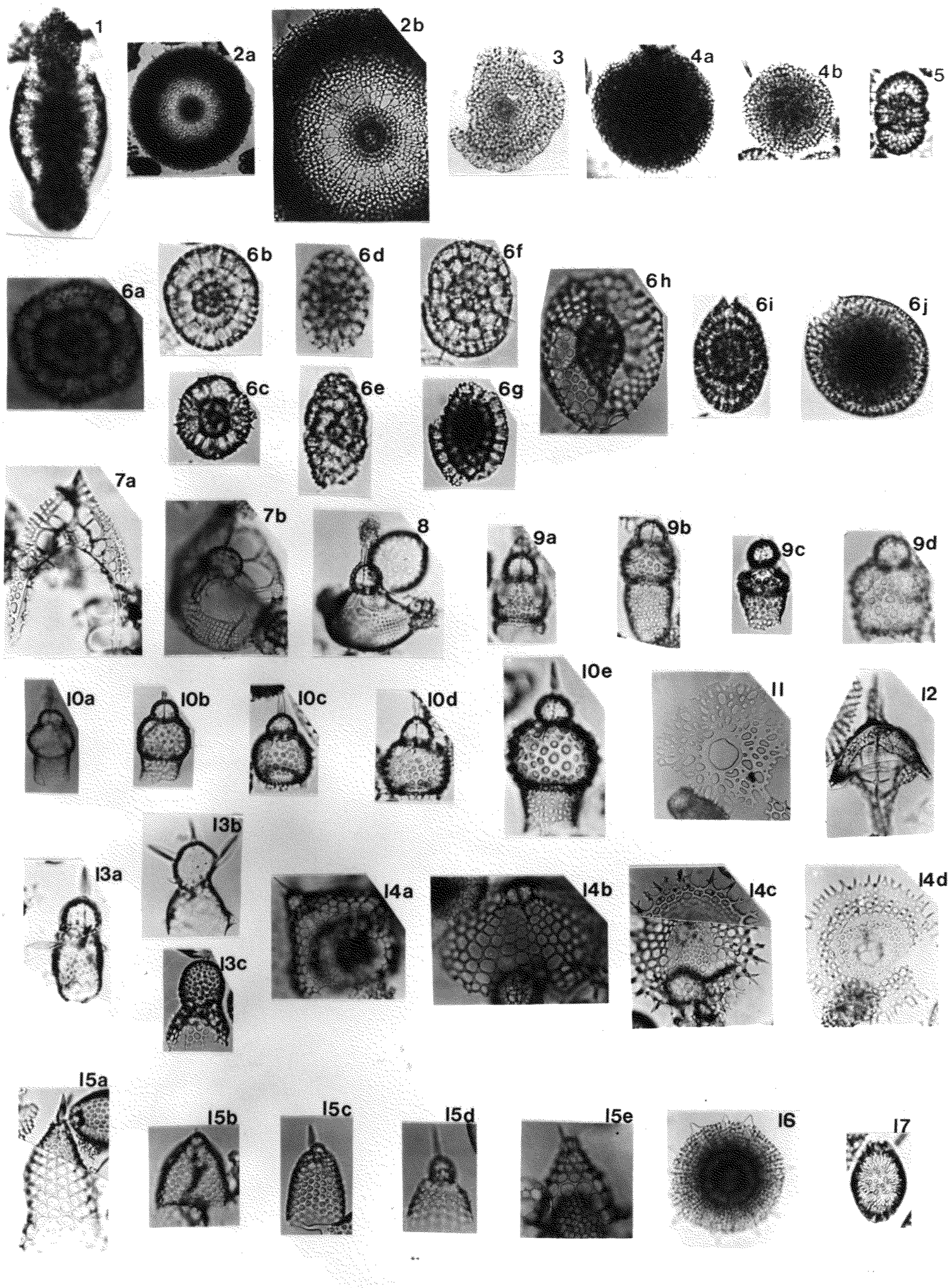
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PLATE XII

PLATE XIII

Fig.1 Artophormis sp. cf. A. gracilis Site 71, 13-4 R(a), W34/4 x153

Fig.2 Artopilium undulatum 36cc R(a), N54/0 x215

Fig.3a Bathropyramis woodringi 44cc R(a), L39/3 x133

Fig.3b " " 44-3 R, M53/1 x200

Fig.4a Beckomiforma mynx Site 71, 13-6C, J57/2 x166

Fig.4b " " 44cc R(a), Q30/4 x146

Fig.5a Beckomiforma hyalina holotype, 40cc R(a), X57/2 x156

Fig.5b " " " 40cc R(a), X57/2 x210

Fig.5c " " " 40cc R(a), X57/2 x239

Fig.5d " " 41-1 R, R32/1 x213

Fig.5e " " 47cc R, F57/2 x200

Fig.6 Calocyclas momumentum Site 71, 14-6 C, Q37/1 x151

Fig.7 Cornutella profunda 47cc R, W63/0 x205

Fig.8a Corocalyptra cervus 44cc R(a), T39/0 x269

Fig.8b " " 42cc R(a), E38/2 x220

Fig.8c " " 42cc R(a), S54/3 x200

Fig.9a Corocalyptra killmari 31-4 R(a), U28/1 x285

Fig.9b " " 42cc R(a), P41/1 x200

Fig.10a Dictyophimus crisiae 34-4 R(a), L28/4 x233

Fig.10b " " 47-5 R, N42/4 x208

Fig.10c " " 19cc R(a), R57/4 x129

Fig.11 Cyclampterium (?) brachythorax 35-3 R, J28/2 x150

Fig.12 Cyclampterium (?) leptetrum 47-3 R, G28/0 x194

Fig.13 Cyclampterium (?) tanythorax 47cc R, S35/0 x122

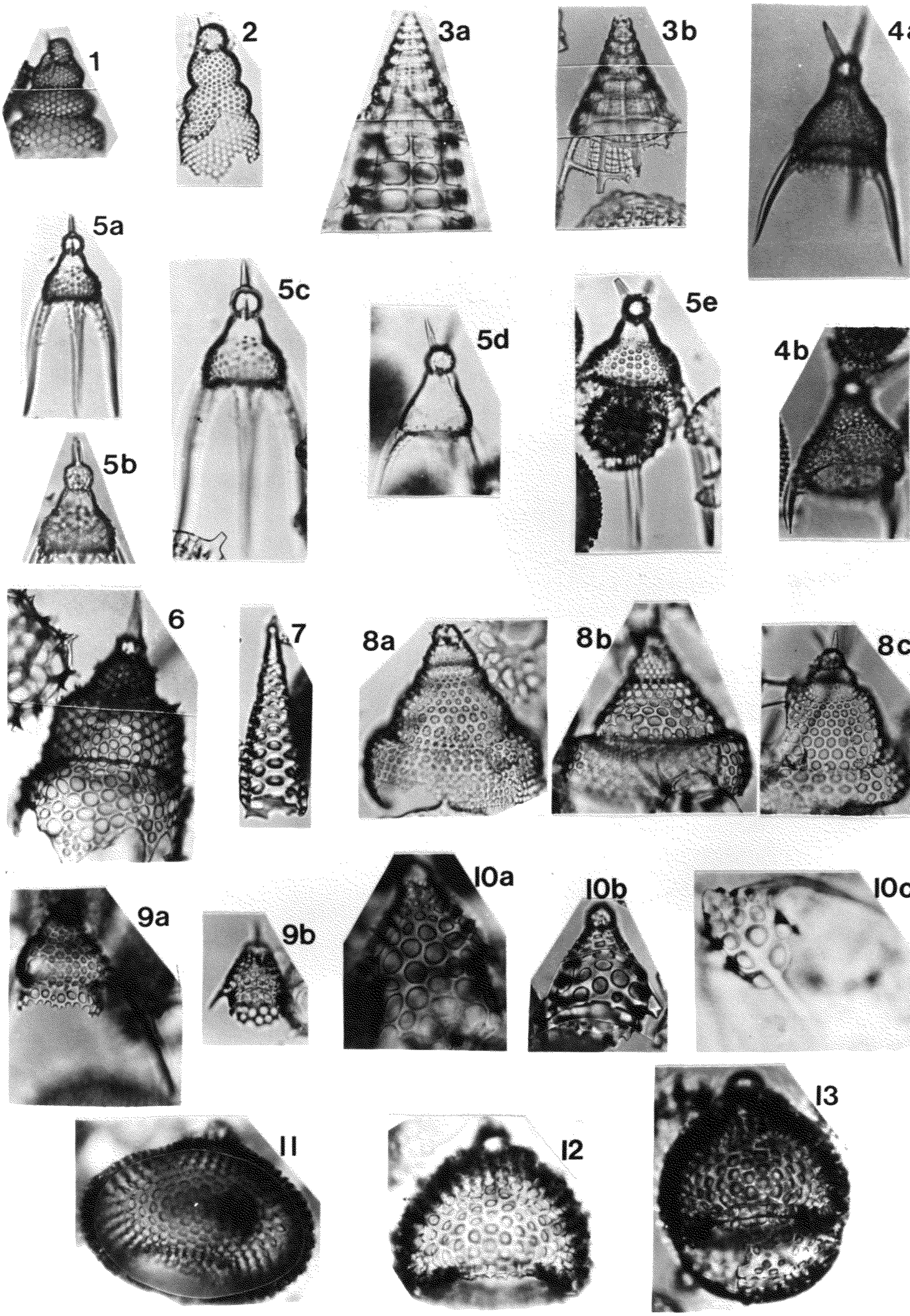

PLATE XIII

PLATE XIV

Fig.1 Cyrtocapsella cornuta Site 71, 14-6 R(c), V59/0 x181

Fig.2 Cyrtocapsella japonica 48-5 R, E38/3 x200

Fig.3a Cyrtocapsella tetrapera 47cc R, T64/0 x200

Fig.3b " " 47cc R, N37/2 x200

Fig.3c Cyrtocapsella sp. aff. C. tetrapera 47cc R, W62/1 x200

Fig.4a Eucyrtidium acuminatum s.l. 44cc R(a), N51/0 x291

Fig.4b " " 34cc R, V55/1 x207

Fig.5a Eucyrtidium anomalum 23cc R(a), X33/2 x253

Fig.5b " " 17-4 R(a), W30/1 x233

Fig.5c " " 38-5 R,W51/0 x223

Fig.6 Eucyrtidium calvertense 32cc R(a), J35/4 x211

Fig.7a Eucyrtidium cienkowskii Group 45cc R(a),Q35/0 x130

Fig.7b " " 43cc R(a), J40/2 x194

Fig.8a Eucyrtidium punctatum Group 47cc R, F51/3 x205

Fig.8b " " " 48-5 R, 042/2 x200

Fig.9a Eucyrtidium sp.2 42cc R(a), M30/4 x250

Fig.9b " " 28cc R(a), L61/4 x250

Fig.9c " " 44cc R(a), H54/0 x235

Fig.10 Eucyrtidium sp.3 38cc R, E59/0 x214

Fig.11 Lithopera bacca 33-4 R, 031/3 x175

Fig.12 Lithopera neotera 47-5 R, S60/2 x216

Fig.13 Lithopera renzae 45-3 R, K41/4 x214

Fig.14 Lithopera baueri 47cc R, L44/0 x200

Fig.15 Lithopera sp. cf. L. thornburgi 50cc R(a), X51/1 x235

Fig.16 Lithopera thornburgi 44cc R(a), K33/2 x227

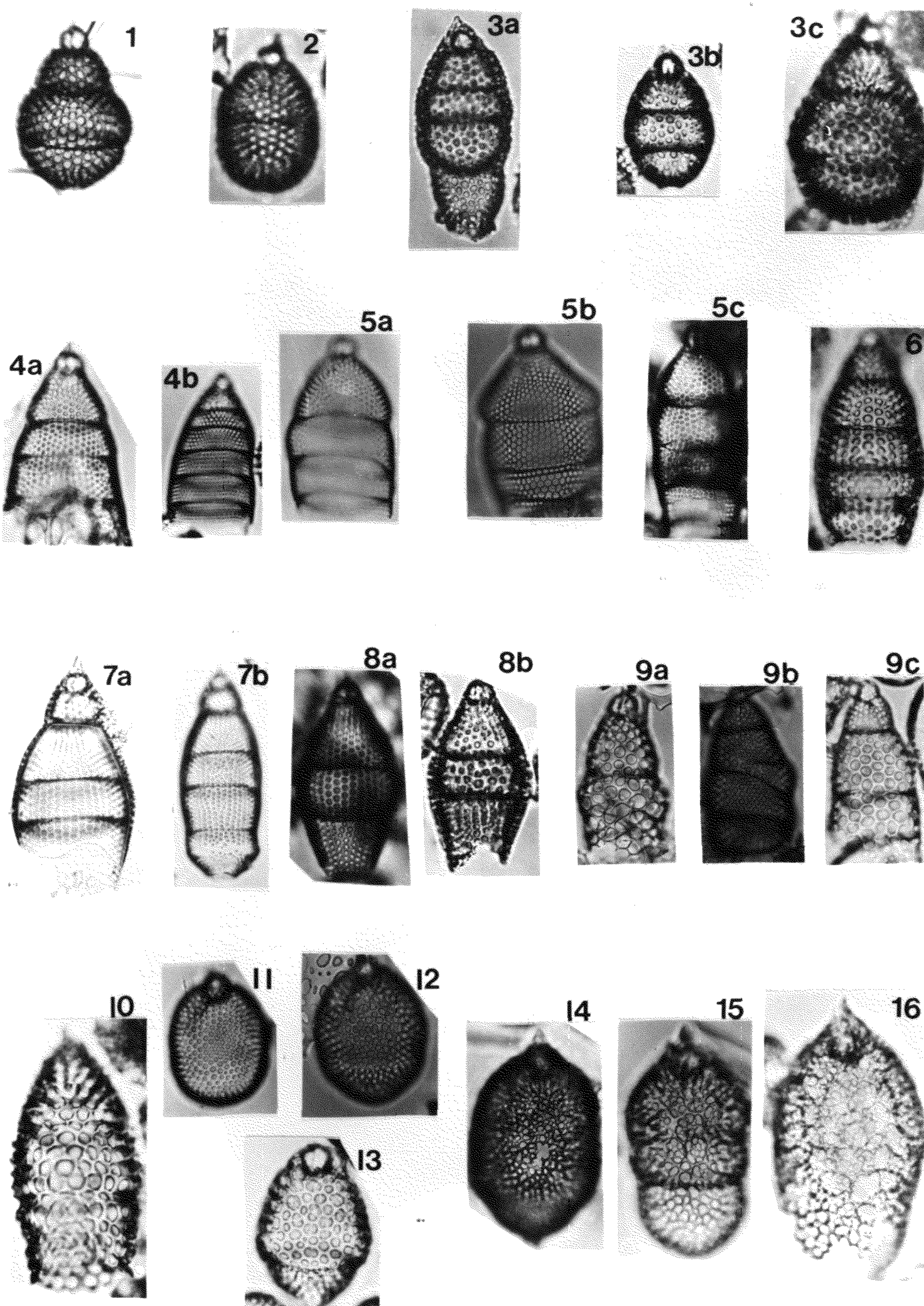

PLATE XIV

PLATE XV

Fig.1a Lychnocanoma grande s.s. 47cc R, P38/0 x140

Fig.1b " " " 18-3 R(a), H59/3 x181

Fig.2 Lychnocanoma grande rugosum 45cc R(a) S41/2 x133

Fig.3a Pterocanium trilobum 49cc R, Q34/4 x204

Fig.3b " " 34cc R, V61/3 x204

Fig.4a Stichocorys delmontensis 48-3 R, X54/0 x204

big.4b " " 38-3 R(a), R57/4 x194

Fig.5a Stichocorys delmontensis Form A 44cc R(a), x264

Fig.5b " " 47-5 R, W56/4 x214

Fig.5c " " 45cc R(a), K49/1 x200

Fig.6a Stichocorys wolffii Site 71, 13-2 R(b), R41/4 x142

Fig.6b " " Site 71,13-2 R(b),H52/3 x168

Fig.6c " " 48cc R, G36/4 x220

Fig.7. Stichocorys wolffii Form A 45cc R(a), G60/2 x214

Fig.8 Stichocorys armata 50cc R(a), H65/0 x192

Fig.9 Stichocorys armata Form A 48-3 R, R63/4 x207

Fig.10 Lipmanella dictyoceras Site 71, 14-6 R(c), Q27/2 x166

Fig.11 Lithostrobus sp. cf. L. hexagonalis Site 71, 15-2 R(a), M36/1 x200

Fig.12 Stichopera pectinata Site 71, 15-4 R(b), E37/0 x160

Fig.13 Stichopilium sp. cf. S. bicorne 46cc R(a), R59/4 x250

Fig.14 Lipmanella sp. cf. Dictyoceras xiphephorum Site 71, 15-2 R(a), M36/1 x163

Fig.15 "Theoperid sp.2" Site 71, 14-2 R(c), T38/1 x138

Fig.16 Stichopilium sp. cf. S. rhinoceros Site 71, 14-6 C, L48/2 x160

Fig.17a Stichopilium rhinoceros Site 71, 15-6 Ph, P31/0 x157

Fig.17b " " 30cc R, H30/0 x207

Fig.18 "Theoperid sp. 1" 32-3 R(a), T27/2 x166

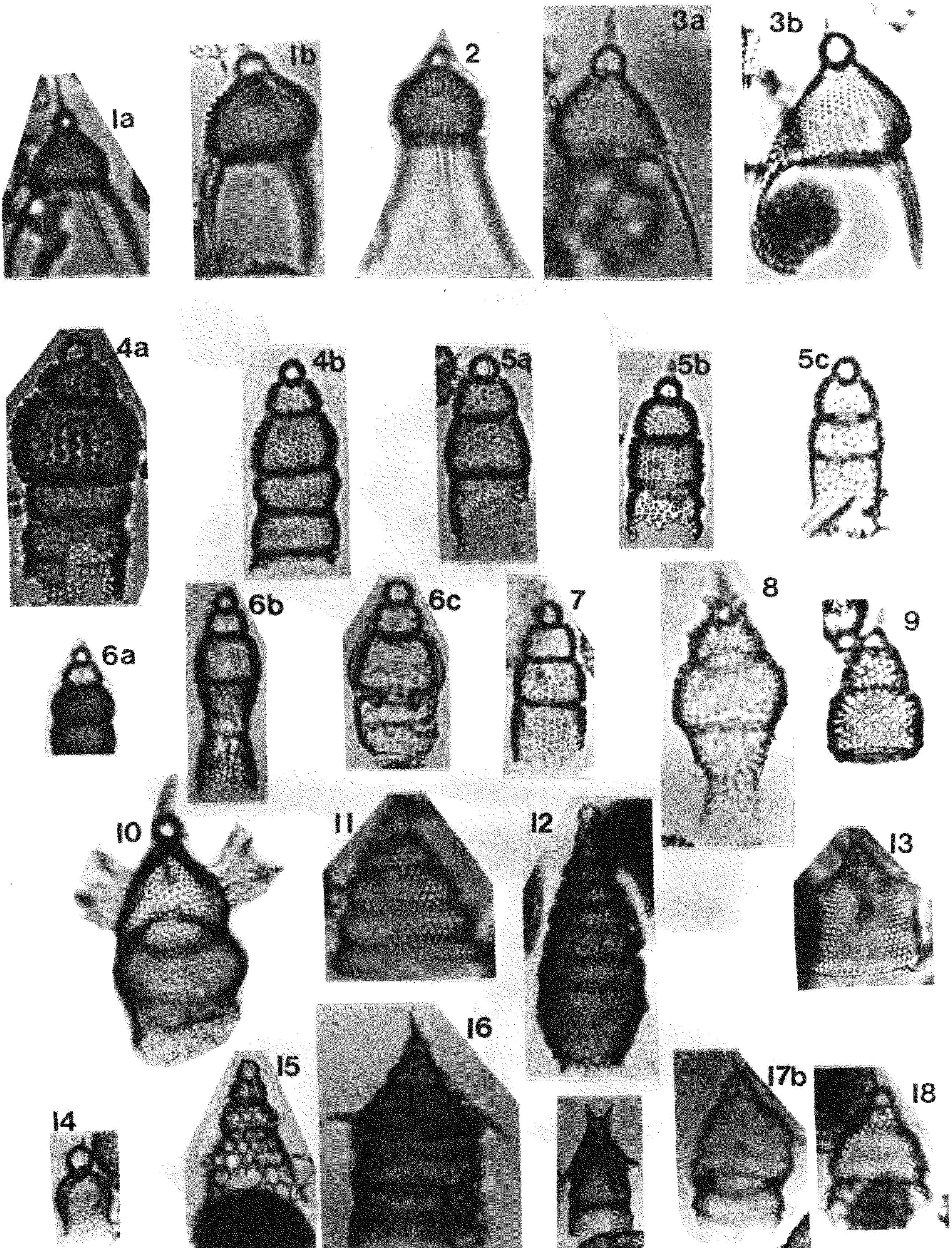
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PLATE XV

PLATE XVI

Fig.1a Theocorys? subcylindrica 45cc R(a), D56/0 x235

Fig.1b " " 39cc R(a), S44/0 x194

Fig.1c " " holotype, 39cc R(a), N42/0 x250

Fig.1d " " 48cc R, O41/3 x225

Fig.1e " " 49cc R, U45/0 x200

Fig.2a Carpocanistrum spp. 46cc R(a), W34/0 x285

Fig.2b " " 47cc R, F55/3 x209

Fig.2c " " 43cc R(a),S59/0 x200

Fig.3 Carpocanistrum sp.1 45cc R(a), N43/0 x225

Fig.4a Carpocanopsis bramlettei 48-3 R, W41/2, x192

Fig.4b " " 44-3 R, P40/2 x200

Fig.4c " " Site 71, 15-4 R(b), M39/1 x169

Fig.5. Carpocanopsis cingulatum 49-5 R(a), P48/2 x166

Fig.6a Carpocanopsis sp. cf. C. cingulatum 38cc R, N57/0 x205

Fig.6b " " " " 40-5 R(a), G58/1 x125

Fig.7 Carpocanopsis cristatum 47cc R, T62/3 x230

Fig.8 Carpocanopsis sp. cf. C. favosum 42cc R(a), M32/0 x180

Fig.9 Androcyclas sp. cf. A. gamphonycha 17cc R(a), J44/2 x200

Fig.10a Anthocyrtidium ehrenbergi 46cc R(a), J45/4 x231

Fig.10b " " 42cc R(a), T45/0 x190

Fig.10c " " 31-4 R(a), D52/3 x210

Fig.11a Lamprocyrtis ? hannai 42-4 R, U57/0 x221

Fig.11b " " " 35-3 R, N58/0 x220

Fig.11c " " 42cc R(a), S62/1 x204

Fig.12a Lamprocyclas maritalis (primitive) 47cc R, W64/0 x195

Fig.12b " " 40-3 R, P50/4 x153

Fig.12c " " (advanced) 47-3 R, K31/0 x200

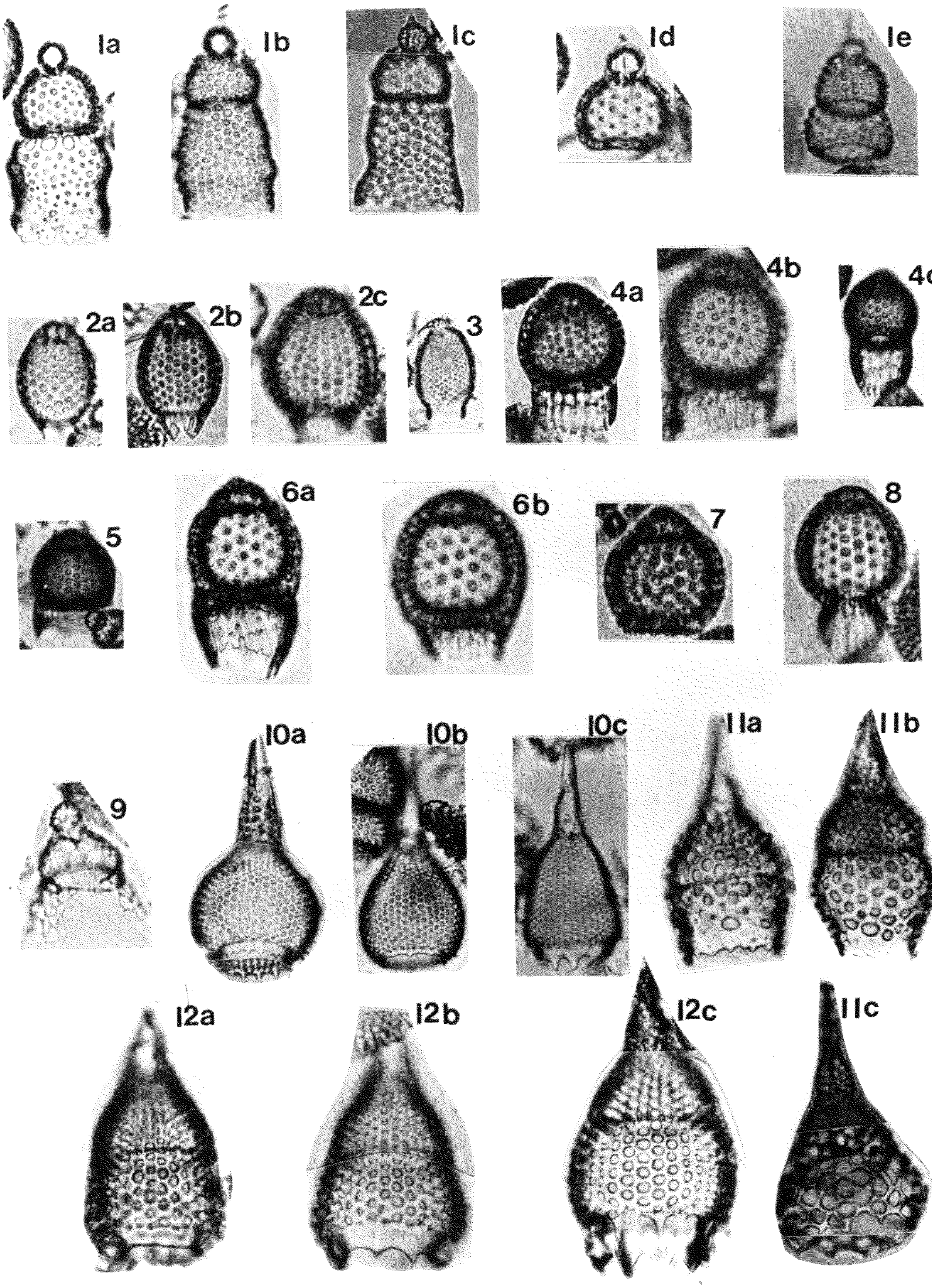
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PLATE XVI

PLATE XVII

Fig.1a	<u>Calocycletta caepa</u>	45cc R(a), X46/1 x128
Fig.1b	" "	Site 71, 13-6 C, D27/2 x142
Fig.1c	" "	47cc R, U40/2 x200
Fig.1d	" "	32-3 R(a), N57/1 x144
Fig.1e	" "	42cc R(a), X42/4 x196
Fig.2	<u>Calocycletta costata</u>	49-5 R(a), M47/4 x135
Fig.3a	<u>Calocycletta virginis</u>	48-3 R, X48/2 x195
Fig.3b	" "	48-3 R, V51/4 x168
Fig.4	<u>Pterocorys campanula</u>	39cc R(a), T45/3 x217
Fig.5a	<u>Sethocorys achillis?</u>	48cc R, Y39/0 x312
Fig.5b	" "	x175
Fig.5c	" "	37-4 R, G55/0 x194
Fig.6a	<u>Theoconus zancleus?</u>	42cc R(a), 049/1 x175
Fig.6b	" "	47cc R, V31/4 x210
Fig.7	<u>Theocorythium sp. cf. T. trachelium</u>	30cc R, W43/2 x223
Fig.8a	<u>Theoconus jovis</u>	44cc R(a), 050/0 x225
Fig.8b	" "	32cc R(a), L35/2 x152
Fig.9	<u>Botryocyrtis spp.</u>	47cc R, G57/1 x240
Fig.10	<u>Botryopyle dictyocephalus</u>	46cc R(a), R47/4 x200
Fig.11	<u>Centrobotrys thermophila</u>	46cc R(a), V35/3 x214
Fig.12	<u>Acrobotrys spp.</u>	46cc R(a), Y43/3 x215

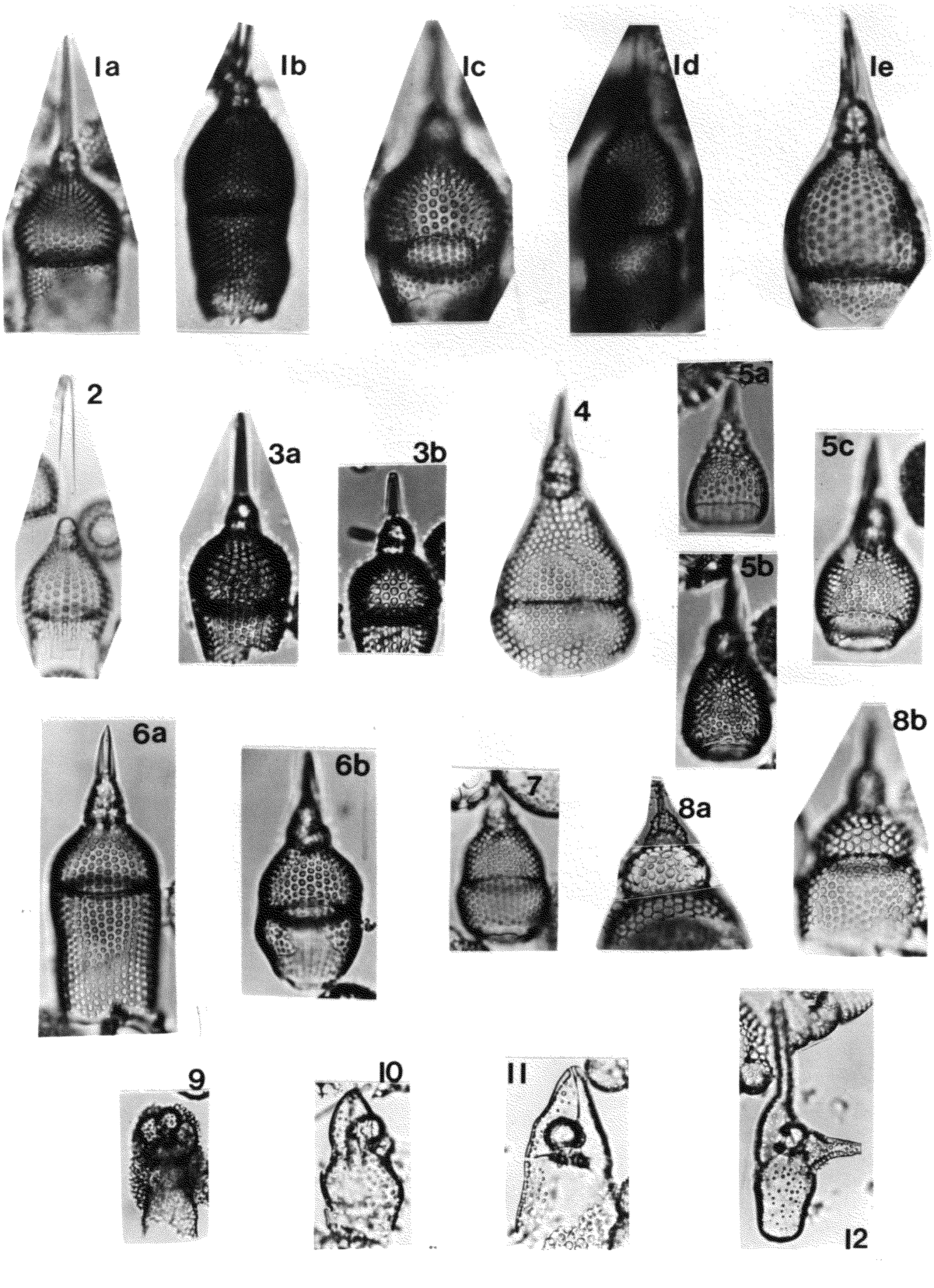

PLATE XVII

PLATE XVIII

Fig.1 Botryostrobus bramlettei 35cc R', V34/2 x207

Fig.2 Botryostrobus auritus-australis 26cc R(a), Y46/1 x245

Fig.3 Botryostrobus miralestensis 48-5 R, O28/3 x184

Fig.4 Botryostrobus sp. aff. B. bramlettei 45cc R(a), H43/2 x222

Fig.5a Carpocanarium spp. 44cc R(a), R57/0 x208

Fig.5b " " 47cc R, J58/2 x233

Fig.5c " " 48-5 R, Q34/0 x350

Fig.6 Carpocanarium sp.1 47cc R, G56/0 x191

Fig.7a Phormostichoartus corbula 45cc R(a), Y56/0 x210

Fig.7b " " Site 71,15-2 R(a), x146

Fig.8 Phormostichoartus doliolum 28cc R(a), E36/3 x220

Fig.9a Phormostichoartus fistula 48-5 Ph, N64/0 x200

Fig.9b " " 44-5 R, J34/0 x214

Fig.9c " " 47-3 R, T36/3 x215

Fig.10a Phormostichoartus marylandicus 47-5 R, T60/0 x230

Fig.10b " " 44-3 R, R59/2 x200

Fig.11a Siphocampe spp. 46cc R(a), S43/3 x210

Fig.11b " " 45cc R(a), Q63/3 x215

Fig.12a Siphostichoartus corona 42cc R(a), O33/4 x185

Fig.12b " " 45cc R(a), O49/2 x200

Fig.13 Siphostichoartus praecorona 47cc R, X48/1 x208

Fig.14a Spyrocyrtis gyroscalaris 42cc R(a), G56/0 x200

Fig.14b " " 42cc R(a), O64/1 x120

Fig.15a Spyrocyrtis spp. Site 71, 14-6 R(c), L60/0 x160

Fig.15b " " 47cc R, Q53/2 x230

Fig.15c " " 42cc R(a), F52/2 x193

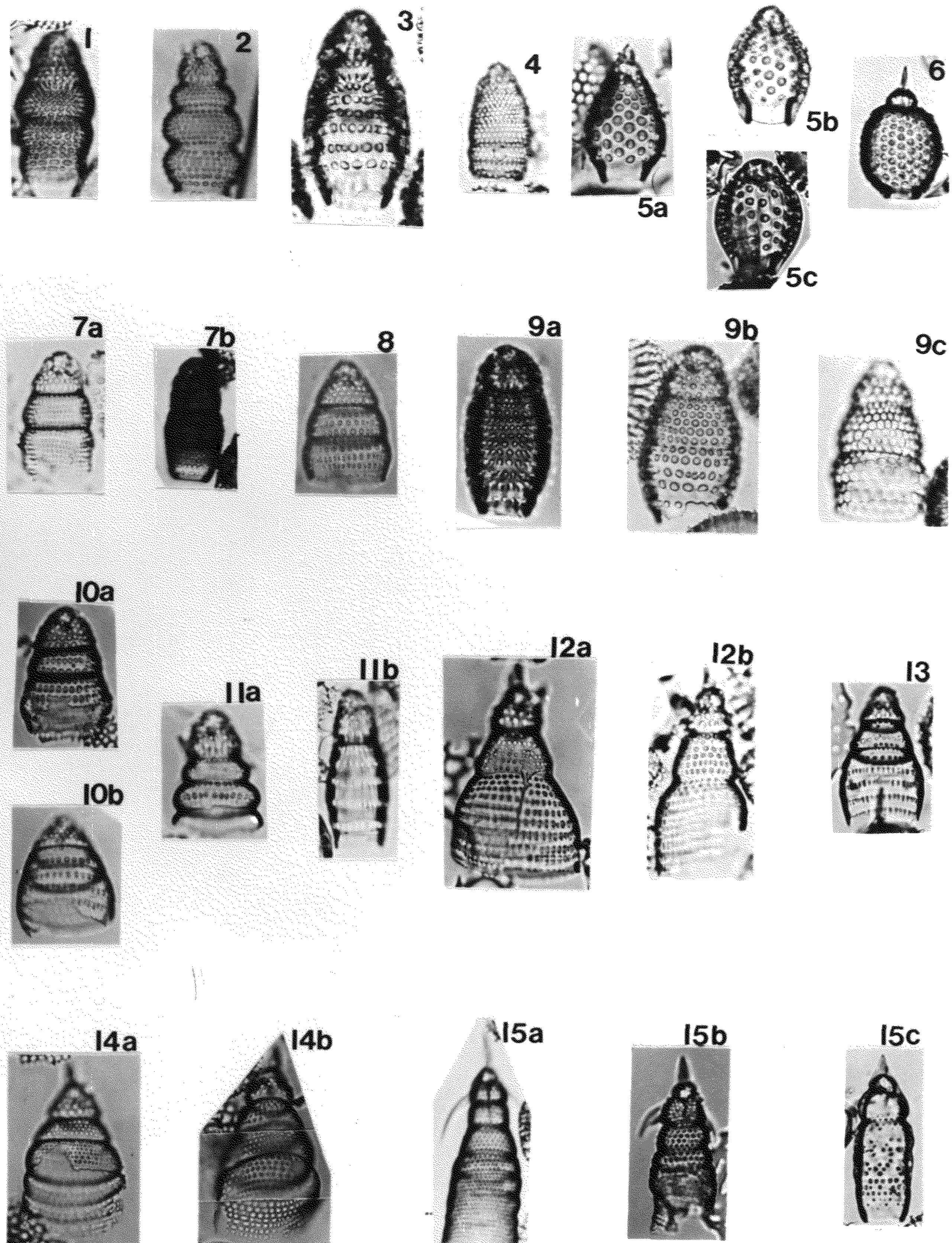
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PLATE XVIII